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Matters related to the work programme of the Open-ended Working Group for the biennium 2024–2025: scientific and technical matters: technical guidelines: technical guidelines on the environmentally sound management of waste lead-acid batteries and on other waste batteries

Technical guidelines on the environmentally sound management of waste lead-acid batteries

Note by the Secretariat

The annex to the present note sets out a revised version of the technical guidelines on the environmentally sound management of waste lead-acid batteries, as revised by the Open-ended Working Group at its fourteenth meeting. The present note, including its annex, has not been formally edited.

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Annex

Draft updated technical guidelines on the environmentally sound management of waste lead-acid batteries

(Draft updated version of 27 June 2024)

Contents

Abbreviations and acronyms

ABS	Acrylonitrile Butadiene Styrene
ACGIH	American Conference of Governmental Industrial Hygiene
ANSI	American National Standards Institute
As	Arsenic
ASTM	American Society for Testing and Materials
BC	Basel Convention
BLV	Biological Limit Value
BOD	Biological oxygen demand
BAT	Best available techniques
Bi	Bismuth
Ca	Calcium
$CaCO_3$	Calcium carbonate
CAS	Chemical Abstracts Service
CDC	US Centres for Disease Control and
CEC	Prevention
CEN	Commission for Environmental Cooperation
	European Committee for Standardization
Cl	chlorine
CNS	Central nervous system
CO_2	Carbon dioxide
COD	Chemical oxygen demand
Cu	Copper
DES	Deep Eutectic Solvents
EC	European Commission
ECHA	European Chemicals Agency
EDTA	Ethylenediamine tetra acetic acid
EIA	Environmental impact assessment
EMS	environmental management system
EN	European standard
EPR	extended producer responsibility
ESM	environmentally sound management
ESP	electrostatic precipitators
EU	European Union
Fe_2O_3	Iron oxide
GHG	Greenhouse gas
H_2O	Water
H_2S	Hydrogen sulphide
H_2SO_4	Sulphuric AcidHigher Income Countries
HIC	
HSE	Health, safety & environment
IAEA	International Atomic Energy Agency
IATA	International Air Transport Association
ILO	International Labour Organization
IMO	International Maritime Organization
ISO	International Organization for Standardization
LAB	Lead-acid Battery
LMICs	Low & Middle Income Countries
MEE	Ministry of Ecology and Environment (China)
MMSD	Mining, Minerals and Sustainable Development (IIED/WBCSD project)
MSW	municipal solid waste
HaOH	Sodium hydroxide
N_2	Nitrogen
NEMA	National Electrical Manufacturers
NEWMOA	Association

	Northeast Waste Management Officials'
	Association
NGO	Non-governmental organisation
NHMRC	National Health and Medical Research
NH_3	Council of Australia
NH_3PbCl_3	Ammonia
$(NH_4)_2CO_3$	Ammonium lead chloride
NH_4Cl	Ammonium carbonate
	Ammonium chloride
NOx	nitrogen oxide
O_2	Oxygen
OEWG	Open-ended Working Group (of the
	Basel Convention)
OECD	Organisation for Economic Co-operation
	and Development
OHSA	Occupational Health Safety
	Administration
Pb	Lead
PbB	Blood lead
PbO	Lead oxide
PbO_2	Lead dioxide
$Pb(OH)_2$	Lead hydroxide
$PbSO_4$	Lead sulphate
PPE	Personal Protection Equipment
PVC	Poly Vinyl Chloride
QA/QC	Quality Assurance/Quality Control
QSP	Quick Start Programme
RPE	Respiratory Protection Equipment
SAICM	Strategic Approach to International
Sb	Chemicals Management
	Antimony
SETAC	Society of Environmental Toxicology
	and Chemistry
SCOEL	Scientific Committee on Occupational
	Exposure Lead
SLI	Starter, Lighting, Ignition
SME	Small Medium Enterprise
Sn	Tin
SO_2	sulphur dioxide
SOP	standard operating procedure
S/S	stabilization and solidification
TCLP	toxicity characteristic leaching procedure
TOC	total organic carbon
ULAB	Used lead-acid batteries
UNDP	United Nations Development
	Programme
UNECE	United Nations Economic Commission
	for Europe
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development
UNITAR	Organization
USAID	United Nations Institute for Training and
	Research
	United States Agency for International
	Development
USEPA	Environmental Protection Agency
	(United States of America)
VLR	Valve regulated lead battery
WCO	World customs organisation
WLAB	waste lead-acid batteries
WHO	World Health Organization
Zn	Zinc

Units of measurement

µg	microgram
mg	milligram
g	gram
kg	kilogram
mg/kg	milligram(s) per kilogram. Corresponds to parts per million (ppm) by mass.
L or l	litre
dL or dl	decilitre
m^3	cubic meter
cm^3	cubic centimeter

I. Introduction

A. Scope

1. The present technical guidelines provide guidance on the environmentally sound management (ESM) of waste lead acid batteries (WLAB)[1] pursuant to decisions BC-15/11 and BC 16/6 of the Conference of the Parties to the Basel convention on the Control of Transboundary Movement of Hazardous Waste and their Disposal. [The terms WLAB and ULAB are used interchangeably, at the domestic level, by some Parties.]

2. This document supersedes the Basel Convention *Technical Guidelines for the Environmental Sound Management of Waste Lead-acid Batteries* of September 2003.

3. These guidelines cover waste lead-acid batteries, which are all categorised as hazardous wastes under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

4. It should be noted that several other technical guidelines also provide guidance relevant to the environmentally sound disposal of WLAB and the materials or components used therein, as follows:

(a) The technical guidelines on the environmentally sound recycling/reclamation of metals and metal compounds (R4) (UNEP, 2004).

(b) The technical guidelines on the environmentally sound management of plastic wastes (UNEP, 2023b).

(c) [For specific guidance on WLAB containing or contaminated with persistent organic pollutants (POPs), see the Basel Convention general technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with Persistent Organic Pollutants (UNEP, 2023a)]

(d) The technical guidelines on physico-chemical treatment (D9)/biological treatment (D8) (UNEP, 1999).

(e) The technical guidelines on the environmentally sound incineration of hazardous wastes and other wastes as covered by disposal operations D10 and R1 (UNEP, 2022d);

(f) The technical guidelines on the environmentally sound disposal of hazardous wastes and other wastes in specially engineered landfill (D5) (UNEP, 2022e).

B. About lead-acid batteries

5. Lead has one of the highest recycling rates of all commonly used materials and is the highest among metals and can be recycled indefinitely without reduction in quality. An average lead-acid passenger car battery can contain up to 10 kilograms of lead in the form of solid lead metal or lead-oxide paste. The amount of lead varies according to battery type. Consequently, each battery represents a valuable source of waste lead for recycling.

6. Globally recycled lead from waste lead-acid batteries (i.e., secondary lead) account for 57% of total annual lead production (11.5 million tonnes; 74% in Europe, and 100% in US) at the time of drafting these guidelines[2]. Approximately 86%[3] of lead produced[4] is used for lead-acid batteries and the demand for these is expected to continue to grow through to 2030. The data would suggest that approximately 10 million tonnes of lead is used for annual battery production and of this about 6.5 million tonnes comes from recycling waste lead-acid batteries.

7. Given the value of lead, battery recycling is a viable and profitable business globally for those engaged in the environmentally sound management of WLAB.

8. The adverse effects of lead on health are extensive and well documented with many epidemiology studies available on WLAB workers, those living close to WLAB[5] disposal[6] facilities,

[1] [The terms WLAB and ULAB are used interchangeably, at the domestic level, by some Parties.]

[2] https://www.ilzsg.org/

[3] https://www.unep.org/topics/chemicals-and-pollution-action/pollution-and-health/heavy-metals/used-lead-acid-batteries

[4] https://www.who.int/publications/i/item/WHO-FWC-PHE-EPE-17.02

[2] https://www.sciencedirect.com/science/article/abs/pii/S0013935117317243

[As defined by the operations in Annex IV of the Basel Convention, which includes recycling, reclamation].

the general population and in particular children. Lead is also toxic to aquatic organisms and pollution can result in adverse environmental impacts.

9. Lead-acid battery electrolyte, which is acidic and contaminated with lead, will have adverse environmental and harmful health implications for local communities if it is discharged without treatment or handled incorrectly[7]. In addition, studies also show the impact on flora and fauna demonstrating the need for and importance of environmentally sound management controls on WLAB.

10. The handling, collection, transportation, storage, and disposal of waste lead-acid batteries in an environmentally sound manner and effectively regulated is essential to prevent the adverse environmental and health impact of lead emissions and other substances, such as battery electrolyte. The environmentally sound disposal of waste lead-acid batteries using appropriate risk management measures and controls provides an economically viable and sustainable solution (conserving natural resources, reducing energy consumption and GHG emissions) for the production of new lead-acid batteries compared to producing and processing mined lead. Open burning or dumping, or deposit into or onto land of WLAB and its components should be strictly avoided.

C. Lead-acid batteries, categories & WLAB waste streams

1. Overview

11. Lead-acid batteries are essentially an electrochemical device which provides electrical energy through the controlled use of chemical reactions. Some batteries use reversible chemical reactions and can be recharged, such as lead-acid car batteries. The discharge-recharge process can be repeated several hundred times, but the lead oxide plates become increasingly contaminated by lead sulphate which eventually inhibits the chemical reactions. In addition, a sludge layer (55-60% $PbSO_4$; 20-25% PbO_2; 1-5% PbO; 1-5% metallic Pb[8]) starts to accumulate at the bottom of the battery[9]. Eventually the high level of contamination prevents recharging, and the battery is no longer useable in its current format as a lead acid battery. [For example, at this moment the battery is "spent" and becomes a used lead-acid battery and therefore a waste.]

12. Whatever application, a typical lead-acid battery contains the following components (Fig 1):

(a) **Positive and negative terminals** made of lead [or other metals], and where the external electrical consumer devices are connected;

(b) **Internal Connectors**: made of lead, that make electrical contact between plates of same polarity and make electrical contact between separated elements;

(c) **Cap and box:** plastic (either polypropylene, a co-polymer or Acrylonitrile Butadiene Styrene (ABS));

(d) **Battery electrolyte:** dilute sulphuric acid solution (15%-20%);

(e) **Element separators**: usually a part of the box and made of the same material, provides chemical and electrical isolation between electrical elements.

(f) **Plate separators**: made of permeable plastic or other porous materials, prevents physical contact between two contiguous plates but, at the same time, allows the free movement of ions in the electrolyte solution;

(g) **Battery plates:** comprise metallic lead structures (grids), covered by a lead dioxide-based 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 in recent years, carbon. The plates manufacturing process also uses expander materials, such as barium sulphate, lampblack and lignin that are added to prevent the plate retraction during use. A standard battery has 13 to 15 plates. Lead-acid batteries typically fail due to sulphation that occurs on the plates. Therefore, a WLAB is likely to contain lead sulphate in the battery paste.

[4] https://www.cdc.gov/niosh/topics/sulfuric-acid/

[8] https://link.springer.com/article/10.1007/s00501-014-0293-6

[9] July 2014, BHM Berg-und Huttenmannische: https://link.springer.com/journal/501/volumes-and-issues/159-7

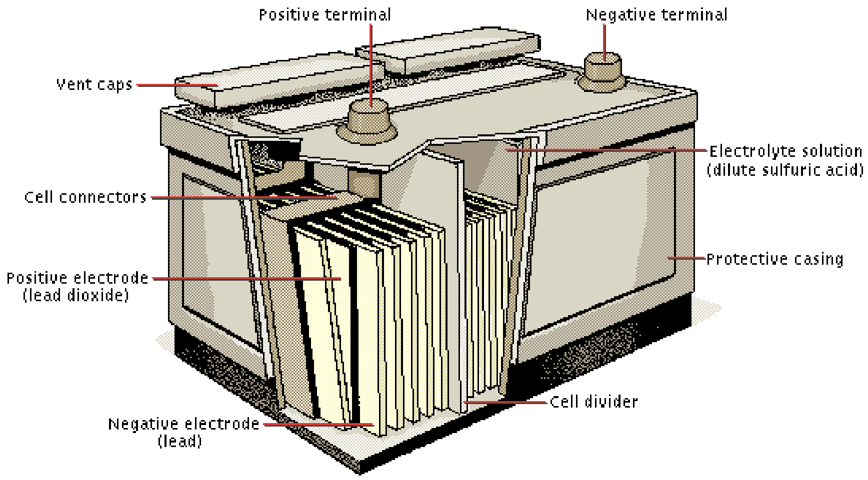

Fig 1 Schematic of a lead-acid battery.

13. In summary a lead-acid battery contains lead metal and oxides (65% of the battery by weight), cell separators (polyester, polypropylene, fibrous glass matt – 7%), electrolyte containing sulphuric acid (16%) and plastic or hard rubber casing (12%). Most of these components can be recovered, recycled and reused.

2. Types and Applications

14. Lead-acid batteries have numerous applications and comprise different voltages, sizes, and weights, ranging from 2 kg no-break sealed batteries (e.g., security alarms) to industrial batteries which may weigh more than 2,000 kg (e.g., forklift truck) or more.

15. [Batteries are typically classified according to their use, as follows:

(a) Automotive – those batteries mainly used as the main energy source for starting, lighting, ignition (SLI batteries) in internal combustion engine such as cars, trucks, tractors, motorbikes, boats, planes, etc. Also used as auxiliary batteries in hybrid and full electric vehicles to power safety functions and other onboard electrics;

(b) Generic/portable - batteries used in, domestic alarm systems, emergency lights, etc.;

(c) Industrial - batteries for stationary applications such as telecommunications, electrical power stations, uninterrupted power supplies or no-breaks, load levelling, alarm and security systems, general industrial use and starting diesel motors, solar panels and wind turbines;

(d) Motive - batteries used to transport loads or people: forklift trucks, golf carts, luggage transportation in airports, wheelchairs, electric cars, buses, etc.;

(e) Special - batteries used in specific scientific, medical, or military applications, and those that are integrated in electric-electronic circuits;

(f) Stop/start – batteries specifically designed to enable vehicles to stop using the engine when stationary and then restart when the accelerator is engaged.]

3. Battery Life

16. Battery life may be considered the period from when the battery is manufactured and ends when the battery becomes a waste[10], during which it is capable of being recharged and retaining its charge. Once the battery cannot be recharged or retain sufficient charge, it reaches its end of life. The main cause of this is due to the sulphation process.

17. [Under ideal conditions, a battery can last up to six years or more[11] depending on the type, but several factors contribute to reduce its lifetime:

(a) An incomplete charging process or the battery remains too long without use or stands a long time between charges;

[10] Article 3 – Definition 59. EU Battery Regulation - 2023/1542 - EN - EUR-Lex (europa.eu)

[11] https://www.batteryskills.com/how-long-do-lead-acid-batteries-last/

(b) Hot weather increases the sulphation process rate;

(c) Deep discharging processes, the deeper the discharge the less will be the lifetime of the battery. This is particularly the case with automobile batteries, but not so for energy storage batteries specifically designed for deep discharge;

(d) Low electrolyte level: air exposed plates become sulphated immediately. This only applied to flooded batteries and not to sealed maintenance free batteries or Valve Regulated Lead batteries (VLR);

(e) Poor quality manufacturing and lower quality lead used in battery production negatively impacts battery life.]

18. [When all these factors are considered, the battery life span ranges enormously from as little as 6 to 24 months to 6 to 10 years or more. [12]To extend the battery life better battery labelling should address the correct procedures to prolong battery life, such as adding only deionised water, or usage tips about maintaining charge and so on. In addition, the adoption of new and improved recharging processes may increase the battery lifetime. Extended battery life has environmental benefits by reducing the recycling frequency, energy inputs and emissions.]

19. At the end of its life the battery, once it is ready to be disposed of, or intended to be disposed of, or required to be disposed, is classified as a hazardous waste under the Basel Convention and should be managed in an environmentally sound manner to protect human health and the environment against the adverse effects which may occur from such wastes.

4. Lead-acid battery waste streams

20. Waste lead-acid batteries may comprise several waste streams, as follows:

(a) Metallic lead and lead alloys;

(b) Lead oxides;

(c) Lead sulphate;

(d) Battery electrolyte – dilute sulphuric acid;

(e) Plastic casing – polypropylene and ABS;

(g) Separators – glass and plastic.

21. All of these waste streams should be managed in an environmentally sound manner as they have the potential to have adverse effects on human health and/or the environment from the lead and acid.

II. Relevant provisions of the Basel Convention and international linkages

A. Basel Convention

1. General provisions

22. The Basel Convention, which entered into force on 5 May 1992, aims to protect human health and the environment against the adverse effects resulting from the generation, management, transboundary movements, and disposal of hazardous and other wastes. It does this via a set of provisions on the transboundary movement of wastes and their ESM. In particular, the Basel Convention stipulates that any transboundary movement (export, import or transit) of wastes is permissible only when the movement itself and the planned disposal of the hazardous or other wastes are environmentally sound. It states that hazardous wastes should, as far as is compatible with environmentally sound and efficient management, be disposed of in the State where they were generated. A set of provisions of the Basel Convention lays out Parties obligations to ensure the ESM of [hazardous and other] wastes. These are listed in paragraphs 23 to 35 below.

23. Article 2 ("Definitions"), paragraph 1, of the Convention defines wastes as "substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law". Management means the collection, transport and disposal of hazardous wastes or other wastes, including the aftercare of disposal sites. Paragraph 4 of that article defines disposal as "any operation specified in Annex IV" to the Convention. Annex IV contains two

[12] https://www.batteryskills.com/how-long-do-lead-acid-batteries-last/#google_vignette

categories of operations: those leading to the possibility of resource recovery, recycling, reclamation, direct reuse or alternative uses (R operations) and those not leading to this possibility (D operations). Paragraph 8 defines the ESM of hazardous wastes or other wastes as "taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the related adverse effects which may result from such wastes."

24. Article 4 ("General obligations"), paragraph 1, establishes the procedure by which Parties exercising their right to prohibit the import of hazardous wastes or other wastes for disposal shall inform the other Parties of their decision. Paragraph 1 (a) states: "Parties exercising their right to prohibit the import of hazardous or other wastes for disposal shall inform the other Parties of their decision pursuant to Article 13." Paragraph 1 (b) states: "Parties shall prohibit or shall not permit the export of hazardous or other wastes to the Parties which have prohibited the import of such wastes when notified pursuant to subparagraph (a) above."

25. Article 4, paragraphs 2 (a)-(e) and 2 (g), and paragraph 8, contain key provisions of the Basel Convention pertaining to ESM, transboundary movement, waste minimization and waste disposal practices aimed at mitigating adverse effects on human health and the environment:

Paragraphs 2 (a) – (e) and 2 (g): "Each Party shall take the appropriate measures to:

(a) Ensure that the generation of hazardous wastes and other wastes within it is reduced to a minimum, considering social, technological and economic aspects;

(b) Ensure the availability of adequate disposal facilities, for the environmentally sound management of hazardous wastes and other wastes, that shall be located, to the extent possible, within it, whatever the place of their disposal;

(c) Ensure that persons involved in the management of hazardous wastes or other wastes within it take such steps as are necessary to prevent pollution due to hazardous wastes and other wastes arising from such management and, if such pollution occurs, to minimize the consequences thereof for human health and the environment;

(d) Ensure that the transboundary movement of hazardous wastes and other wastes is reduced to the minimum consistent with the environmentally sound and efficient management of such wastes, and is conducted in a manner which will protect human health and the environment against the adverse effects which may result from such movement;

(e) Not allow the export of hazardous wastes or other wastes to a State or group of States belonging to an economic and/or political integration organization that are Parties, particularly developing countries, which have prohibited by their legislation all imports, or if it has reason to believe that the wastes in question will not be managed in an environmentally sound manner, according to criteria to be decided on by the Parties at their first meeting;

(f) Prevent the import of hazardous wastes and other wastes if it has reason to believe that the wastes in question will not be managed in an environmentally sound manner;

(g) Paragraph 8: "Each Party shall require that hazardous wastes or other wastes, to be exported, are managed in an environmentally sound manner in the State of import or elsewhere."

26. Under Article 4A (amendment adopted by Decision III/1, known as "Ban Amendment"), which entered into force on 5 December 2019, Parties listed in Annex VII to the Convention (members of the European Union (EU), Organization for Economic Cooperation and Development (OECD) and Liechtenstein) shall prohibit transboundary movements to States not listed in Annex VII of hazardous wastes which are destined for operations according to Annex IV-A and hazardous wastes under Article 1.1(a) which are destined to operations according to Annex IV-B. [13]. ["Other wastes" included in Annex II are not subject to the Ban Amendment.]

2. Provisions relating to waste lead-acid batteries

27. According to Article 1 ("Scope of the Convention"), the Basel Convention covers two types of waste subject to transboundary movement: "hazardous wastes" and "other wastes".

[13] For information on the status of individual Parties in relation to the amendment/s, please see the Status of Ratifications page on the Basel Convention website. https://www.basel.int/Countries/StatusofRatifications/PartiesSignatories/tabid/4499/Default.aspx[14] This entry became effective on 1 January 2025.

28. Paragraph 1 of Article 1 sets out that hazardous wastes in the scope of the Basel Convention are:

a. Wastes that belong to any category contained in Annex I, unless they do not possess any of the characteristics contained in Annex III; and

b. Wastes that are not covered under paragraph (a) but are defined as, or are considered to be, hazardous waste by domestic legislation of the Party of export, import or transit.

29. The relevant Annex I wastes and Annex III hazardous characteristics are summarised in Table 1 below. National tests may be useful for identifying a particular hazardous characteristic in Annex III of the Convention until such time as the hazardous characteristic is fully defined. Guidance documents for Annex III hazardous characteristics H4.1, H11, H12 and H13 were adopted on an interim basis by the Conference of the Parties to the Basel Convention at its sixth and seventh meetings.

Annex 1 Categories of Wastes to be Controlled	
Lead: lead compounds	Y31
Acidic solutions or acids in solid form	Y34
Annex III List of Hazardous Characteristics	
Flammable solids	H4.1
Poisonous (Acute)	H6.1
Infectious substances	H6.2
Corrosives	H8
Toxic (delayed or chronic)	H11
Ecotoxic	H12
Capable after disposal of yielding a material which possess a hazardous characteristic unless they can be shown not to exhibit such characteristics	H13

Table 1 Annex I wastes and Annex III hazardous characteristics

30. At its fourth meeting in February 1998, the Conference of the Parties added the two lists of wastes as two new annexes to the Convention, namely Annex VIII (list A) and Annex IX (list B). These were intended to provide greater certainty and clarity to the entries. List A and List B are kept under review by the Conference of the Parties; in addition, a process was established under Decision BC VIII/15 of the Conference of the Parties to the Basel Convention to facilitate the identification and agreement on new entries. However, Annex I and Annex III remain the factors to characterize wastes as hazardous for the purpose of this Convention, and that List A and List B are not intended to be exhaustive.

31. List A of Annex VIII describes wastes that are “characterized as hazardous under Article 1, paragraph 1 (a) of the Convention” although “their designation on this Annex does not preclude the use of Annex III [hazard characteristics] to demonstrate that a waste is not hazardous” (Annex I, paragraph (b)). List B of Annex IX lists wastes that “will not be wastes covered by Article 1, paragraph 1 (a), of this Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic”.

32. The Basel Convention contains entries on WLAB in List A of Annex VIII of the Convention14 as follows:

A1010 Metal wastes and waste consisting of alloys of any of the following: lead, but excluding such wastes specifically listed on list B;

A1020 Waste having as constituents or contaminants, excluding metal waste in massive form, any of the following: lead or lead compounds;

A1160 Waste lead-acid batteries whole or crushed;

A1170 Unsorted waste batteries excluding mixtures of list B batteries. Waste batteries not specified on list B containing Annex 1 constituents to the extent that render them hazardous;

A3210 Plastic waste, including mixtures of such waste, containing or contaminated with Annex I constituents, to an extent that it exhibits an Annex III characteristic;

A4090 Waste acidic or basic solutions, other than those specified in the corresponding entry on list B;

A1181 Electrical and electronic waste [(note the related entry Y49 in Annex II)[14]

The Convention also includes entries in List B, related to WLAB waste stream generation or arising from disposal operations;

B2120 “Waste acidic or basic solutions with a pH greater than 2 and less than 11.5, which are not corrosive or otherwise hazardous (note the related entry on list A A4090)

B3011 “Plastic waste (note the related entries Y48 in Annex II and on list A A3210): …Plastic waste listed below, provided it is destined for recycling in an environmentally sound manner and almost free from contamination and other types of wastes.”]

33. As stated in Article 1, paragraph 2, “Wastes that belong to any category contained in Annex II that are subject to transboundary movement shall be “other wastes” for the purposes of this Convention”.

B. International linkages

1. World Customs Organisation

34. The Harmonized Commodity Description and Coding System (HS) of tariff nomenclature is an internationally standardized system of names and numbers for classifying traded products, which includes WLAB, has been developed and maintained by the World Customs Organization (WCO).

35. Under the WCO Harmonized System[15] (HS) of tariff nomenclature there are codes for moving traded products such as WLAB as it specifically relates to transboundary movements. Waste lead-acid batteries are classified and coded under Chapter 78 Lead & articles thereof and Chapter 85 Electrical machinery, equipment and parts thereof. The table below summarises codes that could be used for WLAB, in Table 2, and wastes containing WLAB or waste lead acid battery wastes Table 3:

Table 2. HS Codes for WLAB

Chapter/Section /Code	**Description**
Chapter 85	**Electrical machinery & equipment**
Code 8549.11	Waste & scrap lead-acid accumulators; spent lead-acid accumulators

[Table 3. wastes containing WLAB or waste lead acid battery wastes]

Chapter/Section /Code	**Description**
Chapter 78	**Lead & articles thereof**
Section 7802	Lead waste & scrap
Chapter 85	**Electrical machinery & equipment**
Section 8507	Electric accumulators, including separators thereof
Code 8507.01	Lead-acid of a kind for starting piston engines
Code 8507.02	Other lead-acid accumulators
Section 8549	Electrical and electronic waste & scrap

[14] This entry became effective on 1 January 2025.

[15] Harmonized System | WCO Trade Tools

Chapter/Section /Code	Description
Code 8549.12	Other containing lead, cadmium or mercury

36. It should be noted that on occasions WLAB are sometimes classified incorrectly under HS code 780200 which is the designation for scrap lead and general lead waste.

2. Heavy Metals Protocol

37. The objective of the 1998 Protocol on Heavy Metals to the 1979 Convention on Long-Range Transboundary Air Pollution, which was amended in 2012, is to control anthropogenic emissions of heavy metals, including lead, that are likely to have significant adverse human health or environmental effects. Parties to the Protocol are required to reduce emissions of target heavy metals below 1990 levels (or an alternative year between 1985 and 1995) by applying best available techniques for stationary sources and imposing emissions limit values for certain stationary sources. Parties are also required to develop and maintain emission inventories for heavy metals covered under the Protocol. Annex VII to the Protocol requires the development and implementation of programmes for the collection, recycling or disposal of products containing one of the heavy metals listed in Annex I, including lead, in an environmentally sound manner to minimise the impact on human health and the environment.

3. Global Framework on Chemicals

38. In September 2023, the fifth session of the International Conference on Chemicals Management adopted a Global Framework on Chemicals. The framework is based around 28 targets that aim to improve the sound management of chemicals and waste. Governments have committed to creating, by 2030, the regulatory environment to reduce chemical pollution and implement policies to promote safer alternatives. Industry has committed to managing chemicals in a way that reduces chemical pollution and adverse impacts by 2030. In accordance with the framework, stakeholders can submit issues of concern, which will be considered and prioritized by the International Conference on Chemicals Management, at its meetings.

4. UNEP Global Lead-acid Batteries Programmes and UNEA Resolutions

39. In 2017, UNEA adopted resolution 3/9 on “Eliminating exposure to lead paint and promoting environmentally sound management of waste lead-acid batteries” (WLABs) and requested, among others, the Basel Convention to consider updating the technical guidelines on Environmentally Sound Management (ESM) of waste lead-acid batteries.

40. The UNEP Global lead acid battery programme aims to promote the environmentally sound management of waste lead acid batteries through resolutions and plans/programmes, in cooperation with the Basel Convention. As part of this work UNEP conducted a needs assessment survey to identify the challenges[16].

41. A survey was conducted in 102 countries to ascertain their status on waste lead acid batteries, regulations in place, monitoring manufacturing, recycling and trade processes involved with waste lead-acid batteries, as well as specific country needs to enhance and strengthen institutions to manage this issue in a more environmentally sustainable manner.

42. From the responses the results identified the following regional needs:

(a) Asia and the Pacific region expressed need for technical and capacity building as most required;

(b) Latin American region expressed more needs for monitoring system, national strategy, technical and capacity building, legislation, and regulation building;

(c) Africa region expressed needs for monitoring system, public private partnership, technology, and legislation and regulation building.

5. Organisation for Economic Co-operation and Development

43. OECD has adopted a recommendation on ESM of waste that covers such items as the core performance elements of ESM guidelines applying to waste recovery facilities, including: elements of performance that precede collection, transport, treatment and storage; and elements subsequent to

[16] https://www.unep.org/explore-topics/chemicals-waste/what-we-do/emerging-issues/used-lead-acid-batteries-ulab-waste-lead.

storage, transport, treatment and disposal of pertinent residues (OECD, 2004). The OECD Council Decision (2022)[17] on the transboundary movement of waste for recovery aims at facilitating the trade of recyclables in an environmentally sound and economically efficient manner by using a simplified procedure as well as a risk-based approach to assess the necessary level of control for materials. Wastes exported outside the OECD area, whether for recovery or final disposal, do not benefit from this simplified control procedure.

44. Further information may be found in the guidance manual for the implementation of the OECD recommendation on ESM of waste (OECD, 2007)[18].

6. International Labour Organisation (ILO)

(a) ILO Chemical Conventions & Recommendation, 1990

45. The ILO Chemical Convention was established to ensure the protection of the environment, the public and all those working with chemicals and at the 77th session of the ILO it was approved on 6 June 1990. As part of the convention the Chemicals Recommendation, 1990 was adopted to supplement the Chemicals Convention 1990[19].

46. The convention contains several provisions giving employees the right to be consulted on the measures to protect them. Under the convention the competent authority should specify the categories of workers who for reasons of health and safety are not allowed to use specified chemicals or to use them under certain conditions. The provisions also apply to self-employed people.

47. The Convention covers the following:

(a) Classification of chemicals;

(b) Labelling and marking;

(c) Chemical safety data sheets;

(d) Responsibilities of employers;

(e) Operational controls;

(f) Medical surveillance;

(g) First aid and emergencies;

(h) Rights of employees.

48. The list of classified chemicals includes lead, and it is specifically mentioned due to its environmental and health effects. Consequently, under the convention and recommendations it forms an important basis for the ESM of WLAB.

(b) ILO Code of Practice – safety & health

49. The International Labour Organisation has developed a code of practice that provides governments with global guidelines, based on international labour standards and best practice, for addressing specific occupational hazards and this includes lead and the recycling of WLAB. The code aims to ensure that the safety and health of all those involved in non-ferrous metals production and recycling, in large and small enterprises are protected from exposure to workplace hazards. The ILO considers the provisions of the code to represent the minimum standards and where more stringent applicable standards apply, they should have priority.

50. The code, which deals with the production of metal in bulk, focuses on foundries and on the production of primary non-ferrous metals, including from recycled material. It does not deal with mining, nor does it address the fabrication of commercial products made from non-ferrous metals[20].

51. This code was adopted unanimously by a Meeting of Experts on Safety and Health in the Non-ferrous Metals Industries, held in Geneva from 28 August to 4 September 2001. It paves the way for developing a consensus on a comprehensive and practical code that is useful for all those working in

[17] https://www.oecd.org/env/waste/theoecdcontrolsystemforwasterecovery.htm

[18] https://www.oecd.org/env/39559085.pdf#:~:text=On%209%20June%202004%2C%20the%20OECD%20Council%20adopted,Waste%20Prevention%20and%20Recycling%20%28WGWPR%29%20%28as%20of%202001%29.

[19] https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C170.

[20] https://www.ilo.org/global/topics/safety-and-health-at-work/normative-instruments/code-of-practice/WCMS_107713/lang--en/index.htm..

the non-ferrous metals industries. The Governing Body of the ILO approved the publication of the code at its 282nd Session (November 2001).

52. The code sets out the general principles of prevention and protection, including the duties of regulatory authorities, employers, and workers. This first part covers a range of topics, including risk assessment, risk management, training, and workplace and health surveillance. The main part of the code identifies and examines a range of physical hazards that are commonly encountered during the production of non-ferrous metals. These include noise, vibration, heat stress, radiation, confined spaces, dust, and chemicals. Separate chapters deal with furnaces, molten metal, and recycling.

(c) World Health Organisation (WHO)

52 bis The WHO has published Recycling used lead-acid batteries (2017)[21]. This publication explains how used lead-acid batteries can cause significant environmental contamination and human exposure to lead. It provides information about the mechanisms of lead release during recycling, the main routes of exposure, the health impacts, the associated burden of its effects, methods for assessing lead exposure, and the types of control measures needed to prevent lead emissions and exposures.

52 ter WHO aims to inform the health sector on the issues around lead and human health so that they recognize that the recycling and handling of WLAB is a source of lead exposure and can assist in ensuring that effective controls are in place. In addition, it aims to inform policy makers of the health issues surrounding lead exposure to stimulate the introduction and enforcement of controls.

(d) Stockholm Convention on Persistent Organic Pollutants (POPs)

52 quarter The Stockholm Convention on Persistent Organic Pollutants[22] was adopted in May 2001 and came into force in May 2004. The objective of the convention is to protect human health and the environment from POPs. The Convention requires each Party to prohibit and/or take the legal and administrative measures to eliminate the production and use of chemicals listed in Annex A. The Convention also requires the parties to restrict/eliminate the production and use of the chemicals listed in Annex B.

52 quinquies Article 5 requires each party as a minimum to take measures to reduce or eliminate releases from unintentional anthropogenic sources of the chemicals listed in Annex C for example PCDD/PCDF.

52 sexies Under Annex C – Unintentional Production – Part II lists industrial sources which have the potential for comparatively high formation and releases of these chemicals into the environment. In Part III there are a list of other source categories that unintentionally produce POPs, and these include among others thermal processes in the metallurgical industry, which will include secondary lead smelting as this is not mentioned in Part II.

52 septies Annex C Part V provides general prevention measures relating to both best available techniques and best environmental practices to reduce or eliminate the releases of chemicals listed in Part I (e.g. PCDD/PCDF) for both new and existing facilities.

(e) [United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, 1998

52 Octies The 1988 United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances entered into force on 11 November 1990. The convention includes measures against drug trafficking, including provisions against money laundering and the diversion of precursors chemicals. It provides for international cooperation through, for example, extradition of drug traffickers, controlled deliveries and transfer of proceedings. Sulfuric acid recovered from WLAB can be a precursor and it is controlled by this convention[23].

(f) Convention on Biological Diversity

52 novies The Convention on Biological Diversity was adopted on 22 May 1992 and entered into force in on 29 December 1993. In December of 2022, the Parties agreed upon global goals and targets to protect nature. The Kunming-Montreal Global Biodiversity Framework, or The Biodiversity Plan, aims to protect and restore nature, to prosper with nature, to share benefits fairly, and to invest and collaborate for nature. These goals are supported by 23 action targets that address both the direct and indirect drivers of biodiversity loss. Target 7, Reduce pollution to levels that are not harmful to biodiversity, aims at reducing pollution risks and the negative impact of pollution from all sources, by

[21] https://www.who.int/publications/i/item/9789241512855

[22] https://chm.pops.int/TheConvention/Overview/TextoftheConvention/tabid/2232/Default.aspx

[23] https://www.cbd.int/convention

2030, to levels that are not harmful to biodiversity and ecosystem functions and services, considering cumulative effects[24].Article 2 paragraph 8 of the Basel Convention and in line with the UNEP Global Biodiversity Framework, Target 7]

III. Guidance on the environmentally sound management of waste lead-acid batteries

A. General considerations

53. Environmentally sound management (ESM) of hazardous wastes or other wastes" means taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes. It is a broad policy concept that is understood and implemented in various ways by different countries, organizations, and stakeholders. The provisions and guidance documents pertaining to the ESM of hazardous wastes and other wastes under the Basel Convention provide for a common understanding and international guidance to support and implement the ESM of hazardous wastes and other wastes. OECD has also produced core performance elements related to ESM.

54. Examples of technical guidelines and standard operating procedures on the environmentally sound management of waste lead-acid batteries that have been developed for regions and countries include those developed by the Commission for Environmental Cooperation in North America and standard operating procedures developed for use in Ghana but with a view for wider use and uptake[25,26].

1. Basel Convention

55. The 2013 Framework for the environmentally sound management of hazardous wastes and other wastes, adopted by decision BC-11/1 ("ESM framework") (UNEP, 2013) establishes a common understanding of what ESM encompasses and identifies tools and strategies to support and promote the implementation of ESM. In addition, a set of practical manuals for the promotion of the environmentally sound management of wastes (UNEP, 2017c and UNEP,2019h) has been developed. For example, guidance on how to address the environmentally sound management of wastes in the informal sector (as described in the guidance document in the UNEP BC ESM Toolkit)[27] and a practical manual for stakeholders to ensure that notifications of transboundary movements meet environmentally sound management requirements (UNEP, 2022f) has been developed. The ESM framework and manuals are intended as practical guides for governments and other stakeholders participating in the management of hazardous wastes and other wastes and complement the Basel Technical Guidelines.

56. As presented in paragraph 23 of this document, Article 4 of the Basel Convention contains provisions related to the ESM of hazardous wastes and other wastes. ESM is also the subject of the following declarations:

(a) The 1999 Basel Declaration on Environmentally Sound Management, which was adopted at the fifth meeting of the Conference of the Parties to the Basel Convention, calls on the Parties to enhance and strengthen their efforts and cooperation to achieve ESM, including through prevention, minimization, recycling, recovery and disposal of hazardous and other wastes subject to the Basel Convention. This considers social, technological and economic concerns, and through further reduction of transboundary movements of hazardous and other wastes subject to the Basel Convention;

(b) The 2011 Cartagena Declaration on the Prevention, Minimization and Recovery of Hazardous Wastes and Other Wastes was adopted at the tenth meeting of the Conference of the Parties to the Basel Convention. The Declaration reaffirms that the Basel Convention is the primary global legal instrument for guiding the ESM of hazardous wastes and other wastes and their disposal,

[24] https://www.cbd.int/gbf/targets/7

[25] https://www.sustainable-recycling.org/wp-content/uploads/2022/04/ULAB_recycling_SOPs.pdf

[26] http://www.cec.org/files/documents/publications/11665-environmentally-sound-management-spent-lead-acid-batteries-in-north-america-en.pdf

[27] https://www.basel.int/Implementation/CountryLedInitiative/EnvironmentallySoundManagement/ESMToolkit/Overview/tabid/5839/Default.aspx

including efforts to prevent and minimize their generation, and efficiently and safely manage that which cannot be avoided;

(c) The waste management hierarchy is a guiding principle for the ESM of waste and covers prevention, minimization, reuse, recycling, other recovery including energy recovery, and final disposal. The hierarchy encourages treatment options that deliver the best overall environmental outcome, taking into account lifecycle thinking[28] and the circular economy. This approach can make a significant contribution to resource recovery, reduce energy inputs and assist tackling global warming. The waste management hierarchy has also been recognised by the Strategic Framework (adopted by decision BC-10/2), the ESM framework (see its paras. 11, 14, 18, 26 and 43) and in the Guidance to assist Parties in developing efficient strategies for achieving the prevention and minimization of the generation of hazardous and other wastes and their disposal (UNEP, 2017d). The waste hierarchy was also defined and described in UNEP's Global Waste Management Outlook (UNEP, 2015b);

(d) Parties should consider a systemic approach to harmonizing and developing policy frameworks related to waste lead-acid batteries. Such an approach may address health and environmental impacts;

(e) In addition, Parties should develop a range of measures (strategies, legislation, regulations and programmes) and monitor their implementation to support the meeting of ESM objectives. The implementation of national strategies, policies and programmes are effective methods to ensure a structured approach to the implementation of legislation and regulations; monitoring and enforcement; incentives and penalties; technologies; and other tools in which all key stakeholders participate and cooperate (UNEP, 2013). The following sections should be taken into account when establishing, implementing or evaluating ESM.

2. [Life cycle management of lead-acid batteries

57. The concept of life cycle management can serve as a useful approach to promote the ESM of wastes[29]. Life cycle management provides a framework for analysing and managing the sustainability performance of goods and services. Global businesses are using it, for instance, to reduce the carbon, raw material and water footprints of their products, improve their social and economic performance, and make value chains more sustainable (UNEP and SETAC, 2009). When a life cycle management approach is applied to lead-acid batteries, it should be assessed during the following stages: sourcing of raw materials production of lead-acid batteries, their uses; collection and transportation of WLAB and the final disposal of the waste that cannot be recovered.

58. In life cycle management of lead-acid batteries, it is important to give priority to minimising its impact during the production of lead-acid batteries, thereby reducing the lead content of wastes and emissions resulting from the production processes and their use. When using lead-acid batteries, special care should be taken not to emit or release pollutants into the environment. WLAB should be recycled to recover the lead, electrolyte and plastics when appropriate (e.g. not contaminated with POPs and with lead). Wastes from the recovery process may be treated to recover the lead in them (e.g., slags, wastewater treatment sludges, bag house dusts, etc.).

59. The life cycle of the lead-acid battery from raw and secondary material sourcing, production of lead to the WLAB being recycled and products recovered is an example of the circular economy, providing it is conducted in an environmentally sound manner minimising the generation of wastes, emissions and energy consumption from production to disposal. However it is important that there are effective regulatory controls and environmental monitoring by the authorities to ensure that the environmental and health risks are properly managed to improve its life cycle management,]

B. Legislative and regulatory framework

60. Parties to the Basel Convention should examine, where appropriate, their national and subnational strategies, policies, controls, standards, and procedures to ensure that they are in agreement with the Convention and with their obligations under it, including those that pertain to the transboundary movement and ESM of waste lead-acid batteries.

61. Countries should put in place legislation that outlines broad environmental protection principles, powers, and rights. Such legislation should make ESM operational and include requirements for protection of both human health and the environment and give governments the

[28].https://www.basel.int/Implementation/StrategicFramework/Strategicgoalsandobjectives/tabid/3811/Default.aspx.

[29] https://www.weforum.org/publications/consequences-of-a-mobile-future-creating-an-environmentally-conscious-life-cycle-for-lead-acid-batteries/

power to enact and enforce specific rules and regulations on the ESM of waste lead-acid batteries, including provisions for inspections and for establishing penalties for violations (e.g., on illegal shipments).

62. The legislation should enable authorities to require all stakeholders in the LAB supply chain to take and enable relevant authorities to monitor whether facilities where wastes lead-acid batteries are stored, collected, transported, and disposed of, have obtained all the necessary approvals, and can demonstrate due diligence in compliance to ensure such facilities are fully protective of human health and the environment. In addition, any legislation should establish minimum requirements that those involved in waste lead-acid battery management (e.g., generators, collectors, transporters, and recyclers) ensure that the collection, transportation, storage and disposal facilities operate in an environmentally sound and protect human health.

63. Specific components or features of a regulatory framework that would meet the requirements of the Basel Convention and other international agreements are addressed in relevant guidance documents developed under these conventions[30]..The legislative and regulatory approach to adopting an ESM for WLAB should, for example, include:

(a) Registration of waste generators;

(b) Registration of waste carriers;

(c) Authorisation of waste storage facilities;

(d) Authorisation of waste disposal facilities.

1. Extended producer responsibility

64. Extended producer responsibility (EPR,[31]) is an approach that promotes reduction in the environmental impact of products, throughout their lifespan, from production to waste stage. EPR assigns the responsibility of the whole lifecycle of a product to the producer, and involves, collection, and environmentally sound waste disposal[32]. There is no "one-size-fits-all" solution. The EPR instrument(s) that is/are the most appropriate to a specific region/country, taking into consideration market conditions, national capabilities and circumstances should be selected. EPR systems could be mandatory or voluntary and be applied at a national level or sub-national level (e.g. regional, local or community level) in order to develop participatory initiatives and solutions to address the ESM of WLAB.

65. EPR programmes, depending on how they are designed, can achieve a number of objectives, including: (1) to relieve local governments of the financial and in some cases operational burden of disposing of waste/products/materials; (2) to encourage companies to design products for reuse and recyclability and to reduce both the quantity and hazardousness of materials used; (3) to incorporate waste management costs into product prices; and (4) to raise public awareness of the correct routes for collection and disposal and (5) to promote innovation in recycling technology. EPR therefore promotes a market in which prices reflect the environmental costs of products (OECD 2001a).[33] . Detailed descriptions of EPR schemes are available in several OECD publications on the issue.

66. When EPR programmes are used, the environmental authorities may develop regulatory frameworks setting out the responsibilities of relevant stakeholders, standards for the management of products and the components that all EPR programmes should have and encourage participation by relevant parties and the public. The environmental authorities should also monitor the performance of EPR programmes (e.g., amount of product placed on the market, amount of waste collected, amount recycled at end of life and costs accrued for collection, recycling and storage) and make recommendations for improvement as necessary. The responsibility to implement EPR programmes should be shared by all producers of a given product . For example, in EU member states EPR is central to the operation of the new EU Batteries Regulation (EU) 2023/1542.

66 bis [EPR schemes for WLAB can be integrated with electrical and electronic waste EPR schemes, where WLAB is one of the waste streams targeted within the scheme. EPR schemes should define the sources of LAB generation including all relevant importers or generators of LAB in a country. The inventory of WLAB, can provide information in this regard. The use of traceability tools, for example

[30] http://www.basel.int/TheConvention/Publications/GuidanceManuals/tabid/2364/#.

[31] See UNEP/CHW.14/5/Add.1

[32] https://www.basel.int/Implementation/CountryLedInitiative/EnvironmentallySoundManagement/ESMToolkit/Practicalmanuals/tabid/5847/Default.aspx

[33] https://www.oecd.org/environment/extended-producer-responsibility.htm

labelling requirements for LAB, a battery passport[34], the global digital sustainable product passport[35], blockchain[36] and the use of tracking technologies (e.g. emitting chips) on batteries are examples of traceability tools to link the producers to WLAB generation.]

67. Further guidance on EPR is available in the practical manual on extended producer responsibility adopted by decision BC-14/3, in "Extended Producer Responsibility - Guidance for efficient waste management" (OECD, 2016) and in "Development of Guidance on Extended Producer Responsibility (EPR)" (European Commission, 2014).

2. Registration of waste generators

68. An approach to facilitate ESM of WLAB involves the establishment, through regulation, of registers of generators of this type of waste[37]. Such registers should include:

(a) Garages/retailers with collection/take-back facilities;

(b) Recycling centres;

(c) Battery manufacturers/importers/distributors;

(d) Industrial/commercial/public sector WLAB producers (e.g., telecoms, public utilities, hospitals, transport companies).

69. Regulations for generators of WLAB should require them to provide their name, address, the name of the responsible person, their type of business, the quantities of waste generated, and information on any collection schemes, if applicable to these wastes and how the wastes are to be handed over to collectors and sent for recycling. Waste generators should be required to transmit and provide regular updates on this information to the authorities (central or local governments) preferably via an IT based system. Based on the amounts and kinds of waste obtained through registries, Parties should also develop waste inventory programmes.

70. WLAB generators should have a duty to prevent emissions and releases to the environment until the wastes are handed over to collectors or sent to a recycling facility. To prevent environmental releases WLAB should be stored in containers that meet approved standards (see section F). They should strictly comply with national and local legal requirements regarding the management of WLABs and be held liable for remediating or compensating any environmental or health damages that they might cause when handling such wastes, to the degree required by applicable legislation. Large scale waste generators should be subject to inspection and checks to ensure they are complying with the appropriate legislative requirements.

3. Registration of waste carriers

71. Waste carriers, i.e., anyone who normally collects, carries or transports waste in the course of any business who collect and transport hazardous wastes, such as WLAB, should be required to register with the authorities[38]. Often authorities maintain registers of the carriers and issues licenses which enables them to inspect and check that ESM practices are being adhered to, such as WLAB being transported correctly, so that the batteries are protected from damage and short circuits, preventing leakage of electrolyte, and emissions of lead containing materials, the appropriate labels are being clearly displayed on the packaging and vehicle that indicate the type of substance and associated hazards. Waste carriers should be subject to inspection and checks to ensure they are complying with the appropriate legislative requirements.

4. Requirements of temporary waste storage facilities

72. To ensure that WLAB storage facilities comply with ESM, legislation should be developed setting out specific conditions for their safe storage such as types of containers to be used, how they should be stored, storing waste in a secure place to prevent environmental releases, labelling containers, use of covers to prevent rain water ingress and contamination run-off, hazard signage, facility construction requirements (e.g., storing waste on an impermeable floor), monitoring and inspection requirements[39].

5. Requirements of waste disposal facilities

[34] https://www.globalbattery.org/battery-passport/

[35] https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=15598

[36] https://www.sciencedirect.com/science/article/abs/pii/S1364032122000089

[37] https://www.gov.uk/hazardous-waste-producer-registration-wales.

[38] https://www.gov.uk/register-renew-waste-carrier-broker-dealer-england.

[39] https://www.gov.uk/guidance/waste-environmental-permits.

73. Countries should have legislation in place that require the operators of waste disposal and recycling facilities to obtain approval to operate[40]. Approvals should contain specific conditions that have to be adhered to for these approvals to remain valid. A permitting or approval process based on established and transparent criteria on, inter alia, how to operate facilities, emission levels, ambient air standards, lead occupational standards, pollution abatement equipment, maintenance requirements, emissions monitoring, as well as an inspection/audit regime, cleaner production audits (e.g. China assesses production processes and technology, equipment, energy efficiency every 3 years) transparent reporting requirements, publicly available emissions data can be an appropriate approach. Further information on these are contained in various sections of this guidance document (See sections H, I J). It may prove necessary to add requirements specific to WLAB to meet the requirements of ESM, and to comply with the specific requirements of the Basel Convention.

74. Environmental impact assessments (EIA) should always be required to be undertaken to establish the likely environmental impacts and the mitigation measures required of new and existing projects such as WLAB disposal facilities, lead-acid battery manufacturing plant and modifications to existing operations. The EU, for example, has a Directive (Directive 2011/92/EU) setting out its requirements for undertaking an EIA and what is to be covered. The authorities should require the companies who are planning to operate the plant or operate the plant make the modifications to undertake the EIA themselves and submit it to the authorities for review and assessment prior to obtaining approval for a licence setting out the conditions of operation and compliance requirements.

75. Guidance on the requirements for an EIA to be conducted should be published including guidance on screening and the detailed requirements of what should be covered and included in an EIA report (for example both normal operations and worst case scenarios together with emergency measures)

76. The UK, for example, requires a EIA screening exercise[41] to be undertaken to address size, cumulative impacts from other developments, use of natural resources, production of waste, pollution and nuisances, risk of accidents and locations (e.g. wetlands, coastal zones, forest areas, nature reserves and parks, special environmentally designated areas, where environmental quality standards are exceeded and landscapes of historical, cultural or architectural importance) to determine which projects require an EIA. Also, the characteristics of the impact need to be considered (e.g., trans-boundary, magnitude, complexity and probability).

77. Site selection for any new WLAB recycling plant is important to minimize environmental, health and safety risks. It is important to assess potential emissions impacts to the areas around the plant for example, aquifers, groundwater, surface water, farmland, residential areas, businesses, and facilities such as hospitals, schools and processing plants (e.g., food manufacturers). Consideration of factors such as climate, seismic activity, and topography should also be taken into account to assess potential risks from earthquakes, eruptions, flooding, landslides, rock falls, avalanches, and tidal surges. As part of the planning process there is a need to take into account the availability of energy sources, water, emergency services, road links, etc.

78. For existing plant, it is important that future residential and commercial developments do not encroach on the plant to avoid environmental, health and safety risks. This can be managed for example through statutory buffer zones being established to prevent new sensitive developments that present a risk to human health or the environment, (e.g. housing, hospitals, schools, farms, food processing plants, reservoirs, etc.) being constructed near existing facilities. In addition, existing plants must comply with authorizations issued to it, by regularly auditing their plants to assess whether any engineering improvements/mitigating measures can be adopted to minimise any potential impacts from its operations.

78 bis [China, for example, had about 70 WLAB disposal facilities in 2023. They set a minimum facility size of 50,000 tons for new WLAB disposal facilities.

78 ter Some countries stipulate requirements that a plant has to be a certain size to be allowed to operate. For example, China specifies a minimum size of 50,000 tons such an approach may not be possible in many other countries. However, regulators could require a new WLAB to demonstrate the financial viability of the operation by requiring an external financial report to be submitted as part of

[40] https://www.epa.gov/hwpermitting/what-hazardous-waste-permit#:~:text=All%20facilities%20that%20currently%20treat%2C%20store%20or%20dispose,they%20can%20manage%20hazardous%20waste%20safely%20and%20responsibly.

[41] https://www.gov.uk/guidance/environmental-impact-assessment

the approval to operate process. Another approach would be for the operator to obtain a financial guarantee/insurance guarantee in the event of the site needs to be remediated at a future date.]

6. Transboundary movement requirements

79. Transboundary movements of hazardous wastes and other wastes should be kept to a minimum consistent with their environmentally sound and efficient management and conducted in a manner that protects human health and the environment from any adverse effects that may result from such movements. As far as is compatible with their ESM, WLAB should ideally be disposed of in the country where the waste was generated[42].

80. Transboundary movements of lead and lead compounds and WLAB wastes are permitted, except when there are bans at the national or regional level or subject to the Ban Amendment, in the Parties which have ratified it. WLAB transboundary movements should be allowed only if:

(a) The State of export does not have the technical capacity and the necessary facilities, capacity or suitable disposal sites in order to dispose of the wastes in question in an environmentally sound and efficient manner; or

(b) The wastes in question are required as a raw material for recycling or recovery industries in the country of import; or

(c) The transboundary movements in question are in accordance with other criteria decided by the Parties, providing those criteria do not differ from the objectives of this Convention.

(d) Any transboundary movements of hazardous wastes and other wastes considered under the Basel Convention are subject to prior written notification from the exporting country and prior written consent from the importing and, if appropriate, transit countries. Parties shall not permit the export of hazardous wastes and other wastes if the country of import prohibits the import of such wastes in accordance with the Basel Convention;

(e) Parties listed in Annex VII to the Convention (members of the EU, OECD and Liechtenstein), that are bound by the Ban Amendment, shall prohibit transboundary movements to states not listed in Annex VII of hazardous wastes which are destined for operations according to Annex IVA and hazardous wastes under Article 1.1(a) which are destined to operations according to Annex IVB[43];

(f) The Basel Convention also requires that information regarding any proposed transboundary movement of hazardous wastes and other wastes be provided using the accepted notification form and that the approved consignment be accompanied by a movement document from the point where the transboundary movement commences to the point of disposal. Furthermore, hazardous wastes and other wastes subject to transboundary movements should be packaged, labelled and transported in conformity with international rules and standards[44];

(g) When a transboundary movement of hazardous wastes and other wastes to which consent of the countries concerned has been given cannot be completed, the country of export shall ensure that the waste in question is taken back into the country of export for their disposal, in a timely manner, if alternative arrangements cannot be made. In the case of illegal traffic (as defined in Article 9, paragraph 1), as the result of conduct on the part of the exporter or the generator, the country of export shall ensure that the wastes in question are taken back into the country of export for their disposal or otherwise disposed of in accordance with the provisions of the Basel Convention (as per Article 9, paragraph 2). For further information, see the Guidance on the implementation of the Basel Convention provisions dealing with illegal traffic, adopted by COP13 in 2017 (UNEP, 2017g);

(h) No transboundary movements of hazardous wastes and other wastes are permitted between a Party and a non-Party to the Basel Convention unless a bilateral, multilateral or regional agreement or arrangement exists as required under Article 11 of the Convention.

80 bis Lead acid batteries may also be shipped abroad within waste electrical and electronic equipment (WEEE) and end of life vehicles (ELV). The EU for example is proposing a regulation[45] on circularity requirements for vehicle design and on management of end of life vehicles by preventing the export of end of life vehicles and non-roadworthy used vehicles and reducing the harmful pollution

[42] https://www.unep.org/resources/report/guidance-manual-policymakers-and-regulators-environmentally-sound-management-waste

[43] http://www.basel.int/Countries/StatusofRatifications/BanAmendment/tabid/1344/Default.aspx.

[44] https://unece.org/transport/publications/recommendations-transport-dangerous-goods-model-regulations-rev22.

[45] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2023%3A451%3AFIN&qid=1689318552193

effects to those countries receiving the vehicles. It is important to properly distinguish WEEE from used EEE and end of life vehicles from road worthy used vehicles .

7. Other legislative controls

81. Examples of other aspects of the management of WLAB that can be regulated through, a permitting/approval process includes:

(a) Environmental impact assessments (EIA), as appropriate, for example temporary storage.

(b) The establishment of an IT platform, at the national/Federal level, for the complete management of WLABs from producers, WLAB generators, collection operations transportation, storage and disposal operations recording the type and quantity handled at each stage. For example Russia has introduced an integrated IT system for safe hazardous waste management for the entire life cycle from waste generation through to its disposal for use by the supervisory authorities.

(c) Public participation in the permitting or approval process for WLAB treatment facilities as referred to in section III, J;

(d) Requirements for the health and safety of workers and protection of the local community (section III, J);

(e) Decommissioning requirements for WLAB facilities (section III, I), including:

(i) Inspection prior to and during decommissioning;

(ii) Procedures to be followed to protect worker and community health and the environment during decommissioning;

(iii) Post-decommissioning site requirements;

(iv) Establishment of the need for financial guarantee for remediation works.

(f) Emergency contingency planning, spill and accident response (section III, K), including:

(i) Clean-up procedures and post-clean-up concentrations to be achieved;

(ii) Worker training and safety requirements;

(iii) Waste prevention, minimization and management plans;

(iv) Obligations to ensure best-practice management systems and operating procedures [46], including requirements for annual reporting and regular third-party auditing and verification after an incident;

(v) On-site fire and explosion response plans and training;

(vi) Provision of an emergency manifest at the gate to inform professional firefighters of the nature and volume of hazardous materials on-site.

(g) Restrictions on greenhouse gas (GHG) emissions across the life cycle of lead-acid batteries including their management as wastes, including any restrictions as are required to meet nationally determined contributions for parties to the Paris Agreement and encourage greater WLAB recycling and resource conservation.

C. Waste prevention and minimization

1. General considerations

82. Prevention and minimization of wastes are the most important steps in the waste management hierarchy. The Basel Convention affirms that the most effective way of protecting human health and the environment from the dangers posed by hazardous wastes and other wastes is the reduction of their generation to a minimum in terms of quantity and/or hazard potential.

83. In Article 4, paragraph 2, the Basel Convention calls on Parties to “ensure that the generation of hazardous wastes and other wastes is reduced to a minimum”. Waste prevention should be the

[46] https://www.sustainable-recycling.org/wp-content/uploads/2022/04/ULAB_recycling_SOPs.pdf

preferred option in any waste management policy, so that the need for waste management is reduced, enabling resources to be used more efficiently.

84. At the tenth meeting of the Conference of the Parties to the Basel Convention, the Parties, in adopting the Cartagena Declaration committed "to enhancing the active promotion and implementation of more efficient strategies to achieve prevention and minimization of the generation of hazardous waste and other wastes and their disposal".

85. According to the ESM framework, the need to manage wastes and/or the risks and costs associated with waste management can be reduced by not generating wastes and by ensuring that generated wastes are less hazardous (UNEP, 2013).

86. The ESM framework states that "companies that generate wastes (waste generators) are responsible for ensuring the implementation of best available techniques (BAT) and best environmental practices (BEP) when undertaking activities that generate wastes". In doing so, they act to minimize the wastes generated by ensuring research, investment in design, innovation and development of new products and processes that use less resources and energy and that reduce, substitute or eliminate the use of hazardous materials (UNEP, 2013).

87. A practical manual on waste prevention, as part of the set of practical manuals for the promotion of the environmentally sound management of wastes (UNEP, 2017c), provides stakeholders with general guidance on waste prevention principles, strategies and possible measures and tools. The Guidance to assist Parties in developing efficient strategies for achieving the prevention and minimization of the generation of hazardous wastes and other wastes and their disposal (UNEP 2017d) identifies elements of a waste prevention and minimization programme.

D. Identification and inventory

1. Identification of sources of WLAB

88. Identifying the sources of WLAB, is the starting point for an effective ESM. The prime sources include garages/workshops, retailers, scrap metal dealers, motor dealers, recycling centres, industries recycling/reclaiming metals, waste collectors and disposers , including the informal sector[47], as well as producers of lead acid batteries in the case of generated production waste.

2. Inventories

89. Inventories are an important tool for identifying, quantifying, and characterizing WLAB arisings. When developing an inventory for WLAB priority should be given to the identification of the potential significant stakeholders in the value chain and life cycle for WLAB including in the waste stage prioritizing the identification of the potential significant producers and disposers, high volume wastes managers and areas of greatest concern (e.g. locations with significant environmental and health risk, existence of informal collection, disposal or recycling sector, etc.) and disposers.

90. National inventories may be used:

(a) To establish a baseline quantity of lead acid battery manufacturers, importers, exporters, retailers, distributors, WLAB producers, WLAB collectors, WLAB transporters, WLAB exporters and WLAB disposer (formal and informal sector);

(b) To establish an information registry to assist with health, safety and regulatory inspections;

(c) To assist with the preparation of emergency response plans;

(d) To track progress towards minimizing environmental and health concerns;

(e) To provide information for the development of policies, targets and measures to improve the ESM of WLAB, for example about [POPs wastes] and the management of separators and plastic casing of batteries, ;

(f) [To identify POP wastes under the Stockholm Convention;]

91. For further information on the development of national inventories Parties may consult the Practical guidance for the development of inventories of used lead-acid batteries[48] and the methodological guide for the development of inventories of hazardous wastes and other wastes under

[47] Informal sector includes for example waste pickers, recyclers, etc.

[48] https://www.basel.int/Countries/NationalReporting/Guidanceoninventoryofhazardouswastes/tabid/8755/Default.aspx

the Basel Convention. (UNEP, 2015c). The guide focuses on the actions recommended to develop the national information systems that produce the data needed to assist countries in fulfilling their reporting obligations under the Basel Convention.

3. [Developing a national management plan for the ESM of WLAB

92. The development of a national management plan for the ESM of WLAB should be based on a review of the existing situation especially where there are limited controls and regulations, limited information on their management and rural remote communities. A Guidance Manual of this process has been developed, by UNEP, for policy makers and regulators in Africa for the ESM of WLAB[49]. Information from the data obtained in identifying the sources of WLAB and inventories will greatly assist this process. The review, with defined deadlines and responsibilities should form the basis for establishing an action plan which may cover the following:

(a) Identify key areas of concern: problematic areas need to be identified where waste lead-acid batteries are disposed (formally and informally) by conducting a baseline assessment to identify the locations, as well as the current causes, extent and impacts of their activities;

(b) Evaluate the appropriateness of possible actions: consider the options to tackle potential issues (e.g., regulatory, economic, public awareness, voluntary actions, management procedures), based on the socio-economic state and appropriateness for addressing the specific problems identified;

(c) Assess the options: assessment of the potential social, economic, and environmental impacts (positive and negative) of the preferred short-listed instruments/actions. How will the poorest be affected? What impact will the preferred course of action have on different sectors and industries?

(d) Stakeholder engagement: identify and engage with key stakeholder groups (e.g. retailers, consumers, battery manufacturers, industry representatives, local government, manufacturers, civil society, environmental groups, and others) to ensure a broad buy-in. Evidence-based studies should assist in presenting the case, including in-field data collection of the informal sector.

(e) Raise public awareness: the public should be made aware of the health and environmental issues associated with non-environmentally sound WLAB recycling and disposal. Establish a public awareness strategy and implementation;

(f) Training regulators: training for government officials, regulators, and other relevant actors (NGOs) need to be included to raise awareness and a better understanding of the issues and to address the technical aspects required for the sustainable, safe, and environmentally sound recycling system for WLAB in a manner that minimizes the health and environmental impact to lead exposure. The training should include guidance on how to assess the environmental performance of recycling sites and evaluate associated public and occupational health risks;

(g) Incentives: assess the need to provide support and incentives to industry and organisations involved in the handling, collection, storage, and recycling of WLAB;

(h) (Implementation: it is important that progress is monitored, and the effectiveness of the regulations and enforcement are reviewed and adjusted or updated where any issues are identified. It is important for governments to keep the public updated on the progress and benefits achieved, to continue building consensus and demonstrate accountability. It is advisable to review the policy instruments on a regular basis. In the case of regulatory enforcement, it is important to ensure that the WLAB recycling is not illegally carried out in remote areas;(i) Monitoring: for monitoring and supervision of the ESM of WLAB management through the life cycle, it is important to clearly define roles and responsibilities between local, national and sub-national authorities and organizations beforehand. To gather data on effectiveness, governments may consider the introduction of an information management system and legislation for reporting obligations. Progress can be assessed in several ways, including health, safety and environmental (HSE) audits, surveys, impact assessments and stakeholder feedback.]

E. Sampling, analysis and monitoring

93. Sampling, analysis and monitoring of all components of WLAB such as lead, plastics (PP & ABS), acid, wastes and others [such as POPs (i.e. PBDEs) [50] which may be present in plastics such as ABS materials] should be conducted by trained professionals in accordance with well-designed

[49] https://www.unep.org/resources/report/guidance-manual-policymakers-and-regulators-environmentally-sound-management-waste

[50] WRC, March 2023. POPs in WLAB Polymer Casing.

programmes using internationally accepted or nationally approved methods and should be carried out using the same methods throughout the lives of such programmes, quarterly or as appropriate. They should also be subjected to rigorous quality assurance and quality control measures. Mistakes in sampling, analysis or monitoring or deviation from standard operational procedures can result in meaningless data or even programme-damaging data. Each party, as appropriate, should therefore develop standards to ensure that training, protocols and laboratory capabilities are in place for sampling, monitoring and analytical methods and that those standards are enforced.

94. Because there are numerous reasons for sampling, analysing, and monitoring and because waste comes in so many different physical forms, many different sampling, analysis and monitoring methods are available. Although it is beyond the scope of this document to discuss them specifically, the next three sections consider key elements that should be included in sampling, analysis, and monitoring activities.

95. For information on good laboratory practices, the OECD series on best of laboratory practice[51] may be consulted.

1. Sampling

96. The overall objective of any sampling activity is to obtain a sample that can be used for a targeted purpose, e.g., site characterization, compliance with regulatory standards (e.g. hazardous or non-hazardous) or determination of the suitability of proposed treatment or disposal methods. This objective should be identified before sampling is started. It is essentialthat quality requirements for equipment, transportation and traceability be met.

97. Standardized sampling procedures should be established and agreed upon before the start of the sampling campaign. Elements of these procedures may include the following:

(a) The number of samples to be taken, the sampling frequency, the duration of the sampling project, background or control samples and a description of the sampling method to be used (including quality assurance procedures put in place, e.g., use of appropriate sampling containers and field blanks and of chain-of-custody procedures);

(b) (Selection of locations or sites at which WLAB related wastes are generated and time and date of sample-taking (including description and geographic coordinates);

(c) Type of analysis to be performed, identity of person who took the sample and conditions during sampling;

(d) Full description of sample characteristics – labelling;

(e) Preservation of the integrity of samples during transport and storage (before analysis);

(f) Close cooperation between the sampler and the analytical laboratory;

(g) Appropriately trained sampling personnel.

98. Sampling should comply with specific national legislation, where it exists, or with international standards and protocols. In countries where regulations do not exist, qualified staff should be appointed. Sampling procedures include the following:

(a) Development of a standard operational procedure (SOP) for sampling each of the matrices for lead analysis;

(b) Application of well-established sampling procedures such as those developed by the International Organization for Standardization (ISO), the European Committee for Standardization (CEN), the United States Environmental Protection Agency (USEPA), the Global Environment Monitoring System (GEMS) and the American Society for Testing and Materials (ASTM);

(c) Establishment of quality assurance and quality control (QA/QC) procedures.

99. All these steps should be followed if sampling programmes are to be successful. Similarly, documentation should be thorough and rigorous.

100. Lead can occur and be sampled in liquids, solids, gases and biota:

(a) Liquids:

(i) Leachate from landfills/dump sites;

[51] https://www.oecd-ilibrary.org/environment/oecd-series-on-principles-of-good-laboratory-practice-and-compliance-monitoring_2077785x

(ii) Liquid collected from spills;

(iii) Water (surface water, drinking water and industrial effluents);

(b) Solids:

(i) Stockpiles of WLAB;

(ii) Solid waste from industrial sources and disposal/recycling processes (waste slags, contaminated equipment, containers, plastics, redundant equipment, residues, etc.);

(iii) Soil, sediment, rubble, wastewater treatment sludge;

(iv) Dust

(c) Gases:

(i) Air emissions of facilities handling WLAB;

(ii) Lead releases to the air from recycling/treatment activities;

(iii) Flue gas from ventilation and extraction systems;

(d) Biota:

(i) Biological materials (blood samples obtained through health monitoring);

(ii) Flora and fauna.

101. In environmental and human monitoring programmes, both biotic and abiotic matrices may be included:

(a) Plant materials and food;

(b) Blood samples;

(c) Air (ambient, wet or dry deposition or, possibly, snow).

(d) Soil and dust.

2. Analysis

102. Analysis relates to the extraction, purification, separation, identification, quantification and reporting of lead concentrations in the matrix of interest. In order to obtain meaningful and acceptable results, the analytical laboratory should have the necessary infrastructure and proven experience with the matrix and lead (e.g., successful participation in inter-laboratory comparison studies and in external proficiency testing schemes).

103. Accreditation of the laboratory in accordance with ISO 17025 or other standards by an independent body is important. Essential criteria for obtaining high-quality results include:

(a) Specification of the analytical technique used;

(b) Maintenance and calibration of analytical equipment;

(c) Validation of all methods used (including in-house methods);

(d) Training of laboratory staff.

104. As with all chemical analysis, laboratories should use only validated methods, and performance should be evaluated through QA/QC programmes.

3. Monitoring

105. In Article 10 ("International Cooperation"), paragraph 2 (b), the Basel Convention requires Parties to "cooperate in monitoring the effects of the management of hazardous wastes on human health and the environment".

106. Monitoring programmes should be implemented for facilities managing/handling/recycling WLAB, as they provide an indication of whether a facility is operating in accordance with its design and environmental regulations. The information obtained through monitoring programmes should be used to ensure that WLAB are properly managed, to identify potential issues relating to possible lead releases or exposure to lead and other substances to determine whether amendments to the management approach might be appropriate.

4. Reporting to authorities

F. Handling, separation, collection, packaging, labelling, transportation and storage

1. General Considerations

107. The procedures for the handling, separation, collection, packaging, labelling, transportation and storage of WLAB pending their disposal are similar to those applicable for hazardous wastes. However, because of the health and environmental impact of lead, the ESM of WLAB requires the use of particular precautions to prevent the release of lead. The Basel Convention Annex IV includes some operations related to the separation, repacking and storage (D14 & D15) if any WLAB is intended to be disposed of by an operation listed in Section A, and R12 & R13 if WLAB are intended to be disposed of by an operation listed in Section B. In the case of an R12/13 or D13-15 operation, PIC notification form requires information on any subsequent R1-11 or D1-12 facilities when required.

108. To ensure that releases of lead, acids and other hazardous substances from WLAB are kept to a minimum, it is important to raise awareness and educate those involved in handling, separation, collection, packaging, labelling, transportation and storage (e.g., salvagers, transporters, recyclers, and treatment operators) about the risks of lead. Such awareness raising can be achieved through activities such as training, labelling and data information sheets.

108 bis Specific guidance on the most appropriate handling of WLAB is provided in this section, but it is important that generators also consult and adhere to applicable national and local requirements and follow best management practices and adopt standard operating procedures to be used as a guide for environmental and workplace performance[52].

108 ter [Recycling operations should not include the informal sector which comprises battery reconditioners, backyard breakers, melters and smelters. In developing countries and those in economic transition they deal with between 15%- 30% WLAB generated. Any environmental and health issues that arise from the informal sector are associated with the low lead recovery rate, acid releases, wastes and emissions[53].

108 quarter Informal smelters may only be able to achieve about 40% lead recovery for the melting operations and up to 90% recovery for the smelters. The rest of the lead (~60% for the melters) is released into the environment through the waste and emissions. Consequently, there is a significant potential for high impacts to human health and the environment. In addition, any lead not recovered represents a significant financial loss to those undertaking the recycling. These smelters should be identified so that effective sound environmentally management controls of WLAB can be implemented.

108 quinquies Where there is a prominent informal sector the environmental and health risks due to lead pollution are likely to be high. In addition, the domestic supply- demand gap for domestic battery production will be impacted.

108 sexies There are several measures that should be undertaken to address both the environmental and health impacts together with improving resource recovery. These include short-term measures aimed at bringing about significant reductions in lead pollution and long-term measures bring about changes in the recycling activities to benefit the local communities.

108 septies The short-term measures to improve the occupational and environmental performance of partial lead recovery activities in the informal sector, as a minimum, should include:

(a) Preventing the unauthorized disposal of battery electrolyte through effective legislation and enforcement;

(b) Educating and encouraging owners to ensure workers follow simple safety measures, such as wearing neoprene acid resistant gloves, body aprons, boots, eye protection, and

[52] https://www.sustainable-recycling.org/wp-content/uploads/2022/04/ULAB_recycling_SOPs.pdf

[53] https://apps.who.int/iris/bitstream/handle/10665/259447/9789241512855-eng.pdf. https://apps.who.int/iris/bitstream/handle/10665/259447/9789241512855-eng.pdf.

facemasks/respirators that offer sufficient protection from airborne dust/fume/vapours and acid mist. The owners should provide washing facilities, a regime of hand washing before eating or drinking and prohibiting smoking in the workplace;

(c) Legislate so that formal recyclers and users of lead (e.g. battery manufacturers) are not allowed to accept lead containing materials from the informal sector unless they comply with good health and environmental control measures. This could be supported with an information management system to help track and control the movement of WLAB.

108 octies Although there are a number of short-term measures that can be introduced the key to bringing about a sustained improvement is the move to the long-term solution of an environmentally sound management of waste lead-acid battery recycling. This could be achieved by ensuring that the formal sector only purchase whole lead-acid batteries, banning the export of lead-acid battery components (battery paste and plates),

108 novies [shipments of plates and pastes are not considered best practice because of the significant risk of environmental pollution without effective controls and should be discouraged. Battery breaking to recover lead containing plates and paste for transboundary shipment to a smelter can result in significant environmental pollution without proper environmental controls to capture and treat the waste acid and other emissions.] The introduction of an effective collection scheme and the provision of employment opportunities and training for those engaged in the informal sector. Another option would be the introduction of a purchase discount through an extended producer responsibility programme.]

2. Handling

109. Those who handle WLAB should, taking into consideration relevant national regulations, pay special attention to the prevention of lead and acid releases into the environment and workplaces because of the health and environmental exposure of lead and acid and their impacts.

110. End users Waste managers Those handling WLAB should safely handle and prevent any breakage of or damage to WLAB. Wastes of products containing lead or lead compounds such as battery plates, residues should be handled safely and should not be discharged onto the unprotected ground or into storm sewers or other rainfall runoff collection systems. WLAB and waste products containing lead should not be mixed with any other wastes. If such products are accidentally broken or spilled, standard clean-up procedures should be followed. Appropriate personal protective equipment (PPE) should be worn when handling WLAB, especially those that are damaged or leaking, and the PPE should be used appropriately. Exposure to acid (battery electrolyte) can lead to chemical burns.

111.

3. Separation

112. Separate collection of WLAB is important because if such wastes are simply disposed of, e.g., as part of municipal solid waste (MSW), without any separation, the lead and other hazardous wastes could be released into the environment or contaminate other materials in the waste stream or expose others to lead and battery electrolyte. To increase separate collection batteries should be labelled with different symbols and or colours to identify their chemistry or category. In addition, collection and take-back points for different waste streams such as waste batteries can be labelled with (uniform) logos/labelling.

113. Separate collection of WLAB is best facilitated through the labelling of batteries showing they contain lead and acid and that they should be recycled and not disposed of in the general waste stream.

114.

115.

116. [As an example, in the USA the American National Standards Institute (ANSI) developed Standard, ANSI C18.1M-199255F54 which sets out the guidelines for labelling batteries, these include:

[54] https://www.nema.org/docs/default-source/standards-document-library/ansi-c18-1m-part-2_2019-contents-and-scope.pdf?sfvrsn=75bd53f_0.

(a) Manufacturer: The name of the battery manufacturer;

(b) ANSI Number: The ANSI/NEMA number of the battery (where appliable);

(c) The day, month and year the battery was manufactured or the month that the guarantee expires;

(d) The nominal battery voltage;

(e) That the positive and negative terminal posts are clearly marked;

(f) Any other warnings or cautions associated with the battery chemistry or use.

117. It is extremely important to separate WLAB from other waste batteries such as those containing lithium to prevent those entering the feedstock of the recycling streams. Mixing WLAB with other waste batteries can present significant safety hazards with the potential for fires being caused, especially by waste lithium batteries, giving rise to potential health and environmental issues.

4. Collection

118. WLAB collectors or dealers should not break or drain the batteries into separate components and ship or transport the grids or paste separately. Only whole batteries complete with case, electrolyte, plates and paste should be transported to a WLAB recycling facility. There should be no intermediate steps in the process where batteries are broken down and the components separated and sent to another plant in a different location or country unless the plant is authorised to do so and follows environmentally sound management practices.

119. To successfully recycle WLABs there is a need for the installation of an appropriate collection and recovery infrastructure, this could also include an IT based management system (see para 91). It needs to be well organised as it involves a number of key stakeholders in the supply chain such as battery retailers, garages, battery suppliers, businesses, collection companies, secondary recyclers, and consumers. Given the value of lead and the number of batteries circulating there are financial incentives to recover them.

120. There are several established ways of collecting WLAB, these include:

(a) National collection schemes;

(b) Municipal waste recycling facilities;

(c) Local collection schemes;

(d) Collection Incentives:

i. Deposit/refund ;

ii. Purchase discount ;

121. Many countries have the dual system of distribution-collection or deposit refund involving manufacturers, retailers, wholesalers, service stations or other retailing points that provide new replacement batteries to users and retain the used ones to be forwarded to formally licensed/authorised collectors who transfer them to licensed recycling plants. One of the key aspects of any collection scheme is the need for effective control measures being implemented at the collection points to prevent accidents that may have the potential to give rise to human exposure and/or environmental damage. Details of good storage practices are included in F7.

121 bis Those collecting batteries should only transfer/sell them on to a licensed facility that is authorised to dispose of WLAB in an environmentally sound operation. Informal lead recycling operations are a key source of lead pollution with the potential to cause significant human health issues and environmental damage. It is therefore important that collectors only transfer WLAB to those operators that follow and practice environmentally sound management recycling procedures and appropriate standards for protecting the occupational health and safety of employees and others in the community.

(a) National Collection Schemes

122. These schemes involve collecting WLAB through a dual system of battery distribution and waste battery collection. This scheme revolves around manufacturers, retailers, wholesalers, service stations and other retailing outlets providing new or replacement batteries to consumers and the outlet

taking back the old battery to be sent to collection centres or licensed recycling plants. Such a system, also known as reverse logistics, is sustainable because it is based on the economic value of the lead content of the lead battery and can be run by the battery industry without government support. These reverse logistics systems are also being employed as an integral component of Extended Producer Responsibility (EPR) and advocated as a prime example of a circular economy. For example, in Argentina, under the national legislation Hazardous Waste National Law Nos 24.051 and Resolution 544/94), WLAB are classed as hazardous waste and to facilitate recycling at the national level, the seller of new batteries is required to receive the old battery as part of the sale transaction so that they can send it to the disposer. Under the legislation the seller is regarded as the waste generator and is responsible for sending it to a licensed disposal facility.

123. When a battery is taken to a retailer such as a garage it could be checked prior to replacing it to see whether it actually needs replacing. The retailer may be able to undertake a safety check and functionality test to confirm whether it needs replacing or can be recharged. In some places they may be able to recharge the battery as well.

(b) Municipal Waste Collection Facilities Systems

124. Many industrialised countries provide temporary storage facilities, often free of charge, for members of the local community to bring their WLAB waste to them (e.g. car batteries, golf cart batteries, leisure batteries) that may have been purchased over the internet and there is no local retailer who will take them back. Such systems provide a way to capture WLAB that may otherwise be difficult to enter the recycling system. In addition, small businesses can also use these facilities, but they may incur a small charge. Often these facilities store batteries for recycling and have designated containers for different types of batteries, including WLAB. The facility may have a contract with a battery collection company to provide plastic bins, which they come and collect, for storing the lead-acid batteries. The collection company will generally pay the municipality a small fee for providing the service given they will be collecting a commodity that can be sold on to a recycling company.

(c) Local Collection Systems

125. Whilst a common method of collecting WLAB is through the battery retailers using deposit/discount or purchase discount remote users may find it difficult to use one of the above collection schemes., The battery retailer may be some distance away in remote areas, which reduces the likelihood that the consumer will want to return the WLAB.

126. Developing countries, individual salvagers/recyclers will collect discarded materials that can be reused or recycled or sold. They will call at garages, repair shops and breaker's yards for a WLAB so that they might collect it with the prospect of a payment from a trader or recycler. The salvagers will visit waste sites, strip abandoned vehicles and wrecks and, collect WLAB that have been used for domestic standby power and take them to a retailer or collection point. In some instances, the salvager will pay the householder to take away the battery, because it has a resale scrap value. These salvagers are very efficient at finding and collecting WLAB, especially in remote locations. The key issue here will be to ensure human health and the environment are properly safeguarded for those collecting and salvaging WLAB.

(d) Financial Incentives for Collecting WLAB

(i) Deposit & Refund

127. In a number of countries governments have initiated, in cooperation with the battery industry, collection systems based on a financial incentive to return a WLAB, such as a refundable levy on new batteries (these work best with the highest take back percentage), which is repaid to the customer when the old battery is returned to the retailer. Countries have used these financial incentives as shown in the following examples:

(a) USA – Several States require payment of a deposit of USD 5 to 10 on the purchase of all new lead acid automotive batteries. The deposit on the new batteries is refunded when a new battery is bought and the used one returned to the retailer;

(b) Germany – a levy of 10 € on all LAB purchased without the return of an old battery.

(c) Canada – Some retailers will offer a credit on return of an old battery towards the purchase of a new one. Other retailers collect a $10 - $20 CAD deposit on the purchase of a new LAB, which is refunded when the old battery is return to them. In British Columbia: there is an incentive program to encourage consumers living in remote areas to return their used lead-acid batteries, with the subsidy paid varying with the distance travelled and the current price of lead;

(d) Italy: consumers pay an additional charge of €10 when buying a new lead-acid battery. This fee is refunded by the battery manufacturer to an association (e.g., COBAT) which is responsible for collecting WLAB and ensuring that battery recycling is carried out at a licensed plant;

(e) Sweden: battery producers and importers are charged an environmental levy for every battery. This levy covers the cost of battery collection, transportation and recycling and the cost of a public information and awareness programme;

(f) Ghana: the Government has recently imposed a significant levy on the price of new lead-acid batteries and this levy can only be reclaimed by licensed WLAB recyclers. The levy is high enough to provide the licensed recyclers a financial advantage over the informal sector because the informal sector cannot reclaim the levy. This financial instrument effectively keeps the informal sector out of lead battery recycling;

(g) Turkey: In December 2019, the Government of Turkey enacted legislation requiring companies to pay a levy called the "Recycling Contribution Fee" (GEKAP)[55]. GEKAP applies to goods that are potentially harmful to the environment, such as LAB, if they are not recycled correctly.

(h) Brazil: since 1998 there have been requirements for manufacturers and importers to take back WLAB. From 2010 reverse logistics have been normal and distributors and traders have had to provide consumers with places to receive WLAB. In 2020 Brazil had 4453 drop-off points and most of these are in automotive centres that sell new LAB.

128. Recycling contribution fees for returned WLAB can be offset from the total recycling contribution liability paid. If the amount to be offset is greater than the recycling fee payable, the excess portion will be carried over, as a credit, to the following financial period. This system provides incentives for responsible LAB manufacturers to maximise the collection and environmentally sound recycling rates for WLAB.

129. An analysis of the costs and impacts of battery collection and recycling for all battery types, including automotive lead acid batteries was produced in 2018 by the European Union[56], entitled, "Study in support of evaluation of the Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators". Essentially, the report did not provide an encouraging perspective for portable batteries, but WLAB were being collected and recycled at above target levels.

(ii) Purchase Discount

130. Purchase discount schemes operate in a comparable way to the Deposit/Refund systems, but instead of the consumer paying a deposit the first time a LAB is purchased, the consumer will only pay the retail price. However, when the battery needs replacing and it is returned to the retailer, a discount will be given on the price of a replacement battery and the WLAB will be retained by the retailer for collection by a licensed collector/recycler. This will incentivise the purchaser to return the battery at the end of its life.

131. These systems can be run/designed by the collection companies, secondary recyclers or battery manufacturers to either collect or arrange collection of the WLAB. The industry bears the costs and sets up the necessary infrastructure to make the scheme work. Such schemes are in operation in various countries and regions, for example Europe. In other places, for example, the Philippines, a key battery manufacturer has teamed up with the major licensed secondary lead plant to operate such a scheme throughout its 300 retail outlets.

132. The schemes that are initiated and managed by the battery industry are an example of the "Extended Producer Responsibility" (EPR) principle.

133. Purchase discount schemes are the standard for commercial and industrial batteries and is the reason that lead-acid batteries used for motive power and lifting equipment are all recovered.

5. Packaging and labelling

134. WLAB being transported from the collection points to the recycling facilities should be properly packaged and labelled. Packaging and labelling for transport are often controlled by national hazardous waste or dangerous goods transportation legislation, often based on international standards.

[55] https://www.pwc.com.tr/en/hizmetlerimiz/vergi/bultenler/2020/going-green-recycling-contribution-fees-start-in-2020.html.

[56] https://ec.europa.eu/environment/waste/pdf/Published%20Supporting%20Study%20Evaluation.pdf.

If such legislation is lacking or does not provide sufficient guidance, care should be taken to use labels that are in line with the United Nations Globally Harmonized System of Classification and Labelling of Chemicals. IATA, ICAO, IMO and UNECE should be consulted. International standards for the proper packaging, labelling and identification of wastes have been developed, including the following reference materials:

(a) UN Model Regulations on the Transport of Dangerous Goods

(b) UNEC, 2023, Recommendations on the Transport of Dangerous Goods – Model Regulations:

(c) United Nations, 2019b. *Globally Harmonized System of Classification and Labelling of Chemicals*[57] (revised and improved every two years); and

(d) OECD, 2001b. *Harmonised Integrated Classification System for Human Health and Environmental Hazards of Chemical Substances and Mixtures*[58].

(e) Other guidance is contained in reports e.g. CEC (2016) on packaging[59].

135. Given the different types of WLAB they should be sized and sorted by type. If they are being palletized, they should be placed in rows that are even so that the pallets are stacked safely in layers.. Appropriate measure should be taken to prevent the release of electrolyte from the package, e.g. individually packaging batteries or other equally effective methods. WLAB should be stacked upright and evenly to avoid damage and electrolyte leakage and the terminals protected or positioned so that they do not touch. Plastic film and heavy-duty straps can be used to secure the batteries to the pallet in preparation for transportation.

136. UN 2794 approved leak proof plastic WLAB containers should be used to place the collected batteries in them. These containers are designed to be lifted by forklift trucks and avoid the need to handle the batteries, by hand, any further after collection. It also makes it safer and easier to handle and manage at the disposal plant.

137. Labelling systems for batteries should be implemented by battery manufacturers during the production stage to aid their identification and need for separate collection and recycling. Labels should comply with national regulations, which may require the disclosure of the identity and properties of toxic chemical ingredients in products. Labelling systems for products containing lead and acid should include instructions that encourage recycling. The label should also contain a local telephone help line or multilingual web site where safe disposal or collection information can be obtained.

138. Manufacturers should indicate the presence of lead in products containing lead by using the international chemical symbol, “Pb”, on product labels. For example, in the European Union, the chemical symbol “Pb” must be printed on lead-acid batteries under Regulation (EU) 2023/1542)[60]. In addition, they should also show the recycling symbol and be marked with a crossed-out wheeled bin to indicate that they should not be disposed in a domestic rubbish collection bin Several countries have laws or guidelines that impose or suggest minimum standards for labels, but in most countries the labelling requirements are ether based on or are variations of the European Standard for battery labelling contained in the standards defined in EN 50342.

6. Transportation

139. WLAB are classified as a hazardous waste and needs to be handled appropriately when being transported. One of the main problems with these batteries is the potential for leakage of electrolyte from damaged or cracked batteries. Waste batteries should be transported whole inside containers or palletised in a manner that minimises movement and the risk of electrolyte leakage. Plastic bins/containers and pallets should be secured (e.g. stretch-wrapped) to prevent movement with straps on the truck floor, side panels or side bars will assist retaining the load.

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[57] https://unece.org/transport/standards/transport/dangerous-goods/ghs-rev9-2021. https://unece.org/transport/standards/transport/dangerous-goods/ghs-rev9-2021.

[58] https://www.oecd-ilibrary.org/environment/harmonised-integrated-classification-system-for-human-health-and-environmental-hazards-of-chemical-substances-and-mixtures_9789264078475-en. https://www.oecd-ilibrary.org/environment/harmonised-integrated-classification-system-for-human-health-and-environmental-hazards-of-chemical-substances-and-mixtures_9789264078475-en.

[59] http://www.cec.org/files/documents/publications/11665-environmentally-sound-management-spent-lead-acid-batteries-in-north-america-en.pdf

[60] http://data.europa.eu/eli/reg/2023/1542/oj

140. Shipping containers should be well packed for transport. Plastic WLAB bins, containers and pallets inside the container should not be allowed to move while being transported. Therefore, they need to be chocked to avoid this problem.

141. Personal protection equipment, spill kits and other emergency equipment necessary to combat any simple spillage or leakage problems should be provided and the transport team trained in its use and the emergency procedures to follow.

142. Prior to transportation, contingency plans should be documented to minimize environmental impacts associated with spills, fires and other potential emergencies. The shipping documents should include an emergency response telephone number and a certificate that the shipment is in compliance with the regulations. In addition, the shipper should mark the containers with appropriate signs, including the specified label, the proper shipping name and, when the containers contain hazardous wastes, the UN number. For WLAB, the proper shipping name is "Batteries, Wet, Filled with Acid," and the UN number is "UN 2794" (QSC, 2003). During transportation, WLAB should be identified, packaged and transported in accordance with the following: (a) United Nations Recommendations on the Transport of Dangerous Goods: Model Regulations (United Nations, 2023)[61]; and (b) International Maritime Dangerous Goods Code (IMO, 2022)[62]. (c) Waste lead-acid batteries, under certain conditions, are exempted from road transport regulations concerning dangerous goods in some countries, this should be verified in individual countries.

143. Companies transporting hazardous wastes within their own countries should be certified as carriers of hazardous materials and wastes, and their personnel should be qualified and trained in accordance with applicable national and local requirements.

7. Sorting & Storage

(a) Collection facilities

144. All batteries entering a small collection/storage facility, such as a garage or retailer should be checked to ensure that they are not damaged (e.g. cracked cases), missing caps with the potential to leak or are leaking. They should also be checked for battery chemistry and non-lead acid batteries separated to minimise the risks of any incidents and impact on the workers. The batteries should be stored upright in plastic acid-resistant leakproof bins that may simply be sealed and used as the transport container as well minimizing the risk of an accidental spillage.

144 bis Those batteries leaking electrolyte or damaged but not leaking, should be stored in acid resistant leakproof containers (e.g., plastic bins/drums) or packaged separately in heavy duty polyethylene plastic bags and closed securely with a plastic tie to minimise risks to the environment and health in a designated storage area. WLAB presented at the collection locations should not be drained of electrolyte since it may pose a risk to human health and the environment as it contains acid and lead. Effective acid neutralising spill clean-up materials should be available in the event of a spill incident.

145. The storage area should be located well away from areas of high risk to human health and the environment and sheltered from rain and weather, stored away from direct heat sources, and where appropriate be bunded and the ground protected with acid resistant concrete or any other acid-resistant material (e.g., sealed surface with acid resistant paint). WLAB stored outside should be in weatherproof plastic containers with lids and placed on impermeable ground. Enclosed areas should be well ventilated with restricted access and be identified as a hazardous materials storage area. Spill clean-up kits and any other appropriate personal protective safety kit should be available to deal with any spills/incidents. Access to the storage areas should be restricted to authorised personnel only wearing the appropriate PPE.

145 bis In China there are two types of collection facilities (collection point and centralised collection facility. Collection points that hold less than 3 tonnes of WLAB should set a storage area of at least 3m2 . For centralised collection facilities the storage area should be at least 30m3, have acid resistant ground concrete or other acid resistant material that can retain any leakage and be equipped with a waste liquid/water collection system. The storage area has to be sheltered from rain and protected from heat sources. Damaged WLAB should be stored in an acid resistant container which can be sealed and used for transport to minimise the risk of accidental spillage.

146. The number of WLAB stored at the collection facility will depend on the volume handled by the establishment and the capacity of the storage area. Ideally batteries should be collected on a regular

[61] https://unece.org/transport/publications/recommendations-transport-dangerous-goods-model-regulations-rev22.

[62] . https://www.imo.org/en/publications/Pages/IMDG%20Code.aspx

basis to avoid the need to store large quantities of WLAB. Storage times should be kept to a minimum. The Commission for Environmental Cooperation[63] of North America has published some technical guidelines (2016) on WLAB.

(b) Disposal Plants

147. WLAB disposal plants where they are recycled may store up to several thousands of tonnes of batteries. All batteries should have been checked prior to delivery to identify and separate the different types of batteries present, e.g. those in steel cases, and for the presence of lithium batteries given these can cause fires and explosions in the plant. Although lithium batteries should have been removed at the collection stage there is always a risk that some have been missed so further inspections should be undertaken. The different types of batteries can then be segregated and stored in allocated areas before recycling.

148. The batteries should be stored in a designated area in plastic bins/storage containers or on the floor of a covered bay from where they can be scooped up and placed in the battery breaker. The bay should be constructed of an acid-resistant concrete and impermeable floor with a drainage collection system for the electrolyte. This should comprise a sump/drain for the electrolyte so that it can either be treated in an effluent plant or recovered via an acid electrolyte treatment plant for conversion into saleable products such as gypsum. The batteries should not be stored on bare ground or in uncovered areas to prevent lead and acid contaminating soil and groundwater.

149. The covered storage area should have closing doors to minimize the release of lead emissions outside the building. Ideally the area should be under negative pressure and the air extracted via the plant emissions filtration system, details on the types of systems used are specified in the (Best Available Technology Reference Notes) BREF Notes[64].

150. Also included in the storage area should be a firefighting system and safety showers and other emergency equipment and clothing available for personnel in the event of an incident or fire.

151. Only authorized personnel wearing the appropriate PPE should be allowed to enter the WLAB storage area.

G. Environmentally sound disposal

1. General Considerations

152. According to the waste management hierarchy, prevention, minimization, reuse and recycling should be prioritized over other recovery operations and final disposal operations. For pursuing recycling and recovery of plastic and metal wastes, the guidance to assist parties in developing efficient strategies for achieving recycling and recovery of hazardous wastes and other wastes (UNEP, 2019c) may be useful.

153. The disposal of WLAB by the informal sector, including pre-treatment, is not environmentally sound and should not be considered an acceptable practice due its negative impacts on human health and the environment.

154. According to Article 2 of the Basel Convention, "Disposal" means any operation specified in Annex IV to this convention. disposal operations relevant to WLAB and unrecoverable wastes from the processing and recycling of them and provided in Annex IV, part A and B of the Basel Convention are the following, ordered according to the waste management hierarchy:

(a) Recycling / reclamation of metals and metal compounds (R4) plastics (R3), regeneration of acids and bases (R6) ; Recovery of components used for pollution abatement (R7),Use of waste (R11);

(b) Specially engineered landfill ((D5); Physico chemical treatment (D9);

(c) Incineration on land (*D10 and R1*);

(d) Interim operations.

155. Successful WLAB recycling relies on the fact that the batteries have an economic value due to the high lead content. In addition, the polypropylene battery case and battery acid can be recovered and converted into a saleable product, for the automobile, batteries and plastics industry, providing it

[63] http://www.cec.org/publications/environmentally-sound-management-of-spent-lead-acid-batteries-in-north-america.

[64] https://eippcb.jrc.ec.europa.eu/reference/non-ferrous-metals-industries-0

does not contain POPs (e.g. EU, USA, etc). The financial viability of WLAB recycling depends on a number of factors, these include:

(a) The metal price of the recovered and refined Lead. (LME prices[65]);

(b) Sufficient quantities of WLAB to maintain a viable operation;

(c) The costs of collecting and transporting the WLAB to the recycling plant;

(d) The cost of environmental, health and safety measures required to manage risks;

(e) The costs of buying WLAB;

(f) The availability of end-user industries (e.g. battery manufacturers, plastic manufacturers) that require recovered raw materials.

2. Recycling & recovery operations

156. There are several key stages in the recycling/recovery/reclamation process, following battery sorting and storage prior to processing (Section 7 Sorting & Storage), these are:

(a) Battery breaking;

(b) Electrolyte treatment;

(b) Smelting or electrowinning;

(c) Refining;

(d) Plastics treatment;

(e) Wastes final disposal.

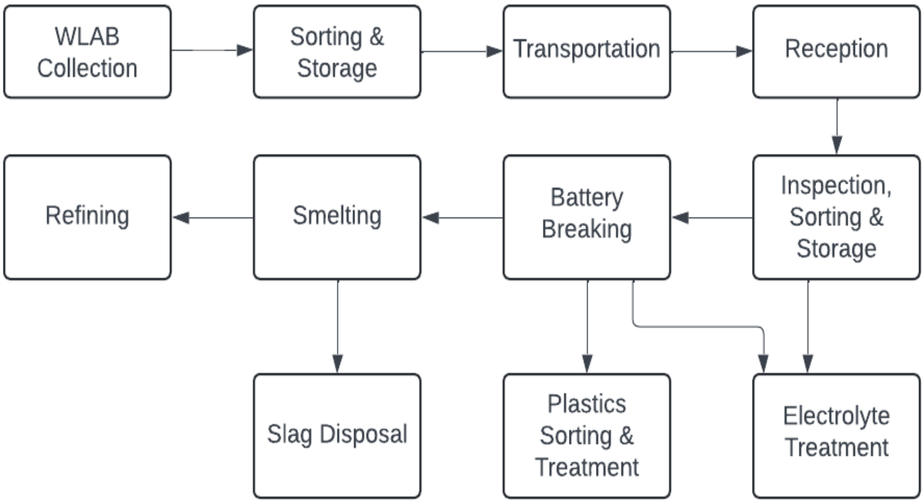


Figure 1. Overview of WLAB collection & processing

157.

158.

159.

160.

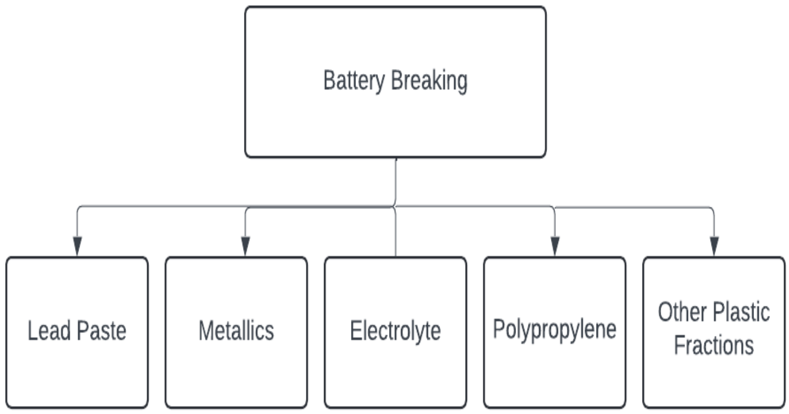
(a) Battery breaking

(i) Process overview

161. The first step in the WLAB recycling process, following battery sorting and storage (Section 7 Sorting & Storage), is referred to as “battery breaking.” This process separates all components, such as lead paste, metallic plates and connectors, polypropylene and other plastics, and acid electrolyte into

[65] https://www.lme.com/en-gb/metals/non-ferrous/lead/#tabIndex=0. https://www.lme.com

streams that are handled separately in the subsequent recycling steps. In general, WLAB breaking should be carried out in specialized battery breaker (hammer mill). It is important to inspect the feedstock to ensure that lithium-ion batteries do not enter the breaker, because if they do, there is a distinct possibility that the battery will explode. Human contact is usually minimized as much as possible, so the batteries are received and directed to the breaking plant by means of automatic conveyors or front-end loaders/forklift trucks.



162.

Figure 2 Battery breaking outputs.

163. Battery breaking methods differ from one another in process details and evolve as new technology becomes available. The suitability of each one for a given lead recovery plant depends on several specific factors such as local economy, quantity of raw materials as well as the demands of the smelting facility. If mechanical battery breaking equipment is unavailable, for whatever reason, , (e.g., some large-format industrial batteries are too large or heavy to put into a mechanical battery-breaker) the safest approach to prepare the battery for smelting would be the following: puncture and drain the electrolyte from the battery and treat it accordingly (e.g. neutralise it or send it for treatment/recycling); remove the top of the battery complete with plates and separators using an approved battery saw, using PPE and equipment under strict health, safety and environmental controls.

164. Once the waste batteries are loaded into the breaker, they are broken down by a hammer mill. This ensures that all components, such as lead plates, connectors, plastic boxes, paste and acid electrolyte are easily separated in the subsequent hydrometallurgical gravitational separation process.

165. Alternatively, the batteries can be fed into a ventilated battery saw (OSHA details)[66] to remove the top of the battery. The plates are then removed in a rotating drum and set aside to be charged to the furnace in a manner similar to the materials from the hammer mill. Lead terminals are removed from the top of the battery either mechanically or manually and can be charged directly to the refining kettles or the bullion casting pots if no refining is required.

166. After breaking, a screening process takes place to separate the various lead and plastic components. The lead oxides and sulphates are separated from the other materials by a hydro-gravitational system in water through a series of sink and float tanks that separate materials based on relative density (e.g. heavy materials sink to the bottom and lighter one's float to the top) and then by slow moving mesh conveyers.

167. Following separation and drying (vacuum drying in certain desulphurization processes), the paste is charged/loaded to the furnace, in the case of pyrometallurgical techniques, or directed to alternative processes, for example hydrometallurgical techniques to the solvent tanks for digestion.

168. In the case of plates recovered from the battery saw the metallic parts, including lead plates grids, connectors and terminals, are then placed in a suitable container in preparation for furnace charging or the solvent tanks for hydrometallurgical processing.

169. The hydro-gravitational processes, through use of the density properties of the WLAB components and hydraulic pumped mechanisms, separates the broken battery component pieces into three discrete fractions: the first one is the light fraction such as the plastics, that is, the case material

[66] eTool : Lead: Secondary Lead Smelter - Engineering Controls - Local Exhaust Ventilation Diagrams - Battery Saw Emission Control | Occupational Safety and Health Administration (osha.gov)

and the separators, the second is the fine slurry of lead oxides and sulphates and the third is the heavy layer consisting of lead grid metallics from the battery plates, the lead connectors, and the terminal posts. The plastics recovered in this process are washed and rinsed, often in the final stage in alkaline solution, to remove any traces of lead oxides and sulphates. In the most modern breakers, the separators are also segregated and discharged from the breaker to be charged to the furnace because they cannot be recycled.

170. After these separation steps, the light fraction is further separated into polypropylene or ABS waste streams (organics), and separators that can contain some organics and sometimes minerals, such as silica and more often a mixture of both. Unless the breaking system is connected to a plastics recycling process, the plastic chips are bagged and stored ready for dispatch to a suitable plastics recycler. The separators, whether polyester or glass matte can be charged to the furnace for disposal.

(b) Electrolyte Treatment

170 bis Depending on the process battery electrolyte can be collected and drained to a sump before it enters the crusher (hammer mill) or collected during the first stage of battery breaking.

170 ter Battery electrolyte can be reconditioned/purified and returned to battery manufacturers to fill new batteries. The reconditioning/purification process typically involves industrial filtration and distillation to concentrate and recover the acid. However, due to the investment costs this can be expensive to make recovery and reconditioning viable for individual WLAB plants. The electrolyte can also be converted into gypsum for use in plaster board or other industries.

171. Electrolyte can be neutralized (pH adjusted), with magnesium hydroxide (Mg(OH)2), to precipitate out contaminants in the form of a filter cake. The pH adjustment reaction is exothermic (produces heat), and it is best practice for this process to occur in fiberglass tanks, rather than polyethylene tanks. This neutralization process produces a sulphate filter cake, which may be hazardous waste.

171 bis [If it is necessary to drain battery electrolyte it will need to be neutralized as follows:

(a) Adding sodium hydroxide to the electrolyte to produce sodium sulphate and water, and in a similar manner, sodium carbonate can be added to also produce sodium sulphate and water, but this process will also liberate carbon dioxide. S*odium sulphate* is used in the manufacture of glass, soaps, textiles, and detergents, but purification involves vacuum distillation, and the equipment is expensive and not necessarily suitable for an SME;

(b) Adding lime or calcium hydroxide to precipitate calcium sulphate, i.e., gypsum. This is a saleable product and can be sold to the cement industry and used for wall boarding;

(c) Adding ammonium carbonate with lead paste so that it reacts with the lead sulphate to form lead carbonate and ammonium sulphate, a rich source of nitrogen.]

172. Technology to recycle the electrolyte could be added. (see Para 184).

(i) Environmental contamination sources

173. This section, and the other two sections on lead reduction and lead refining, are not designed to describe or extensively list all possible sources of contamination or occupational exposure that may occur in the lead recovery processes, as changing and evolving technologies and processes mayl present benefits but also different risks and threats. It is designed, instead, to itemize a short predictable list of common contamination sources. Specific sources of contamination will have to be determined in the light of the process employed. The common sources of environmental impacts and risks in battery breaking are:

(a) Battery acid spillage - acid electrolyte and lead contamination source: battery spillage can be a common source of environmental contamination and potential human health impact since the electrolyte is not only a strong corrosive solution, but also a good carrier of soluble lead and lead particulates. Therefore, if electrolyte spills in an unprotected area, it may contaminate the soil, groundwater or nearby water or injure workers since it is a corrosive liquid that contains lead. If there are spills on unprotected soil, the soil itself becomes a source of lead dust once the solution evaporates and the lead becomes incorporated into soil particles which may be blown and made airborne by the wind or raised as dust by vehicle movements;

(b) Manual battery breaking – source of human health risks and environment damage through heavy spillage and lead contaminated dust formation: manual breaking usually relies on primitive tools, inadequately protected workers and little or no environmental protection measures. The situation is even worse in the case of sealed batteries, which are not easily drained, increasing dramatically the risk of damage to human health when the plates are removed from the case by hand. Therefore, manual battery breaking should be avoided;

(c) Mechanical battery breaking – source of lead particulates and sulphuric acid mist from the hammer mill: the process of breaking batteries in a hammer mill may spread lead particulates and acid mist unless the breaker is housed in a ventilated and sealed building. . Mechanical methods to control sulphuric acid vapors include a vent hood over the point of generation, which should be connected to a wet scrubber. The resulting liquid discharge from the wet scrubber is acidic (unless pH is controlled) and could be used as recycled water in the process or sent to wastewater treatment (described in Section 5) and discharged. Any leaks or spills from this system will produce a corrosive liquid containing lead.

(d) Lead dust contamination is another potential environmental impact. However, the fact that the mill is sealed and the main processes of separation are based on water techniques, the separated and fine materials from the battery breaking process are usually wet, preventing the formation of lead dust. The risk of dust emission is high risk if drained and dry WLAB are processed in a hammer mill. There is also risk of lead contamination of the facility and surrounding community during transport if some of the watery material spills or if the wet material dries and the resulting dust contains lead particles.

(e) Hydraulic separations – contaminated effluent leakage: the hydraulic separations, both metallic from organic and heavy organics from light organics, are usually preformed inside sealed plant and with a closed effluent system. However, if any effluent leakage occurs, it will be acidic and heavily contaminated by lead compounds;

(f) Plastic and chips – contaminated wastes: plastic chips produced in the mechanical breaking will pose a problem unless they are washed thoroughly to remove traces of lead oxides and sulphates and confirmed by sampling and testing. Therefore, it is important that the final traces of lead are removed by a second wash, preferably in an alkaline solution, followed by another rinse in clean water prior to further treatment.

(c) Smelting

(i) Lead reduction

174. Lead reduction refers to three major operations, pretreatment, smelting and refining. The battery scrap obtained from the breaking process is a mixture of several metals or metallic compounds: metallic lead, lead oxides (PbO and PbO2), lead sulphate (PbSO4) and other metals such as calcium (Ca), copper (Cu), antimony (Sb), arsenic (As), tin (Sn) and increasingly, silver (Ag). In order to isolate the metallic lead from this mixture, two methods may be applied: pyrometallurgical processes (most widely used process), also known as fusion-reduction methods, and hydro-metallurgical processes, or electrolytic methods. It is also possible to combine the two and use a hybrid process.

(ii) Pyrometallurgical methods

175. The object of the pyrometallurgical processes, or fusion-reduction methods, is to chemically reduce all metallic compounds to their metallic, or reduced, forms by means of heating and providing adequate fluxing and reducing conditions, compounds or elements (figure 2).

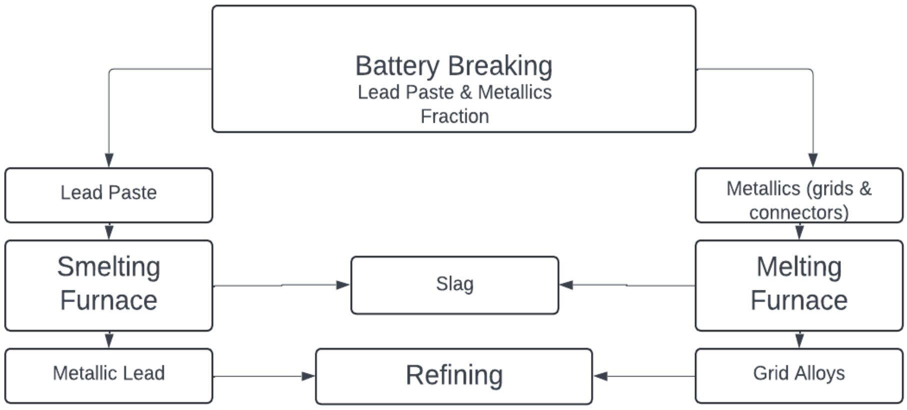


*Figure 3 Lead Paste & Metallics Proce*ssing

176. Prior to smelting, some methods may be employed to de-sulphurise the lead sulphates in the battery paste by reacting it with a mixture of sodium carbonate (Na2CO3) and sodium hydroxide (NaOH), such as in the Engitec CX and related processes, converting the lead sulphate (PbSO4) to lead oxide (PbO). Sometimes the desulphurizing agent may also be iron oxide (Fe2O3) and lime (CaCO3). These procedures reduce the amount of slag formed during smelting and also, depending on the smelting method, the amount of sulphur dioxide (SO2) released and therefore reduces the sulphur dioxide containment and capture problems. However, other methods simply add controlled amounts of scrap iron directly to the furnace in order to capture the sulphur, which will then be referred to and contained in the slag. This process does, however, increase the amount of slag produced.

177. The acid electrolyte should also be treated to extract the dissolved lead content so that it can also be sent to the smelting furnace. This is carried out by neutralization of the electrolyte solution with sodium hydroxide, which precipitates the lead as lead hydroxide (Pb(OH)2). This compound is then removed by decantation or filtration and directed to the furnace. The remaining solution, sodium sulphate diluted in water (Na2SO4), may be further purified and the salt isolated in high purity grades (up to food grade quality), such as in the CX Engitec Impianti process. Alternatively, other products can be produced from the electrolyte as already discussed above.

178. The most energy efficient operation is to charge the metallic fraction to a melting furnace and the lead compounds derived from the de-sulfurization and neutralization processes to a smelting furnace with fluxing and reducing agents. The heat can be provided by a variety of sources depending on the specific fuel or mix employed, such as oil, used oil, gas, natural or biogas and a fuel enrichment burner using oxygen under controlled conditions etc. There are also several different furnace designs in which the smelting process may be carried out: rotatory furnace, reverberatory furnace and blast or electric furnace, bottom blown furnaces and so on. The best technology to employ and reduce emissions will depend upon several factors that include local economics, the planned or projected amount of recycling, and so specific information may be found in the references provided at the end of these guidelines. It should also be noted that certain furnace technologies that facilitate the use of oxy-fuel burners can reduce nitrogen oxide emissions.

179. The fluxing agents, which enable the mix of materials in the furnace to "melt" at a temperature below the lead compounds melting temperature, are added not only to reduce the lead smelting temperature, but also to provide a liquid solvent, which traps several unwanted compounds and impurities during the smelting and reducing processes. As the flux starts to be contaminated with all sorts of impurities from the smelting process the formation of the slag also starts. The physical and chemical properties of this slag, which are important characteristics to be considered in a later treatment, are entirely dependent on the chemical composition of the flux that is used.

180. Reducing agents, on the other hand, are added with the purpose of reducing the lead oxide (PbO) and hydroxide (Pb(OH)2) to metallic lead. It is usually a carbon-based compound such as coke, coal fines or other natural carbon sources.

181. The quantity of flux and reducing agent added should be carefully controlled:

(a) An insufficient amount of flux will not enable all the sulphur and other materials present in the charge material to be controlled and a greater quantity of sulphur dioxide may be released to the atmosphere;

(b) An insufficient amount of reducing agent, on the other hand, will not reduce all lead oxides and sulphates present in the scrap and the slag will be heavily contaminated with lead, which may be a potential source of an environmental hazard.

182. After the process has reduced all the leaded compounds, the molten metallic lead will accumulate at the bottom of the furnace. However, if the material in the furnace is derived from the grid metallics, it will contain other metals of economic value. Therefore, this lead bullion should undergo a refining process before pure lead (99.97% to 99.99% purity) can be recovered from it. Alternatively, it can be partially refined to produce an alloy.

(iii) Hydrometallurgical methods

183. Hydrometallurgical methods are where the smelting operation is replaced by a process where the lead salts are extracted in solution. Typically, hydrometallurgical methods comprise a leaching step, followed by electrowinning or calcination to produce metallic lead (Pb), lead oxides (PbO) or lead oxides (Pb/PbO). These methods still require pyrometallurgical refining to obtain lead in sufficient purity for battery manufacturing.

184. This method shows advantages in comparison with pyrometallurgy as it does not involve high temperature smelting and emissions associated with the process and represents a low energy consuming operation.

185. A number of hydrometallurgical processes to recover lead from WLAB have been developed in a laboratory or on a pilot plant scale basis. So far most have not moved to an industrial scale operation and all face similar challenges: purity of the recovered products, energy efficiency, resource consumption, waste remediation and commercial viability. The overall aim with these methods is to reduce the environmental and health impacts and operating costs compared to traditional pyrometallurgical lead.

186. All hydrometallurgical processes begin with a breaking phase, but in the case of hydrometallurgical recycling the only option is mechanical breaking using a hammer mill, because the grid metallics need to be separated from the battery paste so they can be recycled separately.

187. It is possible to dissolve the grid metallics in a suitable solvent and then recover the lead using an electrolytic process or melt the grid metallics in a furnace and refine it.

188. There are three main types of hydrometallurgical processes, these are:

(a) Leaching followed by electrowinning/electrolysis;

(b) Leaching followed by calcination;

(c) Deep Eutectic Solvents.

a. Leaching followed by electrowinning/electrolysis

189. The objective of electrolytic processes is to electrically and selectively reduce all lead compounds to metallic lead.

190. In hydrometallurgical electrowinning, lead paste undergoes wet processing, where it is dissolved in a solvent, followed by electroreduction to produce metallic lead, typically at ambient temperatures. These deposits can be obtained in high purity, thus eliminating the need for lead refining.

191. The chemical concept behind the electrolytic process is the conversion of all lead compounds into a single chemical species, lead in an oxidation state +II (Pb2+ or plumbous lead) in this case, which is then electrochemically reduced to produce metallic lead.

192. Examples of electrowinning processes include the PLACID, FAST®, FLUBOR® and ACE techniques. Each of these processes are based on different sets of chemical reagents, desulphurisation or reducing agents, electrolyte systems, electrochemical cell design or an order of process steps.

i. PLACID process

193. The PLACID process[67] (figure 3) uses acidic aqueous brines as leaching reagents to produce lead chloride solution from lead paste. Sulphates are removed from the system by adding lime to create gypsum, and metallic impurities (Bi, Cu, As, Sb) are cemented using lead powder. The purified

[67] https://www.osti.gov/biblio/197296.

lead chloride solution is electrolysed producing a high-purity lead (>99.99%) with a recovery efficiency of 99.5%.

194. The electrolysis (electrowinning) produces spongy lead, which is collected on a conveyor belt, pressed to form pure lead platelets (99.99%), and conveyed to a melting kettle for casting into ingots. The acid produced in the electrochemical cell is regenerated and reused in the leaching step.

195. Although the process was developed in the early 1990’s it has still not been transferred for a laboratory and commercially used.

ii. FAST® Pb process

196. The Flakes Auto-Stripping Technology (FAST® Pb Process)[68] is based on an electrochemical flow-cell with an ammonium chloride electrolyte. The process starts with desulphurisation of spent paste, followed by leaching with ammonium chloride. Hydrogen peroxide is used as a reducing agent. The leachate is then purified with lead flakes and fed to electrowinning cell producing lead flakes which are collected to produce metallic lead. The solution (NH4Cl) from the electrolytic process can be reused in the leaching step.

197.

198. Unlike with other electrolytic chloride systems, no chlorine emissions are generated. The process can be run continuously with plating current efficiency of >85%. This process has not yet been commercialised.

iii. FLUBOR® process

199. The FLUBOR® process[69] is another electrolytic process for lead recovery.

200. Thelead paste undergoes sulphidation producing lead sulphide (PbS) which is leached with ferric fluoroborate-fluoroboric acid producing lead fluoroborate. This then undergoes purification to remove antimony, arsenic, bismuth, copper and silver before being fed as an electrolyte for electrowinning.

201. Metallic lead is plated at the cathode, whereas ferric ions are produced at the anode. The solution produced in the anode compartment is regenerated and reused in the leaching step (closed loop leach system).

202. The lead extraction rate of the process is >97% and the produced lead cathodes have a lead content of 99.99%. This process has been run as a demonstration plant in the USA but has not yet been run on a commercial basis.

203. .

iv. (ACE) electrolysis process

204. The Ace Green[70] recycling process involves room temperature electrochemical processing of battery paste.

205. The battery paste is treated with chemicals and sodium hydroxide to remove the sulphur. It then undergoes room temperature electrolysis and produces a spongy lead (99.98% purity). The lead sponge is mechanically pressed into briquettes for refining before casting into ingots. Drosses produced during the refining are electrochemically treated to recover the lead content.

206. The metallics are chemically cleaned to remove any paste before being melted in process kettles followed by refining.

207. This process is modular and can be scaled up to suit any production capacity, it is automated and does not involve smelting furnaces. Two plants are currently operating and using the technology under licence in India and Taiwan.

b. Leaching followed by calcination

208. This process involves leaching followed by calcination to produce leady oxides that can be directly used as a precursor material for battery paste in new batteries. This approach does not require a conversion from lead ingots (metallic lead) to leady oxides, making the route from WLABs to new

[68] https://link.springer.com/chapter/10.1007/978-3-030-37070-1_50.

[69] https://www.engitec.com/index.php?a_lang=en&a_name=lead.

[70] https://www.acegreenrecycling.com/

LABs shorter in comparison with pyrometallurgical or electrowinning methods. As with the hydrometallurgical methods this has not be been developed beyond the laboratory[71].

209.

c. Deep Eutectic Solvents

210. The hydrometallurgical processes use water as a liquid medium. However, the production of lead oxides and leady oxides via chemical methods can be also achieved from non-aqueous solutions. A novel deep eutectic solvents (DESs) have demonstrated high solubility of lead compounds, with little associated hazards.

211. Deep eutectic solvents are liquids formed from a eutectic mixture of typically two components, such as ethylene glycol, urea or choline chloride. These chemicals are commercially available, inexpensive, easily to handle and environmentally benign. In addition, deep eutectic solvents are soluble for various lead compounds, e.g. lead oxides – up to 100g/l.

212. The economics of the process are not yet established, but DES has been shown to produce lead oxides directly from lead paste, without the need for a separate desulphurisation step in a laboratory scale process.

(iv) Lead reduction: environmental contamination sources

213. The common sources of adverse human health and environmental impacts in the pyrometallurgical lead reduction processes are:

(a) Lead compounds derived from the breaking process – Lead and lead compounds in dust and electrolyte; the separated and fine materials from the breaking process are usually wet, since the main processes of separation are based on hydro-gravitational techniques. However, if they are not incorporated in a fully automated process, they will have to be transported from the breaking facility to the reduction facility and some slurry material may spill and fall from the transport system. After drying, these materials become a powder and may contaminate the factory and its surroundings as fine lead dusts. There are also similar problems associated with the processing of drained and dry WLAB because there is a greater
propensity for dust generation. If it is necessary to process dry WLABs through a mechanical hammer mill, they should be interspersed with whole undrained WLAB so that the risk of dry lead dust generation is reduced;

(b) Drosses – lead and metals contaminated materials: drosses are formed during the refining process and they are produced to remove impurities (e.g. tin, zinc, antimony, copper) that are not easily incorporated or wanted in the refined lead. However, these drosses still contain a high percentage of lead that can be recovered and so these by-products are recycled in the pyrometallurgical process by returning them to the furnace. In order to accomplish these tasks, the drosses should be removed and transported to the furnace charging bay, but since they are usually a dusty material and occasionally powdery (copper dross), they may be a source of lead and other metal contamination while being transported;

(c) Filter plant (Baghouse)– lead and metals contaminated dusts: furnace ventilation systems, that is, for the combustion gases and hygiene hoods, need to be ventilated to a filter plant to capture lead dusts formed in the pyrometallurgical process. After being used, they are usually recycled in the same smelting process since they may contain as much as 65% of lead. However, the care and maintenance of these filters may be an important source of contaminating dust, which could pose a risk to the human health and the environment. Besides, over-used filters no longer capture lead dusts as originally intended and the dust emissions from the furnace becomes an important source of fugitive contamination. Finally, the furnace inlet is itself a source of lead dust to the environment, since it can be an open system. The high temperature fume that leaves the furnace inlet and tapping area, for example, have a high lead content, and will be readily absorbed by the human body due to its particle size, that is, 0.1 to 0.7 microns;

(d) Sulphur dioxide emissions – the percentage of sulphur from a given amount of lead scrap load that leaves the reduction system as sulphur dioxide is highly dependent not only on the furnace conditions, but also in the kind of slag material being formed. As a general trend, this number may fall between 0% to 10% and it is significantly reduced if the flux used is a mixture of iron and sodium-based compounds producing sodium slags and pyrites. Ebonite also has 6-10% of sulphur that

[71] https://www.mdpi.com/2673-4605/4/1/78

may contribute to the sulphur dioxide emission if it is added to the furnace charge, although this is now rare as ebonite battery case material has been phased out;

(e) Organic material combustion – tar formation: in a well-structured and controlled refinery tar formation or burning embers is not a significant issue since the reduction process consumes all organic materials. On the other hand, in the less controlled process there is a greater is the risk of tar formation and emissions of burning embers from the furnace, especially in artisan foundries. If the reduction furnace has filters, the emission of tars is an even greater problem since they are very pyrogenic and may produce fires in the filtration plant, thus increasing the risk of an accident and the possibility of a rogue emission. The introduction of afterburners to complete the combustion of gases from the furnace is the usual solution to this problem, but a complete restructuring of the process, removal of organics for example, may present better perspectives. Spark arrestors located in the ducting leading to the baghouse will also reduce the risk of burning embers reaching the filter bags;

(f) Chlorine and chlorine compounds emission: an initial separation of the materials, such as PVC separators, allowed to enter the reduction process reduces the chlorine emission considerably. However, increasing amounts of PVC in the furnace increases the chances of chlorine emissions. The major part of it is absorbed by the basic calcium or sodium slags, however some of the chlorine is chemically converted into Lead chloride which is volatile under furnace conditions but captured by dust filters as the temperature decreases. The risks associated with PVC separators has largely diminished due to the introduction of polyester and glass matte separators;

(g) Slag production: the furnace residues or slag makes up most of the waste production during the reduction process. As an average, around 300-350kg of slag is produced for each tonne of metallic lead, depending on specific factors of the process and the kind of residue being formed (calcium or sodium slags), and up to 5% (w/w) of this slag is composed of lead compounds. Therefore, special consideration should be given to the leachate that may be produced if an unstable water-soluble slag encounters water or moist air. A purpose built under cover storage bay to store this material should be planned well in advance to avoid human health and environmental problems associated with the slag as it degrades

214. Smelting operations should be contained in an enclosed building under negative pressure or with emissions extraction and emissions control systems with local exhaust ventilation to a baghouse. The aim is to mitigate the risk of emissions escaping to atmosphere from the furnace operation, particularly during charging and tapping.

(d) Lead refining

215. Without refining a smelter recycling a mix of plates and lead oxide will produce hard (antimonial) lead. If the plant is producing soft lead, the crude lead bullion will need to undergo a refining process. The objective of refining is to remove as many of the unwanted impurities as possible such as, copper (Cu), antimony (Sb), arsenic (As) and tin (Sn).

216. WLAB recycling plants that process the lead grid plates and the lead paste separately through two or more dedicated furnaces or by campaigning the plates and the oxide separately, will produce two distinctive lead bullions. The bullion produced from the paste will have very few impurities and require minimum refining to produce pure soft lead at either 99.97% or 99.99% purity. The bullion produced by recycling the plates, normally through a melting operation, will contain certain metals used to produce the grid alloys and other possible metallic impurities. This bullion can be refined to produce pure soft lead, but is better suited to produce grid alloys, and whenever possible retaining the metals in the bullion that make up the grid alloy.

217. There are two main methods of lead refining: hydrometallurgical methods, which were described in the lead reduction section, and pyro-metallurgical or thermal processes, which are described here.

(i) Pyrometallurgical Refining

218. Thermal refining is performed in the liquid phase, which means that the crude lead should be melted to temperatures higher than 327ºC (lead melting point), but less than 650ºC (lead boiling point). As a general trend, the process is performed in batches of 20 to 100 tonnes, according to the refining plant capacity.

219. The chemical concept behind the refining process is the addition of specific reagents to the molten lead at appropriate temperatures to remove the unwanted metals in a specific order as they are added selectively (figure 8).

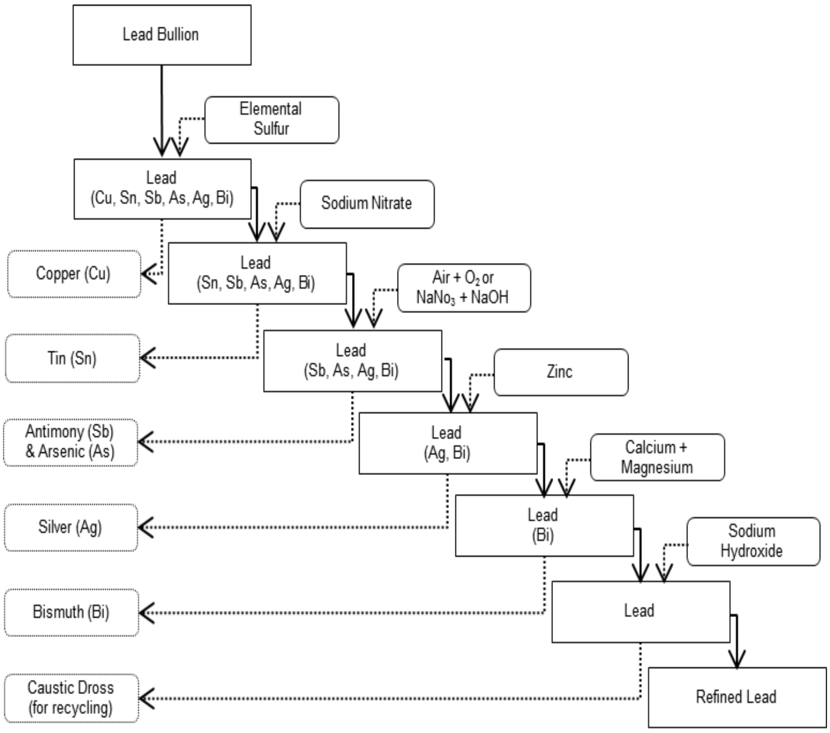


Figure 4: pyrometallurgical lead refining.

220. Copper (Cu) is the first element to be removed with elemental sulphur in a two-phase procedure. In the first step, almost all the copper is removed as copper sulphide (CuS) drosses when elemental sulphur is added to the molten lead bath at 450ºC. The second step is meant to remove all remaining copper by adding small amounts of elemental sulphur to the molten lead at 330ºC until no further reaction takes place. As the use of sulphur requires strict health and safety requirements to prevent fires and good extraction to remove acrid fumes a safer alternative is to use iron pyrites thereby eliminating the risk of fire and acrid fumes.

221. The tin is usually removed in the smelting process and only needs removal in the refining stage if scrap lead grids and other solid lead materials have been added to the refining kettle without passing through the furnace and allowed to melt into the molten bath. The tin is so unstable that just stirring the bath and adding some sodium nitrate (NaNO3) is usually sufficient to remove it. If there is still some residual tin it can be removed using an air lance in the kettle.

222. Arsenic (As) and antimony (Sb) are selectively removed by oxidation with either air enriched with oxygen (O2) or a mixture of sodium nitrate (NaNO3) and sodium hydroxide (NaOH). The temperature of the molten lead is raised to 550ºC and a flow of oxygen enriched air is bubbled into it. The reaction is extremely exothermic, and the temperature easily reaches 650ºC. Then the resulting drosses are a mixture of oxides (25% Sb, 10% As and 65% Pb).

223. Silver (Ag) comes next, but this stage is normally only applied to primary lead bullion because the quantities in WLAB are too small to remove economically. Its removal is carried out by the Parkes Process[72], which makes use of the preferential solubility of silver in molten zinc (Zn) instead of molten lead (Pb). Therefore, metallic zinc (Zn) is added to the molten lead at 470ºC, and the mix is allowed to cool to 325ºC. A silver lead-zinc alloy separates and forms a crust on the surface. The crust is removed, and the zinc separated from the silver by vacuum distillation. The crude silver is further refined using oxygen to produce fine silver.

224. Finally, bismuth (Bi) is removed, if necessary, by treatment of the resulting lead with a mixture of calcium (Ca) and magnesium (Mg), also known as the Kroll-Betterton process[73]. A calcium-magnesium-bismuth alloy is formed as dross on the surface of the molten lead and then removed by skimming. The drosses are oxidized and further refined to produce fine bismuth. This process is not normally applied to WLAB as Bismuth is often one of the beneficial elements added to lead to

72 https://wikipedia.org/wiki/Parkes_process

73 https://en.wikipedia.org/wiki/Betterton%E2%80%93Kroll_process

produce battery alloys and is not usually present in such proportions to cause problems attaining 99.97 or better impurities.

225. The lead is then treated with sodium hydroxide (NaOH) to remove any residual impurities and finally cast into one-tonne blocks or 25 or 40 kilo ingots. Drosses, litharge and other substances formed during the refining process are known as by-products and are returned to the furnace to recover any lead in the by-products.

(ii) Lead refining: environmental contamination sources

226. During refining it is important there are effective control measures in place to minimise the risk of environmental pollution. The major sources of environmental pollution during lead refining are:

(a) Lead fumes: the molten lead tapped from the furnace is introduced directly into the refining kettle, which may be as hot as 1,000ºC or more. Therefore, it is not uncommon that the lead refining process produces large amounts of lead fume and possibly vapour, depending on how quickly the metal cools on impact with the lead in the kettle. Ideally lead should be tapped from the furnace via a refractory lined launder directly into a lead bath or allowed to cool prior to pouring. In any event the refining kettle should be covered and ventilated;

(b) Sulphur dioxide (SO2) emissions: the copper removal by addition of elementary sulphur may produce large quantities of sulphur dioxide (SO2), since sulphur oxidizes readily in the presence of oxygen at the refining temperatures. The use of iron pyrites eliminates this problem;

(c) Dross production and removal – metal contaminants: the dross production and dross removal, from the refining kettle can pose a threat to human health and the environment due to the drosses dusty and physical characteristics. The drosses are in the form of a dry dust, such as the copper dross, with a high percentage of lead and other metals (e.g. arsenic), so it is essential to provide adequate ventilation/extraction during dross removal and the dross should be covered or sealed in a suitable container for storage or return to the furnace or transport to another destination for further treatment. The dross should be treated as a potentially hazardous by-product;

(d) Tin removal with chlorine (Cl_2) and recovery – in some older recycling operations tin was removed by chlorine gas, but this process has so many potential health risks it should not be used because an uncontrolled accidental release or addition of chlorine may release the poisonous gas into the workplace or the environment.;

(e)

(e) Plastic recycling

227. The/disposal of plastic wastes is covered under the Basel Convention technical guidelines on the environmentally sound management of plastic wastes[74]. Plastic wastes containing or contaminated with heavy metals covered under Y31, may possess the hazardous characteristics H6.1, H11, H12 and/or H13. If plastic from WLAB is intended to be recycled, special precautions regarding the use of the recyclate should be taken in order to avoid human exposure (e.g. use as new battery cases). A brief summary of the steps involved at battery recycling facilities is summarised below. More detailed information can be obtained from the ESM of plastic wastes technical guidance.

228. Polypropylene (PP) plastic and acrylonitrile butadiene styrene (ABS) battery case can both be readily separated and collected during the hydro separation stage after the breaker. The polypropylene plastic wastes are a valuable product for automobiles, plastic pipe, drainage and other uses. It represents a good financial income for the recycler. Either the recycling plant will have a PP chip line, or it will need to be sent off site for recycling. The recycling process of involves several phases, which include:

(a) Collection: the plastic chips are generally collected in hoppers or on the floor during the separation of the various waste streams via a mechanical belt sorter. At this stage the PP chip will still be contaminated with residual lead and lead oxide and care is therefore needed during its handling. If the PP chip is going off site it will need to be analysed for contamination levels and be washed to remove the lead residues prior to being dispatched to a recycler. It should not be sold unwashed unless the purchaser can comply with environmentally sound management practices to safeguard environment and health. Further details on the separation process are described in paragraphs (161 and 166);

(b) Cleaning: further cleaning of the PP on site should be carried out before shredding and compounding. Strict quality assurance should be applied to ensure the PP chips are free of lead

[74] http://www.basel.int/Implementation/Plasticwaste/Technicalguidelines/Overview/tabid/7992/Default.aspx.

contamination. Although the process waters from the washing cycles can be reused the final wash should be in clean water;

(c) Shredding: once the plastics have been cleaned, they can be shredded and dried prior to compounding;

(d) Compounding: the final phase is compounding where the plastic is recombined using an extruder, which melts down particles at a high temp, creating plastic pellets. These, pellets canbe readily used by manufacturers to make new lead-acid battery cases or car components.

229.

230.

231.

H. Pollution controls

232. The control of emissions from a recycling plant is an essential operation to minimise the impact on the environment and human health. The permit for a licensed WLAB recycling plant will specify the types of pollution controls to be employed and the amount of monitoring to be undertaken to demonstrate compliance. The cost of pollution control and the treatment of effluents and dusts, and the containment of sulphur dioxide emissions can be in excess of 30% of the investment costs and operating costs when occupational health provisions are included. Guidance on the pollution control technologies that can be employed are contained for example in the EU BAT Reference Notes (Best Available Technology)[75] which cover the lead industry. In addition, the Commission for Environmental Cooperation has developed technical guidelines on the environmentally sound management of WLAB plants in North America.[76] Other countries have their own guidance on pollution control technology. The potential pollution sources that need to be controlled include the following:

(1) Acid electrolyte and process effluents;

(2) Dusts;

(3) Fugitive emissions;

(4) Sulphur dioxide;

(5) Slags;

(6) Unrecoverable wastes (deposits containing heavy metals).

1. Acid and process effluents

233. There are several operations around a recycling plant than can generate effluents. The direct discharge of untreated acid, process effluents, pollution control effluents, and rainwater into the environment without treatment would result in an adverse environmental impact and have significant harmful health implications for local communities and is to be avoided. The sources of process effluents are shown together with typical treatment options/uses in Table 4 below:

Table 4: Potential effluent sources and treatment techniques

Process unit	Operation/source	Use/treatment options
General	Rainwater from roads, yards, roofs, wet cleaning of roads, cleaning of lorries, etc.	Wastewater treatment plant then reuse or recirculation
Battery separation	Process liquor	Used in the desulphurisation process/wastewater treatment plant

[75] https://eippcb.jrc.ec.europa.eu/reference/non-ferrous-metals-industries-0.

[76] http://www.cec.org/publications/environmentally-sound-management-of-spent-lead-acid-batteries-in-north-america/

Process unit	Operation/source	Use/treatment options
Paste desulphurisation	Process liquor	Used in the desulphurisation process/wastewater treatment plant
Smelting and melting operation	Cooling water from furnace, machinery and equipment	Recirculation
Slag granulation	Wet ESP effluent. Granulation water	Recirculation, wastewater treatment plant. Recirculation
Gas-cleaning system	Condensate from gas cooling and wet ESP. Condensate from mercury removal	Removal of suspended dusts and reuse as raw material, wastewater treatment plant. After mercury removal, to wastewater treatment plant. Recirculation
Sulphuric acid	Battery breaking	Neutralisation and discharge via wastewater treatment plant Collection and reuse Gypsum production
Feed storage	Surface water (rain/wetting)	Wastewater treatment plant
Sinter plant	Scrubber (sinter fine cooling)	Wastewater treatment plant
All process units	Maintenance	Wastewater treatment plant
Wastewater treatment plant	nt treatment	Reuse for certain applications/discharge

234. The electrolyte can be collected and processed to produce lead-free acid, which can be re-used as battery electrolyte or sold as dilute sulphuric acid.

235. The electrolyte may be treated with sodium carbonate or calcium carbonate, to produce sodium sulphate or gypsum which can be further purified and sold to the cement industry as an additive, or the building trade for use in wall boarding. A number of lead recycling plants utilize this approach.

236. The direct discharge of neutralized electrolyte into soils, water sources, rivers, lakes and so on, should be avoided. All lead recycling plants should be contained and have an effluent containment lagoon together with some form of treatment unit to treat the effluent. Any wastewater discharged from the recycling facility, including effluent neutralization, rainwater, spilled electrolyte, cleaning water, etc., should be captured, contained, tested (e.g. pH, lead and other metals, sulphates), and treated prior to discharge to protect and maintain the quality of water resources including impact to soils. Modern operations should be designed or modified such that there is a closed loop for the containment of effluent. Treated effluent can be used as a coolant in the casting process or for damping down dusty areas to control fugitive emissions. For example, in the European Commission Implementing Decision 2016/1032 of 13 June 2016 establishing BAT conclusions for the non-ferrous

metals industries (e.g. lead) under Directive 2010/75/EU are BAT-associated techniques and emission levels.[77]

237.

2. Dust collection and air filtration

238. At most of the stages of operation the plant will release fume or dust which is hazardous to health. This should therefore be captured and collected and either returned to the plant or treated before the process gases are released to the environment. On average a recycling plant has to filter around seventy tonnes of air for each tonne of produced lead, it is evident that this is an important process to monitor and control. According to the EU BAT Reference Document for the Non-Ferrous Metals Industries achievable emission values for dust are <4 mg/m3. In order to achieve these values, it is important regular maintenance is carried out on the pollution abatement equipment.

239. The so-called "mechanical" dust, i.e., particulate material with large physical characteristics, is relatively easy to filter and remove from the process gases and the hygiene air. However, the finer the dust, formed as fume condenses, is more difficult to remove and special techniques should be employed to clean the gases and the hygiene air prior to release. There are a wide range of options available and the choice of the most suitable has to be judged as a function of meeting the legal requirements regarding air emissions and the expected contamination levels and the budget. There is a choice of fabric or bag filters, electrostatic precipitators, wet electrostatic precipitators, cyclones, ceramic filters, or a combination of two or three capture strategies, and whether a wet scrubber is needed as the final clean up and capture phase just prior to the release to atmosphere. Where possible all collected dusts should be redirected toward the smelting plant to recover lead. Collection of the baghouse or filter plant dusts should be into sealed bags or drums that can be charged directly to the furnace to minimise the risk of dust escaping into the operating areas.

3. Fugitive emissions

240. Fugitive emissions represent one of the largest sources of lead contamination from a WLAB recycling facility. These are emissions that are not captured before discharge or escape to the atmosphere. There are several sources resulting from material handling, vehicles, wind erosion from storage piles, and other uncontrolled sources. There are also sources from the "red" hot molten lead as it is drained from an unventilated smelting furnace caused by the high vapour pressure of lead and its compounds at about 1000oC. Fugitive emissions can be generated if lead furnace bullion is transferred in an open ladle or "pot" at about 1,000ºC and poured into an unventilated refining kettle, and later during processing if the dusty drosses are skimmed manually without extraction or local ventilation. There are various ways to control fugitive emissions these include building and equipment enclosures, housekeeping, extraction systems, ventilation systems, and negative pressure systems.

241. . Enclosing areas where fugitive emissions may originate is considered best practice. Production (e.g. battery breaker, furnace, refinery and casting) and storage areas should be enclosed to minimize the release of fugitive emissions into the environment with measures in place to control air exchanges such as doors, door curtains or air extraction systems with fabric filters/baghouses to create negative pressure in the building. Where storage areas are lacking enclosures, measures should be adopted to include maintaining low-level moisture in raw materials, use of air misting systems to suppress dust and covering batteries to prevent dust particles becoming airborne.

242. Regular housekeeping practices are important in controlling fugitive emissions. Such measures include but are not limited to wet-washing, use of vacuum cleaners with HEPA filters, immediate cleaning of spills, cleaning maintenance equipment in enclosed areas with air extraction, cleaning equipment before working on it. Moving lead bearing material in enclosed containers for transport to prevent spillage or dust formation.

243. Cleaning paved surfaces is important as lead bearing dust will settle on them. These should be regularly cleaned at least twice per day using machine vacuum sweepers (hand, ride-on, or driven) to collect the dust. The use of mist sprays for roadways is another option in areas of good water supply to suppress dust. Unpaved areas should be seeded to capture and minimize wind-blown dust.

244. Managing the movement of materials and feedstock and handling is important to prevent the generation of fugitives. In addition, the mixing of wet feedstock with dry also helps to minimise dust being released during handling and movement.

245. The use of local exhaust ventilation systems is important to capture dusts and fumes and minimise the release of fugitive emissions. It is important that there are effective management systems

[77] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32010L0075

in place to monitor extraction systems to ensure they are operating properly and to detect operating failures (e.g. pressure drop, air velocity changes) that could cause fugitive emissions to be released.

246. There are two main ways of controlling fugitive emissions from molten lead source:

247.(a) Controlled extraction ventilated charging and tapping of the furnace feed and lead bullion. The lead bullion can be either cast into a 1,2 or 4 tonne mould and then allowed to solidify under a ventilation hood. Only when the lead block has solidified will it be moved to the refining kettle and then gently melted into a liquid bath of molten lead. Any dross produced should be removed in a procedure that ventilates the working area and extracts and contains any dust produced in a baghouse filter system;

248.(b) Tapping the red-hot molten lead from the furnace through a ventilated refractory launder into a bath of molten lead in a ventilated kettle, where the lead bath is about twenty degrees above the freezing point of lead and well below the temperature that can produce fugitive emissions. The bath of molten lead should be covered and ventilated so that any emissions would be removed to the baghouse. As the refining kettle containing the bath of molten lead fills, the lead may be pumped to another kettle to start the refining process.

4. Sulphur dioxide control

249. Sulphur dioxide emissions are formed from the presence of sulphates in the furnace feed from, for example, the electrolyte. Many countries have very tight sulphur dioxide (SO2) emissions which is an important pollutant to control due to its adverse environmental impacts including contribution to acid rain. Its elimination by desulphurisation can be carried out before, during, or after smelting. For example, the European Commission Implementing Decision 2016/1032 establishing BAT conclusions for the non-ferrous metals industries (European Commission, 2016) sets BAT-associated emission levels for SO2 emissions stipulates < 350 mg/m3 for recycling plants.

249 bis Desulphurization prior to smelting involves the removal of the sulphurous compounds via an aqueous reaction with either sodium carbonate or sodium hydroxide. The battery paste is mixed in a reactor with either compound, although carbonate is the common method due to costs. The lead carbonate product is sent to the smelter, but the sodium sulphate (a highly soluble product) requires a separate complex crystallizer or vaporizer plant, to recover a saleable product. The soluble sodium sulphate product should not be disposed from a smelter in the water courses.

250. During smelting desulphurisation can be carried out using iron and sulphur which have a great affinity for each other and will form FeS, (ferrous sulphide) in the furnace. Therefore, iron should be added to the furnace charge material along with a carbon in a metallurgical balance during smelting. The lead sulphate is reduced to lead sulphide and the iron combines with the sulphur, along with sodium, to form sodium lead sulphide called ‘Erdite’ and it reports to the slag. Iron/steel drums used for collecting baghouse dust can be sealed and charged to the rotary furnace. This has a dual advantage: the lead-containing baghouse dust re- mains enclosed throughout the handling processes and the iron of the steel drum acts as a sulphur binding/capturing agent during the smelting process. Feeding lead-containing residues such as baghouse dust back into the furnace is a crucial measure to recycle hazardous process by-product.

251. After smelting desulphurization (Fig 9) can be carried out by dry, semi-dry, semi-wet and wet processes, and a simple alternative is the use of wet scrubbers with calcium carbonate (CaCO3) solution as reagent, which produces gypsum (calcium sulphate). Scrubbers are increasingly being employed to remove the final traces of sulphur dioxide after filtration, other techniques and technologies may emerge as an alternative control.

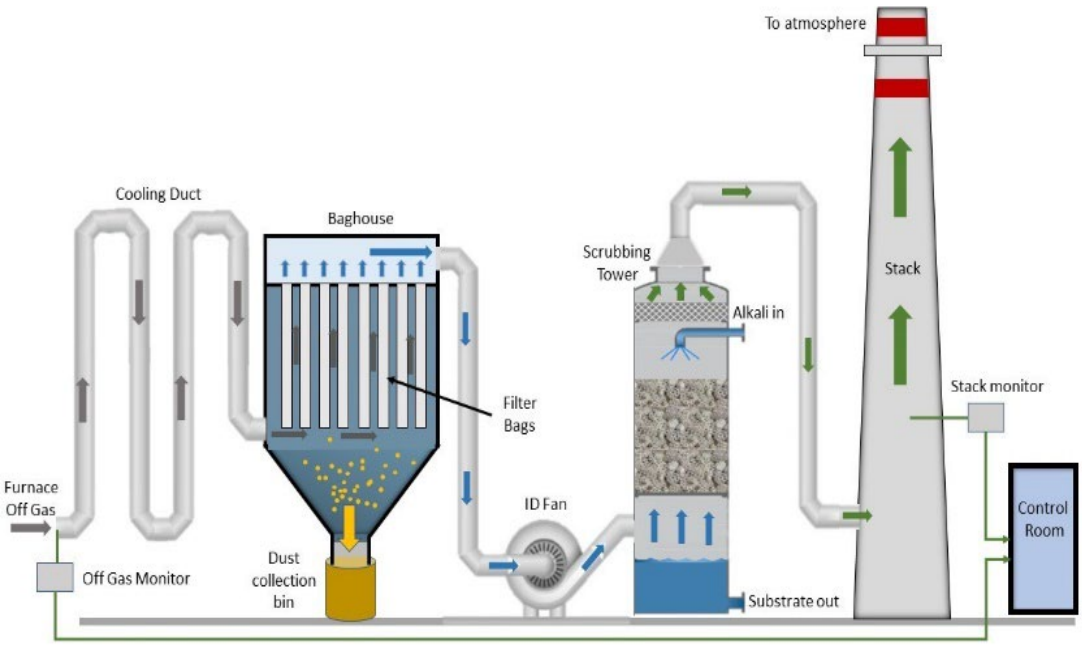


Figure 5: Flue gas desulphurisation

4. Slag wastes

251 bis Slags are a major hazardous waste formed during the battery recycling process and it amounts to 13%-25% of the weight of lead produced. The method of dealing with slag wastes depends on the leachability of the metals and other elements they contain, and this is determined by the fluxes used and the operating conditions.

Adding lime, calcium carbonate (CaCO3), to the furnace produces a non-leachable slag, which is a more environmentally sound furnace waste. It increases the temperature of the furnace and produces more sulphur dioxide, resulting in higher energy costs and affecting the life of the refractories. Lime is much easier to deal with than sodium carbonate (Na2CO3) which produces a leachable slag. The use of lime needs to be undertaken following set procedures to avoid any safety issues in the operation of the furnace.

251 ter Sodium slag does not have any use due to its physical and chemical properties, and, therefore, should be disposed of as a hazardous waste in an engineered landfill for hazardous wastes.

251 quarter Research suggests[78] calcium slags produced from calcium fluxes are stable and can potentially be used as a raw material, as a partial aggregate replacement in cement to produce concrete for, road building, blocks, etc.,

251 quinquies The ability to be able to use slags rather than disposing of them, depends on its leachability, metal levels and potential environmental and health impacts. Where this is not currently possible the slags should be disposed of. at specially engineered hazardous waste landfills (see technical guidelines on specially engineered landfills that have been developed by UNEP Basel Convention[79]).

5. Unrecoverable wastes management

251 sexies The generation of some wastes which cannot be recycled or reused, are produced during the recovery process and, therefore, they will need an environmentally sound destination for disposal. Tests should be carried out to determine if they can be disposed of as a non-hazardous waste or whether the lead and other constituents render the waste to be treated as hazardous that requires it to

[78] https://www.researchgate.net/publication/266573719_Possibility_of_secondary_lead_slag_stabilization_in_concrete_with_presence_of_selected_additives

[79] http://synergies.pops.int/Portals/4/download.aspx?d=UNEP-CHW-WAST-GUID-SpeciallyEngineeredLandfill.English.pdf. http://synergies.pops.int/Portals/4/download.aspx?d=UNEP-CHW-WAST-GUID-SpeciallyEngineeredLandfill.English.pdf.

be disposed of in specially engineered hazardous waste landfills (see BC Technical Guidance D5 Specially Engineered Landfill) where contaminants cannot leach into the groundwater/soil.

251 septies Some of the unrecoverable wastes, such as separators, pallets and packing materials may be put through the furnaces should it be appropriate and meets sound environmental management practices or incinerated (see BC Technical Guidance D10[80]).

251 novies Other waste generated such as contaminated clothing, masks, gloves, cleaning and maintenance materials should be disposed of as hazardous waste unless they can be put through the furnace.

252. Redundant equipment wastes that may be generated from the recycling process is likely to be contaminated with lead and should be tested to assess lead levels and suitable environmentally sound disposal routes.

6. Use of oxygen

253. Oxygen (O2) is used to enrich the combustion fuel used in the furnace processes with the following consequences:

(a) Since air has a big percentage of nitrogen [N_2, ~72% (v/v)] which does not participate in any chemical reaction at normal temperatures, the addition of pure oxygen (O_2) decreases dramatically the amount of combustion off-gas formation (by around five times);

(b) Decrease heat loss, since less cold gas is flowing through the furnace;

(c) Increase furnace production because cycle times are reduced;

(d) Reduces the ventilation requirements to capture the off-gasses and so reduces the energy consumption required to power the baghouse.

254. Using pure oxygen to enrich the air supply to the furnace burners provides a much cleaner production process and is more energy efficient. Excess oxygen for combustion may not always be the best approach.

7. Environmental monitoring

255. Environmental monitoring of the operations is essential to be confirm compliance with the permit and applicable regulations (e.g CEC ESM Guidelines for SLAB 2016, EC BAT Reference for the Non-ferrous Metals Industries 2016). It can be regarded as an environmental contamination thermometer. The data collected can be used to measure performance and detect equipment failures when connected to an alarm system. It can also be used as a source of credibility and trust in the relationship with the regulatory authorities and local community since lead recycling plants are usually regarded as a source of environmental contamination and population lead exposure.

256. Each plant should use recognized monitoring equipment and techniques for checking effluents and wastewater discharges, air emissions, air quality and soil, vegetation, and groundwater.

257. Wastewater/effluents: Wastewater from scrubbers, electrostatic precipitators, plant cleaning wastewater, battery breaking, slag granulation and rainwater runoff should all be directed to the effluent treatment plant for discharge and monitoring. Following treatment at an effluent treatment plant, any effluent, including surface water, leaving the plant should be monitored at a minimum for pH, lead content (dissolved and suspended), other representative heavy metals (As, Hg, and Cd) and sulphates, BOD, COD. Where possible automatic sampling and monitoring should be undertaken and where appropriate connected to an alarm system to alert personnel in the event of plant failure.

258.

259.

260. Air emissions: Emissions from plant processes and hygiene air should be directed to pollution abatement plant and monitored via the stack. Diffuse emissions from around the plant will require monitoring and a number of measures and techniques are available. Continuous or regular monitoring of the furnace off-gases for sulphur dioxide (SO2), NOx, metals (lead, cadmium), dust and VOCs and PCDD/F. Stack emissions should be monitored on a continuous basis and there should be an alarm to alert personnel in the event of plant failure (e.g., split bags in the baghouse). In addition, boundary

[80] https://www.basel.int/Implementation/TechnicalMatters/DevelopmentofTechnicalGuidelines/TechnicalGuidelines/tabid/8025/Default.aspx

lead in air monitoring should be performed at several locations around the plant to measure airborne particulates (lead).

261. Dioxins and furans (persistent organic pollutants – PCDD/PCDF) are aromatic organic compounds formed by relatively low temperature thermal reactions together with the presence of chlorine and is a carcinogen and are subject to the provisions of the Stockholm Convention on POPs (2019)[81]. Secondary raw materials containing chlorine together with the furnace environment may provide good dioxin formation conditions, particularly when the furnace is being charged. Also, the use of carbon reducing agents and fuels may produce a fine carbon powder that, under specific conditions, may react with chlorine derivatives and produce toxic compounds. Also, the presence of copper and iron, both commonly found in lead recycling processes, seems to catalyse dioxin and furan formation. Further information of secondary lead smelters can be found in Guidelines on BATBET Part II adopted under the Stockholm Convention (updated 2019/2021) and TG on ESM of wastes containing or contaminated with unintentionally produced PCDD, PCDF, hexachlorobenzene, PCBs, pentachlorobenzene or polychlorinated napthalenes (Unintentionally produced POPs), adopted under Basel Convention in BC-13/4.

262. PVC separators are no longer used in battery manufacturing so that risk of dioxin formation is greatly reduced. But with iron and copper being in the feedstock it is not totally eliminated. Oxygen enriched air or pure oxygen can be used to ensure complete combustion of organic compounds to reduce the risk of dioxin formation. Activated carbon can also be injected into the gas stream to absorb the organic molecules and, afterwards, be filtered. The filtered dust is a hazardous waste and should not be put in the furnace but disposed of by high temperature incineration.

263. Maintaining complete high temperature combustion of all furnaces is an effective means of control. Monitoring stack emissions is important for checking and ensuring emission levels of PCDD/F are 0.1 ng I-TEQ/Nm3.

264. Air quality: regular monitoring of the air quality inside the enclosed buildings and control cabins/offices, battery breaker, furnace, and refinery to monitor compliance with lead in air limits within the work areas for occupational exposure.

265. Soil, vegetation, and groundwater: periodic monitoring of soils, vegetation and groundwater should be performed to establish whether the operations are impacting the environment and whether any action needs to be taken.

I. Management of contaminated sites

1. Identification, investigation and assessment

266. Soil is classed as contaminated where substances are causing or could cause significant harm to people, property or protected species or significant pollution of surface waters (for example lakes and rivers) or groundwater. A number of countries have established levels of contaminants present in soils which if exceeded result in them being classified as contaminated (para 267).

267. Sites where lead-acid batteries have been manufactured, collected, broken and/or recycled would fall into this category especially if the ground was unprotected. A site assessment and site investigation would need to be carried out to determine whether the soil and groundwater is contaminated, what contaminants are present and their levels to assess what further action, if any, needs to be undertaken.

268. The site assessment should establish what operations occurred on the site, a location plan of the operations and possible areas of concern (e.g.,WLAB storage area, slag storage, waste disposal area, etc.). This would form the basis of determining where to carry out any intrusive soil and groundwater investigations.

269. Following the site assessment, a soil and groundwater investigation may need to be carried out based on the information from the site assessment. The results from the site investigation would then determine whether more detailed investigations would be needed and where they are required. The results from this would establish the nature and extent of any soil and groundwater contamination. In the event of groundwater contamination there would be a need to evaluate hydrogeological impact of this on aquifers and surface water, especially if there is evidence of contaminants migrating off site. This information is then consolidated into a conceptual site model that clearly identifies any potential exposure pathways to receptors.

[81] https://www.pops.int/

270. A risk assessment should then be prepared setting out the nature and extent of contamination, the risks it may pose, the exposure pathways and identification of receptors.The risks identified can be assessed to establish whether they can be satisfactorily reduced to an acceptable level. Land use screening levels can be used in providing a simple test for deciding when land is suitable for use and help to decide what the soil can be used for, for example, industrial, commercial, housing, or agriculture based on the level of contamination and the risks it presents. Soil reference values have been developed (e.g. California[82], UK, Netherland[83]) to assess contamination levels and acceptable use values.

271. Following these stages an environmental impact assessment report should be produced setting out the former use of the site, what activities took place, areas of concern, a description of the contamination, a description of the likely effects and impacts both on and off-site, description of what the soil can be used for, description of the works, if any, needed to rectify the impact. This information can then be used to set the basis for the use of the site and providing the authorities and community with the relevant information and an action plan for addressing the issues identified.

2. WLAB site decommissioning

272. The process for closure and decommissioning of a WLAB site broadly falls into five distinct phases:

(a) Phase 1 is initial information gathering, due diligence, identification of the key stakeholders and understanding the legal and contractual obligations that may be in place;

(b) Phase 2 involves agreeing the necessary studies, including contaminated site assessment and hazardous wastes inventory, that need to be carried out to categorise the environmental status of the site in liaison with the authorities and (if applicable) the landowner and gaining an understanding of the level of clean-up that is required and obtaining approval from the authorities regarding soil/groundwater clean-up levels;

(c) Phase 3 involves carrying out any further investigations, characterising the site and finalising any requirements for remediation with the authorities. Also included in this phase are the negotiation and finalisation of the contracts;

(d) Phase 4 is the actual carrying out of the works and the supervision of them, this includes decontamination and demolition of buildings and equipment, management and disposal of materials generated during decommissioning, dust control and monitoring, site clean-up and soil/groundwater remediation) ;

(e) Phase 5 is the verification that those works have been carried out to the satisfaction of all stakeholders and finalising surrender and exit.

273. During the decommissioning works it is important that they are carried out in a way that minimises the environmental, health and safety impacts on the workers, local community and the environment. This may require extensive monitoring to ensure remedial activities are not releasing harmful levels of lead and other contaminants.

J. Health & Safety

1. General considerations

274. Lead is a naturally occurring and abundant toxic element in the environment (WHO). Its widespread use has resulted in environmental contamination, and significant human health concerns around the world. WHO has made available through its website a range of information on lead, including information for policy makers, technical guidance, training material, guidelines on clinical management of lead exposure.

275. Natural mobilization from weathering, erosion and mobilisation of mineral deposits and gaseous emissions, such as volcanic eruptions, release lead in the environment. However, this represents a minor source in comparison to anthropogenic sources.

275 bis Human activities release lead much more intensely, The lead released into the environment arises from domestic, industrial and transport activities and include burning fossil fuels, leaded aviation fuel, plastics, munitions, steel and industrial processes (e.g. mining and metals processing,

[82] California EPA, https://oehha.ca.gov/risk-assessment/sites

[83] https://www.pbl.nl/sites/default/files/downloads/711701023.pdf

electronic waste, waste incinerators, and the lead industry). Industrial releases account for the largest amount.

275 ter Lead is also used in many products, for example pigments, paints, solder, stained glass, crystal glassware, ammunition, ceramic glazes, jewellery, toys, some traditional cosmetics such as kohl and indoor, and some traditional medicine such as in India, Mexico and Vietnam. It has also been found as a contaminant in spices such as turmeric.

275 quarter WLAB recyclers and in particular the informal sector in LMICs, are a significant source and magnifier of the lead if the appropriate occupational and environmental controls are not implemented. It is important that both workplace controls and emissions controls are implemented to reduce the risks to human health and the environment from waste lead-acid battery recycling.

275 quinquies Lead does not degrade in the environment, although it can exist in various chemical forms. Particulate matter containing lead can be transported through air, water, and soil. In general, atmospheric deposition is the largest source of lead found in soils not impacted by other local non-air sources (e.g., dust from deteriorating leaded paint). Lead is transferred continuously between air, water, and soil by natural chemical and physical processes such as weathering, runoff, precipitation, dry deposition of dust, and stream/river flow; however, soil and sediments appear to be important sinks for lead.

276. Lead in air can enter the human body in a number of ways as shown in the following diagram (Fig 10).

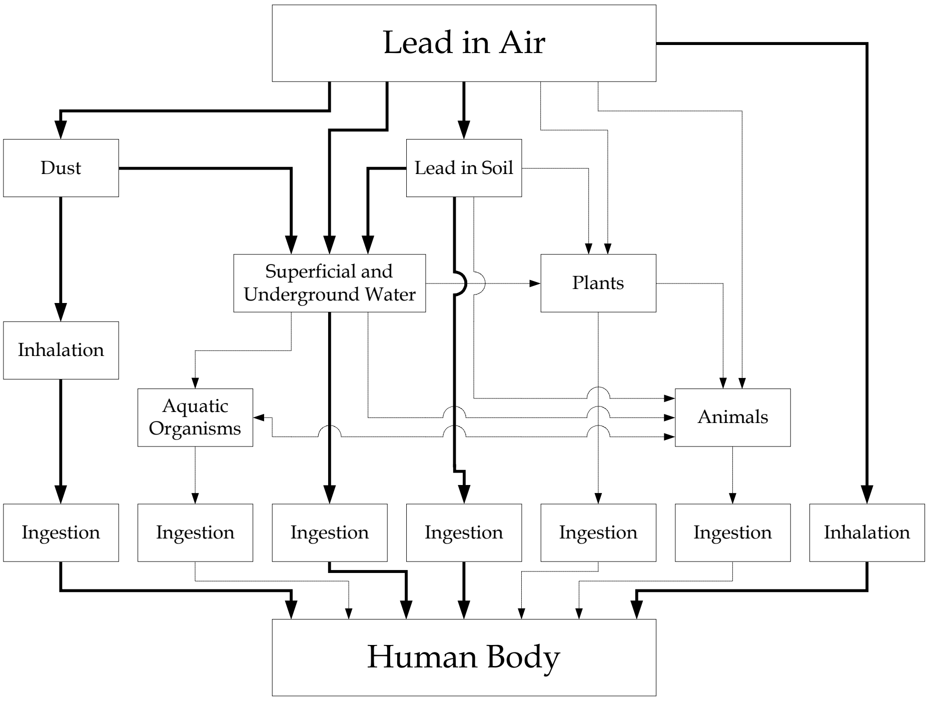


Figure 10: sources of lead into body

277. The most common internal dose metric for lead is the concentration of lead in blood (PbB, typically expressed in terms of µg/dl)). Blood lead concentrations reflect both ongoing exposure and lead stores in bone, which can be transferred to blood.

278. Human exposure to lead is universal and everyone carries a body burden of lead depending on where they live with mean background levels. In the USA general population levels are now<1µg/dl (USA). In data obtained for low middle income countries (LMICs) by a USAID funded study (The Lancet)[84]Illustrates that there is a considerable variation in average adult blood leads ranging from 0.4µg/dl (Sudan) to 11.4 µg/dl (Pakistan). Background mean values for lead level data in children ranged from 1.7µg/dl (Ethiopia) to 9.3µg/dl (Palestine). It was estimated, from pooled data for 34 LMICs, that 630 million children out of a population of 1.3 billion had a level that exceeded 5µg/dl.

[84] https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(20)30278-3/fulltext

278 bis A recent World Bank Study has estimated global cost of lead exposure was US$6·0 trillion (range 2·6–9·0) in 2019, which was equivalent to 6·9% (3·1–10·4) of the global gross domestic product, placing lead exposure as fourth among major environmental health risk factors after ambient particulate matter air pollution, household air pollution from solid fuels, and unsafe household drinking water, sanitation, and handwashing according to the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019.

278 ter Sources of lead exposure, reported in the USAID study, included the informal WLAB recycling and manufacture, metals mining and processing, electronic waste, use of lead as a food adulterant (primarily spices) and for one country lead based pottery glazes were found to be significant.

279. The primary routes of exposure in the body are by inhalation and ingestion (WHO)[85] The site of uptake depends on the size of the particle and the type of lead compound (organic or inorganic), together with the concentration and possible diffusion of the metal throughout the body. Gastrointestinal absorption of lead depends on age (child vs adult), fasting, the presence of nutritional elements (e.g. Calcium, phosphorus, copper, zinc, iron status, intake of fat and other calories), physiochemical characteristics of the medium ingested, including particle size, mineral species, solubility and lead. There is a much higher rate of absorption in those fasting compared to those who are not. Infants and children have far higher rates of absorption compared to adults and can be 40-50% of ingested lead. Pregnant women also have much higher rates of absorption too. A general schematic of the lead distribution may be seen in figure 11.

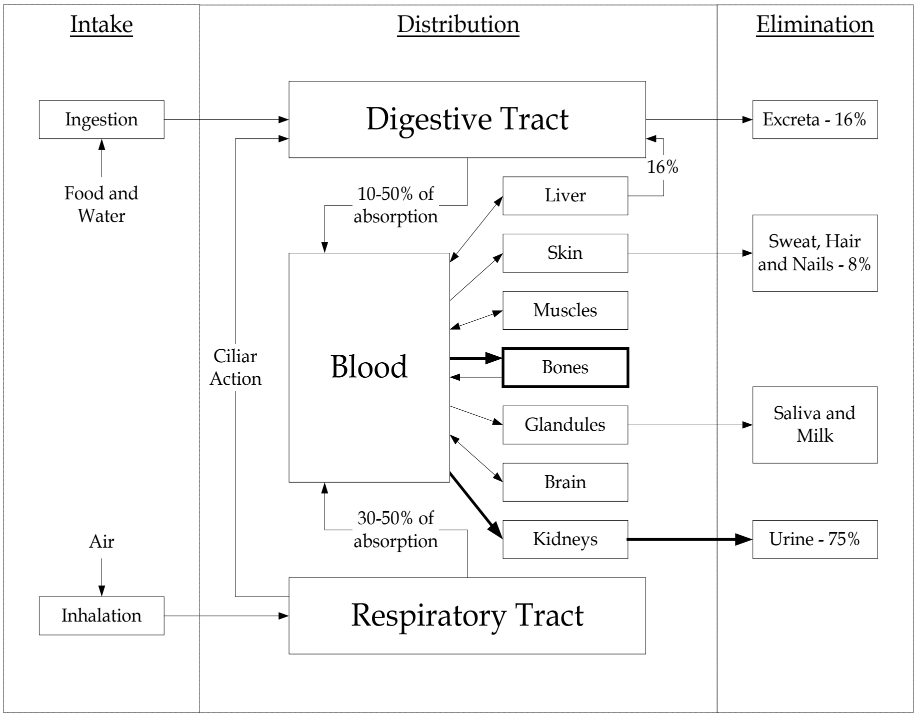


Figure 11: Sources of human exposure to lead

280. In the industrial environment inhalation and ingestion are also the main route of lead uptake if there are inadequate industrial controls (e.g. local exhaust ventilation) and/or if the hygiene control protocols are not followed such as appropriate use of respiratory protection equipment gloves and poor personal hygiene and hand to mouth exposure. Around 20-40% of lead that enters the respiratory tract remains in the body, and a major part of it is directed from the respiratory tract to the stomach by ciliary means. The amount that remains inside the lungs is rapidly absorbed by a process that is independent of the chemical species of lead involved

[85] https://www.who.int/publications/i/item/9789241512855

281. Absorption of lead through the skin is considered negligible except for organic forms of lead. However, lead on the skin can easily be transferred from hand to mouth, for example that can lead to absorption via the gastro-intestinal tract.

282. Gastrointestinal absorption, which is the main non-industrial intake route and concern for young children, can also play a significant role in occupational settings through hand to mouth transfer, e.g. smoking and eating with dirty hands. Approximately 20% of the total lead ingested may be absorbed by adults after a meal and up to 60%-80% on an empty stomach (ATSDR 2010)[86]. It is for this reason that good personal hygiene is an important factor in managing employee blood leads.

283. Children absorb more lead than adults and some data shows that the absorption following ingestion may be as high as 50%, i.e. five times greater than that seen in adults. It is for this reason there is a need to ensure that all exposures to lead are prevented.

284. The absorbed lead is transported to the blood stream where, it is delivered to all organs, especially bones which may retain around 90% of the body's lead content. Therefore, while the blood lead concentration reflects recent exposure, bone lead concentration better reflects longer- term exposure. There is no standardised protocol and technology to measure bone lead, except in a research setting.

285. Urine is the primary route of excretion. Ingested lead is mainly passes through the faeces, reflecting the poor gastrointestinal absorption rate. Lead absorbed by the body and incorporated into the blood stream is eliminated by urine (75% - 80%), gastrointestinal secretions through the liver (16%) and hairs, nails and sweat (8%).

286. Breast feeding women also pass lead through their milk. This may be a significant source of lead in infants of women with high lead exposure and is a significant reason to ensure that women of childbearing age are protected from lead exposure. Lead also crosses the placenta and poses a risk to the foetus. Therefore, it is important that occupational standards are protective of women of childbearing age.

287. The half-life of lead in the body varies according to the tissue. It is almost impossible to determine its elimination rate, since the bones may have a large quantity ready to mobilize into the blood stream. Nevertheless, some half-lives are known for blood and soft tissues (30-40 days) and bones (in excess of 20 years). This means that individuals with little or no current lead exposure may still have relatively high blood lead levels for many months or even years after exposure has ceased due to the release of lead from the bone into the blood.

(a) Toxicity & health effects

287 bis Lead has no physiological role in the body, and no level of exposure has been identified that does not have a deleterious effect.

288. There is a vast database on the toxic effects of lead on human health. and these are summarised in a recent ATSDR toxicological profile (ATSDR, 2020)[87] Lead has been shown to have diverse biological impacts in humans involving cardiovascular & coronary heart disease, neurological, gastrointestinal, renal, haemopoietic, and adverse reproductive effects., There is also limited evidence of genotoxic and carcinogenic effects.

288 bis For the most studied endpoints (neurological, renal, cardiovascular, haematological, immunological, reproductive, and developmental), effects have been found at the lowest PbBs studied (≤5 µg/dl).

289. The toxicity of lead is thought to be due to the lead cation and most studies relate to the amount of absorbed lead and its effects. The toxic mechanism of lead poisoning may be by:

(a) Competing with other essential metabolic metals such calcium and zinc;

(b) Its strong affinity by sulfhydryl (-SH) groups in proteins, which means that several proteins may be chemically changed and become dysfunctional and reflecting badly in several metabolic paths;

(c) Altering the transport of essential ions throughout the body.

290.

[86] https://www.atsdr.cdc.gov/csem/leadtoxicity/biologic_fate.html

[87] https://wwwn.cdc.gov/TSP/ToxProfiles/ToxProfiles.aspx?id=96&tid=22

291. Lead exposure to women of childbearing age is of particular concern and they should be considered as a sensitive sub-population due to the impacts on the health and wellbeing of their unborn child. Lead induced toxicity to the foetus via maternal exposures,for example, can take the form of adverse effects on neurological development.

292. Children are most highly sensitive to lead and at risk due to the fact that they are physically and mentally developing. They are particularly vulnerable to the neurotoxic effects of lead and even low levels of exposure can have significant and, in some cases, irreversible neurological damage. Even at low levels that were once considered safe there are risks to changes in hearing and cognitive development, behaviour (hyperactivity, depression and anxiety) and health. Many children exposed to lead have no obvious symptoms and there are considered to be no safe blood lead levels for them (WHO) (CDC)[88].

293. . The WHO[89] has estimated that lead may be responsible for 30% of the global burden of idiopathic intellectual disability, 4.6% of the global burden of cardiovascular disease and 3% of the global burden of chronic kidney diseases. There is limited evidence that lead compounds may present a carcinogenic risk.

2. Public health management

293 bis Background blood leads for an average adult depend on a range of factors such as age, diet, whether they smoke, where they live and environmental background soil levels[90] . Blood lead levels for those living in areas where lead has been mined for example may be higher due to the presence of lead in the soils and vegetation. There is also a risk from use of lead paint, use of leaded cookware and earthen ware pottery and contaminated spices and other foodstuffs in some areas of the world that can give rise to elevated levels.

293 ter The effects of the greatest public health significance, i.e. adverse neurodevelopmental effects in children and cardiovascular disease in adults, are nonspecific and largely subclinical.

293 quarter Lead exposure is estimated to account for 21.7 million years lost to disability and death (disability-adjusted life years, or DALYs) worldwide due to long-term effects on health, including 30% of the global burden of idiopathic intellectual disability, 4.6% of the global burden of cardiovascular disease and 3% of the global burden of chronic kidney diseases.

293 quinquies Diagnosis of lead poisoning and treatment decisions are based on the history, clinical examination and the results of investigations, including the blood lead concentration, and biomarkers of effect such as in a full blood count. The venous blood lead concentration is the definitive biomarker of exposure and risk on which management decisions are routinely based. Information about the collection and analysis of blood samples for lead can be found in WHO[91] (2021) guidance.

293 sexies WHO (2021) recommends for the general population that in individuals with a blood lead ≥5µg/dl the source of the exposure should be identified, and the appropriate action taken to reduce or terminate the exposure. For children the U.S CDC recommends a blood lead reference value (BLRV) of 3.5µg/dl to be used as a guide to help determine whether medical or environmental follow-up are recommended and prioritize communities with the need for primary prevention of exposure.

293 septies When lead exposure has been confirmed, action should be taken as soon as possible to terminate or reduce the exposure. Chelation therapy is of limited value if exposure continues. As a life-saving measure, however, it may be necessary to chelate children who have severe clinical effects of lead poisoning and continue to be exposed.

293 octies Determination of blood lead levels may be required as part of a health risk assessment for a population at risk of being exposed to lead, such as villagers living in the vicinity of a WLAB recycling or lead processing factory. A portable ASV device (such as "Lead Care"), that does not require skilled laboratory personnel for its operation, can be used.

293 novies Lead exposure limits have been established in some regions for drinking water, ambient air and food (Table 5).

[88] https://www.cdc.gov/nceh/lead/overview.html

[89]https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(23)00166-3/fulltext

[90]https://www.who.int/publications/i/item/9789240037045

[90]https://www.who.int/publications/i/item/9789240037045

[91] See footnote above

Source	Blood Lead Limit
Drinking water	10µg/l [concentrations should be as low as reasonably practicable] (WHO, 2011) 297. 5µg/L (Health Canada 2017)
Food	Not possible to establish a PTWI (JECFA (2010)
Ambient Air	0.5 µg/m3- average annual concentration (EU, 2008) Australia (2016), China (2012) 0.15 µg/dl- three month average (USA, 2016)

Table 5 : Environmental lead exposure limits

3. Occupational exposure - air

294. Lead exposure can occur in many industries including; the mining and manufacturing if lead and lead compounds, battery production and recycling, scrap and waste processing, production of alloys and leaded articles (radiation shielding, ammunition etc), production of specialist glass and ceramics, recycling of waste electronic equipment, and in the demolition, repair and refurbishment of buildings.

295. 294 bis Establishing the appropriate control measures should be based on an assessment of risks and the controls needed to minimise them. Comparing occupational/biological exposure levels and limits will help identify the risk and the control measures needed to protect human health. Setting lead in air limits and monitoring compliance with lead in air limits can help reduce worker exposure by identifying high exposure levels and guide reduction efforts such as local exhaust ventilation. Lead in air limits should be used in combination with biological limits and regular blood lead measurements to identify the reasons for any elevated lead levels.

296. It is important to understand that lead exposure limits may continue to reduce and become more restrictive, as more information and identification of health issues at lower concentrations becomes available. These limits should be periodically reviewed as more data becomes available (e.g.

EU[92], OSHA[93], and California[94]) and reduced as evidence indicates adverse impacts at lower concentrations.

297. The occupational exposure limits shown here should be used as a guide to protect those directly exposed. It is important to understand that information from systematic biologic surveillance (i.e., blood lead measurements) are a better indication of lead exposure, through inhalation and ingestion.. Table 7 provides an overview of occupational lead exposure limits which are in the process of being revised by the EU and US authorities.

Table 7: Occupational Lead Exposure Limits[95, 96, 97]

Jurisdiction/standard setting body	Occupational Exposure Limit
US ACGIH TLV (2001), Safework Australia (2014), China-National Health Commission (2019)	50µg/m^3 (8hr TWA)
California (proposed)[98]	Permissible exposure limit PEL 10µg/m^3 (TWA)
EU[99]	30µg/m^3 (8hr TWA)

Table 7: Occupational Lead Exposure Limits[100, 101, 102]

298. The principle of most of the methods to monitor lead in air concentrations is by using a particle sampler (for inhalable fraction) to trap a sample. Lead compounds are then extracted into solution and further analysed using a suitable technique (e.g., atomic absorption). See Table 8 for further information.

Method	Analytical Technique	LOQ and sample volume/time	Reference
BGI 505-73-01 (inhalable)	GF-AAS Graphite furnace atomic absorption spectroscopy	0.13 µg/m3 for a 1200l sample (2 hours) Flow rate: 10 l/min	DFG, 2012
ISO 15202	ICP-AES (Inductively coupled plasma atomic emission spectroscopy)	17 µg/m3 for a 480 l sample (less than 1 hour)	ISO, 2012
MDHS 91-2 (inhalable)	XRFS (X-ray fluorescence spectrometry)	2 µg/m3 for a 480l sample (4 hours) Flow rate: 2 l/min	UK HSE
OSHA			
NIOSH 7082	Atomic Absorption Spectrophotometer, flame	0.05 to >1 mg/m3 for a 200l air sample	NIOSH

Table 8: Methods for lead and lead compounds in air

[92] https://ec.europa.eu/transparency/documents-register/detail?ref=COM(2023)71&lang=en
[93] https://www.osha.gov/sites/default/files/laws-regs/federalregister/2022-06-28.pdf
[94] https://www.dir.ca.gov/oshsb/Lead.html
[95] https://www.osha.gov/lead
[96] https://echa.europa.eu/oel
[97] https://www.safeworkaustralia.gov.au/safety-topic/managing-health-and-safety/exposure-standards-airborne-contaminants
[98] https://www.dir.ca.gov/oshsb/documents/Lead-proptxt.pdf
[99] https://ec.europa.eu/transparency/documents-register/detail?ref=SWD(2023)36&lang=en
[100] https://www.osha.gov/lead
[101] https://echa.europa.eu/oel
[102] https://www.safeworkaustralia.gov.au/safety-topic/managing-health-and-safety/exposure-standards-airborne-contaminants

(a) Occupational exposure - biological exposure limits (blood lead)

299. There is not strong relationship between the amount of lead the body absorbs and the concentration of lead-in-air. For that reason, use of biological exposure limits are advised. However, it is important that airborne lead limits are set and monitored.

300. Lead in blood (PbB) is the most prominent and best validated biomarker for establishing a biological value for assessing lead exposure. The parameter provides a high sensitivity for current lead exposure and depicts an intermediate observation time featured by an elimination half-time of about one month.

301. Biological limit values vary amongst regulators. Table 4 provides further information on health-based blood lead limits.

302. Table 9: Health based blood lead limits established by independent scientific bodies, excluding women of reproductive capacity.

Institution	Biological Limit Value	Comment
US ACGIH (2017)	20µg/dl	Considering various neurological and neurobehavioral effects and effects of reproduction can be seen down to 20µg/dl
Safe Work Australia (2014)	20-30µg/dl	After considering neurotoxicity, hypertension, reproductive toxicity and carcinogenicity
ECHA RAC opinion (2020)	15µg/dl	Considering neurotoxicity and genotoxicity concerns
Japan - Society for Occupational Health (2021)[103]	15µg/dl	N/A

303. Women of childbearing potential are a sensitive sub-population to the adverse effects of lead exposure and blood lead concentrations. Exposure of women, of childbearing age, to lead must be avoided in the workplace because the BLV for lead is not protective of their offspring. It is recommended that the blood lead of women of childbearing age employed in industries where lead exposure is possible do not exceed those of the general non-occupationally exposed population (<5µg/dl).Suspension or temporary removal from further exposure in the workplace to low lead exposure areas should be considered for those with blood lead concentrations above certain values. In many jurisdictions, suspension/removal from the workplace is mandated when an employees' blood lead level exceeds 30µg/dl and they are moved to low exposure areas with regular (e.g.monthly) blood lead monitoring until their level is reduced below the action level.

304.

[103] https://www.sanei.or.jp/english/files/topics/oels/OEL.pdf

(b) Environmental limits

305. The establishment of environmental and non-occupational exposure limits is recommended to protect human health in the general population but also flora and fauna, examples are shown in Table 10. As is the case with occupational exposure limits, these limits help define the risk management measures that should be adopted at a WLAB recycling plant.

306. People can become exposed to lead from environmental sources as a result of inhalation of lead particles generated by burning materials containing lead, for example, during smelting, recycling, stripping leaded paint, and using leaded gasoline or leaded aviation fuel; and ingestion of lead-contaminated dust, water, and food grown nearby.

307. Determination of blood lead levels may be required as part of a health risk assessment for a population at risk of being exposed to lead, such as villagers living in the vicinity of a WLAB recycling or lead processing factory. A portable ASV device (such as "LeadCare"), that does not require skilled laboratory personnel for its operation, can be used.

308. There is no known 'safe' blood lead concentration for the general population; even blood lead concentrations as <5 µg/dl, may impact children's intelligence and cause behavioural difficulties and learning problems.

309. Background blood leads for an average adult, ranges from <1µg/dl (USA) to <5µg/dl (Australia) depending on a range of factors such as age, diet, whether you smoke, where you live and environmental background levels. Blood lead levels for those living in areas where lead has been mined for example may be higher due to the presence of lead in the soils and vegetation. There is also a risk from use of leaded paint, leaded cookware and earthen ware pottery and contaminated spices and foodstuffs in some areas of the world that can give rise to elevated levels.

Source	Blood Lead Limit
General population blood levels of concern in children	USA, 3.5µg/dl (based upon 97.5% of population) (US CDC, 2012)
Potable Water	10µg/l (provisional) (WHO, 2011) Canada (Health Canada 2017) 5µg/l[104]
Food	Not possible to establish a PTWI (JECFA (2010)
Ambient Air	0.5 µg/m3- average annual concentration (EU, 2008) Australia (2016), China (2012) 0.15 µg/dl – 3 month average (US, 2016)

Table 10: Environmental lead exposure limits

310.

4. Prevention & control

311. The key to controlling employees and contractors' exposure to lead in the workplace is to ensure there is a comprehensive health and safety programme in place to protect the health of everyone and prevent the spread of contamination to others outside the workplace. Such a programme and measures include the following:

(a) There are effective engineering controls and maintenance/monitoring programmes in place to minimise and control the presence of lead contamination in the work area. Such controls include dust and fume extraction and abatement systems (e.g., mist sprays), and containment systems (e.g., hoods);

(b) There are established workplace practices, documented programmes, and standard operating procedures (e.g., as an example those developed for use in Ghana with a view for a wider

[104] https://www.canada.ca/en/health-canada/programs/consultation-lead-drinking-water/document.html1#a11

use and uptake[105]) in place to minimise the risk of exposure these include housekeeping and hygiene controls, sweeping and cleaning measures and equipment and ensuring that all employees/contractors have been properly trained in what to do in the workplace and the procedures to follow. Regular monitoring/auditing of workplace practices and procedures is important to ensure these are being effectively followed;

(c) The provision of Personal protection equipment (PPE e.g., overalls, socks, jackets, shirts, safety boots (including chemical resistant), standard or chemical resistant aprons/clothes, gloves, helmets, safety glasses, face shields, hearing protection) and respiratory protection equipment (RPE e.g., face masks with appropriate assigned protection factor) to minimise exposure to lead and reduce the risk of elevated blood leads;

(d) The provision of employee/contractor training/retraining programmes on blood lead management measures. Specific education and awareness materials should be provided to employees/contractors and also their families. Providing employee specific counselling and where appropriate retraining for those with an elevated blood lead. This is important given the significant role that employee behaviour and personal hygiene plays in causing elevated blood lead levels;

(e) Ensuring effective personal hygiene measures are in place including, daily changes of work clothing/uniform or more frequently if dirty, removing contaminated clothing/PPE before entering a clean area (e.g., canteen, office's, etc.), requiring anyone[106] exposed to lead to shower, scrub their nails and wash hands, arms, face, hair and brush their teeth at the end of the working day before putting on their own clean clothing, no contaminated work clothing to be taken home to wash (all workplace clothing to remain and preferably washed on site to reduce the risk of the spread of lead contamination offsite);

(f) To minimise the risk of elevated lead levels employees should ensure they do not bite their nails, rub their face with contaminated hands or gloves, do not eat or smoke in the workplace and do not have facial hair that adversely affects the use of RPE and wear their respiratory protection in the workplace;

(g) Ensuring workplace risk assessments have been undertaken to identify high risk areas for specific controls and for those who are particularly vulnerable to lead exposure such as women of childbearing age to identify workplaces that are protective against lead exposure;

(h) Under ILO Conventions children under the age of 18 are prohibited from hazardous work and so should be prohibited from entering or working in a WLAB plant or handle lead acid batteries.

5. Engineering controls

312. Effective engineering controls should be regarded as the first line of control in minimising the risk of workers and others (e.g. employee family members and contractors) of being exposed to lead. They are the type of controls that protect everyone by removing hazardous conditions or by placing a barrier between the worker and the hazard. These controls should focus on the source of the hazard, unlike other types of controls that generally focus on the correct use of personal protective equipment to reduce the risk of exposure.

313. Engineering controls are a piece of equipment, a machine, or mechanical device designed to minimise the harm associated with a hazard. Engineering controls can reduce harm by:

(a) Isolating workers from the hazard (e.g., enclosed furnace/refinery control cabin);

(b) Enclosing high-risk operations (e.g., an area that is only opened during maintenance and cleaning);

(c) Extracting lead fume and dust in the work area (e.g., installing Local Exhaust Ventilation (LEV) systems, air filtration systems);

(d) Automating tasks so workers no longer need to perform them (e.g., using robots to skim drosses in refining kettle, loading the furnace, skimming molten lead ingots, stacking ingots);

(e) Automatic dust suppression spray systems to prevent lead dust becoming airborne;

(f) Automatic doors that open and close in lead storage areas.

[105] https://www.sustainable-recycling.org/wp-content/uploads/2022/04/ULAB_recycling_SOPs.pdf

[106] https://www.baua.de/EN/Service/Legislative-texts-and-technical-rules/Rules/TRGS/pdf/TRGS-505.pdf?__blob=publicationFile&v=3

314. The use of engineering controls in the recycling plant is an essential and represents the most effective approach to reduce and control the levels of lead present in the work area and minimise the risk to employees. It is essential that the controls are regularly maintained and that there is an ongoing preventative maintenance programme to ensure they continue to operate as designed.

315. Where feasible design the facility, equipment, or process to remove the hazard and/or substitute something that is not hazardous or is less hazardous, for example by:

(a) Redesigning, changing, or substituting equipment to reduce the generation of excessive dust and fume;

(b) Designing the ventilation with sufficient suction and flow to improve indoor air quality and generally to ensure there are low lead in air levels.

316. If removal is not feasible, enclosing the hazard to prevent exposure in normal operations should be considered, e.g:

(a) Complete enclosure of moving parts of machinery;

(b) Complete containment of refinery kettles to reduce fugitive emissions;

(c) Complete containment of noise and heat.

317. Where complete enclosure is not feasible, establishing barriers or local ventilation to reduce exposure to the hazard should be considered, e.g.:

(a) Ventilation hoods;

(b) Machine guarding, including electronic barriers;

(c) Isolation of a process in an area away from workers, except for maintenance work;

(d) Installing positive pressure control cabins and HEPA air filters to ensure the air in the work area is lead free.

318. For existing WLAB recycling plants consideration should be given to carrying out an assessment to identify engineering controls that could be undertaken to reduce the levels of dust and fume in the plant, this could include, but not limited to the following:

(a) Reviewing battery breaking operations;

(b) Reviewing paste storage and handling and ways of reducing lead becoming airborne;

(c) Establishing measures to reduce sulphur levels in emissions;

(d) Looking at furnace operations and furnace loading and tapping for controlling lead fume entering the work area;

(e) Assessing refining and the dedrossing of the kettles to reduce lead dust/fume being released into the work area;

(f) Reviewing dust handling of air emissions controls, e.g., bag houses.

6. Housekeeping

319. A clean plant is essential for minimising lead exposure and is as important as emission controls and hygiene measures.

320. Dust deposits should be removed on a regular basis to reduce the risk of contaminant dispersion. The methods of cleaning involved should consider the need to minimise the spread of contamination. Either wet cleaning or the use of mobile equipment with high efficiency filters should be used. Dry brushing, sweeping or use of compressed air lines should not be used because of dust generation and spread of contamination. Any residues from housekeeping should be collected and returned to feedstock.

321. Contaminated plant, equipment, containers, and tools, used for example by contractors, should be decontaminated, by approved methods (e.g. washing with suitable solvents such as water), prior to off-site removal. Any equipment to be maintained in a workshop should be cleaned prior to works being carried out to minimise risk of contamination. Contaminated water should be discharged to the wastewater treatment plant.

322. High standards of cleanliness should be adopted to minimize the spread of contaminants and regular workplace checks should be carried out to monitor the effectiveness of the housekeeping measures.

323. Within a plant there are a number of locations other than production areas, which also present a risk of exposure, these include weighbridge office, canteen, break rooms, control rooms, offices, laboratory, toilets, showers, locker rooms, drivers cabs and other areas. A site-specific list of areas should be identified together with a cleaning frequency (e.g., number of times per day). For each specific area a monitoring frequency (e.g., weekly, monthly, quarterly) should be established to check lead in air for exposure and also swab testing to check the effectiveness of housekeeping. The swab/dust wipe testing of surfaces for lead should include tables, chairs, window ledges, cabinets, etc.

7. Personal protection equipment

324. It is important that employees/contractors work use personal protection equipment (PPE) to minimise their risk to lead exposure wherever technical or organisational measures are not feasible or not sufficient. However, employers should not rely on PPE alone to control exposure to lead where other effective control options are also available. PPE can be effective, but only when workers/contractors use it correctly and consistently and if it is properly maintained. PPE might seem to be less expensive than other controls but can be costly over time, especially when used for multiple workers on a daily basis.

325. When other control methods are unable to reduce lead exposure to the established safe levels, PPE should be provided to reduce the exposure and PPE is the only control option available.

326. . Each company should have site-specific documented procedures and PPE/RPE for employees, visitors and contractors. The procedures should include the type of equipment approved and available for use and the circumstances under which particular PPE/RPE is to be worn, type of equipment to be worn, issuance of PPE/RPE and maintenance and cleaning of PPE/RPE. There should be a comprehensive training programme for the safe use of the equipment.

327. Each company should identify a person with overall responsibility for identifying, specifying and approving the type of PPE to be used and worn on site.

328. PPE requirements should be established for specific workplace activities (e.g. hot metal work, etc.) due to the variable operations and include the following categories:

(a) Works clothing/uniform;

(b) Head protection;

(c) Respiratory protection;

(d) Hand protection;

(e) Foot protection;

(f) Other protective gear (e.g. eye & hearing protection).

329. PPE for use by employees, should, for example, include, where appropriate, the following:

(a) Work shirts;

(b) Under trousers;

(c) Overalls (boiler suit);

(d) Socks;

(e) Apron (standard or acid resistant)

(f) Workplace footwear (e.g., leather metatarsal boots, wellington boots with steel toecaps, acid resistant);

(g) Canteen clothing & footwear (e.g., plimsolls);

(h) Gloves, gauntlets etc. (nitrile gloves, foundry gloves, heat resistant gloves);

(i) Hard-hat (often this is part of a battery powered respirator);

(j) Safety glasses, face shields, goggles, etc.;

(k) Respiratory protection equipment (e.g., 3M battery powered helmet & respirator (3M Versaflow), or other powered helmet respirators, neoprene respirator, face masks with at least P2 or N95/FF2 protection, half masks with cartridges, etc.). Selection of an appropriate respirator type must be a result of a risk assessment to determine the minimum assigned protection factor (APF);

(l) Gaiters;

(m) Hearing protection;

(n) Hot metal work protection equipment (e.g., neck capes, kevlar gloves, leather aprons, etc.);

(o) Jackets and body warmers;

(p) Waterproofs.

330. PPE should also be available for use by visitors and include, where appropriate, but not be limited to hard hat, safety glasses, protective over garment e.g., disposable/washable boiler suit, lab coat etc., hearing protection e.g. ear plugs to be worn in designated hearing protection area, respirator - to be worn in designated respiratory protection areas, and protective footwear (e.g., boots with steel toe caps).

331. PPE requirements for contractors should be established prior to commencement of site works. No contractor should carry out work on-site with their own PPE unless this has been authorised by the site person responsible for PPE to prevent contaminated clothing being removed from site.

332. Each employee should be provided with training regarding the use and wearing of PPE (e.g., respiratory protection equipment such as battery powered helmet respirators). No PPE, which requires specific specialist training prior to use, should be issued unless that training has been provided (e.g., breathing apparatus for furnace relining works).

333. PPE and RPE should be checked and cleaned on a regular basis and where it is identified as being unsafe, or not working properly should be withdrawn from use to ensure that those using the equipment are not at risk from exposure to lead.

8. Medical surveillance

334. All employees should have a medical examination when they commence employment. This will establish a health baseline that will allow a medical professional to identify any occupational related health issues, e.g., blood leads, loss of hearing and also any issues which may be present prior to their employment. The levels and frequency for blood leads are discussed in section 9 – blood lead monitoring together with the frequency of monitoring.

335. Regular follow-up health monitoring for example every 12 months should be undertaken to identify any occupational health issues that may arise from their employment.

336. Employees with any occupational health issues should be receive the appropriate medical support and treatment to address the issue of concern so that it can be resolved.

9. Blood lead monitoring

337. Occupational health monitoring and in particular blood lead monitoring is the main way an employees/contractor's exposure to lead can be monitored and to verify that the risk management measures and procedures that are in place are effective.

338. Blood lead levels are the most reliable indicator of occupational exposure. Regular monitoring of employees and contractors should be carried out to identify any exposure issues and establish what mitigating measures should be undertaken if an issue arises. Elevated blood leads are a key indicator of any problems in the workplace with engineering emission controls, workplace procedures, hygiene practices or use of PPE/RPE.

339. All employees/contractors should have their blood lead levels tested on a regular basis by a medical professional (e.g., works doctor/nurse). The frequency of the sampling should depend on the level of lead in the blood. The higher the level the greater the frequency of testing. The relationship between high blood lead and workplace air lead measurements is not that clear given that many employees in high risk areas can have low blood leads. Consequently, the plant should establish the frequency of blood lead testing for anyone exposed to lead based on set blood lead levels, for example <10µg/dl every 12 months, <15µg/dl every 3 months, 15µg/dl-20µg/dl every 2 months and >20µg/dl monthly.

340. The plant should also set an alert level and limit value. An alert level (e.g., 20µg/dl) would require an evaluation of work practices and routes of exposure to be evaluated to see what measure can be adopted to bring about a lowering of blood lead. A limit value (e.g., one measurement above 30µg/dl) should be used to assess whether an employee needs to be reassigned to another work area or job to lower their risk of exposure.

341. The doctor/nurse will take a small sample of blood from a vein and send it to an approved/certified laboratory. The laboratory will return the result to the medical professional who

will discuss the result with the employee/contractor. Preferably, and if local legislation allows, the medical professional will share the result with plant management so that they can see whether any action needs to be taken such as making changes to engineering controls, workplace procedures or changes to employee practices.

342. Lead exposure levels and contamination data are sometimes misleading because they do not always show the complete situation or reflect a person's attitude towards personal protection and procedures to minimise exposure. Employee behaviour in the workplace can play a key role in causing elevated blood leads and it is for this reason that assessing the way they work and undertake their tasks can shed light on potential causes and an opportunity to modify the way they work or follow hygiene procedures through counselling, guidance, or additional training/retraining.

[Co-chairs alternative text section J on Health & Safety

J. Health and Safety

J ALT 1 Lead as well as several other pollutants could be released during management, recycling, and disposal procedures of WLABs. In addition to the lead terminals and plates, batteries contain various plastics or hard rubber (ebonite) and the sulfuric acid electrolyte solution which are lead polluted in WLABs. The components may contain other elements such as arsenic, antimony, barium, and cadmium. These components may form part of the waste and emissions generated at various stages of the recycling process and might end in soil and water contamination Plastic or rubber contaminated with lead, when recuperated or recycled, could release toxic gases, including Sulphur dioxide, chlorine, dioxins and dibenzofurans.[107]

a. Toxic character of lead and toxicity (toxicodynamic)

J ALT 2 Lead[108] is a chemical element and can exist in various chemical forms, is a heavy metal that do not degrade in the environment and persist, can be transported to long distances through air, water, and soil and bioaccumulates. Particulate matter containing lead penetrates de food chain and historic emissions from different sources continue contributing to current exposures.

J ALT 3 Blood Lead Level (BLL) reflects mainly the history of current and previous exposure (half-life of approximately 30 days) and not the larger burden in other tissues, by example in bones (half-life of years to decades). Lead is widely distributed throughout the body and is retained in the body for decades.

J ALT 4 4Both, lead absorbed and from deposits bioaccumulated in the tissues is circulated by the blood. Lead is relatively rapid eliminated from blood compared to the deposits in bones and other tissues as in the brain. As a result, a single BLL control may not be a reliable metric for lead body burden or cumulative exposure, this is why the practice of removing the worker from exposure lowers the BLL but not the lead load accumulated in the tissues, which may remain being toxic and affecting the health for a longer time.[109] [110]

b. Sources and routes of exposure

J ALT 5Manually informal breaking up the battery releases lead particles and lead oxide dust, which are a source of lead pollution and exposure to the worker and community.

J ALT Exposure to lead can occur through occupational and environmental sources from inhalation of lead particles (generated by burning materials containing lead, for example during smelting, recycling, incineration and open burning), ingestion of lead-contaminated dust, water and contaminated food, from

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[107] Recycling used lead-acid batteries: health considerations ISBN 978-92-4-151285-5 © World Health Organization 2017

https://iris.who.int/bitstream/handle/10665/259447/9789241512855-eng.pdf?sequence=1&isAllowed=y

[108] Toxicological profile of lead, CDC, ATSRD, 2020, https://www.atsdr.cdc.gov/ToxProfiles/tp13.pdf

[109] Bone lead and endogenous exposure in an environmentally exposed elderly population. Huling Nie and Brisa Sanchez. Journal of Occupational Environmental Medicine. Oct 2019.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3800179/#:~:text=Unlike%20lead%20in%20blood%2C%20with,human%20body%20resides%20in%20bone.

[110] Recycling used lead-acid batteries: health considerations ISBN 978-92-4-151285-5 © World Health Organization 2017

https://iris.who.int/bitstream/handle/10665/259447/9789241512855-eng.pdf?sequence=1&isAllowed=y

hand-to-mouth behavior and through the skin when lead particles and polluted dust settle on skin, hair and clothes (take-home exposure when workers do not wash and change clothes).

J ALT 6 Infants are born with a BLL burden from maternal prenatal exposure removed from the mother tissues during pregnancy (unique transgenerational exposure since conception, in embryo and fetus (through the placentae). Exposure by breastmilk and along the childhood development period affects the organization of the brain and other organs and have long lasting effects for life. During childhood, absorption is higher compared to adults, and diet and nutrition may increase the absorption when there is a lack of calcium in the diet.[111]

Due the toxicodynamic characteristics of lead (toxic to development, persistent and bioaccumulative), the main concept to evaluate toxicological health effects are evaluated is "chronic low doses exposure" and "early exposure during development stage", as well important is the toxic exposure in reproductive age. The moment of exposure (during stages of development) and duration correlates with health effect and severity of poisoning.

c. Health toxic effects

J ALT 7 According to WHO and CDC, no safe level of lead exposure has been identified. The health effects of lead are the same, regardless of the route of exposure(inhalation or ingestion). A recent publication of the World Bank, the global cost of lead exposure in 2019 was equivalent to 6·9% (3·1–10·4) of the global gross domestic product. 77% (range 70–78) of the cost was the welfare cost of cardiovascular disease mortality, and 23% (22–30) was the present value of future income losses from IQ loss.

J ALT 8 At high levels of poisoning the central nervous system brain can be severely damaged causing coma, convulsions, and death. Adverse effects occur at BLL ≤5 µg/dL increasing the burden and mortality by NCDs (non-communicable diseases) for the most studied endpoints, mainly cardiovascular (hypertension, heart disease, atherosclerosis), neurological, renal, reproductive (in male and females), hematological (anemia) and immunological, among others.

J ALT 9 Lead exposure can have serious consequences for children´s health, in particular affecting brain development, resulting in reduced intelligence quotient (IQ), deficit of intellectual functioning (span attention, organization of thinking, speech articulation, language comprehension, memory and learning efficiency) and behavioral/motor skills (high activity levels, reduced solving flexibility and poor self-control).[112] [113]

d. BLL refences guides

J ALT 10 The European Union[114] adopted a directive that revised the **limit values for lead** as follows: occupational exposure limit from 0.15 milligrams per cubic meter (0.15mg/m3) to 0.03mg/m3, and biological limit value from 70 µg/dL (micrograms per deciliter or 100ml) to 15 µg/dL (30 µg/dL until 2028).[115] To protect against the reprotoxic effects of lead, lower limit values (4.5 µg/dL) for medical surveillance measures will apply as regards female workers of childbearing age.

J ALT 11 The Occupational Safety and Health Administration (OSHA) and a few state agencies in the United States regulate BLLs in workers. Other government agencies and non-government groups offer

[111] Lead poisoning, 2023, World Health Organization, https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health

[112] Lead poisoning effects. Mt Washington Pediatric Hospital, 2024, https://www.mwph.org/health-services/lead-treatment/poisoning-effects#:~:text=Exposure%20to%20lead%20can%20result,learning%20and%20memory%20efficiency%2C%20fine

[113] Global health burden and cost of lead exposure in children and adults: a health impact and economic modelling analysis. Bjorn Larsen and Ernesto Sanchez-Triana from The World Bank.
https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(23)00166-3/fulltext

[114] Protection of workers: Limit values for lead and diisocyanates, European Parliament. February 2024, https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/754563/EPRS_BRI(2023)754563_EN.pdf

[115] Lead accumulates in the bones and is released slowly into the circulatory system. Therefore, according to the adopted directive, workers who have high blood lead levels due to exposure which occurred before the transposition of this directive will undergo regular medical surveillance. They will be able to continue working with lead if their blood lead levels exhibit a declining trend.

recommended lead exposure limits.[116] Among others presented in the BLL reference guide[117], the California Department of Public Health (CDPH) recommends that, if the BLL is between 3.5 to 9 µg/dL, the BLL test be repeated every 3 months for adults until their BLL is less than 3.5 µg/dL[118] [119]. The American College of Occupational and Environmental Medicine (ACOEM) states it is advisable for women who are or may become pregnant to avoid occupational lead exposure that would elevate the BLL greater than or equal to 3.5 µg/dL.]

K. Emergency response

1. Emergency planning

343. The operation of a WLAB recycling plant involves various risks, such as fires (e.g. battery storage areas, bag houses, furnace explosions/fires, lead eruptions from refining kettles), stormwater and effluent overflows, etc. These all present risks the release of lead and other substances and this should be considered/included as part of the planning. Given the risks of operation it is important that its operations and activities are reviewed and all areas where there are risks for fires/explosions, spills or releases of hazardous/polluting materials may occur, and off-site receptors (i.e., surface water, groundwater aquifers and boreholes, residential areas and important ecological habitats) are identified. All identified areas should be clearly highlighted on site plans and included in the emergency plan. In many countries an incident at a lead recycling plant would be regarded as a major accident hazard and there are specific requirements regarding the preparation of emergency plans for incidents.

344. The location and quantity of hazardous substances, (i.e., raw materials and wastes) stored, handled or produced and health, safety and environmental hazards associated with each location should be identified and clearly shown on site plans and included in the emergency plan.

345. Critical equipment including, but not limited to, gas cylinders, tanks and piping, containers, flexible hoses etc. and operations (e.g., tanker unloading, blockages in the wastewater system) that could cause a significant incident/release due to malfunction or abnormal conditions should be identified.

346. The consequences of an emergency should be identified and the risk of such an incident occurring should be assessed. Where a risk is identified adequate engineering controls to prevent or minimise the identified risks for emergency events should be established. Examples of the types of measures to be considered include:

(a) Fire/emergency alarms and firefighting equipment;

(b) Storing gas cylinders in locked cages;

(c) Locking and closing electrical distribution boxes;

(d) Spill and release detection and alarm systems;

(e) Spill diversion and retention systems;

(f) Secondary containment;

(g) Spill control kits;

(h) emergency communications equipment (e.g. radios, telephones).

347. To minimise the risks for key activities, such as, unloading and loading bulk tankers (e.g., fuel oil, caustic, acids, etc.) organisational controls and standard operating procedures should be developed together with identifying and obtaining the appropriate spill control equipment and other emergency equipment to be readily available in the event of an incident arising.

2. Emergency organization and plan

[116] The National Institute for Occupational Safety and Health (NIOSH). Understanding the Blood Lead Levels. BLL reference guide.
https://www.cdc.gov/niosh/topics/lead/referencebloodlevelsforadults.html#ref7

[117] Kosnett MJ, Berenji M, Burton AD, et al. [2023]. American College of Occupational and Environmental Medicine (ACOEM) Position Statement: Workplace Health and Safety Necessitates an Update to Occupational Lead Standard Provisions for Medical Removal Protection, Medical Surveillance Triggers, and the Action Level and Permissible Exposure Level for Lead in Workplace Air: ACOEM Response to OSHA. JOEM Mar 1; 65(3): e170-e176

[118] Adopted CSTE Occupational Subcommittee [2021]. Management Guidelines for Blood Lead Levels in Adults.

[119] California Department of Public Health [2021]. Health-based guidelines for blood lead levels in adults

348. To address emergency situations each company/site should develop and establish an emergency preparedness and response plan and emergency response procedures. The plan should include:

(a) Incident notification (e.g., authorities, emergency services, management);

(b) Emergency actions;

(c) Alarm and evacuation procedures;

(d) Fire exits;

(e) Location of firefighting equipment;

(f) Emergency assembly points;

(g) Contacts details of the emergency services;

(h) Site plan highlighting key areas/risks.

349. The plan should clearly define the roles, responsibilities, and staffing requirements (the Emergency Response Organisation) needed in an emergency. If an emergency response team is established, then sufficient personal protective equipment should be available and appropriate for the emergency.

350. Warning, notification, and communication procedures should be established which include, but are not limited to:

(a) Facility emergency staff (internal contact list);

(b) Local external emergency services (external contact list);

(c) Regulatory agencies (contact list);

(d) Communicating with the public;

(e) Media;

(f) Company management.

351. Copies of the emergency plan should be readily available for use by the emergency services in the event of an emergency and updated on a regular basis, at least once per year or whenever significant changes occur.

3. Emergency response training

352. Each company/site should evaluate emergency training needs of all personnel assigned specific duties and roles in the emergency plan and ensure they receive adequate training. Routine training and refresher training should be provided to the emergency response staff, and tests and drills should be performed on a regular basis so that everyone is familiar with what to do in the event of an emergency. The emergency services should also be invited to attend site to familiarise themselves with the layout and issues that they may need to respond to. Response exercises should include a debriefing session to evaluate any problems and areas for improvement so that these can be corrected and updated.

4. Emergency plan management

353. . A logbook to record activities taken during emergency incidents should be maintained. In the event of an incident the emergency preparedness should be reviewed and amended. Emergency response procedures should also be reviewed and updated, where appropriate, on a regular basis to ensure the plan is up-to-date and accurately reflects the hazards, risks and controls. Public participation is a core principle of the 1999 Basel Declaration on Environmentally Sound Management and many other international agreements. It is essential that the public and all stakeholder groups have a chance to participate in the development of policy related to WLAB the planning of programmes, the development of legislation, the review of documents and data and decision making on local issues related to WLAB. Paragraphs 6 (g) and (h) of the Basel Declaration reflect an agreement to enhance and strengthen efforts and cooperation to achieve ESM regarding the enhancement of information exchange, education, and awareness-raising in all sectors of society, along with cooperation and partnership at all levels between countries, public authorities, international organizations, industry, non-governmental organizations and academic institutions.

L. Awareness and participation

354. Public participation is a core principle of the 1999 Basel Declaration on Environmentally Sound Management and many other international agreements. It is essential that the public and all stakeholder groups have a chance to participate in the development of policy related to WLAB wastes, the planning of programmes, the development of legislation, the review of documents and data and decision making on local issues related to waste lead-acid batteries. Paragraphs 6 (g) and (h) of the Basel Declaration reflect an agreement to enhance and strengthen efforts and cooperation to achieve ESM with regard to the enhancement of information exchange, education, and awareness-raising in all sectors of society, along with cooperation and partnership at all levels between countries, public authorities, international organizations, industry, non-governmental organizations and academic institutions.

355. Articles 6, 7, 8, and 9 of the UNECE 1998 Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention), along with the Escazú Convention, require the parties to conduct fairly specific types of activities regarding public participation in specific government activities, the development of plans, policies and programmes and the development of legislation and call for access to justice for the public with regard to the environment.

356. Public awareness and attitudes to WLAB can affect the population's willingness to cooperate and participate in good waste management practices. General environmental awareness and information on health risks due to inappropriate waste management are important factors which need to be continuously communicated to all sectors of the population.

357. Raising public awareness and promoting public participation is especially critical for the environmentally sound management of WLAB.

358. Producers, Producer Responsibility Organisations (PROs), retailers/distributors, environmental/producer/waste management associations, NGOs, as well as national and local authorities can and should organise awareness raising campaigns/events addressed to business and the public to make people aware of the importance of ESM of all batteries (WLAB) in tackling environmental problems such as lead pollution and improving people’s lives. There exists a variety of communication techniques that can be used, such as door to door information, leaflets, community meetings, media etc. Communication objectives could include:

(a) Emphasize health benefits;

(b) Use simple messages and multiple media types;

(c) Build on existing neighbourhood networks;

(d) Emphasize the economic and environmental benefits of proper WLAB management;

(e) Frame WLAB management activities as a topic of great interest for voters, particularly on important issues (e.g., lead pollution);

(f) Increase visibility and credibility of good WLAB management activities;

(g) Identify instances where city activities support national goals;

(h) Communicate about the national benefits of proper local waste management (e.g., to attract investments);

(i) Tailor communication to the intended audience;

(j) Emphasize the economic benefits to businesses (e.g., better conditions for attracting investment).

359. The public should have access to and be able participate in the process for granting/changing/updating permits/approvals. The authorities should be required to make available to the public (including via the Internet) the basis of the decisions, results of consultations, details of the permit conditions, any derogations and the reasons for it, and measures taken by an operator following permanent cessation of activities. The public should also have access to the legal system or another independent/impartial body for a legal review to challenge decisions/acts/omissions. Prior to any legal action being taken the authorities should have a review process/procedure in place to address any concerns raised.

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