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Report of the Meeting to review Lead batteries ESM Guidelines, Bratislava, March 2014

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MEDITERRANEAN ACTION PLAN

Regional workshop of experts to review Lead Batteries´ Environmentally Sound Management Guidelines

18-19 March 2014, Bratislava, Slovak Republic

Report of the Regional workshop of experts to review Lead Batteries´ Environmentally Sound Management Guidelines

UNEP/MAP
Athens, 2014

Table of content

Report of the meeting

At the kind invitation of Basel convention Regional Centre in Bratislava, UNEP/MAP Secretariat convened a meeting with participation of experts nominated by the Contracting Parties to the Barcelona Convention and its Protocols on environmental sound management of lead batteries in the Mediterranean. This workshop was held in the framework of MedPartnership project and UNEP/MAP PW 2014–2015 adopted by COP18 of the Contracting Parties. The objective of the meeting was to review, discuss, and finalize the proposed draft practical guideline on the environmentally sound management of used lead batteries in the Mediterranean region.

The Meeting was held at the Hotel Premium, Bratislava, Slovak Republic from 18 to19 March 2014.

The workshop was attended by participants from the following countries: Albania, Algeria, Croatia, Israel, Morocco, Montenegro, Palestine, and Tunisia. UNEP/MAP was represented by its programme MEDPOL and The Regional Activity Centre on SCP.

Agenda item 1: Opening of the meeting

1. Ms. Dana Lapešová, Director of the Basel Convention Regional Centre in Slovakia, hosted by the Slovak Environment Agency, opened the meeting and welcomed all participants. Her welcome speech was followed by welcoming remarks made by Ms. Tatjana Hema, Program Officer of MED POL-UNEP/MAP.

2. The full list of participants is attached as Annex I to the present report.

Agenda item 2: Introduction of experts and participants

3. Ms. Tatjana Hema made an introduction to the workshop. She explained that this is the 1st review meeting of the proposed guideline and the aim is to review it and incorporate all comments from participants in order to finalize the mentioned document. She pointed out that it is planned to submit the guideline at the forthcoming meeting of MED POL focal points for approval early next year as an important outcome of the MedPartnership project to UNEP/MAP and the contracting parties. She made a brief presentation of the UNEP/MAP-GEF MedPartnership project and its expected deliverables.

4. Ms. Dana Lapešová introduced workshop's experts who have prepared the working document: "Guidelines for Environmentally Sound Management (ESM) of used lead batteries", Ms. Elena Bodíková and Mr. Jaromír Manhart. She also introduced Mr. Dimitris Tsotsos a consultant at UNEP/MAP who has prepared a document: "Environmentally sound management of lead batteries in the Syrian Arab Republic: Proposals for policy reforms".

5. Immediately after all participants presented themselves and the country they have represented.

a) Election of officers

6. Following a proposal by the Secretariat the meeting agreed to nominate Mr. Khalid Lalami from Morocco to chair the meeting.

b) Adoption of the Agenda

7. The Provisional agenda contained in document UNEP (DEPI)/MED WG. 392/1, was adopted as appears as Annex II to the present report and annotated in in document UNEP(DEPI)/MED WG.392/2.

c) Organization of work

8. It was agreed that the meeting will be held in plenary.

Agenda item 3: Lead batteries ESM in UNEP and Basel Convention programme

9. Under the agenda item, Ms. Dana Lapešová provided brief information about the main aim of the Basel Convention and the Basel Convention Regional Centre's priorities and activities as well as ESM on lead batteries requested by Basel Convention. She has also provided information on different technical guidelines and guidance documents which had been worked out by Basel Convention experts and she informed about relevant decisions from last COP 11.

Agenda item 4: Lead batteries ESM and EU legislative framework, experiences and challenges of the EU Member States – Slovak and Czech Republic

10. Mr. Jaromír Manhart presented used lead batteries ESM and EU legislative framework covering waste management of batteries and accumulators. He has also introduced the Czech legal framework as well as experience and challenges of the Czech Republic.

11. Ms. Elena Bodíková immediately after introduced the situation in sector of waste batteries and accumulators in Slovakia. She also presented a non-state fund Recycling Fund and a model standard European model of Extended Producer Responsibility (EPR). She has expressed respect for cancelation of planned visit to a company recycling the batteries in Slovakia due to a recent fire accident there. A question was raised about the operation and financing of Recycling Fund and it was further clarified. A question whether Slovakia has a statistics regarding specifically illegal transport of lead batteries has also been raised. Ms. Bodíková has explained that there still were cases mainly in the southern part of Slovakia (app. 5%) where an illegal transport takes place between Slovakia and Hungary. Another question dealing with the take back system has been raised. Ms. Bodíková explained that in Slovakia there is no obligation of customer to deliver old battery in shops when you buy a new one - it is only one possibility.

Agenda item 5: Pilot project on Lead Batteries ESM in Syria

12. Mr. Dimitris Tsotsos a consultant at UNEP/MAP presented the results of the project: "Environmentally sound management of lead batteries in the Syrian Arab Republic". The presentation was focused on assessment of the situation in the region (existing environmental legislation, management systems for batteries' collection, treatment/recycling and the role/responsibilities of state institutions) and on proposals for policy/ institutional/ organizational arrangements necessary for the improvement of the existing situation. Mr. Tsotsos has explained that the second part of the project focused on implementing of proposals of policy reforms couldn't be implemented.

13. Following the presentation, the consultant highlighted the need for a complete legal/ regulatory framework on Lead Batteries ESM. Ms. Hema also pointed out that it is very

important to improve the legislation because there is usually in a considerable number of countries in place only basic legislation. In this context she suggested that it would be useful to have all countries presenting in this workshop their national systems in place with regards to ESM of lead batteries and exchange relevant experiences.

Agenda item 6: Review of Draft guidelines on used lead batteries

14. Mr. Jaromír Manhart who has introduced chapters 1, 2 and 3 (Table of contents, Preamble and Introduction) of the guidelines. Immediately after it has been followed by chapter 4 (Used lead batteries, description and production) and 5 (Overview of available standards, technical specification and guidelines on the storage and treatment of batteries and accumulators). Mr. Manhart gave a quick overview of main definitions regarding a rechargeable battery, storage battery, or accumulator (ACCU) in guidelines as well as its description. He also has pointed out at environmental and health aspects in ACCU guidelines described main sources of waste lead batteries and stated some estimation of amounts produced used lead batteries as well as sources of waste lead ACCUs. The presentation continued with overview of available standards, technical specification and guidelines on the storage and treatment of batteries and accumulators mentioning several Best Available Techniques Reference Documents (BREFs), best available techniques (BATs) and Base Erosion and Profit Shifting (BEPs).

15. When reviewing the text of the guideline a question regarding Pre-treatment has been raised what it is and where it can happen. It has been discussed that it contains everything that happens before actual treatment of lead battery. A comment has been stated that due to differences between countries it might be important. After the discussion a proposal to leave the Pre-treatment has been placed, however, it should not be described in such a detail.

16. The afternoon session continued with presentation of Ms. Bodíková who has introduced chapter 6 (Collection, transport and storage of used lead batteries). In her presentation she has introduced a lifecycle of lead B&A, proposed classification of waste B&A, means of transport and storage of used batteries.

17. A question regarding proposed collection yards in the municipalities have been raised by Morocco, whether it is necessary to have them established. Participants explained that in their country one cannot find a battery as a part of the municipal waste as it has a value and can be sold. Ms. Bodíková explained that it is not an obligation (although it should be an obligation due to the environmental protection requirements), but considering the situation in particular country, every country could decide about the best way to deal with this particular issue. Furthermore, considering the situation in Morocco-possibly applicable in several countries, when reviewing the text of the guideline the proposition was made to incorporate into the text that throwing batteries into municipal waste is a wasting of economic resources. The issue of transport has also been discussed. Whether to incorporate into the guideline the transport with the permission or without (transport under certain conditions). The participant from Croatia has expressed a wish to incorporate into the guideline a part dealing with permits for transport. (structure and examples). Also an explanation to a request regarding needs for and ways of suitable packaging has been given using pictures in a guideline.

18. Mr. Manhart gave the presentation on the treatment of used lead batteries, stating the main reasons for the treatment, as well as, describing closely processes of recovery or disposal operations with used lead batteries, including preparation prior to recovery or disposal. Mr. Manhart also touched the issue of hazards that must be taking into account when the treatment of ACCU takes place. He has introduced facilities for treatment and mentioned steps to be made prior to recovery process. A request to incorporate part dealing with workers protection during the process has been made and it has been agreed by speakers to do such. When

reviewing the text the words" General treatment" or "Possible treatment" should be used on page 30 of document UNEP (DEPI)/MED WG. 392/3.

19. Mr. Manhart made a presentation on recovery of used lead batteries. A definition and steps of recovery have been presented followed by examples of possible pre-treatment processes, description of smelting process followed by detailed description of recovery process.

20. A question how to fill in the incinerator avoiding the dust that has been raised by the floor, in response it was explained the importance of the filter system. Two methods of incineration have been presented (continuous and batch). A participant from Morocco pointed out that one of them creates exceeding amounts of hazardous emissions, mentioning also their impact to the environment and the fact that this negative impact is not sufficiently stressed - he would like to incorporate it into the guideline. A participant from Israel stated a question of clarification if the guideline is for treatment of ACCU. Mr. Manhart has explained that the guideline should serve authorities when giving the permissions to companies dealing with ACCUs where ACCUs is a waste. A participant from Morocco has pointed out that the better way to treat the ACCU is breaking as a plastic could also be recovered. Mr. Manhart agreed, however, he explained that in some countries a market for H_2SO_4 or for parts recovered in the process (polypropylene) is missing and proposed to include in guideline that such a method exists, but it is not the best one considering the environment. A participant from Tunisia commented that recovered plastic is not valuable enough. He also introduced the method of treatment of ACCU by changing the electrolyte. Mr. Manhart has explained that such a method is out of the scope of this guideline as the ACCU in this case is not a waste but a valuable product. Furthermore the tables describing limits have been discussed. Mr. Manhart has explained that they vary and depend on countries legislation and proposed to prepare comparisons with EU legislation as well as BREF. Mr. Tsotsos has proposed to leave them in the guideline as an example with the comment that every country should adopt their own limits to be stricter or loser if desirable. A participant from Croatia requested to put some more pictures on page 35 describing the process of feeding and the temperatures connected to the issue. (5 points). A participant from Morocco has further requested describe the nature of combustion and output products. It has been agreed that the speakers will connect it to the BREFs. The Chair has stressed that he would like to focus reader's attention, mainly authorities - often not experts in the field, to consider carefully the permitting process. Mr. Manhart agreed and explained that this was the main reason why it has been linked with BATs and BREFs.

21. Ms. Bodíková gave her third presentation on disposal of used lead batteries. In her presentation she has described the requirements for land filling and also conditions for the acceptance of residues at the landfill (as well as banned land filling of the specific dangerous waste).

22. A participant from Morocco has expressed her concern on such use of waste, as the used batteries represent dangerous waste and they can be recovered, especially lead - forming 70% of a battery and having important economical value, moreover, its reuse spares natural resources. Mr. Tsotsos commented that it should be closely described in the guideline what kinds of residues is to be land filled. A participant from Tunisia raised a question about which hazardous wastes are to be accepted at landfills and which are land filled in Slovakia. Some comments that a part describing land filling should not be covered in this guideline have been made. Ms. Bodíková explained that all waste from recycling of batteries is considered as a hazardous and most of it has to be land filled at special landfills, however, some waste that is considered to be hazardous is also biodegradable and therefore, it is has to be land filled in the way the guideline describes. In the end, it has been agreed to include in preamble of this part which final wastes can be stored at landfills and to indicate the contradictory behaviour of EU when setting up and controlling landfills. Mr. Marzouki has agreed with the disposal process, however, he suggested to avoid its description in detail.

23. Mr. Manhart`s made a presentation on transboundary movement of lead batteries. He has described in close detail the requirements of Basel Convention as well as EU regulations dealing with the transport. He also has showed some examples of bad and unacceptable techniques of packaging and storage. A participant from Albania asked for clarification on signing the consent process. It has been explained into details as well as the process of transboundary movement. A participant from Israel asked what lists apply when classifying such a waste. Mr. Manhart`s answer covered ACCUs (A 1160) and mixed BATTs (1170).

24. Mr. Manhart continued with the presentation of potential sources of environmental contamination during whole used lead batteries processes, showing some examples on pictures.

25. Presentation of guideline was closed by final input from Ms. Bodíková, who has presented the economic aspects. In her presentation she introduced and described the extended producer responsibility (EPR) principle that is preferred by the EU and of collective scheme with giving some examples from Slovakia. Some comments regarding financial guarantee has been made. It has been explained that the financial guarantee covers only functioning of the scheme, but not the actual treatment of wastes. As a remark a participant from Morocco has stated that in Morocco the principle of extended responsibility of the producers applies in the system of battery recovery. A consideration of existence of market for outputs from the process should be taken into account, as well as Ministries and authorities in each country.

26. An opinion was expressed that there is a necessity and need for legislation in the field and obligations as well as sanctions have to apply.

Agenda item 7: Discussion, conclusions, recommendations

27. After reviewing in depth the proposed draft guidelines, all countries participatory in the project namely (Albania, Israel, Morocco, Palestine and Tunisia) made a presentation of their own legal/ regulatory system of Lead Batteries ESM.

    Ms. Tatjana Hema has thanked all participants and informed them about next steps envisaged future meeting to finalize the guideline. She has encouraged them to submit any additional comment in writing on the draft guidelines until the end of March 2014. In addition she suggested the countries to present any proposal they may have for support in order to start ahead of time the implementation of key aspect of the proposed guidelines in accordance with their priorities and specificities.

28. A leaflet prepared by the Regional Centre of Bratislava on ESM of lead acid batteries has been introduced and distributed among participants.

Agenda item 8: Closure of the workshop

The Chair in his closing remarks thanked the participants for their constructive contribution to the meeting, the Regional entre of Bratislava and UNEP/MAP MEDPOL programme.

The Chair declared the meeting closed at 1 p.m. on 19 March 2014.

Annex I
List of Participants

Albania	**Ms. Ledjana Bojaxhi** Specialist Sector of Waste and Industrial Accidents Ministry of Environment Durresi Street, No.27 1001 Tirana Albania Tel: +355 4 22 56 105 e-mail: **Lediana.Karalliu@moe.gov.al** **ledjana_k@yahoo.com** **Mr. Redi Baduni** Director Directory of Environmental Protection Ministry of Environment Durresi Street, No.27 1001 Tirana Albania Tel.: +355 42 22 24 572 Mob: +355 67 20 42 259 e-mail: **redi.baduni@moe.gov.al**
Algeria	**Ms. Anya Saliha Ait Kaci** Ingenieur Base De Donnees Agence Nationale Des Dechets 11, Rue Mohamed Tazairt, BAB EL OUED ALGER Algerie Tel: +213 661510696/ +213 554844300 Fax: +21321978675 e-mail: **anyouchaanya@hotmail.fr**
Croatia	**Ms. Virna Milinov** Senior Expert Advisor Directorate for Environmental Impact Assessment and Sustainable Waste Management Minstry of Environmental and Nature protection Ulica Republike Austrije 14 10000 Zagreb Croatia Tel: +385 1 3717 206 Fax: +385 1 37 17 135 e-mail: **virna.milinov@mzoip.hr**
Israel	**Ms. Sivan Hayat** Regional hazardous substances permitting coordinator Hazardous substances department Ministry of Environmental Protection Israel 91 Herzel st.

	72100 Ramla P.O BOX 562 Israel Tel: +972-506237640 Fax: +972-8-9152143 e-mail: **Sivanh@sviva.gov.il**
Montenegro	**Mr. Pavle Durašković** Head of Environment department Environment department Institute of Hydrometeorology and seismology 4th Proleterske Brigade 19 81000 Podgorica Montenegro Tel: +382 20 655 365 Fax: +382 20 655 197 e-mail: **pavle.djuraskovic@meteo.co.me**
Morocco	**Dr. EL ABED Loubna** Service Sols et Déchets Direction de la Surveillance et de la Prévention des Risques Ministère Délégué chargé de l'Environnement 9 Avenu Al Arar Secteur 16 Hay Riad Rabat Maroc Tel : 06 63 10 32 04 Fax : 0537576645 Email : **elabedloubna@hotmail.com** **http://www.environnement.gov.ma/** **Mr. Khalid Lalami** Directeur Adjoint Direction de la Surveillance et de la prevention des Risques Ministere Délegué chargé de l´Environment 9 Avenu Al Arar Secteur 16 Hay Riad Rabat Maroc Tel.: + 212 661 348879 Fax: + 212 537 576646 e-mail: **lalami@environnement.gov.ma**
Palestine	**Mr. Amjad Kharraz** Director Environment Quality Authority Nablus office Environment Quality Authority Nablus City, West Bank Palestine Tel: +970 59 9 674 809 Fax: +970 9 2341632 e-mail: **engkharraz@yahoo.com**
Tunisia	**Mr. Abderrazak Marzouki** Deputy Director Risk Prevention General Directorate of Environment and Quality

	of Life Ministry of Equipment, Land-Use Planning and Sustainable Development Boulevard de la terre centre urbain nord 1080 Tunis Tunisia Tel: +216 70 728 644 Fax:+216 70 628 655 e-mail: **dgeqv@mineat.gov.tn**, **marzoukiabderrazak@yahoo.fr**
UNITED NATIONS ENVIRONMENT PROGRAMME COORDINATING UNIT FOR THE MEDITERRANEAN ACTION PLAN	**Ms. Tatjana Hema** Programme Officer Mediterranean Pollution Assessment and Control Programme (MED POL) Vassileos Konstantinou 48 Athens 11635 Greece Tel: +30 210 7273115 Fax: +30 210 7253196 Mobile: +30 694 5935318 e-mail: **tatjana.hema@unepmap.gr** **Mr. Dimitris Tsotsos** Consultant UNEP/MAP Delfon 5 15451 N.Psyhico-Athens Greece Tel: +30 210 6715255 Mobile: + 30 6936773334 e-mail: **tsotsosd@gmail.com**
Regional Activity Centre for Sustainable Consumption and Production (RAC/SCP, UNEP/MAP)	**Mr. Frederic Gallo** Project coordinator Regional Activity Centre for Sustainable Consumption and Production (RAC/SCP, UNEP/MAP) carrer d'Anglí, 31 3rd floor. 08017 Barcelona (Catalunya) Spain Tel.: +34 93 553 87 90 Fax: +34 93 553 87 95 Skype: fredericgallo e-mail: **fgallo@scprac.org** Web: **www.cprac.org**
Basel Convention Regional Centre	**Ms. Dana Lapešová** Head of BCRC Slovak Environment Agency Hanulova 5/D 844 40 Bratislava Slovak Republic Tel.: + 421 2 60201639 Fax: +421 2 64282683

	e-mail: **dana.lapesova@sazp.sk** **Ms. Ivana Jašíková** Junior programme manager of BCRC Slovak Environment Agency Hanulova 5/D 844 40 Bratislava Slovak Republic Tel.: + 421 2 60201638 Fax: +421 2 64282683 e-mail: **ivana.jasikova@sazp.sk**
Speakers	**Ms. Elena Bodíková** Consultant EIB Consult s.r.o. I.Bukovčana 26 841 08 Bratislava Slovak Republic Tel.: + 4212 64774940 Mobile: +421 904 128130 e-mail: **elena.bodikova@eibconsult.sk** **Mr. Jaromír Manhart** Project Manager Environmental Services Waste Management SGS Czech Republic, s.r.o K Hájům 1442 155 00 Prague 5 Czech Republic Mobile: +420 725 786 420, +420 776 278 737 Fax: +420 234 708 100 Skype: jaromir.manhart e-mail: **Jaromir.Manhart@sgs.com** **manhartjaromir@seznam.cz**

Annex II Agenda of the meeting

1. Opening remarks - UNEP/MAP MED POL and BCRC, Slovakia.
2. Introduction of experts and participants.
3. Lead batteries ESM in UNEP and Basel Convention programme (Ms. Dana Lapešová).
4. Lead batteries ESM and EU legislative framework, experiences and challenges of the EU Member States – Slovak and Czech Republic (Ms. Elena Bodikova, Mr. Jaromir Manhart).
5. Pilot project on Lead Batteries ESM in Syria (Mr. Dimitris Tsotsos).
6. Review of Draft guidelines on used lead batteries ESM (Ms. Elena Bodikova, Mr. Jaromir Manhart).
   - Collection, transport and storage of used batteries.
   - Treatment of used batteries, treatment facilities.
   - Recovery of used batteries.
   - Disposal of used batteries.
   - Transboundary movement of used batteries (legal and technical aspects).
   - Economical aspects of the ESM of used batteries.
7. Discussion, conclusions, recommendations.
8. Closure of the workshop.

Annex III Lead Batteries´ Environmentally Sound Management Guidelines

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal

Guidelines for environmentally sound management of used lead batteries

UNEP/SSFA/2013/DEPI/FMEB-MAP/076

December 2013
Prepared by Basel Convention Regional Centre Bratislava

Table of contents

Preamble

Mediterranean Action Plan (MAP) is a regional cooperative effort involving 21 countries bordering the Mediterranean Sea, as well as the European Union. Through the MAP, these Contracting Parties to the Barcelona Convention and its Protocols are determined to meet the challenges of protecting the marine and coastal environment while boosting regional and national plans to achieve sustainable development.

MAP focuses on many activities with the aim to help the parties in their effort. One of them is the Small-scale Funding Scheme. In the frame of the Scheme the agreement between United Nations Environment Programme, an international inter-governmental organization established by the General Assembly of the United Nations and represented by its Mediterranean Action Plan Coordinating Unit and Basel Convention Regional Centre in Bratislava enables to implement project with the aim to facilitate the implementation of the National Action Plans of the Mediterranean countries to cope with the environmentally sound management of used lead batteries and enforcement procedures.

Introduction

The aim of the project is to develop practical guidelines for the Environmental Sound Management of used batteries based on the Syrian experience and on the Basel Convention guidelines as well as to undertake training on their use by the other countries of the Mediterranean area. The guidelines consider the results of the previous MAP and Basel Convention activities, namely the Technical Guidelines for the Environmentally Sound Management of Waste Lead – acid Batteries by Secretariat of the Basel Convention (2003) [1] and the project UNEP held in 2011 within the activity entitled "Facilitation of the Policy and Legislative Reforms for Pollution Control of the Strategic Partnership for the Mediterranean Sea Large Marine Ecosystems" [2].

The project UNEP [2] was aimed at proposal for policy reforms in the field of environmentally sound management of lead batteries in the Syrian Arab Republic. The analysis of current situation and possibilities and challenges for Syria prepared by Dimitrios Tsotsos within the project can be summarised in next conclusions:

1. The improvement and modification of existing national legislation in Syria is necessary, however it contains a "nucleus" for waste management
2. The overall management of used lead batteries is mostly organised by the private market, as a consequence the environmentally sound management of these wastes are not met
3. The authorities face the difficulty to find out how these operations are taking place because they are elaborated by many small collectors, recyclers who are difficult to be found and controlled
4. The overall system is fragmented and not organised especially the part concerning collection / storage / recycling of used batteries
5. In cases of new investments the existing regulatory / operational procedures are adequate and allow regional / central authorities to obtain a good overview of the process to be applied
6. The factory of Syrian Company for Batteries and Liquid Gases in Aleppo can be the key unit in the country for the treatment /recycling of used lead batteries after re-organisation and replacement of old fashioned technologies by Best Available Techniques; the systematic organisation of the whole chain of management must take place
7. Measurements of emissions from lead processing sources are not conducted by the Aleppo District; therefore a clear picture about the pollution load generated from this factory does not exist
8. Ambient air quality measurements of lead have been reduced to a minimum
9. The existing reporting system between the Regional Districts and the Ministry of Environmental Affairs gives a good insight into the prevailing local conditions, however it should be slightly re-organised in order to avoid too much bureaucratic /administrative burden to the regional authorities

The main recommendation of the project is to prepare and implement the re-organisation of the whole chain of the collection, transport, storage and recycling of lead batteries in Syria. The proposals can be summarised as follows:

1. The producers / importers of lead batteries have to undertake the obligation to collect and recycle the used lead batteries. In doing so, they have to organise collective or single systems (in form of companies), which will undertake the collection, transport, storage and treatment / recycling on their behalf
2. In-plant pollution reduction measures have to be introduced in the existing lead recycling plant of the Syrian Company for Batteries and Liquid Gases in Alepppo as well as in any new plants which will eventually be installed in Syria in the future
3. For the successful implementation of the new policy the Syrian environmental authorities have to intensify the enforcement of the legislation by increasing the frequency of controls in order to minimise the illegal market of used lead batteries
4. The existing environmental legislation and institutional structures in Syria have to be modified accordingly.

In order to implement the recommendations the system of collection, transport, storage, treatment, recycling and disposal of used lead batteries in environmentally sound manner must be built in the countries. The management of used lead batteries has great negative impact on environment, in case of illegal or inappropriate handling, that is why every step of the system must be regulated to prevent environmental damage.

The guidelines have the ambition to help state authorities as well as private investors to put into praxis modern and environmental – friendly technologies that will solve the environmental problems and bring new job opportunities to Syrian market.

Among others, the aim of the guidelines are also to assist competent authorities and other stakeholders when implementing, further improving, and evaluating the efficiency of the management system on used lead batteries and accumulators. The introduced guidelines can help the authorities of the Syrian Arab Republic to prepare legal and practical conditions to implementation of the environmentally sound management of used lead batteries, as it contains practical proposals, graphs and pictures showing the good practice in the countries of the Central and Eastern Europe region.

In the following for the ease of reading, frequently only the term “batteries” is used, while in effect always “batteries and accumulators” are meant.

Used lead batteries, description and production

Definitions

Battery - any device that stores energy for later use; common use of the word, “battery”, however, is limited to an electrochemical device that converts chemical energy into electricity, by use of a galvanic cell.
Galvanic cell - a device consisting of two electrodes (an anode and a cathode) and an electrolyte solution; batteries may consist of one or more galvanic cells.
Lead battery - the electrical accumulator in which the active material of the positive plates is made up of lead compounds and that of the negative plates is essentially lead, the electrolyte being a dilute sulphuric acid solution.
Used lead battery - the battery which is no longer capable to be recharged or cannot retain its charge properly, its lifetime reaches its end and it becomes a waste.
Management of used lead batteries - the overall process of collection, transport, recovery and or disposal of used lead batteries, including the supervision of such operations
Separate collection - the gathering of used lead batteries, including the preliminary sorting and preliminary storage of used lead batteries for the purposes of transport to a treatment facility
Storage - placing of used lead batteries in the room of waste management or treatment facilities in sites with impermeable surfaces and suitable weatherproof covering or in suitable containers

Treatment of used lead batteries - means recovery or disposal operations with used lead batteries, including preparation prior to recovery or disposal
Recovery - means any operation the principal result of which used lead batteries serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy
Recycling - means any recovery operation by which used lead batteries materials are reprocessed into products, materials or substances whether for the original or other purposes
Fractions of used lead batteries – material parts and pieces produced from treatment of used lead batteries and relevant by-processes of used lead batteries
Disposal - means any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy

Description of a lead battery

A battery mainly consists of electrodes (two plates, made from lead) placed in an electrolyte solution (sulphuric acid). The metal in the anode oxidises releasing negatively charged electrons and positively charged metal ions. The electrons travel from the anode to the cathode. The electrons combine with the material in the cathode through reduction and release a negatively charged metal – oxide ion. When the anode is fully oxidised or the cathode is fully reduced, the chemical reaction will stop and the battery is considered to be discharged. The schematic description of a lead battery is shown in Figure 1.

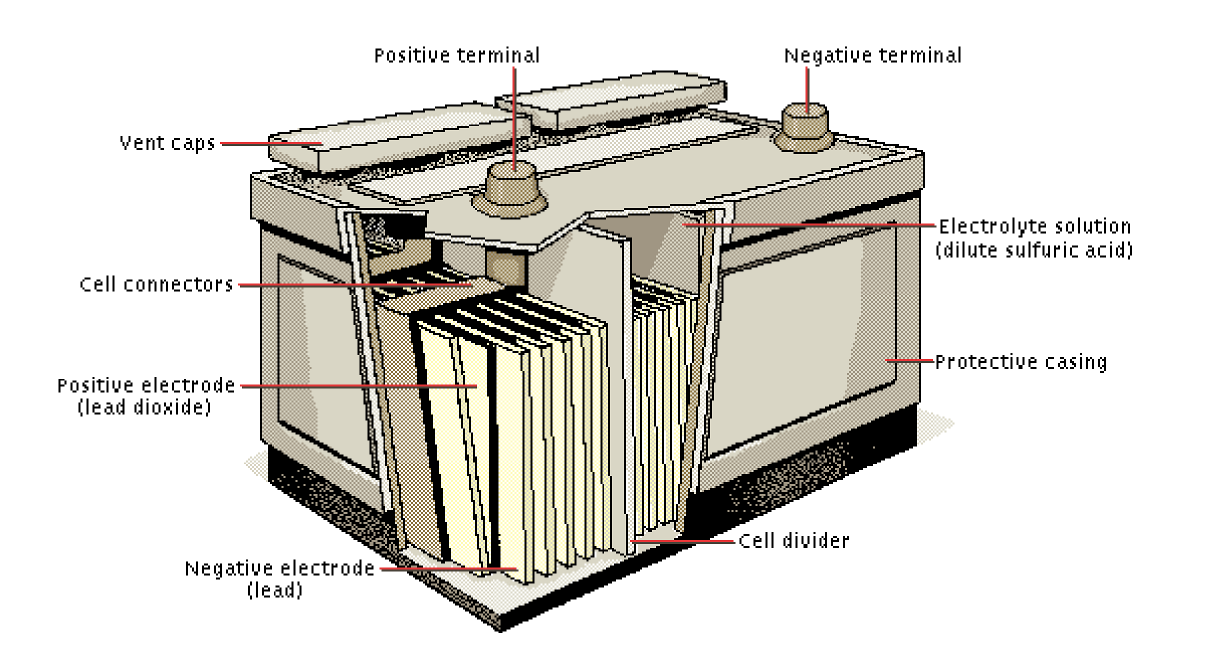

Figure 1: Scheme of a lead battery (Author: Neil McNiven)

Positive and negative terminals: made of lead, and where the external electricity consumer devices are connected;
Plugs: one for each battery element, where distilled/deionized water can be replaced whenever needed and also to provide an escape route for gases formed in the cells;
Connectors: made of lead, that make electrical contact between plates of same polarity and also make electrical contact between separated elements;
Cap and box: originally made of ebonite, but now more commonly made from either polypropylene or co-polymer;
Sulphuric acid solution: the electrolyte of the battery;
Element separators: usually a part of the box and made of the same material provide chemical and electrical isolation between the electrical elements. They are connected in a serial layout in order to increase the final voltage of the battery;
Plate separators: made of PVC or other porous materials, avoid physical contact between two contiguous plates but, at the same time, allowing free movement of ions in the electrolyte solution;
Negative plates: constituted by a metallic lead grid covered by a lead dioxide (PbO2) paste;
Positive plates: constituted by metallic lead plates;
Battery element: a series of negative and positive plates placed consecutively and isolated between each other with plate separators. Plates of same polarity are electrically connected.
The battery plates are constituted by metallic lead structures, known as grids, covered by a lead dioxide paste, in the case of the negative plates, or by a porous metallic lead paste, in the case of the positive plates. The lead used in both the plates may also contain several other chemical elements such as antimony, arsenic, bismuth, cadmium, copper, calcium, silver, tin and sometimes other elements. The plates manufacture process also uses expander materials, such as barium sulphate, lampblack and lignin added in order to prevent the plate retraction during use. Once prepared, the plates are dried, cured and shaped ready to be assembled into the battery elements.
Automotive battery manufactures produce a full range of starter batteries for all types of vehicles using petrol and diesel engines. The characteristic of lead acid batteries are large weight, relatively short shelf life without recharge, and a good ability to deliver high currents. Lead batteries are very adapted for uses requiring (occasional) high current draw, and where charging is regular (i.e. automotive). The lead battery has high energy storage capacity and low cost.

Environmental and health aspects

Used batteries pose a threat to our environment and should be managed properly. The toxic materials present in the battery can cause harm to the environment and to human beings also. This is the reason why waste battery recycling should be done properly. The incorrect management of waste lead batteries cause danger to waters, soil and air, as well as to human health.

Batteries are safe, but precaution applies when touching damaged cells and when handling lead acid systems that have access to lead and sulphuric acid. Lead batteries are labelled as hazardous material.

Lead is a toxic metal that can enter the body by inhalation of lead dust or ingestion when touching the mouth with lead-contaminated hands. If leaked onto the ground, the acid and lead particulates contaminate the soil and become airborne when dry.

Exposure to lead causes a variety of health effects, and affects children in particular. Lead is a metal with no known biological benefit to humans. Too much lead can damage various systems of the body including the nervous and reproductive systems and the kidneys, and it can cause high blood pressure and anemia.

There is no known safe blood lead concentration. But it is known that, as lead exposure increases, the range and severity of symptoms and effects also increases [3].

The sulfuric acid in a lead acid battery is highly corrosive and is potentially more harmful than acids used in other battery systems. Eye contact can cause permanent blindness; swallowing damages internal organs that can lead to death.

First aid treatment calls for flushing the skin for 10 to 15 minutes with large amounts of water to cool the affected tissues and to prevent secondary damage. Immediately remove contaminated clothing and thoroughly wash the underlying skin. Always wear protective equipment when handling the sulfuric acid [4].There are many facilities which have implemented scrap battery recycling as part of their pollution prevention efforts. The facility that makes the decision to implement used battery recycling will help to protect the environment and insure the compliance with environmental laws. There are many benefits of the lead battery scrap processing.

a) Used battery recycling keeps all the hazardous metals in one place;
b) The metals obtained in discharged car battery processing are reused in manufacturing process to build more batteries;
c) The plastic (PP) from outer case of battery is also recycled for further use;
d) Lead waste battery processing follows good environmental policy;
e) The battery scrap recycling saves natural resources.

The major use of lead in the world is in the form of lead acid batteries. Lead acid storage batteries are an essential component of the automotive industry for which there are currently no electro-chemical, economic or environmentally acceptable alternatives. So this makes the used battery recycling more important. Lead recycling saves money, lead and most importantly, the environment.

Sources of waste lead batteries, estimation of amounts of produced used lead batteries

Lead batteries are used in vehicles of all types. As the amount of vehicles is gradually increasing all around the world, the amount of used batteries is also growing (in Figure 2 and 3 the examples of the European market for automotive batteries are shown).

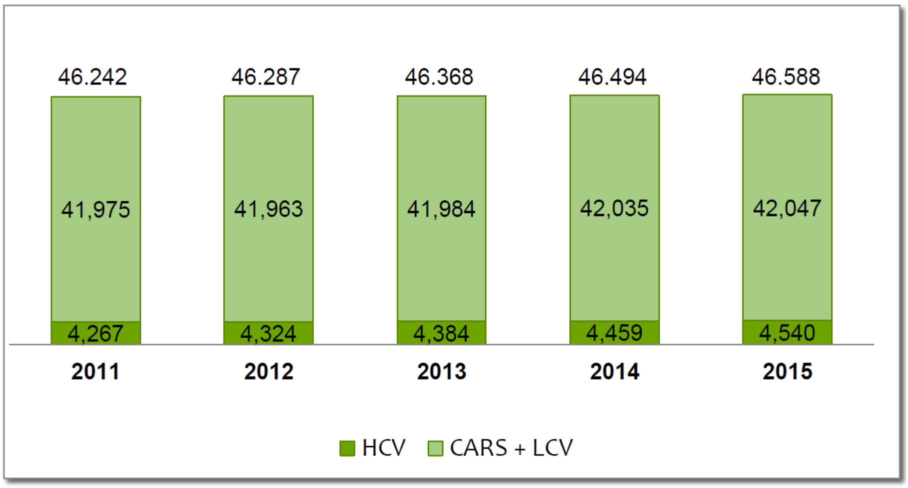

Figure 2: Aftermarket battery volume for EU (2011 – 2015, in k Units). [5]

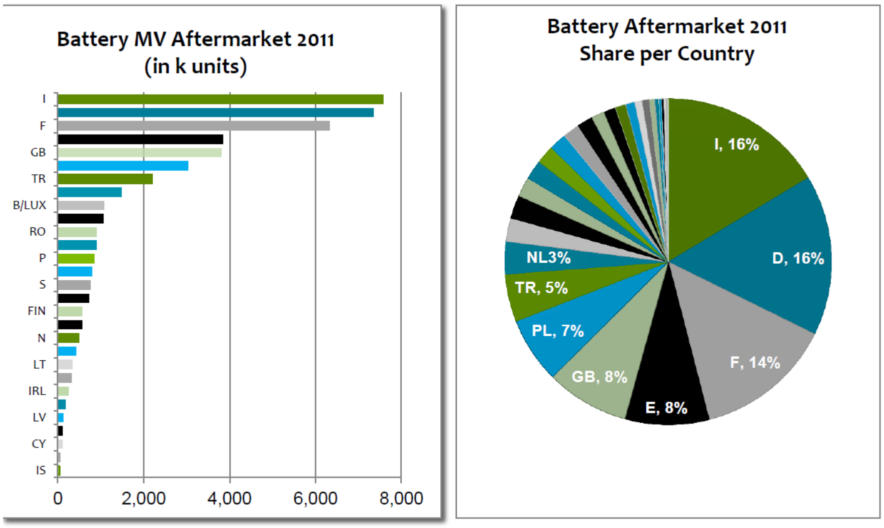

Figure 3: Aftermarket battery per country in 2011. [5]

Another example is the consumption of lead acid batteries in Australia provided by the Australian Battery Recycling (ABRI) Initiative from 2010 [6]. In total, about 9.2 million lead acid batteries are purchased and 7.8 million reach the end of their useful life in Australia every year. By weight, lead acid batteries make up 91 %, or over 120,000 tonnes of the batteries disposed of in Australia. Australian households purchase more than 7.6 million or 86,000 tonnes of lead acid batteries each year, and dispose of more than 6.4 million or 92,000 tonnes of them. Lead acid batteries are most commonly used in cars, according to both the Pollinate and the ABRI research (see Table1). Car batteries make up 63 % of all lead acid batteries used in Australia.

Table 1: Lead acid battery use in Australian households reported by Australian Battery Recycling Initiative in 2010 based on the survey. [6]

%	Q1 Items owned	Q2 Most recent change
Car	87	80
Home alarm systems	23	12
Motorcycle	8	3
Boat	8	2
Solar panel	19	2
Electric scooter	1	1
None of these	11	-
n	1000	893

Q1: Which of the following items do you have?
Q2: Which of the following items had their battery changed MOST recently?
Base: Total sample Australians aged 14 – 64 (September 2011, n = 1000)

The source of used lead batteries in the country are mostly professional car services, construction companies using internal car maintenance, agricultural farms using internal car maintenance and some other industrial companies. In countries with lower living standard also individuals change car batteries by themselves and households represent an important source of used lead batteries. In European countries the amount of produced used lead batteries per inhabitant and year is approximately 1.2 – 1.5 kg.
A typical composition of lead – acid battery scrap is given in Table 2 [7].

Table 2: Composition of typical lead – acid automotive battery scrap [7]

Component	Wt - %
Lead (alloy) component (grid, poles…)	25 - 30
Electrolyte paste (fine particles of lead oxide and lead sulphate)	35 - 45
Sulphuric acid (10 – 20% H_2SO_4)	10 - 15
Polypropylene	4 - 8
Other plastics (PVC, PE, etc.)	2 - 7
Ebonite	1 - 3
Other materials (glass, etc.)	< 0.5

Overview of available standards, technical specification and guidelines on the storage and treatment of batteries and accumulators

European Union Legislative Framework

The European Commission's "Questions and answers on the Batteries Directive" [8] provide an introduction to the requirements which must be met by EU waste battery treatment systems and to the requirements which must be met during export of waste batteries:

- Does the EU Batteries Directive (2006/66/EC) [9] lay down any requirements for treatment of waste batteries?

In addition to levels of recycling efficiency, the Directive specifies how waste batteries are to be treated. The minimum requirement is that fluids and acids must be removed. The Directive also describes the conditions under which waste batteries must be treated and stored (Article 12(2) and Annex III, Part A).

- What requirements must be met if batteries are exported for recycling?

When waste batteries are exported outside the European Union, Member States must require sound evidence that the recycling takes place under conditions equivalent to those set out in the EU Batteries Directive, including recycling efficiencies.

Article 12(2) and Annex III, Part A of the EU Batteries Directive (2006/66/EC) [9] set following requirements on waste battery treatment:

- Exclusively best available techniques are to be used.
- The minimum requirements set to be met include:
  a) *Treatment shall, as a minimum, include removal of all fluids and acids.*
  b) *Treatment and any storage, including temporary storage, at treatment facilities shall take place in sites with impermeable surfaces and suitable weatherproof covering or in suitable containers.*
- Recycling processes shall achieve the following minimum recycling efficiencies:
  1. *recycling of 65 % by average weight of lead-acid batteries and accumulators, including recycling of the lead content to the highest degree that is technically feasible while avoiding excessive costs;*
  2. *recycling of 75 % by average weight of nickel-cadmium batteries and accumulators, including recycling of the cadmium content to the highest degree that is technically feasible while avoiding excessive costs; and*
  3. *recycling of 50 % by average weight of other waste batteries and accumulators.*

In Article 13 of the EU Batteries Directive (2006/66/EC) [9] it is recommended

a) that Member States shall encourage the development of new recycling and treatment technologies and

b) that Member States shall encourage treatment facilities to introduce certified environmental management schemes (e.g. EMAS or ISO 14000).

No further details on how to treat waste batteries and accumulators are provided by EU legislation [9].

Best Available Techniques Reference Documents of the European Commission

In order to specify what the Best Available Techniques for the respective sectors and industrial processes are a number of Reference Documents on Best Available Techniques (BREFs) were prepared on the request of the European Commission. A dedicated BREF on waste battery treatment does not exist. However, following BREFs contain some specifications which are relevant for waste battery treatment:

i. Reference Document on Best Available Techniques on Emissions from Storage [10] (for a summary of this BREF see Table 3).
ii. Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, [11], [7] (for a summary of this BREF see Table 4).
iii. Best Available Techniques (BAT) Reference Document for Iron and Steel Production , [12] (for a summary of this BREF see Table 5).
iv. Reference Document on Best Available Techniques for the Waste Treatment Industries [13] (for a summary of this BREF see Table 6).

Table 3: Summary of the BREF on Emissions from Storage [10]

The BREF on Emissions from Storage addresses the storage and the transfer/handling of liquids, liquefied gases and solids, regardless of the sector or industry. It addresses emissions to air, soil and water. However, most attention is given to emissions to air. Energy and noise are also addressed but to a lesser extent.

Following storage methods for solids are addressed in particular:

• Heaps

• Sacks and bulk bags

• Silos and bunkers

• Packaged dangerous solids

• Containers and the storage of containers.

For the transfer and handling of solids, techniques such as mobile unloading devices, grabs, dump pits, fill pipes, thrower belts, conveyors and feeders are described. In each case the emission sources are identified.

Table 4: Summary of the BREF on Best Available Techniques in the Non Ferrous Metals Industries , [7], [11]

The BREF on best available techniques in the Non Ferrous Metals Industries covers the techniques for the production of both primary and secondary non-ferrous metals. The production of 42 non-ferrous metals and the production of ferro alloys are addressed. Ten groups of metals with similar production methods are dealt with in the document:

• Copper and its alloys, Tin and Beryllium

• Aluminium and its alloys

• Zinc, Lead, Cadmium, Antimony and Bismuth etc.

• Precious metals

• Mercury

• Refractory metals, e.g. Chromium, Tungsten, Vanadium, Tantalium, Niobium, Rhenium, Molybdenum

• Ferro alloys, e.g. IronChromium, IronSilicon, IronManganese, SiliconManganese, IronTitanium, IronMolybdenum, IronVanadium, IronBoron

• Alkali and alkaline earth metals, Sodium, Potassium, Lithium, Strontium, Calcium, Magnesium and Titanium

• Nickel and Cobalt

• Carbon and graphite electrodes. The production of carbon and graphite anodes is included because of the production of anodes at some aluminium smelters as an integral part of the production process.

Table 5: Summary of the Best Available Techniques (BAT) Reference Document for Iron and Steel Production [12]

The BREF on Best Available Techniques for Iron and Steel Production covers the processes involved in the production of iron and steel in integrated works as well as the production of steel in electric arc furnace steelworks. The main operations covered are:

• Loading, unloading and handling of bulk raw materials

• Blending and mixing of raw materials

• Coke production

• Sintering and palletisation of iron ore

• Production of molten iron by a blast furnace route, including slag processing

• Production and refining of steel using the basic oxygen process, including upstream ladle desulphurisation, downstream ladle metallurgy and slag processing

• Production of steel by electric arc furnaces, including downstream ladle metallurgy and slag processing

• Continuous casting.

Other downstream metal processing activities can be found in other BREF documents (e.g. see BREF on Ferrous Metals Processing Industry [12] or BREF on Smitheries and Foundries Industry [14])

Table 6: Summary of the BREF for the Waste Treatment Industries [13]

The BREF for the Waste Treatment Industries covers the installations of a number of waste (hazardous and non-hazardous) treatment processes, and deals with: • Common waste treatment processes such as temporary waste storage, blending and mixing, repackaging, waste reception, sampling, checking and analysis, waste transfer and handling installations, and waste transfer stations • Biological waste treatment processes such as aerobic/anaerobic treatment processes and mechanical and biological treatment processes •Physico-chemical waste treatment processes of such as neutralisation, chromic acid and cyanide treatment, dewatering, filtration, harbour reception facilities, oil/water separation, precipitation, separation of Mercury from waste, settlement, solidification and stabilisation, and UV and ozone treatment • Treatment processes to recover waste material for secondary use such as the re-concentration of acids and bases, the recovery of metals from liquid and solid photographic waste, the regeneration of organic solvents and spent ion exchange resins, and the re-refining of waste oils • Treatment processes to produce mainly solid and liquid fuels from hazardous and non-hazardous waste.

The Best Available Techniques from the BREF for the Waste Treatment Industries [13] are of special importance for meeting the requirements set out in Annex III Part A of the EU Batteries Directive [9]. Some examples on relevant topics from this BREF are:

a) Requirements for the treatment of waste containing mercury;
b) Requirements to be considered during crushing, shredding and sieving operations;
c) Best Available Techniques to prevent or control emissions;
d) Best Available Techniques to prevent soil contamination;
e) Best Available Techniques for storage and handling;
f) Best Available Techniques on the management of the residues generated by the waste treatment process.

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal

Basel Convention on the Control of Transboundary Movements of the Hazardous Wastes and Their Disposal regulates conditions for transboundary shipment of hazardous wastes to protect environment of the developing countries from the negative effects of inappropriate waste disposal. The Secretariat of the Basel Convention has published several guidelines, one of them dealing with management of waste lead – acid batteries [1]. The guideline in detail describes applied technologies of waste lead batteries treatment and recycling together with environmental and health aspects.

Collection, transport and storage of used lead batteries

The used lead batteries are an important source of environmental hazard and it is necessary to operate the effective system of management of used lead batteries. The result of the system is the environmentally safe handling and disposal of lead wastes as well as the production of valuable secondary raw materials.
The life cycle of lead batteries consists of these steps:
a) Production
b) Consumption
c) Collection and sorting
d) Transport
e) Storage
f) Treatment (dismantling)
g) Recovery (recycling)
h) Disposal
The scheme of life cycle of lead batteries is shown in Figure 4.

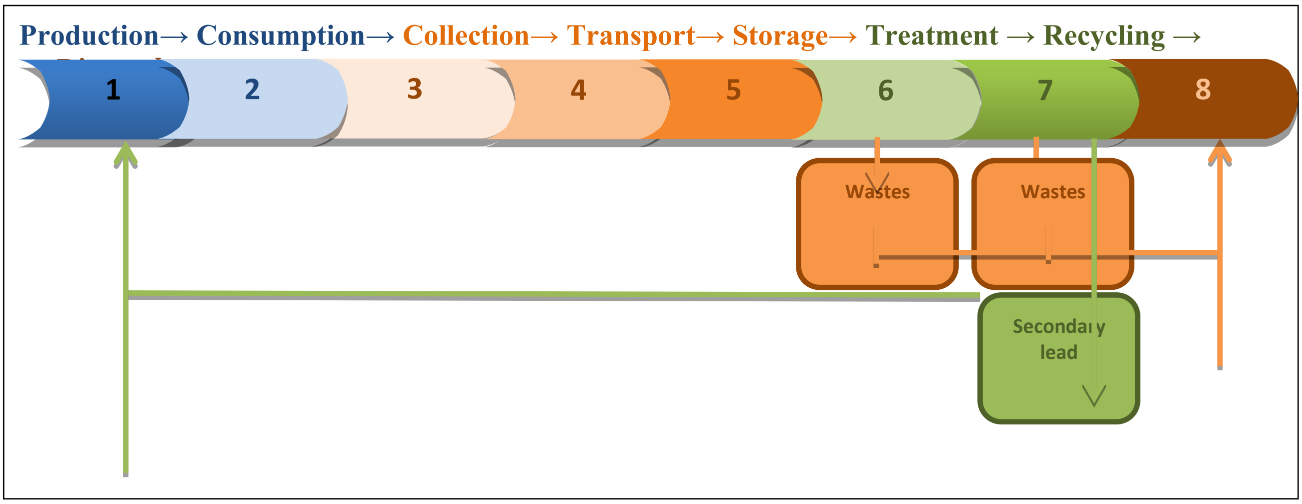

Figure 4: Simplified life cycle of lead batteries

The used lead batteries system consists of the steps 3 to 8. All these activities must be under the strict control of authorities including the permit system for waste management activities.
There are listed the most comprehensive ways of treatment and requirements identified by an investigation of many potential sources:

General treatment requirements

a) Collected waste batteries and accumulators shall be stored in weatherproof conditions in leak proof containers that are acid- or alkali-resistant depending on the electrolyte used.
b) The mercury content of all recovered fractions, with the exception of the pure mercury fraction, shall not exceed 20 mg/kg dry mass.

Treatment of lead accumulators

- Lead accumulators shall be treated separately from all other batteries and accumulators.
- At any rate, the treatment of lead accumulators shall demonstrably recover lead and plastics of adequate purity so that they can be recycled and thus, shall ensure their re-introduction in the production cycle.

- The lead content of the recovered plastics shall not exceed 500 mg/kg.

- The treatment shall include measures to prevent diffusive lead emissions.
- Free sulphuric acid shall be recovered.

Collection and sorting of used lead batteries

As used batteries are a valuable source of lead it is important to provide separate collection under controlled conditions to get the material for recovery as clean as possible. The second reason for controlled collection is environmental protection to prevent unprofessional dismantling with release of electrolyte to waters or soil.
The aim of separate collection is to get the used lead batteries from waste producers to authorised treatment facilities to prevent environmental and health hazards.
The outcome of the project [2] proposed the extended producer responsibility where the producers (importers) are obliged to provide (prepare, organise and finance) the system of waste collection, treatment and disposal. The producers will provide one or several systems of separate collection of waste batteries in order to meet collection limits given by legislation.
There are several systems of separate collection of used lead batteries. The simplest system is collection at sources, in vehicle services where the important amounts of used lead batteries are arisen. The services have special containers for used lead batteries. It is prohibited to open or dismantle waste batteries. The container should be double-bottomed and market with notice containing information on the waste type, hazardous properties and first-aid instructions. The batteries should be placed into the container bottom down to prevent spilling of the electrolyte.

Picture 1: Container for separate collection of used lead batteries in vehicle service

Picture 2: Container for separate collection of used lead batteries in gas station in Slovakia

The other separate collection system is the collection in gas stations. Gas station is equipped with double-bottom container where the used lead batteries are placed (bottom down). Take-back system in specialised shops can be also introduced; the seller (distributor) of new lead batteries is obliged to take back waste battery free of charge when the customer is buying a new one.

The next system is mobile collection organised by producers in cooperation with municipalities. The vehicle responsible for shipment of hazardous wastes having all permits and marking collects used lead batteries in municipalities in given term and given place. This system enables to collect used batteries from households and small facilities as farms or small services. The used lead batteries can be also collected in collection points operated by municipalities in special containers.

Picture 3: Collection point operated by municipality Košice (Slovakia)

All collection systems are organised and financed by producers (importers). It is expected that collection is realised on the basis of agreements between operators of collection places (gas stations, services, municipalities) and producers (importers). It is acceptable to realise the separate collection on the basis of the agreement between operator of collection place and authorised treatment facility.
It is necessary to control that all collected waste batteries will get to the authorised treatment facility or exported in accordance with the Basel Convention.
Based on the different treatment requirements and treatment options for the different battery types, a classification of batteries and accumulators according to different battery chemistry types, like the one shown in Table 7, is recommended. Batteries and accumulators should be sorted and prepared for separate treatment according to these battery chemistry types.

Due to the different characteristics of batteries containing **liquids** and **other** batteries, a differentiation between batteries containing liquids and batteries which are free of liquids is proposed (see also different recommendations for storage – chapter 6.3).

A mixture of liquid and non-liquid containing waste batteries should be regarded as batteries containing liquids.

Table 7: Recommended sorting fractions of batteries and accumulators

Sorting fraction - **Battery type according to battery chemistry**	**Remarks**
Pb-acid accumulators - liquid	including sealed lead acid accumulators with non-fixed electrolyte (using a catalyst to re-combine

	hydrogen and oxygen)
Pb accumulators – others	in sealed accumulators (sealed lead accumulators - SLA) the electrolyte is fixed by adding silica gel or by using a fibreglass mat (absorbent glass mat accumulator - AGM)

This classification according to battery chemistries is used to give information on specific storage requirements (see chapter 6.3) and on specific treatment requirements.

Transport of used lead batteries

Every transport must be controlled by state authorities (Regional Districts) by the means of permits. The permit must contain the following minimum information:

1. Name and identification of sender receiver (address, ID number, statutory or other responsible person)
2. Name and identification of receiver (address, ID number, statutory or other responsible person, method of next waste management – storage, treatment, recycling, disposal)
3. Name and identification of transporter (address, ID number, statutory or other responsible person)
4. Amounts of transported waste
5. Identification of the transported waste (waste code or other identification including indication of hazardous characteristic)
6. The duration of the permit

It is strongly recommended to authorise the transporters (companies providing transport of hazardous wastes) by the Ministry of Environmental Affairs.
The transport must be realised only in vehicles that meet safety requirements. The vehicle must be labelled.

		
explosive substances	toxic substances	irritant substances

Figure 5 : Labelling of hazardous cargos according to ADR

The vehicle must be furnished with first-aid set, set for elimination of accident consequences and the driver must be instructed on techniques in the case of accident.

Storage of used lead batteries

Storage, including temporary storage, of waste batteries at treatment facilities shall take place in sites with impermeable surfaces and suitable weatherproof covering or in suitable containers. Table 8 shows recommendations on breaking down these requirements to a more detailed specification [15].

These specifications are valid for storage at treatment facilities including sorting facilities and storage facilities.

***Storage buildings* [10]**

Storage buildings are used for storing all kinds of substances, from drums with flammable liquids, cylinders with pressurised gas, to packaged products such as chemicals and pesticides or chemical wastes awaiting disposal. They can be a standalone building or be part of another building.

Good design and construction of storage buildings containing dangerous materials focuses on events such as fire, explosion and releases of dangerous substances, in particular to prevent or control them as much as possible. Also good management practices and operational procedures are important.

Mostly, but not always, storage buildings are constructed from non-combustible materials. The degree of fire-resistance offered by the building itself determines the minimum distance to other buildings and to the boundaries of the danger zone. With a sufficient degree of fire resistance the storage building can be part of another establishment.

The storage space can be separated into different compartments for storing different types of hazardous material each by partition walls or by leaving a storage-free zone empty between the compartments. Some warehouses have an inbuilt store within the main warehouse. This interior store can be used to store particularly hazardous materials, such as highly flammable liquids or gases as well as peroxides.

The floors of the building are usually made of non-combustible material, are liquid-tight and are resistant to the stored substances.

The roof of the building is resistant to wind-blown fires, with the roof structure being of a fire resistant construction to prevent fire entering the store. The degree of fire-resistance depends on different factors such as, how close the store is to the border of the site or other buildings and the type of substances stored.

A storage building is normally equipped with adequate ventilation to prevent the formation of an explosive gas mixture from leakages and to extract any harmful or unpleasant fumes.

The use of electrical equipment can generate sparks that might ignite a fire in the storage building. Therefore, it is important to use explosion-protected electrical equipment. However, proper earthing of the steel structure also may be sufficient.

If a fire breaks out in a storage facility, part of the stored substances may be released.
The storage facility should be constructed in such a way that the released substance cannot cause any harm. In particular provisions are to be taken to prevent polluted extinguishant from entering the soil, the sewage systems or surface water.

Outside storage (storage yards) [10]

In principle, measures and provisions for storing dangerous (packaged) materials outside do not differ from those for storage inside a building. The amount and type of substances stored determines the minimum distances from boundaries and buildings to be observed. To protect the storage from direct sunlight and rain, the storage area may be covered by a roof.

The provisions for collecting for spilled substances and possibly released extinguishant are the same as those applied in storage buildings as described above. When the storage is not covered with a roof, provisions for the cleaning of possibly polluted rainwater and its controlled discharge should be in place.

The level of fire prevention and fire-fighting measures depend on many factors, such as the flammability of the stored substances, the flammability of the packaging and the quantity of material stored.

Table 8: Proposal for the specification of the minimum treatment requirement: "Impermeable surfaces and suitable weatherproof covering" [15]

Proposed Specifications for Waste Battery Storage	Applying to batteries:	
	containing liquids	other
Surfaces in operational areas should be resistant to chemicals and fire	yes	yes
Storage of waste batteries at treatment and recycling facilities must take place in a proper building or a covered place with the following minimum requirements:		
- Impermeable and acid and/or alkali resistant floor depending on the electrolyte used	yes	no
- Efficient water collection system which directs spilled liquids towards the effluent or electrolyte treatment plant	yes	no
Storage in a proper building or under cover must also be applied to any container that is pending, sampling or emptying.	yes	yes
Storage may be carried out without cover if the stored waste batteries and containers are not affected by ambient conditions (such as sunlight, temperature, water)	yes	yes
Covered areas need to have adequate provision for ventilation.	yes	yes
Containers holding substances that are known to be sensitive to heat, light and water, and thus must stay under cover and protected from heat and direct sunlight, are to be available in sufficient quantities and need to have free access to appropriate storage areas.	yes	yes
For storing quantities of more than 2,500 litres or kilograms of dangerous substances a storage building and/or an outdoor storage area covered with a roof has to be used according to the BREF on Emissions from Storage [10]	yes	yes
For storing quantities of less than 2,500 litres or kilograms of dangerous substances, at least a storage cell4 has to be used	yes	yes

according to the BREF on Emissions from Storage [10]		
Batteries with alkaline and acidic electrolyte shall be stored separately	yes	no

The limit of 2,500 kilograms introduced in Table 8 as the threshold for requiring a dedicated storage building may be applied to collection facilities like stores, car repair centres etc. where batteries and accumulators are taken back from final users. In these facilities batteries and accumulators are stored until a pick-up service transports them to treatment facilities.
Used lead batteries can be stored only in special storehouses designated for storage of hazardous wastes. The place for storage must be covered and the floor must be made from acid-resistance materials. It is forbidden to store used lead batteries near heating sources or fire because the danger of explosion is present. It is also forbidden to smoke or use open fire in the storehouse. The storehouse must be equipped with air exhaustion system. The storehouse must be connected to sewage system or retention tank.
The used batteries must be placed to double-bottom containers or the storehouse must be constructed as the catch tank or the containers must be placed into the catch tank to prevent the leakage of the electrolyte.
The storehouse as well as the containers with waste batteries must be marked with notice containing information on waste type, hazardous properties and first-aid instructions. The first-aid set must be placed in the storehouse (close to the door easily available).
The mobile storehouse can be used but the temperature of the ambient air must be measured because the temperature over 40°C can cause the danger of spontaneous explosion.

Picture 4: Mobile storehouse of hazardous wastes

It is recommended to regulate the requirements for storage of hazardous waste by legislation and to submit special permits for storage of hazardous waste by authorities (Regional Districts).
The intention is that this small scale storage for portable batteries and accumulators does not to need a permit for the storage of hazardous wastes, as long as the batteries are not stored longer than one year

(interim storage).

The interim / small scale storage for portable batteries and accumulators has to fulfil technical requirements such as:

- suitable containers are to be used (see Table 9),
- all storage areas have impermeable surfaces (see Table 8),
- the storage building and/or the outdoor storage area are covered with a roof (see Table 8),
- the storage building or area is inaccessible for unauthorised person.

In addition

- an interim storage for portable batteries and accumulators must be limited to the storage of this type of batteries;
- it shall also be limited by a maximum storage quantity and/or a maximum storage time of the average turnover of batteries. Proposed limits are:
    - a maximum storage quantity of 7,5 t (amount for a full ‘medium-size’ truck),
    - a maximum storage time of 1 year;
- this interim / small scale storage facility should fall under the same inspection requirements as the regular storage facilities which need permits.

Table 9 shows recommendations on which requirements should be fulfilled in order to make a container suitable for waste battery storage [15].

Table 9: Proposal for the specification of the minimum treatment requirement: “suitable containers” [15]

Proposed Specification for a Suitable Waste Battery Storage Container	**Applying to batteries:**	
	containing liquids	**other**
Storage must take place in leak proof containers that are acid and/or alkali resistant depending on the electrolyte used.	yes	no
Use UN standardized containers	yes	yes
Containers must be clearly labelled as regards the nature of the waste and the relevant danger symbols	yes	yes
If appropriate, the use of re-usable packaging (drums, containers, IBCs5, pallets, etc.) should be maximised.	yes	yes

Treatment of used lead batteries

The treatment of used lead batteries is sometimes called wet technology, as the liquid electrolyte is present.

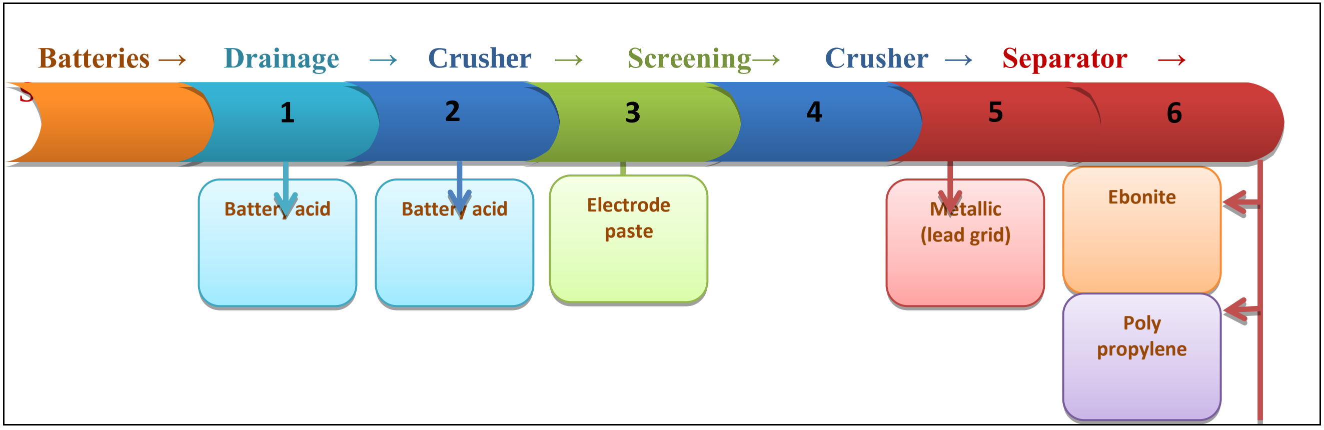

Figure6: Typical used lead batteries recovery process [7]

The Technical Guidelines [1] describes following treatment steps:

- battery breaking – including a description of processes and potential sources of environmental contamination,
- lead reduction including a description of pyro metallurgical and hydrometallurgical methods and potential sources of environmental contamination,
- lead refining - especially describing pyro metallurgical refining and potential sources of environmental contamination.

As pollutants which potentially are emitted from the treatment processes e.g. electrolyte, dust, sulphur dioxide (SO2) are described and some measures for pollution prevention are mentioned. Relevant requirements for lead-acid accumulators derived from the Technical Guidelines [1] are included in Chapter 3.5 - Special care on batteries and accumulators with liquid electrolyte and Chapter 4.4 - Treatment requirements with regard to the battery chemistry.

Requirements for removal of fluids

According to the EU Batteries Directive (2006/66/EC) Article 12(2) and Annex III, Part A [9], waste battery treatment shall, as a minimum, include removal of all fluids and acids

Table 10 specifies specifications for removal of fluids and acids as recommended in [15] in order to limit the environmental impact of these processes.

Table 10: Proposal for the specification of the minimum treatment requirement: "Removal of all fluids and acids, their collection and treatment" [15]

Proposed Specification for the Removal of Fluids and Acids from Waste Batteries	**Applying to batteries:**	
	containing liquids	**other**
Batteries should be drained and prepared for recycling by adequately trained workers wearing personal protection.	yes	-
In operational areas a ground cover has to be utilised that may retain any leakage and direct it to a collecting container from where it can be removed.	yes	-
The capacity to retain leakage must at least be equal to the amount of liquid stored	yes	-
Surfaces of operational areas, drainage systems and other subsurface structures should be maintained, including applying measures to prevent or quickly clear away leaks and spillages.	yes	-
Electrolyte should be directed to appropriate treatment	yes	-

(recycling/recovery or appropriate waste treatment)		
Recycling/recovery of electrolyte should be done if appropriate; direct discharge of neutralised and/or untreated electrolyte should be avoided.	yes	-
When applying a neutralisation process customary measurement methods have to be used.	yes	-
Neutralised waste water from the neutralisation process has to be stored separately	yes	-
A final inspection of the neutralised waste water from the neutralisation process has to be performed	yes	-

In specific cases the removal of fluids is not feasible, e.g. if the electrolyte is solidified (lead acid gel accumulators). In such cases the recycling process must be optimised individually with the aim to minimise emissions and hazards to human health as well as to achieve high recycling efficiency.

There are two main types of process for the recovery of lead from automotive batteries:

a) Batteries are drained of acid and fed whole into a blast or shaft furnace (Varta process). Whole batteries and fluxes are fed into a blast furnace via a seal and oxygen enriched air is used in the blast. Antimonial lead bullion is produced, along with silica based slag and a lead/iron matte that can be recovered in a primary lead smelter. Organic components in the furnace off-gases are oxidised in an after- burner and the gases are then cooled and filtered in a fabric filter. The filter dust is de-chlorinated and returned to the furnace.

b) Batteries are drained of acid broken and separated into various fractions using automated proprietary equipment (MA and CX processes). Both the MA and CX (Engitec) processes use hammer type mills to crush the whole batteries. The crushed material then passes through a series of screens, wet classifiers and filters to obtain separate fractions containing metallic components, lead oxide sulphate paste, polypropylene, non-recyclable plastics and rubber and dilute sulphuric acid. Some processes use a second milling stage before the plastic fraction is finally treated. Polypropylene is recycled as far as possible. The sulphuric acid drained from the batteries is neutralised unless there is a local use for it and the sodium sulphate produced can be re-crystallised and sold. These are strongly market dependent options.

Several alternatives are used to deal with the sulphur contained in the battery materials.

a) Prior to smelting, the lead sulphate paste may be de-sulphurised by reaction with sodium carbonate or sodium hydroxide (in the CX and related processes).

b) Lead sulphate can be separated and sent to an installation capable of treating the sulphur content in the gases for example one of the direct smelting primary lead processes.

c) The sulphur may be fixed in the slag or as a Fe/Pb matte.

Paste de-sulphurisation prior to smelting can reduce the quantity of slag produced and, depending on the smelting method used, the amount of sulphur dioxide released to the air.

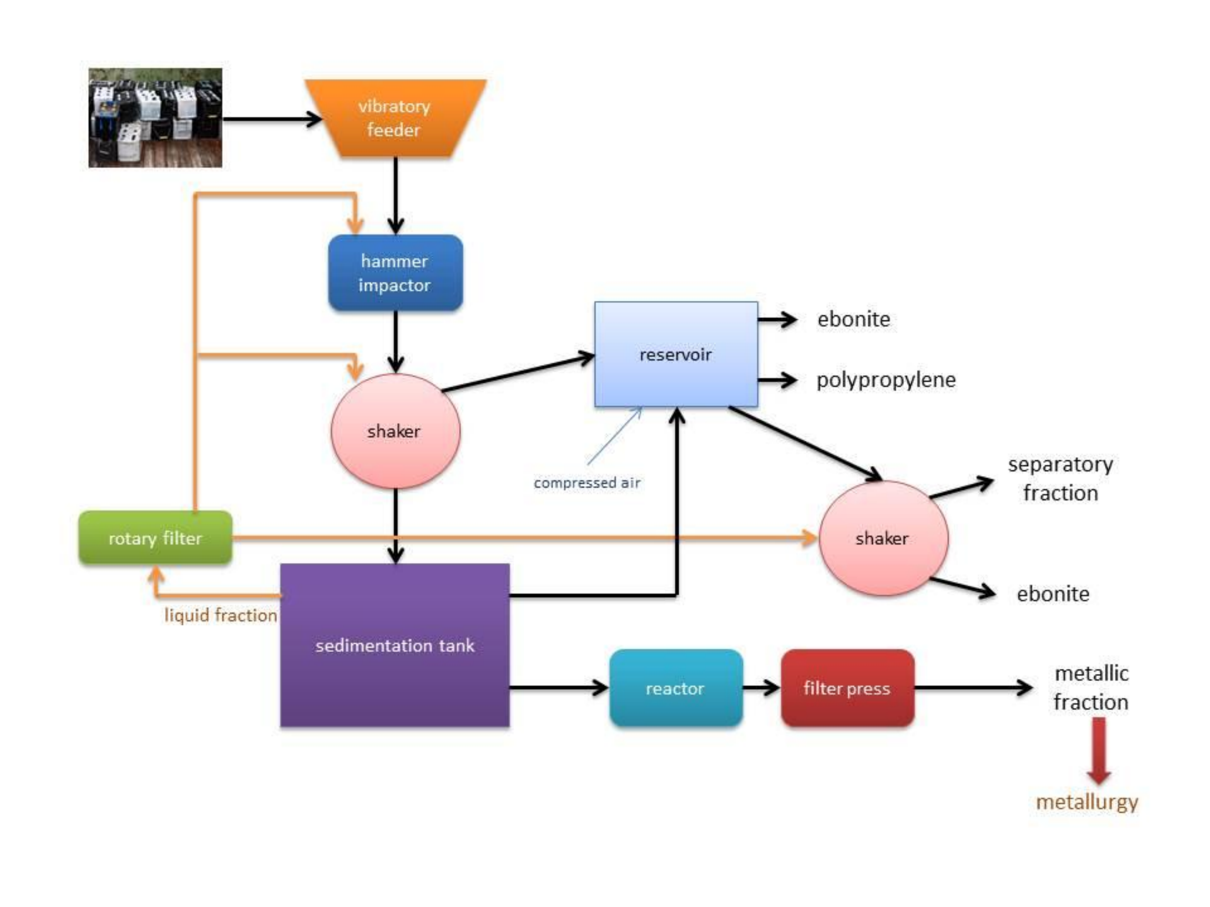

Figure7: Example of scheme of the wet treatment technology (Engitec) [16]

During the treatment processes the environmental hazard must be taken into account. The collecting vessel must be acid-resistant, usually having special pavestone bottom and walls covered by resistant foil and stainless steel. The space around collecting vessel is monitored for leakage.
The main environmental issues of the lead industry are air and water pollution and the generation of hazardous wastes. The facilities generally have their own wastewater treatment facilities and wastewater recycling is usually practised. Many wastes are reused but the major item is leach residue that has a high environmental impact. Some local aspects, like noise, are relevant to the industry. Due to the hazardous nature of some solid and liquid waste streams, there is also a significant risk for soil contamination.

Recovery of used lead batteries

The recovery of secondary lead consists of smelting, refining and doping.

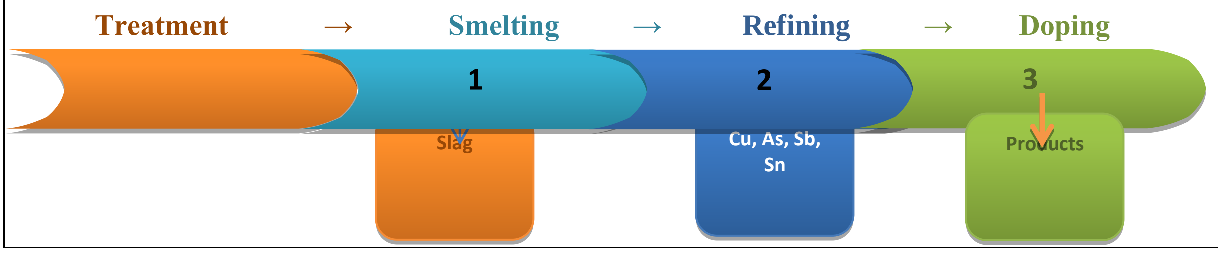

Figure 8: Typical used lead batteries recovery process [10]

Picture 5: Secondary lead installation of the company Mach Trade (Slovakia)

Recovery of lead from products of wet technology is operated in metallurgy part of the technology (dry or smelting processes). The lead and lead paste are transported to the smelting reactor that can be:

a) rotary furnace,
b) reverberatory furnace and blast or electric furnace,
c) rotary kiln,
d) ISA Smelt furnace,
e) electric furnace.

Rotary and reverberatory furnaces can be either gas or oil fired. Oxygen enrichment is used in several installations. Smelting is usually carried out in batches, slag and metal are tapped out separately and batches of slag are treated to recover more lead and produce a slag that is stable. The bulk of the sulphur in the charge is fixed in the slag, which is a sodium-iron-sulphur compound with small amounts of lead and other metals.

In the ISA Smelt process de-sulphurised paste and reductant are continuously fed into the furnace and lead bullion is tapped periodically. When the process vessel contains the maximum volume of slag, reductant and fluxes are added to produce high antimony bullion and a discard slag. The slag may also be reduced in a separate furnace.

The electric resistance furnace is used for complex secondary materials and uses an open slag bath covered by coke. Raw materials are fed onto the top of the bath where they react to produce metal and slag, which are tapped periodically. The waste gas contains CO and is burnt and flue dust is collected.

The furnace is fed with input materials that are lead metal and lead pasta, resp. dust outlet, slag formers, reductant and calcinated soda. After feeding the input opening is closed and the furnace is heated. After the smelting the content of furnace is poured out to pre-heated mould. The slag remains in the top part of the mould and the lead is pin down to ingot mould [16].

The following tables give input and output balances for some lead plants in Europe [11].

Table 11: Input and output data for a battery recovery plant without de-sulphurisation

Input			Output		
Melting materials	*t/t Pb*	*2.12*	*Products*		
Battery scrap	%	63	Lead and lead alloys	t/t Pb	1
Other melting materials	%	21	Battery paste	t/t Pb	0.5
Bullion, scrap lead	%	16	Polypropylene	t/t Pb	0.07
Reagents	t/t Pb	0.14	*Residues*		
Steel borings	%	46	Residual plastics	t/t Pb	0.10
Petrol coke	%	32	Slag	t/t Pb	0.23
Soda	%	22	*Others*		
Others			Exhaust gases	Nm^3/t Pb	70 000
Electric energy	MWh/t Pb	0.26			
Natural gas	MWh/t Pb	1.19			
PP chips (external)	t/t Pb	0.04			

Table 12: Input and output data for a battery recovery plant with de-sulphurisation

Input			Output		
Melting materials	*t/t Pb*	*1.41*	*Products*		
Battery scrap	%	79.0	Lead and lead alloys	t/t Pb	1
Other melting materials	%	3.8	Sodium sulphate	t/t Pb	0.096
Bullion, scrap lead	%	16.6	Polypropylene	t/t Pb	0.051
Flue dust incinerator	%	0.6	*Residues*		
Reagents	t/t Pb	0.307	Residual plastics	t/t Pb	0.108

NaOH	%	49.8	Metallurgical slag	t/t Pb	0.18
Steel borings	%	9.4	*Others*		
Petrol coke	%	17.6	Exhaust gases	Nm^3/t Pb	37 000
Soda	%	23.1			
Others					
Electric energy	MWh/t Pb	0.20			
Natural gas	MWh/t Pb	0.73			
Steam	MWh/t Pb	0.84			

After the recovery of lead from battery scrap the refining of crude lead is operated. Lead bullion may contain varying amounts of copper, silver, bismuth, antimony, arsenic and tin. Lead recovered from secondary sources may contain similar impurities, but generally antimony and calcium dominate. There are two methods of refining crude lead:

a) electrolytic refining, which refining uses anodes of de-copperised lead bullion and starter cathodes of pure lead,
b) pyrometallurgical refining that consists of a series of kettles, which are indirectly heated by oil or gas.

Copper is the first element to be removed and separates as sulphide dross. If the crude metal is deficient in sulphur more must be added in the form of sulphur powder or pyrite. The sulphide dross is removed from the metal surface by mechanical skimmers that discharge into containers. Arsenic, antimony and tin are removed by oxidation. The usual method, often referred to as ’’lead softening’’, involves a reaction with a mixture of sodium nitrate and caustic soda, followed by mechanical skimming to remove the oxide dross. Air/oxygen can also be used as the oxidising agent. After refining the doping according to the requirement of customers follows.

The essential element of the production is chemical analysis of intermediate products and products usually streamed at analysis of content of Sn, Sb, Bi, Cu, As, Ag, Zn, Cd, Ni, Se, Te, Fe, Al, Ca, S and Pb.

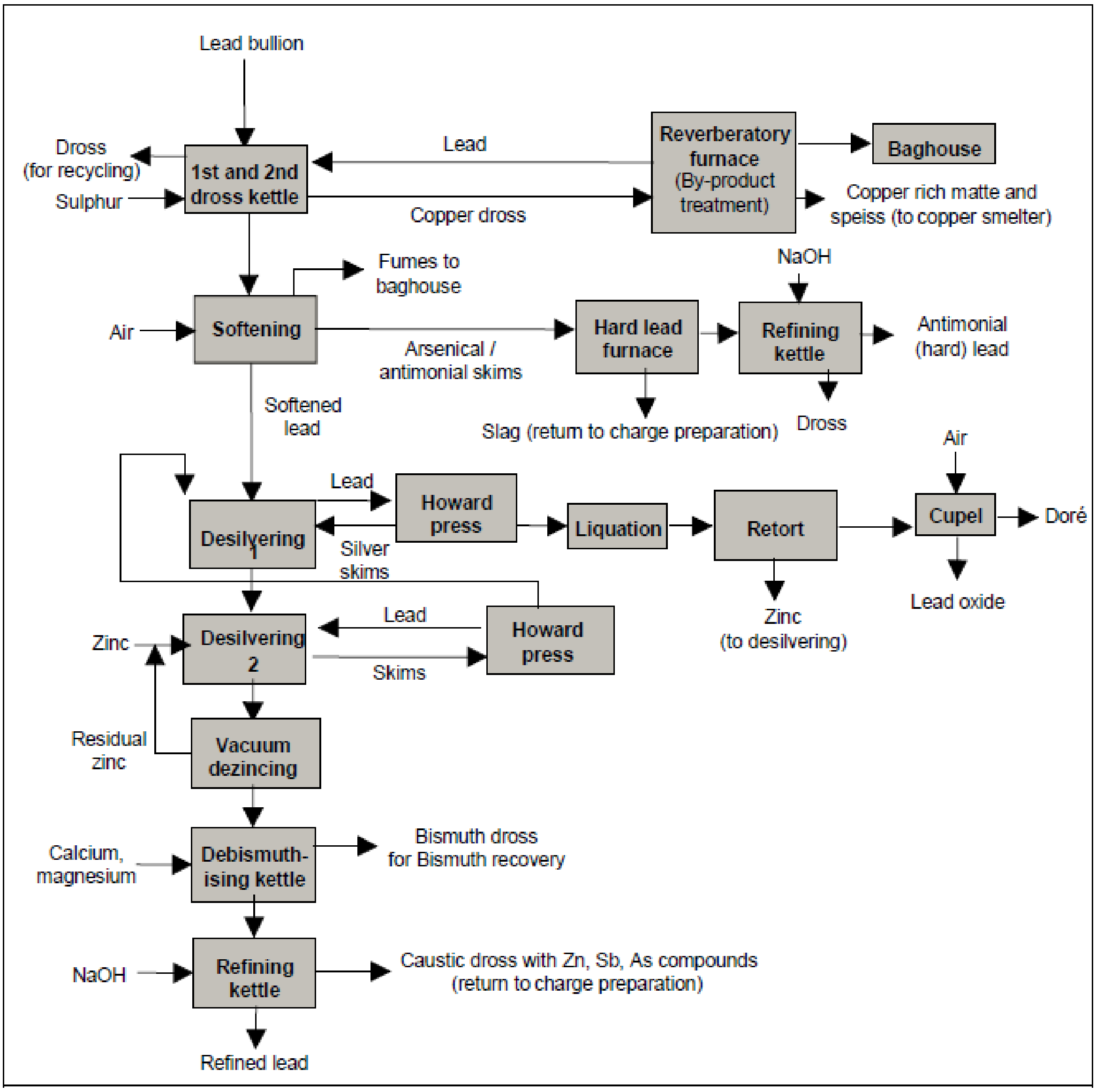

Figure 10: Diagram of lead refining process [11]

The process of lead scrap recovery produces emissions to air and waste waters. The main emissions to air are [7]:

- sulphur dioxide SO_2, other sulphur compounds and acid mists;
- oxides of nitrogen NO_X and other nitrogen compounds;
- metals and their compounds;
- dust;
- VOC´s and PCDD/F.

Table 13: Mass release of metals from battery scrap recovery in some plants in Europe [7]

Process	Production	Dust	Zn	Pb	Cd	As

Battery – Whole (shaft)						
-process	49 000	10 - 25	0.1	2.5	<0.1	<0.15
-refinery	53 000	0.49	NA	0.024	NA	NA
-secondary*		<2 mg/Nm^3	NA	<0.01	NA	NA
Battery – desulphurised paste						
-process	43 000	1 - 3	NA	0.1 - 1	0.01	0.18
-refinery	52 000	4	NA	0.5	0.02	0.24
-secondary*		6	NA	0.3	NA	0.02
Battery – Whole (short rorary)						
-process	10 000	15 - 35	NA	<0.5	NA	<0.3

Secondary hood dedusting

Table 14: Example of national emission limits for standard conditions (dry gas) for secondary lead technology (Slovak Republic)

Pollution source	Emission limit (mg/m^3)		
	Solid pollutants	SO_x	NO_x
Transport and handling	50		
Furnace aggregates	20	350	400
Smelting and casting	10	350	400

The battery breaking and washing stages produce an effluent which is acidic and contains lead and other metals in suspension and solution. This effluent is neutralised and the water is recycled in the process. If possible, the acid is used elsewhere. A portion is usually bled from the system to control dissolved salts. Cooling water can also arise from cooling the crushing process [7].

These processes also produce contaminated surface water and consequently this water is also treated and reused. It is common practice to discharge a bleed of this sealed water circuit after further treatment and analysis. Road and surface contamination is minimised by the frequent wet cleaning of roads, hard standing areas, lorries and by cleaning up spillages.

The quality and quantity of waste water depends on the process used, the composition of the raw materials used in the process and the practices used by the operators. The reuse of process water and rainwater is common.

Cooling water from the granulation of slag or the cooling pond is usually recirculated in a closed circuit system.

Typical components in waste water from some processes are given in Table [7].

Table 15: Typical waste water analysis [7]

Process	Effluent (m^3/yr)	Flow (m^3/h)	Main components (mg/l)					
			Pb	Cd	As	Zn	Ni	CO
Mechanical battery separation (CX)+ Rotary Furnace *	190 000	<0.2						
Mechanical battery separation (MA) + rotary furnace *	124 000		0.02	0.07	<0.0005	0.27	0.09	
Whole battery *	150 000	40	0.4	0.01	<0.001	0.01	<0.05	96
Shaft furnace *	17 000		<0.2	<0.1		<0.3		
CX + rotary furnace + Pb refinery *	105 000	2.1	0.13	0.01	0.01		0.03	

*Secondary furnaces

Table 16: Example of national emission limits for waste waters discharged to surface waters (Slovak Republic)

Component	mg/l
pH	6.0 – 9.0
Suspended solids	40
Al	3.0
As	0.1
Cd	0.2
Cr total	0.8
Cr 6+	0.1
Cu	0.8
Hg	0.05
Ni	0.8
Pb	0.4
Sn	1.6
V	1.6
Zn	2.0
CN^{-}_{tox}	0.1
AOX	2.0
Non-polar extractable substances	3.0

Disposal of used lead batteries

The main objective of the environmental policy in the field of used lead batteries is to maximise the separate collection, reuse lead as valuable recoverable resource and to minimise disposal of used batteries as mixed municipal waste.

According to Article 14 of the EU Batteries Directive (2006/66/EC) [9] the European Member States shall prohibit the disposal in landfills or by incineration of waste industrial and automotive batteries and accumulators. However, residues of any batteries and accumulators that have undergone both treatment and recycling may be disposed of in landfills or by incineration.

From the above, it becomes clear that waste management such as landfilling and incineration cannot be considered as an environmentally sound management of used lead batteries, not only for economic reasons but also for health and environmental reasons.

However, there are cases in which the disposal is necessary, especially when no treatment and recycling facilities exist or the fractions got from dismantling of used batteries are not suitable for consequent recovery in the country which is not the European Member States.

The disposal of used lead batteries or fractions of dismantling of used batteries can be permitted, when no viable end market is available, only in landfills or underground long-term storages that are designed and operated for disposal of hazardous wastes. Such landfills of underground storages must be authorised by state authorities (Regional Districts or Ministry of Environmental Affairs).

It is recommended to ban the incineration of used lead batteries.

Landfills for hazardous wastes

The location of the landfill for hazardous wastes must take into account:

d) secure distance from the boundary of the future landfill site to residential and recreation areas, waterways, water bodies and water sources,
e) geological, hydrological, hydrogeological and mechanical-geological conditions in the vicinity,
f) the protection of nature, landscape and cultural heritage in the vicinity,
g) the acceptable burden on the territory,
h) possible extreme meteorological effects and their impacts,
i) conclusions from an environmental impact assessment study.

A landfill must be sealed in such a way that a geological barrier or an artificial base sealing layer for the landfill and a top sealing layer for the landfill result in protection of the soil, surface water and groundwater after closure. The landfill base and sides shall consist of a geological barrier with thickness ≥ 5 m and permeability $k_r \leq 1.0 \times 10^{-9}$.

Picture 6: Landfill foundation

Where the geological barrier fails to meet these requirements, it shall be completed artificially. The artificially completed geological barrier (mineral layer) shall be no less than 0.5 m thick with permeability of $k_r \leq 1.0 \times 10^{-10}$. The landfill sealing must be supplemented by at least one layer of high-density polyethylene foil (HDPE), 2.5 mm thick. The artificial mineral sealing layer must have characteristics preventing adverse changes to the landfill base due to the landfilling and capable of adapting to base deformations; it shall be laid in two layers of 0.25 m each. In the case of the soil which is to be used as the artificial mineral sealing layer, the following characteristics shall be measured: grain size, humidity, limits of consistency and derived values, absorption capacity, organic content, calcium content, clay-like minerals, density according to Proctor, hydraulic permeability, modulus of rigidity and shearing strength. A protective layer at least 0.2 m thick shall be laid between the plastic foil and the drainage layer in order to protect the plastic foil against mechanical damage; the protective layer shall consist of sand or gravel with a grain size of not less than 8 mm. Various types of suitable geotextiles can also be used as an additional layer.

Picture 7: Artificial geological barrier for landfill

Picture 8: Artificial barrier using HDPE foil for landfill

Picture 9: Foundation of landfill

Appropriate measures shall be taken at any landfill in order to control leachate and manage the leachate regime providing in particular for control of water from precipitations entering into the landfill body, prevention of surface water and groundwater from entering into the landfill waste, drainage and collection of leachate, the treatment of leachate collected from the landfill in order to comply with discharge values into the sewerage system or recipient or transport of the leachate to a suitable sewage treatment plant.

The drainage layer of the landfill must be at least 0.5 m thick. Gravel with a diameter of 16/32 mm not containing calcareous admixtures shall be used as the material for the drainage layer. Drainage pipes shall have a diameter of at least 200 mm. Slit holes shall be at least 2 mm wide and at least 30 mm long. Pipelines with circle holes shall have holes with a diameter of at least 12 mm. Pipelines shall be wrapped in a suitable geotextile protecting against the entry of fine particles. The drainage pipelines must empty into a leachate accumulation tank. Sewer manholes with an inside diameter of at least 1.0 m shall be built for inspection and cleaning of the drainage pipelines at intervals of not more than 150 m. The drainage pipelines must be flushed at least twice a year. The longitudinal gradient of the drainage pipelines must be at least 1%, and the gradient of the internal drainage (transverse gradient) shall be at least 2%. There shall be a suitable peripheral drainage system of suitable dimensions for the drainage of surface water from the vicinity of the landfill.

Landfill gas shall be collected from all landfills receiving biodegradable waste. The collected landfill gas must be treated and used to produce energy; if the landfill gas collected cannot be used to produce energy, it must be flared. The collection, treatment and use of landfill gas shall be carried on in a manner which minimises or does not have any negative effects on the environment and human health.

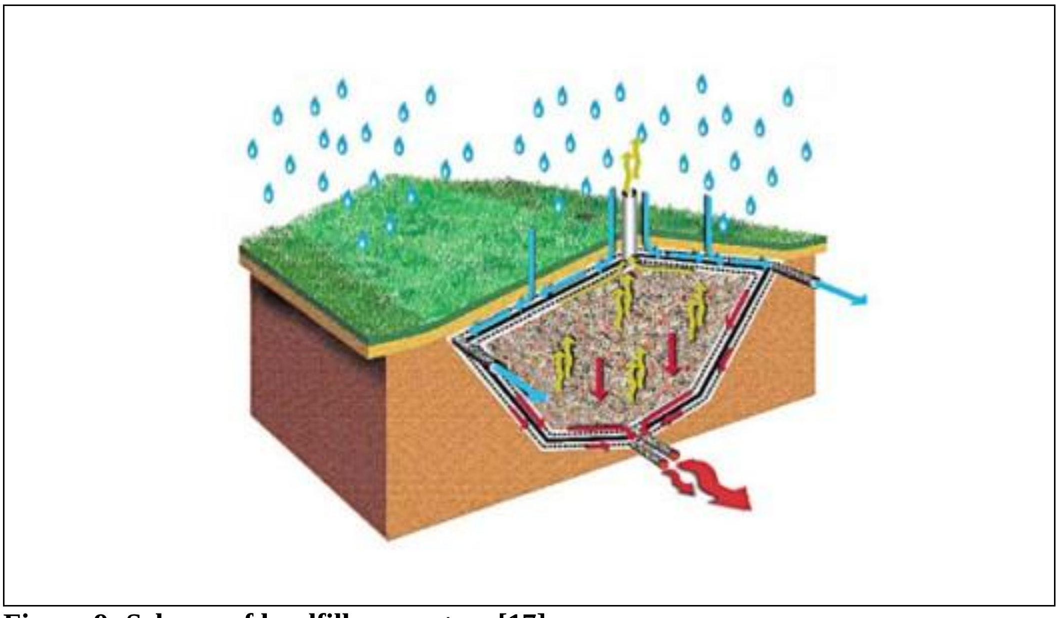

Figure 9: Scheme of landfill gas system [17]

A landfill site shall have:

a) an information board,
b) an approach road to the landfill and paved carriageways at the landfill site,
c) a fence and lockable gates,
d) a weighing-machine,
e) operating premises containing all the necessary equipment,
f) fire extinguisher,
g) a sealing system,
h) a drainage system with a leachate collection tank,
i) a drainage system for landfill gas and an installation for its use or disposal, except for landfills for wastes where landfill gas is not likely to originate,
j) a groundwater monitoring system,
k) a landfill gas monitoring system, except for landfills for wastes where landfill gas is not likely to originate,
l) a drainage system for surface water,

m) an installation for cleaning vehicles,
n) other installations necessary for operation of the landfill.

Any landfill must have a fence in order to prevent free access to the landfill. The gates must be locked outside operating hours. The system of control and access to the landfill must contain measures to prevent dumping of wastes at the landfill without a consent of the landfill operator. On landfills where an artificial sealing barrier is used, the geological substratum of the landfill, considering the morphology of the landfill, must be sufficiently stable to prevent settlement that may cause damage to the artificial bottom sailing.

During the operation of a landfill measures shall be taken to minimise effects of the landfill on the environment caused by emissions of odours and dust, wind-blown material, noise and traffic, birds, vermin and insects, formation of aerosols or fires.

The landfill must be equipped and operated in such a way that dirt from it, caused mainly by the vehicles/means of transport, is not dispersed onto public roads and the surrounding land.

At the dump site waste shall be deposited in layers 0.3 to 0.5 m thick, which are then compacted; the working layer after compacting shall be no more than 2.0 m thick. Waste shall be compacted no later than the day following its dumping unless provided otherwise. The first layer of waste shall be deposited at the bottom of the landfill in such a way as not to damage the sealing and drainage systems of the landfill; the first layer of deposited waste may only be compacted if it is 2 m thick; the first layer may not contain waste which could damage the base of the landfill.

The emplacement of waste on the landfill site shall take place in such a way as to ensure stability of the waste deposited and associated structures of the landfill and the necessary construction equipment, particularly in respect of avoidance of slippages.

The operator of the landfill must provide the monitoring of:

a) meteorological data (precipitation, temperature, wind, evaporation, humidity),
b) emission data (amount and composition of leakage, emissions of gases),
c) measurements of quality of underground water (pH, TOC, phenols, heavy metals, fluorides, hydrocarbons…),
d) topography of the landfill.

For monitoring groundwater quality in the vicinity of a landfill site, a sufficient number of measuring points must be constructed; there must be at least three, one in the groundwater inflow region and two in the outflow region. The original values of groundwater quality must be ascertained before commencement of landfill operations.

If a landfill is located in an area with such suitable geological conditions such that at the location of the landfill and in its surrounding there are minerals meeting requirements for the sealing of the landfill and there is no underground water level up to a depth of 30 m under the landfill base and its occurrence is not likely in the future, the requirement for measuring points may be waived; however, such landfills must be monitored using geophysical methods at least once a year.

At the time of closure of a landfill, a surface sealing must be constructed, containing an artificial sealing layer, a sealing mineral layer with the same characteristics as the sealing layer at the landfill base, a drainage layer at least 0.5 m thick, a top soil cover at least 1.0 m thick.

After issuing a certificate on the closure of a landfill, the landfill shall be considered as definitely closed, and the operator of the landfill shall ensure monitoring and control of the landfill for at least 30 but not more than 50 years after issuing the certificate of closure of the waste landfill.

On closure of a landfill operation terminated the top of the landfill must be closed in a manner ensuring the same sealing efficiency as the bottom sealing of the landfill, drainage of leachate and landfill gas must be ensured, the top sealing layer must prevent surface water from entering the landfill body and must be resistant against the effect of settlement of the landfill, the landfill must be reclaimed in such a way that it has no disturbing effects on the surrounding landscape, on reclamation of the landfill, no trees can be planted that could cause damage to the functionality of the top sealing layer of the landfill through their roots and monitoring of the landfill shall be covered.

The underground long-term storage for hazardous wastes

Hazardous wastes including used lead batteries can be stored in long-term underground storages as closed salt- or potash-mines in appropriate containers.
The very strict controls on the accepted types of waste are undertaken at the mine in drums or bulk containers. After verification the used lead batteries, if accepted by the mine, are loaded into transit capsules for transport underground.
Drums are then offloaded and stacked in their allocated safe storage areas to a maximum height determined by their contents. The location of each waste consignment is recorded for future reference.
Once each disposal zone has been filled, walls (known as stoppings) are erected between the rock salt pillars to create physical barriers between storage zones. The operation of long-term storage must be held in that way that no harm for underground water or ambient air is ensured.
Usually underground mines undertake extensive research, establish detailed design and operational procedures and produce thorough qualitative and quantitative short and long-term risk assessments, all supported by complementary evidence.
Thanks to the geological and hydro-geological features that so effectively isolate the underground beds of rock salt from the biosphere, even in the worst case scenario the facility is likely to have “little or no adverse consequence” on the environment.

Accepting waste for disposal

Waste may only be accepted at a landfill or a long-term storage if the waste holder presents to the operator of the landfill or a long-term storage with each delivery of waste document on quantity and type of waste delivered, a consignment note and identification notes for hazardous wastes, details about the characteristics and composition of waste in the form of report on analytical control of wastes.

Picture 10: Balancing of container at the acceptation of the waste for disposal

At the time of delivery of the verification of whether the required waste documentation is complete and correct, verification of the data, and other conditions agreed for waste acceptance, control of quantity of waste delivered, visual inspection of waste delivery in order to verify declared information concerning origin, characteristics and composition of waste, ensuring controlled random sampling of waste and tests and analyses of waste in order to verify given information about origin, characteristics and composition of waste and recording accepted waste must be done. The operator of the landfill or a long-term storage shall confirm the acceptance of the waste to the waste holder, indicating the date and time of its acceptance.

Transboundary movement of used lead batteries

The transboundary movement of used lead batteries is subject of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. The import and export are a matter of notification of state authorities of both exporting and importing parties according to the article 6 of the Convention.
Such notification shall contain the declarations and information specified in Annex V A, written in a language acceptable to the State of import. Every shipment must be accompanied by the documentation containing information defined in Annex V B of the Convention.
The used lead batteries are classified as “A1160 Waste lead-acid batteries, whole or crushed” with Y-code “Y31 Lead; lead compounds” and H-codes “H1 Explosives”, “H8 Corrosives” and “H11 Toxic”.
Entry A1160 refers to “waste lead-acid batteries, whole or crushed”, while entry A1170 refers to “unsorted waste batteries excluding mixtures of only list B batteries and waste batteries not specified on list B containing Annex I constituents to an extent to render them hazardous”.
The mirror entry B1090 refers to “waste batteries conforming to a specification, excluding those made with lead, cadmium or mercury”. However, it can be assumed that all marketed battery systems contain at least one Annex I constituent, namely the electrolyte (which is either an acid Y34, alkali Y35, or a solvent Y42). Regardless of this classification, waste batteries are to be classified as hazardous waste in accordance with Article 1,1,b of the Convention anyhow. Therefore every transboundary transport of waste batteries is to be notified.
If the country of import is the EU Member State it is necessary to follow requirements of Regulation on shipment of waste [18]. The used lead batteries are defined as”A1160 Waste lead-acid batteries, whole or crushed” and only import for recovery is allowed, the import for disposal is allowed only the Community and its Member States, have concluded bilateral or multilateral agreements or arrangements with the country of export or in cases on exceptional grounds during situation of crisis, peacemaking, peacekeeping or war according to the Article 41 of the Regulation. The procedural requirements are described in Article 44 of the Regulation with the requirement of prior written notification in accordance with Article 4 of the Regulation and the conditions for shipment of the waste are given by Article 44 (4) of the Regulation.
To allow the Competent Authority a full evaluation of the foreign waste treatment or recycling process the notifier of the transboundary transport should at least provide the Competent Authority with the following (technical) information:

a) Chemical composition of the wastes (data from literature, no chemical analysis required in the case of batteries).
b) A technical description of the waste treatment / recycling process including a mass flow scheme.
c) Information of the recovery (R-operation) or disposal (D-operation) of the output of the treatment / recovery process.
d) Relevant information on the license (date of expire, licensed wastes).
e) Information on emissions (reference to BAT, mandatory or plant specific emission limits, current measurements of the emission to air and/or water, type of applied emission abatement technique).
f) Existence of a quality assurance system or an environmental performance assessment.

The Competent Authority shall scrutinize these documents and consent in the transboundary movement only if the environmentally sound treatment appears to be secured.
If the waste lead batteries are shipped into countries that signed international convention ADR [19] or RID [20] the requirements of the convention must be met.
For the transport of batteries and accumulators the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) [19] has to be considered. This is an agreement that

prescribes requirements for the transboundary transport of dangerous goods by road vehicles. The ADR specifies detailed requirements for the transport of the different battery types e.g. batteries, wet, filled with acids.

General requirements for "transport" / ADR

Requirements regarding the transport of lead-acid batteries from the Technical Guideline for the Environmentally Sound Management of Waste lead-acid Batteries [1] were summarised [4] as follows:

- Used batteries must be transported inside shock resistant and acid resistant sealed containers.
- In order to prevent move of containers during transport they must be well packed to the transport vehicle (i.e. they must be bound, shrink wrapped or stacked properly).
- The transport vehicle should be identified with symbols (transport of corrosive and hazardous products).
- The container shall be labelled with UN-Number 2794 BATTERIES, wet, filled with acid, electric storage, Class 8.
- A minimum set of specific equipment to combat spillage or leakage during transport must be available in the transport vehicle.
- Drivers and auxiliaries should be trained.
- Effective personal protection equipment is to be provided and available in the transport vehicle.
- Transport schedule and route is to be selected in a way that reduces the risk of possible accidents.

In principle the provisions of the ADR are applicable to the transport of waste batteries. However, according to Vol. II, clause 598 of the ADR 'used storage batteries' are not subject to requirements of ADR when:

- their cases are undamaged;
- they are secured in such a way that they cannot leak, slip, fall or be damaged, e.g. by stacking at pallets;
- there are no dangerous traces of alkalis or acids on the outside of the articles;
- they are protected against short circuiting.

Special care for batteries and accumulators with a liquid electrolyte

Batteries and accumulators with free liquid electrolyte may cause specific damage during storage and transport. They shall be kept separately based on the nature of their electrolyte (acidic, alkaline or organic) and stored in tight, leak proof and stable containers. It is recommended to use UN-tested and correctly labelled containers even for intermediate storage to avoid extensive manipulation/repackaging when the batteries are shipped.
Lead acid batteries are listed under UN-Number 2794/Class 8, alkaline batteries under UN-Number 2795/Class 8.
Accumulators with an organic electrolyte until recently have not been in common use and therefore are not mentioned in the ADR.

Sealed batteries/accumulators (e.g. consumer batteries type AA, AAA, C, D) are normally not regarded as batteries with liquid electrolyte. However, sealed lead acid batteries should be regarded as accumulator with liquid electrolyte since the acid may leak out quite easily due to mechanical damage. It is therefore recommended to collect, store and transport seal lead acid batteries in the same way as normal lead acid batteries.

Economic aspects of environmentally sound management of used lead batteries

The project [2] proposes the application of extended producer responsibility as a system for financing the environmentally sound management of used lead batteries according to the model of EU stated in the Battery Directive [9] The extended producer responsibility is based on the responsibility of producers / importers of batteries to establish and operate system of separate collection, treatment and recovery of used batteries what means also to finance whole system. The producers can fulfil their obligations individually or collectively through collective scheme.
Producers must cooperate with producers (holders) of used batteries, as services and maintenance facilities as well as with municipalities to provide for separate collection of used batteries in order to fulfil legal limits of collection, given usually as a percentage of amount put on the market. The industrial association or governmental authority (ministry, agency…) collects data on amount of batteries put on the market during the years by every producer / importer. Every producer / importer can calculate his market share that is a base for calculation of the collection share.
The producer / importer is also obliged to fulfil recycling and recovery limits. He must cooperate also with the facilities dealing with the treatment and recovery of used lead batteries in the country or abroad. If the price of the treatment of used batteries is minus the producer / importer must pay also the costs connected with treatment.
If the producer / importer fulfil his obligation individually he has to finance the separate collection of the amount of used batteries that is equivalent to his collection share. If the producer / importer join the collective scheme then he pays to the system money equal to the amount of batteries that he put on the market and rate. The rate reflects real costs of separate collection, treatment and recovery of used batteries, as well as the costs of the information campaigns and the operation of the collective scheme itself.
However, obtaining secondary lead from used lead batteries is economically attractive, cutting about 25 % from the energy bill compared with mining primary lead. In addition, batteries are a ubiquitous product with a predictable lifetime, and the large market for recycled lead creates economies of scale. As a result, battery manufacturers rely heavily on secondary lead, most of it sourced from recycled batteries. Some of the lead recycled from batteries in the informal sector, however, does not re-enter the manufacturing sector but is used instead for other purposes, such as sinkers for fishing lines.
The costs of used lead batteries treatment and recovery vary according to the market situation. It is impossible to make estimation of the costs because prices in Europe are different from the prices in other regions.
The simplified scheme of waste, finance and information streams in used lead batteries EPR system is given in Figure 11.

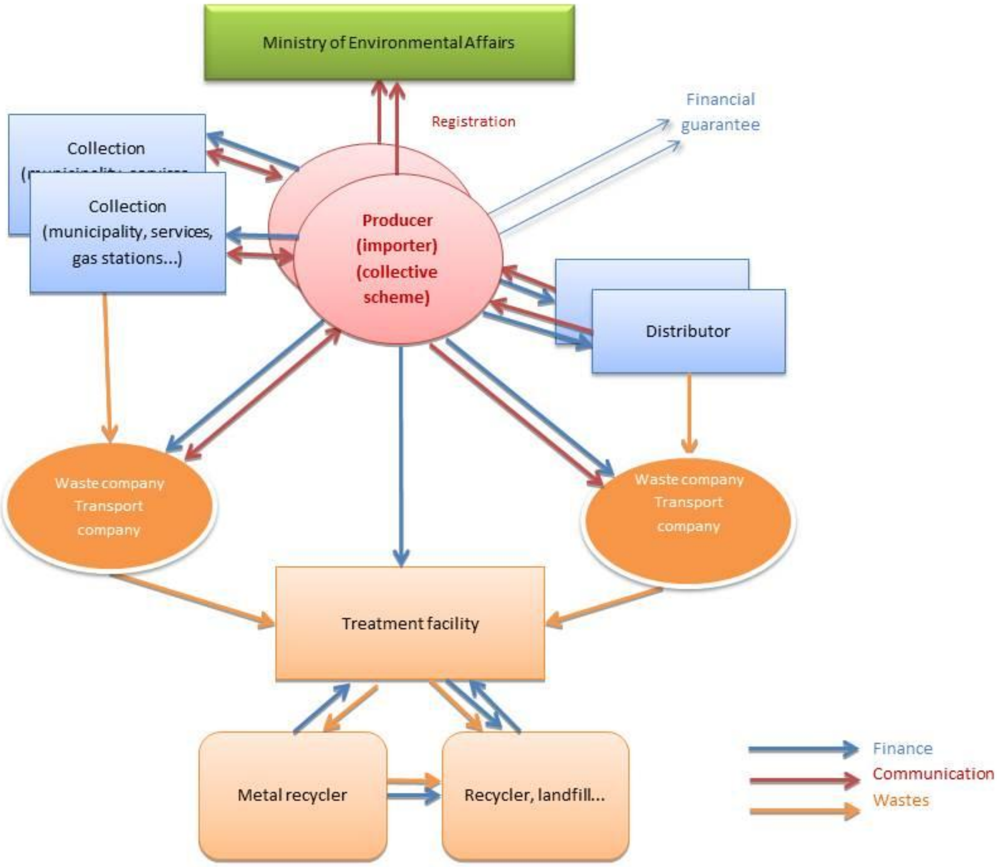

Figure 10: Scheme of waste, finance and information streams in used lead batteries EPR system

Last but not least, it must be understood that the lead environmentally sound management process is deeply embedded in social and economic aspects that dictate several problems as well as several solutions not covered and which could not possibly be covered in this guideline. Therefore, a specific contextual map should be generated, encompassing local politics, economical aspects, social aspects, local and international market aspects, etc., and the lead recycling plant inserted into this context. No solutions or orientations given here should be taken for granted but, instead, analyzed under the lights of this contextual map and its possibilities.

Conclusions and recommendations

As the lead batteries are at once an important source of secondary lead and environmental danger it is necessary to operate efficient system for environmentally sound management of used lead batteries in the countries. The very effective model for used batteries is implemented in European Union based on extended producer responsibility. This model generalise sufficient financial sources that can cover all costs of separate collection, treatment and recycling of used lead batteries. This is the main assumption for building an effective system.

The first and the most important step of used lead batteries management is separate collection. It is recommended to collect used batteries in places of their production, i.e. in services and maintenance operations. Effective system is mobile collection when mostly batteries from households and very small operations are collected. There are also other collection systems available for used batteries collection.

The efficiency of secondary lead production is depended on the sorting and treatment of used lead batteries. It is recommended to operate treatment in the same facility and technology as recycling by metallurgical technologies but it is not the necessary condition. The treatment means dismantling of used lead batteries in order to get metals and other components. It is recommended to respect European standards for used lead batteries treatment given by BREF documents, mainly given by BREF on Non-Ferrous Metals [7]. European standards also cover the best available techniques for lead recycling.

Some wastes arisen during the processes of treatment and recycling cannot be recovered and they must be landfilled on special landfills for hazardous wastes. The technical and environmental conditions for landfilling of hazardous wastes are also introduced.

The necessary part of all steps of waste management is transport. As lead batteries (new or used) are hazardous and introduce danger especially for waters (surface or underground) special conditions for transport must be followed.

The system of environmental sound management of used lead batteries can be successfully implemented only when four conditions will be met:

c) legislative rules are effective and applicable,
d) all or at least most of producers /importers of lead batteries are participating in the system,
e) facilities for lead recycling are available in appropriate distance (best of all in the country or in a not-very-far distance in neighbouring countries),
f) effective state control and supervision to prevent human health and environmental hazard together with good law enforcement.

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