ESTIMATION OF HAZARDOUS WASTE GENERATION IN SELECTED PRIORITY SECTORS OF OSTIM OIZ, ANKARA

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

ARZU KAYABINAR

IN PARTIAL FULLFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
ENVIRONMENTAL ENGINEERING

DECEMBER 2010

Approval of the thesis:

ESTIMATION OF HAZARDOUS WASTE GENERATION IN SELECTED PRIORITY SECTORS OF OSTIM OIZ, ANKARA

submitted by **ARZU KAYABINAR** in partial fulfillment of the requirements for the degree of **Master of Science in Environmental Engineering Department, Middle East Technical University** by,

Prof. Dr. Canan Özgen _____
Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. Göksel Demirer _____
Head of Department, **Environmental Engineering**

Prof. Dr. Filiz B. Dilek _____
Supervisor, **Environmental Engineering Dept., METU**

Examining Committee Members:

Prof. Dr. Celal F. Gökçay _____
Environmental Engineering Dept., METU

Prof. Dr. Filiz B. Dilek _____
Environmental Engineering Dept., METU

Prof. Dr. Kahraman Ünlü _____
Environmental Engineering Dept., METU

Dr. Emre Alp _____
Environmental Engineering Dept., METU

Dr. Zeynep Yöntem _____
General Manager, Ekodenge Env. Con. and Eng. Ltd.

Date: **17.12.2010**

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name : Arzu Kayabınar

Signature :

ABSTRACT

ESTIMATION OF HAZARDOUS WASTE GENERATION IN SELECTED SECTORS OF OSTIM OIZ, ANKARA

Kayabınar, Arzu

M.Sc., Department of Environmental Engineering

Supervisor: Prof. Dr. Filiz B. Dilek

December 2010, 233 pages

In this study, Hazardous Waste Production potential for the selected priority sectors in OSTIM Organized Industrial Zone (OIZ), Ankara is investigated. A general inventory study is conducted based on both absolute and minor entries in Waste List of Regulation on General Principles of Waste Management, Annex 4.

Processes included in priority sectors are identified; moreover, each process is analyzed in terms of inputs entering and outputs leaving. Generated hazardous wastes from each sector are classified as process based, side processes based, and non-process based. After determination of codes and amounts of wastes, hazardous waste generation factors are generally calculated as “kg of waste generated per ton of product or raw material processed”. Calculated hazardous waste generation factors are compared with the estimated ones in literature if there is any and a specific range is determined for each waste factor. By use of sector specific hazardous waste generation factors and total capacity values sectoral hazardous waste generation amounts are calculated for OSTIM OIZ.

The most crowded and potentially polluter sectors are determined from 14 main producer sectors of OSTIM OIZ. Accordingly, machining, casting of ferrous metals, treatment and coating of metals, maintenance and repair of motor vehicles and manufacture of rubber products are selected priority sectors studied in this thesis study. It is observed that among selected priority sectors highest generation occurs in machining sector, which involve high amounts of 12 01 coded HWs as metal grindings and waste oil mixtures. In addition, manufacturing of rubber products sector has no significant hazardous waste generation.

Keywords: hazardous waste, hazardous waste generation factors, Waste List, OSTIM Organized Industrial Zone

ÖZ

ANKARA OSTİM OSB'NİN SEÇİLMİŞ ÖNCELİKLİ SEKTÖRLERİNDE TEHLİKELİ ATIK ÜRETİMİNİN TAHMİNİ

Kayabınar, Arzu

Yüksek Lisans, Çevre Mühendisliği Bölümü

Tez Yöneticisi: Prof. Dr. Filiz B. Dilek

Aralık 2010, 233 sayfa

Bu çalışmada, Ankara OSTİM Organize Sanayi Bölgesindeki seçilen öncelikli sektörler için Tehlikeli Atık Üretim potansiyeli incelenmiştir. Atık Yönetimi Genel Esaslarına İlişkin Yönetmeliğin Atık Listesi, Ek-4'te yer alan hem muallaklı (M) hem de kesin (A) girişlere dayalı genel bir envanter çalışması yürütülmüştür.

Öncelikli sektörlerde bulunan prosesler tanımlanmış; ayrıca, her proses girdiler ve çıktılar açısından analiz edilmiştir. Her sektörden ortaya çıkan tehlikeli atıklar, proses tabanlı, yan proses tabanlı ve proses dışı olarak sınıflandırılmıştır. Atık kodlarının ve miktarının tespitinden sonra, tehlikeli atık üretim faktörleri genellikle "üretilen ton ürün ya da işlenen hammadde başına oluşan kg atık miktarı " şeklinde hesaplanmıştır. Hesaplanan tehlikeli atık üretim faktörleri, literatürde var olan hesaplanmış verilerle karşılaştırılmış ve her biri için özel bir aralık belirlenmiştir. Sektörel tehlikeli atık üretim faktörleri ile toplam kapasite değerleri kullanılarak OSTIM OSB için sektörel tehlikeli atık üretim miktarı hesaplanmıştır.

En kalabalık ve potansiyel kirletici sektörler OSTİM OSB'nin üretim yapan 14 ana sektörleri arasından belirlenmiştir. Bu doğrultuda, talaşlı imalat, demir döküm, metal kaplama, araç tamir ve bakımı ve kauçuk ürün imalatı seçilmiş öncelikli sektörlerdir. Seçilen öncelikli sektörler içerisinde en fazla üretiminin, yüksek miktarda 12 01 kodlu tehlikeli atıklardan metal talaşı ve atık yağ karışımları içeren talaşlı imalat sektöründe oluştuğu gözlenmiştir. Buna ek olarak, kauçuk ürün imalatı sektöründe önemli bir tehlikeli atık üretimi yoktur.

Anahtar Sözcükler: tehlikeli atık, tehlikeli atık üretim faktörü, atık listesi, OSTİM Organize Sanayi Bölgesi

To my family,

ACKNOWLEDGMENTS

I would like to express my deepest gratitude to my thesis supervisor Prof. Dr. Filiz B. Dilek, for her guidance, valuable suggestions, encouragement, and deepest patience during the study period of my thesis.

I would also like to thank my committee members Prof Dr. Celal F. Gökçay, Prof. Dr. Kahraman Ünlü, Dr. Emre Alp and Dr. Zeynep Yöntem for their further and valuable discussions, comments, suggestions and contributions to this study.

I would also like to express my deepest regards to Prof. Dr. Ülkü Yetiş for her precious help, support and guidance in my thesis studies.

I am also grateful to Orhan Aydın, Sıtkı Öztuna, Adem Arıcı, and Ahmet Rıza Balım from OSTIM Organized Industrial Zone Management, for their understanding and support during my entire graduate education.

Finally, my greatest thanks go to my family members; my mother, my father, and my sister for their endless support and deepest confidence in me. I am and will always be pleased to be a member of such a strong family.

TABLE OF CONTENTS

ABSTRACT iv
ÖZ vi
ACKNOWLEDGMENTS ix
TABLE OF CONTENTS x
LIST OF TABLES xiii
LIST OF FIGURES xvii
ABBREVIATIONS xix

CHAPTERS
1. INTRODUCTION 1
2. BACKGROUND INFORMATION 4
2.1. Hazardous Wastes 4
2.1.1 General 4
2.1.2 Waste Inventory and Waste Generation Factors 7
2.2 Legal Framework Regarding Hazardous Wastes (LFRHW) 12
2.2.1 LFRHW in European Union 12
2.2.2 LFRHW in Turkey 14
2.3 Hazardous Waste Management in Turkey 17
2.3.1 Hazardous Waste Record System of Ministry of Environment and Forestry 17
2.3.2 Hazardous Waste Problem in Organized Industrial Zones 18
2.3.2.1 General Information about Organized Industrial Zones 18
2.3.2.2 Current Situation on Hazardous Waste Issue in OSTİM OIZ 19
3. METHODOLOGY 24

3.2 Study Approach 27
3.2.1 Sector Selection (Priority Sectors) 28
3.2.1.1 Determination of possible HW codes in selected sectors 30
3.2.2 Pilot Plant Studies 31
3.2.2.1 Approach to Estimate Hazardous Waste Generation 32
3.2.2.1.1. Process Analysis 32
3.2.2.1.2. Waste Analysis 32
3.2.2.2. Determination of Waste Generation Factors 33
3.2.3 Estimation of Sectoral HW Generation 34
4. RESULTS AND DISCUSSION 35
4.1 Priority Sectors in OSTIM OIZ 35
4.1.1. NACE Rev.2 Codes in selected priority sectors 36
4.2 Sectoral Studies 37
4.2.1 Casting of Ferrous Metals 38
4.2.1.1. Hazardous Wastes (HW) in Casting of Ferrous Metals 38
4.2.1.2. Pilot Plant Studies 43
4.2.1.2.1. Pilot Plant 1: C.1 43
4.2.1.2.2. Pilot Plant 2: C.2 51
4.2.1.2.3. Summary for Casting of Ferrous Metals 54
4.2.2. Machining 60
4.2.2.1. Hazardous Wastes (HW) in Machining 61
4.2.2.2. Pilot Plant Studies 64
4.2.2.2.1. Pilot Plant 1: M.1 65
4.2.2.2.2. Pilot Plant 2: M.2 72
4.2.2.2.3. Summary for Machining 75
4.2.3. Treatment and Surface Coating of Metals (Electroplating and Hot dip galvanizing) 81
4.2.3.1. HWs in Treatment and Surface Coating of Metals 82
4.2.3.2. Pilot Plant Studies 88

4.2.3.2.1. Pilot Plant 1: G.1 88
4.2.3.2.2. Pilot Plant 2: G.2 100
4.2.3.3. Summary for Treatment and Coating of Metals 104
4.2.4. Maintenance and Repair of Motor Vehicles 111
4.2.4.1. HWs in Maintenance and Repair of Motor Vehicles 112
4.2.4.2. Pilot Plant Studies 119
4.2.4.2.1. Pilot Plant 1: A.1 119
4.2.4.2.2. Pilot Plant 2: A.2 131
4.2.4.2.3. Summary for Maintenance and Repair of Vehicles 137
4.2.5. Manufacture of Rubber Products 143
4.2.5.1. HWs in Manufacture of Rubber Products 144
4.2.5.2. Pilot Plant Studies 147
4.2.5.2.1. Pilot Plant 1: R.1 147
4.2.5.2.2. Pilot Plant 2 156
4.2.5.3. Summary for Manufacture of Rubber Products 161
5. CONCLUSION 166
6. RECOMMENDATIONS FOR FUTURE STUDY 172
REFERENCES 173
APPENDICES
APPENDIX A - WASTE LIST FROM EUROPEAN WASTE CATALOGUE AND RGPWM .. 180
APPENDIX B - SECTORS AND SUB SECTORS OF OSTIM OIZ 212
APPENDIX C - SECTORAL INFORMATION 214
APPENDIX D - SAMPLE CALCULATIONS FOR HWGFs AND SECTORAL HW GENERATION 232

LIST OF TABLES

TABLES

Table 2.1 Properties of Hazardous Wastes [3] 5
Table 2.2 Different factors influencing the waste generation in the manufacturing industry [19] 8
Table 2.3 Waste factors: levels, interested parties, and examples [19] 11
Table 2.4 Classification of SME's [23] 21
Table 3.1 Sectoral profile of OSTIM OIZ in 2010 [24] 25
Table 3.2 General profile of manufacturing sectors of OSTIM OIZ in 2010 26
Table 4.1 NACE Rev.2 Codes of selected priority sectors in OSTIM OIZ 36
Table 4.2 Wastes from casting of ferrous pieces [4] 39
Table 4.3 Hazardous wastes generated from ferrous foundries [27] 40
Table 4.4 Types and amount of process specific HWs in C.1 47
Table 4.5 Types and amount of HWs from side processes in C.1 48
Table 4.6 Types and amount of non-process based HWs in C.1 49
Table 4.7 HW generation factors (HWGF) in C.1 50
Table 4.8 Types and amount of process specific HWs in C.2 52
Table 4.9 Classification and quantity of non-process based HWs in C.2 53
Table 4.10 HW generation factors (HWGF) in C.2 54
Table 4.11 Comparison of HW generation factors (HWGF) in ferrous metals casting 55
Table 4.12 Total HW generation in casting of ferrous metals sector 59
Table 4.13 Inputs and outputs in metal shaping (adapted from [30]) 61
Table 4.14 Wastes from shaping of metals [4] 62
Table 4.15 Hazardous wastes generated from machining [31] 63
Table 4.16 Types and amount of process specific HWs in M.1 69

Table 4.17 Types and amount of non-process based HWs in M.1 70
Table 4.18 HW generation factors (HWGF) in M.1 71
Table 4.19 Types and amount of process specific HWs in M.2 72
Table 4.20 Types and amounts of non-process based HWs in M.2 73
Table 4.21 HW generation factors (HWGF) in M.2 74
Table 4.22 Comparison of HW generation factors (HWGF) in machining 76
Table 4.23 Total HW generation in machining sector of OSTIM OIZ 80
Table 4.24 Wastes resulting from electroplating processes (adapted from [32]) 83
Table 4.25 Wastes from treatment and coating of metals [4] 84
Table 4.26 Hazardous wastes generating from metal coating [33] 85
Table 4.27 Chemical consumption amounts in G.1 91
Table 4.28 Types and amount of process specific HWs in G.1 96
Table 4.29 Types and amount of non-process based HWs in G.1 98
Table 4.30 HW generation factors (HWGF) in G.1 99
Table 4.31 Types and amount of process specific HWs in G.2 101
Table 4.32 Types and amount of non-process based HWs in G.2 102
Table 4.33 HW generation factors (HWGF) in G.2 103
Table 4.34 Comparison of HW generation factors (HWGF) in treatment and coating of metals 105
Table 4.35 Total HW generation in treatment and coating of metals sector 110
Table 4.36 Process wastes of maintenance and repair of motor vehicles [36] 112
Table 4.37 End-of-life vehicles from different means of transport (including off-road machinery) and wastes from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 16 06 and 16 08) [4] 113
Table 4.38 Possible hazardous wastes of maintenance and repair of motor vehicles from 13, 14, 15, 16 and 20 coded wastes [4] 114
Table 4.39 Typical hazardous wastes resulting from vehicle repair shops [37] 116
Table 4.40 Types and amount of process specific HWs in A.1 124
Table 4.41 Types and amount of HWs from side processes in A.1 127

Table 4.42 Types and amount of non-process based HWs in A.1 128
Table 4.43 HW generation factors (HWGF) in A.1 129
Table 4.44 Types and amount of process specific HWs in A.2..... 132
Table 4.45 Types and amount of HWs from side processes in A.2 134
Table 4.46 Types and amount of non-process based HWs in A.2..... 134
Table 4.47 HW generation factors (HWGF) in A.2 135
Table 4.48 Comparison of HW generation factors (HWGF) in maintenance and repair of motor vehicles 139
Table 4.49 Total HW generation in maintenance and repair of motor vehicles 141
Table 4.50 Waste Parameters for Dry Processing of Rubber Manufacturing [40] ... 145
Table 4.51 Wastes from the MFSU of Plastics, Synthetic Rubber and Man-made Fibers [4]..... 145
Table 4.52 Types and amount of process specific HWs in R.1..... 151
Table 4.53 Types and amount of HWs from side processes in R.1 153
Table 4.54 Types and amount of non-process based HWs in R.1..... 154
Table 4.55 HW generation factors (HWGF) in R.1 155
Table 4.56 Types and amount of process specific HWs in R.2..... 157
Table 4.57 Types and amount of HWs from side processes in R.2 158
Table 4.58 Types and amount of non-process based HWs in R.2..... 159
Table 4.59 HW generation factors (HWGF) in R.2 160
Table 4.60 Comparison of HW generation factors (HWGF) in manufacturing of rubber products 162
Table 4.61 Total HW generation in manufacturing of rubber products sector of OSTIM OIZ 164
Table 5.1 Comparison of total hazardous waste generation in selected priority sectors 168
Table A.1 Comparison of total hazardous waste generation in selected priority sectors 180
Table B.1 Sectors and Sub sectors of OSTIM OIZ 212

Table C.1 Unit Processes, Inputs, and Outputs of Metalworking Industry [42] 220
Table C.2 Types of main processes in treatment and coating of metals [2]..... 222
Table C.3 Inputs and outputs from main processes in treatment and coating of metals (adapted from [44])..... 223
Table C.4 Major pollutants of auto repair shops [36]..... 228

LIST OF FIGURES

FIGURES

Figure 2.1 Waste factors within the DPSIR-assessment framework [19] 9
Figure 2.2 Waste Factors – source oriented approach [19] 10
Figure 2.3 Waste Factors – source oriented approach [19] 21
Figure 3.1 A general view from OSTIM OIZ 24
Figure 3.2 Development of Methodology 27
Figure 4.1 Process specific hazardous wastes in foundries [27] 41
Figure 4.2 Process flow diagram of C.1 44
Figure 4.3 Inputs and outputs for preparation of sand cores and molds processes in C.1 45
Figure 4.4 Inputs and outputs for melting of metal and casting processes in C.1 46
Figure 4.5 Inputs and outputs for sandblasting and grinding processes in C.1 46
Figure 4.6 Inputs and outputs for cleaning and painting processes in C.1 48
Figure 4.7 Process flow diagram-1 of M.1 65
Figure 4.8 Process flow diagram-2 of M.1 66
Figure 4.9 Inputs and outputs for hot steel forging process in M.1 67
Figure 4.10 Inputs and outputs for machining process in M.1 68
Figure 4.11 Process specific hazardous wastes in treatment and coating of metals [33] 87
Figure 4.12 Process flow diagram-1 of G.1 for zinc electroplating 90
Figure 4.13 Process flow diagram-2 of G.1 for hot dip manganese phosphate galvanizing 91
Figure 4.14 Inputs and outputs for degreasing, pickling, and rinsing-1 processes in G.1 93

Figure 4.15 Inputs and outputs for zinc coating and rinsing-2 processes in G.1 94
Figure 4.16 Inputs and outputs for passivating and rinsing-3 processes in G.1 94
Figure 4.17 Inputs and outputs for hot degreasing & rinsing-4, acidic pickling & rinsing-5 and activation processes in G.1 95
Figure 4.18 Inputs and outputs for manganese phosphate coating and rinsing-6 processes in G.1 95
Figure 4.19 Inputs and outputs for greasing processes in G.1 96
Figure 4.20 Hazardous wastes in maintenance and repair of motor vehicles 118
Figure 4.21 Process flow diagram of auto body repair in A.1..... 120
Figure 4.22 Process flow diagram of mechanical maintenance and repair in A.1.... 121
Figure 4.23 Process flow diagram of cleaning in A.1 121
Figure 4.24 Process flow diagram of auto body painting in A.1 122
Figure 4.25 Inputs and outputs for mechanical maintenance and repair process... 123
Figure 4.26 Inputs and outputs for auto body repair process 123
Figure 4.27 Inputs and outputs for auto body painting process 123
Figure 4.28 Inputs and outputs for cleaning process..... 127
Figure 4.29 Process Specific Hazardous Wastes in Manufacture of Rubber Products146
Figure 4.30 Process Flow Diagram of R.1..... 148
Figure 4.31 Inputs and outputs for preparation of rubber compound process 149
Figure 4.32 Inputs and outputs for moldings and vulcanization process 150
Figure 4.33 Inputs and outputs for finishing processes..... 150
Figure 4.34 Inputs and outputs for metal processing..... 152
Figure C.1 Metal casting [26] 216
Figure C.2 Inputs and outputs from metal foundries [26] 218
Figure C.3 Induction furnace [41] 219
Figure C.4 Description of electrolytic baths [34] 224
Figure C.5 Inputs and outputs for electroplating process [30] 226
Figure C.6 Inputs and outputs for hot dip galvanizing process [30] 227

Figure C.7 Discrimination of the two terms: “NR processing” and “NR manufacturing” 229
Figure C.8 General Process Flow Diagram of Manufacturing of Rubber Products ... 230

ABBREVIATIONS

ASHRAE	: Refrigerating and Air-Conditioning Engineers
BAT	: Best Available Techniques
BREFs	: Reference documents on Best Available Techniques
CNC	: Computer Numerical Control
EEA	: European Environmental Agency
EMAD	: Environmental Management and Audit Directorate
EMAS	: Environmental Management and Audit System
EPA	: Environmental Protection Agency
EPER	: European Pollutant Emission Register
EU	: European Union
EUEL	: European Union Environmental Legislation
EWC	: European Waste Catalogue
GDP	: Gross Domestic Product
IPPC	: Integrated Pollution Prevention and Control
ISO	: International Standards Organization
HW	: Hazardous Waste
HWGF	: Hazardous Waste Generation Factor
HWRS	: Hazardous Waste Record System
LEED	: Leadership in Energy and Environmental Design
MoEF	: Ministry of Environment and Forestry
NACE	: Nomenclature statistique des Activités économiques dans la Communauté Européenne
OIZ	: Organized Industrial Zone
OSTIM OIZ	: OSTIM Organized Industrial Zone

PM	: Particulate Matter
PRTR	: Pollutant Release and Transfer Register
RCHW	: Regulation on Control of Hazardous Wastes
RCRA	: Resource Conservation and Recovery Act
RCSW	: Regulation on Control of Solid Wastes
RGPWM	: Regulation on General Principles of Waste Management
SME	: Small and Medium Sized Enterprises
TSI	: Turkish Standards Institution
VOC	: Volatile Organic Carbon

CHAPTER 1

INTRODUCTION

Hazardous wastes are special types of wastes that can be harmful to human being, environment, or ecosystem. Therefore, strict control and regulation of these wastes is required for their proper management. In fact, national legislation defines the rules for proper hazardous waste management.

Recently in Turkey, national legislation regarding hazardous wastes set up strict rules for proper management of the wastes. The most important and crucial step is to determine the amount and types of hazardous wastes to be managed. To this end, in Regulation on General Principles of Waste Management (RGPWM, Official Gazette No. 26927 and 2008) hazardous wastes are provided with their codes in the Waste List (Annex 4). As an obligation, companies in Turkey, have to report annual hazardous waste generation amounts in web based "Hazardous Waste Record System" of Ministry of Environment and Forestry (MoEF). Since system is too new for companies, once registered to the system they face with different problems even in determination of proper codes for their wastes. Because, aforementioned Waste List is a full list in which wastes are classified under NACE codes without any clear process specification. Hence, it is really very difficult even impossible for the industries to match their wastes with those in the list. Classification of possible hazardous waste codes on sectoral basis would be very beneficial to the industries during their reporting.

Furthermore, management of hazardous wastes is a big problem for small companies, especially for Small and Medium Enterprises (SMEs) in Turkey. Being small in size and budget, handling of hazardous waste seems to be an extra burden on these companies.

OSTIM Organized Industrial Zone (OSTIM OIZ) which is located in Ankara is one of the biggest Organized Industrial Zone's (OIZ) in Turkey, with a number of 5008 SMEs including 17 main sectors and 100 sub-sectors. In 2010, metal and metal treatment, building and construction, machinery and machine equipments, construction machines and automotive are the priority producer sectors in OSTIM OIZ due to their high number of companies. In addition to this, being small in size and high in numbers, most of the OSTIM OIZ companies are not aware of the recent developments in waste management system of Turkey and have difficulties in proper identification and discrimination of hazardous wastes.

Therefore, there is a need to collect data on sectoral waste amounts and to determine the waste generation factors in order to set a proper hazardous waste management system in OSTIM OIZ. This thesis study aims to develop a hazardous waste inventory in OSTIM OIZ based on information from literature and pilot plant studies conducted in the region for each selected priority sector. Based on local investigation and evaluation studies in OSTIM OIZ companies, sectoral waste generation factors are aimed to be determined in order to estimate the hazardous wastes generated. This hazardous waste inventory study is expected to be used as a crucial tool for OSTIM OIZ Administrative Board regarding a proper management of wastes in the region.

Another aim of this study is to prepare a guide document for SMEs in Turkey in a sectoral basis for identification of possible hazardous wastes and estimation of waste generation by using waste factors determined from pilot plant studies or

literature review. The resulting waste factors are also representative values for the most important and abundant producers of Turkey as SMEs.

CHAPTER 2

BACKGROUND INFORMATION

2.1. Hazardous Wastes

2.1.1 General

According to Resource Conservation and Recovery Act (RCRA) (42 U.S.C. 6901 *et seq,* 2002) definition of a hazardous waste is given as:

A waste (usually a solid waste) that has the potential to give a hazard to human health or living organisms due to the fact that it is non-degradable or persistent in nature, or it can be biologically magnified, or it can be lethal, or it can cause detrimental cumulative effects [1].

Hazardous waste can lead to *short-term acute hazards* (e.g. acute toxicity by ingestion, inhalation, or skin absorption) or *long-term environmental hazards* (e.g. resistance to biodegradation, pollution of underground or surface waters) [2].

According to Annex III of Council Directive of 12 December 1991 on hazardous waste (EEC, 1991) and similarly Appendix-III A of Regulation on General Principles of Waste Management of Turkey (RGPWM, Official Gazette No: 26927, 2008) which is in full harmony with 91/689/EEC, properties of wastes which render them hazardous are given in Table 2.1.

Table 2.1 Properties of Hazardous Wastes [3]

Code	Hazardous Property	Explanation
H1	*Explosive*	Substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene.
H2	*Oxidizing*	Substances and preparations which exhibit highly exothermic reactions when in contact with other substances, particularly flammable substances.
H3-A	*Highly flammable*	• Liquid substances and preparations having a flash point below 21 °C (including extremely flammable liquids), or • Substances and preparations which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy, or • Solid substances and preparations which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition, or • Gaseous substances and preparations which are flammable in air at normal pressure, or • Substances and preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities.
H3-B	*Flammable*	Liquid substances and preparations having a flash point equal to or greater than 21 °C and less than or equal to 55 °C.
H4	*Irritant*	Non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation.
H5	*Harmful*	Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may involve limited health risks.
H6	*Toxic*	Substances and preparations (including very toxic substances and preparations) which, if they are inhaled or ingested or if they penetrate the skin, may involve serious, acute or chronic health risks and even death.
H7	*Carcinogenic*	Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce cancer or increase its incidence.

Table 2.1 (continued) [3]

Code	Hazardous Property	Explanation
H8	*Corrosive*	Substances and preparations which may destroy living tissue on contacts.
H9	*Infectious*	Substances containing viable micro-organisms or their toxins which are known or reliably believed to cause disease in man or other living organisms.
H10	*Teratogenic*	Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce non-hereditary congenital malformations or increase their incidence.
H11	*Mutagenic*	Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce hereditary genetic defects or increase their incidence.
H12		Substances and preparations which release toxic or very toxic gases in contact with water, air or an acid.
H13		Substances and preparations capable by any means, after disposal, of yielding another substance, i.e. a leachate, which possesses any of the characteristics listed above.
H14	*Ecotoxic*	Substances and preparations which present or may present immediate or delayed risks for one or more sectors of the environment.

According to Article 17 of RGPWM (Official Gazette No. 26927, 2008), wastes which are marked with (*) in Waste List are hazardous wastes. In the Article, hazardous wastes are described as the wastes that have one or more of the properties listed in Table 2.1.

In the Waste List of RGPWM (Official Gazette No. 26927, 2008), some wastes appear with a mark either (A) or (M). Those marked with (A) are classified in hazardous waste class regardless their hazardous waste concentration. Regarding to those marked with (M), it is stated that in the studies which will be conducted to determine the hazardous properties of (M) marked wastes, comparisons regarding

H3-H8, H10 and H11 properties listed in Appendix-III A are to be made with the concentration values given in Appendix- III B [4].

The whole Waste List is given in Appendix A of this thesis document.

2.1.2 Waste Inventory and Waste Generation Factors

Waste inventory can be basically described as creating a list of all of the waste streams (regulated wastes and emissions from manufacturing operations including liquid and solid hazardous wastes, air emissions, wastewater, etc.) at facilities [18].

Generally waste inventories help waste generators:

- to identify wastes as hazardous, recyclable, and landfill wastes,
- to keep up with changes in regulations, and
- to manage costs resulting from meeting environmental requirements[18].

There are various factors affecting the waste generation of a country from industrial activities as tabulated in Table 2.2.

Environmental indicators and factors related with different environmental policy fields (e.g. air pollution, resource depletion, and waste, etc.) are important tools for following changes, screening trends, and making projections in waste generation. Since they are mostly related with emissions from human activities, determination of factors is not so easy for some of the waste types due to lack of proper and consistent information [19].

Table 2.2 Different factors influencing the waste generation in the manufacturing industry [19]

general environmental policy	environmental goals (sustainable development); public demand; consumption patterns; environmental pressure groups; etc.
legal instruments	regulations/laws (production process, additive environment measures, pre-treatment, recycling, disposal, transfrontier shipment, bans, ...); classification/definition and declaration of waste; etc.
economic instruments	levies/taxes; disposal fees; recycling fees; implementation cost of clean technology; etc.
persuasive instruments	voluntary agreements; information availability (minimisation, disposal); promotion/support of innovative technology; etc.
enforcement/ control	control of emissions, of waste flows, of declaration (production source, treatment plants, ...); etc.
production process	design/operation/maintenance of technology used; state-of-the-art; material input; operation costs; investment costs; investment cycles; etc.
product	design of product; material input; material costs; use; durability; easy to repair; etc.
additive environment protection measures	end-of-pipe measures (waste water and air emission treatment; pre-treatment of waste); etc.
waste prevention	minimisation technology; environmental management; material substitution; pre-treatment; production and product design; etc.
recovery (recycling/re-use)	infrastructure; plants/techniques (availability, capacity,...); ownership; costs; etc.
disposal	infrastructure; plants/techniques (availability, capacity,...); ownership; costs; etc.
logistic/services	waste collection system (techniques/ownership/ management); infrastructure; sorting/pre-treatment; etc.
others	consumer/client demand; marketing; market conditions/ competition; EMAS/ISO 14001; neighbourhood complaints; etc.

According to DPSIR (i.e. driving force, pressure, state, impact, response) assessment framework, waste factors are related to driving force (production, consumption, and treatment of waste) and pressure (emissions of waste) as depicted in Figure 2.1.

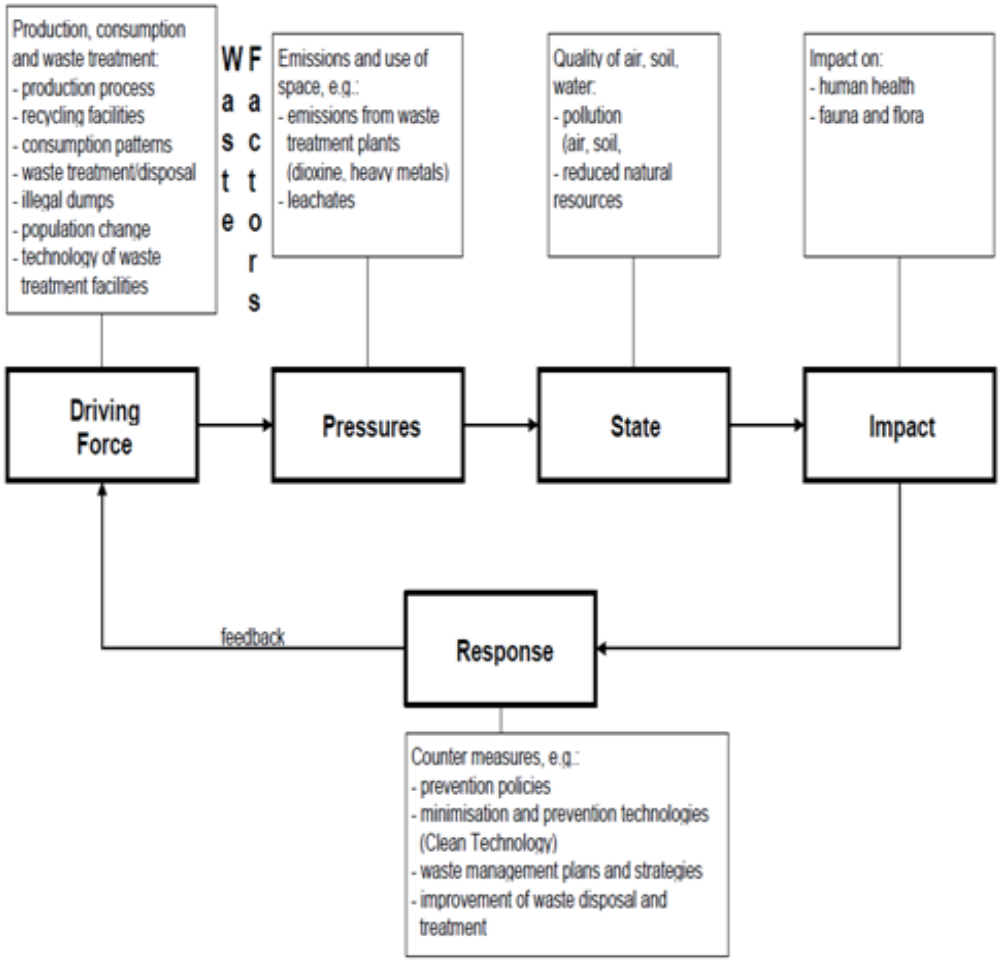

Figure 2.1 Waste factors within the DPSIR-assessment framework [19]

However, this approach restricts development of waste factors (e.g. quantity of waste generated per inhabitant, quantity of waste per product produced) due to

difficulties in data access. Therefore, source oriented approach is developed as a new methodology which focuses on not only waste generation but also waste prevention and minimization [19]. Main components involved in determination of waste factors with source oriented approach are given in Figure 2.2.

Waste factors may vary according to different levels depending on different characteristics, purposes, conclusions of users or interested parties [19].

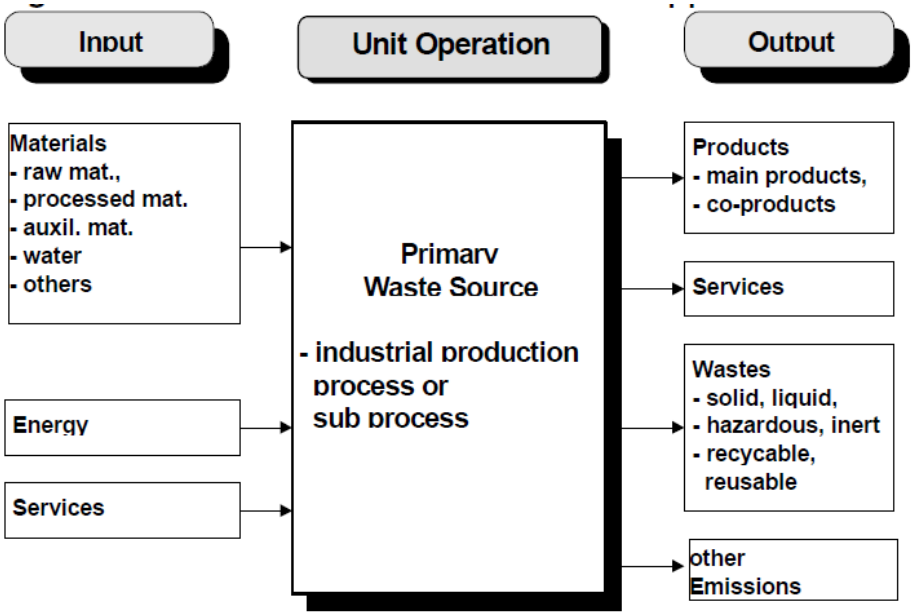

Figure 2.2 Waste Factors – source oriented approach [19]

At **national level** waste factors relate environmental data with economic aspects, such as "the quantity of waste per Gross Domestic Product (GDP) or per inhabitant" [19].

At **industrial sector level** waste factors are related with amount of waste as a whole (e.g. the entire electricity supply industry produces … tons of slag, filter dusts and other residues per year), or specific type of fuel (e.g. coal-fired power plants produce … tons of slag, filter dusts and other residues per year) or product type (e.g. … tons of residues per MWh produced) [19].

At **enterprise level** or **production site level** authorities mostly focus on implementing an Environmental Management and Auditing System (EMAS) and are more interested in waste productivity [19].

At **technology level,** waste factors can be further classified as *process level* and *sub process level*. Waste factors are generally calculated as "the quantity of waste per unit product" (e.g. 9 kg of paint sludge per car in a car manufacturing plant) [19].

Examples of waste factors for different levels and interested parties are given In Table 2.3.

Table 2.3 Waste factors: levels, interested parties, and examples [19]

Level	Interested party (customer)	Waste factor (example)
national and regional	political decision makers, statistic offices, economists, public administration	waste quantity per BIP, per inhabitant
industrial sectors	statistic offices, economists, industrial associations	waste quantity per product or financial turnover

Table 2.3 (continued) [19]

enterprises, production sites	management, waste management authorities	waste quantity per product or financial turnover
technology: production process and sub-processes	management, engineer, waste management authorities	waste quantity per input of raw material or per product unit
consumer	private and industrial consumer, consumer associations	waste quantity per product bought

2.2 Legal Framework Regarding Hazardous Wastes (LFRHW)

2.2.1 LFRHW in European Union

Waste management part of European Union Environmental Legislation (EUEL) consists of various instruments regarding wastes and hazardous wastes. In fact, the most important directives regarding hazardous wastes in EU Legislation are Directive on Waste (2008/98/EC) and Directive on Hazardous Waste (91/689/EEC).

Council Directive 2008/98/EC of 19 November 2008 on waste establishes a legal framework with the articles about generation, management, hierarchy and treatment of wastes [5].

Council Directive 91/689/EEC of 12 December 1991 on hazardous waste is valid until the end of 2010. This directive gives a uniform definition, important properties, and a full list with corresponding codes (according to their nature or the activity which generated them) of hazardous wastes. Furthermore, it supports the Framework Directive on Waste (Directive 2006/16/EC) by articles about proper hazardous waste management and record system [3].

Regulation (EC) No 166/2006 defines a reporting system, European Pollutant Release and Transfer Register (PRTR), and sets the rules for the regular reporting of information on pollutants and waste by Member States to the Commission. "PRTRs" provide public access to information on releases and off-site transfers of pollutants (including waste) and enable monitoring environmental compliance of industries within EU through the internet [6].

In addition to this, Integrated Pollution Prevention and Control (IPPC) Directive (2008/1/EC) has also related issues regarding hazardous wastes. The IPPC Directive (2008/1/EC), which replaces Directive 96/61/EC, states that industrial and agricultural activities with a high pollution potential (as defined in Annex I to the Directive e.g. energy, production and processing of metals, chemical industry, etc.) should have a permit. This permit can be given for those which meet the environmental requirements and are responsible for prevention of the pollution. According to the Directive, the Commission is responsible for enhancing communication network between Member States and the industries to disseminate information about best available techniques (BATs), monitoring data, and developments. In Directive, the definition of "BATs" is given with the explanations of words as “techniques”, “available techniques”, and also “best” and can be given as the most effective technology opportunities in terms of environmental, economical, and technical aspects [7].

Reference documents on Best Available Techniques (BREFs) prepared by The European IPPC Bureau are important guides for competent authorities in Member States while giving permits to polluter installations in EU [8].

2.2.2 LFRHW in Turkey

In Turkey, the legislative framework regarding hazardous wastes have four important legal tools; the Law on Environment (Official Gazette No. 2872, 1983) amended by Law (Official Gazette No. 5491, 2006), Regulation on Control of Solid Wastes (RCSW) (Official Gazette No. 20814, 1991), amended in 1991, 1992, 1994, 1998, 1999, 2000, 2002 and 2005, Regulation on Control of Hazardous Wastes (RCHW) (Official Gazette No. 25755, 1995 and amended in 2005), and Regulation on General Principles of Waste Management (RGPWM) (Official Gazette No. 26927, 2008).

First of all, The Law on Environment (Official Gazette No. 5491, 2006) is a major environmental milestone by providing a legal basis for responsibilities, roles, and applications for different actors (e.g. municipalities, Ministry of Environment and Forestry (MoEF), polluters, etc.). This Law defines the terms of protection of natural resources, polluter liability, the principles of user and polluter pays, sectoral integration, public awareness and public involvement [9]. Moreover, it highlights on liability of hazardous waste generators for proper management of their wastes according to related regulations and includes administrative penalties regarding hazardous wastes [10].

Secondly, RCSW (Official Gazette No. 20814, 1991) sets the fundamental rules for national waste management system including reduction of waste production, separation of recoverable waste at its source and recycling of these wastes and disposal of non-recyclable wastes with environment-friendly methods [11]. Furthermore, in RCSW (Official Gazette No. 20814, 1991) general principles and regulations regarding hazardous wastes as a specific type of solid wastes are determined [12].

Thirdly, the RCHW (Official Gazette No. 25755, 2005) of Turkey prepared based on the Environmental Law and the Basel Agreement sets the rules for national hazardous waste management system [11]. This Regulation also defines the legal requirements for disposal of and control actions regarding generation and transportation of hazardous wastes and also for obtaining registration and licensing of hazardous waste disposal installations [13].

Next, the aim of the RGPWM (Official Gazette No. 26927, 2008) is the determination of general principles for management of wastes from their generation to disposal, without giving any harm to environment and human health. It consists of some articles about liabilities of major stakeholders in waste management, classes of wastes, waste disposal methods, waste recovery processes and finally general waste list including hazardous wastes [4].

This legislation is also supported by a number of more specific regulations, including [14]:

- *Regulation on Control of Packaging and Packaging Waste (Official Gazette No. 26562, 2007)*
- *Regulation on Control of Waste Oils (Official Gazette No. 26952, 2008)*
- *Regulation on Control of Waste Batteries and Accumulators (Official Gazette No. 25569, 2004)*
- *Regulation on Control of the Tyres which have completed their life-cycle (Official Gazette No. 26357, 2007)*
- *Regulation on Control of the Vehicles which have completed their life-cycle (Official Gazette No. 27448, 2009)*
- *Regulation on Control of Medical Wastes (Official Gazette No. 25883, 2005)*
- *Regulation on Excavation Soil, Construction and Demolition Waste Control (Official Gazette No. 25406, 2004)*

- *Regulation on Control of Polychlorinated Biphenyls and Polychlorinated Terphenyls (Official Gazette No. 26739, 2007)*
- *Regulation on Landfilling of Wastes (Official Gazette No. 27533, 2010)*
- *Regulation on Incineration of Wastes (Official Gazette No. 27721, 2010)*

In addition to this, The Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel Convention) was signed in 1989 and was ratified in 1994. Basel Convention regulates the international relations regarding hazardous wastes and prevents illegal transfer of hazardous waste from developed countries to Turkey [9].

Finally, as an example for supporting regulations, Regulation on Control of Waste Batteries and Accumulators (Official Gazette No. 25569, 2004) establishes a legal framework for proper management of battery and accumulator products and their wastes. According to this Regulation, this kind of waste is a special kind of waste that should be separately collected from domestic waste and should not be disposed directly to the environment [9].

Recently, Turkey has progressed well in adoption of EU legislation into national legal framework especially in terms of waste management regarding with Waste Framework Directive (2008/98/EC) and the Hazardous Waste Directive (91/689/EEC). However, the integration of environmental issues into other policies has not been achieved yet and need some more time [15].

2.3 Hazardous Waste Management in Turkey

2.3.1 Hazardous Waste Record System of Ministry of Environment and Forestry

Waste Management Department of Ministry of Environment and Forestry (MoEF) is responsible for two separate systems to establish national inventories regarding environment in general and also waste management [11].

According to the Article 9 of RCHW (Official Gazette No. 25755, 2005); hazardous waste generating companies must inform the Ministry annually about their waste amounts by filling “Hazardous Waste Notification Form” [13].

Within the concept of the LIFE Third Countries Project TCY/TR/000292 “Improvement of Industrial Hazardous Waste Management in Turkey”, a web-based “Hazardous Waste Record System” (HWRS) was programmed by TURKSTAT’s IT department for the MoEF. MoEF started online entry in April 2008 for 2007 data in coordination with Provincial Department of Environment and Forestry [16].

The HRWS is a Java based application for data collection which is also linked with MoEF´s Environmental Information System. The HWRS comprises of a business register for the information (retrieved from Union of Chamber and Commodity, UCCE) about waste generators; a facility register for the information from recovery and disposal installations; the data collection system for MoEF about national waste generation; a password-restricted access for industry to enter specific data [16].

For waste generators direct access to HWRS is supplied with the web based data entry tool on the web page of the Ministry of Environment and Forestry (http://cbs.cevreorman.gov.tr).

For login to the system user ID and Password is required. This information was directly sent to all registered companies in Turkish Industry database by MoEF and companies can easily access to system in declaration periods [16].

Waste generators have to enter their company profile (company name, address, NACE codes etc.) and also waste data (waste code, amount, management method etc.) for the system [17]. Pull-down menus on waste codes and links to the facility register to select the appropriate installation by mouse click facilitates the use of the system [16].

2.3.2 Hazardous Waste Problem in Organized Industrial Zones

2.3.2.1 General Information about Organized Industrial Zones

According to Organized Industrial Zones Law (Official Gazette No. 4562, 2000) of Ministry of Industry and Trade, Organized Industrial Zones (OIZs) are defined as

“the good and service production zones, which are formed by allocating the land parcels, the borders of which are approved, for the industry in a planned manner and within the framework of certain systems by equipping such parcels with the necessary administrative, social, and technical infrastructure areas and repair, trade, education, and health areas as well as technology development regions within the ratios included in zoning plans and which are operated in compliance with the provisions of this Law in order to ensure that the industry gets structured in approved areas, to prevent unplanned industrialization and environmental problems, to guide urbanization, to utilize resources rationally, to benefit from information and informatics technologies, and to ensure that the types of industries are placed and developed within the framework of a certain plan” [24].

This Law authorizes OIZs to construct their own infrastructure and provide different services (e.g. electricity, natural gas, water, wastewater, communication, etc.) in management of the industrial zones [20].

2.3.2.2 Current Situation on Hazardous Waste Issue in OSTİM OIZ

OSTIM Organized Industrial Zone (OSTIM OIZ), one of the biggest OIZ in Ankara, has been founded in 1997; discharge its duties according to Regulation on Organized Industrial Zones Implementation (Official Gazette No. 27327, 2009). OSTIM OIZ is directed by a regional director appointed by the plenary committee and Administrative Board.

Since its foundation, major services provided by OSTIM OIZ Management to the members of industrial zone can be given as follows [21];

- Electricity and natural gas
- Land development-housing and infrastructure
- Environmental management and audit
- Security service
- Inauguration
- Fair organization
- Human resources
- Customer satisfaction
- Informatics and communication
- Press and public relations
- Education
- Occupational health and safety
- Clustering

Aiming to become a best model to their companies, in 2010 OSTIM OIZ has taken TS EN ISO 14001 and TS 18001 (OHSAS) certificates from Turkish Standards Institution (TSI) and established “Integrated Management System” with the basic principle of “zero faults, zero waste, and zero occupational accident”. Moreover, High Performance Green Building of OSTIM OIZ which was designed according to American Society of Heating, Leadership in Energy and Environmental Design (LEED) criteria of Refrigerating and Air-Conditioning Engineers (ASHRAE) was constructed in 2009 and is currently being used as administrative building in OIZ.

In OSTIM OIZ, out of 5000 member firms, 31% of firms are activating in trade, and 69% of firms are operating in manufacture and other business areas [21]. There are 17 main sectors and 139 sub-sectors involved in OSTIM OIZ and these sectors can be listed as follows;

- Automotive
- Building and Construction
- Chemicals
- Construction Machines
- Electric-Electronics
- Food
- Health
- Machine and Machine Equipments
- Metal and Metal Treatment
- Packing - Paper - Print - Stationary
- Plastics-Rubber
- Service
- Technical Tools, Benches and Equipments
- Technology and Informatics

- Textile and Leather
- Urban Furniture and Landscape
- Various Commercial Activities

Moreover, sub groups of these main sectors are given in Appendix B.

Majority of the companies in OSTIM OIZ are classified in Small and Medium Sized Enterprises (SME) based on their company profiles. According to EU and also for Turkey, as given in Table 2.4, "SME"s current definition categorizes companies with fewer than 10 employees as **"micro"**, those with fewer than 50 employees as **"small"**, and those with fewer than 250 as **"medium"** [23]. In terms of OSTIM OIZ, according to survey conducted in 2009, **76,9 %** of companies are in micro class, 21,4 % of companies are in small class, and only 1,7 % of companies are in medium class.

Table 2.4 Classification of SME's [23]

Enterprise category	Number of Employees	Turnover or Balance Sheet (total)
medium	< 250	≤ 25 million TL
small	< 50	≤ 5 million TL
micro	< 10	≤ 1 million TL

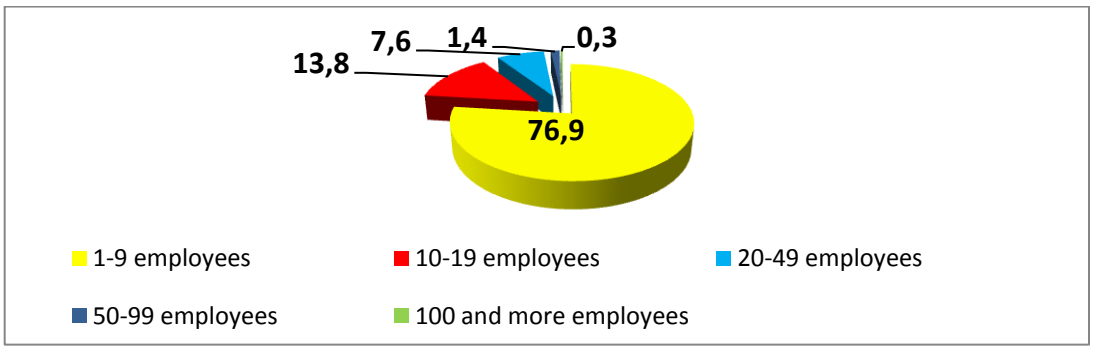

Figure 2.3 Waste Factors – source oriented approach [19]

Moreover, according to the survey, **46 %** of OSTIM OIZ companies are producers and **54 %** are dealing with trade or other services. In addition to this, majority of the producing companies in OSTIM OIZ are defined as sub-suppliers of bigger factories in Ankara, in Turkey or in different countries of the world. Meanwhile, the term "producing" refers to "manufacturing" in OSTIM OIZ in most of the cases, since small companies are generally in charge of processing raw materials instead of producing them (e.g. production of rubber products instead of production of natural/synthetic rubber).

Currently, Environmental Management and Audit Directorate (EMAD) of OSTIM OIZ is responsible for management of wastes in OIZ. Directorate was established in 2003 and is responsible of taking actions towards protection of environment in OIZ with a team of Environmental Engineers, Environment Audit Team and workers. EMAD is aimed for informing companies in OSTIM OIZ about environmental issues and making companies obey the rules set by national legislation. Apart from environmental audits, EMAD is in charge of providing consultancy services regarding environmental issues (management of solid/packaging/hazardous/… wastes, wastewater, air emissions, noise etc).

In this respect, domestic wastes and construction and demolition wastes are collected by Municipality of Yenimahalle and controlled by EMAD. Packaging wastes are also collected by the licensed firm of Municipality in coordination with EMAD. However, no proper waste recording exists about these wastes.

Due to companies being small in size, small amounts of hazardous wastes are generated per many enterprises in OSTIM OIZ compared to other OIZ's. Similarly, types and characteristics of wastes vary depending on the main/sub sectors of OSTIM OIZ. An environmental questionnaire was conducted in 2005 by commissioned environmental engineers to OSTIM OIZ companies in order to get

direct information from companies regarding their environmental and production status. Unfortunately, majority of the questions on the amount and types of wastes were unanswered due to both lack of information and unwillingness in declaration.

As stated in Article 126 of Regulation on Organized Industrial Zones Implementation (Official Gazette No. 27327, 2009), OSTIM OIZ is authorized to ensure the participants' compliance with their obligations and to supervise them within the framework of the Regulation on the Control of Hazardous Wastes. In addition, participants have to store their hazardous wastes on a temporary basis, get them transported by licensed carriers, and disposed of in licensed facilities [22].

Yet, an integrated waste inventory including both types and amounts that is the first and crucial step of a proper hazardous waste management system is missing in OSTIM OIZ. Because of this deficiency, there is no proper management system regarding hazardous wastes.

CHAPTER 3

METHODOLOGY

3.1 Study Area

In this study, OSTIM Organized Industrial Zone (OSTIM OIZ) was selected as a study area. A general view from OSTIM OIZ is given in Figure 3.1. Based on the information gathered from OSTIM OIZ database (www.ostim.org.tr) in January 2010, sectoral profile of OSTIM OIZ can be summarized as in Table 3.1.

Figure 3.1 A general view from OSTIM OIZ

Table 3.1 Sectoral profile of OSTIM OIZ in 2010 [24]

No	Sectors	Number of Companies	% of Total
1	AUTOMOTIVE	788	15,73
2	BUILDING AND CONSTRUCTION	650	12,98
3	METAL AND METAL TREATMENT	553	11,04
4	CONSTRUCTION MACHINES	471	9,40
5	SERVICE*	414	8,27
6	MACHINE AND MACHINE EQUIPMENTS	397	7,93
7	VARIOUS COMMERCIAL ACTIVITIES*	313	6,25
8	ELECTRIC-ELECTRONICS	258	5,15
9	TECHNICAL TOOLS, BENCHES AND EQUIPMENTS	224	4,47
10	PLASTICS-RUBBER	156	3,12
11	PACKING-PAPER-PRINT-STATIONERY	152	3,04
12	CHEMICALS	135	2,70
13	TECHNOLOGY AND INFORMATICS*	123	2,46
14	FOOD AND INDUSTRIAL KITCHEN	122	2,44
15	TEXTILE AND LEATHER	90	1,80
16	HEALTH	87	1,74
17	URBAN FURNITURES AND LANDSCAPE	75	1,50
TOTAL		**5008**	**%100**

*non-producer sectors

As it can be seen from Table 3.1, Automotive, Building and Construction, Metal and Metal Treatment are the most dominating sectors in OSTIM OIZ in terms of number of firms.

However, this profile represents a general picture of OSTIM OIZ including manufacturing, service and other activities. Since industrial hazardous waste generation is aimed to be estimated in this study, companies performing service and other activities (i.e. non-manufacturing) were excluded from the list given in Table 3.1. In this respect, non-producer sectors marked with "*" in Table 3.1, namely Service, Commercial Activities, and Technology and Informatics, were

eliminated at first hand from the general list. While determining the profile of producer sectors, only companies which have selected “manufacturing” choice in 2009 Questionnaire of OSTIM OIZ were chosen among the others belonging to 14 sectors in the new list. Number of companies in manufacturing sectors of OSTIM OIZ was accordingly determined as tabulated in Table 3.2.

Table 3.2 General profile of manufacturing sectors of OSTIM OIZ in 2010

NO	Manufacturing Sectors	Number of Manufacturing Companies	% of sector
1	METAL AND METAL TREATMENT	619	27,13
2	BUILDING AND CONSTRUCTION	498	21,82
3	MACHINE AND MACHINE EQUIPMENTS	379	16,61
4	CONSTRUCTION MACHINES	195	8,55
5	AUTOMOTIVE	162	7,10
6	ELECTRIC-ELECTRONICS	108	4,73
7	PLASTICS AND RUBBER	81	3,55
8	FOOD AND INDUSTRIAL KITCHEN	54	2,37
9	PACKING-PAPER-PRINT-STATIONERY	40	1,75
10	TECHNICAL TOOLS, BENCHES AND EQUIPMENTS	37	1,62
11	CHEMICALS-DYES	33	1,45
12	URBAN FURNITURES AND LANDSCAPE	31	1,36
13	TEXTILE AND LEATHER	26	1,14
14	HEALTH	19	0,83
TOTAL		**2282**	**% 100**

As can be seen from Table 3.2, Metal and Metal Treatment, Building and Construction, and Machine and Machine Equipments are number wise dominating manufacturing sectors in OSTIM OIZ.

3.2 Study Approach

In this study, hazardous waste production potential of the selected manufacturing sectors in OSTIM OIZ was investigated. A general inventory study was conducted, in which potential industrial activities which can lead to the formation of wastes classified as hazardous in Annex 4 of RGPWM (Official Gazette No. 26927, 2008) were determined. The methodology followed is summarized in Figure 3.2 and is explained in the following sections.

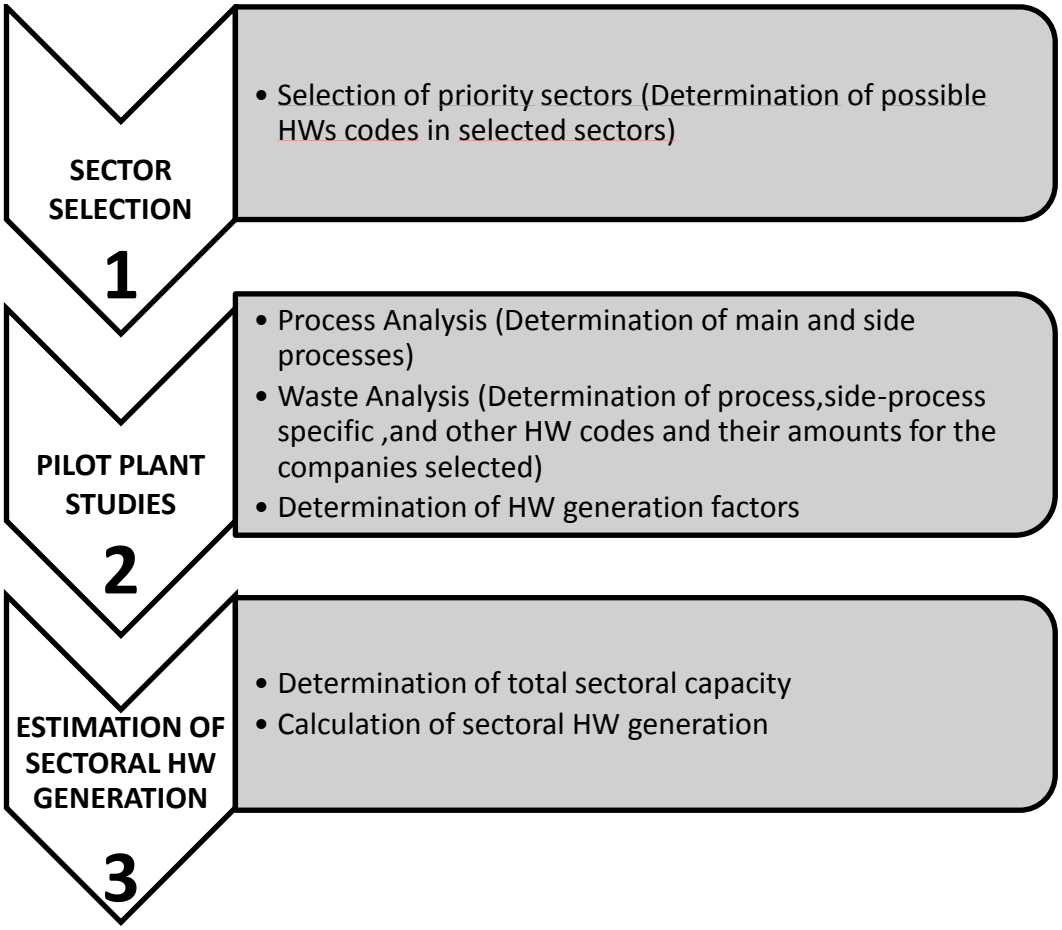

Figure 3.2 Development of Methodology

3.2.1 Sector Selection (Priority Sectors)

Within the limited time of this thesis study, it was impossible to include all manufacturing sectors of OSTIM OIZ. Therefore, priority sectors were determined. To this purpose, sectors having less than 5 % (in terms of number of companies) were eliminated, at first hand, from the list given in Table 3.2. The remaining sectors (metal and metal treatment, building and construction, machine and machine equipments, construction machines and automotive) were further analyzed in terms of their profiles. While doing so, firstly, OSTIM OIZ Directorate classification system (Appendix B) was examined. This system divides industries into various sub groups by products and processes. For example, in metal and metal treatment sector there are 18 sub-sectors involved. However, 7 of these sub groups are classified as metal processing and the remaining ones are given as different types of metal products. For metal processing, it is easy to identify the sub-processes, inputs, and outputs, and in a way, to estimate the HW generation. However, for metal products, since categorization system is too general (such as stainless sheet, metal tools, metal decoration, etc.) it is hard to make standardization. Therefore, for metal and metal treatment sector, **machining** (as a most crowded sub-sector) was chosen to consider during HW estimation studies. Sub-sectors of **metal coating** and **casting, modeling and forging works** were also included since they are known as polluter sectors of OSTIM OIZ.

Moreover, according to the report of International Competition Analysis of Sectors in OSTIM OIZ (December 2007) prepared by an independent consultancy company, Building and Construction, Plastics, Metal and Metal Treatment (Machining sector), Automotive, Machinery, Electric and Electronics, Technology and Informatics and Construction Machines were the selected sectors for competitiveness analysis with *Diamond Model (Porter, 1990)*. Based on this

information, it can be stated that predetermined priority sectors for HW estimation studies are similar with the ones analyzed for competition analysis.

In Building and Construction sector, steel construction has the highest number of firms among other sub groups. Production of spare parts of construction machines and special products are also important sub-sectors in OSTIM OIZ. However, these sub-sectors are also primarily related with machining sub-sector of the metal sector, and therefore, they are not taken as separate sub-sectors in HW estimation studies. On the other hand, the remaining sub-sectors of Building and Construction sector involve mainly final shaping and assembly operations; therefore, no significant amount of HW generation from these sub-sectors was expected.

Machine and machine equipments sector involves production of various types of machines and their equipments. Although there are various products, mainly machining process is involved in production of machines. Therefore, this sector was investigated under machining sub-sector category.

Construction machines sector can be divided into two sub groups as repair and maintenance of machines and production of spare parts. Production of spare parts sub-sector is mainly related with metal shaping processes, therefore, they are included in HW determination studies under machining sub-sector. In addition to this, repair and maintenance services of construction machines were not included in this thesis study. Because, types and maintenance period of these machines are so variable, so, it would be hard to conduct sufficient pilot studies in this sub-sector within the limited time of this thesis study.

Next, for **automotive** sector **auto repair** activities were included in sectoral HW estimation studies in OSTIM OIZ because of having the highest priority among its sub-sectors.

Finally, although it is not included in priority sector list, plastics and rubber sector was also selected for HW estimation studies in OSTIM OIZ, based on its HW generation potential. **Rubber industry** was chosen for analysis since it has a higher HW generation potential compared to plastics industry in OSTIM OIZ.

3.2.1.1 Determination of possible HW codes in selected sectors

After selection of the sectors to be studied, possible HW codes generated from these sectors were determined. For the determination of sector specific hazardous wastes, guidance documents were investigated from literature. The role of these documents in determination of sector specific HWs are explained in this section.

While searching sectoral information from literature there is a need for standardization of the sectors in order to use same nomenclature. With the aim of uniform classification within all Member States, EU has developed an international integrated system of economic classification called as The Statistical Classification of Economic Activities in the European Community (in French: Nomenclature statistique des Activités économiques dans la Communauté Européenne), abbreviated as NACE [25]. Therefore, possible NACE Rev.2 codes of each priority sector were determined and new codes were used in the sectoral studies.

As it was mentioned in Chapter 2, in Section 2.2, Legal Framework Regarding Hazardous Wastes part; in EU Directive on waste (2008/98/EC) and Directive on

hazardous waste (91/689/EEC), and in Turkey RCHW (Official Gazette No. 25755, 2005) and RGPWM (Official Gazette No. 26927, 2008) are the main legal guides for definition and classification of hazardous wastes. Since Annex-4 of the RGPWM and European Waste Catalogue consists of the most current and similar waste lists, these documents were taken as reference for the determination of sectoral hazardous waste lists. According to NACE Rev.2 codes, related HW codes are determined from Waste List of RGPWM (Appendix A) for each selected priority sector.

Moreover, in line with IPPC Directive, sectoral reference documents on Best Available Techniques (BREFs) were helpful in collecting information about sectors, processes, waste amounts and waste generation factors.

For detailed sector and process analysis, sector specific guidelines and process specific handbooks were investigated. Furthermore, LIFE HAWAMAN Project, "Improvement of Industrial Hazardous Waste Management in Turkey", Guide Documents on Specific Sectors and also on Classification of Hazardous Wastes were helpful in hazardous waste identifications and estimations.

In addition to this, sectoral information was collected from various sources in order to make further analysis in sub-sectors and processes.

3.2.2 Pilot Plant Studies

For estimation of HW generation in priority sectors, pilot plant studies were conducted in various companies of OSTIM OIZ. Two (if required three) representative and voluntary companies were selected for each sectoral study and investigated in detail.

The reason for selection of second (if required third) company was to check and verify the results from first plant study and literature, and also to determine an interval for HW amounts and HWGFs, if possible.

3.2.2.1 Approach to Estimate Hazardous Waste Generation

Two basic steps, namely, process analysis and waste analysis were followed during the estimation of HW generation from pilot plants.

3.2.2.1.1. Process Analysis

During the pilot plant studies, firstly, main processes applied in plants were identified and process flow diagrams were determined. Inputs (as raw materials and additives) and outputs (as mid-products, final products, and wastes) for each sub process were determined and then, outputs were evaluated for HW generation.

Apart from main processes, side processes were also taken into account and HWs which are possible to come out from these processes were also reported.

3.2.2.1.2. Waste Analysis

Possible HW codes determined for selected sectors were investigated in the pilot plants. Once they are matched with the wastes in pilot plants, process specific and side-process specific hazardous wastes were reported with their codes and amounts. Matching of HWs in pilot plants with predetermined sectoral HW codes is a crucial step, since there are various types of HW codes and their properties should be investigated in detail for accurate matching.

Since most of the companies in OSTIM OIZ are in “micro” size, there is no proper recording and data storing system in such plants. Therefore, data collection from companies required long and exhaustive days to spend. Whenever data could not be gathered from company recording system (accounting, capacity, products or process based, etc.), personal interviews with company owners and workers were conducted.

By the help of data gathered from pilot plant studies, HW codes were identified for the plant studied. Thereafter, annual amounts of process and sector specific HWs were sought.

3.2.2.2. Determination of Waste Generation Factors

By the help of the data obtained from site investigations, waste amounts and waste generation factors were determined on process specific and sector-specific basis. These factors were based on calculated and/or estimated values.
According to the information given in Chapter 2.1.2, source-oriented approach was adopted in this inventory study, and also waste generation factors were estimated at industrial sector level and at technology level, in other words, **amount of waste related to the product** (e.g. x tones of residues per ton produced) and/or **related to process & sub-process level** (e.g. 10 kg waste water sludge per 1000 kg net production of electroplated material; or 9 kg of oil per car).

Hazardous waste generation factors (HWGFs), used in estimation of the approximate quantity of HW generated from different industries in OSTIM OIZ, can be defined as “the ratio of the quantity of HW generated to the quantity of the product produced or raw material processed ”.

3.2.3 Estimation of Sectoral HW Generation

Amounts of HWs resulting from selected sectors and corresponding HWGFs were determined from sectoral pilot plant studies. This information was used in estimation of total sectoral HW generation in OSTIM OIZ. Total capacity of selected priority sectors was calculated by multiplying the total number of companies in sector with an average capacity value for each. In addition to this, total HW generation from selected priority sectors was calculated by multiplying the sectoral HWGFs with the corresponding total capacities.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Priority Sectors in OSTIM OIZ

As stated in Section 3.1, in OSTIM OIZ the total of 5008 firms grouped into 17 economic activity sectors. Of these sectors, 14 fall into the manufacturing class represented by 2282 firms, which are most relatively small in size. In this study, the intention was to work with some selected manufacturing sectors that would contribute to the hazardous waste load to a greater extent considering the difficulties of reaching to all sectors within the limited time allocated for this thesis study.

Based on this, manufacturing sectors with a high numbers of firms were selected as a priority sectors in OSTIM OIZ are, namely, Metal and Metal Treatment, Building and Construction, Machine and Machine Equipments, Construction Machines, Automotive as also indicated in Table 3.2. From these sectors *casting, modeling and forging works, machining, metal coating, auto repair* sub-sectors were chosen to work with in sectoral HW estimation studies within the limited time of this thesis study. In addition to these, although it comprises only 3.55 % of manufacturing sectors *rubber industry* was also included due to its competitive potential to generate hazardous wastes.

4.1.1. NACE Rev.2 Codes in selected priority sectors

As mentioned in Section 3.2.1.1, in this study, latest version of NACE codes, NACE Rev. 2 codes, of selected priority sectors and their sub-sectors in OSTIM OIZ are determined for uniform classification and given in Table 4.1.

Table 4.1 NACE Rev.2 Codes of selected priority sectors in OSTIM OIZ

Selected Sectors and Sub-Sectors in OSTIM OIZ	NACE Rev.2 codes
Metal and Metal Treatment	**C - MANUFACTURING** **24 - Manufacture of basic metals** **25 - Manufacture of fabricated metal products, except machinery and equipment**
Casting, modeling and forging works	24.5 - Casting of metals 25.5 - Forging, pressing, stamping and roll-forming of metal; powder metallurgy
Machining	25.62 - Machining
Metal coating	25.61 - Treatment and coating of metals
Automotive	**C - MANUFACTURING** **45 - Wholesale and retail trade and repair of motor vehicles and motorcycles**
Auto repair services	45.20 - Maintenance and repair of motor vehicles
Plastics - Rubber	**C - MANUFACTURING** **22 - Manufacture of rubber and plastic products**
Rubber industry	22.1 - Manufacture of rubber products

In the following sections, studies conducted on predetermined priority sectors toward the estimation of hazardous waste generation and waste generation factors are presented. In sector studies, NACE Rev.2 codes of priority sectors were used for uniform classification.

4.2 Sectoral Studies

During the sectoral studies, firstly, each priority sector was taken into consideration with their detailed sector and process analysis through sector specific guidelines and process specific handbooks, where available. Then, possible waste codes were determined using the waste list given in RGPWM (No: 26927, 2008) in the light of explanations provided in the sector specific guidance documents (LIFE HAWAMAN, 2009). For each waste code determined, literature findings were searched to find out typical waste generation factors for a given sector.

Following these steps, at least two representative firms as pilot plants were identified by searching through OSTIM OIZ records as well as the information available in the web sites of the companies. Then, field work in these selected plants was initiated toward the estimation of hazardous waste generation and waste generation factors. Analysis of the second pilot plant was especially aimed at cross checking and confirming the findings obtained at the first pilot plant. If confirmed, the hazardous waste generation from the sector of concern was estimated according to the gathered data. Otherwise, a third plant was considered for further confirmation. During these analysis, not only process specific wastes but also, wastes from side processes (where available), and non-process based wastes were also identified. For each waste code determined, literature findings were also searched to find out typical waste generation factors for a given sector and comparison was made with those obtained through field analysis.

Results from sectoral studies are given in the following sections of 4.2.

4.2.1 Casting of Ferrous Metals

Ferrous metals, non-ferrous metals and alloys are melted and converted into new products in foundries. Lamellar cast iron, malleable and nodular iron, and steel are the main types of ferrous metals casted in foundries [26].

In OSTIM OIZ generally malleable and nodular iron casting is done in small sized foundries; therefore, only casting of ferrous metals is investigated in this thesis study. There are also foundries for aluminum casting in OSTIM OIZ; however, since the total number of companies is small and technology employed in companies differs, they are not included in HW estimation studies.

In addition to this, general information about casting of ferrous metals is given in Appendix C.1. Hazardous waste estimation studies for casting of ferrous metals in general and also as specific to OSTIM OIZ are discussed in the following sections.

4.2.1.1. Hazardous Wastes (HW) in Casting of Ferrous Metals

General wastes from foundries can be grouped into three main categories as hazardous, non-hazardous and recyclable for solid, liquid, and gaseous wastes. Solid wastes consists of sand, filter dust, metal, plastic, paper, wood, electronic, textile, demolition, domestic, glass and rubber wastes. Generation of waste sand from molding process, slag and dust (containing zinc, lead, and cadmium) from melting process occur in significant amounts. Chemicals, dyes, oils and cooling wastewater are most common liquid wastes originating from casting process. Regarding the air emissions, CO, NOx, SOx vapor are gaseous wastes emitted from casting processes. In addition to this, dust or particulate matters (PM) from various processes of metal casting (melting, treatment of molten metal, mold

manufacture, shake-out and cleaning), oil mists from lubrication of metals, odor and alcohol vapor from surface treatment and VOCs are emitted [27, 28].

In the Waste List of RGPWM (No:26927, 2008), hazardous wastes supposed to be generated as a result of casting of ferrous metals are included under four digit chapter heading of 10 09, titled as wastes from casting of ferrous pieces as listed in Table 4.2.

Table 4.2 Wastes from casting of ferrous pieces [4]

10 WASTES FROM THERMAL PROCESSES		
waste code	**10 09 wastes from casting of ferrous pieces**	**Absolute /Minor**
10 09 05*	casting cores and molds which have not undergone pouring containing dangerous substances	M
10 09 07*	casting cores and molds which have undergone pouring containing dangerous substances	M
10 09 09*	flue-gas dust containing dangerous substances	M
10 09 11*	other particulates containing dangerous substances	M
10 09 13*	waste binders containing dangerous substances	M
10 09 15*	waste crack-indicating agent containing dangerous substances	M

Furthermore, according to LIFE HAWAMAN Project (LIFE 06 TCY/TR/000292) Guide Document on casting sector, possible hazardous wastes that can originate from casting of ferrous metals are given in Table 4.3, together with their sources and codes. In this table, apart from 10 09 coded hazardous wastes, 06 01 01, 15 01 10, and 16 11 03 coded hazardous wastes are also included. Moreover, another waste code namely 10 09 99 is also given in Table 4.3. According to RGPWM (No: 26927, 2008) this code can be used for hazardous wastes which cannot be matched with other codes in the list and is called as wastes not

otherwise specified. Moreover, in Table 4.3, 10 09 99 code is used for classification of sludges from sand regeneration and waste sands from sandblasting.

Table 4.3 Hazardous wastes generated from ferrous foundries [27]

Source of waste	Definition of waste	Waste code
Preparation of molds, casting	molding sand	**10 09 05***
	sand from sand molds and cores	**10 09 07***
Sand regeneration (dry scrubber)	dust from sand regeneration	**10 09 09***
Finishing, cleaning of dust	dust containing iron	
Sand regeneration (wet scrubber)	sludge from sand regeneration	**10 09 99**
Finishing, sandblasting	sand from sandblasting	
Preparation of molds	waste binders	**10 09 13***
Quality control	dust and liquid wastes from crack control	**10 09 15***
Preparation of molds (cold box)	amine sulphate	**06 01 01***
Preparation of molds	ferrous packaging containing hazardous wastes	**15 01 10***
Melting of metal	refractory coating in furnaces	**16 11 03***

According to sectoral information given in Appendix C.3, preparation of pattern, preparation of molds, preparation of core, molding, metal melting, casting and finishing are the main process included in casting of metals. In Figure 4.1, types and origin of possible process specific hazardous wastes from ferrous metal casting are illustrated.

Apart from process specific HWs given in Figure 4.1, other possible HWs can be generated as a result of processes in maintenance area, laboratory, infirmary and

recreational facilities. Other HWs that should also be considered in metal casting are waste oil (13 01), contaminated packaging materials (15 01 10), contaminated wastes (15 02 02), waste batteries (16 06 01), medical waste (18 01), fluorescent tubes (20 01 21), discarded electrical and electronic equipment (20 01 35) [27].

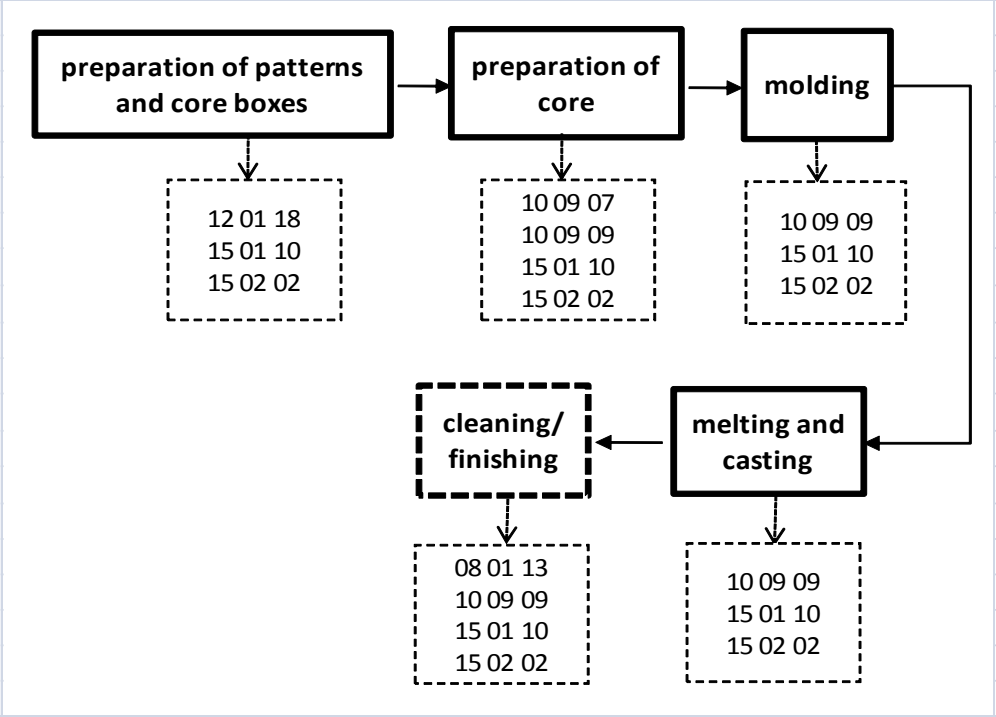

Figure 4.1 Process specific hazardous wastes in foundries [27]

12 01 18 coded hazardous waste named as metal sludge is mainly related with metal working processes in pattern preparation and production of core boxes. Moreover, 15 01 10 and 15 02 02 coded hazardous wastes are generated as a result of different materials used in these two processes.

All types of hazardous wastes listed under for digit code of 10 09 are minor entries as it can be seen from Table 4.2. Definition of each waste code is given below according to the information about minor entries in LIFE HAWAMAN Project Document on Classification of Hazardous Wastes – Volume 2.

10 09 05 coded HWs (casting cores and moulds which have not undergone pouring containing dangerous substances) result from excess or scrap products as molds or cores and contain sands, regenerated sands, hardened binders and additives [29].

10 09 07 coded HWs (casting cores and moulds which have undergone pouring containing dangerous substances) not only cover waste sands from molds and cores containing organic or inorganic binders and additives, but also sands and metal residues from sandblasting process. In fact, phenol concentration in molding sand is an important factor in determination of hazardous property of these wastes [29].

10 09 09 coded HWs (flue-gas dust containing dangerous substances) can result from various processes like regeneration of sands and finishing. Hazardous property of these wastes can be determined according to concentrations of Pb, Ni, dioxin and furan [29].

10 09 13 coded HWs generating from mold and cores production consist of residues from resins and additives. Moreover, 10 09 15 coded HWs are mainly related to chemicals used for control of possible cracks onto castings.

Metal shaping and painting processes are widely used side processes involved in ferrous metal foundries. Therefore, possible HWs generated as a result of side processes in ferrous foundries could be determined as 08 01 and 12 01 coded

waste categories in the Waste List of RGPWM (No: 26927, 2008). However, 12 01 code is not specific for side processes; because it is also used for classification of process specific HWs resulting from preparation of patterns and core boxes.

4.2.1.2. Pilot Plant Studies

Two different companies, called as C.1 and C.2, are selected from ferrous metal casting sector for pilot plant studies in OSTIM OIZ. In both pilot plants, induction furnaces are used in metal melting.

Process specific, side process specific, and non-process based hazardous wastes from ferrous metal casting are further investigated in production processes of C.1 and C.2 and are given in the following sections. The results obtained from the companies are compared with each other and with literature figures in summary part (Section 4.2.1.2.3).

4.2.1.2.1. Pilot Plant 1: C.1

C.1 is producing grey pig and nodular cast iron parts for automotive industry such as tractor parts, types of differential cases, brake piston housings, suction manifolds, bearing blocks etc. with a capacity of 2400 ton/year. General process flow diagram of iron casting in C.1 is given in Figure 4.2.

Aluminum patterns are produced in a different company of C.1 which is located at another OIZ. Therefore, hazardous wastes generated from pattern preparation could not be determined and therefore concluded in this study.

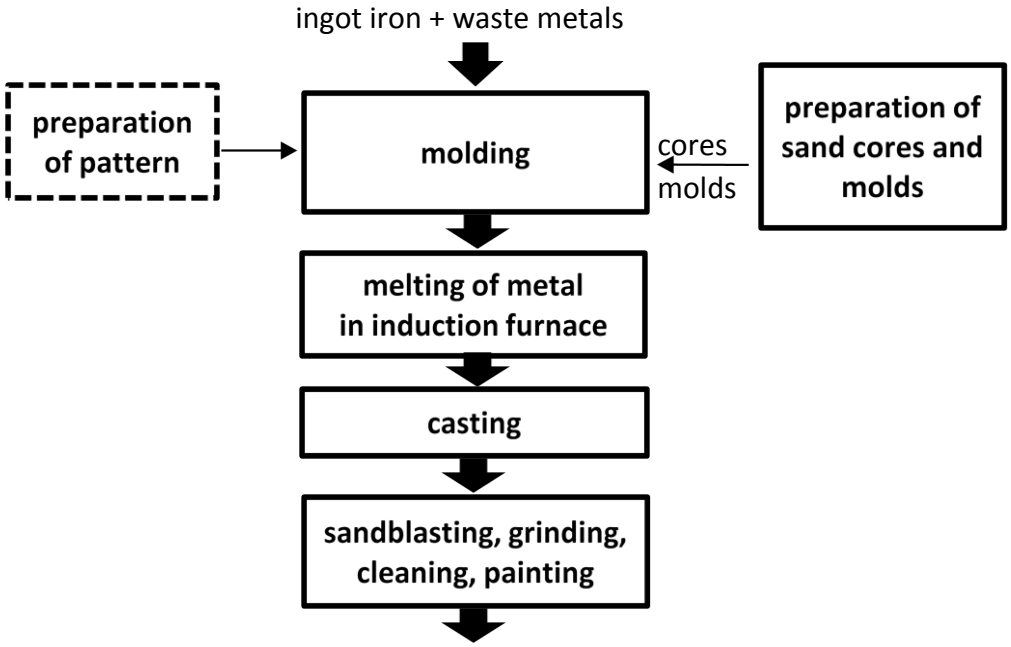

Figure 4.2 Process flow diagram of C.1

Silica sand, chromite sand, resin (depends on the type of core) and gases (as catalysts) are used for the production of different types of cores (cold-box with amine gas, CO_2, and shell core) in C.1. Moreover, coal dust (2-3%), bentonite (4-5%), silica sand and water are used for sand mold preparation. While casting, coal dust is burned in mold and water vapor or gases exit through sand particles. According to production engineer in C.1, this operation avoids formation of spaces or cracks into castings and results in proper products.

Ingot iron (grey and nodular cast) and their scrap metals (15-20 %) are melted in induction furnace and poured into molds. After casting, molds are cooled for a while (30 min-2 hrs) depending on the type and shape of the product. Once castings are cooled enough, they are put onto vibrating sieve for separation of extra parts (mold sands etc.).

For final finishing purposes on products, castings are entered into sequential processes, such as sandblasting, grinding, and painting (if required). Sandblasting and grinding operations are done with machines and painting is accomplished as dip coating using industrial paints.

HW originating from processes: For identification of process specific HWs in C.1, inputs and outputs of each process are investigated and results are given in Figure's 4.3, 4.4, and 4.5, for preparation of sand cores and molds, melting of metal and casting, and finishing processes, respectively.

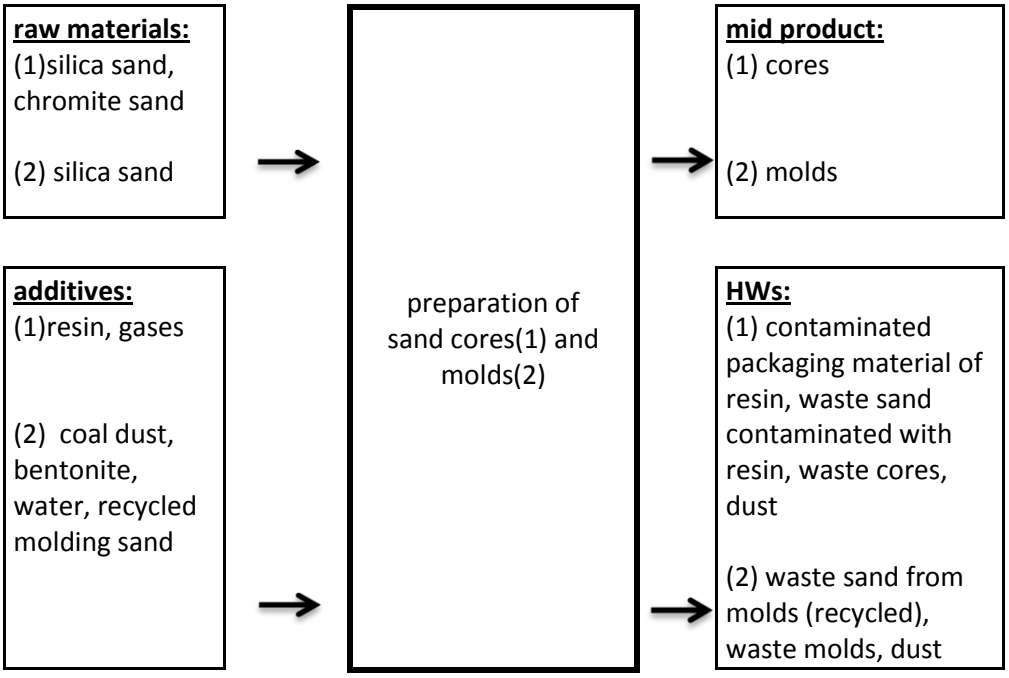

Figure 4.3 Inputs and outputs for preparation of sand cores and molds processes in C.1

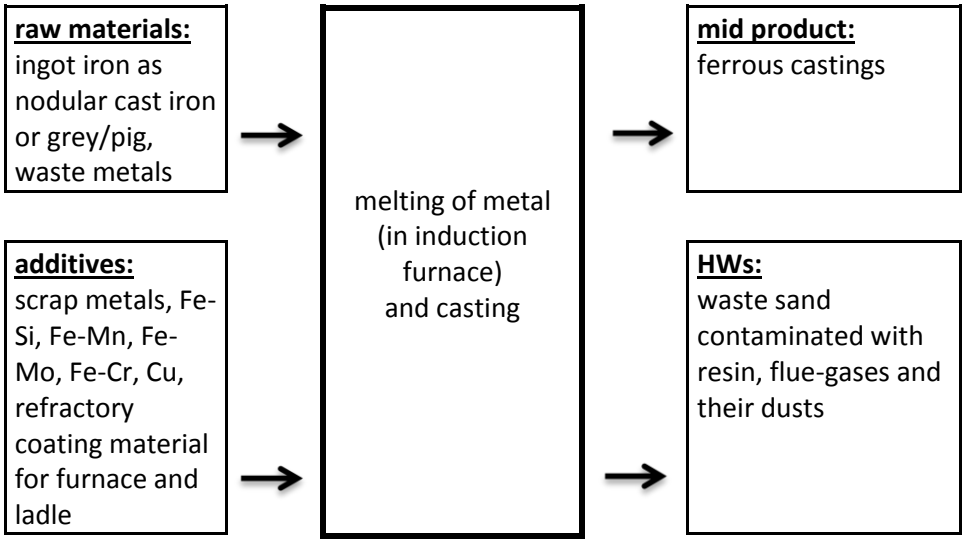

Figure 4.4 Inputs and outputs for melting of metal and casting processes in C.1

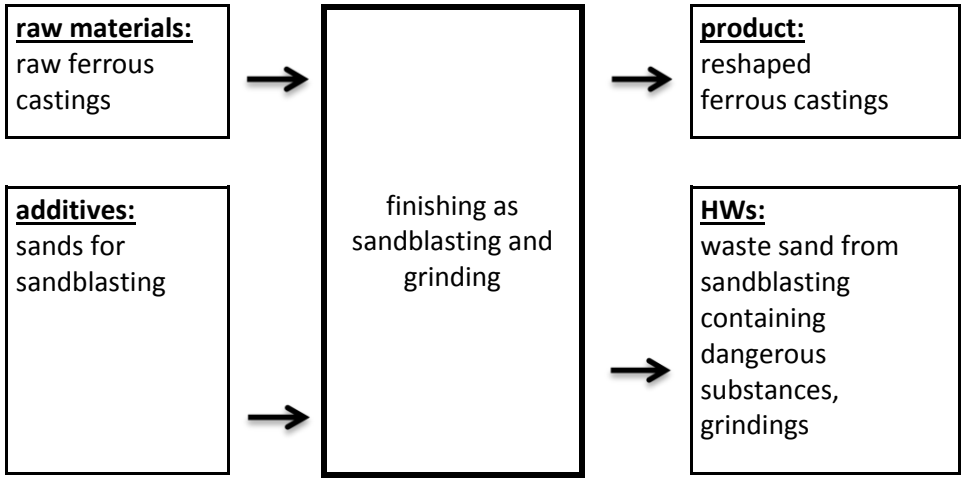

Figure 4.5 Inputs and outputs for sandblasting and grinding processes in C.1

Among finishing processes, sandblasting and grinding are taken as main processes since they are applied to all products casted in C.1, and their wastes are identified with 4-digit coded waste category of 10 09. However, cleaning and painting processes are generally performed based on customer needs in C.1. Therefore, HW estimation studies for these processes are given in side processes

part. Finally, types and amounts of process specific HWs originating from C.1 is given in Table 4.4.

Table 4.4 Types and amount of process specific HWs in C.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste
1	waste core sands, waste mold sands	**10 09 07** casting cores and moulds which have undergone pouring containing dangerous substances	M	180 000 kg
2	sands and metal residues from sandblasting, grindings as metal dust	**10 09 99** wastes not otherwise specified		18 000 kg
3	packaging material of binders as resin	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	250 kg

HW originating from side processes: For determination of HWs from side processes of C.1, cleaning and painting processes are considered. Inputs and outputs including the HWs generated are given in Figure 4.6. Types and amounts of HWs generated as a result of cleaning and painting processes in C.1 are presented in Table 4.5.

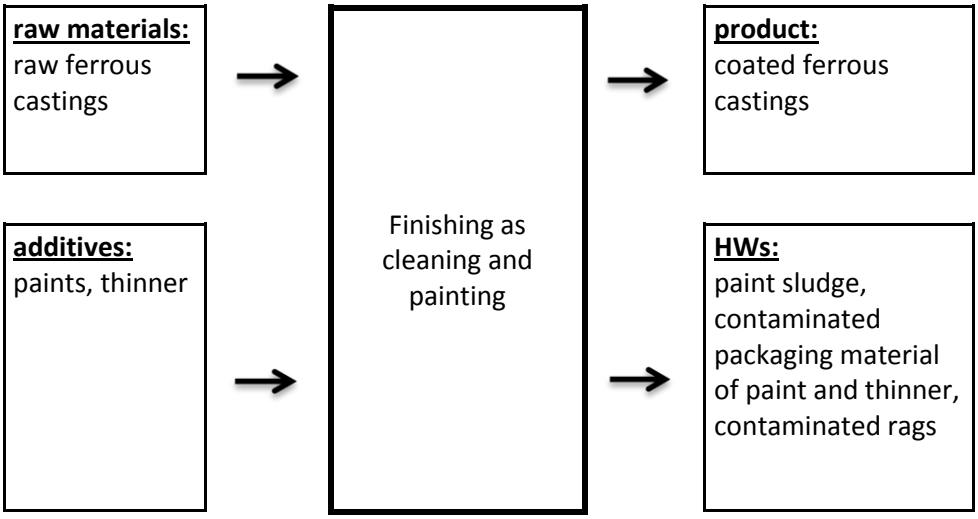

Figure 4.6 Inputs and outputs for cleaning and painting processes in C.1

Table 4.5 Types and amount of HWs from side processes in C.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste
1	paint sludges	**08 01 13** sludges from paint or varnish containing organic solvents or other dangerous substances	M	392 kg
2	packaging material of dyes and thinner	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	40 kg
3	contaminated rags	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	10 g

Other HW (non-process based): Non-process based HWs originating from C.1 are listed in Table 4.6 with their codes and amounts.

Table 4.6 Types and amount of non-process based HWs in C.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	hydraulic oil from compressor	**13 01 13** other hydraulic oils	A	15 kg
2	contaminated wiping cloths, work gloves, and working cloths	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	10 kg 240 pairs = 60 kg 20 cloths = 40 kg
3	batteries	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	10 batteries
4	wasted toners and cartridges	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	6 cartridges
5	fluorescent tubes	**20 01 21** fluorescent tubes and other mercury-containing waste	A	5 tubes

HW generation factors (HWGF): Hazardous waste generation factors were determined in terms of “kg of waste generated per ton of castings” or “waste item generated per ton of castings”, where appropriate, using the production capacity information for C.1. Capacity of C.1 was taken as 2400 tons per year for casting of grey and nodular cast iron. All these estimations were performed using 2009 records. Calculated HWGFs are given in Table 4.7.

Table 4.7 HW generation factors (HWGF) in C.1

No	Type of waste	A/M	Annual amount of waste (kg or item*)	HWGF-1 (kg waste or waste item*/ ton castings)
HWs originating from processes (10 and 15 coded wastes)				
1	**10 09 07** casting cores and moulds which have undergone pouring containing dangerous substances	M	180 000 kg	75
2	**10 09 99** wastes not otherwise specified		18 000 kg	7,5
3	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	250 kg	0,104
HWs originating from side processes (08 and 15 coded wastes)				
4	**08 01 13** sludges from paint or varnish containing organic solvents or other dangerous substances	M	392 kg	0,163
5	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	40 kg	0,017
6	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	10 kg	0,004
Non-process based HWs (13,15, 16 and 20 coded wastes)				
7	**13 01 13** other hydraulic oils	A	15 kg	0,006
8	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	100 kg	0,042
9	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	10 batteries	0,004*
10	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	6 cartridges	0,003*
11	**20 01 21** fluorescent tubes and other mercury-containing waste	A	5 tubes	0,002*

4.2.1.2.2. Pilot Plant 2: C.2

The second pilot plant (C.2) is a smaller foundry compared to C.1 and produces spare parts for construction machines, water pumps and mills. Similar to C.1, nodular and grey cast iron is melted in induction furnaces and poured into sand molds. Only one type of core, *CO_2 hardened*, is used in casting. In preparation of cores, silica sand is mixed with resin and the mixture is hardened by CO_2 within the borders of metal patterns. Furthermore, silica sand, bentonite, and coal dust is used for preparation of molds. After each casting process, molds are damaged and cannot be used again; however molding sand is collected (95 %) and reused due to its recyclable content.

Hazardous waste estimation studies in C.2 and their results are given in following sections.

HW originating from processes: Similar main processes given for C.1 are involved in C.2 in ferrous metal casting. Types and amounts of process specific HWs for C.2 is given in Table 4.8. In C.2 all sand residues from casting, sandblasting, and grinding processes are collected in the same place and sent with same bags. In other words, they are not recorded separately in the plant. Therefore, specific amounts for each code of waste could not be determined. As it is given in Table 4.8, total amount of wastes, 60 000 kg, covers both 10 09 07 and 10 09 99 coded HWs. However, according to company owner the majority of these wastes are composed of waste sands.

Table 4.8 Types and amount of process specific HWs in C.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste
1	waste core sands, waste mold sands	**10 09 07** casting cores and moulds which have undergone pouring containing dangerous substances	M	60 000 kg
	sands and metal residues from sandblasting, grindings as metal dust	**10 09 99** wastes not otherwise specified		
2	packaging material of binders as resin	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	108 kg

HW originating from side processes: After sandblasting and grinding, there is no any side process (like painting, etc.) for ferrous castings in C.2. Therefore, there isn't any HW generation from side processes in C.2.

Other HW (non-process based: Non-process based HWs generating from in C.2 is summarized in Table 4.9.

Table 4.9 Classification and quantity of non-process based HWs in C.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	contaminated wiping cloths, work gloves, and working cloths	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	5 kg 120 pairs = 30 kg 20 cloths = 40 kg
2	batteries	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	**A**	4 batteries
3	wasted toners and cartridges	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	1 cartridges
4	fluorescent tubes	**20 01 21** fluorescent tubes and other mercury-containing waste	**A**	2 tubes

HW generation factors (HWGF): In calculations for HWGF in C.2, the capacity of foundry was taken as 480 ton/year. Results obtained are tabulated in Table 4.10.

Table 4.10 HW generation factors (HWGF) in C.2

No	Type of waste	A/M	Annual amount of waste (kg or item*)	HWGF-2 (kg waste or waste item*/ ton castings)
HWs originating from processes (10 and 15 coded wastes)				
1	**10 09 07** casting cores and moulds which have undergone pouring containing dangerous substances	M	60 000 kg	125
2	**10 09 99** wastes not otherwise specified			
3	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	108 kg	0,225
Non-process based HWs (13,15, 16 and 20 coded wastes)				
4	**13 01 13** other hydraulic oils	A	-	-
5	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	75 kg	0,16
6	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	4 batteries	0,008*
7	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	1 cartridges	0,002*
8	**20 01 21** fluorescent tubes and other mercury-containing waste	A	2 tubes	0,004*

4.2.1.2.3. Summary for Casting of Ferrous Metals

For casting of ferrous metals sector, calculated HWGFs from two pilot companies in OSTIM OIZ and literature figures are summarized in Table 4.11.

Table 4.11 Comparison of HW generation factors (HWGF) in ferrous metals casting

No	Type of Waste	A/M	HWGF -1 (kg waste or waste item*/ ton castings)	HWGF -2 (kg waste or waste item*/ ton castings)	HWGF from literature (kg waste or waste item*/ ton castings)	HWGF (kg waste or waste item*/ ton castings)
HWs originating from processes (10 and 15 coded wastes)						
1	**10 09 07** casting cores and moulds which have undergone pouring containing dangerous substances	M	75	125	*200-500* [27]	75-200
2	**10 09 99** wastes not otherwise specified	-	7,5		-	-
3	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	0,104	0,225	-	0,1 – 0,23
HWs originating from side processes (12 and 15 coded wastes)						
4	**08 01 13** sludges from paint or varnish containing organic solvents or other dangerous substances	M	0,163	-	-	-
5	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	0,017	-	-	-
6	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	0,004	-	-	-

Table 4.11 (continued)

No	Type of Waste	A/M	HWGF -1 (kg waste or waste item*/ ton castings)	HWGF -2 (kg waste or waste item* / ton castings)	HWGF from literature (kg waste or waste item*/ ton castings)	HWGF (kg waste or waste item*/ ton castings)
Non-process based HWs (13,15, 16 and 20 coded wastes)						
7	**13 01 13** other hydraulic oils	A	0,006	-	-	-
8	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	0,042	0,16	-	0,042-0,16
9	**16 06 01** lead batteries **16 06** 02 Ni-Cd batteries **16 06 03** mercury containing batteries	A	0,004	0,008	-	0,004-0,008*
10	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	0,003	0,002	-	0,002-0,003*
11	**20 01 21** fluorescent tubes and other mercury-containing waste	A	0,002	0,004	-	0,002-0,004*

For determination of HWGF and estimation of sectoral HW generation, required equations for calculations are given in Appendix D part. In addition to this, sample calculations for ferrous metal casting sector is given in Appendix D.

As seen from Table 4.11, waste generation amounts and factors could be determined only for 10 09 07 and 10 09 99 coded HWs in pilot plants. On the other hand, there is no specific data in C.1 and C.2 for the amounts of 10 09 05 coded HWs as unused casting cores and molds. Since foundries are small, production capacities are not so much, and production is based on customer demands; production processes are in control and generally there is no excess production.

In addition, *10 09 07* coded HWs which are waste sands, stands for the largest amount waste generated by volume in this sector among the other HWs. These wastes are minor entries; therefore, priority should be given to the determination of their hazardous property through laboratory analysis for proper disposal technique.

HWGF from the literature could be found only for 10 09 07 coded HWs. As given in Table 4.11, calculated HWGFs from pilot plants in OSTIM OIZ are smaller than that obtained from the literature. This indicates that waste sand generation in OSTIM OIZ foundries are less in amount as compared to others. As mentioned in previous sections, these wastes result from preparation of sand molds and cores and also from casting processes. Majority of the molding sand in each casting process can be recycled since there is no resin or any other chemical usage in mold preparation.

For *10 09 09* coded HWs (flue-gas dust containing dangerous substances), since there is no proper collection system for air emissions in micro sized companies of

OSTIM OIZ, amount of these wastes could not be estimated. In literature, HWGFs for dusts from induction furnaces in foundries are given as 3 kg/ ton of molten metal [28] and 0,06 -1 kg/ ton metal charge (for steel) [26] .

15 01 10 coded HWs as contaminated packaging of resins resulting from preparation of cores are also included in process specific HWs. Since there is no resin usage in preparation of sand molds, amount of this waste is less in ferrous casting foundries of OSTIM OIZ.

Waste sands from sandblasting and metal dusts from grinding processes are classified as *10 09 99* coded HWs as mentioned in Table 4.3 based on the information from LIFE HAWAMAN Project (LIFE 06 TCY/TR/000292) Guide Document on casting sector. However, according to Waste List of RGPWM (No: 26927, 2008) (Appendix A), *99* ended codes are given for HWs when there is no matching in the whole list. On the other hand, 12 01 16 coded HW (waste blasting material containing dangerous substances) can be also a suitable code for this type of waste due to their similar constituents. In fact, this problem should be asked for MoEF in a written form for clarification of waste code and hazardous property.

Finally, no HWs were determined and classified under the codes of *10 09 11, 10 09 13, and 10 09 15* in the pilot plants studied.

HWGFs could not be determined for side process specific HWs, since side processes are not common for all ferrous metal foundries in OSTIM OIZ as in the case of pilot plant studies.

For the estimation of total HWs generation from ferrous metals casting sector in OSTIM OIZ, total number of companies in this sector and their capacities should

be known. There are 8 ferrous metal foundries in this sector according to the OSTIM OIZ Directorate database and average capacity of a foundry can be taken as 1500 ton castings/year. Results obtained are given in Table 4.12.

According to Table 4.12, although number of firms in ferrous metal casting is less, process specific HW generation potential of this sector in OSTIM OIZ is in considerable amounts. Since 10 09 coded HWs are minor entries, their hazardous property should be further investigated for proper handling techniques.

Table 4.12 Total HW generation in casting of ferrous metals sector

HW Category	HWGF (kg waste or waste item*/ ton castings)	Capacity (ton castings/ year)	Annual HW generation (ton/year or *item/year)
HWs originating from processes (10 and 15 coded wastes)			
10 09 (wastes from casting of ferrous pieces)	75 - 200	12 000	900 - 2400
15 01 10 (contaminated packaging of oils)	0,1 - 0,23		1,2 - 2,76
Non-process based HWs (13,15, 16 and 20 coded wastes)			
15 02 02 (waste work gloves and cloths)	0,04 - 0,16	12 000	0,48 - 1,92
16 06 (waste batteries)	0,004 - 0,008*		48 - 96*
16 02 13 (waste cartridges)	0,002 - 0,003*		24 - 36*
20 01 21 (waste fluorescent tubes)	0,002 - 0,004*		24 - 48*

While evaluating these HW generation estimations, the following validation criteria should be taken into account for ferrous metal casting sector of OSTIM OIZ:

- Only ferrous metal casting (as nodular and grey cast iron) was covered.
- In foundries, metal melting is performed in induction furnaces.
- HWs (12 01 coded) from preparation of pattern as a side process could not be estimated and since not being performed in foundries.
- HWs from painting as another side process could not be estimated since it is not common for all foundries.

4.2.2. Machining

Fabricated metal products industry can be divided into three main sub sectors which are metal fabrication, metal preparation, and metal finishing [30]. Each sub sector also has various unit processes for different types of products. Detailed information about these processes is given in Appendix C.2. As mentioned in Appendix C.2, shaping, bonding, and heat treatment operations are main processes of metal fabrication.

As given in Appendix B, OSTIM OIZ Directorate sector classification system divides metal and metalworking sector based on products produced and processes applied. Being the most crowded sector in OSTIM OIZ, metal sector mainly consists of metal fabrication (metalworking) processes. Having the highest portion among metalworking sub-sectors, machining (as a type of metal shaping processes) was chosen for HW estimation studies in OSTIM OIZ. Studies in metal preparation and metal finishing operations are also given in section 4.2.3.

4.2.2.1. Hazardous Wastes (HW) in Machining

Wastes from metal shaping processes can be classified into three main groups as can be depicted from Table 4.13.

Table 4.13 Inputs and outputs in metal shaping (adapted from [30])

Processes	Inputs	Outputs		
		Air emissions	Process ww	Solid waste
Metal cutting and/or forming	Cutting oils, degreasing and cleaning solvents, acids, alkalis, and heavy metals	Solvent wastes (e.g. 1,1,1-trichloroethane, acetone, xylene, toluene, etc.)	Waste oils (e.g. ethylene glycol) and acid (e.g., hydrochloric, sulfuric, nitric), alkaline, and solvent wastes	Metal chips (e.g. scrap steel and aluminum), metal bearing cutting fluid sludges, and solvent still-bottom wastes

Moreover, hazardous wastes expected to be generated as a result of shaping of metals are included under four digit chapter heading of *12 01 (wastes from shaping and physical and mechanical surface treatment of metals and plastics)* in the Waste List of RGPWM (No:26927, 2008), as listed in Table 4.14.

Table 4.14 Wastes from shaping of metals [4]

12 WASTES FROM SHAPING AND PHYSICAL AND MECHANICAL SURFACE TREATMENT OF METALS AND PLASTICS		
waste code	**12 01 wastes from shaping and physical and mechanical surface treatment of metals and Plastics**	**Absolute /Minor**
12 01 06*	mineral-based machining oils containing halogens (except emulsions and solutions)	A
12 01 07*	mineral-based machining oils free of halogens (except emulsions and solutions)	A
12 01 08*	machining emulsions and solutions containing halogens	A
12 01 09*	machining emulsions and solutions free of halogens	A
12 01 10*	synthetic machining oils	A
12 01 12*	spent waxes and fats	A
12 01 14*	machining sludges containing dangerous substances	M
12 01 16*	waste blasting material containing dangerous substances	M
12 01 18*	metal sludge (grinding, honing and lapping sludge) containing oil	M
12 01 19*	readily biodegradable machining oil	A
12 01 20*	spent grinding bodies and grinding materials containing dangerous substances	M

In LIFE HAWAMAN Project (LIFE 06 TCY/TR/000292) Guide Document on metal sector, possible hazardous wastes resulting from metalworking companies are indicated as presented in Table 4.15 together with their sources and codes.

Table 4.15 Hazardous wastes generated from machining [31]

Source of waste	Definition of waste	Waste code
Lubricating and cooling in metalworking	mineral-based machining oils free of halogens (except emulsions and solutions)	12 01 07*
	machining emulsions and solutions free of halogens	12 01 09*
Metalworking, metal shaping (honing, grinding, lapping processes)	machining sludges containing dangerous substances	12 01 14*
	metal sludge (grinding, honing and lapping sludge) containing oil	12 01 18*
	spent grinding bodies and grinding materials containing dangerous substances	12 01 20*
Degreasing processes	degreasing wastes containing dangerous substances	11 01 13*
	other solvents and solvent mixtures	14 06 03*
	sludges or solid wastes containing other solvents	14 06 05*

As given in Table 4.14, *12 01 06/07/08/09/10/12/19* coded wastes are liquid wastes resulting from cooling liquids in metal cutting processes. Generally cooling liquids are classified into three main groups, namely water-immiscible, water-mixable, and water-mixed oils [31]. According to LIFE HAWAMAN Project (LIFE 06 TCY/TR/000292) Guide Document on metal sector, especially *12 01 07* and *12 01 09* codes are the most suitable codes for this type of HWs as given in Table 4.15. In fact, this may be due to their constituents. For example, for 12 01 07 code, waste oil is defined as "mineral-based machining oils free of halogens" and also waste oil-water mixtures are defined as "machining emulsions and solutions free of halogens" for 12 01 09 code.

12 01 14/18/20 coded hazardous wastes are solid wastes generating from honing, grinding, and lapping processes in metal shaping. According to the

information about minor entries in LIFE HAWAMAN Project Document on Classification of Hazardous Wastes – Volume 2, 12 01 14 coded HWs are defined as waste sludges resulting from filtration of machine lubricants containing oils and synthetic oils, metal particulates, and water. 12 01 18 coded HWs are defined as metal sludges from honing, grinding, lapping processes. In addition to this, 12 01 20 coded HWs involve spent grinding bodies and grinding materials contaminated with oil [29]. Oil content of this kind of wastes is an important parameter to determine whether they are hazardous or not. To illustrate, metal filings and turnings containing oil content "less than 1 %" are classified as non-hazardous wastes and can be coded as *12 01 01/02/03/04/05* according to RGPWM (No: 26927, 2008).

Moreover, *12 01 16* coded HWs are wastes resulting from blasting of metal surfaces and contain mineral/metal blasting residues. Benzofurane, heavy metals (e.g. Zn and Cr), organotin compounds and paint material are main contaminants that determine the hazardous property of this type of wastes [29].

As given in Table 4.3, apart from process specific 12 01 coded HWs, *11 01 13, 14 06 03*, and *14 06 05* coded HWs can result from degreasing process involved in machining. However, degreasing process is a side process for machining and these wastes should be taken as side process specific HWs.

4.2.2.2. Pilot Plant Studies

Pilot studies are conducted in two companies from metalworking sector and their results are given in the following sections.

4.2.2.2.1. Pilot Plant 1: M.1

The first pilot plant, M.1, is specialized in machining and forging techniques since 1969 and produces spare parts to be used in automotive and construction machines. Process flow diagrams for hot steel forging and machining in M.1 are depicted in Figure's 4.7 and 4.8, respectively.

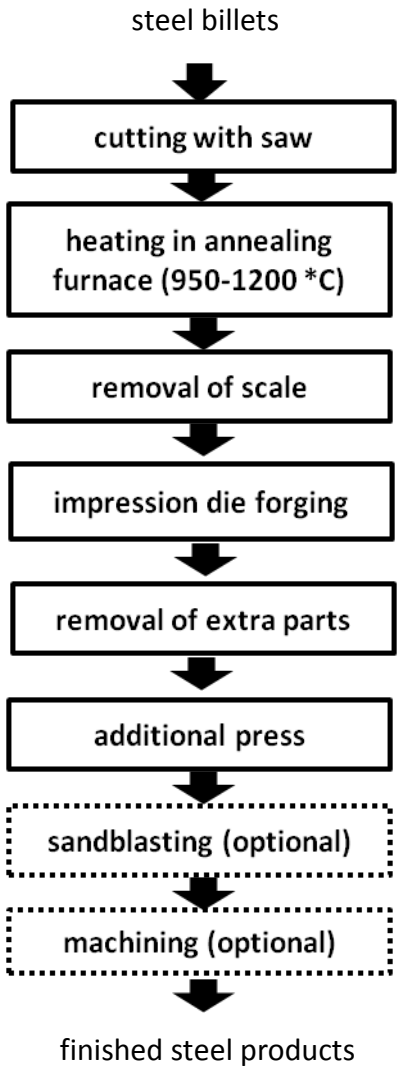

Figure 4.7 Process flow diagram-1 of M.1

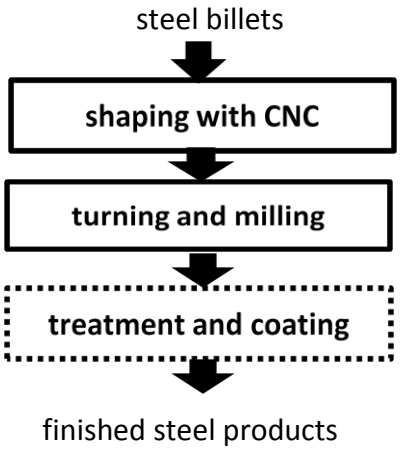

Figure 4.8 Process flow diagram-2 of M.1

M.1 has a total capacity of 450 ton/year for steel forging (300 ton/year) and machining (150 ton/year) processes according to 2009 records. Though forging and machining processes seem to be separate processes, they are indeed linked processes. For example, for some types of products in M.1 steel billets are firstly processed in forging, and then further shaped in machining whereas some products do not need forging processes and thus they are directly taken to the machining part. Similarly, for some forged products there is no need for other shaping processes.

In hot steel forging, steel billets are firstly cut into desired parts and heated in annealing furnace up to 950-1200^{o}C. After heating, possible impurities onto soft steel are removed by scale breaking. Type of forging technique used in M.1 is impression die forging as given in Figure 4.7. Softened steel is pressed in a die molding for desired shapes. After molding, extra parts from products are separated and products are pressed once more for final shaping. Sandblasting and machining (demonstrated with dashed line in Figure 4.7) are optional

processes after forging in M.1, since it is used for some portion of the forged products.

In machining, Computer Numerical Control (CNC) machines are used for cutting of steel into desired shapes. Manuel turning and milling operations are also applied for further shaping of products. Treatment and coating of metal products are side processes in M.1, but they are not conducted inside the plant due to place restrictions in production area. Therefore, products which require surface finishing processes are sent to another company in OSTIM OIZ for surface cleaning and painting operations.

HW originating from processes: Inputs and outputs from forging and machining processes were examined to estimate process specific HWs in M.1 and results from these studies are given in Figure's 4.9 and 4.10, respectively.

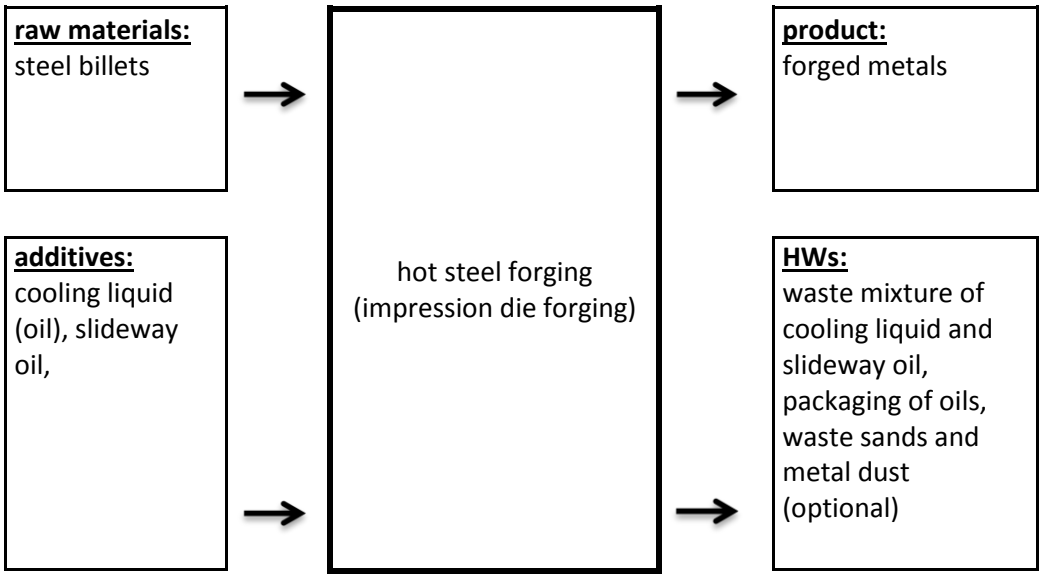

Figure 4.9 Inputs and outputs for hot steel forging process in M.1

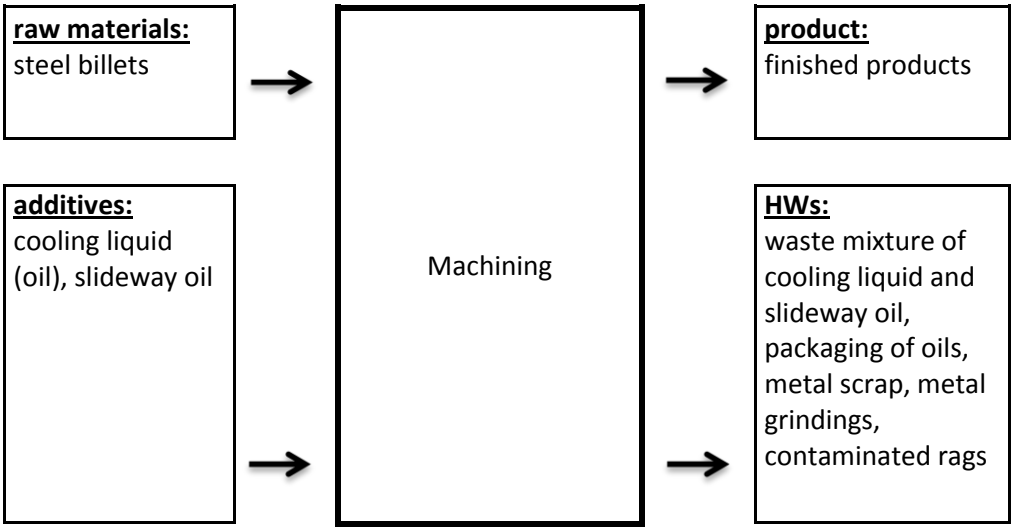

Figure 4.10 Inputs and outputs for machining process in M.1

Metal scrap resulting from pressing and extra parts removal processes in forging is not presented in Table 4.9 as hazardous waste since there is no contamination of metal with oils in these processes. However, metal scrap in machining process is classified as hazardous in Table 4.10, since it is contaminated with oils used in cutting processes.

Moreover, as it can be seen from Figure 4.9 and 4.10, similar wastes (waste mixture of cooling liquid and slideway oils and packaging of oils) generate from forging and machining processes. Waste oils are resulting from cutting of steel billets in forging. On the other hand, majority of the waste oil is coming from machining processes and this oil is used for shaping processes in CNC machines. Slideway oils are used for movement of the machine and while moving residues from these oils are mixed with cutting fluids. Generally, cooling fluids are recycled in the system, but due to contamination with slideway oils, they are changed after a period of time. Therefore, these wastes are not separately collected in the plant and there is no information about the amounts of oil

consumption for each process. Therefore, process specific HWs from forging and machining processes are given in the same table (Table 4.16).

Table 4.16 Types and amount of process specific HWs in M.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste
1	waste mixtures of cooling liquid and slideway oil	**12 01 09** machining emulsions and solutions free of halogens	A	500 kg
2	metal grindings	**12 01 20** spent grinding bodies and grinding materials containing dangerous substances	M	25 000 kg
3	metal scrap			20 000 kg
4	waste sand and metal dust from blasting	**12 01 16** waste blasting material containing dangerous substances	M	1000 kg
5	packaging material from oils	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	28 kg
6	contaminated rags	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	200 kg

HW originating from side processes: As mentioned in process specific HWs part, surface treatment and coating processes applied for surface cleaning (degreasing, pickling) and painting are side processes in M.1. However, since these processes are not performed inside the plant, HWs resulting from side processes were not identified and calculated for M.1.

Other HW (non-process based): Non-process based HWs generating in M.1 are given in Table 4.17 with their codes and quantities.

Table 4.17 Types and amount of non-process based HWs in M.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	waste hydraulic oil from presses and other machinery	**13 01 13** other hydraulic oils	A	Unknown[1]
2	contaminated work gloves, and working cloths	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	480 pairs = 120 kg 48 cloths = 96 kg
3	batteries	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	5 batteries
4	wasted toners and cartridges	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	3 cartridges
5	fluorescent tubes	**20 01 21** fluorescent tubes and other mercury-containing waste	A	1 tube

[1] supposed to be generated from M.1 but amount of waste could not be determined.

HW generation factors (HWGF): In M.1, HWs generated are not separately recorded for forging and machining processes. Therefore, based on the assumption that most of the forged metals are also processed in machining, the total capacity of M.1 was taken into consideration (as 450 ton/year) in HWGF

calculations. Hazardous waste generation factors were determined in terms of "kg of waste or waste item generated per ton metal processed" or as given in Table 4.18.

Table 4.18 HW generation factors (HWGF) in M.1

No	Type of waste	A/M	Annual amount of waste (kg or item*)	HWGF-1 (kg waste or waste item*/ ton metal processed)
HWs originating from processes (10 and 15 coded wastes)				
1	**12 01 09** machining emulsions and solutions free of halogens	A	500 kg	1,11
2	**12 01 20** spent grinding bodies and grinding materials containing dangerous substances	M	45 000 kg	100
3	**12 01 16** waste blasting material containing dangerous substances	M	1000 kg	2,22
4	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	28 kg	0,06
5	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	200 kg	0,44
Non-process based HWs (13,15, 16 and 20 coded wastes)				
6	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	216 kg	0,48
7	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	5 batteries	0,011*
8	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	3 cartridges	0,007*
9	**20 01 21** fluorescent tubes and other mercury-containing waste	A	1 tube	0,002*

4.2.2.2.2. Pilot Plant 2: M.2

The second pilot plant selected to study (M.2), runs in machining sub-sector, producing various products used in defense sector and automotive. Moreover, there is no other process (i.e. forging) involved in M.2. Machining process is similar for the two pilot plants studied; therefore, process flow diagram for M.2 is not repeated in this section. Process specific and non-process based HWs generating from M.2 are given in the following sections.

HW originating from processes: Types of HWs resulting from machining processes in M.2 are similar with the determined wastes in M.1 as given in Table 4.19. Different types of metals (steel, aluminum, and brass) can be processed in M.2, but since steel has the highest portion, only steel products are taken into consideration in this study.

Table 4.19 Types and amount of process specific HWs in M.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste
1	waste mixtures of cooling liquid and slideway oil	**12 01 09** machining emulsions and solutions free of halogens	A	320 kg
2	grindings and scrap from steel processing	**12 01 20** spent grinding bodies and grinding materials containing dangerous substances	M	20 000 kg
3	waste sand and metal dust from blasting	**12 01 16** waste blasting material containing dangerous substances	M	100 kg
4	packaging material from oils	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	32 kg
5	contaminated rags	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	100 kg

HW originating from side processes: Similar to M.1, surface treatment and coating processes of M.2 are performed in a different company in OSTIM OIZ. Therefore, HW generation from side processes could not be determined for M.2.

Other HW (non-process based): Other types of HWs generating from M.2 are given in Table 4.20 with their amounts and codes.

Table 4.20 Types and amounts of non-process based HWs in M.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	contaminated work gloves, and working cloths	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	720 pairs = 180 kg 30 cloths = 60 kg
2	batteries	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	4 batteries
3	wasted toners and cartridges	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	3 cartridges
4	fluorescent tubes	**20 01 21** fluorescent tubes and other mercury-containing waste	A	20 tubes

HW generation factors (HWGF): Annual amount of steel processed in M.2 is 60 ton/year and during the calculations of HWGF's this capacity value was used. Results obtained are presented in Table 4.21.

Table 4.21 HW generation factors (HWGF) in M.2

No	Type of waste	A/M	Annual amount of waste (kg or item*)	HWGF-2 (kg waste or waste item*/ ton metal processed)
HWs originating from processes (10 and 15 coded wastes)				
1	**12 01 09** machining emulsions and solutions free of halogens	A	320 kg	5,33
2	**12 01 20** spent grinding bodies and grinding materials containing dangerous substances	M	20 000 kg	333,33
3	**12 01 16** waste blasting material containing dangerous substances	M	100 kg	1,67
4	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	32 kg	0,53
5	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	100 kg	1,67
Non-process based HWs (13,15, 16 and 20 coded wastes)				
6	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	240 kg	4
7	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	4 batteries	0,07*
8	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	3 cartridges	0,05*
9	**20 01 21** fluorescent tubes and other mercury-containing waste	A	20 tube	0,33*

4.2.2.2.3. Summary for Machining

Machining is an essential sub-sector for various sectors like automotive, construction machines, defense, machinery and electronics. Accordingly, it is considered as a wide sector in which various types of processes are used, different raw materials are processed, and a variety of products are generated.

Furthermore, in OSTIM OIZ, companies in machining sub sector are in the form of SME's and have a wide range of product types. For the majority of these small companies, types of products and production capacities change year by year. Therefore, it is very difficult to give precise results for HWGFs in this sector, in OSTIM OIZ.

In this section, results obtained from pilot plant studies on the process specific and non-process based HWs and corresponding HWGFs in machining sub sector of OSTIM OIZ are discussed. Types and amounts of possible side process specific HWs could not be determined from pilot plant studies, since these processes are performed outside of these small companies. Calculated HWGFs from pilot plant studies are tabulated together in Table 4.22 to allow comparison. A range for each waste generation factor was determined based on the pilot plant studies and provided in the last column of Table 4.22.

Table 4.22 Comparison of HW generation factors (HWGF) in machining

No	Type of Waste	A/M	HWGF -1 (kg waste or waste item*/ ton metal processed)	HWGF -2 (kg waste or waste item*/ ton metal processed)	HWGF -3 (kg waste or waste item*/ ton metal processed)	HWGF (kg waste or waste item*/ ton metal processed)
HWs originating from processes (10 and 15 coded wastes)						
1	**12 01 09** machining emulsions and solutions free of halogens	A	1,11	5,33	2,4	1,11-5,33
2	**12 01 20** spent grinding bodies and grinding materials containing dangerous substances	M	100	333,33	200	100-333
3	**12 01 16** waste blasting material containing dangerous substances	M	2,22	1,67	-	1,67-2,22
4	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	0,06	0,53	0,2	0,06-0,53
5	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	0,44	1,67	0,6	0,44-1,67

Table 4.22 (continued)

No	Type of Waste	A/M	HWGF -1 (kg waste or waste item*/ ton metal processed)	HWGF -2 (kg waste or waste item*/ ton metal processed)	HWGF -3 (kg waste or waste item*/ ton metal processed)	HWGF (kg waste or waste item*/ ton metal processed)
Non-process based HWs (13,15, 16 and 20 coded wastes)						
6	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	0,48	4	1	0,48-4
7	**16 06 01** lead batteries **16 06** 02 Ni-Cd batteries **16 06 03** mercury containing batteries	A	0,011	0,07	0,03	0,011-0,07*
8	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	0,007	0,05	0,02	0,007-0,05*
9	**20 01 21** fluorescent tubes and other mercury-containing waste	A	0,002	0,33	0,01	0,002-0,33*

Therefore, in order to confirm the provided ranges for HWGFs, another pilot plant study was conducted through a quick search. This third company (M.3) produces spare parts for construction machines and has a capacity of 100 ton steel /year. HWGFs for M.3 are also given in Table 4.22. It can be seen that the values fall into the ranges determined based on the studies conducted in M.1 and M.2. Although literature values are not available to compare, three pilot plants results confirmed each other, hence, indicating that they are representative for the sector.

As seen from Table 4.22, there are five main types of process specific HWs resulting from machining sector in OSTIM OIZ. Among these wastes, *12 01 20* coded HW, *spent grinding bodies and grinding materials containing dangerous substances,* generates in highest amounts. However, there are different types for *12 01 20* coded HWs since type of metal processed in machining sector varies. To illustrate, there are three different types of waste metal scrap and grindings (steel, aluminum, and brass) for the three pilot plants studied. And, there are many other plants in which different metals are processed with different capacities. Considering the limited time of this thesis study, it was not possible to conduct more pilot studies in order to be able to give ranges for the other possible metal wastes in OSTIM OIZ. However, in OSTIM OIZ steel is the most widely processed metal in machining sector. Therefore, a suitable range for HWGF could be determined only for steel wastes from the results of pilot plant studies as given in Table 4.22.

During the pilot plant studies, it was observed that cooling liquids (oils) are used for proper cutting and slideway oils are used for easy movement of machinery parts in CNC or universal machines. Generally water-mixable or water-mixed cooling oils are used in the machines and after recycling residual cooling and slideway oil wastes are collected in the same part of the machines. With the

code of *12 01 09*, *machining emulsions and solutions free of halogens,* waste oil mixtures are the second type of important wastes in terms of their considerable amounts in machining sector.

Sandblasting is also a process included in OSTIM OIZ machining sector and waste blasting materials are classified as *12 01 16* (*waste blasting material containing dangerous substances*) coded HWs. Amount of wastes from 12 01 16 code seem to be less compared to other 12 01 coded HWs.

15 01 10 (as contaminated packaging of oils) and *15 02 02* (as contaminated rags) coded HWs are also included in the list of process based HWs, since they are directly generated from production processes in machining sector.

On the other hand, it can be concluded that calculated HWGFs for non-process based HWs have a wide range compared to process based HWs. This is not an unexpected result, since non-process based are not dependent on production capacity. Instead they are related with different factors such as number of workers, production area, etc. However, determined ranges for non-process HWGFs are helpful in estimation of total HW generation from this sector.

For estimation of total HWs generation from machining sector in OSTIM OIZ, total number of companies in this sector and their capacities should be known. Companies in this sector were determined from OSTIM OIZ Directorate database, but there is no information about recent capacities of these companies. On the basis of the assumption that companies in machining sector of OSTIM OIZ have an average capacity of 150 ton metal processed/year, total HW generation for 119 companies is calculated as given in Table 4.23.

Table 4.23 Total HW generation in machining sector of OSTIM OIZ

HW Category	HWGF (kg waste or waste item*/ ton metal processed)	Capacity (ton metal processed/ year)	Annual HW generation (ton/year or *item/year)
HWs originating from processes (12 and 15 coded wastes)			
*12 01 (*wastes from shaping and physical and mechanical surface treatment of metals and plastics*)*	102,78–340,55	17 850	1834,6 – 6078,8
15 01 10 (contaminated packaging of oils)	0,06 – 0,53		1,07 - 9,46
15 02 02 (contaminated rags)	0,44 – 1,67		7,85 - 29,81
Non-process based HWs (15, 16 and 20 coded wastes)			
15 02 02 (waste work gloves and cloths)	0,48 - 4	17 850	8,57 – 71,4
16 06 (waste batteries)	0,01-0,05*		178,5 – 892,5*
16 02 13 (waste cartridges)	0,007 – 0,04*		124,95- 714*
20 01 21 (waste fluorescent tubes)	0,002 – 0,33*		35,7 – 5890,5*

In Table 4.23, total HW generation for machining sector in OSTIM OIZ is given. However, this amount should be higher since as mentioned before automotive, construction machine, building and construction, machinery and electronics sectors also involve machining processes for metal parts of the products. Since total production capacities of these sectors in machining were not known, they could not be included in total sectoral HW estimation study.

Therefore, while evaluating Table 4.23, following issues should be taken into consideration:

- Number of machining companies was taken as 119 according to OSTIM OIZ database. However, this number seems to be less than the actual value, since machining is a fundamental process also for sectors like automotive, machinery, electronics, building and construction, etc.
- HWs and HWGFs could be calculated only for steel processing in CNC machines as they are most commonly used in machining sector of OSTIM OIZ.
- HWs from side processes (as surface treatment and coating, surface cleaning and painting) could not be determined since it is observed that these processes were not applied within the micro sized plants of OSTIM OIZ.
- Only pilot plant studies were considered since no literature value was reached to make a comparison.

4.2.3. Treatment and Surface Coating of Metals (Electroplating and Hot dip galvanizing)

In surface treatment and coating of metals there are various techniques used in industry providing different specifications for metal surfaces such as corrosion resistance, hardness, wear resistance, anti-frictional characteristics, electrical or thermal conductivity, or decoration. Detailed information about these techniques is given in Appendix C.3.

In OSTIM OIZ, electroplating (also called as galvanizing) and hot dip galvanizing are the most common techniques involved in the companies of metal coating

sector. Therefore, hazardous wastes resulting from these two techniques are investigated in this thesis study.

4.2.3.1. HWs in Treatment and Surface Coating of Metals

Wastes from electroplating can be categorized into three main groups in terms of their sources of generation as *wastes from materials storage*, *wastes from plating*, and *wastes from auxiliary activities*. Moreover, wastes resulting from all activities in electroplating can be given as wastewater, solid wastes, and air emissions and summarized in Table 4.24.

In addition to this, according to the Waste List of RGPWM (No:26927, 2008), hazardous wastes expected to be generated as a result of treatment and coating of metals are included in two sub groups of Chapter 11 as four digit chapter heading of *11 01*, titled as *wastes from chemical surface treatment and coating of metals and other materials (for example galvanic processes, zinc coating processes, pickling processes, etching, phosphating, alkaline degreasing, anodizing) and 11 05*, titled as *wastes from hot galvanizing processes* as listed in Table 4.25.

Table 4.24 Wastes resulting from electroplating processes (adapted from [32])

Type of waste	Description
wastewater	• Regeneration eluates from resins and osmosis • Diluted effluents from the rinsing of parts • Depleted and polluted concentrated bath solutions • Polluted solutions from fume treatment equipment
industrial wastes (liquid and solid)	• Depleted surface preparation baths: degreasing and pickling • Polluted and depleted process baths: anodising, neutralisation with bisulphite, chromium baths polluted with heavy metals and trivalent chromium. • Demetalising solutions • Solutions and treatment filters from emissions into the atmosphere • Empty drums and containers • Sludge from effluent treatment • Different types of filter and absorbent material: filters, active carbon, absorbents, dirty rags, etc. • Material used in waste water treatment: depleted ion exchange resins, inverse osmosis filters, etc.
air emissions	• Emissions of dust and particulates from mechanical pre-treatment operations (shot peening, polishing, etc.) • Diffuse emissions from the baths (pre-treatment and process), consisting basically of water vapor from solutions that work at a certain temperature (>50ºC) • Emissions of volatile organic compounds from baths for pre-treating parts • Vapor containing chromic acid from chroming processes • Pollutant gases from combustion boilers used to heat baths or to dry parts

Table 4.25 Wastes from treatment and coating of metals [4]

11 WASTES FROM CHEMICAL SURFACE TREATMENT AND COATING OF METALS AND OTHER MATERIALS; NON-FERROUS HYDRO-METALLURGY		
waste code	**11 01 wastes from chemical surface treatment and coating of metals and other materials (for example galvanic processes, zinc coating processes, pickling processes, etching, phosphating, alkaline degreasing, anodizing)**	**Absolute /Minor**
11 01 05*	pickling acids	A
11 01 06*	acids not otherwise specified	A
11 01 07*	pickling bases	A
11 01 08*	phosphatising sludges	A
11 01 09*	sludges and filter cakes containing dangerous substances	M
11 01 11*	aqueous rinsing liquids containing dangerous substances	M
11 01 13*	degreasing wastes containing dangerous substances	M
11 01 15*	eluate and sludges from membrane systems or ion exchange systems containing dangerous substances	M
11 01 16*	saturated or spent ion exchange resins	A
11 01 98*	other wastes containing dangerous substances	M
waste code	**11 05 wastes from hot galvanizing processes**	**Absolute /Minor**
11 05 03*	solid wastes from gas treatment	A
11 05 04*	spent flux	A

Furthermore, according to LIFE HAWAMAN Project (LIFE 06 TCY/TR/000292) Guide Document on metal coating sector, most common hazardous wastes resulted from metal coating processes are given in Table 4.26 with their sources and codes.

Table 4.26 Hazardous wastes generating from metal coating [33]

Source of waste	Definition of waste	Waste code
pickling	pickling acids (sulphuric, nitric, hydrochloric acid)	**11 01 05***
wastewater treatment, regeneration of process baths	sludges and filter cakes	**11 01 09***
rinsing	rinsing wastewater containing dangerous substances	**11 01 11***
degreasing	degreasing wastes containing dangerous substances	**11 01 13***
	other solvents and solvent mixtures	**14 06 03***
	sludges or solid wastes containing other solvents	**14 06 05***
	chlorofluorocarbons, HCFC, HFC	**14 06 01***
	other halogenated solvents and solvent mixtures	**14 06 02***
	sludges or solid wastes containing halogenated solvents	**14 06 04***

11 01 05/07 coded wastes result from surface cleaning processes before coating. According to the type of chemical used (acid or alkali) in cleaning process, proper code can be chosen for waste baths.

11 01 08 coded wastes as phosphatising sludges, are resulting from process baths in phosphate (e.g. manganese phosphate, zinc phosphate) coating. Apart from 11 01 08, *11 01 09* and *11 01 15* coded wastes are the two types of sludges containing dangerous substances resulting from different techniques in wastewater treatment. According to Table 4.26, 11 01 09 coded wastes are sludges and filter cakes generating from wastewater treatment and regeneration of process baths. This type of wastes consist of sludges (bottom residues from sedimentation of heavy metals with NaOH/CaOH) and filter cakes (cakes from

filtration of sludges in filter press) which may contain metals and heavy metals from coating and residues from alkaline degreasing or acidic pickling processes. However, according to LIFE HAWAMAN Project Guide Document on Classification of Hazardous Wastes-Volume 2, 11 01 15 coded wastes are defined as sludges from ion exchange systems of wastewater treatment and contain residues from waste process baths [29].

11 01 11 coded hazardous wastes are generally defined as "aqueous rinsing liquids containing dangerous substances" according to Table 4.25. On the other hand, depending of their sequence in process flow diagram there is a difference in classification of rinsing wastewaters as hazardous wastes. To illustrate, rinsing wastewaters from degreasing are coded as *11 01 13* due to their similar contents. Accordingly, rinsing liquids from pickling processes are classified in *11 01 05 or 11 01 07* codes depending on their acid or basic content. However, other rinsing wastewaters after coating processes are classified in *11 01 11* code [3].

11 01 13 coded HWs involve waste acidic (mostly) or basic degreasing baths and also rinsing wastewater after degreasing processes as mentioned.

11 01 16 coded hazardous wastes (saturated and spent ion exchange resins) are absolute wastes and possibly resulting from treatment of rinsing wastewaters.

As given in Table 4.25, any other hazardous waste resulting from metal coating processes can be classified under six digit code of *11 01 98*, unless they are matched with the codes in the list of 11 01. However, this application should be under the permit of MoEF.

Moreover, as given in sectoral information part in Appendix C.3, main processes of hot dip galvanizing are similar with electroplating. Differences between two techniques are pre-coating step called as fluxing involved in hot dip galvanizing and the types of coating process. Accordingly, wastes from hot dip galvanizing processes (such as surface preparation and rinsing) are similar with the wastes in electroplating. *11 05 03* coded wastes from air treatment and *11 05 04* coded wastes from fluxing are other types of hazardous wastes in hot dip galvanizing.

Based on the explanations about process specific hazardous wastes in electrolytic and hot dip galvanizing, possible wastes resulting from each process are given in Figure 4.11. Passivation and fluxing processes are demonstrated with "dashed line" in flow diagram since they are specific processes for electroplating and hot dip galvanizing techniques respectively. In addition to this, *11 01 98* code in Figure 4.11 is used for waste baths from coating and passivation processes, since there is no other proper code for such types of wastes.

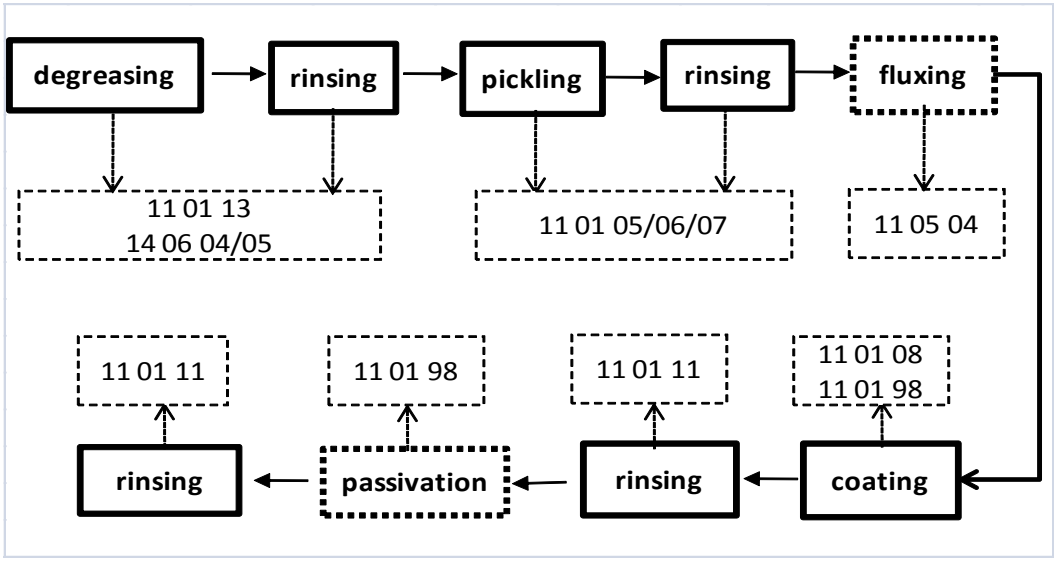

Figure 4.11 Process specific hazardous wastes in treatment and coating of metals [33]

Furthermore, *08 01* coded *(wastes from MFSU and removal of paint and varnish)* and *12 01* coded *(wastes from shaping and physical and mechanical surface treatment of metals and plastics)* HWs can result from side processes (painting, machining, etc.) involved in treatment and coating of metals sector.

4.2.3.2. Pilot Plant Studies

Two pilot plants (called as G.1 and G.2) are selected from electroplating and hot dip galvanizing sector for estimation of sectoral HW generation in OSTIM OIZ.

Estimation studies for p*rocess specific, side process specific,* and *non-process based hazardous wastes* in G.1 and G.2 are summarized in the following sections. The results from pilot plants are compared with each other and literature findings in summary part.

4.2.3.2.1. Pilot Plant 1: G.1

The first pilot plant, G.1, is in metal coating sector since 1989 and involve different coating techniques such as electroplating (zinc) (528 ton/year), manganese phosphate hot dip galvanizing (48 ton/year), electrolysis silver/tin/gold coating (in minority and based on customer needs) and alodine coating (2,4 ton/year). In this thesis study, zinc electroplating and manganese phosphate hot dip coating processes of G.1 are investigated since other coating techniques are done rarely.

In electroplating processes of G.1, 30-40 % HCl and a special chemical (GALVAN 71) are used for degreasing and acidic pickling processes in the same bath. This process bath is reloaded in every two months and wastes from this bath are collected in a tank for sedimentation. In every two years bottom sludges (40 kg)

of this tank are collected. After degreasing, the first rinsing process is done as dipping with cascade water rinse systems (150 L per each of the 3 tanks). One of the rinsing tanks is reloaded weekly, and others are reused.

There are two different types of zinc electroplating in G.1. For small products like bolts and gears, cyanide zinc coating is done in barrels. However, bigger products like iron castings are processed with acidic rack plating. Cyanide plating baths are filtrated two times per year and residues are taken from the bottom of the tank. Moreover, acidic plating baths are filtrated daily and residues after filtration are collected. Rinsing after coating processes is done with stagnant water in (80 L) three cascade rinsing system water tanks.

In zinc electroplating process of G.1, products are further coated in passivation process for protection of coatings. Chemicals including Cr^{3+} are used in blue, yellow, and black passivating. Passivation tanks are changed weekly. Final rinsing process is done with flowing water. Finally in drying process, small products are dried with centrifuge system (5 min) and bigger products are hanged up. Main processes in zinc electroplating are given in process flow diagram-1 of G.1, in Figure 4.12.

For pretreatment of metals before hot dip galvanizing, degreasing (hot), acidic pickling, and activation processes are done separately in G.1. Hot degreasing bath is changed once in a year and activation bath is renewed weekly in G.1. All rinsing steps involved in hot dip galvanizing are stagnant and water baths (200 L) are changed weekly. The baths used in each hot dip galvanizing process in G.1 have a capacity of 200 L and 7 baths are used for manganese phosphate coating process.

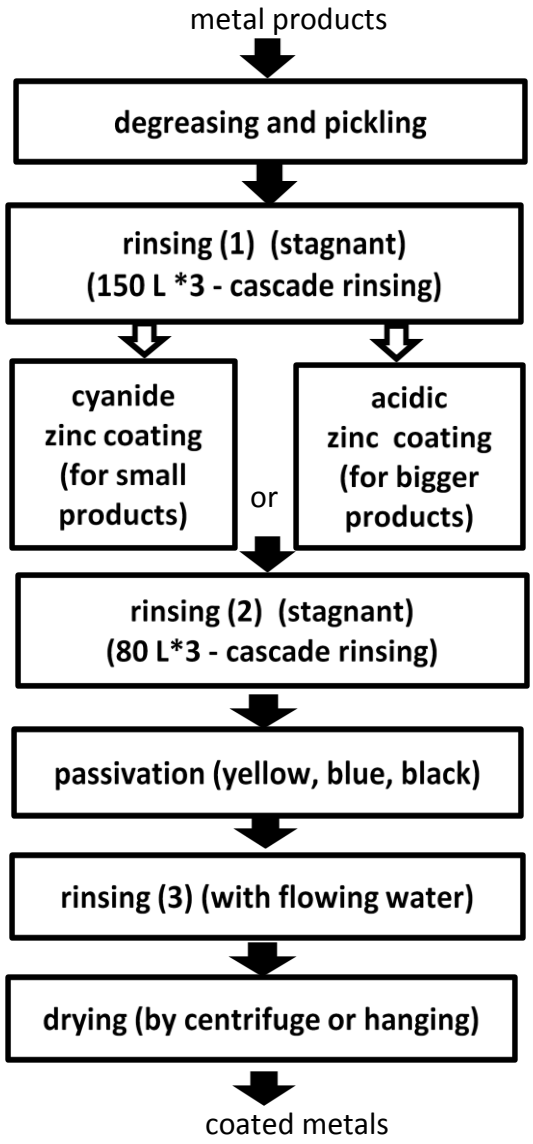

Figure 4.12 Process flow diagram-1 of G.1 for zinc electroplating

In addition to this, main processes involved in hot dip manganese phosphate galvanizing in G.1 are depicted in Figure 4.13.

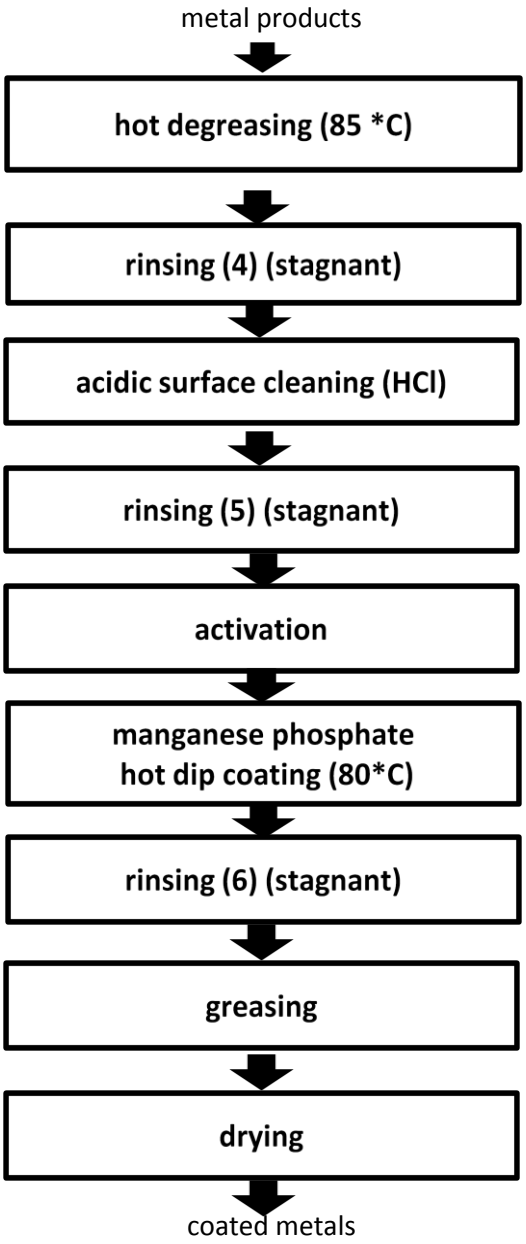

Figure 4.13 Process flow diagram-2 of G.1 for hot dip manganese phosphate galvanizing

In addition to this, amounts of chemical consumption in electroplating and hot dip galvanizing processes of G.1 are given in Table 4.27.

Table 4.27 Chemical consumption amounts in G.1

Type of coating	Type of process	Type of chemical used in process	Amount of chemical used (L or kg / month)[1]	Type of packaging for chemical (tare weight) [1]	Amount of packaging wasted (pieces/ year) [1]
electrogalvanizing	degreasing and pickling	HCl	250 L	plastic can (3 kg)	60
		GALVAN 71	20 L	plastic can (1,6 kg)	10
	cyanide zinc coating	NaOH	100 L	plastic bags (0,15 kg)	48
		ZnO	100 kg		48
		NaCN	150 kg	barrel (5,3 kg)	36
	cyanide and acidic zinc coating	polishing agent	100 L	plastic can (1,6 kg)	36
	acidic zinc coating	NH_4Cl	12,5 kg	plastic bags (0,15 kg)	6
		$ZnCl_2$	12,5 kg		6
	passivation	blue passivating agent(Cr^{3+})	60 kg	plastic can (1,6 kg)	24
		yellow passivating agent(Cr^{3+})	40 kg	plastic can (1,8 kg)	12
		dark passivating agent(Cr^{3+})	6 kg	plastic can (1,8 kg)	2
hot dip galvanizing	degreasing	hot degreasing chemical	25 kg	plastic bags (0,15 kg)	12
	manganese phosphate coating	manganese phosphate	50 kg	plastic bags (0,15 kg)	24
	greasing	oil	15 L	metal tins (1,5 kg)	12
	activation	activation chemical	2,5 kg	plastic can (1,6 kg)	12

[1] data taken from chemical sale company of G.1 in OSTIM OIZ

HW originating from processes: Inputs and outputs for each process in electroplating and hot dip galvanizing were determined for estimation of process specific HWs in G.1. Results for electroplating processes are summarized in Figure's 4.14 (for degreasing, pickling, and rinsing-1 processes), 4.15 (for coating and rinsing-2 processes), and 4.16 (passivation and rinsing-3 processes). Moreover, results for hot dip galvanizing processes are given in 4.17 (hot degreasing, acidic pickling, rinsing-4 and-5 and activation processes), 4.18 (for coating and rinsing-6 processes), and 4.19 (for greasing process).

Input and output analysis for electroplating processes in G.1

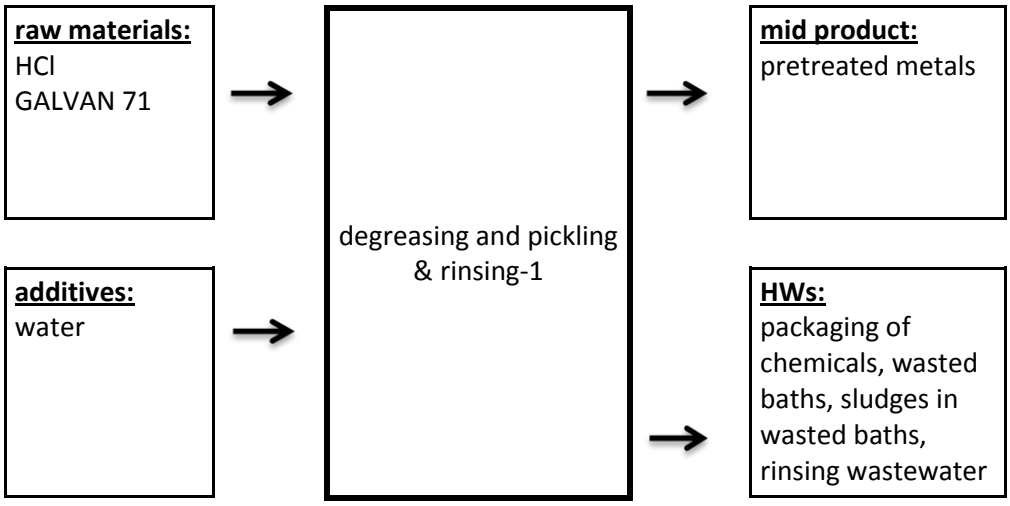

Figure 4.14 Inputs and outputs for degreasing, pickling, and rinsing-1 processes in G.1

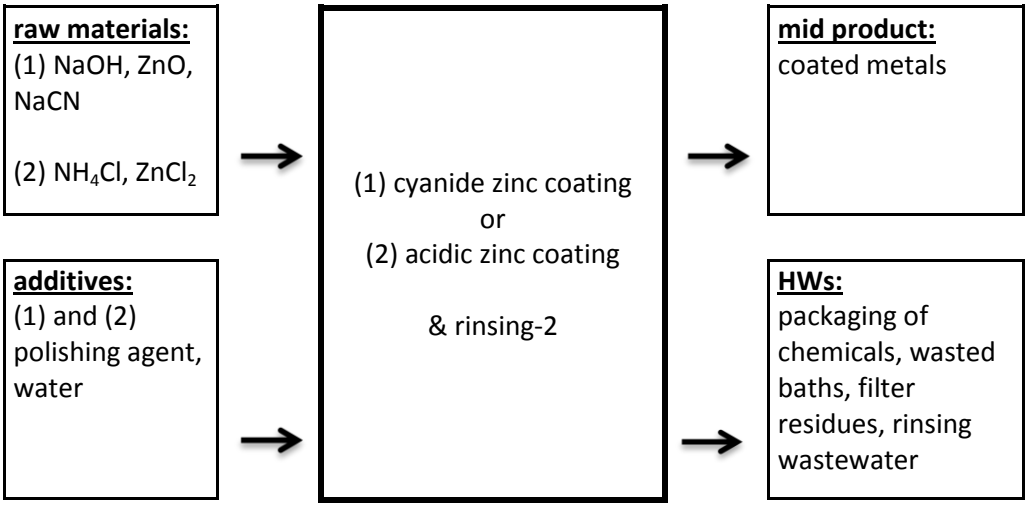

Figure 4.15 Inputs and outputs for zinc coating and rinsing-2 processes in G.1

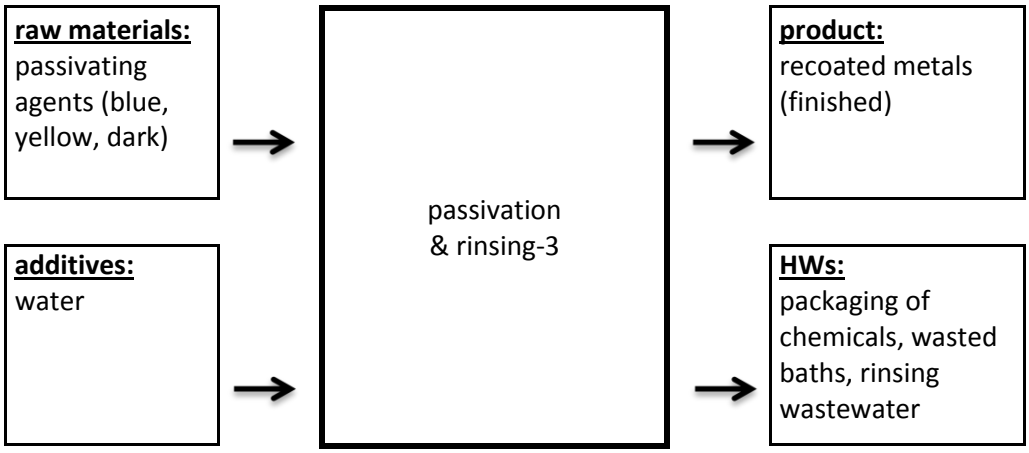

Figure 4.16 Inputs and outputs for passivating and rinsing-3 processes in G.1

Input and output analysis for hot dip galvanizing processes in G.1

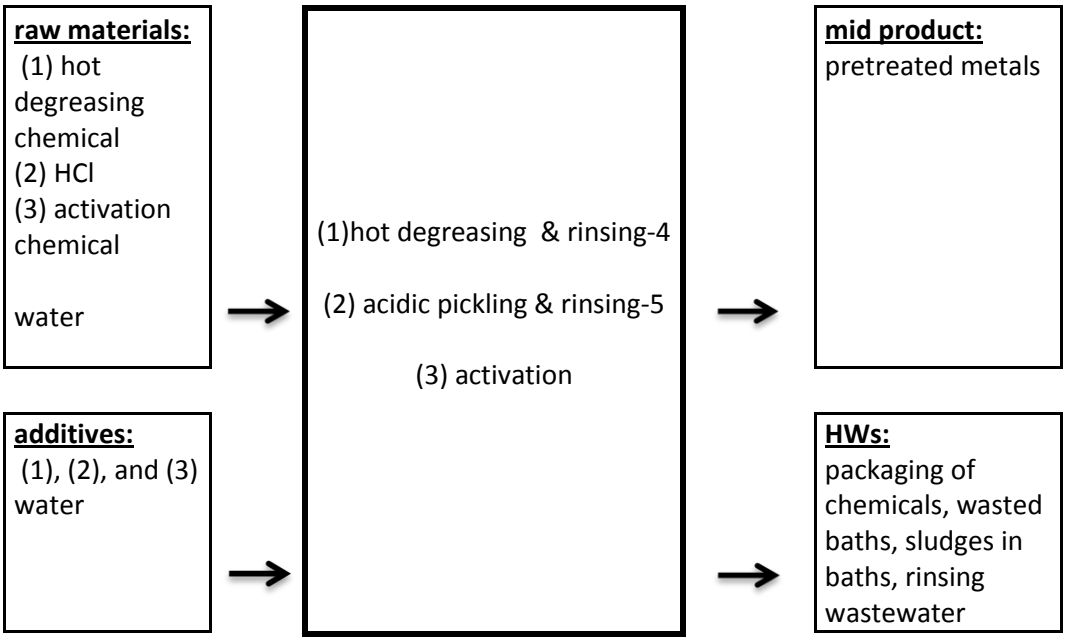

Figure 4.17 Inputs and outputs for hot degreasing & rinsing-4, acidic pickling & rinsing-5 and activation processes in G.1

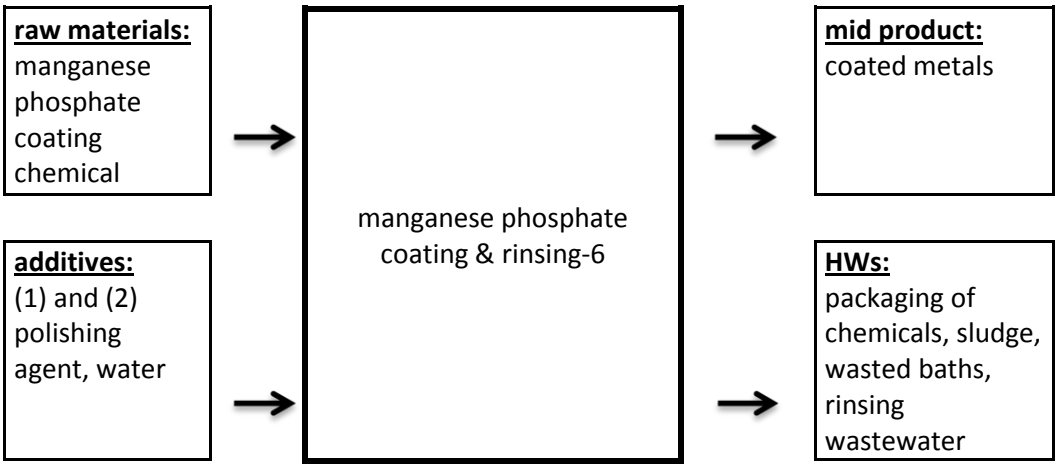

Figure 4.18 Inputs and outputs for manganese phosphate coating and rinsing-6 processes in G.1

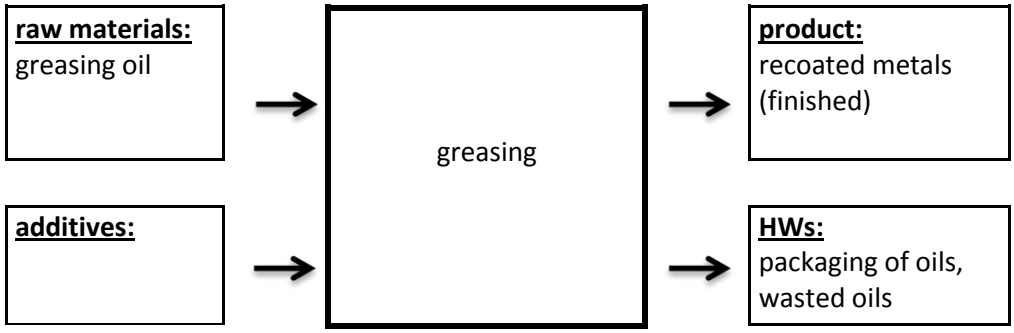

Figure 4.19 Inputs and outputs for greasing processes in G.1

Types and amounts of process specific HWs from G.1 for zinc electroplating and manganese phosphate hot dip coating processes are given in Table 4.28.

Table 4.28 Types and amount of process specific HWs in G.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste
from zinc electroplating processes				
1	wastewater from degreasing and pickling	**11 01 13** degreasing wastes containing dangerous substances	M	4500 kg
2	wastewater from rinsing-1			7200 kg
3	sludge from degreasing and pickling	**11 01 09** sludges and filter cakes containing dangerous substances	M	20 kg
4	filter cakes from filtration of coating baths			10 kg
5	waste baths from passivation	**11 01 98** other wastes containing dangerous substances	M	3840 kg
6	wastewater from rinsing-2	**11 01 11** aqueous rinsing liquids containing dangerous substances	M	1920 kg
7	wastewater from rinsing-3			198 000 kg

Table 4.28 (continued)

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste
8	contaminated packaging of chemicals	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	328,2 kg
from hot dip manganese phosphate galvanizing processes				
9	wastewater from degreasing	**11 01 13** degreasing wastes containing dangerous substances	M	200 kg
10	wastewater from rinsing-4			9600 kg
11	wastewater from acidic pickling	**11 01 05** pickling acids	A	200 kg
12	wastewater from rinsing-5			9600 kg
13	wastewater from activation	**11 05 04** spent flux	A	9600 kg
14	sludge from coating	**11 01 08** phosphatising sludges	M	36 kg
15	wastewater from rinsing-6	**11 01 11** aqueous rinsing liquids containing dangerous substances	M	9600 kg
16	contaminated packaging of chemicals	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	42,6 kg

HW originating from side processes: There isn't any side process involved in G.1 after coating processes. Therefore, there is no side process specific HW generation from electroplating and hot dip galvanizing processes in G.1.

Other HW (non-process based): Apart from process specific HWs, other HWs generated from G.1 are tabulated in Table 4.29.

Table 4.29 Types and amount of non-process based HWs in G.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	contaminated wiping cloths, work gloves, and working cloths	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	384 pairs = 96 kg 16 cloths = 32 kg
2	batteries	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	2 batteries
3	wasted toners and cartridges	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	1 cartridge
4	fluorescent tubes	**20 01 21** fluorescent tubes and other mercury-containing waste	A	1 tube

HW generation factors (HWGF: In calculations of HWGF in G.1, the capacity is taken as 528 ton/year for zinc electroplating and 48 ton/year for hot dip manganese phosphate galvanizing processes. In HWGF calculations, different capacities are taken into account for process based HWs. Moreover, for non-process wastes total capacity of M.1 is taken as 576 ton coatings/year. Results from this section are tabulated in Table 4.30.

Table 4.30 HW generation factors (HWGF) in G.1

No	Type of waste	A/M	Amount of waste (kg or item*)	HWGF-1 (kg waste or waste item*/ ton plated metal)
HWs originating from processes (11 and 15 coded wastes)				
for zinc electroplating				
1	**11 01 13** degreasing wastes containing dangerous substances	M	11 700 kg	22,16
2	**11 01 09** sludges and filter cakes containing dangerous substances	M	30 kg	0,06
3	**11 01 11** aqueous rinsing liquids containing dangerous substances	M	199 920 kg	378,64
4	**11 01 98** other wastes containing dangerous substances	M	3840 kg	7,27
5	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	328,2 kg	0,62
for hot dip manganese phosphate galvanizing				
6	**11 01 13** degreasing wastes containing dangerous substances	M	9800 kg	204,17
7	**11 01 05** pickling acids	A	9800 kg	204,17
8	**11 05 04** spent flux	A	9600 kg	200
9	**11 01 08** phosphatising sludges	M	36 kg	0,75
10	**11 01 11** aqueous rinsing liquids containing dangerous substances	M	9600 kg	200
11	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	42,6 kg	0,89
Non-process based HWs (13,15, 16 and 20 coded wastes)				
12	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	128 kg	0,22
13	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	2 batteries	0,004*

Table 4.30 (continued)

No	Type of waste	A/M	Amount of waste (kg or item*)	HWGF-1 (kg waste or waste item*/ ton plated metal)
Non-process based HWs (13,15, 16 and 20 coded wastes)				
14	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	1 cartridge	0,002*
15	**20 01 21** fluorescent tubes and other mercury-containing waste	A	1 tube	0,002*

4.2.3.2.2. Pilot Plant 2: G.2

The second pilot plant, G.2, is a new company (2009) compared to G.1 and involves only zinc electroplating and manganese phosphate hot dip galvanizing processes for different products from automotive sector. Same processes in G.1 are involved in G.2; therefore, process flow diagrams for G.2 are not given in this section.

For rinsing cascade system is not used in G.2. In electroplating all rinsing steps are done as stagnant; however, in hot dip galvanizing flowing water is used.

Results of estimation studies for process specific, side process specific, and non-process based HWs in G.2 are given in the following sections.

HW originating from processes: Since G.1 and G.2 have same processes for zinc electroplating and manganese phosphate galvanizing, same types of HWs are generated from processes. Types and amounts of HWs from main processes in G.2 are tabulated in Table 4.31.

Table 4.31 Types and amount of process specific HWs in G.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste
from zinc electroplating processes				
1	ww from degreasing and pickling	**11 01 13** degreasing wastes containing dangerous substances	M	10 000 kg
2	ww from rinsing-1		M	60 000 kg
3	sludge from degreasing and pickling	**11 01 09** sludges and filter cakes containing dangerous substances	M	100 kg
4	filter cakes from filtration of coating baths			-
5	waste baths from passivation	**11 01 98** other wastes containing dangerous substances	M	30 000 kg
6	ww from rinsing-2	**11 01 11** aqueous rinsing liquids containing dangerous substances	M	60 000 kg
7	ww from rinsing-3			60 000 kg
8	contaminated packaging of chemicals	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	652 kg
from hot dip manganese phosphate galvanizing processes				
9	Ww from degreasing	**11 01 13** degreasing wastes containing dangerous substances	M	600 kg
10	ww from rinsing-4			52 800 kg
11	ww from acidic pickling	**11 01 05** pickling acids	A	1400 kg
12	ww from rinsing-5			52 800 kg
13	ww from activation	**11 05 04** spent flux	A	4800 kg
14	sludge from coating	**11 01 08** phosphatising sludges	M	350 kg
15	ww from rinsing-6	**11 01 11** aqueous rinsing liquids containing dangerous substances	M	52 800 kg
16	contaminated packaging of chemicals	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	60 kg

HW originating from side processes: For treated and coated metals there isn't any side process involved in G.2. Therefore, HW generation from side processes could not be estimated in G.2.

Other HW (non-process based): Non-process based HWs generating in M.2 are given in Table 4.32 with their corresponding codes and amounts.

Table 4.32 Types and amount of non-process based HWs in G.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	contaminated wiping cloths, work gloves, and working cloths	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	480 pairs = 120 kg 20 cloths = 40 kg
2	batteries	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	4 batteries
3	wasted toners and cartridges	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	4 cartridges
4	fluorescent tubes	**20 01 21** fluorescent tubes and other mercury-containing waste	A	1 tube

HW generation factors (HWGF): G.2 has a capacity of 1000 ton/year for zinc electroplating and 60 ton/year for hot dip manganese phosphate galvanizing. In calculations of HWGFs in G.2, for process based HWs, waste amounts are divided by corresponding capacity value. In addition to this, for determination of

generation factors for non-process HWs total capacity is taken as 1060 ton coatings/year. The results from this section are given in Table 4.33.

Table 4.33 HW generation factors (HWGF) in G.2

No	Type of waste	A/M	Amount of waste (kg or item*)	HWGF-2 (kg waste or waste item*/ ton plated metal)
HWs originating from processes (11 and 15 coded wastes)				
for zinc electroplating				
1	**11 01 13** degreasing wastes containing dangerous substances	M	70 000 kg	70
2	**11 01 09** sludges and filter cakes containing dangerous substances	M	100 kg	0,1
3	**11 01 11** aqueous rinsing liquids containing dangerous substances	M	120 000 kg	120
4	**11 01 98** other wastes containing dangerous substances	M	30 000 kg	30
5	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	652 kg	0,65
for hot dip manganese phosphate galvanizing				
6	**11 01 13** degreasing wastes containing dangerous substances	M	53 400 kg	890
7	**11 01 05** pickling acids	A	54 200 kg	903,33
8	**11 05 04** spent flux	A	4800 kg	80
9	**11 01 08** phosphatising sludges	M	350 kg	5,83
10	**11 01 11** aqueous rinsing liquids containing dangerous substances	M	52 800 kg	880
11	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	60 kg	1

Table 4.33 (continued)

No	Type of waste	A/M	Amount of waste (kg or item*)	HWGF-2 (kg waste or waste item*/ ton plated metal)
Non-process based HWs (13,15, 16 and 20 coded wastes)				
12	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	160 kg	0,151
13	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	4 batteries	0,004*
14	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	4 cartridge	0,004*
15	**20 01 21** fluorescent tubes and other mercury-containing waste	A	1 tube	0,001*

4.2.3.3. Summary for Treatment and Coating of Metals

In section 4.2.3, zinc electroplating and hot dip manganese phosphate galvanizing processes are investigated for estimation of sectoral HW generation in OSTIM OIZ. The calculated HWGFs from pilot plant studies and the other waste generation factors from literature are tabulated in Table 4.34.

In Table 4.26, HWGFs are given for process specific HWs in zinc electroplating and manganese phosphate hot dip galvanizing processes separately. Moreover, HWGFs for non-process based HWs are tabulated in Table 4.34.

Table 4.34 Comparison of HW generation factors (HWGF) in treatment and coating of metals

No	Type of Waste	A/M	HWGF -1 (kg waste or waste item*/ ton plated metal)	HWGF -2 (kg waste or waste item*/ ton plated metal)	HWGF from literature (kg waste or waste item*/ ton plated metal)	HWGF (kg waste or waste item*/ ton plated metal)
HWs originating from processes (10 and 15 coded wastes)						
for zinc electroplating						
1	**11 01 13** degreasing wastes containing dangerous substances	M	22,16	70	300-4100 [34][1]	22,16-70
2	**11 01 11** aqueous rinsing liquids containing dangerous substances	M	378,64	120		120-378,64
3	**11 01 09** sludges and filter cakes containing dangerous substances	M	0,06	0,1	0,18 [34][2]	0,06 - 1
4	**11 01 98** other wastes containing dangerous substances	M	7,27	30	-	7,27-30
5	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	0,62	0,65	-	0,62-0,65

[1]treated wastewater or released water in steel coating by zinc and zinc nickel

[2]solid wastes as oily sludge or filter cake

Table 4.26 (continued)

No	Type of Waste	A/M	HWGF -1 (kg waste or waste item/ ton plated metal)	HWGF -2 (kg waste or waste item/ ton plated metal)	HWGF from literature (kg waste or waste item*/ ton plated metal)	HWGF (kg waste or waste item*/ ton plated metal)
for hot dip manganese phosphate galvanizing						
6	**11 01 13** degreasing wastes containing dangerous substances (as rinsing wastewater)	M	200	880	2-5000 [35][3] [35]	200-880
7	**11 01 05** pickling acids (as rinsing wastewater)	A	200	880		200-880
8	**11 01 11** aqueous rinsing liquids containing dangerous substances	M	200	880		200-880
(6)	**11 01 13** degreasing wastes containing dangerous substances (as process bath)	M	4,17	10	0-5,4 [35]	4,17-10
(7)	**11 01 05** pickling acids (as process bath)	A	4,17	23,3	10-40 [35]	4,17-23,3
9	**11 05 04** spent flux	A	200	80	0-20 [35]	80-200
10	**11 01 08** phosphatising sludges	M	0,75	5,83	1,5-36 [35][4]	0,75-5,83
11	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	0,89	1	-	0,89-1

[3] treated wastewater or released water in continuous hot dip galvanizing

[4] plate scrap in continuous hot dip galvanizing

Table 4.26 (continued)

No	Type of Waste	A/M	HWGF -1 (kg waste or waste item*/ ton plated metal)	HWGF -2 (kg waste or waste item*/ ton plated metal)	HWGF from literature (kg waste or waste item*/ ton plated metal)	HWGF (kg waste or waste item*/ ton plated metal)
HWs originating from processes (10 and 15 coded wastes)						
12	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	0,22	0,151	-	0,151-0,22
13	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	0,004*	0,004*	-	0,004*
14	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	0,002*	0,004*	-	0,002-0,004*
15	**20 01 21** fluorescent tubes and other mercury-containing waste	A	0,002*	0,001*	-	0,001-0,002*

In electroplating processes, *11 01 13 and 11 01 11* coded HWs generate in high amounts due to their rinsing wastewater contents. In G.1, cascade rinsing system is used in the plant except final rinsing after zinc electroplating. Therefore, the highest generation of *11 01 11* coded rinsing wastewater is due to uncontrolled usage of flowing water in this process step. On the other hand, stagnant water is used in G.2 for all rinsing steps in electroplating. This situation verifies that usage of cascade rinsing system in rinsing processes is more efficient than stagnant water usage, and stagnant water is more efficient than flowing water in terms of water consumption and wastewater generation amounts.

HWGFs for each HW type could not be determined from literature; however findings are tabulated in Table 4.34.

For electroplating processes, total amount of wastewater to be treated is given in Table 4.34 in order to compare HWGFs generated as wastewater per ton of plated metal from pilot plants. According to the information in Table 4.34, total wastewater generation amounts in pilot plants are in the given range determined from literature. In addition to this, amount of filter cake and sludge generated from electroplating processes are less than given value from literature. Therefore, in determination of suitable ranges for HWGFs, calculated data from pilot plant studies are directly used.

For hot dip galvanizing processes, in order to compare HWGFs from pilot plant studies with literature findings, HWGFs are given separately for different types of HWs. To illustrate, in literature HWGF for wasted pickling acid baths (*11 01 05*) is given as 10-40 kg/ ton plated metal and HWGFs from pilot plants are in this range. However, for the other type of *11 01 05* coded HW as rinsing wastewaters after pickling processes are evaluated in total wastewater generation together with *11 01 11 and 11 01 13* coded HWs.

Similar to electroplating processes, for **hot dip galvanizing processes** rinsing wastewaters (classified as *11 01 05, 11 01 11, and 11 01 13* coded HWs) have the highest amounts in total HW generation.

Moreover, for *11 01 13* coded HWs as waste degreasing baths and *11 05 04* coded HWs as spent flux baths, it can be seen from Table 4.34 that HWGFs from pilot plants differ from the values in literature.

Finally for non-process based HWs, suitable ranges for HWGFs are determined based on the findings of pilot plant studies and tabulated as in Table 4.34.

After determination of proper ranges for HWGFs, total HW generation from treatment and coating of metals sector in OSTIM OIZ is calculated as given in Table 4.35.

According to 2009 data, there are 18 companies in treatment and coating of metals sector in OSTIM OIZ. In addition to this, according to pilot plant studies, average capacities for zinc electroplating and manganese phosphate hot dip galvanizing processes in OSTIM OIZ can be taken as 750 ton/year and 55 ton/year respectively. Then, total capacity of 13 companies in OSTIM OIZ are taken as 9750 ton/year for zinc electroplating processes, and 715 ton/year for manganese phosphate hot dip galvanizing processes. Since remaining five companies have different coating techniques (e.g. hard chromium coating, nickel plating, etc.), they are not included in total amount of sectoral HW estimation studies. Results of the estimation studies are tabulated in Table 4.35.

Table 4.35 Total HW generation in treatment and coating of metals sector

HW Category	HWGF (kg waste or waste item*/ ton plated metal)	Capacity (ton plated metal/ year)	Annual HW generation (ton/year or *waste item/ year)
HWs originating from processes (11 and 15 coded wastes)			
for electroplating processes			
11 01 (wastes from treatment and coating of metals)	149,5-479,6	9750	1457,5-4676,5
15 01 10 (contaminated packaging of chemicals)	0,62-0,65		6,05-6,34
for hot dip galvanizing processes			
11 01 (wastes from treatment and coating of metals)	689,1-2879,1	715	492,7-2058,6
11 05 04 (spent flux)	80-200		57,2-143
15 01 10 (contaminated packaging of chemicals)	0,89-1		0,64-0,72
Non-process based HWs (13,15, 16 and 20 coded wastes)			
15 02 02 (waste work gloves and cloths)	0,15-0,22	10 465	1,57-2,3
16 06 (waste batteries)	0,004*		41,86*
16 02 13 (waste cartridges)	0,002-0,004*		20,93-41,86*
20 01 21 (waste fluorescent tubes)	0,001-0,002*		10,47-20,93*

To conclude, total HW generation seems to be high in treatment and coating of metals sector of OSTIM OIZ. These wastes mainly consist of rinsing wastewaters and they are directly disposed to the Ankara Metropolitan Municipality sewerage system. Since there is no wastewater pretreatment system in companies,

hazardous property of these wastes should be investigated and proper disposal technique must be chosen immediately. Once these wastewaters are treated, they will not be regarded as HWs anymore.

Finally, some important aspects in HW estimation studies for treatment and coating of metals sector in OSTIM OIZ are pointed below:

- Only (most common) zinc electroplating and manganese phosphate hot dip galvanizing processes were included in HW estimation studies.
- Rinsing wastewaters were directly taken as HWs since there is not any pretreatment or treatment system in metal coating companies of OSTIM OIZ.
- Water usage pattern in rinsing processes is also an important and effective issue in HW estimations.

Therefore, estimated HW generation values should be considered within these limitations.

4.2.4. Maintenance and Repair of Motor Vehicles

Automotive sector consists of auto producers, auto spare parts producers, showrooms for sale and repair shops. Automotive repair shops, new car dealerships, and diesel engine repair shops, three main parts in automotive repair industry, produce significant amounts of hazardous solvent wastes, aqueous wastes, and sludges [36].

Further information about this sub-sector including main processes, their inputs and outputs are given in Appendix C.4. Hazardous waste estimation studies for

maintenance and repair of motor vehicles in general and also as specific to OSTIM OIZ are discussed in the following sections.

4.2.4.1. HWs in Maintenance and Repair of Motor Vehicles

The major waste generating processes in maintenance and repair of motor vehicles are: scheduled car maintenance (replacement of engine oil, oil filters, transmission fluid, radiator fluids), nonscheduled maintenance/ repair (replacement of spent batteries, worn brakes, shocks, tires, etc.), cleaning of the shop area and cleaning of parts in order to perform repairs [36].

Possible wastes generated from these processes are summarized in Table 4.36 with their specific pollutants.

Table 4.36 Process wastes of maintenance and repair of motor vehicles [36]

Operation	Waste Material	Pollutants
Shop Cleanup	Outdated supplies	Solvents, caustic cleaners, automotive (oils, alcohols, acids)
	Dirty rags and sawdust	Oil and grease, heavy metals solvents
	Alkaline floor cleaner	Caustics, oil and grease, heavy metals
	Clarifier sludge	Oil and grease, heavy metals
Parts cleaning	Solvents	Petroleum distillates, aromatic hydrocarbons, mineral spirits, naphtha, chlorinated compounds, oil and grease, heavy metals
	Air emissions	Petroleum distillates, aromatic hydrocarbons, mineral spirits, naphtha, chlorinated compounds, oil and grease, heavy metals
	Aqueous cleaners	Acids and alkalis, oil and grease, heavy metals, blended heavy oils

Table 4.36 (continued)

Operation	Waste Material	Pollutants
Parts cleaning	Dirty baths	Acids and alkalis, oil and grease, heavy metals, blended heavy oils
Auto maintenance	Motor oil	Blended mineral oil, heavy metals
	Transmission fluid	Blended mineral oil, heavy metals
	Engine coolant	Ethylene, glycol, lead
	Batteries	Sulfuric acid, lead
	Brakes	Asbestos
	Refrigerant	CFC-12

According to the Waste List given in Annex 4 of RGPWM (No:26927, 2008), hazardous wastes expected to be generated as a result of processes of maintenance and repair of motor vehicles are included under four digit chapter heading of 16 01, titled as *end-of-life vehicles from different means of transport (including off-road machinery) and wastes from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 16 06 and 16 08)* as listed in Table 4.37.

Table 4.37 End-of-life vehicles from different means of transport (including off-road machinery) and wastes from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 16 06 and 16 08) [4]

16 WASTES NOT OTHERWISE SPECIFIED IN THE LIST		
waste code	**16 01 end-of-life vehicles from different means of transport (including off-road machinery) and wastes from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 16 06 and 16 08)**	**Absolute /Minor**
16 01 04*	end-of-life vehicles	M
16 01 07*	oil filters	A
16 01 08*	components containing mercury	M
16 01 09*	components containing PCBs	M
16 01 10*	explosive components (for example air bags)	A

Table 4.37 (continued)

16 WASTES NOT OTHERWISE SPECIFIED IN THE LIST		
waste code	**16 01 end-of-life vehicles from different means of transport (including off-road machinery) and wastes from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 16 06 and 16 08)**	**Absolute /Minor**
16 01 11*	brake pads containing asbestos	M
16 01 13*	brake fluids	A
16 01 14*	antifreeze fluids containing dangerous substances	M
16 01 21*	hazardous components other than those mentioned in 16 01 07 to 16 01 11 and 16 01 13 and 16 01 14	M

In addition to this, *13 01/02/05/07, 14 06, 16 06* coded wastes in RGPWM (No: 26927, 2008) are also related to main processes of maintenance and repair of motor vehicles. Among mentioned coded wastes, hazardous wastes which are only related to maintenance and repair of motor vehicles are given in Table 4.38.

Table 4.38 Possible hazardous wastes of maintenance and repair of motor vehicles from 13, 14, 15, 16 and 20 coded wastes [4]

13 OIL WASTES AND WASTES OF LIQUID FUELS (except edible oils, and those in chapters 05, 12 and 19)		
waste code	**13 01 waste hydraulic oils**	**Absolute /Minor**
13 01 01*	hydraulic oils, containing PCBs (15)	A
13 01 04*	chlorinated emulsions	A
13 01 05*	non-chlorinated emulsions	A
13 01 09*	mineral-based chlorinated hydraulic oils	A
13 01 10*	mineral-based non-chlorinated hydraulic oils	A
13 01 11*	synthetic hydraulic oils	A
13 01 12*	readily biodegradable hydraulic oils	A
13 01 13*	other hydraulic oils	A

Table 4.38 (continued)

13 OIL WASTES AND WASTES OF LIQUID FUELS (except edible oils, and those in chapters 05, 12 and 19)		
waste code	**13 02 waste engine, gear and lubricating oils**	**Absolute /Minor**
13 02 04*	mineral-based chlorinated engine, gear and lubricating oils	A
13 02 05*	mineral-based non-chlorinated engine, gear and lubricating oils	A
13 02 06*	synthetic engine, gear and lubricating oils	A
13 02 07*	readily biodegradable engine, gear and lubricating oils	A
13 02 08*	other engine, gear and lubricating oils	A
waste code	**13 05 oil/water separator contents**	**Absolute /Minor**
13 05 01*	solids from grit chambers and oil/water separators	A
13 05 02*	sludges from oil/water separators	A
13 05 03*	interceptor sludges	A
13 05 06*	oil from oil/water separators	A
13 05 07*	oily water from oil/water separators	A
13 05 08*	mixtures of wastes from grit chambers and oil/water separators	A
waste code	**13 07 wastes of liquid fuels**	**Absolute /Minor**
13 07 01*	fuel oil and diesel	A
13 07 02*	petrol	A
13 07 03*	other fuels (including mixtures)	A
14 WASTE ORGANIC SOLVENTS, REFRIGERANTS AND PROPELLANTS (except 07 and 08)		
waste code	**14 06 waste organic solvents, refrigerants and foam/aerosol propellants**	**Absolute /Minor**
14 06 01*	chlorofluorocarbons, HCFC, HFC	A
14 06 02*	other halogenated solvents and solvent mixtures	A
14 06 03*	other solvents and solvent mixtures	A
14 06 04*	sludges or solid wastes containing halogenated solvents	A
14 06 05*	sludges or solid wastes containing other solvents	A

Table 4.38 (continued)

16 WASTES NOT OTHERWISE SPECIFIED IN THE LIST		
waste code	**16 06 batteries and accumulators**	**Absolute /Minor**
16 06 01*	lead batteries	A
16 06 02*	Ni-Cd batteries	A
16 06 03*	mercury-containing batteries	A
16 06 06*	separately collected electrolyte from batteries and accumulators	A

Moreover, possible hazardous wastes resulted from maintenance and repair of motor vehicles are determined in LIFE HAWAMAN Project (LIFE 06 TCY/TR/000292) Guide Document related to auto repair shops as presented in Table 4.39. In Table 4.39 bold marked hazardous waste codes are the most important waste types in maintenance and repair of motor vehicles in terms of their quantities and properties.

Table 4.39 Typical hazardous wastes resulting from vehicle repair shops [37]

Source of waste	Definition of waste	Waste code
Hydraulic systems (hydraulic and shock absorber oil)	mineral-based non-chlorinated hydraulic oils	13 01 10*
	synthetic hydraulic oils	13 01 11*
	readily biodegradable hydraulic oils 13 01	13 01 12*
Oil exchange (motor/gear oil)	mineral-based chlorinated engine, gear and lubricating oils	13 02 04*
	mineral-based non-chlorinated engine, gear and lubricating oils	**13 02 05***
	synthetic engine, gear and lubricating oils	**13 02 06***

Table 4.39 (continued)

Source of waste	Definition of waste	Waste code
Grit chambers of oil/water separators and their residues	solids from grit chambers and oil/water separators	**13 05 01***
	sludges from oil/water separators	**13 05 02***
	interceptor sludges	**13 05 03***
	oil from oil/water separators	**13 05 06***
	oily water from oil/water separators	**13 05 07***
	mixtures of wastes from grit chambers and oil/water separators	**13 05 08***
Contaminated fuel oil and diesel	fuel oil and diesel	13 07 01*
	petrol	13 07 02*
	other fuels (including mixtures)	13 07 03*
a) Cleaning of parts with steam or hot water b) Cleaning of floor contaminated with oil c) Pressurized air production in compressor	other emulsions	13 08 02*
Cooling agents	chlorofluorocarbons, HCFC, HFC	14 06 01*
Cleaning (with petrol, cleaning agents)	other solvents and solvent mixtures	**14 06 03***
Maintenance, painting, oil exchange, cleaning	packaging containing residues of or contaminated by dangerous substances	**15 01 10***
Cleaning, maintenance	absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	**15 02 02***
Oil exchange	oil filters	**16 01 07***
Maintenance and repair	components containing mercury	16 01 08*
Maintenance and repair	explosive components (for example air bags)	16 01 10*
Maintenance and repair	brake fluids	**16 01 13***
Maintenance and repair	antifreeze fluids containing dangerous substances	**16 01 14***
Shock absorbers	hazardous components other than those mentioned in 16 01 07 to 16 01 11 and 16 01 13 and 16 01 14	16 01 21*

Table 4.39 (continued)

Source of waste	Definition of waste	Waste code
Maintenance (batteries from ignition switch)	lead batteries	16 06 01*
Maintenance (batteries)	Ni-Cd batteries	16 06 02*
	mercury-containing batteries	16 06 03*
Repair (acids of accumulators)	separately collected electrolyte from batteries and accumulators	16 06 06*
Repair (catalysts)	spent catalysts contaminated with dangerous substances	16 08 07*
Fluorescent tubes	fluorescent tubes and other mercury-containing waste	20 01 21*

Periodic or non-periodic maintenance, repair after accident or breakdown, cleaning of parts and painting of parts are the main processes of this sector as mentioned in Appendix C.4. These processes are usually not dependent on each other and not followed one by one. Accordingly, possible hazardous wastes from each process are given separately in Figure 4.20.

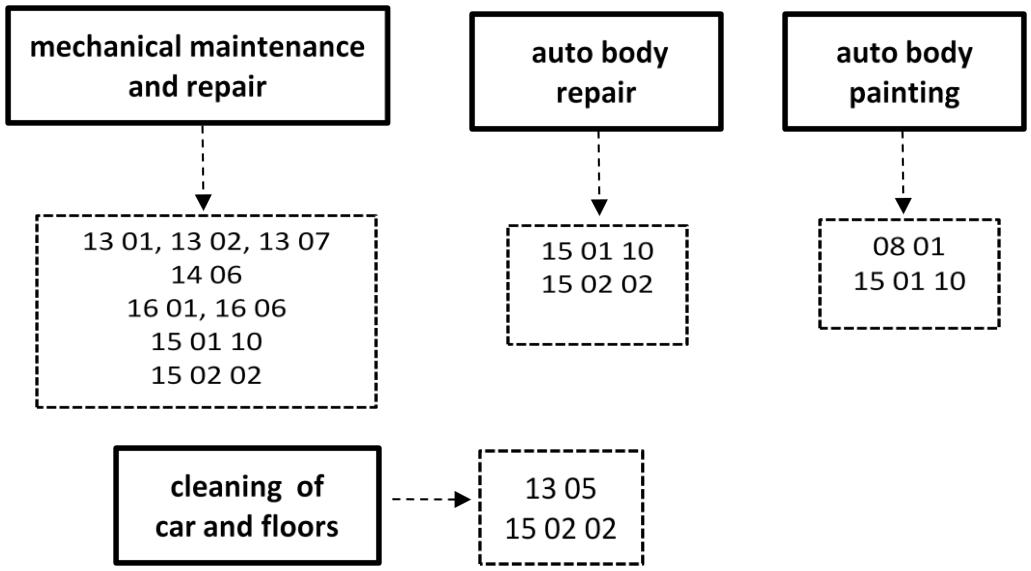

Figure 4.20 Hazardous wastes in maintenance and repair of motor vehicles

4.2.4.2. Pilot Plant Studies

In OSTIM OIZ, there are totally 204 car repair shops, some of which are authorized big services. In this thesis study, only authorized services are considered since it is thought that it is easier to access to the information about all types of processes, types and amounts of HWs due to relatively well documentation in such places.

The results of pilot plant studies conducted in two different car services in OSTIM OIZ are given in sections 4.2.4.2.1 and 4.2.4.2.2. Because of the privacy, the exact titles of the companies are not given, but alternatively they are called as A.1 and A.2.

During the pilot plant studies, hazardous wastes generated as a result of maintenance and repair of motor vehicles were analyzed under three groups, namely, *process specific wastes*, wastes *from side processes*, and *non-process based wastes*.

4.2.4.2.1. Pilot Plant 1: A.1

The first selected company for the maintenance and repair of motor vehicles sector is called as A.1 and has been an authorized service, since 1994, of a well known automobile trademark in Turkey.

There are 10 workers for maintenance and repair and 5 employees for other works in A.1. Moreover, according to 2009 records, 400 vehicles were accepted for auto body repair/painting, 1000 vehicles entered in A.1 due to periodic mechanical maintenance, and 1000 vehicles were accepted for mechanical repair purposes.

Mechanical maintenance and repair, auto body repair and painting, and cleaning are the main activities implemented in A.1; flow diagrams for each process can be depicted from Figures 4.21, 4.22, 4.23 and 4.24 auto body repair, for mechanical maintenance and repair, cleaning, and auto body painting processes respectively.

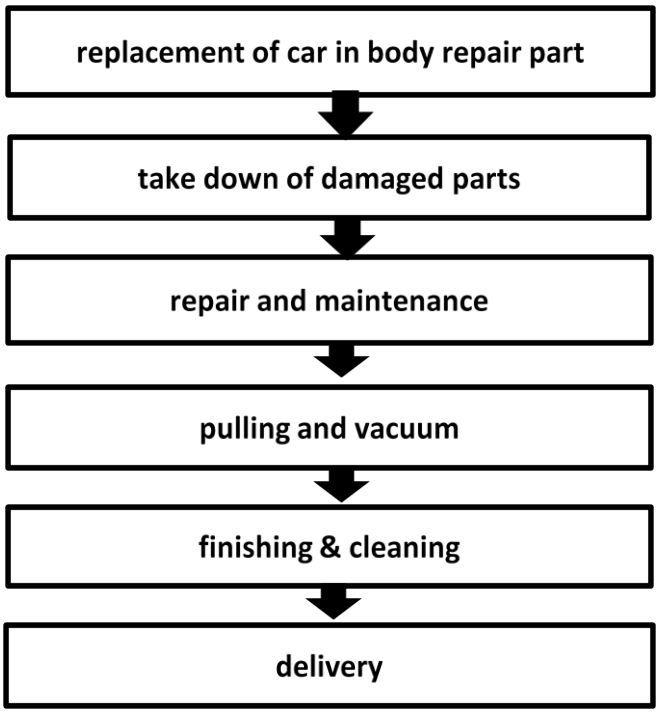

Figure 4.21 Process flow diagram of auto body repair in A.1

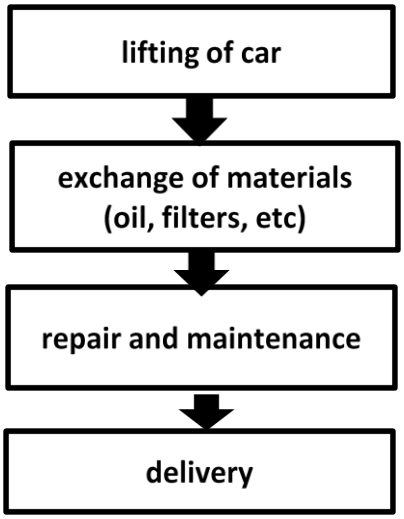

Figure 4.22 Process flow diagram of mechanical maintenance and repair in A.1

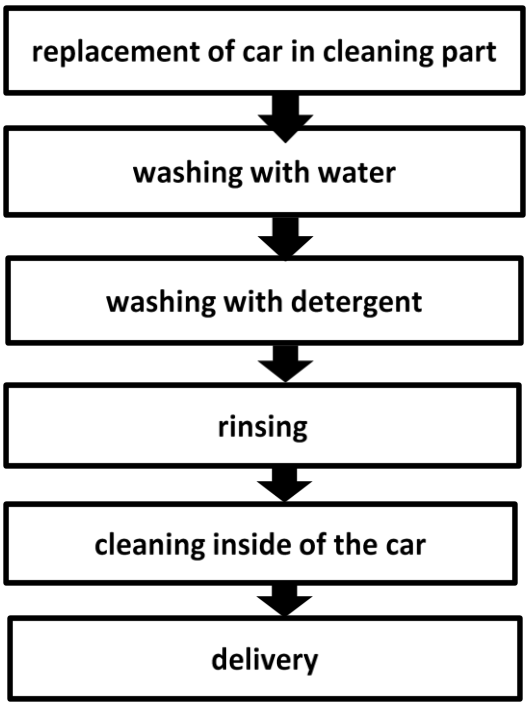

Figure 4.23 Process flow diagram of cleaning in A.1

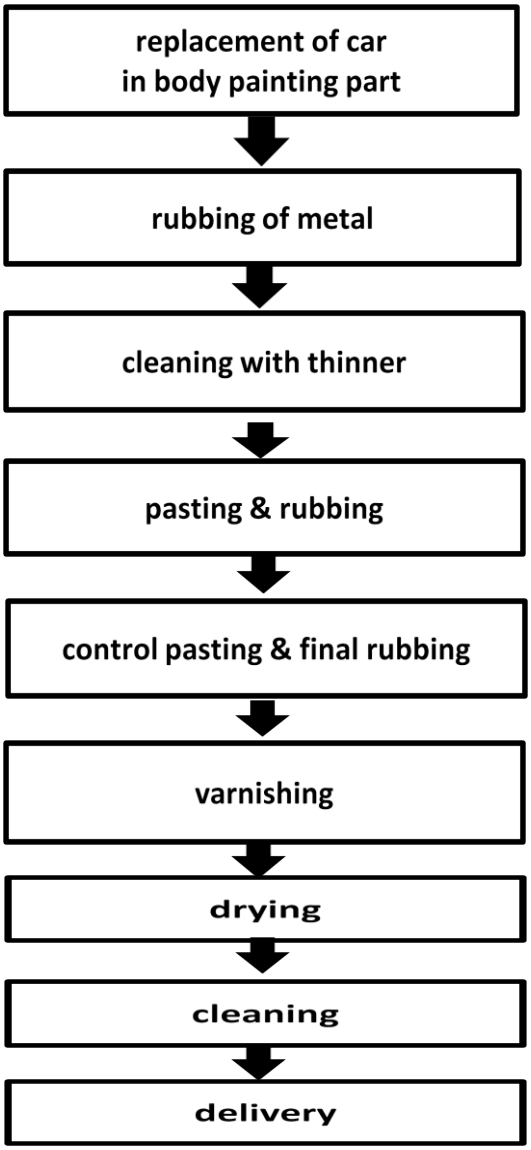

Figure 4.24 Process flow diagram of auto body painting in A.1

HW originating from processes: Inputs used in processes and outputs as hazardous wastes originating from each process are summarized in Figures 4.25, 4.26 and 4.27 for the processes of mechanical maintenance and repair, auto body repair and auto body painting, respectively. HWs mentioned in Section 4.2.4.1 were searched in A.1 while evaluating the wastes of processes.

Moreover, in Table 4.40 process specific HWs originating from A.1 are given with their codes and amounts.

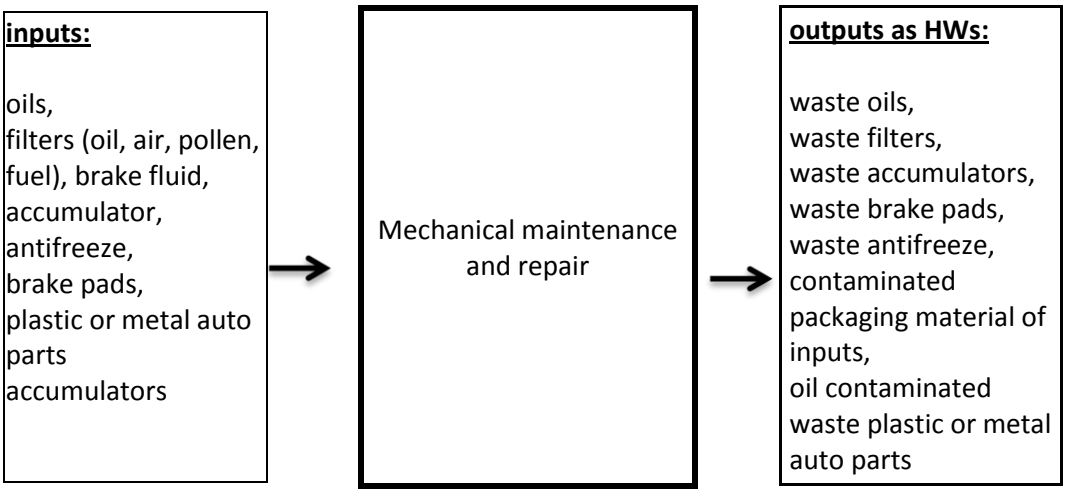

Figure 4.25 Inputs and outputs for mechanical maintenance and repair process

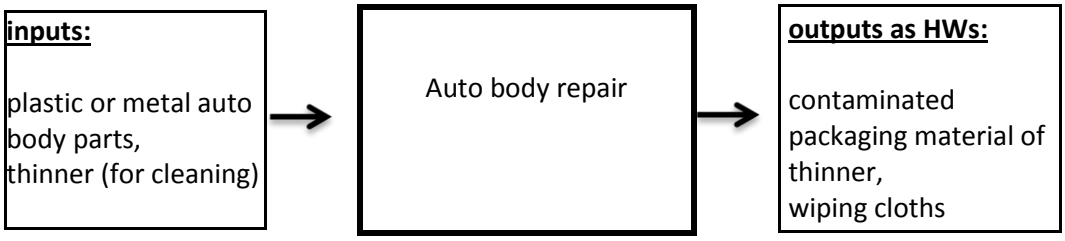

Figure 4.26 Inputs and outputs for auto body repair process

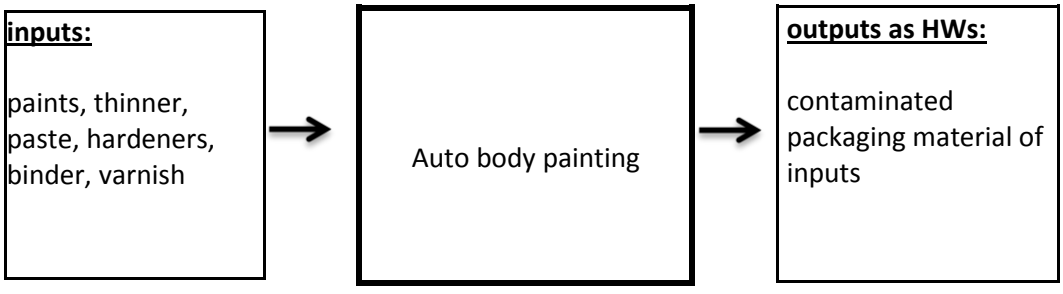

Figure 4.27 Inputs and outputs for auto body painting process

Table 4.40 Types and amount of process specific HWs in A.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	Hydraulic oil	**13 01 13** other hydraulic oils	A	10 kg
2	Engine oil	**13 02 08** other engine, gear and lubricating oils	A	4370 kg
3	Gear oil	**13 02 08** other engine, gear and lubricating oils	A	25 kg
4	Oil filters	**16 01 07** oil filters	A	1000 filters
5	Fuel filters for both diesel and petrol	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	450 filters
6	Antifreeze	**16 01 14** antifreeze fluids containing dangerous substances	M	280 kg
7	Brake fluids	**16 01 13** brake fluids	A	10 kg
8	Brake pads	**16 01 11** brake pads containing asbestos	M	300 pairs
9	Accumulator	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury-containing batteries **16 06 06** separately collected electrolyte from batteries and accumulators	A	50 accumulators
10	Wiring	**16 01 21** hazardous components other than those mentioned in 16 01 07 to 16 01 11 and 16 01 13 and 16 01 14	M	2 kg
11	Waste metal parts	**16 01 21** hazardous components other than those mentioned in 16 01 07 to 16 01 11 and 16 01 13 and 16 01 14	M	1000 kg
12	Packaging material of oil (engine, hydraulic, gear)	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	1200 pieces

Table 4.40 (continued)

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
13	Packaging material of paints	15 01 10 packaging containing residues of or contaminated by dangerous substances	M	200 pieces
14	Packaging material of thinner	15 01 10 packaging containing residues of or contaminated by dangerous substances	M	15 pieces
15	Packaging material of varnish	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	100 pieces
16	Packaging material of binder	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	15 pieces
17	Packaging material of paste	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	30 pieces
18	Packaging material of hardener	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	25 pieces
19	Packaging material of antifreeze	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	700 pieces
20	Packaging material of windshield washer liquid (antifreeze-water mixture)	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	1000 pieces

In A1, generally, mechanical maintenance is done periodically for cars; however mechanical repair is an unplanned activity. Moreover, mechanical maintenance is conducted through a plan and manual according to the brand of vehicle, whereas mechanical repair is different and depends on type of accident or breakdown happened with the car. Therefore, it is difficult to estimate the types and the amounts of HWs resulting only from repair of motor vehicles.

Accordingly, data given in Table 4.32 is about HWs originated from maintenance activities, auto body painting and repair in A.1.

For oil wastes (No 1, 2 and 3 in Table 4.32), it is difficult to determine the exact six digit waste code under *13 01 and 13 02* categories since it is dependent on type of oil used (synthetic, chlorinated, mineral-based, readily biodegradable or not). Such records were not available in the plant. Therefore, waste hydraulic oils are classified in *13 02 13* code (other hydraulic oils),and also waste engine and gear oils are grouped in *13 02 08* (other engine, gear and lubricating oils) code.

Moreover, for contaminated packaging materials amount of wastes are given as pieces (No 4, 5, 12-20 in Table 4.32), since there was no accurately recorded data and, even for those available it was too difficult to convert the pieces into a mass unit (kg).

Finally, *16 01 13* coded brake fluids (No 7 in Table 4.32) are in fact a sub-type of hydraulic oils, however, since they are not petroleum based they have a special code. Therefore, they are not included under *13 01* coded waste hydraulic oils.

HW originating from side processes: Cleaning is done for two main purposes in A.1, namely, cleaning of auto body/ parts and washing of floor. Since it is not a part of maintenance and repair processes, it can be classified as a side process. Inputs and outputs from this side process in A.1 are given in Figure 4.28. In addition to this, types and amounts of HWs determined are presented in Table 4.41.

Figure 4.28 Inputs and outputs for cleaning process

Table 4.41 Types and amount of HWs from side processes in A.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste
1	wastewater containing oil and detergents	**13 05 07** oily water from oil/water separators	A	12 000 kg
2	waste oil	**13 05 06** oil from oil/water separators	A	-
3	sludges	**13 05 02** sludges from oil/water separators	A	380 kg
4	packaging material of detergents	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	12 kg

Amount of waste oil originating from oil/water separator (No 2 in Table 4.41) could not be determined separately in A.1, since they are collected and stored together with the waste engine oil (No 2 in Table 4.40).

Other HW (non-process based): Non-process based HWs from A.1 is listed in Table 4.42 with their codes and amounts.

Table 4.42 Types and amount of non-process based HWs in A.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	contaminated wiping cloths, work gloves, and working cloths	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	100 kg 50 pairs=12,5 kg 40 cloths = 80 kg
2	batteries	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing batteries	A	15 batteries
3	wasted toners and cartridges	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	2 cartridges
4	fluorescent tubes	**20 01 21** fluorescent tubes and other mercury-containing waste	A	20 tube

In fact, in the plant, there are supposed to be other HWs, such as waste oils (hydraulic) from machinery (e.g. lifts, compressor). But, they could not be estimated since there was no recent and reliable information about them.

HW generation factors (HWGF): In A.1, hazardous waste generation factors were determined in terms of "kg of waste generated per car maintenance/painted" or "waste item generated per car maintenance/painted", where appropriate.

A.1 has a total capacity of 1000 cars per year for maintenance services and 400 cars for auto body repair and painting services according to the 2009 records. Therefore, hazardous waste generation factors were calculated according to the relevant capacities mentioned above, and are summarized in Table 4.43. For process specific HWs, in general capacity of A.1 was taken as 1000 cars/year

representing for the maintenance service. However, for some (* signed in Table 4.35) process specific HWs capacity of A.1 was taken as 400 indicating the auto body repair and painting services. Moreover, for side specific and other HWs, capacity was taken as 1400 cars/year, assuming that all cars serviced in A.1 are washed.

Table 4.43 HW generation factors (HWGF) in A.1

No	Type of waste	A/M	Annual amount of waste (kg or item*)	HWGF1 (kg waste or waste item*/ car)
HWs originating from processes (13,15, and 16 coded wastes)				
1	**13 01 13** other hydraulic oils	A	10 kg	0,01
2	**13 02 08** other engine, gear and lubricating oils (as engine oils)	A	4370 kg	4,37
3	**13 02 08** other engine, gear and lubricating oils (as gear oils)	A	25 kg	0,025
4	**16 01 07** oil filters	A	1000 filters	1*
5	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances (fuel filters)	M	450 filter	0,45*
6	**16 01 14** antifreeze fluids containing dangerous substances	M	280 kg	0,28
7	**16 01 13** brake fluids	A	10 kg	0,01
8	**16 01 11** brake pads containing asbestos	M	300 pairs	0,3*
9	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury-containing batteries **16 06 06** separately collected electrolyte from batteries and accumulators	A	50 accumulators	0,05*

Table 4.43 (continued)

No	Type of waste	A/M	Annual amount of waste (kg or item*)	HWGF1 (kg waste or waste item*/ car)
HWs originating from processes (13,15, and 16 coded wastes)				
10	**16 01 21** hazardous components other than those mentioned in 16 01 07 to 16 01 11 and 16 01 13 and 16 01 14 (as wiring, cables)	M	2 kg	0,002
11	**16 01 21** (as waste metal parts)	M	1000 kg	1
12	**15 01 10** packaging containing residues of or contaminated by dangerous substances (from engine, hydraulic, gear oils)	M	1200 pieces	1,2*
13	**15 01 10** (from antifreeze)	M	700 pieces	0,7*
14	**15 01 10** (from windshield washer liquid)	M	1000 pieces	1*
15	**15 01 10** (from paint)	M	200 pieces	0,5*
16	**15 01 10** (from thinner)	M	15 pieces	0,038*
17	**15 01 10** (from varnish)	M	100 pieces	0,25*
18	**15 01 10** (from binder)	M	15 pieces	0,038*
19	**15 01 10** (from paste)	M	30 pieces	0,075*
20	**15 01 10** (from hardener)	M	25 pieces	0,063*
HWs originating from side processes (13 and 15 coded wastes)				
21	**13 05 07** oily water from oil/water separators	A	12 000 kg	8,57
22	**13 05 06** oil from oil/water separators	A	-	-
23	**13 05 02** sludges from oil/water separators	A	380 kg	0,27
24	**15 01 10** (from detergents)	M	12 pieces	0,009

*HWs from auto body painting

Table 4.43 (continued)

No	Type of waste	A/M	Amount of waste (kg or item*)	HWGF1 (kg waste or waste item*/ car)
Non-process based HWs (15, 16 and 20 coded wastes)				
25	**15 02 02** as contaminated wiping cloths, work gloves, and working cloths	M	192,5 kg	0,14
26	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury-containing batteries	A	15 batteries	0,011*
27	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	2 cartridges	0,001*
28	**20 01 21** fluorescent tubes and other mercury-containing waste	**A**	20 tubes	0,014*

*HWs from auto body painting

4.2.4.2.2. Pilot Plant 2: A.2

The second pilot plant selected for this sector is another authorized service of the same well known auto trademark in order to be able to compare the types and amounts of HWs in two pilot plants. Accordingly, main processes and side processes of A.2 are identical with the ones in A.1 mentioned in Section 4.2.4.2.1. Therefore, only types and amounts HWs are given for A.2 in the following sections.

HW originating from processes: In Table 4.44, amounts of HWs are given. As seen from this table, HWs resulting from process in A.2 are similar with those in A.1. Only difference between A.1 and A.2 is that there are no waste

accumulators and waste metal parts in A.2, since they are handed in customers directly after repair.

Table 4.44 Types and amount of process specific HWs in A.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	Hydraulic oil	**13 01 13** other hydraulic oils	A	15 kg
2	Engine oil	**13 02 08** other engine, gear and lubricating oils	A	9072 kg
3	Gear oil	**13 02 08** other engine, gear and lubricating oils	A	35 kg
4	Oil filters	**16 01 07** oil filters	A	2016 pieces
5	Fuel filters for both diesel and petrol	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	1008 pieces
6	Antifreeze	**16 01 14** antifreeze fluids containing dangerous substances	M	280 kg
7	Brake fluids	**16 01 13** brake fluids	A	15 kg
8	Brake pads	**16 01 11** brake pads containing asbestos	M	500 pieces
9	Accumulator	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury-containing batteries **16 06 06** separately collected electrolyte from batteries and accumulators	A	-
10	Wiring	**16 01 21** hazardous components other than those mentioned in 16 01 07 to 16 01 11 and 16 01 13 and 16 01 14	M	2 kg

Table 4.44 (continued)

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
11	Waste metal parts	**16 01 21** hazardous components other than those mentioned in 16 01 07 to 16 01 11 and 16 01 13 and 16 01 14	M	-
12	Packaging material of oil (engine, hydraulic, gear)	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	2500 pieces
13	Packaging material of paints	15 01 10 packaging containing residues of or contaminated by dangerous substances	M	500 pieces
14	Packaging material of thinner	15 01 10 packaging containing residues of or contaminated by dangerous substances	M	700 pieces
15	Packaging material of varnish	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	500 pieces
16	Packaging material of binder	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	40 pieces
17	Packaging material of paste	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	300 pieces
18	Packaging material of hardener	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	40 pieces
19	Packaging material of antifreeze	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	70 pieces
20	Packaging material of windshield washer liquid (antifreeze-water mixture)	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	60 pieces

HW originating from side processes: HWs from side processes in A.2 are given in Table 4.45 together with their amounts.

Table 4.45 Types and amount of HWs from side processes in A.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste
1	wastewater containing oil and detergents	**13 05 07** oily water from oil/water separators	A	14 400 kg
2	waste oil	**13 05 06** oil from oil/water separators	A	-
3	sludges	**13 05 02** sludges from oil/water separators	A	700 kg
4	packaging material of detergents	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	15 pieces

Other HW (non-process based): Non-process based HWs from A.2 are listed in Table 4.46 together with their codes and amounts.

Table 4.46 Types and amount of non-process based HWs in A.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	contaminated wiping cloths, work gloves, and working cloths	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	150 kg 50 pairs=12,5 kg 70 cloths = 70 kg
2	batteries	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury containing	A	20 batteries
3	wasted toners and cartridges	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	10 cartridges
4	fluorescent tubes	**20 01 21** fluorescent tubes and other mercury-containing waste	A	15 tubes

HW generation factors (HWGF):

Hazardous waste generation factors were determined in terms of “kg of waste generated per car maintenance/painted” or “waste item generated per car maintenance/painted”, where appropriate, according to the capacity of A.2.

According to company owner, A.2 has a daily capacity of 7 cars for maintenance and 2 cars for auto body repair and painting. Similar to A.1, HWGFs were calculated for the corresponding capacities. For process specific HWs capacity of A.2 was taken as 2016 cars/year representing for the maintenance. However, for some (* signed in Table 4.47) process specific HWs, capacity of A.1 was taken as 576 indicating for auto body repair and painting services. Moreover, for side specific and other HWs, capacity was taken as 2592 cars/year, assuming that all cars serviced in A.2 are washed.

Table 4.47 HW generation factors (HWGF) in A.2

No	Type of waste	A/M	Annual amount of waste (kg or item*)	HWGF2 (kg waste or waste item*/ car)
HWs originating from processes (13,15, and 16 coded wastes)				
1	**13 01 13** other hydraulic oils	A	15 kg	0,0074
2	**13 02 08** other engine, gear and lubricating oils (as engine oils)	A	9072 kg	4,5
3	**13 02 08** other engine, gear and lubricating oils (as gear oils)	A	35 kg	0,0174
4	**16 01 07** oil filters	A	2016 pieces	1*
5	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances (fuel filters)	M	1008 pieces	0,5*

Table 4.47 (continued)

No	Type of waste	A/M	Annual amount of waste (kg or item)	HWGF2 (kg waste or waste item*/ car)
HWs originating from processes (13,15, and 16 coded wastes)				
6	**16 01 14** antifreeze fluids containing dangerous substances	M	280 kg	0,1389
7	**16 01 13** brake fluids	A	15 kg	0,0074
8	**16 01 11** brake pads containing asbestos	M	500 pieces	0,2480*
9	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury-containing batteries **16 06 06** separately collected electrolyte from batteries and accumulators	A	-	-
10	**16 01 21** hazardous components other than those mentioned in 16 01 07 to 16 01 11 and 16 01 13 and 16 01 14 (as wiring, cables)	M	2 kg	0,0010
11	**16 01 21** (as waste metal parts)	M	-	-
12	**15 01 10** packaging containing residues of or contaminated by dangerous substances (from engine, hydraulic, gear oils)	M	2500 pieces	1,2401*
13	**15 01 10** (from antifreeze)	M	500 pieces	0,2480*
14	**15 01 10** (from windshield washer liquid)	M	700 pieces	0,3472*
15	**15 01 10** (from paint)	M	500 pieces	0,8681*
16	**15 01 10** (from thinner)	M	40 pieces	0,0694*
17	**15 01 10** (from varnish)	M	300 pieces	0,5208*
18	**15 01 10** (from binder)	M	40 pieces	0,0694*
19	**15 01 10** (from paste)	M	70 pieces	0,1215*
20	**15 01 10** (from hardener)	M	60 pieces	0,1042*
HWs originating from side processes (13 and 15 coded wastes)				
21	**13 05 07** oily water from oil/water separators	A	14 400 kg	5,56
22	**13 05 06** oil from oil/water separators	A	-	-
23	**13 05 02** sludges from oil/water separators	A	700 kg	0,2701

Table 4.47 (continued)

No	Type of waste	A/M	Amount of waste (kg or item*)	HWGF2 (kg waste or waste item*/ car)
HWs originating from side processes (13 and 15 coded wastes)				
24	15 01 10 (from detergents)	M	15 pieces	0,0058*
Non-process based HWs (15, 16 and 20 coded wastes)				
25	**15 02 02** as contaminated wiping cloths, work gloves, and working cloths	M	232,5 kg	0,09
26	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries **16 06 03** mercury-containing batteries	A	20 batteries	0,0077*
27	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	10 cartridges	0,0039*
28	**20 01 21** fluorescent tubes and other mercury-containing waste	**A**	15 tubes	0,0058*

4.2.4.2.3. Summary for Maintenance and Repair of Vehicles

Maintenance and repair of motor vehicles sector have various types of HWs as known from pilot plant studies. Through pilot plant studies, it was confirmed that two-digit *13, 15, and 16* coded HWs are the relevant codes for maintenance and repair of motor vehicles. Especially four-digit *13 01/02/05* and *16 01/02/06* coded wastes are observed in pilot plant analysis.

In Table 4.47, HWGFs for the pilot plants studied are summarized. It can be easily inferred from these results that waste engine oils, oil filters, and oily wastewater are major HWs in maintenance and repair of motor vehicles sector

considering their significant amounts. In addition to this, HWGFs for the wastes generated from this sector could not be found in the literature; therefore, no relevant comparison was possible to make.

As it can be deduced from Table 4.47, majority of the HWGFs determined are very close to each other, with even exact match for some. Therefore, it can be stated with confidence that most of the maintenance process specific HWGFs (for waste oils, filters, brakes, antifreeze) are correct and representative of its sector. On the other hand, HWGFs for auto body painting wastes (Table 4.47) appeared to happen within a small range, though not very wide. Consequently, there is no need for other pilot plant study and HWGFs for this sector is calculated by taking the average values of HWGFs of two pilot plants.

As mentioned in process specific HWs part, for waste oils it was not possible to identify the waste codes with six-digit due to unknown types of oils used in the plants. For determination of exact codes of waste oils, laboratory analysis should be conducted for waste samples to characterize. However, within the limited capacity of this thesis study, this could not be realized.

While determining HWGFs for *15 01 10* coded HWs as contaminated packaging of inputs (e.g. oils, paints, etc.), for unique classification, weight of one waste package is taken as 1 kg. Based on this assumption, a typical value for HWGF of 15 01 10 coded waste could be determined as given in Table 4.47.

Table 4.48 Comparison of HW generation factors (HWGF) in maintenance and repair of motor vehicles

No	Type of Waste	A/M	HWGF -1 (kg waste or waste item*/ car)	HWGF -2 (kg waste or waste item*/ car)	HWGF (kg waste or waste item*/ car)
HWs originating from processes (13, 15, and 16 coded wastes)					
1	**13 01 13** other hydraulic oils	A	0,01	0,007	0,085
2	**13 02 08** other engine, gear and lubricating oils	A	4,4	4,52	4,45
3	**16 01 07** oil filters	A	1*	1*	1*
4	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances (fuel filters)	M	0,45*	0,5*	0,5*
5	**16 01 14** antifreeze fluids containing dangerous substances	M	0,28	0,14	0,21
6	**16 01 13** brake fluids	A	0,01	0,007	0,009
7	**16 01 11** brake pads containing asbestos	M	0,3*	0,25*	0,28*
8	**16 01 21** hazardous components other than those mentioned in 16 01 07 to 16 01 11 and 16 01 13 and 16 01 14	M	0,002	0,001	0,0015
9	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	3,86	3,6	3,73

Table 4.48 (continued)

No	Type of Waste	A/M	HWGF -1 (kg waste or waste item*/ car)	HWGF -2 (kg waste or waste item*/ car)	HWGF (kg waste or waste item*/ car)
HWs originating from side processes (13 and 15 coded wastes)					
10	**13 05 07** oily water from oil/water separators	A	8,57	5,56	7,07
11	**13 05 02** sludges from oil/water separators	A	0,27	0,27	0,27
12	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	0,009	0,006	0,008
Non-process based HWs (13,15, 16 and 20 coded wastes)					
13	**15 02 02** as contaminated wiping cloths, work gloves, and working cloths	M	0,14	0,09	0,12
14	**16 06 01** lead batteries **16 06** 02 Ni-Cd batteries **16 06 03** mercury containing batteries	A	0,011*	0,008*	0,009*
15	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	0,001*	0,004*	0,003*
16	**20 01 21** fluorescent tubes and other mercury-containing waste	A	0,014*	0,006*	0,01*

For estimation of total HW generation from maintenance and repair of motor vehicles sector in OSTIM OIZ, total capacity of repair shops are calculated. There are 224 repair shops in OSTIM OIZ and 20 of these shops are big authorized services. Capacity of repair shops is taken as 5 cars per day for bigger shops and 2 cars per day for smaller shops. Results of the HW generation estimation studies are summarized in Table 4.49.

Table 4.49 Total HW generation in maintenance and repair of motor vehicles

HW Category	HWGF (kg waste or waste item*/ car)	Capacity (car /year)	Annual HW generation (ton/year or *waste item/year)
HWs originating from processes (13,15, and 16 coded wastes)			
13 01 13 (waste hydraulic oils)	0,085	146304	12,44
13 02 08 (engine and gear oils)	4,45		651,05
16 01 07 (oil filters)	1*		146 304*
15 02 02 (fuel filters)	0,5*		73 152*
16 01 14 (antifreeze fluids)	0,21		30,72
16 01 13 (brake fluids)	0,009		1,32
16 01 11 (brake pads)	0,28*		40 965*
16 01 21 (wiring)	0,0015		0,22
15 01 10 (contaminated packaging of inputs)	3,73		545,71

Table 4.49 (continued)

HW Category	HWGF (kg waste or waste item*/ car)	Capacity (car /year)	Annual HW generation (ton/year or *waste item/year)
HWs originating from side processes (13 and 15 coded wastes)			
13 05 07 (oily water)	7,07	146304	1034,37
13 05 02 (oily sludges)	0,27		39,5
15 01 10 (contaminated packaging of inputs)	0,008		1,17
Non-process based HWs (13 and 15 coded wastes)			
15 02 02 (waste work gloves and cloths)	0,12	146304	17,56
16 06 (waste batteries)	0,009*		1316,74*
16 02 13 (waste cartridges)	0,003*		438,91*
20 01 21 (waste fluorescent tubes)	0,01*		1463,04*

According to Table 4.49, waste engine and gear oils generate in high amounts in car repair services among process based HWs. For waste items in process based HWs, it is hard to make a comparison with other waste amounts but it can be concluded that waste oil and fuel filters have the highest amounts in generation.

Finally, side process specific and non-hazardous based HW generation from maintenance and repair of motor vehicles sector in OSTIM OIZ are also in considerable amounts and should be taken into account for proper collection and disposal.

For maintenance and repair of motor vehicles sector, the followings should be taken into account as a source of uncertainties in evaluating the estimated HW figures presented in Table 4.20.

- Capacity for authorized big services was taken as 5 cars/day and for smaller ones 2 cars/day.
- In determination of HWGFs, averages of two similar results from pilot plants were taken since values were too close to each other.
- In calculation of HW generation amounts for 15 01 10 coded wastes, weight of one package was taken as 1 kg on average considering the diverse characteristics of these kind of wastes in the study area.

4.2.5. Manufacture of Rubber Products

Manufacturing of rubber products is a sector which uses raw materials from natural, synthetic or regenerated rubber processing for different applications in various industries such as automotive, building and construction, agriculture, clothing and also health [38].

Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres and manufacture of other rubber products are the two sub-parts of this sector according to NACE Rev.2 classification. In this thesis study, manufacture of other rubber products is studied due to production profiles of OSTIM OIZ companies.

General information about this sector including main processes, their inputs and outputs is given in Appendix C.5. Studies conducted toward the estimation of hazardous waste for this sector in general and also as specific to OSTIM OIZ are summarized in the following sections.

4.2.5.1. HWs in Manufacture of Rubber Products

The major environmental concerns from manufacture of rubber products can be given as fugitive particulate matter (PM) from compounding and mixing; Volatile Organic Carbon (VOC) emissions from mixing, milling, extruding, calendering, vulcanizing, and grinding processes; wastewater from cooling, heating, vulcanizing, and cleaning operations; solid wastes from grinding, cooling, heating, vulcanizing, and cleaning operations [39].

Dust and rubber particles (from grinding), waste rubber (from mixing, milling, calendering, extruding, molding) are the main types of solid wastes in rubber manufacturing. In addition to this, uncured rubber waste, cured rubber waste, and off-specification products are three different types of waste rubber. Uncured rubber wastes are usually recycled in the production; however uncured and off-specification wastes cannot be reprocessed easily at the facility. When rubber is heated, its wastes are called as scorched rubber and these wastes are not recyclable [39]. Moreover, possible wastes from dry processing of rubber manufacturing with their sources and generation factors are summarized in Table 4.50.

In Turkey, according to the Waste List given in Annex 4 of RGPWM (No:26927, 2008), hazardous wastes expected to be generated as a result of processes of rubber manufacturing are included under four digit chapter heading of 07 02, titled as *wastes from the MFSU of plastics, synthetic rubber and man-made fibers* as listed in Table 4.51. As can be understood from the title of this waste category, these wastes include not only those from rubber manufacturing but also those from plastic, synthetic rubber and man-made fibers. Therefore, the waste list given in Table 4.51 was sorted out to find out those belonging to rubber manufacturing only.

Table 4.50 Waste Parameters for Dry Processing of Rubber Manufacturing [40]

Waste Stream	Source	Quantity (kg/ton of product)
Floor sweepings	Material Handling Compounding Area Mixing Area	3
Dust from particulate emission control equipment	Material Handling Compounding Area Mixing Area	13
Scrap rubber stock (uncured)	Mixing Area Forming (Calendering)	42
Flash trimmings (cured rubber)	Finishing	114
Grindings (cured rubber)	Finishing	23
Rejects	Curing Finishing	69
Cord rejects	Calendering Forming	4
Metal inserts	Forming	-
Waste oils	Mixing Calendering Forming	nominal

Table 4.51 Wastes from the MFSU of Plastics, Synthetic Rubber and Man-made Fibers [4]

07 WASTES FROM ORGANIC CHEMICAL PROCESSES		
waste code	**07 02 wastes from the MFSU of plastics, synthetic rubber and man-made fibres**	**Absolute /Minor**
07 02 01*	aqueous washing liquids and mother liquors	A
07 02 03*	organic halogenated solvents, washing liquids and mother liquors	A
07 02 04*	other organic solvents, washing liquids and mother liquors	A
07 02 07*	halogenated still bottoms and reaction residues	A
07 02 08*	other still bottoms and reaction residues	A
07 02 09*	halogenated filter cakes and spent absorbents	A
07 02 10*	other filter cakes and spent absorbents	A
07 02 11*	sludges from on-site effluent treatment containing dangerous substances	M
07 02 14*	wastes from additives containing dangerous substances	M
07 02 16*	waste containing dangerous silicones	M

Generally, manufacture of rubber products covers main processes such as preparation of rubber compound, molding, vulcanization and finishing as also stated in Appendix C.5. Furthermore, these production processes of rubber industry are mainly mechanical and dry manufacturing processes. Only for production of dipped goods such as gloves and prophylactics, wet processes of rubber manufacturing; compounding and mixing, dipping, drying, curing are used as main unit operations [40].

Since wet processing is not used in OSTIM OIZ companies, possible hazardous wastes from this process are not included in this study.

In Figure 4.29, possible process specific hazardous wastes from manufacturing of rubber products and their origin are illustrated. It can be seen from the figure that *07 02 01/03/04/07/08/09/10/11* coded wastes are not included because it is concluded that they are not mainly related to dry rubber manufacturing.

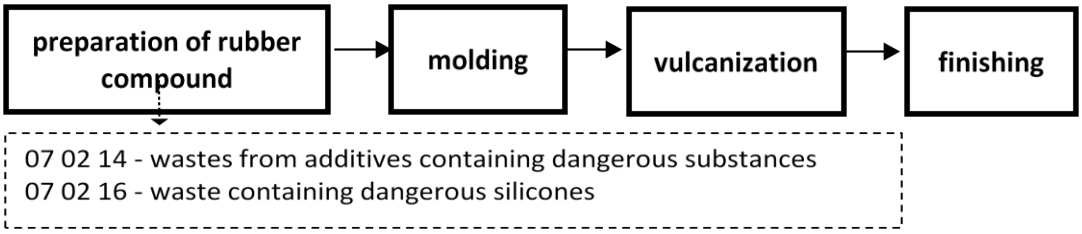

Figure 4.29 Process Specific Hazardous Wastes in Manufacture of Rubber Products

4.2.5.2. Pilot Plant Studies

Pilot plant studies in OSTIM OIZ are conducted in two different rubber manufacturing companies in order to ensure the accuracy of the findings from the studies so that they are really representative of the sector in OSTIM OIZ. Because of the privacy, the exact titles of the companies are not provided. Instead, they are referred as R.1 for pilot plant 1 and R.2 for pilot plant 2.

During the pilot plant studies, hazardous wastes generated as a result of manufacturing of rubber products were analyzed under three groups, namely, *process specific wastes*, wastes *from side processes*, and *non-process based wastes*. The results obtained from the companies were compared not only with each other, but also with literature figures.

4.2.5.2.1. Pilot Plant 1: R.1

Company 1 was selected as pilot plant 1 (called as R1) as to represent the rubber manufacture industry in OSTIM OIZ. This company is serving for this sector since 1980 with a wide range of products such as rubber parts of earth moving machines, animal mats, vibration rubbers, o-ring/conical felt caps, floor coatings, paving playground tiles and automotive rubber parts, etc. General process flow chart of the company is given in Figure 4.30. Since some of the rubber products have metal parts, side process of metal manufacturing is included in the chart.

In this plant, natural, synthetic and regenerated rubbers are used as raw materials and different types of additives are involved in the processes according to the recipe of the desired product. As illustrated in Figure 4.30, preparation of rubber compound, molding, vulcanization, and finishing are the main processes in this plant. On the other hand, preparation of molds is not included in the

process flow diagram as molds are purchased from other companies or provided by customers.

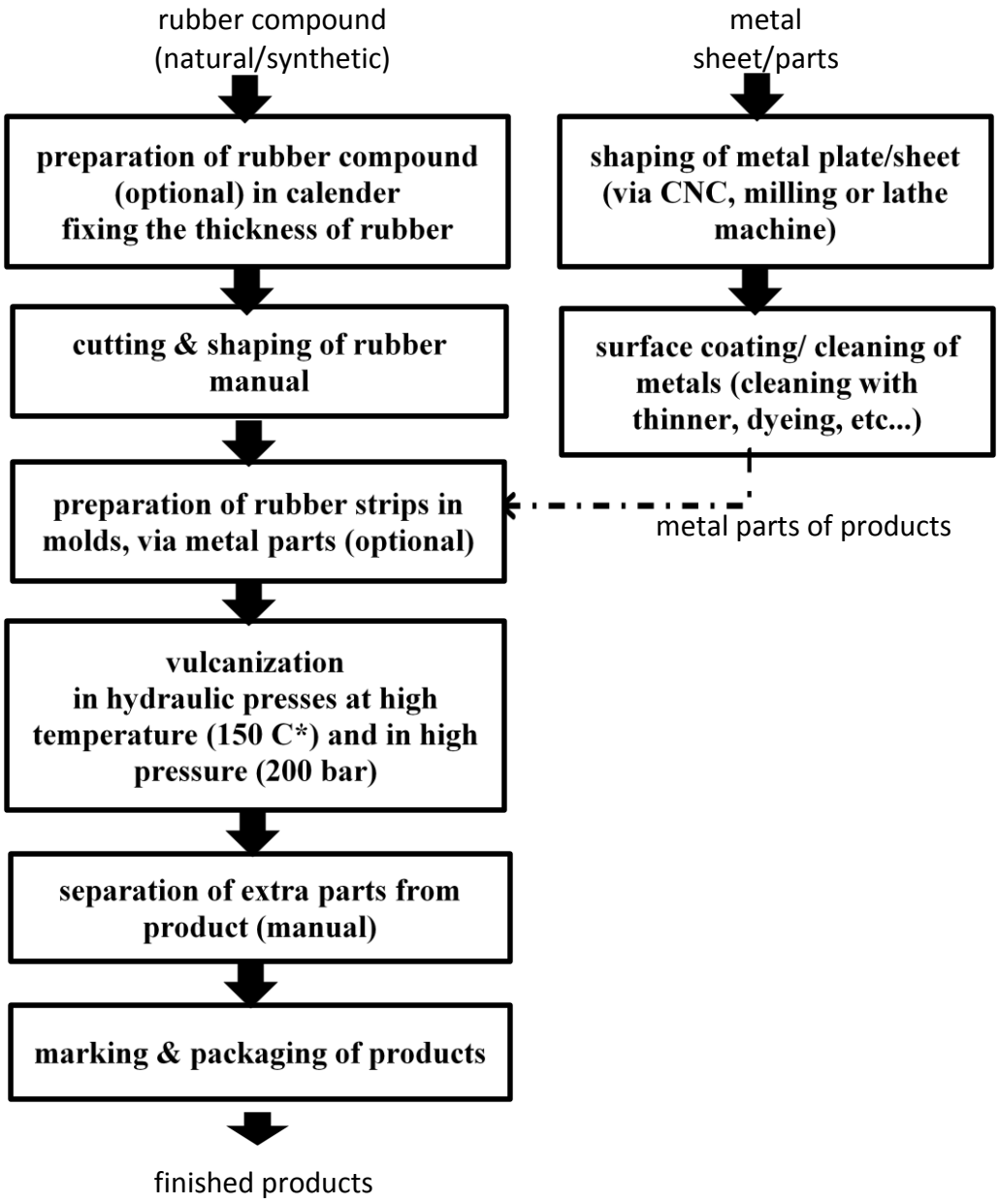

Figure 4.30 Process Flow Diagram of R.1

HW originating from processes: Inputs, outputs, and hazardous wastes originating from rubber compound preparation; molding-vulcanization and finishing processes are summarized in Figures 4.31, 4.32 and 4.33, respectively. While determining HW from processes, firstly, all wastes from each process are listed, then are evaluated according to Waste List of RGPWM (No: 26927, 2008) in order to identify their corresponding waste codes and also to determine if they are hazardous or not.

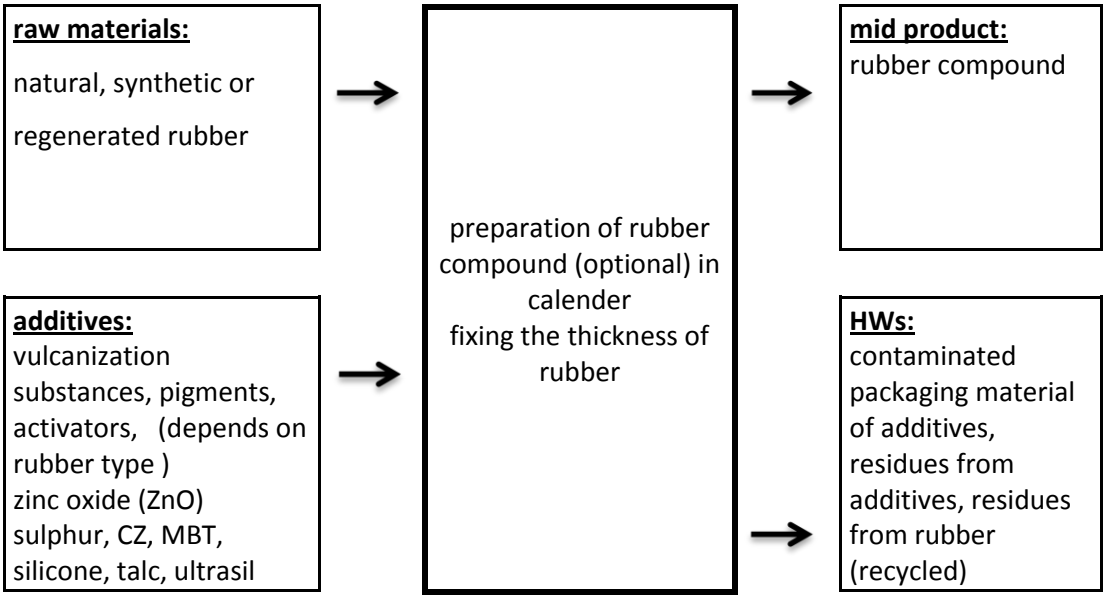

Figure 4.31 Inputs and outputs for preparation of rubber compound process

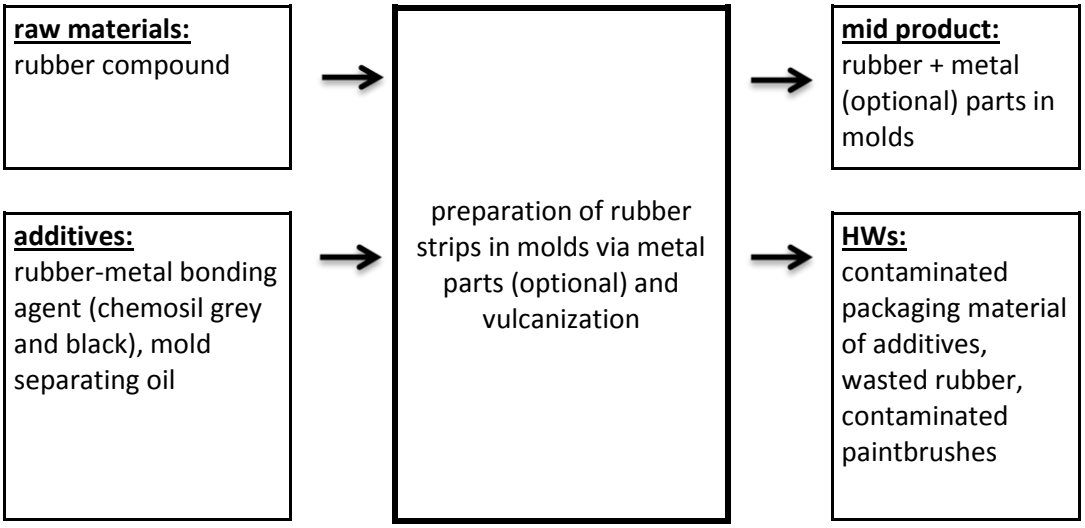

Figure 4.32 Inputs and outputs for moldings and vulcanization process

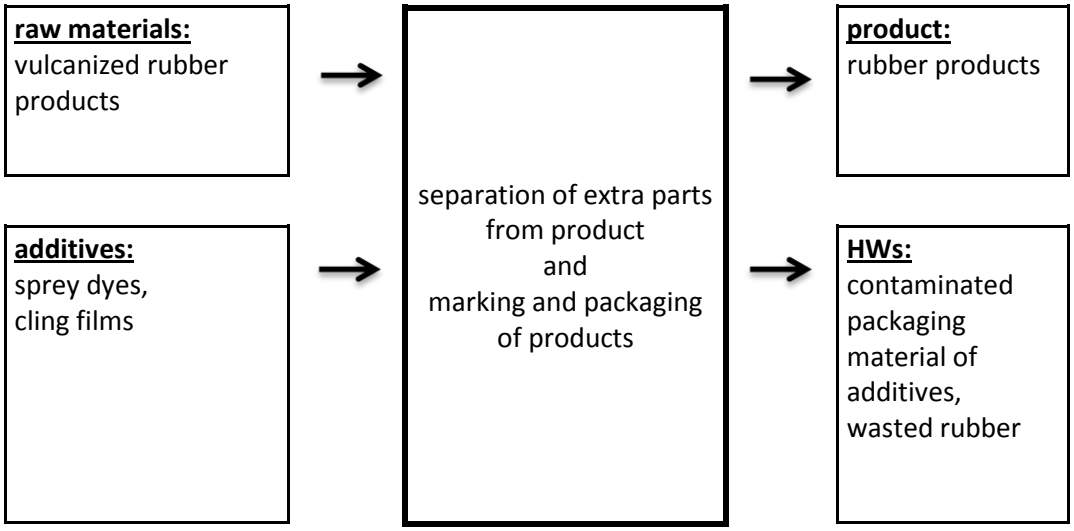

Figure 4.33 Inputs and outputs for finishing processes

Following the identification of HWs originating from processes, their annual amounts are determined by detailed mass analysis. Amount of contaminated packaging wastes are directly correlated with amounts of input materials used. However, for wasted rubber and residues from additives, since the amount is

highly dependent on type and shape of the product, it was too hard to gather real data on amounts from plant owners. For R.1, classification of process specific HWs and their amounts are given in Table 4.52.

Table 4.52 Types and amount of process specific HWs in R.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste
1	wasted rubber after vulcanization	**07 02 99*** wastes not otherwise specified		3 000 kg
2	wastes from additives	**07 02 14** wastes from additives containing dangerous substances	M	Unknown
3	packaging material of additive substances for vulcanization (MBT,CZ, etc).	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	Unknown
4	packaging material of thinner	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	48 pieces = 24 kg
5	paintbrushes (chemosil contaminated)	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	48 pieces = 96 kg
6	packaging material of rubber-metal bonding substance: chemosil (grey and black)	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	48 pieces =12 kg
7	tins of sprey paints	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	48 pieces =2,4 kg

It should be mentioned here that wasted rubber generated in this plant does not match directly to any waste codes given for the sector. However, there exists a code of 07 07 99* which is a specific code that can only be used with a special permit of MoEF provided that waste is characterized through sample analysis and its hazardous property is clarified. Nevertheless, in this part, wasted rubber is categorized under this specific code though sample analysis is missing.

HW originating from side processes: In this plant, since some of the rubber products have metal parts, metal processing is also included in general flow diagram. Shaping and painting (as surface treatment) processes are the side processes of manufacturing of rubber products as observed in R.1. In Figure 4.34, raw materials, additives, products and HWs from side processes are shown. Metal grindings originate from shaping process, whereas contaminated packages of paints and contaminated painting rolls result from painting of metal sheets.

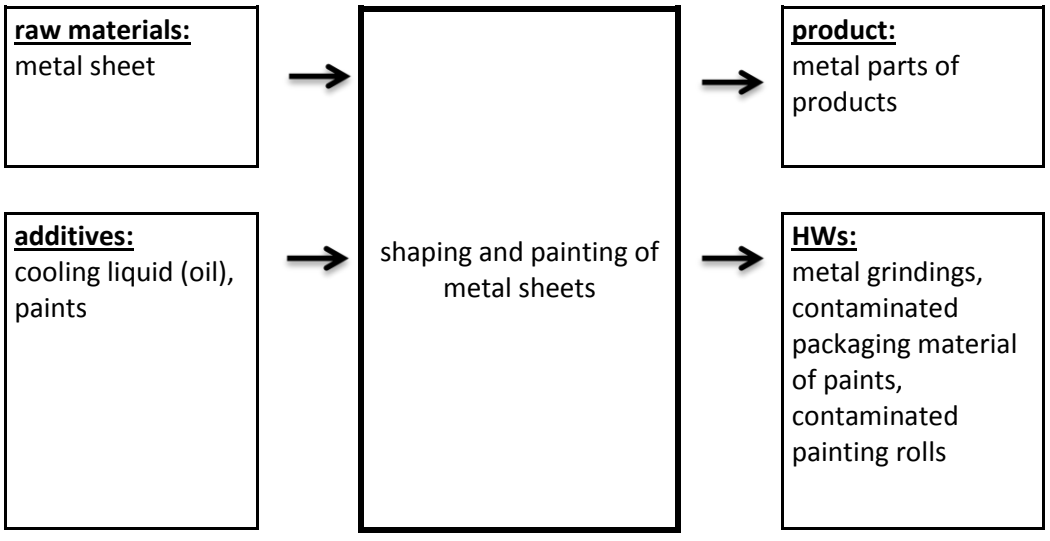

Figure 4.34 Inputs and outputs for metal processing

Moreover in Table 4.53, classification of these HWs according to RGPWM (No: 26927, 2008) is demonstrated. 12 02 20 coded hazardous waste from *12 Wastes from shaping and physical and mechanical surface treatment of metals and plastics* category is an expected finding from waste analysis in this plant. Calculated amounts of HWs generated from side processes are also given in Table 4.53.

Table 4.53 Types and amount of HWs from side processes in R.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	metal grindings	**12 01 20** spent grinding bodies and grinding materials containing dangerous substances	M	3 000 kg
2	packaging material of paints	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	24 pieces =12 kg
3	painting rolls	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	6 pieces = 12 kg

Other HW (non-process based): Apart from process specific and side process originated HWs, there are also other types of HWs which can be named as "non-process based HWs" in this sector. According to the waste list of RGPWM (No: 26927, 2008), such wastes are listed in categories of 13, 15, 16, 17, 18, 19 and 20. These wastes are not directly generated as a result of process itself, but come out in the process area depending on the plant conditions. Accordingly, observed non-process based HWs from R.1 is listed in Table 4.54 with their codes and amounts.

Table 4.54 Types and amount of non-process based HWs in R.1

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item)
1	contaminated wiping cloths	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	120 kg
2	contaminated work gloves	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	300 pairs =75 kg
3	contaminated working cloths	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	20 cloths = 40 kg
4	waste oils from hydraulic presses	**13 01 13** other hydraulic oils	A	(100 kg in every 4 year) 25 kg
5	batteries	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries	A	20 batteries
6	fluorescent tubes	**20 01 21** fluorescent tubes and other mercury-containing waste	A	2 tubes
7	wasted toners	**08 03 17** waste printing toner containing dangerous substances	A	4 toners

HW generation factors (HWGF): In R.1, hazardous waste generation factors are determined in terms of "kg of waste or waste item generated per ton of rubber product", which requires capacity information. Hazardous waste generation factors for R 1 are summarized in Table 4.55.

Table 4.55 HW generation factors (HWGF) in R.1

No	Type of waste	A/M	Annual amount of waste (kg or item*)	HWGF-1 (kg waste or waste item*/ ton rubber produced)
HWs originating from processes (07 and 15 coded wastes)				
1	**07 02 99** wastes not otherwise specified (wasted rubber)		3 000	40
2	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	134,4	1,79
HWs originating from side processes (12 and 15 coded wastes)				
3	**12 01 20** spent grinding bodies and grinding materials containing dangerous substances (metal grindings)	M	3 000	40
4	**15 01 10** packaging containing residues of or contaminated by dangerous substances (for wasted packages of paints)	M	24	0,32
Non-process based HWs (08, 13,15, 16 and 20 coded wastes)				
5	**15 02 02** as contaminated wiping cloths	M	235	4,7
6	**13 01 13** other hydraulic oils (from presses)	A	25	0,5
7	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries	A	20*	0,4*
8	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	A	4*	0,08*
9	**20 01 21** fluorescent tubes and other mercury-containing waste	A	2*	0,04*

According to the Capacity Report given by UCCE (January 2008) of R.1, annual production capacity of plant is 100 ton of rubber products. However, company owner claimed that it is the maximum capacity of the plant and 75 ton per year is more realistic figure to account.

Calculated waste amounts (Table's 4.52, 4.53, and 4.54) are directly divided by the production capacity of the plant to estimate the HWGFs. However, it was difficult to convert the amounts into kg base for some types of wastes. For example, as a non-process based HW, amounts of working cloths are determined as 20 cloths per 5 employees annually. Although, sizes of cloths differ, it was assumed that 1 cloth is approximately 2 kg. Other assumptions considered are also indicated in corresponding Tables where appropriate.

4.2.5.2.2. Pilot Plant 2

Company selected as pilot plant 2 (called as R2) was established in 1986 in OSTIM OIZ to produce and sell hydraulic sealing machine parts and other rubber products such as concrete pump pistons, shock absorbers, engine mountings, couplings and bellows.

In this plant, natural rubber compound and other types of synthetic rubber compound (e.g. EPDM, NBR (nitril), SBR, polyurethane) are used as raw material for various types of products. Since rubber compound is directly purchased, preparation of rubber compound process is slightly different from R1 as such that as an additive substance only ZnO is used in mixing process. Similar to R1, metal parts are included in some of the rubber products and metal processing is added as a side process.

HW originating from processes: Since main process of rubber manufacturing in plant 2 is similar with processes in plant 1, inputs and outputs are not repeated in this part. HWs originating from processes and their corresponding amounts are shown in Table 4.56.

Since there is a difference between two plants in preparation of rubber compound process in terms of additives, in second plant *07 02 14 wastes from additives containing dangerous substances* is excluded from the previous list in R.1.

Table 4.56 Types and amount of process specific HWs in R.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	wasted rubber after vulcanization	**07 02 99*** wastes not otherwise specified		3 600 kg
2	packaging material of thinner	**15 01 10** packaging containing residues of or contaminated by dangerous substances	**M**	40 pieces = 20 kg
3	paintbrushes (chemosil contaminated)	**15 01 10** packaging containing residues of or contaminated by dangerous substances	**M**	10 pieces = 20 kg
4	packaging material of rubber-metal bonding substance: chemosil (grey and black)	**15 01 10** packaging containing residues of or contaminated by dangerous substances	**M**	50 pieces = 100 kg

HW originating from side processes: HW generation from side processes in R.2 is similar to those in R.1 since side processes are same. In molding process, since metal castings are purchased readily, preparation of molds is composed of metal

processing, only. Therefore, HWs from preparation of molds and from preparation of metal parts are calculated together and are provided in the same table (Table 4.57).

Table 4.57 Types and amount of HWs from side processes in R.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item)
1	metal grindings	**12 01 20** spent grinding bodies and grinding materials containing dangerous substances	M	6 000 kg
2	packaging material of paints	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	10 pieces = 5 kg
3	painting rolls	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	4 pieces = 8 kg

Other HW (non-process based): Non-process based HWs from R.2 are given in Table 4.58 with their codes and amounts.

15 02 02 coded contaminated wiping cloths, work gloves, contaminated working cloths are collected in same container in R.2 since 2009, therefore amount of these wastes are taken into consideration as total as given in Table 4.58.

Table 4.58 Types and amount of non-process based HWs in R.2

No	Type of waste	Classification of waste wrt RGPWM	A/M	Annual amount of waste (kg or item*)
1	contaminated working cloths, wiping cloths, and work gloves	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	300 kg
2	waste oils from hydraulic presses	**13 01 13** other hydraulic oils	A	(200 kg in every 5 year) =20 kg
3	batteries	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries	A	10 batteries
4	wasted toners	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	6 toners
5	fluorescent tubes	**20 01 21** fluorescent tubes and other mercury-containing waste	A	3 tubes

HW generation factors (HWGF): HWGFs are calculated as similar to those in R1, i.e. waste amounts are divided by the annual capacity of the plant. According to Capacity Report (November 2009), plants has a maximum production capacity of 75 ton. In calculation of HWGFs, production capacity of R.2 is taken as 70 ton per year based on plant owner declaration. Calculated values are presented in Table 4.59.

Table 4.59 HW generation factors (HWGF) in R.2

No	Type of waste	A/M	Annual amount of waste (kg or item*)	HWGF-2 (kg waste or waste item*/ ton rubber produced)
HWs originating from processes (07 and 15 coded wastes)				
1	**07 02 99** wastes not otherwise specified (wasted rubber)		3 600	51,43
2	**15 01 10** packaging containing residues of or contaminated by dangerous substances	M	140	2
HWs originating from side processes (12 and 15 coded wastes)				
3	**12 01 20** spent grinding bodies and grinding materials containing dangerous substances (metal grindings)	M	6 000	85,71
4	**15 01 10** packaging containing residues of or contaminated by dangerous substances (for wasted packages of paints)	M	13	0,19
Non-process based HWs (08, 13,15, 16 and 20 coded wastes)				
5	**15 02 02** as contaminated wiping cloths	M	300	4,29
6	**13 01 13** other hydraulic oils (from presses)	A	20	0,29
7	**16 06 01** lead batteries **16 06 02** Ni-Cd batteries	A	20*	0,14*
8	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	A	6*	0,09*
9	**20 01 21** fluorescent tubes and other mercury-containing waste	A	3*	0,04*

4.2.5.3. Summary for Manufacture of Rubber Products

In Table 4.60 HWGFs for the two pilot plants are summarized. Pilot plant studies conducted for rubber product manufacturing industry in OSTIM OIZ revealed that *07 and 15 coded* wastes are process specific HWs. Special emphasis should be given to the wasted rubber (*07 07 99*). This waste is generated in high amounts in OSTİM OIZ and unfortunately and no proper code could be found in the waste list.

As it can be easily revealed from Table 4.60, waste codes of *12 and 15* are major waste codes for the side processes for both plants. Metal grindings (*12 01 20*) have the largest amount among other wastes.

Regarding the non-process based hazardous wastes, same types of wastes are observed to be generated in both plants, whereas generation factors differ slightly depending on plant conditions, such as number of employees, etc.

In order to determine total HW generation from manufacturing of rubber products sector, total capacity of 16 companies is calculated as 960 ton/year (60 ton per each). Results of estimation of total HW generation from this sector are given in Table 4.61.

According to Table 4.61, it can be concluded that annual HW generation from this sector is not in significant amounts. However, hazardous property of *07 02* coded HWs should be further investigated.

Table 4.60 Comparison of HW generation factors (HWGF) in manufacturing of rubber products

No	Type of Waste	A/M	HWGF -1 (kg waste or waste item*/ ton rubber produced)	HWGF -2 (kg waste or waste item*/ ton rubber produced)	HWGF from literature (kg waste or waste item*/ ton rubber produced)	HWGF (kg waste or waste item*/ ton rubber produced)
HWs originating from processes (07 and 15 coded wastes)						
1	**07 02 99** wastes not otherwise specified (wasted rubber)		40	51,43	137 [40]	40-51,43
2	**15 01 10** packaging containing residues of or contaminated by dangerous substances (for wasted packages of paints)	M	1,79	2	-	1,79-2
HWs originating from side processes (12 and 15 coded wastes)						
3	**12 01 20** spent grinding bodies and grinding materials containing dangerous substances (metal grindings)	M	40	85,71	-	40-85,71
4	**15 01 10** packaging containing residues of or contaminated by dangerous substances (for wasted packages of paints)	M	0,32	0,19	-	0,19-0,32

No	Type of Waste	A/M	HWGF -1 (kg waste or waste item*/ ton rubber produced)	HWGF -2 (kg waste or waste item*/ ton rubber produced)	HWGF from literature (kg waste or waste item*/ ton rubber produced)	HWGF (kg waste or waste item*/ ton rubber produced)
Non-process based HWs (13,15, 16 and 20 coded wastes)						
5	**15 02 02** absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M	4,7	4,29	-	4,29-4,7
6	**13 01 13** other hydraulic oils (from presses)	A	0,5	0,29	-	0,29-0,5
7	**16 06 01** lead batteries **16 06** 02 Ni-Cd batteries **16 06 03** mercury containing batteries	A	0,4*	0,14*	-	0,14-0,4*
8	**16 02 13** discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	M	0,08*	0,09*	-	0,08-0,09*
9	**20 01 21** fluorescent tubes and other mercury-containing waste	A	0,04*	0,04*	-	0,04*

Table 4.61 Total HW generation in manufacturing of rubber products sector of OSTIM OIZ

HW Category	HWGF (kg waste or waste item/ ton rubber produced)	Capacity (ton rubber produced /year)	Annual HW generation (ton/year or *item/year)
HWs originating from processes (07 and 15 coded wastes)			
07 02 (wastes from the MFSU of plastics, synthetic rubber and man-made fibres)	40-51,43	960	38,4-49,37
15 01 10 (contaminated packaging of inputs)	1,79-2		1,72-1,92
HWs originating from side processes (12 and 15 coded wastes)			
12 01 20 (metal grindings)	40-85,71	960	38,4-82,8
15 01 10 (contaminated packaging of oils)	0,19-0,32		0,18-0,31
Non-process based HWs (15, 16 and 20 coded wastes)			
15 02 02 (waste work gloves and cloths)	4,29-4,7	960	4,12-4,51
13 01 13 (waste hydraulic oils)	0,29-0,5*		278,4-480*
16 06 (waste batteries)	0,14-0,4*		134,4-384*
16 02 13 (waste cartridges)	0,08-0,09*		76,8-86,4*
20 01 21 (waste fluorescent tubes)	0,04		38,4

Finally, in evaluation of HW estimation given in Table 4.61, the following issues are of importantance in terms of validity of the results:

- Natural and regenerated rubber is processed in rubber manufacturing companies of OSTIM OIZ.
- Depending on different products, various types of raw materials and additives can be used, and this could affect the HW generation.
- Presented estimations are valid for only dry rubber processing, as OSTIM OIZ companies do not apply wet rubber processing.

CHAPTER 5

CONCLUSION

Hazardous waste generation of selected priority sectors in OSTIM Organized Industrial Zone (OSTIM OIZ) was investigated in this thesis study. Furthermore, process specific and sector specific hazardous waste generation factors were calculated and evaluated. Total hazardous waste generation from selected priority sectors was also estimated. Estimated HWGFs and total hazardous waste generation amounts are summarized in Table 5.1.

In this study, hazardous waste potential of the selected priority sectors only in OSTIM OIZ could be investigated due to time limitation. For the selected sectors it was also difficult to gather data from pilot plant studies and generalize the findings to the others. Most of the companies are in the form of SMEs and have varieties in production capacities and product types. Moreover, most of the companies do not have a final product of a sector but instead they manufacture sub-industry products of various sectors. This case also leads to difficulties in sectoral classification.

As can be inferred from Table 5.1, HW generation potential is highest for the machining sector among the other studied sectors of OSTIM OIZ. Highest amount of generation in 12 01 coded HW mainly results from generation of metal grindings contaminated with oil from metal shaping operations. However, this amount should be taken with caution and should be considered as the minimum

amount for the region since machining activities in other sectors (construction machines, machinery, building and construction, automotive) could not be estimated due to lack of information in their sectoral distribution. Corresponding waste generation could not be included in this study.

Sector of treatment and coating of metals appeared as the second highest contributor to hazardous waste generation in OSTIM OIZ. Rinsing wastewaters and waste process baths are main polluting elements of this sector. Main stream of hazardous waste in this sector appeared at 11 01 coded hazardous wastes. Being a minor entry (i.e. M coded waste); these are required to be characterized further through laboratory analysis so that they could be considered as absolute hazardous wastes (i.e. A coded waste) or not.

Moreover, it is observed that manufacturing of rubber products sector has less contribution in total hazardous waste generation in OSTIM OIZ.

Maintenance and repair of motor vehicles sub sector of automotive sector has diverse HWs most of them are absolute entries. Therefore, hazardous waste generation potential of this sector is very crucial to consider for OSTIM OIZ Directorate.

Waste oils mostly arising from maintenance and repair of motor vehicles sector have different types and require different codes for classification. Annual waste generated from the whole sector is estimated as 1241,46 ton/year (except waste items). Waste engine and gear oils are the mostly generated oil type from this sector.

Table 5.1 Comparison of total hazardous waste generation in selected priority sectors

HW Category	HWGF (kg waste or waste item*/ ton product produced or raw material processed)	Annual HW Generation (ton/year or *item/year)
CASTING OF FERROUS METALS		
HWs originating from processes (10 and 15 coded wastes)		
10 09 (wastes from casting of ferrous pieces)	75 - 200	900 - 2400
15 01 10 (contaminated packaging of oils)	0,1 - 0,23	1,2 - 2,76
Non-process based HWs (13,15, 16 and 20 coded wastes)		
15 02 02 (waste work gloves and cloths)	0,04 - 0,16	0,48 - 1,92
16 06 (waste batteries)	0,004 - 0,008*	48 - 96*
16 02 13 (waste cartridges)	0,002 - 0,003*	24 - 36*
20 01 21 (waste fluorescent tubes)	0,002 - 0,004*	24 - 48*
MACHINING		
HWs originating from processes (12 and 15 coded wastes)		
12 01 (wastes from shaping and physical and mechanical surface treatment of metals and plastics)	102,78–340,55	1834,6 – 6078,8
15 01 10 (contaminated packaging of oils)	0,06 – 0,53	1,07 - 9,46
15 02 02 (contaminated rags)	0,44 – 1,67	7,85 - 29,81
Non-process based HWs (15, 16 and 20 coded wastes)		
15 02 02 (waste work gloves and cloths)	0,48 - 4	8,57 – 71,4
16 06 (waste batteries)	0,01-0,05*	178,5 – 892,5*
16 02 13 (waste cartridges)	0,007 – 0,04*	124,95- 714*
20 01 21 (waste fluorescent tubes)	0,002 – 0,33*	35,7 – 5890,5*
TREATMENT AND COATING OF METALS		
HWs originating from processes (11 and 15 coded wastes)		
for electroplating processes		
11 01 (wastes from treatment and coating of metals)	149,5-479,6	1457,5-4676,5
15 01 10 (contaminated packaging of chemicals)	0,62-0,65	6,05-6,34

Table 5.1 (continued)

HW Category	HWGF (kg waste or waste item*/ ton product produced or raw material processed)	Annual HW Generation (ton/year or *item/year)
for hot dip galvanizing processes		
11 01 (wastes from treatment and coating of metals)	689,1-2879,1	492,7-2058,6
11 05 04 (spent flux)	80-200	57,2-143
15 01 10 (contaminated packaging of chemicals)	0,89-1	0,64-0,72
Non-process based HWs (15, 16 and 20 coded wastes)		
15 02 02 (waste work gloves and cloths)	0,15-0,22	1,57-2,3
16 06 (waste batteries)	0,004*	41,86*
16 02 13 (waste cartridges)	0,002-0,004*	20,93-41,86*
20 01 21 (waste fluorescent tubes)	0,001-0,002*	10,47-20,93*
MAINTENANCE AND REPAIR OF MOTOR VEHICLES		
HWs originating from processes (13,15, and 16 coded wastes)		
13 01 13 (waste hydraulic oils)	0,085	12,44
13 02 08 (engine and gear oils)	4,45	651,05
16 01 07 (oil filters)	1*	146 304*
15 02 02 (fuel filters)	0,5*	73 152*
16 01 14 (antifreeze fluids)	0,21	30,72
16 01 13 (brake fluids)	0,009	1,32
16 01 11(brake pads)	0,28*	40 965*
16 01 21(wiring)	0,0015	0,22
15 01 10 (contaminated packaging of inputs)	3,73	545,71
HWs originating from side processes (13,15, 16 and 20 coded wastes)		
13 05 07 (oily water)	7,07	1034,37
13 05 02 (oily sludges)	0,27	39,5
15 01 10 (contaminated packaging of inputs)	0,008	1,17
Non-process based HWs (13 and 15 coded wastes)		
15 02 02 (waste work gloves and cloths)	0,12	17,56
16 06 (waste batteries)	0,009*	1316,74
16 02 13 (waste cartridges)	0,003*	438,91
20 01 21 (waste fluorescent tubes)	0,01*	1463,04

Table 5.1 (continued)

HW Category	HWGF (kg waste or waste item*/ ton product produced or raw material processed)	Annual HW Generation (ton/year or *item/year)
MANUFACTURE OF RUBBER PRODUCTS		
HWs originating from processes (07 and 15 coded wastes)		
07 02 (wastes from the MFSU of plastics, synthetic rubber and man-made fibres)	40-51,43	38,4-49,37
15 01 10 (contaminated packaging of inputs)	1,79-2	1,72-1,92
HWs originating from side processes (12 and 15 coded wastes)		
12 01 20 (metal grindings)	40-85,71	38,4-82,8
15 01 10 (contaminated packaging of oils)	0,19-0,32	0,18-0,31
Non-process based HWs (15, 16 and 20 coded wastes)		
15 02 02 (waste work gloves and cloths)	4,29-4,7	4,12-4,51
13 01 13 (waste hydraulic oils)	0,29-0,5*	278,4-480*
16 06 (waste batteries)	0,14-0,4*	134,4-384*
16 02 13 (waste cartridges)	0,08-0,09*	76,8-86,4*

It can be easily seen from Table 4.42, *15 01 10* (as contaminated packaging material) and *15 02 02* (as contaminated material) are common codes among the process and side process based wastes for the studied sectors. *15 02 02* coded HWs also appear in non process based HWs generation. The annual waste amount to be generated ranged as 557,74 - 568,39 ton/year for *15 01 10* and 40,15 – 127,5 ton/year for 15 02 02 coded wastes.

Total amounts of side process specific HWs could not be estimated for all selected sectors since they are highly variable for the small size companies of OSTIM OIZ. Generally main processes are commonly involved in these small companies and side processes are performed outside the companies.

Waste factors are useful tools in waste management for control of waste generation amounts and making projections or scenarios on future waste arising. In this respect, this document is thought to be an important guide for SMEs in Turkey in terms of sectoral hazardous waste generation estimations with the help of the findings from real waste generators.

In this study, the annual amounts generated in OSTIM OIZ were estimated by extrapolating the pilot plant findings based on the total capacities involved. Here, the basic assumption was that the HWGFs will not change with the capacity changes in the companies. Moreover, the companies are of micro-sized and are working on order base. Therefore, the capacity estimations should be taken cautiously into consideration in interpreting the results. Furthermore, comparison with literature values could not be possible, as the specific values could not be reached from the literature sources due to untypical characteristics of the sectors present in OSTIM OIZ. Consequently, the HW estimations were primarily based on the pilot plant findings.

As a final remark, the results provided in this thesis study should be taken into consideration as a rough estimation of the hazardous waste generation in OSTIM OIZ, as it needs to be verified further through more pilot studies, considering the highly variable nature of the companies involved.

CHAPTER 6

RECOMMENDATIONS FOR FUTURE STUDY

This thesis study was conducted for estimation of hazardous waste generation of selected priority sectors in OSTIM OIZ. Furthermore, process specific and sector specific hazardous waste generation factors were calculated and evaluated. Other manufacturing sectors could not be investigated due to time limitations of the study. However, for an integrated hazardous waste inventory and a proper management plan, all sectors should be analyzed and sectoral hazardous waste generation potential should be determined in further studies.

For verification of HWGFs, new pilot plant studies can be concluded and their results should be reported for different scenarios.

In addition to this, sectoral classification system of OSTIM OIZ Directorate should be renewed since it is not in line with NACE Rev.2 classification. Therefore, sectoral groups should be reorganized and estimations should be based on new classification.

Finally, in further studies Industrial production capacity of the sectors in OSTIM OIZ should also be investigated for estimation of total hazardous waste generation in the region.

REFERENCES

1. Pitchel J., Waste Management Practices: municipal, hazardous, and industrial, Taylor & Francis Group, 2005, USA

2. Maltezou S. P., Biswas A. K., Sutter H., Hazardous waste management : selected papers from an international expert workshop convened by UNIDO in Vienne, Tycooly International Publishing Ltd., 1987, USA

3. COUNCIL DIRECTIVE of 12 December 1991 on hazardous waste (91/689/EEC)

4. Regulation on General Principles of Waste Management (RGPWM), Official Gazette No. 26927 and 2008 (in Turkish: Atık Yönetimi Genel Esaslarına İlişkin Yönetmelik)

5. COUNCIL DIRECTIVE of 15 July 1975 on waste (75/442/EEC)

6. Regulation of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register [(EC) No 166/2006]

7. COUNCIL DIRECTIVE of 15 January 2008 on integrated pollution prevention and control (2008/1/EC)

8. European IPPC Bureau (EIPPCB), Home Page, http://eippcb.jrc.es/index.html, Last date accessed: November 20, 2010

9. Environment Operational Program (CCI No: 2007 TR 16 I PO 001**)**, MoEF, 2007, Ankara

10. Law on Environment, Official Gazette No. 5491 and 2006 (in Turkish: Çevre Kanunu)

11. Waste Management in Turkey: National Regulations and Evaluation of Implementation Results, Performance Audit Report, Turkish Court of Accounts, 2007, Ankara

12. Regulation on Control of Solid Wastes (RCSW), Official Gazette No. 20814, 1991 (in Turkish: Katı Atıkların Kontrolü Yönetmeliği)

13. Regulation on Control of Hazardous Wastes (RCHW), Official Gazette No. 25777, 2005 (in Turkish: Tehlikeli Atıkların Kontrolü Yönetmeliği)

14. The Ministry of Environment and Forestry (MoEF), Department of Waste Management, Home page: Legislation regarding Waste Management http://www.atikyonetimi.cevreorman.gov.tr/yonetmelikler.htm, Last date accessed: November 20, 2010

15. EUROPA Environment: Cooperation with third countries - Turkey, http://europa.eu/legislation_summaries/environment/cooperation_with_third_countries/e15113_en.htm, Last date accessed: November 20, 2010

16. LIFE HAWAMAN Project, “Improvement of Hazardous Waste Management in Turkey” (LIFE06 TCY/TR/000292), The Ministry of Environment and Forestry (MoEF), http://www.lifetcy06.cevreorman.gov.tr/gosteren.php?id=172]TASK C, Last date accessed: August 20, 2010

17. Tehlikeli Atik Beyan Formu Atık Üreticileri için Kullanım Kılavuzu, Çevre Yönetimi Genel Müdürlüğü Atık Yönetimi Dairesi Başkanlığı, 2010, http://atikyonetimi.cevreorman.gov.tr/atikyonetimi/AnaSayfa/solmenu/onlineislemler.aspx?sflang=tr, Last date accessed: August 20, 2010

18. Creating Waste Inventory Lists, The Pacific Northwest Pollution Prevention Resource Center (PPRC), http://www.pprc.org/pubs/workbook/chap1.pdf, Last date accessed: July 09, 2010

19. Development and application of waste factors - an overview, European Environment Agency, Copenhagen, 1999

20. Organized Industrial Zones Law, Official Gazette No. 4562, 2000 (in Turkish: Organize Sanayi Bölgeleri Kanunu)

21. OSTİM Organize Sanayi Bölge Müdürlüğü, Home Page, www.ostim.org.tr, Last date accessed: November 30, 2010

22. Regulation on Organized Industrial Zones Implementation, Official Gazette No. 27327, 2009 (in Turkish: Organize Sanayi Bölgeleri Uygulama Yönetmeliği)

23. Regulation on Definition, Qualification and Classification of Small and Medium Sized Enterprises, Official Gazette No:9617, 2005

24. OSTİM Organized Industrial Zone Directorate, Web based database, www.ostim.org.tr/adminpanel, Last date accessed: November 30, 2010

25. EUROSTAT (Statistical Office of the European Communities), NACE Rev.2 - Statistical classification of economic activities in the European Community, 2008, http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-07-15/EN/KS-RA-07-015-EN.PDF, Last date accessed: August 15, 2010

26. Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Smitheries and Foundries Industry, European Commission Institute for Prospective Technological Studies, 2005, Spain

27. LIFE 'HAWAMAN' "Türkiye'de Sanayiden Kaynaklanan Tehlikeli Atıkların Yönetiminin İyileştirilmesi Projesi Döküm Sektörü Rehber Doküman, T.C. Çevre ve Orman Bakanlığı, 2009, Ankara

28. Pollution Prevention and Abatement Handbook 1998, The World Bank Group, 1999, USA

29. LIFE 'HAWAMAN' "Türkiye'de Sanayiden Kaynaklanan Tehlikeli Atıkların Yönetiminin İyileştirilmesi Projesi" Tehlikeli Atıkların sınıflandırılması Kılavuzu Cilt 2, T.C. Çevre ve Orman Bakanlığı, 2009, Ankara

30. Office of Compliance Sector Notebook Project (EPA/310-R-95-007) Profile of the Fabricated Metal Products, Environmental Protection Agency, 1995, Washington, http://www.epa.gov/ compliance / resources / publications / assistance/ sectors / notebooks /fabmetsnpt1.pdf, Last date accessed: October 05, 2010

31. LIFE 'HAWAMAN' "Türkiye'de Sanayiden Kaynaklanan Tehlikeli Atıkların Yönetiminin İyileştirilmesi Projesi Metal Sektörü Rehber Doküman, T.C. Çevre ve Orman Bakanlığı, 2009, Ankara, http://atikyonetimi.cevreorman.gov.tr/atikyonetimi/AnaSayfa/solmenu/kilavuzlar.aspx?sflang=tr, Last date accessed: October 15, 2010

32. Alternatives for preventing pollution in the surface treatment industry, Regional Activity Centre for Cleaner Production (RAC/CP), Mediterranean Action Plan, UNEP 2000

33. LIFE 'HAWAMAN' "Türkiye'de Sanayiden Kaynaklanan Tehlikeli Atıkların Yönetiminin İyileştirilmesi Projesi" Metal Kaplama Galvanizasyon Rehber Doküman, T.C. Çevre ve Orman Bakanlığı, 2009, Ankara

34. Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Surface Treatment of Metals and Plastics, European Commission Institute for Prospective Technological Studies, 2005, Spain

35. Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Ferrous Metals Processing Industry, European Commission Institute for Prospective Technological Studies, 2005, Spain

36. Guides to Pollution Prevention: The Automotive Repair Industry, U.S. Environmental Protection Agency, 1991, USA

37. LIFE 'HAWAMAN' "Türkiye'de Sanayiden Kaynaklanan Tehlikeli Atıkların Yönetiminin İyileştirilmesi Projesi Oto Tamirhaneleri Rehber Doküman, T.C. Çevre ve Orman Bakanlığı, 2009, Ankara

38. Ahmed R., Klundert A., Lardinois I., RUBBER WASTE Options for Small - scale Resource Recovery, Urban Solid Waste Series 3, TOOL Publications and WASTE, 1996, Netherlands, http://www.bvsde.paho.org/bvsacd/cd48/rubber-waste.pdf, Last date accessed: October 20, 2010

39. U.S. Environmental Protection Agency (EPA), Profile of Rubber and Plastics Industry, EPA Office of Compliance Sector Notebook Project, 2005, Washington, http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/rubplasn.pdf, Last date accessed: October 20, 2010

40. U. S. EPA, Assessment of Industrial Hazardous Waste Practices, Rubber and Plastics Industry Rubber Products Industry, 1978

41. A Cleaner Production Manual for the Queensland Foundry Industry, The Queensland Environmental Protection Agency, The UNEP Working Group Centre for Cleaner Production, 1999

42. Guyer H., Industrial Processes and Waste Stream Management, John Wiley and Sons, 2003, USA

43. Environmentally Sound Technologies in the Metal Finishing Industry, Technology Section in the Sectoral Issues and Policies Division of the United Nations Economic and Social Commission for Western Asia (ESCWA), 2001, New York

44. Office of Compliance Sector Notebook Project (EPA/310-R-95-007) Profile of the Fabricated Metal Products, Environmental Protection Agency, 1995, Washington, http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/fabmetsnpt1.pdf, Last date accessed: October 18, 2010

APPENDIX A

WASTE LIST FROM EUROPEAN WASTE CATALOGUE AND RGPWM

Table A.1 Comparison of total hazardous waste generation in selected priority sectors

Entries with asterisk (*) represent hazardous wastes.

01	**WASTE RESULTING FROM EXPLORATION, MINING, QUARRYING, AND PHYSICAL AND CHEMICAL TREATMENT OF MINERALS**	**Absolute/ Minor**
01 01	***wastes from mineral excavation***	
01 01 01	wastes from mineral metalliferous excavation	
01 01 02	wastes from mineral non-metalliferous excavation	
01 03	***wastes from physical and chemical processing of metalliferous minerals***	
01 03 04*	acid-generating tailings from processing of sulphide ore	A
01 03 05*	other tailings containing dangerous substances	M
01 03 06	tailings other than those mentioned in 01 03 04 and 01 03 05	
01 03 07*	other wastes containing dangerous substances from physical and chemical processing of metalliferous minerals	M
01 03 08	dusty and powdery wastes other than those mentioned in 01 03 07	
01 03 09	red mud from alumina production other than the wastes mentioned in 01 03 07	
01 03 99	wastes not otherwise specified	
01 04	***wastes from physical and chemical processing of non-metalliferous minerals***	
01 04 07*	waste containing dangerous substances from physical and chemical processing of nonmetalliferous minerals	M

Table A.1 (continued)

01 04 08	waste gravel and crushed rocks other than those mentioned in 01 04 07	
01 04 09	waste sand and clays	
01 04 10	dusty and powdery wastes other than those mentioned in 01 04 07	
01 04 11	wastes from potash and rock salt processing other than those mentioned in 01 04 07	
01 04 12	tailings and other wastes from washing and cleaning of minerals other than those mentioned in 01 04 07 and 01 04 11	
01 04 13	waste from stone cutting and sawing other than those mentioned in 01 04 07	
01 04 99	waste not otherwise specified	
01 05	***drilling muds and other drilling wastes***	
01 05 04	freshwater drilling muds and wastes	
01 05 05*	oil-containing drilling muds and wastes	M
01 05 06*	drilling muds and other drilling wastes containing dangerous substances	M
01 05 07	barite-containing drilling muds and wastes other than those mentioned in 01 05 05 and 01 05 06	
01 05 08	chloride-containing drilling muds and wastes other than those mentioned in 01 05 05 and 01 05 06	
01 05 99	wastes not otherwise specified	
02	**WASTES FROM AGRICULTURE, HORTICULTURE, AQUACULTURE, FORESTRY, HUNTING AND FISHING, FOOD PREPARATION AND PROCESSING**	
02 01	**wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing**	
02 01 01	sludges from washing and cleaning	
02 01 02	animal-tissue waste	
02 01 03	plant-tissue waste	
02 01 04	waste plastics (except packaging)	
02 01 06	animal faeces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site	
02 01 07	waste from forestry	
02 01 08*	agrochemical waste containing dangerous substances	M
02 01 09	agrochemical waste other than those mentioned in 02 01 08	
02 01 10	waste metal	
02 01 99	wastes not otherwise specified	
02 02	**wastes from the preparation and processing of meat, fish and other foods of animal origin**	

Table A.1 (continued)

02 02 01	sludges from washing and cleaning	
02 02 02	animal-tissue waste	
02 02 03	materials unsuitable for consumption or processing	
02 02 04	sludges from on-site effluent treatment	
02 02 99	waste not otherwise specified	
02 03	**wastes from fruit, vegetables, cereals, edible oils, cocoa, coffee, tea and tabacco preparation and processing; conserve production; yeast and yeast extract production, molasses preparation and fermentation**	
02 03 01	sludges from washing, cleaning, peeling, centrifuging and separation	
02 03 02	waste from preserving agents	
02 03 03	wastes from solvent extraction	
02 03 04	materials unsuitable for consumption or processing	
02 03 05	sludges from on-site effluent treatment	
02 03 99	wastes not otherwise specified	
02 04	**wastes from sugar processing**	
02 04 01	soil from cleaning and washing beet	
02 04 02	off-specification calcium carbonate	
02 04 03	sludges from on-site effluent treatment	
02 04 99	wastes not otherwise specified	
02 05	**wastes from the dairy products industry**	
02 05 01	materials unsuitable for consumption or processing	
02 05 02	sludges from on-site effluent treatment	
02 05 99	wastes not otherwise specified	
02 06	**02 06 wastes from the baking and confectionery industry**	
02 06 01	materials unsuitable for consumption or processing	
02 06 02	wastes from preserving agents	
02 06 03	sludges from on-site effluent treatment	
02 06 99	waste not otherwise specified	
02 07	**wastes from the production of alcoholic and non-alcoholic beverages (except coffee, tea and cocoa)**	
02 07 01	wastes from washing, cleaning and mechanical reduction of raw materials	
02 07 02	wastes from spirits distillation	
02 07 03	wastes from chemical treatment	
02 07 04	materials unsuitable for consumption or processing	
02 07 05	sludges from on-site effluent treatment	
02 07 99	waste not otherwise specified	

Table A.1 (continued)

03	**WASTES FROM WOOD PROCESSING AND THE PRODUCTION OF PANELS AND FURNITURE, PULP, PAPER AND CARDBOARD**	
03 01	**wastes from wood processing and the production of panels and furniture**	
03 01 01	waste bark and cork	
03 01 04*	sawdust, shavings, cuttings, wood, particle board and veneer containing dangerous substances	M
03 01 05	sawdust, shavings, cuttings, wood, particle board and veneer other than those mentioned in 03 01 04	
03 01 99	wastes not otherwise specified	
03 02	**wastes from wood preservation**	
03 02 01*	non-halogenated organic wood preservatives	A
03 02 02*	organochlorinated wood preservatives	A
03 02 03*	organometallic wood preservatives	A
03 02 04*	inorganic wood preservatives	A
03 02 05*	other wood preservatives containing dangerous substances	M
03 02 99	wood preservatives not otherwise specified	
03 03	**wastes from pulp, paper and cardboard production and processing**	
03 03 01	waste bark and wood	
03 03 02	green liquor sludge (from recovery of cooking liquor)	
03 03 05	de-inking sludges from paper recycling	
03 03 07	mechanically separated rejects from pulping of waste paper and cardboard	
03 03 08	wastes from sorting of paper and cardboard destined for recycling	
03 03 09	lime mud waste	
03 03 10	fibre rejects, fibre-, filler- and coating-sludges from mechanical separation	
03 03 11	sludges from on-site effluent treatment other than those mentioned in 03 03 10	
03 03 99	wastes not otherwise specified	
04	**WASTES FROM THE LEATHER, FUR AND TEXTILE INDUSTRIES**	
04 01	**wastes from the leather and fur industry**	
04 01 01	fleshings and lime split wastes	
04 01 02	liming waste	
04 01 03*	degreasing wastes containing solvents without a liquid phase	M
04 01 04	tanning liquor containing chromium	
04 01 05	tanning liquor free of chromium	

Table A.1 (continued)

04 01 06	sludges, in particular from on-site effluent treatment containing chromium	
04 01 07	sludges , in particular from on-site effluent treatment free of chromium	
04 01 08	waste tanned leather (blue sheetings, shavings, cuttings, buffing dust) containing chromium	
04 01 09	wastes from dressing and finishing	
04 01 99	wastes not otherwise specified	
04 02	**wastes from the textile industry**	
04 02 09	wastes from composite materials (impregnated textile, elastomer, plastomer)	
04 02 10	organic matter from natural products (for example grease, wax)	
04 02 14*	wastes from finishing containing organic solvents	M
04 02 15	wastes from finishing other than those mentioned in 04 02 14	
04 02 16*	dyestuffs and pigments containing dangerous substances	M
04 02 17	dyestuffs and pigments other than those mentioned in 04 02 16	
04 02 19*	sludges from on-site effluent treatment containing dangerous substances	M
04 02 20	sludges from on-site effluent treatment other than those mentioned in 04 02 19	
04 02 21	wastes from unprocessed textile fibres	
04 02 22	wastes from processed textile fibres	
04 02 99	wastes not otherwise specified	
05	**WASTES FROM PETROLEUM REFINING, NATURAL GAS PURIFICATION AND PYROLYTIC TREATMENT OF COAL**	
05 01	**wastes from petroleum refining**	
05 01 02*	desalter sludges	A
05 01 03*	tank bottom sludges	A
05 01 04*	acid alkyl sludges	A
05 01 05*	oil spills	A
05 01 06*	oily sludges from maintenance operations of the plant or equipment	A
05 01 07*	acid tars	A
05 01 08*	other tars	A
05 01 09*	sludges from on-site effluent treatment containing dangerous substances	M
05 01 10	sludges from on-site effluent treatment other than those mentioned in 05 01 09	
05 01 11*	wastes from cleaning of fuels with bases	A
05 01 12*	oil containing acids	M

Table A.1 (continued)

05 01 13	boiler feedwater sludges	
05 01 14	wastes from cooling columns	
05 01 15*	spent filter clays	A
05 01 16	sulphur-containing wastes from petroleum desulphurisation	
05 01 17	bitumen	
05 01 99	wastes not otherwise specified	
05 06	**waste from the pyrolytic treatment of coal**	
05 06 01*	acid tars	A
05 06 03*	other tars	A
05 06 04	waste from cooling columns	
05 06 99	wastes not otherwise specified	
05 07	**waste from natural gas purification and transportation**	
05 07 01*	wastes containing mercury	M
05 07 02	wastes containing sulphur	
05 07 99	wastes not otherwise specified	
06	**WASTES FROM INORGANIC CHEMICAL PROCESSES**	
06 01	**wastes from the manufacture, formulation, supply and use (MFSU) of acids**	
06 01 01*	sulphuric acid and sulphurous acid	A
06 01 02*	hydrochloric acid	A
06 01 03*	hydroflouric acid	A
06 01 04*	phosphoric and phosphorous acid	A
06 01 05*	nitric acid and nitrous acid	A
06 01 06*	other acids	A
06 01 99	wastes not otherwise specified	
06 02	**wastes from the MFSU of bases**	
06 02 01*	calcium hydroxide	A
06 02 03*	ammonium hydroxide	A
06 02 04*	sodium and potassium hydroxide	A
06 02 05*	other bases	A
06 02 99	wastes not otherwise specified	
06 03	**wastes from the MFSU of salts and their solutions and metallic oxides**	
06 03 11*	solid salts and solutions containing cyanides	M
06 03 13*	solid salts and solutions containing heavy metals	M
06 03 14	solid salts and solution other than those mentioned in 06 03 11 and 06 03 13	
06 03 15*	metallic oxides containing heavy metals	M
06 03 16	metallic oxides other than those mentioned in 06 03 15	
06 03 99	wastes not otherwise specified	

Table A.1 (continued)

06 04	**metal-containing wastes other than those mentioned in 06 03**	
06 04 03*	wastes containing arsenic	M
06 04 04*	wastes containing mercury	M
06 04 05*	wastes containing other heavy metals	M
06 04 99	wastes not otherwise specified	
06 05	**sludges from on-site effluent treatment**	
06 05 02*	sludges from on-site effluent treatment containing dangerous solutions	M
06 05 03	sludges from onsite effluent treatment other than those mentioned in 06 05 02	
06 06	**wastes from the MFSU of sulphur chemicals, sulphur chemical processes and desulphurisation processes**	
06 06 02*	wastes containing dangerous sulphides	M
06 06 03	wastes containing sulphides other than those mentioned in 06 06 02	
06 06 99	wastes not otherwise specified	
06 07	**wastes from the MFSU of halogens and halogen chemical processes**	
06 07 01*	wastes containing asbestos from electrolysis	M
06 07 02*	activated carbon from chlorine production	A
06 07 03*	barium sulphate sludge containing mercury	M
06 07 04*	solutions and acids, for example contact acid	A
06 07 99	wastes not otherwise specified	
06 08	**wastes from the MFSU of silicon and silicon derivatives**	
06 08 02*	waste containing dangerous silicones	M
06 08 99	wastes not otherwise specified	
06 09	**wastes from the MFSU of phosphorus chemicals and phosphorous chemical processes**	
06 09 02	phosphorus slag	
06 09 03*	calcium-based reaction wastes containing or contaminated with dangerous substances	M
06 09 04	calcuim-based reaction wastes other than those mentioned in 06 09 03	
06 09 99	wastes not otherwise specified	
06 10	**wastes from the MFSU of nitrogen chemicals, nitrogen chemical processes and fertiliser manufacture**	
06 10 02*	wastes containing dangerous substances	M
06 10 99	wastes not otherwise specified	
06 11	**wastes from the manufacture of inorganic pigments and opacificiers**	

Table A.1 (continued)

06 11 01	calcium-based reaction wastes from titanium dioxide production	
06 11 99	wastes not otherwise specified	
06 13	**wastes from inorganic chemical processes not otherwise specified**	
06 13 01*	inorganic plant protection products, wood-preserving agents and other biocides	A
06 13 02*	spent activated carbon (except 06 07 02)	A
06 13 03	carbon black	
06 13 04*	wastes from asbestos processing	A
06 13 05*	soot	A
06 13 99	wastes not otherwise specified	
07	**WASTES FROM ORGANIC CHEMICAL PROCESSES**	
07 01	**wastes from the manufacture, formulation, supply and use (MFSU) of basic organic chemicals**	
07 01 01*	aqueous washing liquids and mother liquors	A
07 01 03*	organic halogenated solvents, washing liquids and mother liquors	A
07 01 04*	other organic solvents, washing liquids and mother liquors	A
07 01 07*	halogenated still bottoms and reaction residues	A
07 01 08*	other still bottoms and reaction residues	A
07 01 09*	halogenated filter cakes and spent absorbents	A
07 01 10*	other filter cakes and spent absorbents	A
07 01 11*	sludges from on-site effluent treatment containing dangerous substances	M
07 01 12	sludges from on-site effluent treatment other than those mentioned in 07 01 11	
07 01 99	wastes not otherwise specified	
07 02	**wastes from the MFSU of plastics, synthetic rubber and man-made fibres**	
07 02 01*	aqueous washing liquids and mother liquors	A
07 02 03*	organic halogenated solvents, washing liquids and mother liquors	A
07 02 04*	other organic solvents, washing liquids and mother liquors	A
07 02 07*	halogenated still bottoms and reaction residues	A
07 02 08*	other still bottoms and reaction residues	A
07 02 09*	halogenated filter cakes and spent absorbents	A
07 02 10*	other filter cakes and spent absorbents	A
07 02 11*	sludges from on-site effluent treatment containing dangerous substances	M

Table A.1 (continued)

07 02 12	sludges from on-site effluent treatment other than those mentioned in 07 02 11	
07 02 13	waste plastic	
07 02 14*	wastes from additives containing dangerous substances	M
07 02 15	wastes from additives other than those mentioned in 07 02 14	
07 02 16*	waste containing dangerous silicones	M
07 02 17	waste containing silicones other than those mentioned in 07 02 16	
07 02 99	wastes not otherwise specified	
07 03	**wastes from the MFSU of organic dyes and pigments (except 06 11)**	
07 03 01*	aqueous washing liquids and mother liquors	A
07 03 03*	organic halogenated solvents, washing liquids and mother liquors	A
07 03 04*	other organic solvents, washing liquids and mother liquors	A
07 03 07*	halogenated still bottoms and reaction residues	A
07 03 08*	other still bottoms and reaction residues	A
07 03 09*	halogenated filter cakes and spent absorbents	A
07 03 10*	other filter cakes and spent absorbents	A
07 03 11*	sludges from on-site effluent treatment containing dangerous substances	M
07 03 12	sludges from on-site effluent treatment other than those mentioned in 07 03 11	
07 03 99	wastes not otherwise specified	
07 04	**wastes from the MFSU of organic plant protection products (except 02 01 08 and 02 01 09), wood preserving agents (except 03 02) and other biocides**	
07 04 01*	aqueous washing liquids and mother liquors	A
07 04 03*	organic halogenated solvents, washing liquids and mother liquors	A
07 04 04*	other organic solvents, washing liquids and mother liquids	A
07 04 07*	halogenated still bottoms and reaction residues	A
07 04 08*	other still bottoms and reaction residues	A
07 04 09*	halogenated filter cakes and spent absorbents	A
07 04 10*	other filter cakes and spent absorbents	A
07 04 11*	sludges from on-site effluent treatment containing dangerous substances	M
07 04 12	sludges from on-site effluent treatment other than those mentioned in 07 04 11	
07 04 13*	solid wastes containing dangerous substances	M

Table A.1 (continued)

07 04 99	wastes not otherwise specified	
07 05	**wastes from the MFSU of pharmaceuticals**	
07 05 01*	aqueous washing liquids and mother liquors	A
07 05 03*	organic halogenated solvents, washing liquids and mother liquors	A
07 05 04*	other organic solvents, washing liquids and mother liquors	A
07 05 07*	halogenated still bottoms and reaction residues	A
07 05 08*	other still bottoms and reaction residues	A
07 05 09*	halogenated filter cakes and spent absorbents	A
07 05 10*	other filter cakes and spent absorbents	A
07 05 11*	sludges from on-site effluent treatment containing dangerous substances	M
07 05 12	sludges from on-site effluent treatment other than those mentioned in 07 05 11	
07 05 13*	solid wastes containing dangerous substances	M
07 05 14	solid wastes other than those mentioned in 07 05 13	
07 05 99	wastes not otherwise specified	
07 06	**wastes from the MFSU of fats, grease, soaps, detergents, disinfectants and cosmetics**	
07 06 01*	aqueous washing liquids and mother liquors	A
07 06 03*	organic halogenated solvents, washing liquids and mother liquors	A
07 06 04*	other organic solvents, washing liquids and mother liquors	A
07 06 07*	halogenated still bottoms and reaction residues	A
07 06 08*	other sill bottoms and reaction residues	A
07 06 09*	halogenated filter cakes and spent absorbents	A
07 06 10*	other filter cakes and spent absorbents	A
07 06 11*	sludges from on-site effluent treatment containing dangerous substances	M
07 06 12	sludges from on-site effluent treatment other than those mentioned in 07 06 11	
07 06 99	wastes not otherwise specified	
07 07	**wastes from the MFSU of fine chemicals and chemical products not otherwise specified**	
07 07 01*	aqueous washing liquids and mother liquors	A
07 07 03*	organic halogenated solvents, washing liquids and mother liquors	A
07 07 04*	other organic solvents, washing liquids and mother liquors	A
07 07 07*	halogenated still bottoms and reaction residues	A
07 07 08*	other still bottoms and reaction residues	A

Table A.1 (continued)

07 07 09*	halogenated filter cakes and spent absorbents	A
07 07 10*	other filter cakes and spent sbsorbents	A
07 07 11*	sludges from on-site effluent treatment containing dangerous substances	M
07 07 12	sludges from on-site effluent treatment other than those mentioned in 07 07 11	
07 07 99	wastes not otherwise specified	
08	**WASTES FORM THE MANUFACTURE, FORMULATION, SUPPLY AND USE (MFSU) OF COATINGS (PAINTS, VARNISHES AND VITREOUS ENAMELS,) ADHESIVES, SEALANTS AND PRINTING INKS**	
08 01	**wastes from MFSU and removal of paint and varnish**	
08 01 11*	waste paint and varnish containing organic solvents or other dangerous substances	M
08 01 12	waste paint and varnish other than those mentioned in 08 01 11	
08 01 13*	sludges from paint or varnish containing organic solvents or other dangerous substances	M
08 01 14	sludges from paint or varnish other than those mentioned in 08 01 13	
08 01 15*	aqueous sludges containing paint or varnish containing organic solvents or other dangerous substances	M
08 01 16	aqueous sludges containing paint or varnish other than those mentioned in 08 01 15	
08 01 17*	wastes from paint or varnish removal containing organic solvents or other dangerous substances	M
08 01 18	wastes from paint or varnish removal other than those mentioned in 08 01 17	
08 01 19*	aqueous suspensions containing paint or varnish containing organic solvents or other dangerous substances	M
08 01 20	aqueous suspensions containing paint or varnish other than those mentioned in 08 01 19	
08 01 21*	waste paint or varnish remover	A
08 01 99	wastes not otherwise specified	
08 02	**wastes from MFSU of other coatings (including ceramic materials)**	
08 02 01	waste coating powders	
08 02 02	aqueous sludges containing ceramic materials	
08 02 03	aqueous suspensions containing ceramic materials	
08 02 99	wastes not otherwise specified	
08 03	**wastes from MFSU of printing inks**	
08 03 07	aqueous sludges containing ink	

Table A.1 (continued)

08 03 08	aqueous liquid waste containing ink	
08 03 12*	waste ink containing dangerous substances	M
08 03 13	waste ink other than those mentioned in 08 03 12	
08 03 14*	ink sludges containing dangerous substances	M
08 03 15	ink sludges other than those mentioned in 08 03 14	
08 03 16*	waste etching solutions	A
08 03 17*	waste printing toner containing dangerous substances	M
08 03 18	waste printing toner other than those mentioned in 08 03 17	
08 03 19*	disperse oil	A
08 03 99	wastes not otherwise specified	
08 04	**wastes from MFSU of adhesives and sealants (including waterproofing products)**	
08 04 09*	waste adhesives and sealants containing organic solvents or other dangerous substances	M
08 04 10	waste adhesives and sealants other than those mentioned in 08 04 09	
08 04 11*	adhesive and sealant sludges containing organic solvents or other dangerous substances	M
08 04 12	adhesive and sealant sludges other than those mentioned in 08 04 11	
08 04 13*	aqueous sludges containing adhesives or sealants containing organic solvents or other dangerous substances	M
08 04 14	08 04 14 aqueous sludges containing adhesives or sealants other than those mentioned in 08 04 13	
08 04 15*	08 04 15* aqueous liquid waste containing adhesives or sealants containing organic solvents or other dangerous substances	M
08 04 16	08 04 16 aqueous liquid waste containing adhesives or sealants other than those mentioned in 08 04 15	
08 04 17*	rosin oil	A
08 04 99	wastes not otherwise specified	
08 05	**wastes not otherwise specified in 08**	
08 05 01*	waste isocyanates	A
09	**WASTES FROM THE PHOTOGRAPHIC INDUSTRY**	
09 01	**wastes for the photographic industry**	
09 01 01*	water-based developer and activator solutions	A
09 01 02*	water-based offset plate developer solutions	A
09 01 03*	solvent-based developer solutions	A
09 01 04*	fixed solutions	A
09 01 05*	bleach solutions and bleach fixer solutions	A

Table A.1 (continued)

09 01 06*	wastes containing silver from on-site treatment of photographic wastes	M
09 01 07	photographic film and paper containing silver or silver compounds	
09 01 08	photographic film and paper free of silver or silver compounds	
09 01 10	single-use cameras without batteries	
09 01 11*	single-use cameras containing batteries included in 16 06 01, 16 06 02 or 16 06 03	A
09 01 12	single-use cameras containing batteries other than those mentioned in 09 01 11	
09 01 13*	aqueous liquid waste from on-site reclamation of silver other than those mentioned in 09 01 06	A
09 01 99	wastes not otherwise specified	
10	**WASTES FROM THERMAL PROCESSES**	
10 01	**wastes from power stations and other combustion plants (except 19)**	
10 01 01	bottom ash, slag and boiler dust (excluding boiler dust mentioned in 10 01 04)	
10 01 02	coal fly ash	
10 01 03	fly ash from peat and untreated wood	
10 01 04*	oil fly ash and boiler dust	A
10 01 05	calcium-based reaction wastes from flue-gas desulphurisation in solid form	
10 01 07	calcium-based reaction wastes from flue-gas desulphurisation in sludge form	
10 01 09*	sulphuric acid	A
10 01 13*	fly ash from emulsified hydrocarbons used as fuel	A
10 01 14*	bottom ash, slag and boiler dust from co-incineration containing dangerous substances	M
10 01 15	bottom ash, slag and boiler dust from co-incineration other than those mentioned in 10 01 14	
10 01 16*	fly ash from co-incineration containing dangerous substances	M
10 01 17	fly ash from co-incineration other than those mentioned in 10 01 16	
10 01 18*	wastes from gas cleaning containing dangerous substances	M
10 01 19	wastes from gas cleaning other than those mentioned in 10 01 05, 10 01 07 and 10 01 18	
10 01 20*	sludges from on-site effluent treatment containing dangerous substances	M

Table A.1 (continued)

10 01 21	sluges from on-site effluent treatment other than those mentioned in 10 01 20	
10 01 22*	aqueous sludges from boiler cleansing containing dangerous substances	M
10 01 23	aqueous sludges from boiler cleansing other than those mentioned in 10 01 22	
10 01 24	sands from fluidised beds	
10 01 25	wastes from fuel storage and preparation of coal-fired power plants	
10 01 26	wastes from cooling-water treatment	
10 01 99	wastes not otherwise specified	
10 02	**wastes from the iron and steel industry**	
10 02 01	wastes from the processing of slag	
10 02 02	unprocessed slag	
10 02 07*	solid wastes from gas treatment containing dangerous substances	M
10 02 08	solid wastes from gas treatment other than those mentioned in 10 02 07	
10 02 10	mill scales	
10 02 11*	wastes from cooling-water treatment containing oil	M
10 02 12	waste from cooling-water treatment other than those mentioned in 10 02 11	
10 02 13*	sludges and filter cakes from gas treatment containing dangerous substances	M
10 02 14	sludges and filter cakes from gas treatment other than those mentioned in 10 02 13	
10 02 15	other sludges and filter cakes	
10 02 99	wastes not otherwise specified	
10 03	**wastes from aluminium thermal metallurgy**	
10 03 02	anode scraps	
10 03 04*	primary production slags	A
10 03 05	waste alumina	
10 03 08*	salt slags from secondary production	A
10 03 09*	black drosses from secondary production	A
10 03 15*	skimmings that are flammable or emit, upon contact with water, flammable gases in dangerous quantities	M
10 03 16	skimming other than those mentioned in 10 03 15	
10 03 17*	tar-containing wastes from anode manufacture	M
10 03 18	carbon-containing waste from anode manufacture other than those mentioned in 10 03 17	
10 03 19*	flue-gas dust containing dangerous substances	M
10 03 20	flue-gas dust other than those mentioned in 10 03 19	

Table A.1 (continued)

10 03 21*	other particulates and dust (including ball-mill dust) containing dangerous substances	M
10 03 22	other particulates and dust (including ball-mill dust) other than those mentioned in 10 03	
10 03 23*	solid wastes from gas treatment containing dangerous substances	M
10 03 24	solid wastes from gas treatment other than those mentioned in 10 03 23	
10 03 25*	sludges and filter cakes from gas treatment containing dangerous substances	M
10 03 26	sludges and filter cakes from gas treatment other than those mentioned in 10 03 25	
10 03 27*	wastes from cooling-water treatment containing oil	M
10 03 28	wastes from cooling-water treatment other than those mentioned in 10 03 27	
10 03 29*	waste from treatment of salt slags and black drosses containing dangerous substances	M
10 03 30	wastes from treatment of salt slags and black drosses other than those mentioned in 10 03 29	
10 03 99	wastes not otherwise specified	
10 04	**wastes from lead thermal metallurgy**	
10 04 01*	slags from primary and secondary production	A
10 04 02*	dross and skimmings from primary and secondary production	A
10 04 03*	calcium arsenate	A
10 04 04*	flue-gas dust	A
10 04 05*	other particulates and dust	A
10 04 06*	solid wastes from gas treatment	A
10 04 07*	sludges and filter cakes from gas treatment	A
10 04 09*	wastes from cooling-water treatment containing oil	M
10 04 10	waste from cooling-water treatment other than those mentioned in 10 04 09	
10 04 99	wastes not otherwise specified	
10 05	**wastes from zinc thermal metallurgy**	
10 05 01	slags from primary and secondary production	
10 05 03*	flue-gas dust	A
10 05 04	other particulates and dust	
10 05 05*	solid waste from gas treatment	A
10 05 06*	sludges and filter cakes from gas treatment	A
10 05 08*	wastes from cooling-water treatment containing oil	M
10 05 09	wastes from cooling-water treatment other than those mentioned in 10 05 08	

Table A.1 (continued)

10 05 10*	dross and skimmings that are flammable or emit, upon contact with water, flammable gases in dangerous quantities	M
10 05 11	dross and skimmings other than those mentioned in 10 05 10	
10 05 99	wastes not otherwise specified	
10 06	**wastes from copper thermal metallurgy**	
10 06 01	slags from primary and secondary production	
10 06 02	dross and skimmings from primary and secondary production	
10 06 03*	flue-gas dust	A
10 06 04	other particulates and dust	
10 06 06*	solid wastes from gas treatment	A
10 06 07*	sludges and filter cakes from has treatment	A
10 06 09*	wastes from cooling-water treatment containing oil	M
10 06 10	waste from cooling-water treatment other than those mentioned in 10 06 09	
10 06 99	wastes not otherwise specified	
10 07	**wastes from silver, gold and platinum thermal metalurgy**	
10 07 01	slags from primary and secondary production	
10 07 02	dross and skimmings from primary and secondary production	
10 07 03	solid wastes from gas treatment	
10 07 04	other particulates and dust	
10 07 05	sludges and filter cakes from gas treatment	
10 07 07*	wastes from cooling-water treatment containing oil	M
10 07 08	wastes from cooling-water treatment other than those mentioned in 10 07 07	
10 07 99	wastes not otherwise specified	
10 08	**wastes from other non-ferous thermal metallurgy**	
10 08 04	particulates and dust	
10 08 08*	salt slag from primary and secondary production	A
10 08 09	other slags	
10 08 10*	dross and skimming that are flammable or emit, upon the contact with water, flammable gases in dangerous quanities	M
10 08 11	dross and skimmings other than those mentioned in 10 08 10	
10 08 12*	tar-containing waste from anode manufacture	M
10 08 13	carbon-containing wastes from anode manufacture other than those mentioned in 10 08 12	

Table A.1 (continued)

10 08 14	anode scrap	
10 08 15*	flue-gas dust containing dangerous substances	M
10 08 16	flue-gas dust other than those mentioned in 10 08 15	
10 08 17*	sludges and filter cakes from flue-gas treatment containing dangerous substances	M
10 08 18	sludges and filter cakes from flue-gas treatment other than those mentioned in 10 08 17	
10 08 19*	wastes from cooling-water treatment containing oil	M
10 08 20	wastes from cooling-water treatment other than those mentioned in 10 08 19	
10 08 99	wastes not otherwise specified	
10 09	**wastes from casting of ferrous pieces**	
10 09 03	furnace slag	
10 09 05*	casting cores and moulds which have not undergone pouring containing dangerous substances	M
10 09 06	casting cores and moulds which have not undergone pouring other than those mentioned in 10 09 05	
10 09 07*	casting cores and moulds which have undergone pouring containing dangerous substances	M
10 09 08	casting cores and moulds have undergone pouring other than those mentioned in 10 09 07	
10 09 09*	flue-gas dust containing dangerous substances	M
10 09 10	flue-gas dust other than those mentioned in 10 09 09	
10 09 11*	other particulates containing dangerous substances	M
10 09 12	other particulates other than those mentioned in 10 09 11	
10 09 13*	waste binders containing dangerous substances	M
10 09 14	waste binders other than those mentioned in 10 09 13	
10 09 15*	waste crack-indicating agent containing dangerous substances	M
10 09 16	waste crack-indicating agent other than those mentioned in 10 09 15	
10 09 99	wastes not otherwise specified	
10 10	**wastes from casting of non-ferrous pieces**	
10 10 03	furnace slag	
10 10 05*	casting cores and moulds which have not undergone pouring, containing dangerous substances	M
10 10 06	casting cores and moulds which have not undergone pouring, other than those mentioned in 10 10 05	
10 10 07*	casting cores and moulds which have undergone pouring, containing dangerous substances	M

Table A.1 (continued)

10 10 08	casting cores and moulds which have undergone pouring, other than those mentioned in 10 10 07	
10 10 09*	flue-gas dust containing dangerous substances	M
10 10 10	flue-gas dust other than those mentioned in 10 10 09	
10 10 11*	other particulates containing dangerous substances	M
10 10 12	other particulates other than those mentioned in 10 10 11	
10 10 13*	waste binders containing dangerous substances	M
10 10 14	waste binders other than those mentioned in 10 10 13	
10 10 15*	waste crack-indicating agent containing dangerous substances	M
10 10 16	waste crack-indicating agent other than those mentioned in 10 10 15	
10 10 99	wastes not otherwise specified	
10 11	**wastes from manufacture of glass and glass products**	
10 11 03	waste glass-based fibrous materials	
10 11 05	particulates and dust	
10 11 09*	waste preparation mixture before thermal processing, containing dangerous substances	M
10 11 10	waste preparation mixture before thermal processing, other than those mentioned in 10 11 09	
10 11 11*	waste glass in small particles and glass powder containing heavy metals (for example from cathode ray tubes)	M
10 11 12	waste glass other than those mentioned in 10 11 11	
10 11 13*	glass-polishing and -grinding sludge containing dangerous substances	M
10 11 14	glass-polishing and -grinding sludge other than those mentioned in 10 11 13	
10 11 15*	solid wastes from flue-gas treatment containing dangerous substances	M
10 11 16	solid wastes from flue-gas treatment other than those mentioned in 10 11 15	
10 11 17*	sludges and filter cakes from flue-gas treatment containing dangerous substances	M
10 11 18	sludges and filter cakes from flue-gas treatment other than those mentioned in 10 11 17	
10 11 19*	solid wastes from on-site effluent treatment containing dangerous substances	M
10 11 20	solid wastes from on-site effluent treatment other than those mentioned in 10 11 19	
10 11 99	wastes not otherwise specified	
10 12	**wastes from manufacture of ceramic goods, bricks, tiles and construction products**	

Table A.1 (continued)

10 12 01	waste preparation mixture before thermal processing	
10 12 03	particulates and dust	
10 12 05	sludges and filter cakes from gas treatment	
10 12 06	discarded moulds	
10 12 08	waste ceramics, bricks, tiles and construction products (after thermal processing)	
10 12 09*	solid wastes from gas treatment containing dangerous substances	M
10 12 10	solid wastes from gas treatment other than those mentioned in 10 12 09	
10 12 11*	wastes from glazing containing heavy metals	M
10 12 12	wastes from glazing other than those mentioned in 10 12 11	
10 12 13	sludge from on-site effluent treatment	
10 12 99	wastes not otherwise specified	
10 13	**wastes from manufacture of cement, lime and plaster and articles and products made from them**	
10 13 01	waste preparation mixture before thermal processing	
10 13 04	wastes from calcination and hydration of lime	
10 13 06	particulates and dust (except 10 13 12 and 10 13 13)	
10 13 07	sludges and filter cakes from gas treatment	
10 13 09*	wastes from asbestos-cement manufacture containing asbestos	M
10 13 10	wastes from asbestos-cement manufacture other than those mentioned in 10 13 09	
10 13 11	wastes from cement-based composite materials other than those mentioned in 10 13 09 and 10 13 10	
10 13 12*	solid wastes from gas treatment containing dangerous substances	M
10 13 13	solid wastes from gas treatment other than those mentioned in 10 13 12	
10 13 14	waste concrete and concrete sludge	
10 13 99	wastes not otherwise specified	
10 14	**waste from crematoria**	
10 14 01*	waste from gas cleaning containing mercury	A
11	**WASTES FROM CHEMICAL SURFACE TREATMENT AND COATING OF METALS AND OTHER MATERIALS; NON-FERROUS HYDRO-METALLURGY**	
11 01	**wastes from chemical surface treatment and coating of metals and other materials (for example galvanic processes, zinc coating processes, pickling processes, etching, phosphating, alkaline degreasing, anodising)**	

Table A.1 (continued)

11 01 05*	pickling acids	A
11 01 06*	acids not otherwise specified	A
11 01 07*	pickling bases	A
11 01 08*	phosphatising sludges	A
11 01 09*	sludges and filter cakes containing dangerous substances	M
11 01 10	sludges and filter cakes other than those mentioned in 11 01 09	
11 01 11*	aqueous rinsing liquids containing dangerous substances	M
11 01 12	aqueous rinsing liquids other than those mentioned in 11 01 11	
11 01 13*	degreasing wastes containing dangerous substances	M
11 01 14	degreasing wastes other than those mentioned in 11 01 13	
11 01 15*	eluate and sludges from membrane systems or ion exchange systems containing dangerous substances	M
11 01 16*	saturated or spent ion exchange resins	A
11 01 98*	other wastes containing dangerous substances	M
11 01 99	wastes not otherwise specified	
11 02	**waste from non-ferrous hydrometallurgical processes**	
11 02 02*	sludges from zinc hydrometallurgy (including jarosite, goethite)	A
11 02 03	wastes from the production of anodes for aqueous electrolytical processes	
11 02 05*	wastes from copper hydrometallurgical processes containing dangerous substances	M
11 02 06	wastes from copper hydrometallurgical processes other than those mentioned in 11 02 05	
11 02 07*	other wastes containing dangerous substances	M
11 02 99	wastes not otherwise specified	
11 03	**sludges and solids from tempering processes**	
11 03 01*	waste containing cyanide	A
11 03 02*	other wastes	A
11 05	**wastes from hot galvanising processes**	
11 05 01	hard zinc	
11 05 02	zinc ash	
11 05 03*	solid wastes from gas treatment	A
11 05 04*	spent flux	A
11 05 99	wastes not otherwise specified	
12	**WASTES FROM SHAPING AND PHYSICAL AND MECHANICAL SURFACE TREATMENT OF METALS AND PLASTICS**	
12 01	**wastes from shaping and physical and mechanical surface treatment of metals and plastics**	
12 01 01	ferrous metal filings and turnings	

Table A.1 (continued)

12 01 02	ferrous metal dust and particles	
12 01 03	non-ferrous metal filings and turnings	
12 01 04	non-ferrous metal dust and particles	
12 01 05	plastics shavings and turnings	
12 01 06*	mineral-based machining oils containing halogens (except emulsions and solutions)	A
12 01 07*	mineral-based machining oils free of halogens (except emulsions and solutions)	A
12 01 08*	machining emulsions and solutions containing halogens	A
12 01 09*	machining emulsions and solutions free of halogens	A
12 01 10*	synthetic machining oils	A
12 01 12*	spent waxes and fats	A
12 01 13	welding wastes	
12 01 14*	machining sludges containing dangerous substances	M
12 01 15	machining sludges other than those mentioned in 12 01 14	
12 01 16*	waste blasting material containing dangerous substances	M
12 01 17	waste blasting material other than those mentioned in 12 01 16	
12 01 18*	metal sludge (grinding, honing and lapping sludge) containing oil	M
12 01 19*	readily biodegradable machining oil	A
12 01 20*	spent grinding bodies and grinding materials containing dangerous substances	M
12 01 21	spent grinding bodies and grinding materials other than those mentioned in 12 01 20	
12 01 99	wastes not otherwise specified	
12 03	**wastes from water and steam degreasing processes (except 11)**	
12 03 01*	aqueous washing liquids	A
12 03 02*	steam degreasing wastes	A
13	**OIL WASTES AND WASTES OF LIQUID FUELS (except edible oils, and those inchapters 05, 12 and 19)**	
13 01	**waste hydraulic oils**	
13 01 01*	hydraulic oils, containing PCBs (15)	A
13 01 04*	chlorinated emulsions	A
13 01 05*	non-chlorinated emulsions	A
13 01 09*	mineral-based chlorinated hydraulic oils	A
13 01 10*	mineral-based non-chlorinated hydraulic oils	A
13 01 11*	synthetic hydraulic oils	A
13 01 12*	readily biodegradable hydraulic oils	A
13 01 13*	other hydraulic oils	A

Table A.1 (continued)

13 02	**waste engine, gear and lubricating oils**	
13 02 04*	mineral-based chlorinated engine, gear and lubricating oils	A
13 02 05*	mineral-based non-chlorinated engine, gear and lubricating oils	A
13 02 06*	synthetic engine, gear and lubricating oils	A
13 02 07*	readily biodegradable engine, gear and lubricating oils	A
13 02 08*	other engine, gear and lubricating oils	A
13 03	**waste insulating and heat transmission oils**	
13 03 01*	insulating or heat transmission oils containing PCBs	A
13 03 06*	mineral-based chlorinated insulating and heat transmission oils other than those mentioned in 13 03 01	A
13 03 07*	mineral-based non-chlorinated insulating and heat transmission oils	A
13 03 08*	synthetic insulating and heat transmission oils	A
13 03 09*	readily biodegradable insulating and heat transmission oils	A
13 03 10*	other insulating and heat transmission oils	A
13 04	**bilge oils**	
13 04 01*	bilge oils from inland navigation	A
13 04 02*	bilge oils from jetty sewers	A
13 04 03*	bilge oils from other navigation	A
13 05	**oil/water separator contents**	
13 05 01*	solids from grit chambers and oil/water separators	A
13 05 02*	sludges from oil/water separators	A
13 05 03*	interceptor sludges	A
13 05 06*	oil from oil/water separators	A
13 05 07*	oily water from oil/water separators	A
13 05 08*	mixtures of wastes from grit chambers and oil/water separators	A
13 07	**wastes of liquid fuels**	
13 07 01*	fuel oil and diesel	A
13 07 02*	petrol	A
13 07 03*	other fuels (including mixtures)	A
13 08	**oil wastes not otherwise specified**	
13 08 01*	desalter sludges or emulsions	A
13 08 02*	other emulsions	A
13 08 99	wastes not otherwise specified	
14	**WASTE ORGANIC SOLVENTS, REFRIGERANTS AND PROPELLANTS (except 07 and 08)**	
14 06	**waste organic solvents, refrigerants and foam/aerosol propellants**	
14 06 01*	chlorofluorocarbons, HCFC, HFC	A
14 06 02*	other halogenated solvents and solvent mixtures	A

Table A.1 (continued)

14 06 03*	other solvents and solvent mixtures	A
14 06 04*	sludges or solid wastes containing halogenated solvents	A
14 06 05*	sludges or solid wastes containing other solvents	A
15	**WASTE PACKAGING; ABSORBENTS, WIPING CLOTHS, FILTER MATERIALS AND PROTECTIVE CLOTHING NOT OTHERWISE SPECIFIED**	
15 01	**packaging (including separately collected municipal packaging waste**	
15 01 01	paper and cardboard packaging	
15 01 02	plastic packaging	
15 01 03	wooden packaging	
15 01 04	metallic packaging	
15 01 05	composite packaging	
15 01 06	mixed packaging	
15 01 07	glass packaging	
15 01 09	textile packaging	
15 01 10*	packaging containing residues of or contaminated by dangerous substances	M
15 01 11*	metallic packaging containing a dangerous solid porous matrix (for example asbestos), including empty pressure containers	M
15 02	**absorbents, filter materials, wiping cloths and protective clothing**	
15 02 02*	absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	M
15 02 03	absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02	
16	**WASTES NOT OTHERWISE SPECIFIED IN THE LIST**	
16 01	**end-of-life vehicles from different means of transport (including off-road machinery) and wastes from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 16 06 and 16 08)**	
16 01 03	end-of-life tyres	
16 01 04*	end-of-life vehicles	M
16 01 06	end-of-life vehicles, containing neither liquids nor other hazardous components	
16 01 07*	oil filters	A
16 01 08*	components containing mercury	M
16 01 09*	components containing PCBs	M
16 01 10*	explosive components (for example air bags)	A
16 01 11*	brake pads containing asbestos	M

Table A.1 (continued)

16 01 12	brake pads other than those mentioned in 16 01 11	
16 01 13*	brake fluids	A
16 01 14*	antifreeze fluids containing dangerous substances	M
16 01 15	antifreeze fluids other than those mentioned in 16 01 14	
16 01 16	tanks for liquefied gas	
16 01 17	ferrous metal	
16 01 18	non-ferrous metal	
16 01 19	plastic	
16 01 20	glass	
16 01 21*	hazardous components other than those mentioned in 16 01 07 to 16 01 11 and 16 01 13 and 16 01 14	M
16 01 22	components not otherwise specified	
16 01 99	wastes not otherwise specified	
16 02	**wastes from electrical and electronic equipment**	
16 02 09*	transformers and capacitors containing PCBs	M
16 02 10*	discarded equipment containing or contaminated by PCBs other than those mentioned in 16 02 09	M
16 02 11*	discarded equipment containing chlorofluorocarbons, HCFC, HFC	M
16 02 12*	discarded equipment containing free asbestos	M
16 02 13*	discarded equipment containing hazardous components (16) other than those mentioned in16 02 09 to 16 02 12	M
16 02 14	discarded equipment other than those mentioned in 16 02 09 to 16 02 13	
16 02 15*	hazardous components removed from discarded equipment	A
16 02 16	components removed from discarded equipment other than those mentioned in 16 02 15	
16 03	**off-specification batches and unused products**	
16 03 03*	inorganic wastes containing dangerous substances	M
16 03 04	inorganic wastes other than those mentioned in 16 03 03	
16 03 05*	organic wastes containing dangerous substances	M
16 03 06	organic wastes other than those mentioned in 16 03 05	
16 04	**waste explosives**	
16 04 01*	waste ammunition	A
16 04 02*	fireworks wastes	A
16 04 03*	other waste explosives	A
16 05	**gases in pressure containers and discarded chemicals**	
16 05 04*	gases in pressure containers (including halons) containing dangerous substances	M
16 05 05	gases in pressure containers other than those mentioned in 16 05 04	
16 05 06*	laboratory chemicals, consisting of or containing dangerous substances, including mixtures	M

Table A.1 (continued)

16 05 07*	discarded inorganic chemicals consisting of or containing dangerous substances	M
16 05 08*	discarded organic chemicals consisting of or containing dangerous substances	M
16 05 09	discarded chemicals other than those mentioned in 16 05 06, 16 05 07 or 16 05 08	
16 06	**batteries and accumulators**	
16 06 01*	lead batteries	A
16 06 02*	Ni-Cd batteries	A
16 06 03*	mercury-containing batteries	A
16 06 04	alkaline batteries (except 16 06 03)	
16 06 05	other batteries and accumulators	
16 06 06*	separately collected electrolyte from batteries and accumulators	A
16 07	**wastes from transport tank, storage tank and barrel cleaning (except 05 and 13)**	
16 07 08*	wastes containing oil	M
16 07 09*	wastes containing other dangerous substances	M
16 07 99	wastes not otherwise specified	
16 08	**spent catalysts**	
16 08 01	spent catalysts containing gold, silver, rhenium, rhodium, palladium, iridium or platinum (except 16 08 07)	
16 08 02*	spent catalysts containing dangerous transition metals (17) or dangerous transition metal compounds	M
16 08 03	spent catalysts containing transition metals or transition metal compounds not otherwise specified	
16 08 04	spent fluid catalytic cracking catalysts (except 16 08 07)	
16 08 05*	spent catalysts containing phosphoric acid	M
16 08 06*	spent liquids used as catalysts	A
16 08 07*	spent catalysts contaminated with dangerous substances	M
16 09	**oxidising substances**	
16 09 01*	permanganates, for example potassium permanganate	A
16 09 02*	chromates, for example potassium chromate, potassium or sodium dichromate	A
16 09 03*	peroxides, for example hydrogen peroxide	A
16 09 04*	oxidising substances, not otherwise specified	A
16 10	**aqueous liquid wastes destined for off-site treatment**	
16 10 01*	aqueous liquid wastes containing dangerous substances	M
16 10 02	aqueous liquid wastes other than those mentioned in 16 10 01	
16 10 03*	aqueous concentrates containing dangerous substances	M
16 10 04	aqueous concentrates other than those mentioned in 16 10 03	
16 11	**waste linings and refractories**	

Table A.1 (continued)

16 11 01*	carbon-based linings and refractories from metallurgical processes containing dangerous	M
17 03 02	bituminous mixtures containing other than those mentioned in 17 03 01	
17 03 03*	coal tar and tarred products	A
17 04	**metals (including their alloys)**	
17 04 01	copper, bronze, brass	
17 04 02	aluminium	
17 04 03	lead	
17 04 04	zinc	
17 04 05	iron and steel	
17 04 06	tin	
17 04 07	mixed metals	
17 04 09*	metal waste contaminated with dangerous substances	M
17 04 10*	cables containing oil, coal tar and other dangerous substances	M
17 04 11	cables other than those mentioned in 17 04 10	
17 05	**soil (including excavated soil from contaminated sites), stones and dredging spoil**	
17 05 03*	soil and stones containing dangerous substances	M
17 05 04	soil and stones other than those mentioned in 17 05 03	
17 05 05*	dredging spoil containing dangerous substances	M
17 05 06	dredging spoil other than those mentioned 17 05 05	
17 05 07*	track ballast containing dangerous substances	M
17 05 08	track ballast other than those mentioned in 17 05 07	
17 06	**insulation materials and asbestos-containing construction materials**	
17 06 01*	insulation materials containing asbestos	M
17 06 03*	other insulation materials consisting of or containing dangerous substances	M
17 06 04	insulation materials other than those mentioned in 17 06 01 and 17 06 03	
17 06 05*	construction materials containing asbestos (18)	M
17 08	**gypsum-based construction material**	
17 08 01*	gypsum-based construction materials contaminated with dangerous substances	M
17 08 02	gypsum-based construction materials other than those mentioned in 17 08 01	
17 09	**other construction and demolition waste**	
17 09 01*	construction and demolition wastes containing mercury	M
17 09 02*	construction and demolition wastes containing pcb (for example pcb-containing sealants,	M

Table A.1 (continued)

17 09 03*	other construction and demolition wastes (including mixed wastes) containing dangerous substances	M
17 09 04	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03	
18	**WASTES FROM HUMAN OR ANIMAL HEALTH CARE AND/OR RELATED RESEARCH (except kitchen and restaurant wastes not arising from immediate health care)**	
18 01	**wastes from natal care, diagnosis, treatment or prevention of disease in humans**	
18 01 01	sharps (except 18 01 03)	
18 01 02	body parts and organs including blood bags and blood preserves (except 18 01 03)	
18 01 03*	wastes whose collection and disposal is subject to special requirements in order to prevent infection	A
18 01 04	18 01 04 wastes whose collection and disposal is not subject to special requirements in order to prevent infection (for example dressings, plaster casts, linen, disposable clothing, diapers)	
18 01 06*	chemicals consisting of or containing dangerous substances	M
18 01 07	chemicals other than those mentioned in 18 01 06	
18 01 08*	cytotoxic and cytostatic medicines	A
18 01 09	medicines other than those mentioned in 18 01 08	
18 01 10*	amalgam waste from dental care	A
18 02	**wastes from research, diagnosis, treatment or prevention of disease involving animals**	
18 02 01	sharps except (18 02 02)	
18 02 02*	wastes whose collection and disposal is subject to special requirements in order to prevent	A
18 02 03	wastes whose collection and disposal is not subject to special requirements in order to prevent infection	
18 02 05*	chemicals consisting of or containing dangerous substances	M
18 02 06	chemicals other than those mentioned in 18 02 05	
18 02 07*	cytotoxic and cytostatic medicines	A
18 02 08	medicines other than those mentioned in 18 02 07	
19	**WASTES FROM WASTE MANAGEMENT FACILITIES, OFF-SITE WASTEWATER TREATMENT PLANTS AND THE PREPARATION OF WATERINTENDED FOR HUMAN CONSUMPTION AND WATER FOR INDUSTRIAL USE**	
19 01	**wastes from incineration or pyrolysis of waste**	

Table A.1 (continued)

19 01 02	ferrous materials removed from bottom ash	
19 01 05*	filter cake from gas treatment	A
19 01 06*	aqueous liquid wastes from gas treatment and other aqueous liquid wastes	A
19 01 07*	solid wastes from gas treatment	A
19 01 10*	spent activated carbon from flue-gas treatment	A
19 01 11*	bottom ash and slag containing dangerous substances	M
19 01 12	bottom ash and slag other than those mentioned in 19 01 11	
19 01 13*	fly ash containing dangerous substances	M
19 01 14	fly ash other than those mentioned in 19 01 13	
19 01 15*	boiler dust containing dangerous substances	M
19 01 16	boiler dust other than those mentioned in 19 01 15	
19 01 17*	pyrolysis wastes containing dangerous substances	M
19 01 18	pyrolysis wastes other than those mentioned in 19 01 17	
19 01 19	sands from fluidised beds	
19 01 99	wastes not otherwise specified	
19 02	**wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation)**	
19 02 03	premixed wastes composed only of non-hazardous wastes	
19 02 04*	premixed wastes composed of at least one hazardous waste	A
19 02 05*	sludges from physico/chemical treatment containing dangerous substances	M
19 02 06	sludges from physico/chemical treatment other than those mentioned in 19 02 05	
19 02 07*	oil and concentrates from separation	A
19 02 08*	liquid combustible wastes containing dangerous substances	M
19 02 09*	solid combustible wastes containing dangerous substances	M
19 02 10	combustible wastes other than those mentioned in 19 02 08 and 19 02 09	
19 02 11*	other wastes containing dangerous substances	M
19 02 99	wastes not otherwise specified	
19 03	**stabilised/solidified wastes**	
19 03 04*	wastes marked as hazardous, partly (20) stabilised	A
19 03 05	stabilised wastes other than those mentioned in 19 03 04	
19 03 06*	wastes marked as hazardous, solidified	A
19 03 07	solidified wastes other than those mentioned in 19 03 06	
19 04	**vitrified waste and wastes from vitrification**	

Table A.1 (continued)

19 04 01	vitrified waste	
19 04 02*	fly ash and other flue-gas treatment wastes	A
19 04 03*	non-vitrified solid phase	A
19 04 04	aqueous liquid wastes from vitrified waste tempering	
19 05	**wastes from aerobic treatment of solid wastes**	
19 05 01	non-composted fraction of municipal and similar wastes	
19 05 02	non-composted fraction of animal and vegetable waste	
19 05 03	off-specification compost	
19 05 99	wastes not otherwise specified	
19 06	**wastes from anaerobic treatment of waste**	
19 06 03	liquor from anaerobic treatment of municipal waste	
19 06 04	digestate from anaerobic treatment of municipal waste	
19 06 05	liquor from anaerobic treatment of animal and vegetable waste	
19 06 06	digestate from anaerobic treatment of animal and vegetable waste	
19 06 99	wastes not otherwise specified	
19 07	**landfill leachate**	
19 07 02*	landfill leachate containing dangerous substances	M
19 07 03	landfill leachate other than those mentioned in 19 07 02	
19 08	**wastes from waste water treatment plants not otherwise specified**	
19 08 01	screenings	
19 08 02	waste from desanding	
19 08 05	sludges from treatment of urban waste water	
19 08 06*	saturated or spent ion exchange resins	A
19 08 07*	solutions and sludges from regeneration of ion exchangers	A
19 08 08*	membrane system waste containing heavy metals	M
19 08 09	grease and oil mixture from oil/water separation containing only edible oil and fats	
19 08 10*	grease and oil mixture from oil/water separation other than those mentioned in 19 08 09	A
19 08 11*	sludges containing dangerous substances from biological treatment of industrial waste	M
19 08 12	sludges from biological treatment of industrial waste water other than those mentioned in 19 08 11	
19 08 13*	sludges containing dangerous substances from other treatment of industrial waste water	M
19 08 14	sludges from other treatment of industrial waste water other than those mentioned in 19 08 13	
19 08 99	wastes not otherwise specified	

Table A.1 (continued)

19 09	**wastes from the preparation of water intended for human consumption or water for industrial use**	
19 09 01	solid waste from primary filtration and screenings	
19 09 02	sludges from water clarification	
19 09 03	sludges from decarbonation	
19 09 04	spent activated carbon	
19 09 05	saturated or spent ion exchange resins	
19 09 06	solutions and sludges from regeneration of ion exchangers	
19 09 99	wastes not otherwise specified	
19 10	**wastes from shredding of metal-containing wastes**	
19 10 01	iron and steel waste	
19 10 02	non-ferrous waste	
19 10 03*	fluff-light fraction and dust containing dangerous substances	M
19 10 04	fluff-light fraction and dust other than those mentioned in 19 10 03	
19 10 05*	other fractions containing dangerous substances	M
19 10 06	other fractions other than those mentioned in 19 10 05	
19 11	**wastes from oil regeneration**	
19 11 01*	spent filter clays	A
19 11 02*	acid tars	A
19 11 03*	aqueous liquid wastes	A
19 11 04*	wastes from cleaning of fuel with bases	A
19 11 05*	sludges from on-site effluent treatment containing dangerous substances	M
19 11 06	sludges from on-site effluent treatment other than those mentioned in 19 11 05	
19 11 07*	wastes from flue-gas cleaning	A
19 11 99	wastes not otherwise specified	
19 12	**wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified**	
19 12 01	paper and cardboard	
19 12 02	ferrous metal	
19 12 03	non-ferrous metal	
19 12 04	plastic and rubber	
19 12 05	glass	
19 12 06*	wood containing dangerous substances	M
19 12 07	wood other than that mentioned in 19 12 06	
19 12 08	textiles	
19 12 09	minerals (for example sand, stones)	

Table A.1 (continued)

19 12 10	combustible waste (refuse derived fuel)	
19 12 11*	other wastes (including mixtures of materials) from mechanical treatment of waste	M
19 12 12	other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11	
19 13	**wastes from soil and groundwater remediation**	
19 13 01*	solid wastes from soil remediation containing dangerous substances	M
19 13 02	solid wastes from soil remediation other than those mentioned in 19 13 01	
19 13 03*	sludges from soil remediation containing dangerous substances	M
19 13 04	sludges from soil remediation other than those mentioned in 19 13 03	
19 13 05*	sludges from groundwater remediation containing dangerous substances	M
19 13 06	sludges from groundwater remediation other than those mentioned in 19 13 05	
19 13 07*	aqueous liquid wastes and aqueous concentrates from groundwater remediation containing dangerous substances	M
19 13 08	aqueous liquid wastes and aqueous concentrates from groundwater remediation other than those mentioned in 19 13 07	
20	**MUNICIPAL WASTES (HOUSEHOLD WASTE AND SIMILAR COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL WASTES) INCLUDING SEPARATELY COLLECTED FRACTIONS**	
20 01	**separately collected fractions (except 15 01)**	
20 01 01	paper and cardboard	
20 01 02	glass	
20 01 08	biodegradable kitchen and canteen waste	
20 01 10	clothes	
20 01 11	textiles	
20 01 13*	solvents	A
20 01 14*	acids	A
20 01 15*	alkalines	A
20 01 17*	photochemicals	A
20 01 19*	pesticides	A
20 01 21*	fluorescent tubes and other mercury-containing waste	A
20 01 23*	discarded equipment containing chlorofluorocarbons	A
20 01 25	edible oil and fat	

Table A.1 (continued)

20 01 26*	oil and fat other than those mentioned in 20 01 25	A
20 01 27*	paint, inks, adhesives and resins containing dangerous substances	M
20 01 28	paint, inks, adhesives and resins other than those mentioned in 20 01 27	
20 01 29*	detergents containing dangerous substances	M
20 01 30	detergents other than those mentioned in 20 01 29	
20 01 31*	cytotoxic and cytostatic medicines	A
20 01 32	medicines other than those mentioned in 20 01 31	
20 01 33*	batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries	A
20 01 34	batteries and accumulators other than those mentioned in 20 01 33	
20 01 35*	discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components	M
20 01 36	discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35	
20 01 37*	wood containing dangerous substances	M
20 01 38	wood other than that mentioned in 20 01 37	
20 01 39	plastics	
20 01 40	metals	
20 01 41	wastes from chimney sweeping	
20 01 99	other fractions not otherwise specified	
20 02	**garden and park wastes (including cemetery waste)**	
20 02 01	biodegradable waste	
20 02 02	soil and stones	
20 02 03	other non-biodegradable wastes	
20 03	**other municipal wastes**	
20 03 01	mixed municipal waste	
20 03 02	waste from markets	
20 03 03	street-cleaning residues	
20 03 04	septic tank sludge	
20 03 06	waste from sewage cleaning	
20 03 07	bulky waste	
20 03 99	municipal wastes not otherwise specified	

APPENDIX B

SECTORS AND SUB SECTORS OF OSTIM OIZ

Table B.1 Sectors and Sub sectors of OSTIM OIZ

Packing - Paper - Print - Stationary	Automotive
Paper and paper products	Accumulator production and sale
Plastic cardboard packing	LPG conversion systems
Packing Materials	Auto tire - tire chain
Stationeries for school and office	Auto sale and service
Publication and printing facilities	Auto Scissors Chassis Trailer Production and Repair
Various Commercial Activities	Vehicle mounted equipment producers
Household appliances	Mineral lubricant, filter and fuel oil
Stores and boutiques	Automotive sub-industry manufacturers
Hunting and Fishing Gear	Auto spare part and accessories
Restaurants	**Plastics & Rubber**
Market-tea shop-buffet	Rubber industry
Other	Plastic injection
Electric-Electronics	Polyurethane material
Illumination equipments	Composite products
Electric works-equipments	Plastic products
Electronic control systems - equipments - automotion	Plastic mould
Electric transmission and distribution equipment	**Health**
Electrical machine and equipment	Medical devices
	Medical services
	Medical equipments and disposables
Food	**Technical Tools, Benches and Equipments**
Industrial kitchens	Production and sale of gear and reducer
Food machines	Welding materials
Food materials	Bearing, felt, V-belt
Meal factories	Tool benches
Service	Wire Brush and Equiqments
Certification-quality control	Electrical and mechanical tools
Society - foundation - cooperative	Fitting, hose production and sale
Finance and accounting	Technical hardware and bolt
Shipment, cargo, rescue	Electrical small tools
Advertisement and agency services	**Construction Machines**
Consultancy services	Construction machines repair, maintenance services
Real estate	Construction machines spare part production
Engineering services	Construction machines spare part trade
Marketing - organization	Construction machines trade - rental

Table B.1 (continued)

Urban Furnitures and Landscape
Environmental arrangement-landscape
Park-garden equipment
Play gardens and playgrounds
Sport facilities and equipment
Chemicals
Paint production and sale
Cosmetics
Fire extinguisher chemicals and security
Production and sale of various gases
Cleaning materials
Machine and Machine Equipments
Asphalt machines, plants and equipments
Hydraulic pneumatic systems
Conveyors and systems
Mining and cement industry machines
Water purification, drilling and water pump systems
Weighting systems
Tree prosseser machines
Air pressure systems / compressors
Welding machines
Laboratory testing devices
Marble tile and granite machines
Agricultural machines, tools and spare parts
Machine production and sale
Machine and Machine Equipments
Textile and Leather
Bag-shoe manufacturers
Garment and accessories
Tent and canvas works
Personnel safety equipments
Technology and Informatics
Alarm and guard systems
Computer sale and service
Network systems
R&D and engineering services
Communication devices
Software, informatics and computer programs

Metal and Metal Treatment
Sale of iron and steel products
Casting, modeling and forging works
Expanded metal products
Metal decoration
Metal die work
Stainless steel
Metal cutting
Surface treatment
Saw sale and wearing
Metal and Metal Processing Materials
Iron joinery
Forged iron decoration
Sandblasting and heat treatment
Metal goods
Metal coating
Sheet cutting, bending and pres
Grinding
Non-ferrous colored metals
Steel and steel extrude products-steel rope
Building and Construction
Elevator and crane systems
Perceptual dam equipments
Steel door and safe boxes
Ventilating, heating and cooling systems
Construction materials production and sale
Scaffold, mould and prefabricated construction systems
Central heating boilers, tank and silo systems
Furniture and decoration
Wired fence and fence systems
Fire brick, refractor material
Glass - ceramic materials
Steel construction
Construction machines production and spare parts
Civil engineering
Isolation and insulating
Marble tile, granite works
Pvc and aluminium
Road equipment-traffic control systems

APPENDIX C

SECTORAL INFORMATION

C.1 Casting of ferrous metals

The casting of metals is an essential sector for various sectors. In fact, automotive, general engineering, and construction sectors are the major sectors in which casted products are mainly used.

Generally casting of metals can be divided into two main groups which are;

- *the casting of ferrous materials* such as lamellar cast iron, malleable and nodular iron, steel and
- *the casting of non-ferrous materials* such as aluminum, magnesium, copper, zinc, lead and their alloys [26].

Another classification of this sector can be also made according to molding types as lost or permanent molds. Lost molds (sand casting) are mostly used in ferrous casting, whereas non-ferrous foundries generally use permanent molds (die-casting) [26]. Moreover, investment casting and lost foam casting are also different techniques in which temporary patterns made from wax or foam can be used. [41]

Lamellar iron (carbon in the form of flakes), nodular iron (carbon in spheroidal form), and compact graphite iron (carbon in bonded form) are main types of raw

material for iron casts which depends on the form and the amount of the carbon (2,4 - 4 % carbon) in iron-carbon alloy [26].

Moreover, the terms used for different types of cast iron are grey iron (lamellar, nodular and compact graphite iron with a grey surface), ductile iron (nodular cast iron with an increased ductility), and malleable iron (less carbon containing iron that is more extendable and easily shaped) [26].

Flow diagram of metal casting is demonstrated in Figure C.1. As it can be seen from Figure C.1 that pattern making, metal melting and treatment, mold production, casting, cooling, shake-out and finishing are the main processes of this sector.

In pattern making, patterns are usually made of metal, plastic, wood or plaster materials and shaped as identical with products that will be casted. Patterns are used in the preparation of lost molds.

The molten metal is poured into molds for outer shape of castings; on the other hand, core is used for defining inner spaces of casting products. In ferrous casting, chemically bonded, clay-bonded or unbonded molds and cores are generally made of sand, especially silica sand. In addition to this, bentonite, resins, coal dusts and iron oxide are the most widely used binders and materials in lost core and mold preparation [27].

As in the case of casting with lost molds, sand, ceramic, shell, plaster, and precious moldings are usually used. On the contrary; metal, pressurized, blow, continuous moldings are the main types of molds while casting with permanent molds [26].

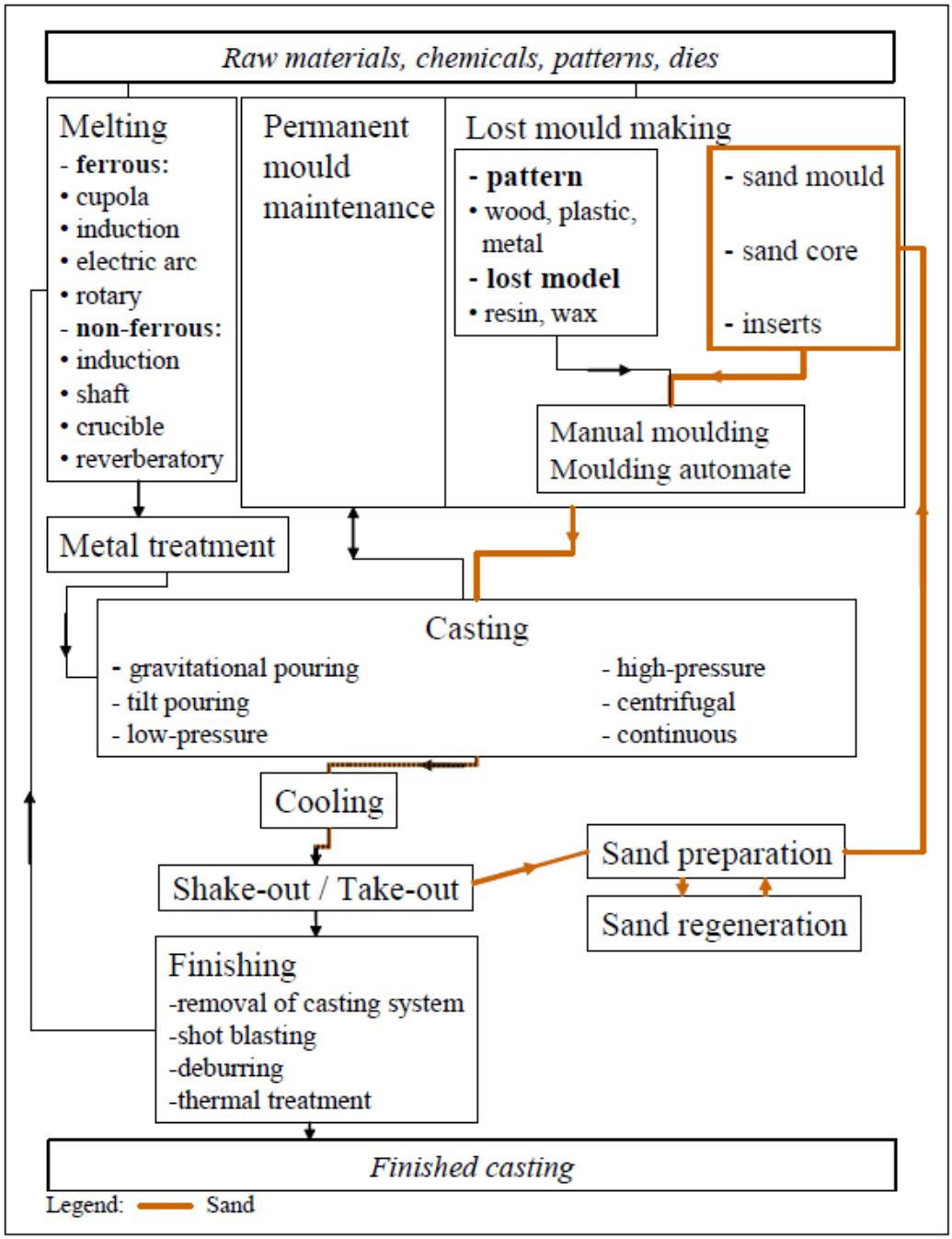

Figure C.1 Metal casting [26]

Preparation of molds and cores with chemically-bonded sand consists of **cold-setting processes** (i.e. phenolic, acid catalysed - Furan, acid catalysed – Polyurethane, etc.), **gas-hardened processes** (i.e. Cold-box, Resol – ester - SO_2 hardened furan resins - SO_2 hardened epoxy/acrylic - CO_2 hardened sodium silicate (water glass) - CO_2 hardened alkaline phenolic), and **hot curing processes** (Hot-box - phenolic and/or furan based - Warm-box - Shell (Croning) - Linseed oil - Alkyd oil, baked) [27].

On the other hand, a naturally bonded sand (green sand) mold mixture contains silica, bentonite clay, carbonaceous material and water [41].

Next, lip and teapot ladles are generally used in pouring of molten metal into prepared molds. Moreover, pouring, solidification (1^{st} cooling), shake-out and casting (2^{nd} cooling) are the sub-processes of casting in lost molding [27].

The last step in casting is finishing process which includes removal of the running system (via grinding, cutting, sawing), removal of sand, removal of pouring burrs (via grinding, tumbling), repair of casting errors and preparation of the casting for mechanical post-treatment, assembly, thermal treatment and coating [27].

In production processes various materials are used and different environmental factors are observed in foundries. In fact, Figure C.2 summaries all possible inputs and outputs related to metal foundries.

In foundries, furnaces used in metal melting can be classified into two main groups depending on their fuels as electrical and fueled. In arc and induction furnaces electricity is used as fuel, whereas in fueled furnaces (e.g. Cupola or ladle) liquid (oil), gaseous (natural gas) or solid fuels (coal) can be used [27].

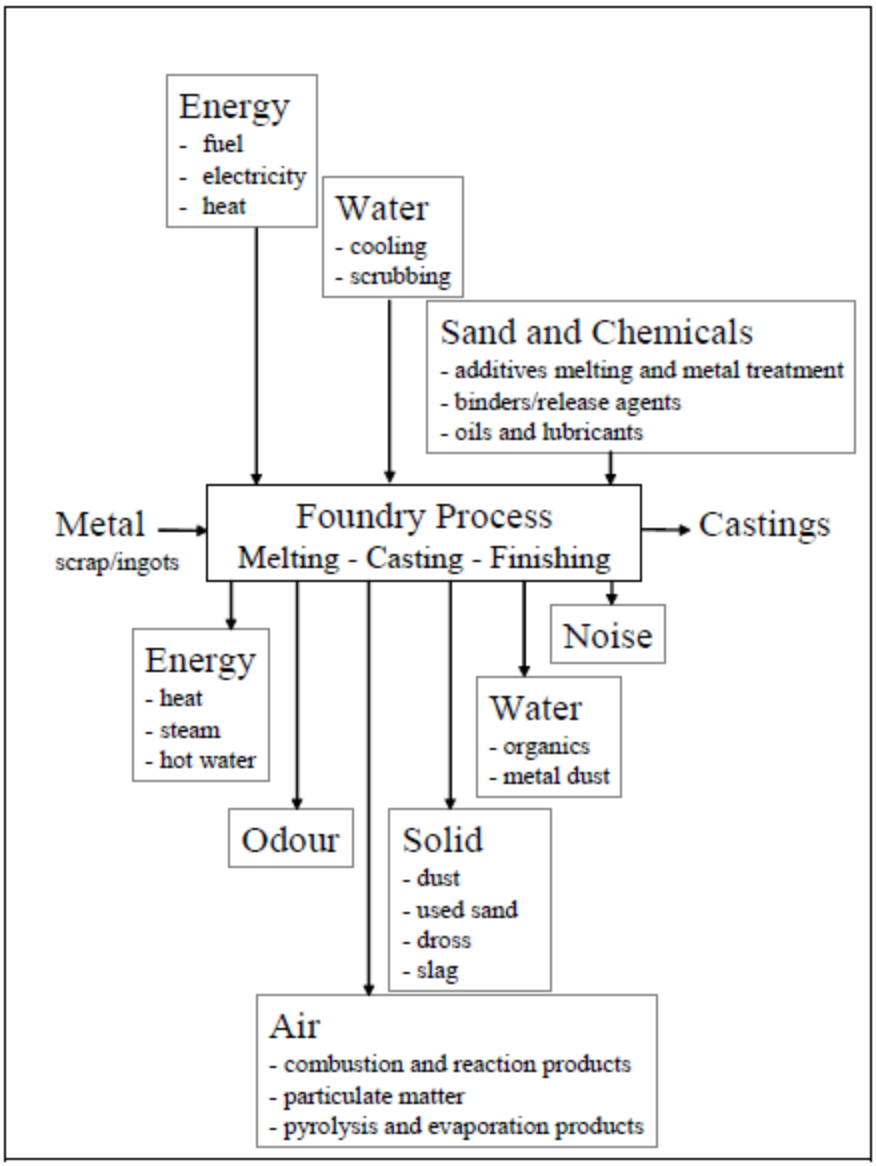

Figure C.2 Inputs and outputs from metal foundries [26]

While operating induction furnaces, metal is melted by heat produced as a result of electrical resistance from a strong magnetic field [26]. General description of an induction furnace is given in Figure C.3.

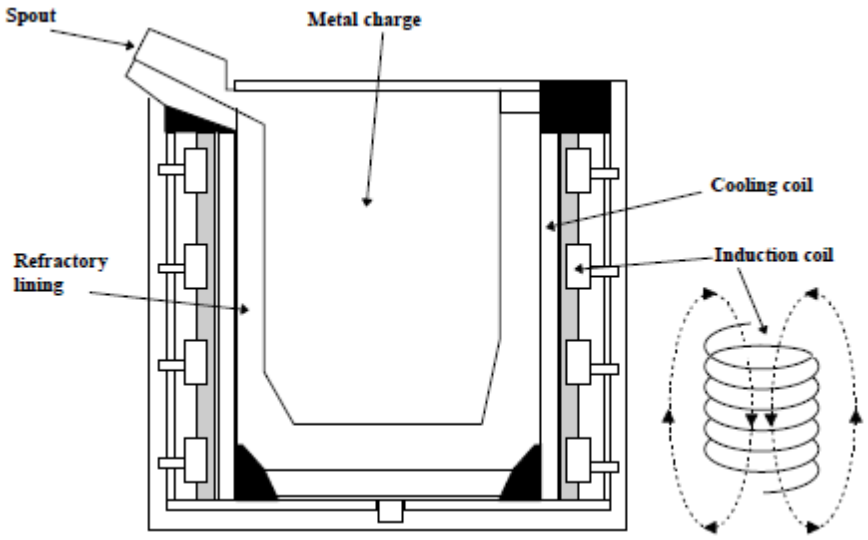

Figure C.3 Induction furnace [41]

C.2 Metalworking Industry: Machining

Main processes in metal sector can be categorized in three main groups as metal fabrication, metal preparation, and metal finishing [30]. This section describes the major industrial processes within the metal fabrication (metalworking) industry, including the materials used and the processes employed.

General flow diagram for metalworking industry is depicted in Table C.1. In Table C.1, it can be observed that the order of unit operations may vary from one manufacturer to the other in this sector. Moreover, possible inputs and outputs are also given for each process in the flow diagram.

In order to improve physical properties of metals, **heat treating** or **cold pressure** methods are used. **Shearing, forming,** and **machining processes** are the main types of shaping processes of metals [42].

Table C.1 Unit Processes, Inputs, and Outputs of Metalworking Industry [42]

Other Input Materials	Metal Stock Materials ↓	Waste Materials
cutting fluids, hydraulic fluids, lubricants, cooling fluids, (cleaning solutions, acids and alkalis from previous cleaning operations)	**Shaping Operations (shearing, forming, machining)**	cutting fluids, hydraulic fluids, lubricants, cooling fluids, (cleaning solutions, acids and alkalis from previous cleaning operations)
	↓ ↑	
abrasive media, acids, alkalis, water, solvents, emulsifying agents, surfactants	**Surface Preparation (solvent degreasing, emulsion cleaning, acid cleaning, alkali cleaning, stripping)**	Volatile solvents, acid fumes, waste solvents, metal bearing, wastewater, solvent still bottoms, wastewater treatment sludges
	↓ ↑	
flux, non-ferrous and ferrous metal filler rods, heavy metals, cutting fluids, solvents, water, compressed gas	**Bonding Operations (welding, brazing, soldering, adhesive bonding)**	Metal fumes, organic vapors, metal slag, waste flux, metal bearing rinsewater
	↓ ↑	
Water, brines, heavy metals, cyanide, oils, compressed gases, carburizing compounds, carbonitriding compounds, nitriding compounds	**Heat Treatment (hardening, tempering, annealing, normalizing, case hardening, flame hardening, induction hardening)**	Waste oils, spent quenchants, spent baths, volatile organics, metal and cyanide bearing wastewater, metal fumes
	↓	
Polishing compounds, acids, alkalis, water	**Surface Treatment (etching, polishing)**	Polishing sludges, etching sludges, metal bearing wastewater, acid fumes, metal fumes, polishing powders, metal bearing dust, spent etchants
	↓ Finished product	

Shearing processes such as **piercing, punching, blanking,** and **trimming** include shaping of metals into required forms by cutting or opening spaces into materials. On the other hand, **bending, extruding, drawing, rolling, spinning,**

coining, and **forging** are basic types of forming processes in which metal is reshaped without cutting. In addition to this, **drilling, milling, turning, shaping, sawing,** and **grinding** are well-known machining processes in which metal pieces are reshaped in special machines and via special equipments by producing small metal residues [42].

Metalworking fluids are used in machining operations to decrease negative effects from friction and heat generated in cutting processes. Mineral oils, natural oils, synthetic lubricants and compounded fluids are the most widely used types of metalworking fluids in this sector [42].

Moreover, these fluids enable to keep temperature of working surfaces in control, decrease friction and vibration by lubricant, clean working place by sweeping metal grindings or residues and prevent metal surfaces from corrosion or surface oxidation [42].

C.3 Treatment and coating of metals

Treatment and coating of metal surfaces is generally applied between manufacture of metals and assembly, finishing, and packaging of final product. Surface treatment of metals is made in order to enhance surface properties, improve hardness and wear resistance, and prevent from corrosion. Moreover, due to these advantages automotive and transportation, building and construction, and packaging are main sectors in which applications of surface treatment are widely used [34].

In general surface preparation and cleaning, surface finishing, and rinsing are the main processes of treatment and coating of metals. In Table C.2, most widely

used types of main processes in treatment and coating of metals are summarized.

Table C.2 Types of main processes in treatment and coating of metals [2]

Main process	**Types of processes**
Surface preparation and cleaning	• *Abrasive blasting* • *Degreasing* • *Soaking in alkaline cleaners* • *Acid cleaning and pickling* • *Electro cleaning* • *Ultrasonic cleaning*
Rinsing	• *Flowing* • *Stagnant* • *On-demand* • *Cascade rinses*
Surface finishing	• *Electroplating* (Nickel, copper, zinc, silver, cadmium plating) • *Anodizing* • *Chemical conversion coating* (chromating, phosphating, metal coloring, passivating) • *Immersion plating* (aluminum, copper alloys, steel, brass, bronze, cadmium, copper, gold, lead, nickel, palladium, rhodium, ruthenium, silver, tin, and zinc) • *Electroless plating* (nickel plating) • *Painting* (solvent spray, electrostatic spray, dipping/flow methods) • *Hot dip galvanizing* (zinc)

In addition to this, inputs and outputs as air emissions, wastewater, and solid wastes from these processes are tabulated in Table C.3.

Table C.3 Inputs and outputs from main processes in treatment and coating of metals (adapted from [44])

Processes	Inputs	Outputs		
		Air emissions	Process wastewater	Solid waste
Solvent degreasing and emulsion, alkaline, and acid cleaning	Solvents, emulsifying agents, alkalis, and acids	Solvents: from solvent degreasing and emulsion cleaning	Solvent, alkaline, and acid wastes	Ignitable wastes, solvent wastes, and still bottoms
Anodizing	Acids	Metal-ion-bearing and acid mists	Acid wastes	Spent solutions and wastewater treatment sludges, and base metals
Chemical conversion coating	Metals and acids	Metal-ion-bearing and acid mists	Metal salts, acid, and base wastes	Spent solutions and wastewater treatment sludges, and base metals
Electroplating	Acid/ alkaline solutions, heavy metal bearing solutions, and cyanide bearing solutions	Metal-ion-bearing and acid mists	Acid/ alkaline cyanide and acid waste	Metal and reactive wastes
Electroless plating	Metal salts, complexing agents, and alkalis	Metal-ion-bearing mists	Cyanide and metal wastes	Cyanide and metal wastes
Other metal finishing techniques (including polishing, hot dip galvanizing, and etching)	Metals and acids	Metal fumes and acid fumes	Metal and acid wastes	Polishing sludges, hot dip tank dross, and etching sludges

Electroplating (Galvanizing)

Electroplating is one of the widely used surface coating method and can be defined as coating of a metal surface with a thin protective layer using electrochemical processes [43]. As it is demonstrated in Figure C.4, electric current is applied in process baths (electrolysis) and one of the electrodes called as cathode becomes negatively charged, whereas the other one called as anode becomes positively charged. The cations in the electrolyte will move towards the cathode, thus metals ions (M^+) are reduced to a metallic state (M) and stick on the metal being plated (Eqns 1,2,3,4). Therefore, in electrolytic baths the object to be plated serves as cathode and the anode is used as a plating material [34]. In addition to this, brass, cadmium, copper, chromium, nickel and zinc are most widely used metals and alloys in this type of plating [43].

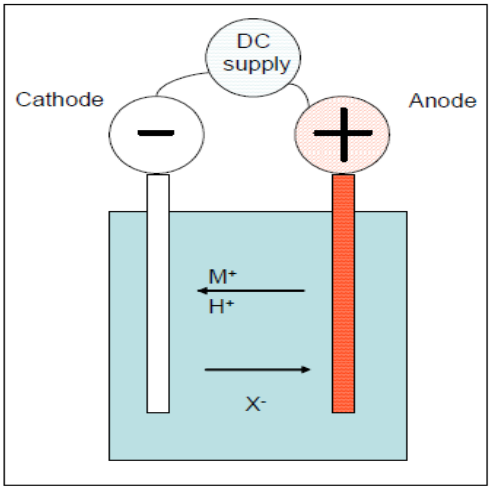

Figure C.4 Description of electrolytic baths [34]

Reactions in acid solution can be given as [34]:

anode reaction: $2H_2O \rightarrow 4H^+ + O^2 \uparrow + 4e^-$ *Electrolysis of water* (C.1)

cathode reaction: $M^+ + e^- \rightarrow M \downarrow$ *Reduction to metal* (C.2)

On the other hand, reactions in alkali solution are:

anode reaction: $4OH^- \rightarrow O^2 \uparrow + 2H_2O + 4e^-$ (C.3)

cathode reaction: $M^+ + e^- \rightarrow M \downarrow$ (C.4)

As it is demonstrated in Figure C.5, pretreatment (cleaning, degreasing, and other preparation steps), plating, rinsing (if required passivating) are main processes involved in electroplating [28]. Main inputs and outputs for each electroplating process are also depicted in Figure C.5.

Barrel plating (for small and numerous workpieces) and rack plating (for bigger particles by hanging) systems are used in electroplating [42]. In addition to this, in electrolytic zinc plating there are three main methods of electroplating which are **acid zinc, alkaline zinc, and cyanide zinc** plating. Moreover, electrolytic zinc plating is followed by *chromic or chromatising passivation process (blue, green, yellow or black)* in order to further increase of resistance to corrosivity [30].

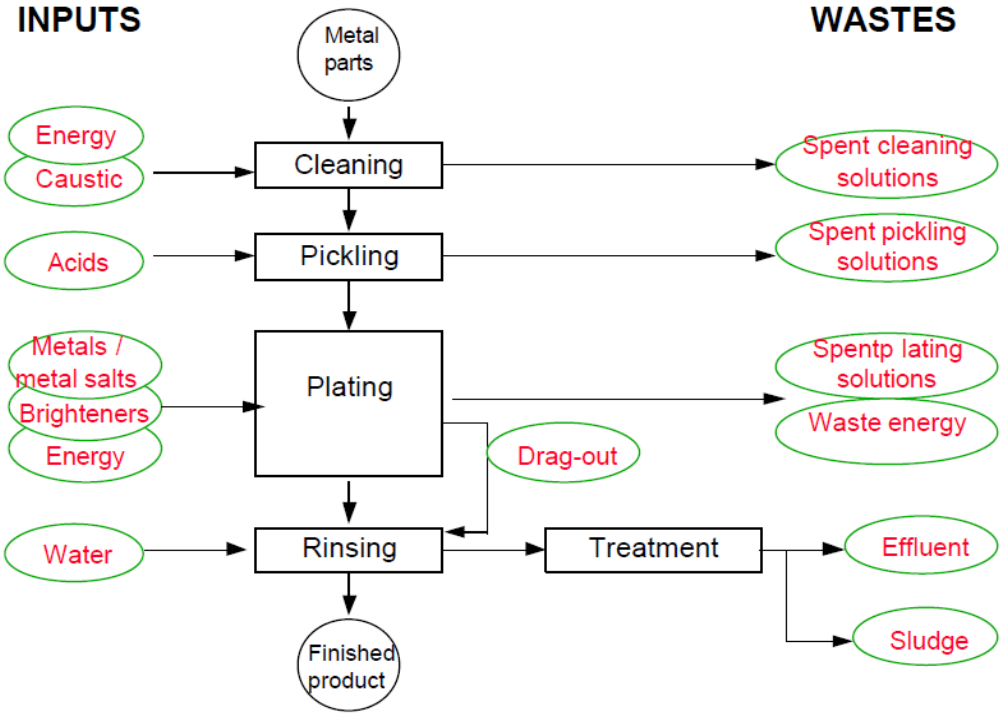

Figure C.5 Inputs and outputs for electroplating process [30]

Hot dip galvanizing

Providing more qualified solutions for protection of steel from corrosion, galvanizing is a non-electrolytic coating process in which the coating metal (zinc) is alloyed to the prepared steel surface [30].

Hot caustic degreasing, pickling, flux coating, hot dip coating at 450 ^{o}C and rinsing are main processes involved in hot dip galvanizing. Main inputs and outputs for these processes are given in Figure C.6.

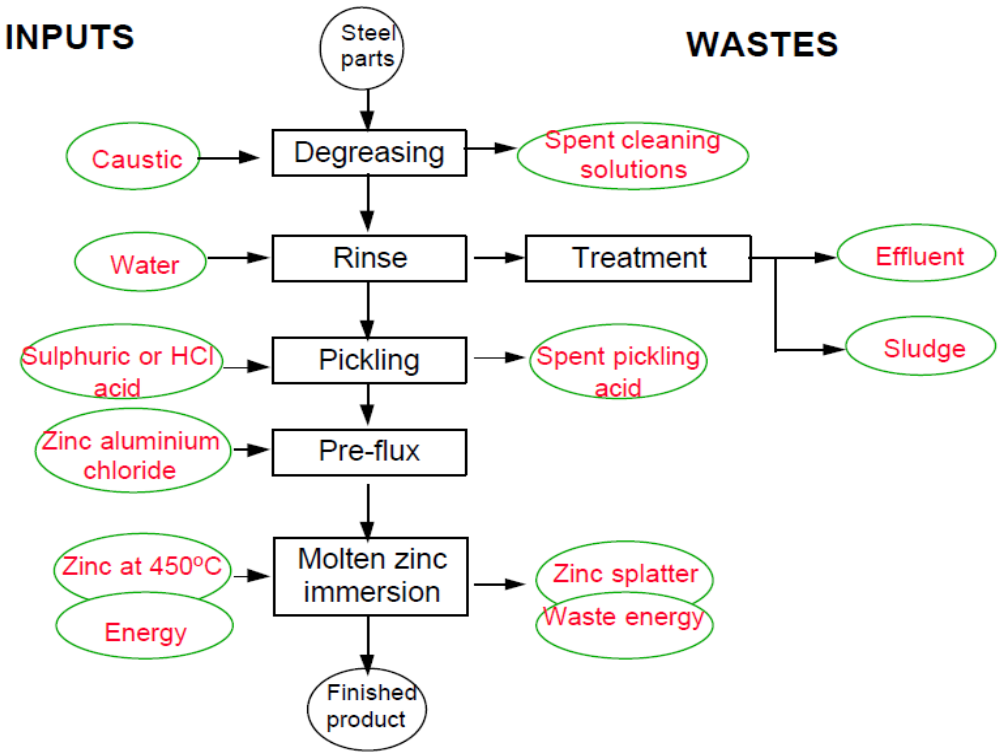

Figure C.6 Inputs and outputs for hot dip galvanizing process [30]

C.4 Maintenance and Repair of Motor Vehicles

Automotive repair shops, new car dealerships, and diesel engine repair shops are the most important components of the automotive repair industry [36].

Replacement of automotive fluids (e.g. motor oil, radiator coolant, transmission fluid. brake fluid), replacement of non-repairable equipment (e.g. brake shoes/ pads, shocks, batteries, belts, mufflers, electrical components, water pumps), and repair of fixable equipment (e.g. brake calipers/rotors/drums, alternators, fuel pumps, carburetors, power train components) are the main processes in maintenance and repair of motor vehicles [36].

For better visual inspection of the parts and removal of contaminated lubricants/greases, cleaning is also a necessary activity in automotive repair shops. Depending on customer needs and type of breakdown or accident, repairable parts are usually changed with new parts and non-repairable parts are sold to automotive part manufacturers [36]. Major polluters of auto repair shops are given in Table C.4.

Table C.4 Major pollutants of auto repair shops [36]

Operation	Waste Material	Pollutants
Shop Cleanup	Outdated supplies	Solvents, caustic cleaners, automotive (oils, alcohols, ethylene, glycol, acids)
	Dirty rags and sawdust	Oil and grease, heavy metals solvents
	Alkaline floor cleaner	Caustics, oil and grease, heavy metals
	Clarifier sludge	Oil and grease, heavy metals
Parts cleaning	Solvents	Petroleum distillates, aromatic hydrocarbons, mineral spirits, naphtha, chlorinated compounds, oil and grease, heavy metals
	Air emissions	Petroleum distillates, aromatic hydrocarbons, mineral spirits, naphtha, chlorinated compounds, oil and grease, heavy metals
	Aqueous cleaners	Adds and alkalis, oil and grease, heavy metals, blended heavy oils
	Dirty baths	Adds and alkalis, oil and grease, heavy metals, blended heavy oils
Auto maintenance	Motor oil	Blended mineral oil, heavy metals
	Transmission fluid	Blended mineral oil, heavy metals
	Engine coolant	Ethylene, glycol, lead
	Batteries	Sulfuric acid, lead
	Brakes	Asbestos
	Refrigerant	CFC-12

C.5 Manufacturing of Rubber Products

Generally, as it is illustrated in Figure C.7, processing and manufacturing of rubber are the two different parts of Rubber Industry.

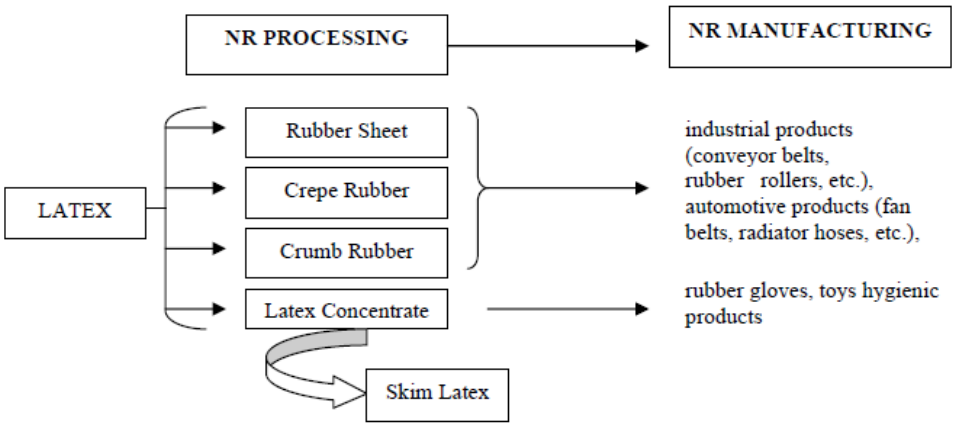

Figure C.7 Discrimination of the two terms: "NR processing" and "NR manufacturing"

Manufacturing of rubber products is a sector which uses raw materials from natural, synthetic or regenerated rubber processing for different applications in various industries such as *automotive* (e.g. tyres, V- belts, O-rings, etc.), *building and construction* (e.g. bridge bearings, parts of dams, flooring and roofing materials, etc.), *agriculture* (e.g. harness, collars, horse-shoes, tyres of agricultural machinery, etc.), *clothing* (e.g. footwear, underwear, textile, etc.) and also *health* (as latex goods in medicine and surgery e.g. draw sheets, gloves, finger stalls, etc.).

Natural rubber (NR), chemically named as polyisoprene, consists of caoutchouc or latex, which is obtained from the sap of the rubber tree, Hevea Brasiliensis. Styrene-butadine-rubber (SBR), ethylene-propylene (EP), nitrile (NBR) and butyl

rubbers (IIR) are the different types of synthetic rubber produced by means of polymerization processes from mineral oil.

There are various processes included in manufacturing of rubber products depending on the type of raw material used and specifications of product that will be formed. Various processes of rubber manufacturing are presented in Figure C.8 and described briefly below.

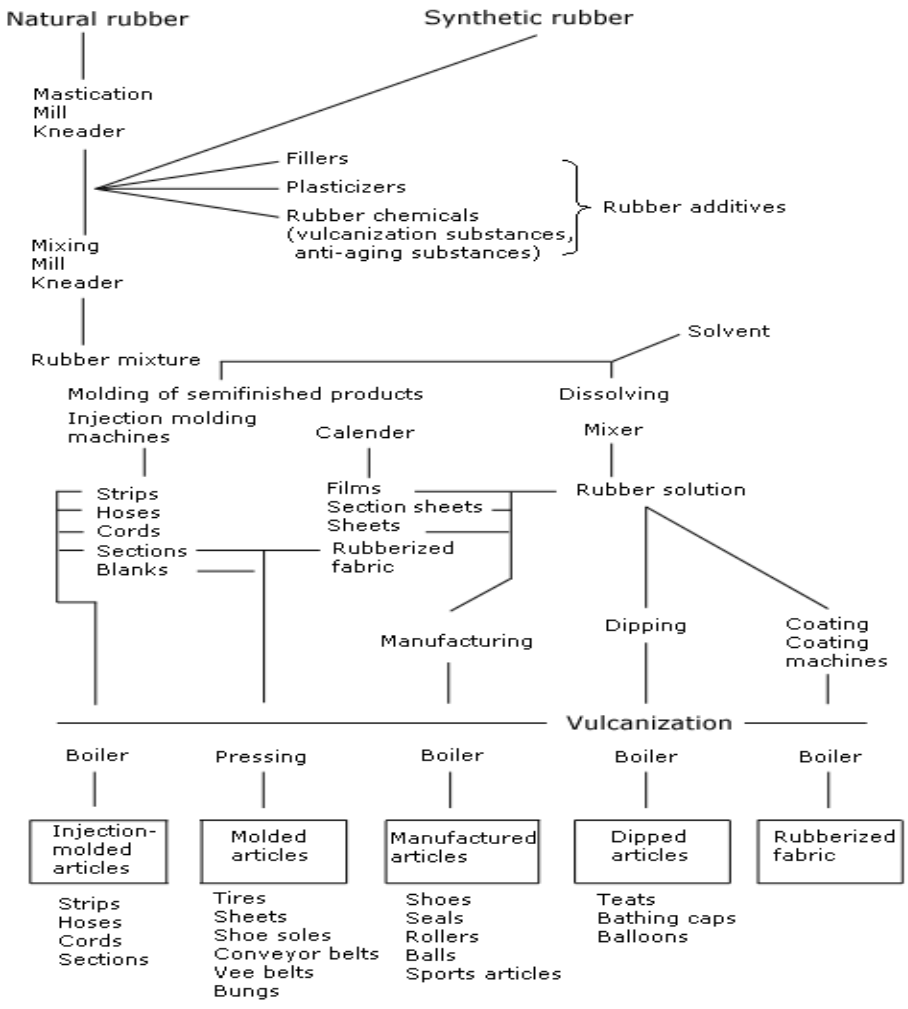

Figure C.8 General Process Flow Diagram of Manufacturing of Rubber Products

According to the Figure C.8, it can be observed that *preparation of rubber mixture (mastication and mixing), molding*, and *vulcanization* are the main processes in manufacturing of rubber products.

As a preliminary stage to processing the raw rubber, *mastication* is a process in which special mechanical equipment and special additives are used for improvement of the plasticity and reduction of the viscosity.

In *mixing process*, different types of fillers, plasticizers and rubber chemicals are used to form a homogeneous mass in mills or closed kneaders. In fact, polymers, activators, fillers (carbon black), anti-degradants, plasticizers, accelerators, vulcanization agents and other materials such as processing aids, fire retardants, colorants and blowing agents are the main components that may be used in different types of rubber products [32].

Depending on the type and different shapes of the rubber products, there are different steps in *moulding process* including injection moulding, calendering, pressure molding and extrusion.

In *vulcanization process*, the rubber is heated under pressure for some time for conversion of rubber molecules into network of cross links by the help of vulcanizing agents. This process is an irreversible process by changing the state of rubber from thermoplastic to the elastic. Pressure vulcanization in which pressure and heat is used and free vulcanization in which hot air, steam, `salt baths' or microwave systems are used are the two methods of vulcanization [32].

APPENDIX D

SAMPLE CALCULATIONS FOR HWGFs AND SECTORAL HW GENERATION

D.1 Sample Calculation for HWGFs

In this section, a general equation (D.1) for calculation of HWGFs is given and a sample calculation for HWGF of 10 09 07 coded HW (casting cores and moulds which have undergone pouring containing dangerous substances) is demonstrated.

$$\mathbf{HWGF} = \text{annual amount of HW } \left(\frac{\text{kg or item of waste}}{\text{year}}\right) / \text{ annual capacity } \left(\frac{\text{ton}}{\text{year}}\right) \qquad \textbf{(D.1)}$$

For pilot plants C.1 and C.2, HWGFs are;

$$\boldsymbol{HWGF1\ for\ 10\ 09\ 07} = 180\,000 \left(\frac{\text{kg}}{\text{year}}\right) / 2400 \left(\frac{\text{ton of castings}}{\text{year}}\right) = \boxed{75 \frac{\text{kg}}{\text{ton of castings}}}$$

$$\boldsymbol{HWGF2\ for\ 10\ 09\ 07} = 60\,000 \left(\frac{\text{kg}}{\text{year}}\right) / 480 \left(\frac{\text{ton of castings}}{\text{year}}\right) = \boxed{125 \frac{\text{kg}}{\text{ton of castings}}}$$

D.2 Sample Calculation for Sectoral HW Generation

In section D.2, sample calculations are given for estimation of sectoral HW generation. As an example, total sectoral capacity and total sectoral HW

generation in casting of ferrous metals sector are calculated by using equations D.2 and D.3, respectively.

$$\textbf{Total sectoral capacity} = \text{number of companies in sector} \times \text{ average capacity of companies } \left(\frac{\text{ton}}{\text{year}}\right) \quad \textbf{(D.2)}$$

$$\textbf{Total sectoral HW generation } \left(\frac{\textbf{ton}}{\textbf{year}}\right) = \text{total sectoral capacity } \left(\frac{\text{ton}}{\text{year}}\right) \times \text{HWGF } \left(\frac{\text{kg or item of waste}}{\text{ton raw material processed or product}}\right) / 1000 \quad \textbf{(D.3)}$$

where, HWGF represents for sum of all HWGFs for 6-digit coded wastes in same 4-digit waste category.

Therefore, most of the sectoral HW generation results are calculated and reported as 4-digit waste categories.

Furthermore, total HW generation for ferrous metals casting sector can be calculated as follows:

There are 8 ferrous foundries in OSTIM OIZ and average capacity of a ferrous foundry can be taken as 1500 ton/year, since pilot plants, C.1 and C.2, have capacities of 2400 and 480 ton/year respectively.

$$\textbf{Total sectoral capacity} = 8 \text{ (ferrous foundries)} \times 1500 \left(\frac{\text{ton}}{\text{year}}\right) = \boxed{12\,000 \left(\frac{\text{ton}}{\text{year}}\right)}$$

$$\textbf{Total sectoral HW generation } \left(\frac{\textbf{ton}}{\textbf{year}}\right) = 12\,000 \left(\frac{\text{ton}}{\text{year}}\right) \times [75 - 200] \left(\frac{\text{kg}}{\text{ton castings}}\right) / 1000 = \boxed{[900 - 2400] \left(\frac{\text{ton}}{\text{year}}\right)}$$