PREVENT Waste Alliance E-Waste Working Group

PREVENT
Abfall Allianz

Piloting of treatment solutions and innovative finance models for problematic e-waste fractions.

Technical training concepts: Waste Batteries Management

COMING UP TODAY

PREVENT

- Brief overview on PREVENT
- Who do we have with us and what are your challenges?
- Batteries 101 with Mario Champagne
- 1st hour: the basics, identifying, classifying and sorting,
- 2nd hour: Management of Lithium Ion, Lead Acid
- 3rd hour: portable batteries and general aspects like collection, transport

- Questions can be posted into the chat


PREVENT
Waste Alliance
Together for a circular economy

WHO WE ARE

PREVENT

Launched in **May 2019** by the **German Federal Ministry for Economic Cooperation and Development** (BMZ).

Platform for **exchange and international cooperation** in the field of **circular economy.**

More than **200 organisations** from the

- private sector
- academia
- civil society
- public institutions.

MISSION AND VISION

PREVENT

We want to contribute to

- **minimising waste,**
- **eliminating pollutants and**
- **reutilising resources in the economy.**

We strive to **reduce waste pollution** in low- and middle-income countries through **developing functioning waste management and circular economy approaches**. We work together for **waste prevention, collection, and recycling** as well as the increased **uptake of secondary resources**. As a result, we commit to our individual responsibility for a circular economy.

OUR WORKING GROUPS

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WG Plastics
Conservation of resources, prevention of plastic waste and development of recycling systems for plastic packaging

WG E-Waste
Establishment of take-back and recycling systems for waste electric and electronic equipment

WG Framework Conditions
Improvement of framework conditions for waste management and circular economy at municipal level

Awareness raising and behaviour change: Best Practices and recommendations

Financing mechanisms: Extended Producer Responsibility (EPR), ‘Credit’ Systems

ACTIVITIES IN THE E-WASTE WORKING GROUP

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Activities on Refurbishment to come

PREVENT- StEP WG: experiences on and improving implementation of the PIC notification process for export of e-waste fractions

Closing e-waste cycles - PREVENT Waste Alliance (prevent-waste.net)

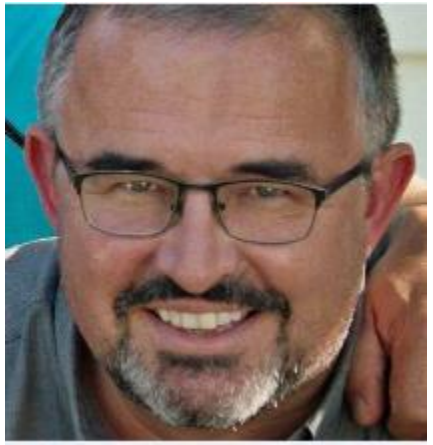
PRESENTATION BY

PREVENT

- Mario Champagne, chemical engineer
- Technical and Audit Manager for
  - European Recycling Platform
  - H2 Compliance
  - Companies of the LANDBELL Group
- 17 years of experience in WEEE and Batteries Recycling services
- 550 site audits in over 33 countries.

LANDBELL GROUP

- DS — Facility waste management and transport packaging (DACH)
- European Recycling Platform — Multinational WEEE, batteries and packaging compliance
- H2 COMPLIANCE — Global consultancy for environmental and chemical compliance
- LANDBELL — Take-back scheme for packaging in Germany
- prodigentia — Digital compliance and take-back solutions



LEARNING OBJECTIVES

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- Understand the different battery types and how to identify, sort and manage these.
- Understand how to protect yourself, others and the environment when working with batteries arising from e-waste recycling processes.
- Understand what options you have in your facility, locally or internationally to treat batteries and the costs/processes involved.
- Know what to look for and be aware of when identifying equipment providers and downstream processing facilities.

MAIN TOPICS COVERED

- Type of batteries
- Chemistries and Identification tips
- Environment, Health & Safety aspects
- Emergency situations management
- Collection and Handling
- Receiving and Storage
- Sorting
- Conditioning for transfer
- Legal aspects for transfer
- Recycling, Reuse and Disposal
- References

STARTING QUESTIONS

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- Which region are you from?
- What kind of organisation are you working in?
- What are your main challenges managing batteries in your activities?
- What sort of batteries do you normally deal with in your activities?

- https://forms.office.com/r/sNZSMLiDX1

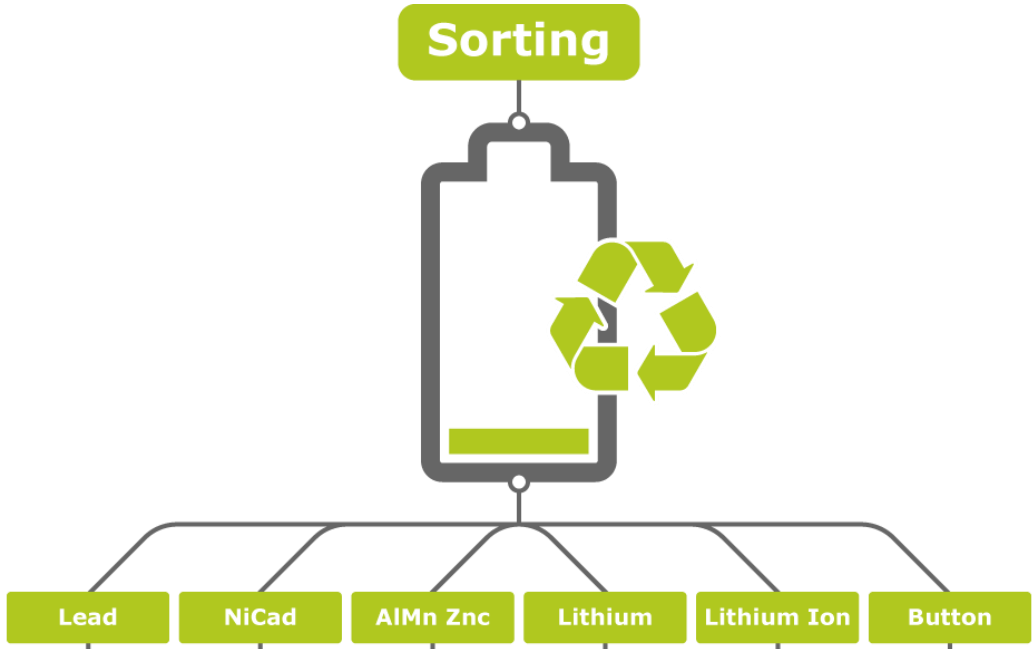
WHY IDENTIFY AND SORT BATTERIES?

- Pre-requisite to enable safe and environmentally sound management.
  - Leaks
  - Arcs and Fires
  - Protect Life, Environment and Assets
- To get to profitability in recycling
  - Critical Raw Materials -> extract value
  - Commodities-> avoid contamination by mixing chemistries

Sorting is the first reflex to have as one chemistry deserves one process.

Sorting is easy to implement by building one's own experience which is a process relevant for the recycler in a low or a middle-income country.

But what is a battery ? How are they classified? What is good to know about them? How to recognize their types?



Source: European Recycling Platform

SOME DEFINITIONS

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DEFINITION

- A **battery or an accumulator** is a source of electrical energy generated **by direct conversion of chemical energy** and is either one or more:

- **primary battery** cells that are non-rechargeable or disposable, which provide electric current over a period and then die as the chemical reaction depleted the elements. **Single use**
- **secondary battery** cells that are **accumulators or rechargeable** batteries, which accumulate energy from power source and release it.
- In rechargeable batteries, the **chemical reaction is reversible** and therefore they can be recharged many times.

CHARACTERISTICS

- Many shapes
- Many formats
- Many brands
- Characterized by their voltage and size
- Look for Volts or (+/-) signs

Some are identified by

- their capacity in mAh in batteries pack.
- volts

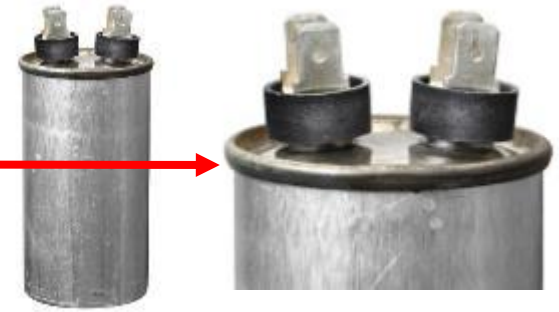
CAUTION: NOT A BATTERY

- **Starting Capacitors** are used to assist a single-phase electric motor in starting.
- Starting capacitors are most easily identified by **plastic casing** or outer shell.
- Capacitors with ratings above 70 microfarad (μF) and below 120 μF are starting capacitors.

Microwave capacitors (1)
LDA capacitors (2)

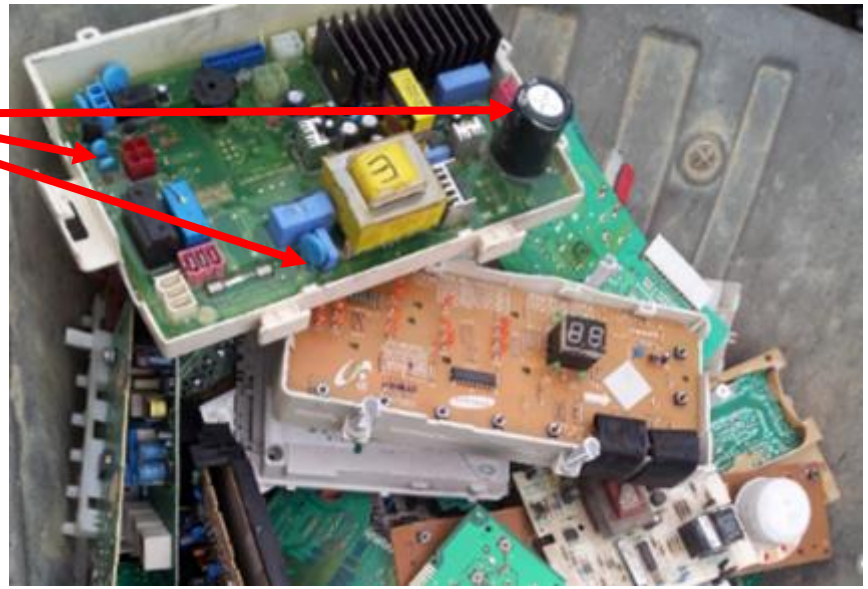
- Look for **μF**
- Pins and bolts
- Sealed

- **Running Capacitors are** designed to stay in a motor circuit for the entire cycle of operation.
- Running capacitors are identified by rectangular or oval metal casings. An oil-filled capacitor manufactured **after 1979 may have "NO PCBs" stamped on its casing.**



ELECTROLYTIC CAPACITORS

- Various shapes of Electrolytic Capacitors*
- Capacitors are widely used as parts of electrical circuits in many common electrical devices, on printed circuit boards.
- Metal smelters are equipped to manage the potential pollution that could be released.
- To be verified if present in batteries loads coming from e-waste recyclers.



Images Landbell

If it is indicated "PCB", you need to find a way for a hazardous waste treatment process, specialized incineration at high temperature.

DRY & WET BATTERIES

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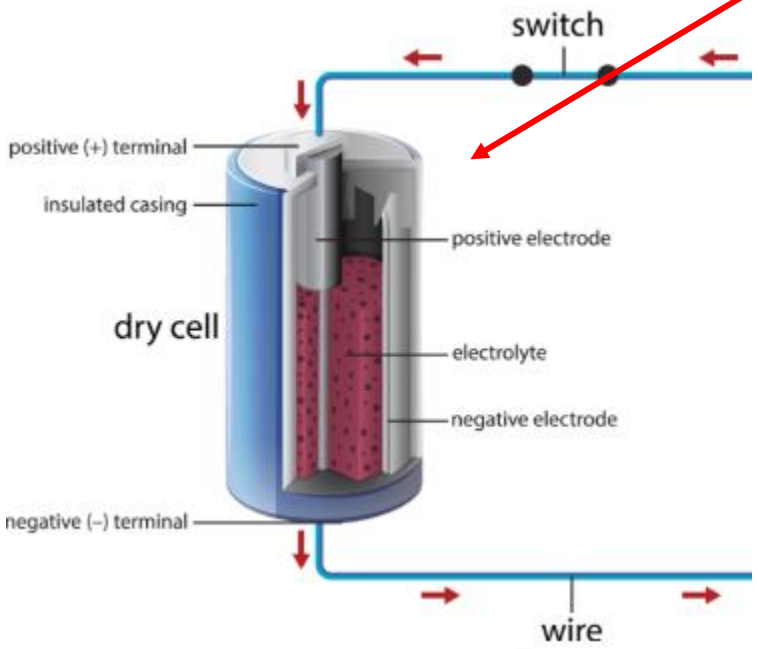
Dry:

- All dry cell batteries have a metal electrode or graphite rod covered by an electrolyte paste, all within a metal container.
- Dry cells can be either primary or secondary cells.



Wet:

- A wet cell battery generates power from a pair of electrodes and a liquid electrolyte solution.
- Wet cells can be either primary or secondary cells, like your car battery.

- All batteries contain a corrosive liquid or semi-liquid electrolyte that is either a strong acid or a strong base

CLASSIFICATIONS OF BATTERIES

In Europe, we split waste batteries and accumulators (WBA) into:

- **Industrial and automotive batteries and accumulators**
- **Portable batteries and accumulators:**

  - **Primary** -> single use
  - **Secondary** –> rechargeable

    - In general, same processing step may apply but secondary ones may have more residual current and as they have in general various shape, leading to various components in the fractions (plastic casings, wires, membranes)

    - **In fact: chemistry implies a specific process to ensure recovery of material and avoid pollution risks .**

INDUSTRIAL AND AUTOMOTIVE BATTERIES AND ACCUMULATORS

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Automotive

- A battery of any size or weight used **for starting or ignition power** for a vehicle engine, or to power lighting in the vehicle.
- Batteries providing the **power to drive** electric vehicles are **industrial batteries not automotive.**

Non-Automotive Lead-Based Batteries

- These types of batteries **power heavy-duty industrial equipment, alarm systems and emergency lighting.**
- The same disposal rules for lead-acid automobile batteries apply to them.

Pb -> Lead – Some Facts

- Vehicle batteries contain around 8 kg of lead and about 4 liters of corrosive, lead-contaminated **sulfuric acid,** which can be recycled.
- Most of these can get recycled at 90%+.
- BUT BE AWARE: Important to recycle in appropriate facilities – unregulated lead battery recycling in low and middle incomes countries is world's most polluting industry

INDUSTRIAL AND AUTOMOTIVE BATTERIES AND ACCUMULATORS

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Industrial Batteries

- An industrial battery or battery pack is a battery of any size or weight, with one of the following characteristics.
- It is:
  - designed exclusively for industrial or professional uses
  - used as a **source of power for propulsion** in an electric vehicle or a ‘hybrid’ vehicle (a.k.a. "EV" batteries)
  - unsealed but not an automotive battery (ex: boat)
    - Electrolyte flowing freely, flooded .
  - sealed and not a portable battery.
    - Leak-free, gel battery, just enough liquid in acid-saturated fiberglass mats
- “Electric Vehicle” (EV) means propelled by electric propulsion and intended for carrying people or goods. This includes electric cars, wheelchairs, bicycles, airport vehicles, etc.

PORTABLE BATTERIES AND ACCUMULATORS

PREVENT

Portable

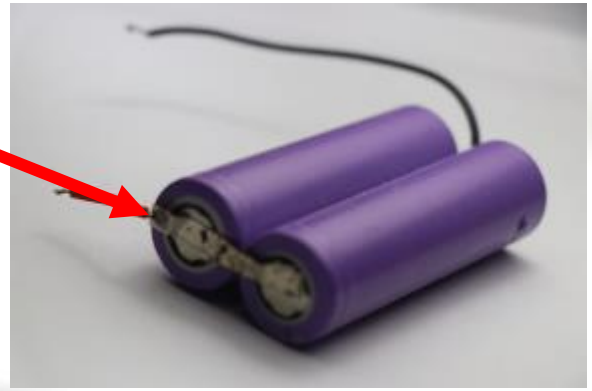
- A portable battery or battery pack is:
  - sealed
  - under 4 kilograms
  - not an automotive or industrial battery
  - not designed exclusively for industrial or professional use
- Portable batteries have thousands of everyday uses.
- Batteries similar in shape and size to the ones you use at home are most likely portable.

- You'll find them:
  - in televisions and DVD remote controls,
  - in portable music players and speakers,
  - as button cells fixed to the motherboard of a personal computer or laptop,
  - in wristwatches,
  - used to start domestic lawn mowers,
  - powering bicycle lights, household torches and hand tools.

PORTABLE BATTERIES AND ACCUMULATORS - BATTERY PACKS

PREVENT

- Battery packs are protected together by an outer casing, but inside you'll find individual batteries linked by contacts.



- Nickel Cadmium (Ni Cd)
- Cd is an heavy metal. "Don’t throw to garbage" and the “Cd” sign is normally present.

SINGLE-USE BATTERIES

PREVENT

- Single-use batteries, of any size, are some of the most common household batteries.
- Single-use batteries can be found throughout home in a variety of sizes including AA, AAA, 9V, D-cell and others.
- These are the batteries inside your TV remotes, flashlights, children's toys and other small electronics. **If the battery is not rechargeable, it falls into this category.**

- Nowadays , single-use batteries are made of common metals deemed non-hazardous.
- Prior to 1996, single-use batteries contained mercury and were treated as hazardous waste.
- **One exception is a button cell battery found in a watch, which is hazardous and should be processed by enclosed thermal treatment to recover mercury.**

Images Landbell,

RECHARGEABLE BATTERIES

PREVENT

- Rechargeable batteries are also common at home.
- You'll find them in cellphones, digital cameras, power tools, laptops and other more powerful electronics in your home.
- There are many kinds of rechargeable batteries.

- Nickel metal hydride and nickel cadmium batteries are found in electronics such as cordless power tools, digital cameras, two-way radios and cordless phones.
- Lithium-ion batteries are found in most portable devices such as cellphones and laptops.

- Rechargeable batteries may contain heavy metals that are hazardous to the environment.

TO SUMMARIZE: PRIMARY VS SECONDARY

Batteries (Primary)
Alkalines
Salines
Lithium metal

Accumulators (secondary)
Lead acid
NiCd (Nickel Cadmium)
Ni Mh (Nickel Metal Hydrure)
Li-ion (Lithium ion)

- Salines: A **salt-water battery** that employs a concentrated saline solution as its electrolyte. To be processed with alkaline batteries.

CHEMISTRIES & IDENTIFICATIONS TIPS

- In sorting centers in Europe, the cells and batteries can be separated into 8 distinct flows with manual and / or semi-automatic sorting, sometimes more.

- Here the most common in Europe.

1. Alkaline, salt and zinc-air batteries: 75 to 80%
2. Lithium batteries
3. Mercury batteries
4. NiCd accumulators
5. NiMH accumulators
6. Li-ion accumulators
7. Lead-acid batteries
8. Fractions of plastics, papers and other contamination are often present.
   - To be extracted for recovery. -> packaging, lighters, cans, telephone, etc.

Note $$$: To maximize profitability, it may be valuable to sort in subcategories the 8 categories. Depends on the market & opportunities. Ex: Li-ion sub-categories

CHEMISTRIES & IDENTIFICATIONS TIPS

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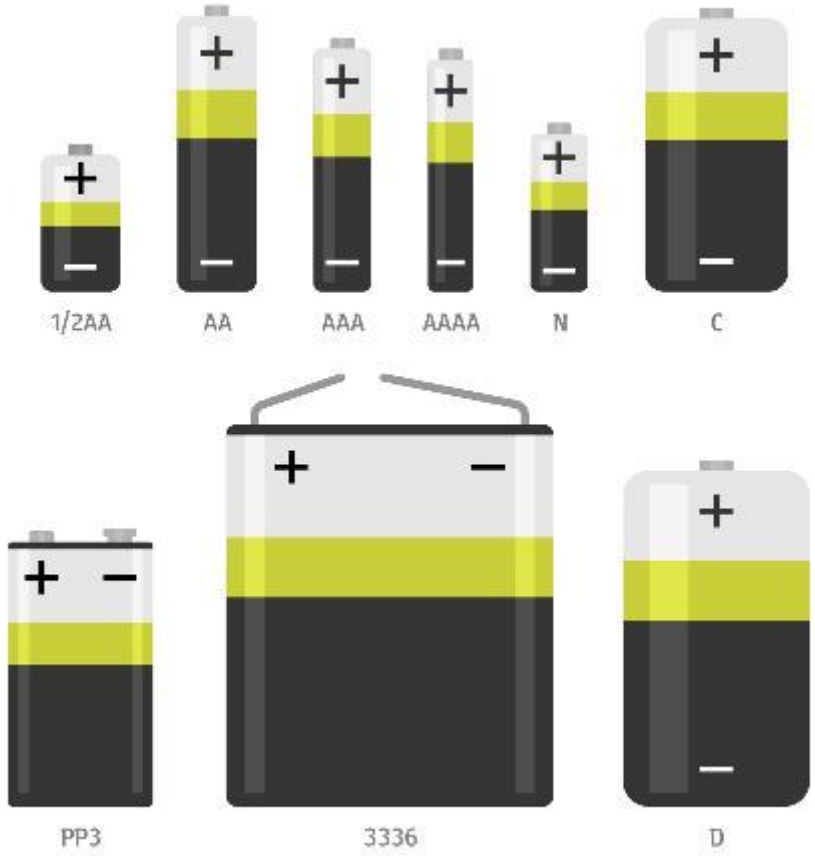
- On the batteries or their packaging, there are letters and numbers: AAA, LR6, AA, C, D, 9V ... Depending on the code to which these indications refer, information is obtained on the composition and / or the shape of the battery.

- The ANSI (American National Standard Institute) code refers to the dimensions of the batteries. These are codes AAA, AA, C, D, PP3, etc.



IEC 60086 BATTERY TYPE DESIGNATION SYSTEM

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- The IEC (International Electrotechnical Commission) code describes the composition and size of the batteries.

- See next tables from Wikipedia for more examples

Example : LR 44

Number of elements making up the battery. Here there are 3.

1st letter: Chemical system. Here, **L stands for alkaline** battery.

- If no letter: saline battery
- M = mercury oxide
- S = silver oxide
- F = lithium battery
- P = zinc-air battery
- H = Ni MH batteries
- K = NiCd batteries

2nd letter: Shape of the elements making up the stack. Here, **R means Round (coin, button or cylindrical)**

- S = Square
- F = flat
- P = Not round

Number: Coded dimensions of the battery. Here, 44 corresponds to 44 mm in height. But the numbers are not always about “mm”, as previous versions of the codification system were using code numbers to identify specific overall dimensions.

BATTERY COMPOSITION

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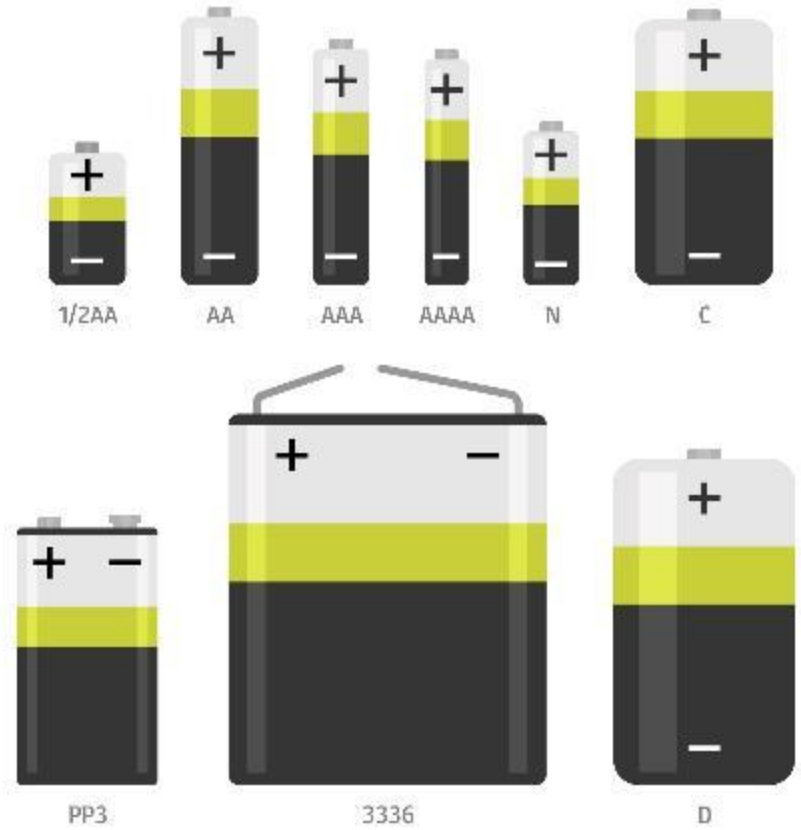
IEC codes for battery electrochemical systems[7]

Letter code	Negative electrode	Electrolyte	Positive electrode	Nominal voltage (V)	Maximum open circuit voltage (V)	Main article
(none)	Zinc	Ammonium chloride, Zinc chloride	Manganese dioxide	1.5	1.725	Zinc-carbon battery
A	*Zinc*	*Ammonium chloride, Zinc chloride*	*Oxygen*	*1.4*	*1.55*	Zinc-air battery
B	Lithium	Organic electrolyte	Carbon monofluoride	3.0	3.7	Lithium battery
C	Lithium	Organic electrolyte	Manganese dioxide	3.0	3.7	
E	*Lithium*	*Non-aqueous inorganic electrolyte*	*Thionyl chloride*	*3.6*	*3.9*	
F	Lithium	Organic electrolyte	Iron disulfide	1.5	1.83	
G	*Lithium*	*Organic electrolyte*	*Copper(II) oxide*	*1.5*	*2.3*	
L	Zinc	Alkali metal hydroxide	Manganese dioxide	1.5	1.65	Alkaline battery
M (withdrawn)	*Zinc*	*Alkali metal hydroxide*	*Mercuric oxide*	*1.35*		Mercury battery
N (withdrawn)	*Zinc*	*Alkali metal hydroxide*	*Mercuric oxide, manganese dioxide*	*1.4*		
P	Zinc	Alkali metal hydroxide	Oxygen	1.4	1.68	Zinc-air battery
S	Zinc	Alkali metal hydroxide	Silver oxide	1.55	1.63	Silver-oxide battery
Z	Zinc	Alkali metal hydroxide	Manganese dioxide, nickel oxyhydroxide	1.5	1.78	Nickel oxyhydroxide battery

IEC SIZES CODE



- https://en.wikipedia.org/wiki/List_of_battery_sizes

IEC size codes for round batteries

Number code	Nominal diameter	Nominal height	Common name
R25	32	91	F
R20	34.2	61.5	D
R14	26.2	50.0	C
R6	14.5	50.5	AA
R1	12.0	30.2	N
R03	10.5	44.5	AAA

In millimeters

IEC recommended round cell diameter and height codes

Number code	Maximum diameter	Maximum height
4	4.8	
5	5.8	
6	6.8	
7	7.9	
9	9.5	
10	10.0	
11	11.6	
12	12.5	1.20
16	16	1.60
20	20	2.00
23	23	
24	24.5	
25		2.50
30		3.00
36		3.60
50		5.00

IEC CODE EXAMPLES

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Examples of IEC battery designations

Designation	Series Cells	System	Shape	Standardized code or diameter code	Diameter modifier	Height code	Height adjustment modifier	Modifier(s)	Parallel strings	Remarks
R20			R	20						A single zinc-carbon cell, "size 20" which is equivalent to D, or ANSI "13" size
4R25X	4		R	25				X		A zinc-carbon lantern battery, consisting of 4 round "size 25" cells in series. Terminated with spring terminals.
4LR25-2	4	L	R	25					2	An alkaline lantern battery, consisting of 2 parallel strings of 4 round "size 25" cells in series
6F22	6		F	22						A zinc-carbon rectangular battery, consisting of 6 flat "size 22" cells. Equivalent to a PP3 or transistor battery.
6P222/162	6		P	222		162				A zinc-carbon battery, maximum dimensions: length 192 mm, width 113 mm, and height 162 mm. Consisting of 6 cells in series.
CR17345		C	R	17		345				A single-cell round lithium cell, 17 mm diameter, 34.5 mm height

ALKALINE VS ZINC CARBON

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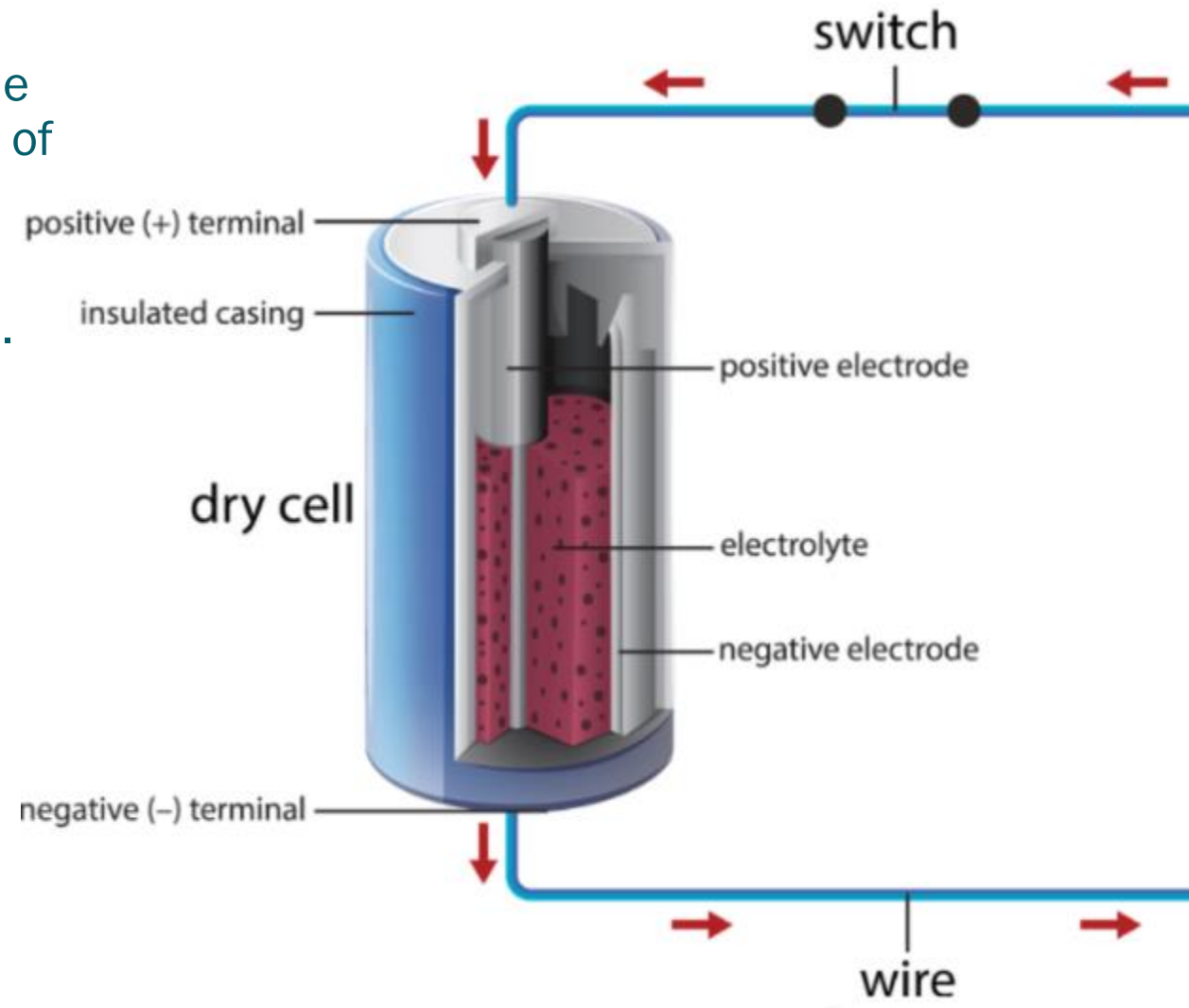
- The electrolyte of alkaline batteries consists of a concentrated aqueous solution of potassium hydroxide (KOH) to which zinc oxide is added to retard corrosion of the zinc.
- This electrolyte is alkaline (basic) in contrast to the electrolyte of regular zinc-carbon cells, which is acidic.
- Note: some old alkaline batteries may show traces of mercury -> to verify thru sampling!
- Although the active materials in alkaline cells are basically the same as in zinc carbon cells, the significant differences are in the electrolyte and cell construction.
- Check for Zinc Carbon marking
- **Processed with alkaline batteries anyway.**



LITHIUM PRIMARY

Lithium Primary are single use batteries:

- Cylinder, round, many shapes.
- Look for "Lithium" but may be indicated "Do not recharge"

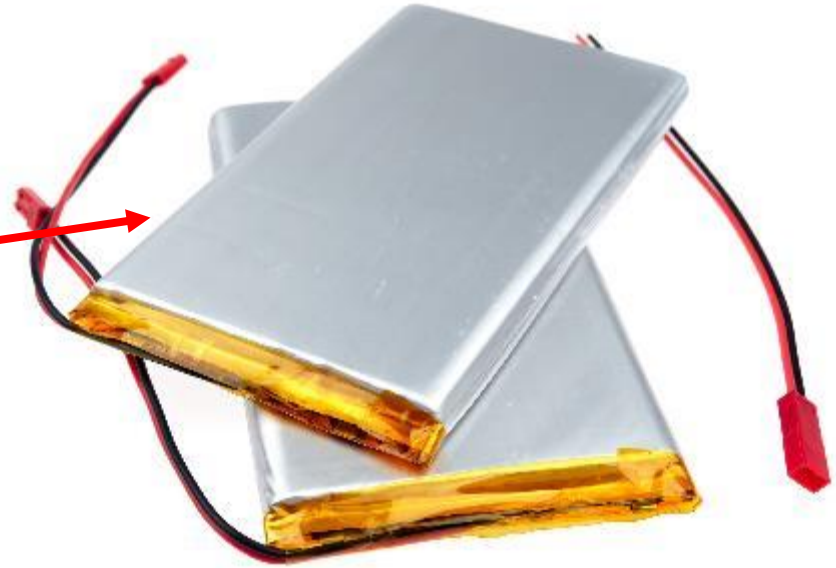
A special one:

- Lithium Thionyl Chloride (LiSOCL2)

Long life- low discharge one (10-20 yrs life)

LITHIUM SECONDARY

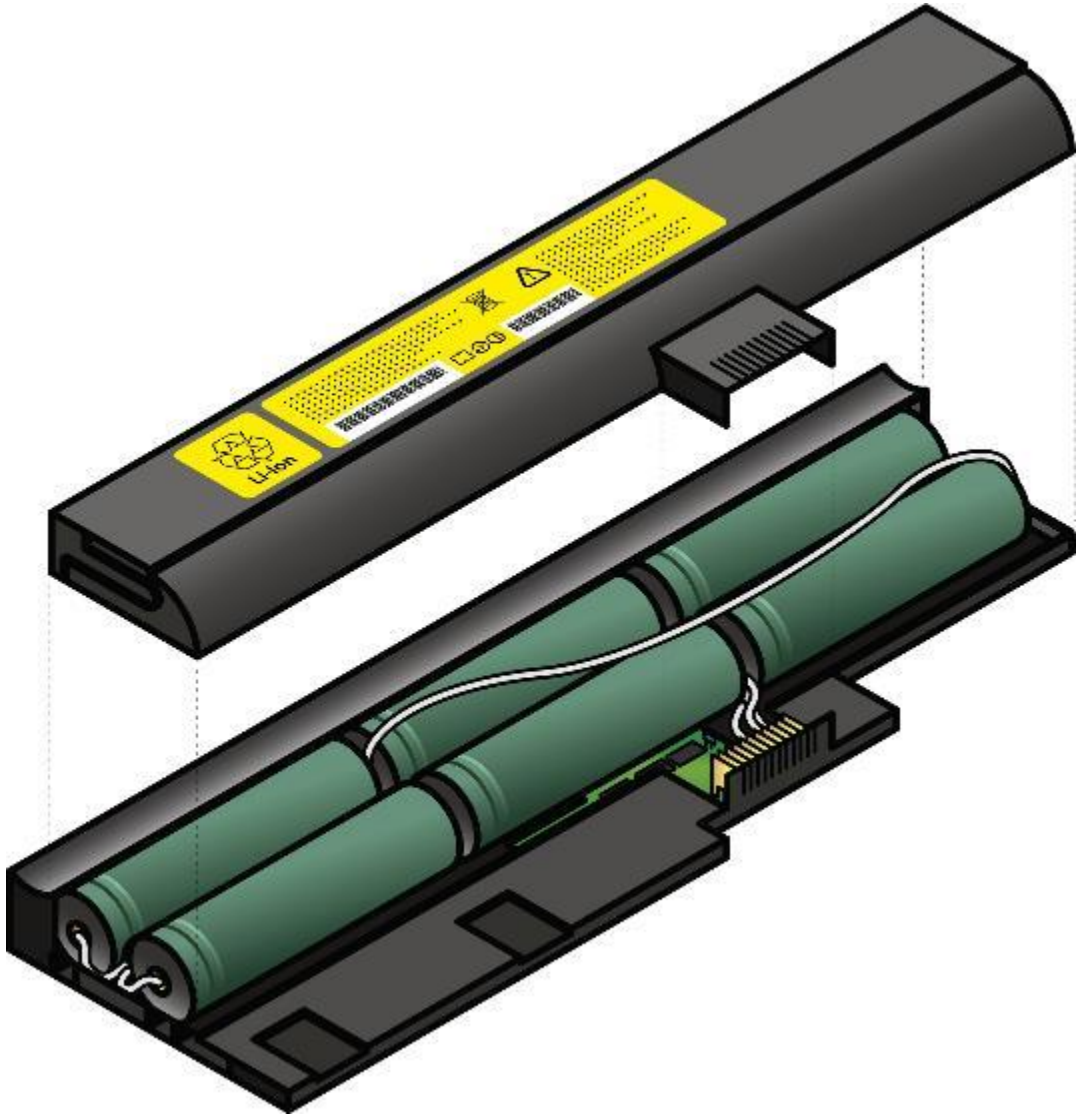
- There are nearly a dozen different chemistries of rechargeable.
- Lithium-Ion batteries, but we will be specifically talking about **Lithium-Ion Polymer** and **Lithium Ion** as groups.



hard shell

LITHIUM ION – INSIDE VIEW

- contains a small printed circuit board and cylindrical lithium batteries linked by contacts



DIFFERENCES IN LI- SECONDARY

- Lithium Ion Polymer cells tend to be thin rectangles in a silver bag.
- They are soft-shelled and have an easy to damage casing.
- They often weigh a little less and come in smaller capacity.
- These are often called:
  - Lithium Ion Polymer
  - Li-Poly
  - LiPoly
  - LiPo

- Lithium Ion cells tend to be either rectangular or cylindrical.
- They are hard-shelled with a strong casing. They often weigh a little more and have larger capacities but they are also more robust and are hard to puncture.
- They're often used for laptop batteries. These are often called:
  - Lithium Ion
  - Li-Ion
  - LiIon
  - LiCo (lithium cobalt, the anode chemistry)

- Despite the structural differences, you should treat them similarly and consider them as two versions of the same kind of battery.

LIFEPO4

- Lithium Iron Phosphate (LiFePO4), most common one used in off-grid solar applications and e-scooters.
- Normally clearly written on it.
- **LFP batteries are cobalt-free**

NON IDENTIFIABLE BATTERIES

PREVENT

- Rusty and damaged batteries for which you can’t identify if they are alkaline or lithium or NiMH.
- Batteries very old, that suffered of leaks or that were inadequately stored, facing moisture environment.
- If there are no possibilities of sorting them, usually they are mixed with alkaline batteries and shredded all together.

NON IDENTIFIABLE CASES - EXTRA EFFORT

- Alkaline head

- Li Primary head

NiMh head

- Rusty batteries can be sorted but they need an extra effort from you to allow this.
- Usually, they can be sorted because there are some slight differences (size, anode and cathode covers).

Images Getty Image, Duracell and EBAY

LET'S TRY

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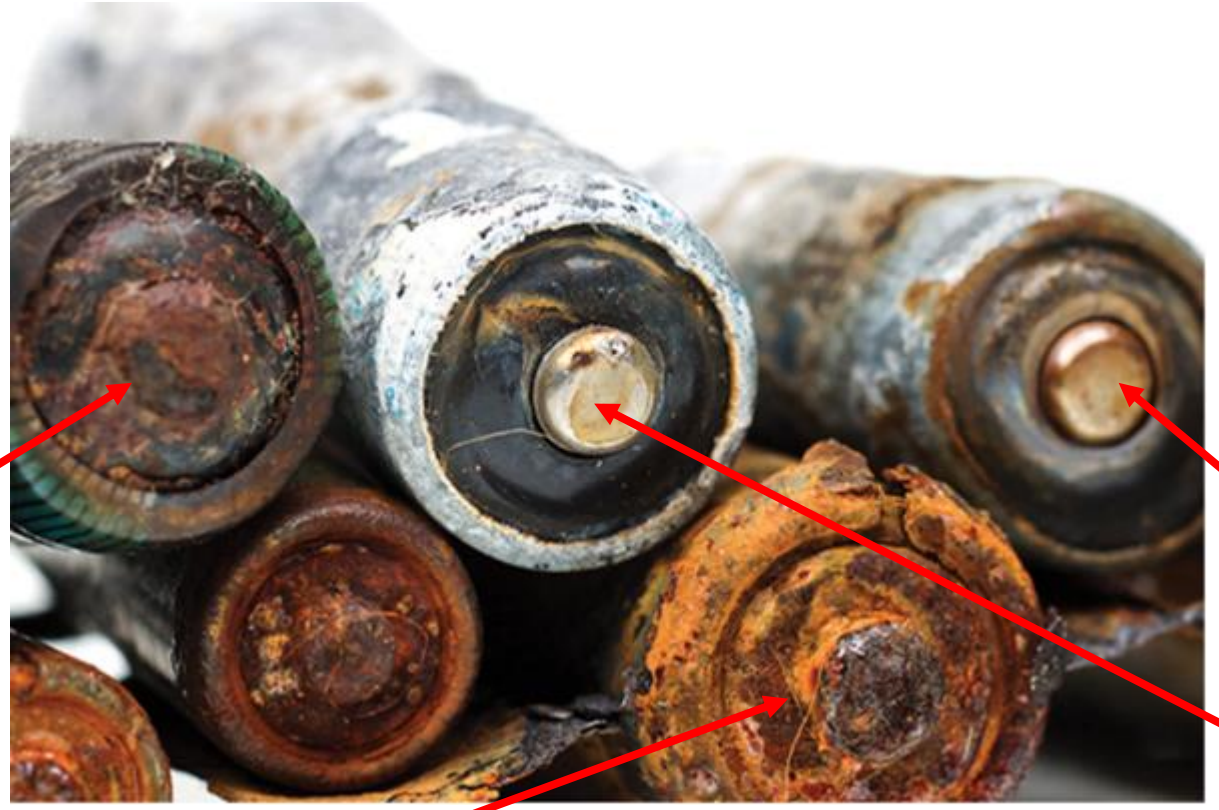
- primary



- secondary

Images: Getty , wastemanagementreview.com.au, EBAY

SPECIAL CASE: SORTING BUTTON CELLS

- Button cells are available in the same size under different manufacturer specific names.
- Can be differentiate by their letters and voltage.
- Silver oxide batteries contain 2–4% silver, which can be reutilized in the manufacturing of electronics.

Chemistry	Alkaline	Silver-Oxide	Zinc Air	Mercury-Oxide
Voltage	1.5V	1.55V	1.4 - 1.45V	1.35V
Notes			mostly used as hearing aid batteries	contains mercury; not in use anymore
Typical Labels	LR##, LR####, AG##	SR##, SR##SW, SR####SW, SG##	PR##, P###, Z###	MR##, MR####

LR-44

Image fr.rs-online.com

MRB 625

Image amazon

SORTING BUTTON CELLS

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- Lithium button/coin cells are mostly primary (non-rechargeable) 3V batteries.
- Their negative electrode is lithium, while positive electrode is either manganese-dioxide or carbon-monofluoride.

- **Manganese-dioxide lithium** batteries' labels start with “C”. Nominal voltage is **3.0 V.**

- Carbon-monofluoride lithium batteries' labels start with “B”. Nominal voltage is 2.8 V.

WHY SORTING IS GOOD FOR THE PLANET?

We saw that some batteries have potentially toxic metals in them such as cadmium, lead and, historically, mercury. Why is sorting good?

- Diverting these metals from nature, landfill and recycling them instead is important to ensure that the metals don't leak out of landfills and pollute drinking water sources.
- Most batteries can be recycled, which means potentially valuable material, particularly metals, can be reclaimed from them.
- Recycling batteries minimizes the need to mine virgin resources and protect the habitat.
- Reduce carbon footprint of manufacturing process.

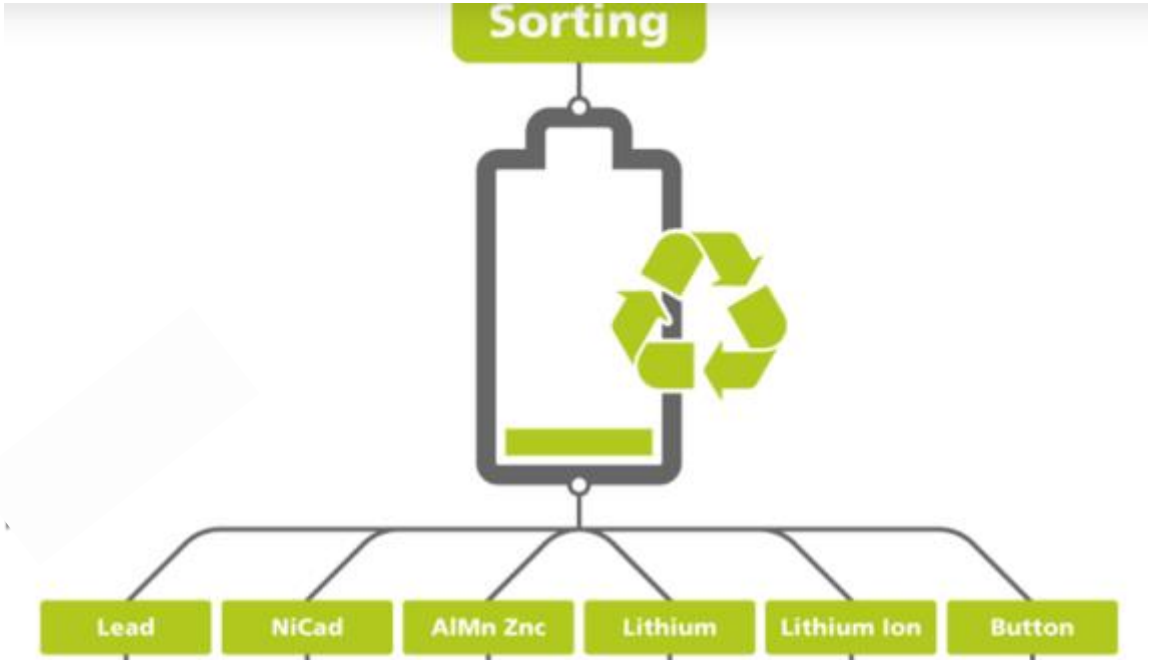


Image ERP UK

OK, NOW I KNOW HOW TO IDENTIFY DIFFERENT TYPES OF BATTERY. NOW WHAT?

PREVENT

- What can I do with different volumes?
  - 10 tonnes of lead acid batteries is easier to manage than 10 tonnes of mixed batteries. Less working steps
  - 10 tonnes a year or 833 kg /month ?
  - 100 tonnes a year or 8.3 tonnes/ month ?
  - 1000s tonnes a year or 83 tonnes/month ?
    - Ex: basic set-up : the rate for sorting strongly depends on the “quality” of the incoming batteries, it means that a mix of batteries could be sorted between 0.5 to 2 Tons/shift per man.

kg/month		833	8300	83000
20 days/month	per day	42	415	4150
8 hours / day	per hour	5	52	519

- What technology makes sense when?
  - Many variables to establish a case.
  - Type of batteries, volumes, available storage capacity, loose, packed, dirty batteries?
  - Local processes and outlets?
  - Etc.

HOW TO SET UP A MANUAL SORTING PROCESS?

PREVENT

What do I need to sort batteries?

- Thankfully, **lead acid batteries** are easy to solve (but watch out for alkaline fence batteries pack that look similar)
- For mixed batteries: -> small quantities
  - Most of them could be alkalines. 70 to 80%
  - The challenge is to spot the non alkalines.
  - You need a table and boxes/ drums identified with the chemistry you want to sort.
  - You can drop/ throw them in boxes/ drums **except for Li-ion and Lead to avoid breakage.**
  - Watch out : May have some small Lead acid from UPS/ Alarm systems
- Staff pre-requisite: -> to be a good sorter
  - Good sight, able to distinct colors, shapes and small details
  - Reading knowledge is primordial
  - Good memory
  - Meticulous. Quality driven.
  - Judgment

HOW TO SET UP A MANUAL SORTING PROCESS?

- **Remember :** Throughout the battery sorting process, battery types are separated based on chemistries because each chemistry may have a different processing type of available downstream vendors.
  - Note: WBA recyclers are performing quality controls on the sorted WBA loads they receive.
- Debris, contamination and any other materials should be sent to safe and compliant processing and reclamation processes. Example: collection box on the street (danger => syringes, as collection boxes are often used as trash cans)
- Pertinent identification of containers and drums is needed..
- Establish procedure and guidance for employees based on local bat types.
- **Best practice:** Create posters for your staff based on chemistries.

HOW TO SET UP A MANUAL SORTING PROCESS?

- For larger quantities, feed a hopper that feeds a conveyor, where all non-alkaline batteries are removed.
- As alkaline and saline batteries may represent more than 75% of batteries, these are not removed from the conveyor. They will end up at the conveyor end in a large box, big bag or drum.
- Nickel-cadmium (NiCd), nickel-metal hydride (NiMH), small lead-acid batteries, Li Primary and secondary are removed from the conveyor belt.
- Conveyor with stop and go button, ideally.
- Some chemistry with critical metals are sorted for their positive price value.
- Positive value for : Lead Acid batteries, NiMh and Li-ion with cobalt.

Image Eurodieuze-

SORTING - CHEMISTRIES DISTRIBUTION - EU

PREVENT

- General Data Eu 2017
- Good habit to keep statistics on types, weight, quantities, level of impurities, and quantity of batteries difficult to be identified.
- See the annual trends, helps predict budget needed for treatment & potential incomes.

Alkaline/Zinc-Carbon	77.9%
Nickel-Cadmium	11.4%
Nickel-Metal Hydride	2.9%
Lithium-Ion Rechargeable	3.4%
Lead-Acid	1.4%
Lithium Primary Mixed	0.8%
Mixed Small Button	0.3%
Waste (Paper/Packaging)	1.4%
Industrial Batteries	0.7%
Mixed Batteries	100%

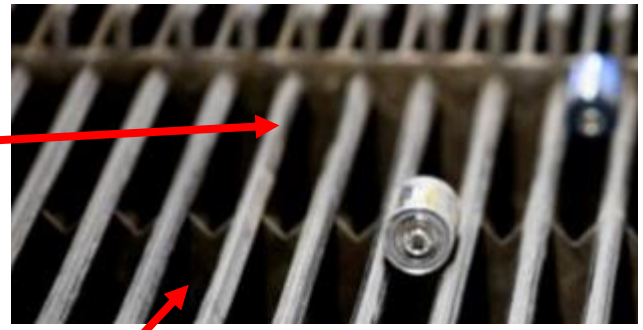
Data source Perchards study 2017

SORTING IDEAS FOR THE ENGINEER IN YOU

Mechanical sorting based on batteries physical properties or dimensions.

Examples:

- A metal grid over a hopper to capture large batteries.
- **Removal of button cells through interstices**
- Zinc batteries with a metal housing can be removed from the conveyor by means of rotating magnet.
- Vibrating screen and sorting according to their shape and size **by adjusting spacing between sorting bars.**



- The shapes and physical dimension can be used to design simple sorting tools.

SORTING- IF YOU HAVE BUDGET

Automatic Sorting

- Optical Lens with a High Speed Data processors
- Compare passing batteries with computer's images bank.

Or

- Can also detect the chemical composition of each cell based on dimensions, weight and magnetic resonance. (radio waves giving an insight of the internal composition)

- https://www.youtube.com/watch?v=kp1TEkf_kyE

- 500 kg/h capacity
- order of cost : 200 k€ +

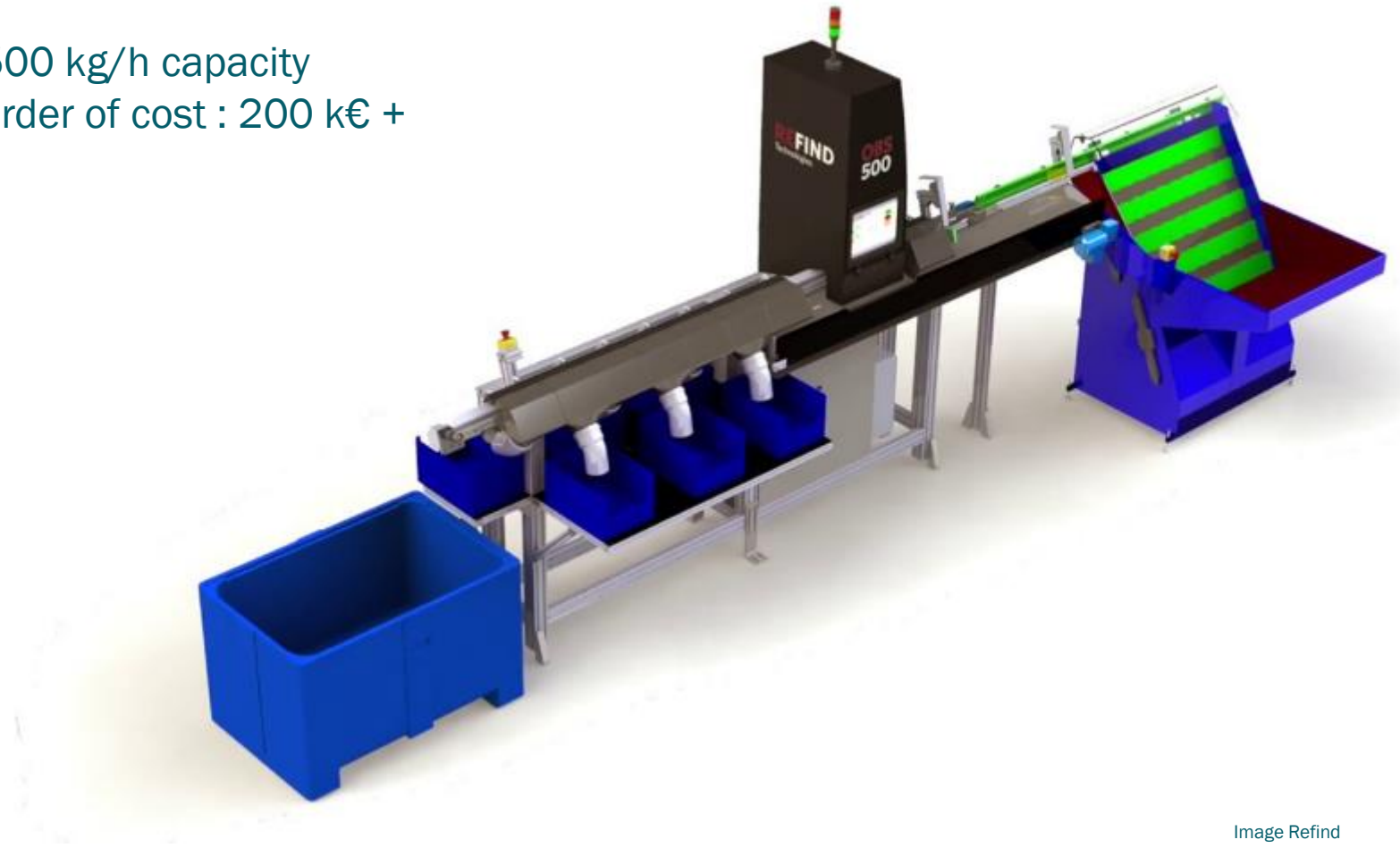


Image Refind

WE HAVE GONE UNTIL NOW THROUGH MANY TYPES OF BATTERIES AND WAYS TO IDENTIFY THEM.

PREVENT

Why is knowledge of chemistries so important?

EHS aspects: Know the risk for the environment and the safety of your employees.

Storage conditions	Handling conditions	Processing conditions	What could happen if?	Potential liabilities

Processing aspects:

Each type of cell and battery requires specific treatment technologies, and that's why meticulous sorting process is needed, to avoid contamination of process output fractions, which will lead to optimized recycling.

PRIORITISING BATTERY SORTING/ IDENTIFICATION

PREVENT

What is important to look at here?

- Chemistries present
- Risks associated

Separate into different types? Why?

- Avoid risks
- Increase value
- Based on market opportunities

What do I need to be aware of when I do this?

- Knowledge of chemistries-> identification tips
- Storage practice
- H&S practices for handling

PRIORITISING BATTERY SORTING/IDENTIFICATION

PREVENT

What is it important to be aware of in the market before launching yourself in this type of activity?	Should I collect all batteries and how?	What should I do from a business point of view?
• Local authorized processes for treatment • Opportunities for second-hand material recovery • Presence of competitors • Laws and regulations • Compliance scheme for WBA (EPR) • Grant opportunities • Collection methods	• Batteries may arrive mixed • Your decision depends on the market, opportunities and risks. • Do you need to organise a network for collection?	• Estimate volumes • Get pricing and cost for each chemistry • Evaluate if sufficient infrastructures and manpower • Estimate operating costs • Estimate potential turnover • Get environmental permits for foreseen activities

PRIORITISING BATTERY SORTING/IDENTIFICATION

PREVENT

Most common batteries will depend on what you are collecting.

- From offices? -> probably rechargeable ones
- From stores? -> portables single used -> **alkaline batteries, mixed**
- From garages or industries -> Lead acid
- **From e-waste recyclers? Mixed**

Volumes?

- Small, justifying one operator?
- Medium, justifying a trained TEAM?
- Large, justifying a process?

Where am I going to have profit or losses?

- Profit : metals and CRM (cobalt- nickel)
- Losses : hazardous waste management related

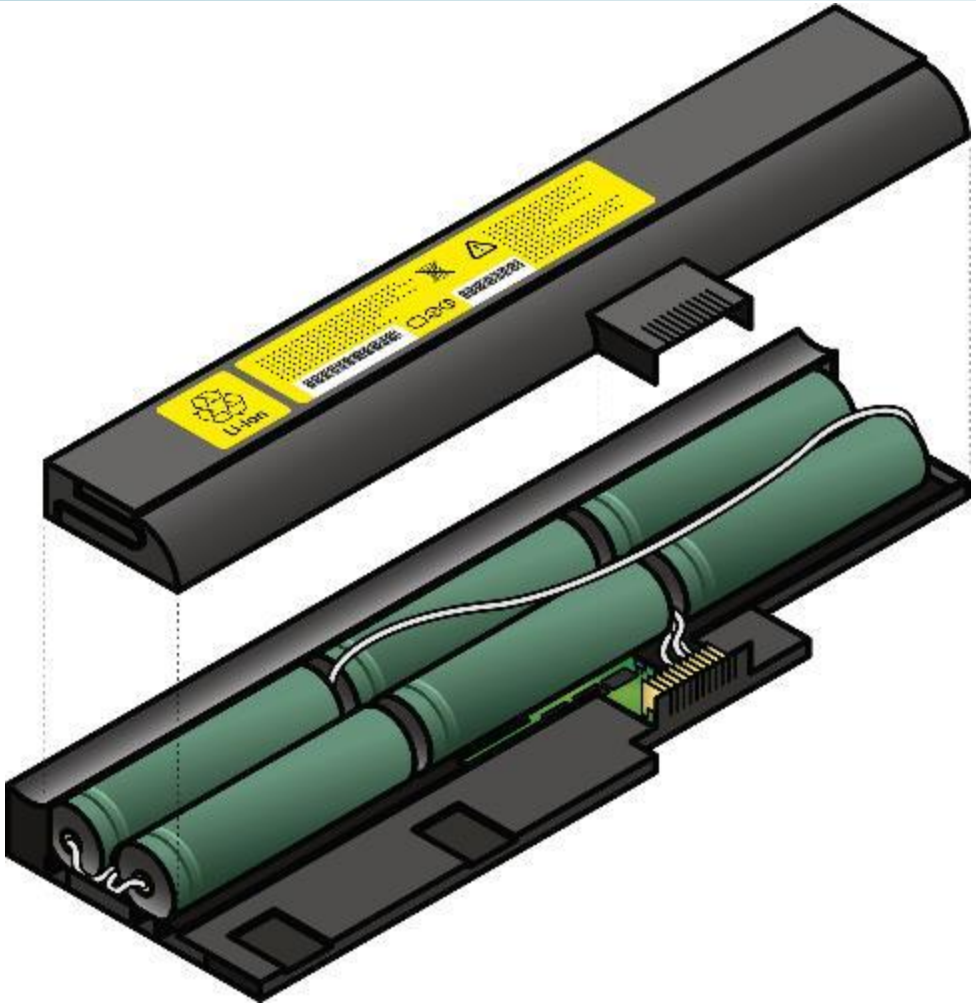
What is most hazardous? How can you contribute to reduce pollution?

- Lead and sulfuric acid in Lead acid
- Cadmium in NiCd
- Mercury, if present in **alkaline batteries**

Questions on sorting and identification?

LET'S TALK ABOUT LITHIUM

PREVENT



WE KNOW HOW TO IDENTIFY DIFFERENT TYPES OF BATTERY. NOW WHAT BY MAIN CATEGORIES

PREVENT

For Lithium-Ion batteries:

Lithium-ion batteries come in a variety of sizes and shapes, and often are not designed to be disassembled.

Good cells may be reused and repurposed. -> Testing?

Dead cells need to be recycled:

- If possible : - > correct packaging and then export according to Basel to specialized enterprise that will extract the most of it.

ALTERNATIVE: SHREDDING LOCALLY

PREVENT

But if not possible to export due to local issues ->

Alternative is shredding to get main constituents:

- Black mass and metals.
- Black mass to be exported.
- But risks of fire (watch YouTube videos on Li shredding)
- You may have to immerse fractions for a while but then the issue of water management and handling wet material will need to be considered.

WE KNOW HOW TO IDENTIFY DIFFERENT TYPES OF BATTERY. NOW WHAT BY MAIN CATEGORIES

PREVENT

Lithium Ion batteries are generally recycled in processes that separate them into these end products:

- cobalt and lithium salt concentrate;
- stainless steel;
- and copper, aluminum, and plastic.

IN THE EU: HYDROMETALLURGY

Rechargeable lithium systems (Li ion or Li polymer) are processed to recover the metal content, in particular cobalt, nickel and copper).

They go through a shredding process where steel, copper and aluminum are separated. Shredding may occur in liquid phase to avoid fire

Also recovered, the non-metal fraction (mainly polymers) which is sent for polymer recycling.

The black mass can be sent to thermal or hydrometallurgical treatment for extraction of the valuable metals, like cobalt, through sludges filtration, in the filter cake.

Huge plants with major investments.

WE KNOW HOW TO IDENTIFY DIFFERENT TYPES OF BATTERY. NOW WHAT BY MAIN CATEGORIES

PREVENT

Landfilling or dumping these batteries is not recommended.

Cobalt, copper, and other metals found in lithium-ion batteries can readily leak out from the casing of buried batteries and contaminate soil and groundwater.

Not talking here of the eventual fires that may occur. Sleeping bomb!

LITHIUM ION STORAGE ASPECTS

PREVENT

- Don’t keep inside your building drums containing damaged lithium batteries but protect it from moisture and rain.
- Ideally stored in a metallic drum with HDPE internal layer, in an area far from combustibles material, in a weatherproof area.
- Get the load to hazardous waste treatment site through authorized and specialized carriers, if possible.
- Drums containing lithium batteries may release volatile hydrocarbon emissions. Better to avoid smoking in the area.
- Temperature monitoring by infrared reader every time drums are moved is recommended. Look for hot spot!

Risky situation in above image. Why?

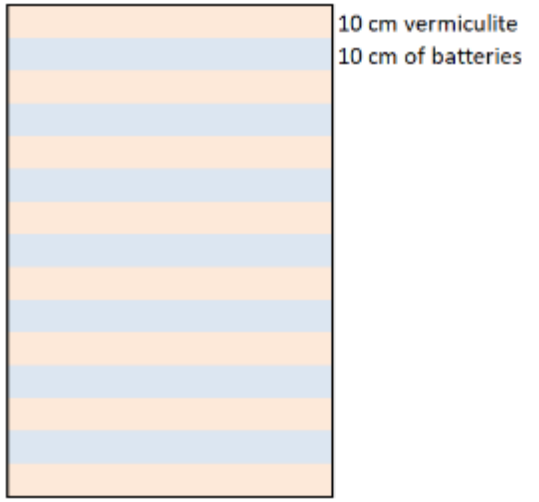
STORAGE OF LITHIUM BATTERIES

PREVENT

- In metallic drums with HPDE bag.
- Separated by dry media, such as dry sand or vermiculite, that will help avoid contacts and movement of batteries.
- Hard to find dry sand of quality. Weight issue. (could be 25% of the weight) and not easy to keep dry.
- Damaged batteries in plastic bags.
- Ideally, avoid arc creation and tape contacts.
- Stored away from combustible material.
- Avoid moisture and rain.
- Avoid physical shock that could lead to breakage.
- Special emergency measures shall be in place to control sudden metal blaze.

Image Channel News

- Example with vermiculite in a metal drum homologated class II with a bag of 200µm thickness
- Ideally a metal drum in case of fire.
- Vermiculite top and bottom to avoid contacts and absorb chocks.
- Batteries layered



DAMAGED LITHIUM BATTERIES

PREVENT

- A corroded or bloated lithium battery is highly dangerous.
- For safe storage while awaiting proper disposal, place the battery in a container of dry sand or another chemically-inert cushioning material, like cat litter or vermiculite.

- Improper storage and transportation can lead to fires or even escalate to an explosion.
- Lithium-ion batteries that are damaged can also release toxins into the air so must be isolated immediately for everyone's safety.

LITHIUM ION EMERGENCY SITUATIONS MANAGEMENT

PREVENT

If a battery is punctured and starts to burn:

- Probably too late to get it outside to let it burn in an open space.
- One of the methods for the disposal of the battery is to submerge it in the tub of water. For this purpose, saltwater will be used. The quantity should be one cup of salt per gallon of water.
- Do not disturb the battery for a few days and keep it in the water. Do not dispose of it in the trash as it may be hazardous.

- Stay away from it when it burns as toxic gas may be released.

- Glued batteries in cell phones are a fire risk, when trying to force them out. DANGER for the employee.

EMERGENCY SITUATIONS MANAGEMENT

PREVENT

- Also, can be used, as per picture, Lith-EX , extinguishers designed for Lithium batteries. Class A E

Battery Type	Fire Involving Batteries
Lithium (primary, non-rechargeable)	Use Class D extinguishing agent with copper powder DO NOT use water A Class D fire extinguisher is **used on combustible metals**, such as magnesium, titanium, sodium, etc., which require an extinguishing medium that does not react with the burning metal.
Lithium-Ion (secondary, rechargeable)	Use an ABC dry chemical fire extinguisher or water hose Fight the fire based on fuelling material An extinguisher with an ABC rating is suitable for **energized electrical equipment.**

Image Safelincs

WHEN IT GOES BAD!

- An example here of why good battery sorting per type is important.
- For example, shredding a lithium battery with a batch of alkaline could cause a fire event.
- Or puncturing a li-ion polymer battery, can lead to a major blaze.

- See here further guidance: Recommendations for tackling fires caused by lithium batteries in WEEE

REUSE AND REPURPOSING OF LITHIUM ION BATTERIES

PREVENT

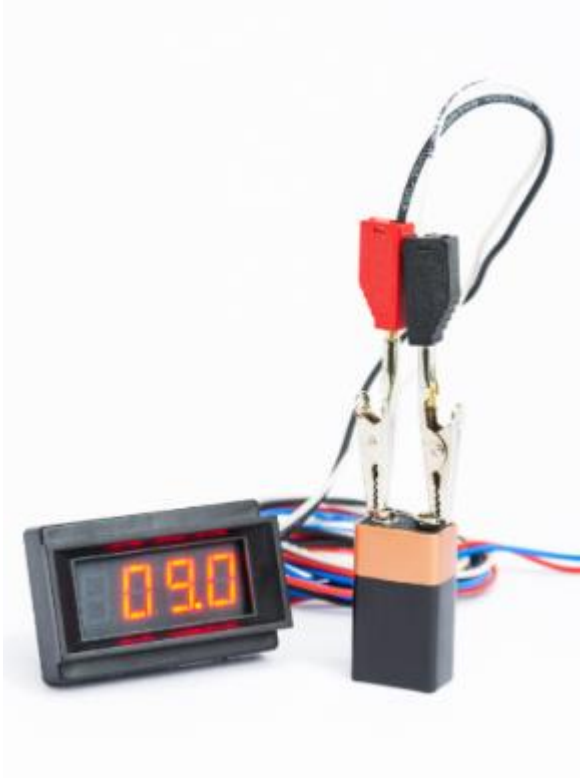
Storage for re-use:

- Batteries should be stored away from **sunlight, heat, and humidity**.
- Keep the storage area ventilated and dry, and maintain a relatively steady temperature.
- The ideal battery storage temperature is around 15°C, but room temperature is fine.

REUSE FOR SUSTAINABILITY

PREVENT

- Testing for reuse / remarketing
- Invest in a multimeter for approximatively 18€ on the web that will allow you to verify the residual current in all types of batteries.



SAVE THE GOOD ONES

PREVENT

Primary batteries

- Applicable to alkaline and saline with acceptable look and state.
- Invest in multi size testing unit with LED display. Easy to find on the web stores. Pricing range from 2,5€ to 15€.
- Some studies show that approximatively 30% of batteries are in « Good » status. Peoples are throwing away good batteries.

Voltage AAA, AA,C,D	Status	Actions
< 1,2 V	Weak	Discard
1,2 V to 1,3 V	Average	Use in low consumption equipment
> 1,3 V	Good	Remarket

Some batteries have Powercheck feature allowing knowledge of cell status.

Images cdiscount, ali express

RECHARGE AND REUSE FOR SUSTAINABILITY

PREVENT

- For non rechargeable batteries:
- Regenbox.org (France)
- Regenbox was created based on an old patent from 1980 that fell into the public domain. (Namely:Ray-O-Vac Renewal)
- Slow regeneration of chemical elements by micro impulsion of current.
- Build it yourself, but 96€
- Does it work?

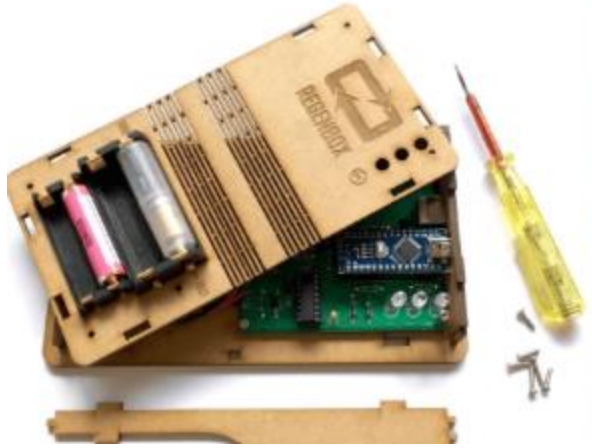


Image regenbox.org

RECHARGE AND REUSE FOR SUSTAINABILITY

Some enterprises from China have developed chargers for non-rechargeable batteries;

- Pricing around 15€.
- Many different models.

Web experience feedback on it:

Applicable for alkaline (not saline) in good state.

- Residual current must be around 1,2 V.
  If voltage is too weak, battery will not last.
- Subsequent new life in hours are lower and depleting charge after charge
- Can be recharged approx. 3 times, not more based on manufacturer comments
- ISSUES: Overcharging, causes batteries to leak, sometimes days after.
- Conclusion: could be risky

Image Madeinchina.com

RECHARGE AND REUSE FOR SUSTAINABILITY

PREVENT

Secondary Batteries

- If cylinder type rechargeable accumulators are collected, it is worthy to check if they still work well.
- Select only the ones in good shape.
- Charger and testing units for rechargeable batteries type AA and AAA, easy to find on the web for approximatively 18€.
- Discard the ones not accepting the charge process.
- Remarket or reuse the other ones.
- CAUTION: **Do not attempt to recharge non rechargeable batteries with these chargers.**

Image ali express

REPURPOSING FOR SUSTAINABILITY

- Batteries recovered from WEEE are tested individually. Those passing controls are assembled in new products.

- https://www.aceleronenergy.com/
- https://brillpower.com/
- https://www.powervault.co.uk/

- And many other companies involved in repurposing of EOL batteries from Electric Vehicles.

- Safety and quality standards in development/should be applied!

AFRICAN PILOT PROJECT 2021

PREVENT

- An African recycler in the scope of this pilot project has a stockpile of 60t of waste LIB.
- The goal here is to find an economic and ecological solution which can be readily replicated in other countries with similar waste fraction

Challenge no.1

- The batteries were not sorted.
- First step: sort in order to understand the composition and value of the battery stock.

Sorting advice given - nominal voltage measurements:

- LFP conventionally have a nominal voltage of 3.2V and multiples of these (6.4 V, 9.6 V, 12.8 V, 25.6 V)
- LCO have a nominal voltage of ~ 3.6 and multiples of these (7.2 V, 10.8 V, 14.4 V, 18 V

AFRICAN PILOT PROJECT 2021

PREVENT

Results of sorting 60t of batteries:

- Only **2 t** lithium cobalt oxide (LCO) batteries, mostly from notebooks,
- **58 t** are Lithium-Iron-Phosphate (LFP) batteries from solar energy storage units.

- Waste LCO batteries generally have a positive treatment value because of the cobalt content.
- This is not the case with LFP batteries as they have no retrievable material in the process of recycling. They represent only a cost factor.
- The cost factors linked to the LFP batteries are logistics (~3 500€/ 20ft container) plus a treatment fee (~1 000€/t).
- As per our simulation, the economic value of LCO cannot finance the shipment and treatment of the entire battery mix → **another solution is needed**

AFRICAN PILOT PROJECT 2021

PREVENT

- Recycling of EOL LFP batteries in Europe is cost intensive
- Repurposing was considered with a European partner specialized in battery refurbishing. The company has experience and growing operation in East Africa
- In order to evaluate the technical health of the batteries on stock, 300 cells were tested by the African recycler using SkyRC MC3000, a charger.
- Although the test results were generally positive, a more robust and detailed testing was judged necessary. This can only be executed at the repurposing partner's facility using their technical infrastructure.
- Upon a successful test, repurposing equipment will be deployed at the recycler's facility to repurpose the remaining load.

Challenge no.2: shipping batteries for further testing

- Basel notification process between 2 countries to send EOL batteries (hazardous waste) to repurposing partner is necessary
- The process is long.

AFRICAN PILOT PROJECT 2021

PREVENT

Potential gains from the repurposing project

Economical aspects:

- The market or economic value of LFP battery pack is:
  - ~ USD 68 to USD 520 ->refurbished
  - ~ USD 140 to USD 800 ->brand new

  The dependent factors are size (134 o 24 cells per pack) and the normal capacity.
- A cell averagely weighs 75g.

  Assuming that 60% of the cells in the 58t stock can be repurposed, the project brings positive value.

Ecological aspects:

- The revenue generated can partially finance the logistics and treatment of the non-repurposed 40%.
- This is an option of investigation of the plausibility of using part of the funds to finance the final take back of refurbished cells at their final EOL.
- A conclusive opinion here will only depend upon the quality of the total battery mix.
- Still need to find a management option at end of life once these cells are completely dead!

Questions on Lithium Ion batteries?

LET'S TALK ABOUT LEAD ACID!

PREVENT

LEAD ACID POLLUTION ISSUES

- Most polluting industry in the world according to "Pure Earth"... leads to 800 million children suffering from lead poisoning worldwide. You do not want your batteries to contribute to this -> death sentence for workers and local community if ends up in wrong hands.
- We know that most recyclers will not be able to engage in recycling this type of batteries directly, as an environmentally friendly rotary furnace facility costs from 4 Million Euros upwards.
- If you have a downstream partner, you need to make sure they are not engaging in malpractice. Not simply a question of selling to the highest bidder, as in unregulated markets, the highest bidder could be extremely polluting
- Duty of Care rules should be the rule!

(pureearth.org)

WE KNOW HOW TO IDENTIFY DIFFERENT TYPES OF BATTERY. NOW WHAT BY MAIN CATEGORIES

PREVENT

- Acid batteries can be correctly packaged and sent to lead smelter meeting international requirements.
- You need to perform Duty of Care to ensure that any lead offtaker meets such standards. *(Duty of Care topic later in the next slides)*
- *The carrier, the shipper, and the end receiver.*
- If you don‘t have these facilities in your country, then you may need to safely store these and look for export options or develop a process that meets EH&S principles, but we already said it is "€€€€€€€".
- We all shall aim to avoid this.

WHAT IS THE PROCESS? WHAT CAN BE DONE WITH LEAD BATTERIES FRACTIONS ?

PREVENT

Lead acid batteries are crushed into pieces, the broken battery is then placed into a vat. The lead and heavy materials fall to the bottom and the plastic floats. The polypropylene pieces are then brushed aside and separated from the lead and heavy metals. Each of the materials then goes into its separate recycling “stream”.

The plastic polypropylene pieces are washed and then melted into a liquid state. When the liquid hardens the plastic is then turned into smaller plastic pellets and the cycle restarts as these pellets are then used for manufacturing other battery cases.

The lead parts of the battery are melted to separate the impurities from the ingots. The impurities get swept away while the ingots such as gold or steel are sent back for manufacturing of new batteries.

Sulfuric acid is the last material to be dealt with when recycling lead acid batteries. Firstly, you can neutralize the acid with an industrial compound similar to baking soda, and this neutralization will turn the acid into water.

The water is then tested and treated by a water treatment plant to be sure it meets standards of clean water.

The second way to recycle the sulfuric acid is to convert the acid to sodium sulfateby using caustic soda. Sodium sulfate is an odorless powder that is used in detergent and textile manufacturing but also to produce fertilizers.

LEAD ACID RECYCLING PROCESS - LINGOTS

PREVENT

The process is to melt and reduce lead compounds into metal, and then to refine this metal for new applications, like batteries.

Contrary to other recycled products, lead quality is not lowered through secondary smelting, and is of the same high grade as lead from primary smelting

HOW TO CARRY OUT DUTY OF CARE OF YOUR DOWNSTREAM OPERATORS?

PREVENT

Points of control: (playing large)

- Permit verification (transport, storage, treatment)
- Capacity to accept additional volume
- Measurement tools (scale calibration)
- Proof of destruction (documents, evidences)
- Storage practices before treatment
- Processing: % of recycling, % of residues
- Nature of residual waste, contamination level, destination (dowsntream vendors approved by authorities, safe handling and destruction/ disposal procedures.)
- Emissions: gaseous/ aqueous: Proof of monitoring and compliance

HOW TO CARRY OUT DUTY OF CARE OF YOUR DOWNSTREAM OPERATORS?

PREVENT

- Chimneys have monitoring devices with maintenance
- Emissions abatement devices, description & maintenance
- PPE used by employees (respiratory protection, gloves, heat / burns protection)
- Health monitoring aspect (do they care about peoples)
- Product and residues storage containment
- Emergency plan (accident, fire, explosions, releases)
- Communications with surrounding communities
- Environmental impact study - Presence of aquifer in the area, animal reserves, agricultural fields.
- Do they have a process for changes management? (HAZOP studies)

HOW TO COPE WITH DAMAGED LEAD ACID BATTERIES ?

PREVENT

- Batteries and any other types of waste that could potentially contribute chemicals to the environment should be handled with care.
- Contact with battery acid can cause chemical burns. The sulfuric acid (electrolyte) in batteries is highly corrosive. .. it can damage clothing, irritate the skin, and cause metallic corrosion if left uncleaned.
- These types of burns might not show up right away. It can take several minutes or hours for symptoms to start to appear.
- Always practice good hygiene and wash your hands after handling a battery and before eating. If you handle the lead plates in a battery and don't wash your hands properly, you could be exposed to lead.

- Keep away from mouth an eyes.
- Be sure to have adequate non-perforated rubber gloves when handling any batteries showing evidence of leak.
- Wash the gloves with water and avoid projection on others.
- Safety shower is always a good thing to have (or source of abundant water) in case of acid spraying.

PROTECT YOUR EMPLOYEES

PREVENT

- Batteries and any other types of waste that could potentially contribute chemicals to the environment should be handled with care.

Standard Personal Protective Equipment (PPE) suggested includes:

- Gloves and apron (perforation and acid resistant)
- Integral safety glasses (with side protection)
- Safety shoes (acid resistant)
- Company clothes
- Safety helmet if any batteries movements occur above employees' height in the workplace.

EMERGENCY SITUATIONS MANAGEMENT

The enterprise should establish plans to face these typical emergency situations:

- Acid spraying or contact with body parts
- Leaks management.
- Neutralization with sodium bicarbonate.
- Caustic soda is risky, heat generation, but also risk for handling. Preferably Sodium Bicarbonate.

With training and drills.

Caution

- Wear approved gloves when touching the electrolyte. On exposure to skin, flush with water immediately, for 15 to 30 minutes.
- If eye exposure occurs, flush with water for 15 minutes and consult a physician immediately.

HANDLING, STORAGE AND SHIPPING

PREVENT

- Don’t stock Lead acid batteries on pallets/ may fall and spill.
- Use containers that are sound, sealable and not damaged or leaking
- Label containers according to the local requirements.
- Use sealed plastic containers, avoid storage outside under rain. Covered area or sealed cover
- Protect from the weather and physical damage.
- Keep the containers sealed or always closed.
- Will secure loads for future transport

Questions on Lead Acid Batteries?

LET'S TALK ABOUT PORTABLE BATTERIES

PREVENT

MANAGEMENT OPTIONS FOR MIXED SINGLES USE ALKALINE BATTERIES. SOME QUESTIONS?

PREVENT

Can I throw all these in a bucket/box without worrying about it? Alkalines, no problem.

Do they need to be fully discharged? No, but anyway generally plastic drums, big bags , plastics cages, metal drums with plastic inlay.

Can I send internationally if I don‘t have these? Yes, we have a list of proposed sites at the end.

What are the main separations I should aim for? Steel & black mass if not sent to cast iron production as a whole unit.

WE KNOW HOW TO IDENTIFY DIFFERENT TYPES OF BATTERY. NOW WHAT BY MAIN CATEGORIES

PREVENT

Button cells and single use alkaline batteries:

Where can they be sent ?

Button cells and Alkaline can go through thermal process. An issue is the potential presence of mercury. System shall be able to recover any emissions of it.

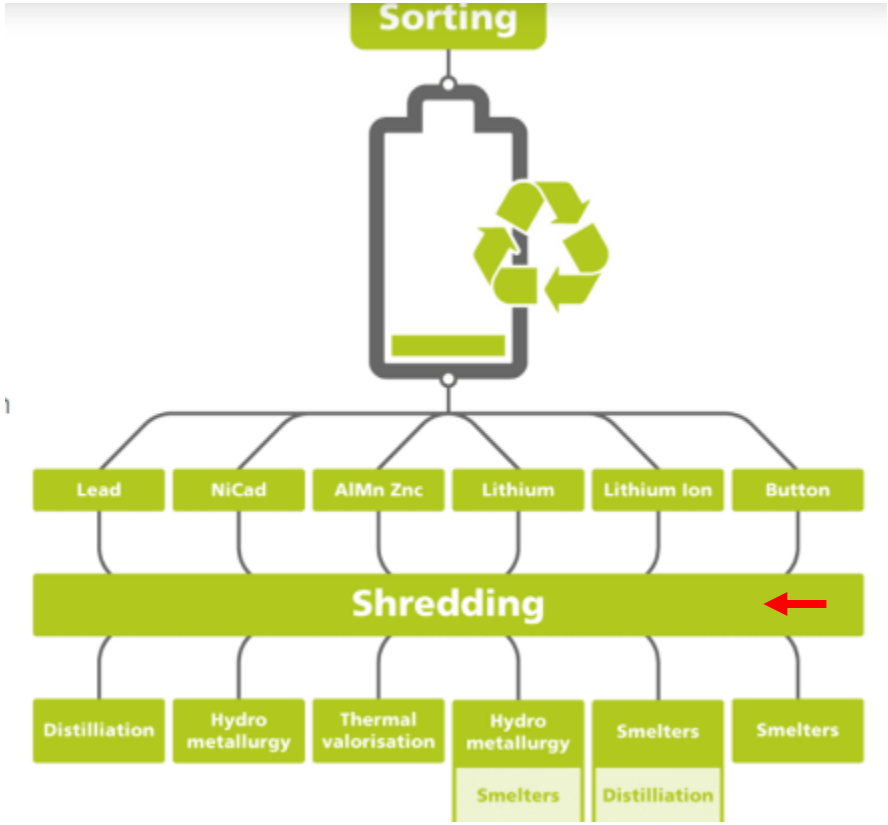
Pyrolisis treatment or cast-iron production can be used (in special conditions)

You can also shred to extract metals from black mass. And have the black mass used in a metal recovery process.

SHREDDING PROCESS OF ALKALINE BATTERIES- FACTS

PREVENT

- Mechanical process to grind the batteries into three different products; a paper/plastic fraction, a steel fraction, and a zinc-manganese concentrate.
- The zinc manganese concentrate can be used as a micronutrient in fertilizer to improve soil fertility! **But this needs to be managed with fertilizers producers to have the proper recipe.**



- Generally, paper and plastic can be used for energy recovery.
- Metals can be sent to foundries for transformation.
- The zinc manganese can be processed for zinc recovery.
- Shredding needs to be done in closed controlled atmosphere:
  - Black fine powder released
  - Strong and irritating ammonia odor released.
  - Fire detection system with Nitrogen or water releases in case of spark for large units

A shredder cost approx. 1,8million EUR for the Alkaline/ ZnC processing with a treatment capacity 2,500kg/h.

SHREDDING – ALKALINE BATTERIES- MORE FACTS

PREVENT

The general way to clean the air stream emitted from the process and loaded with dust particles is the bag filters system, allowing high surface of contact to allow capture of dust particles and high velocity and air flow rate.

The air extracted from the shredding process, after particles removal can be washed in a scrubber system or passed through a carbon bed system that will get saturated over time.

After shredding, there is generally a magnetic separation system that will allow removal of all **ferrous fractions, around 16% of the mass**, to be sent to recycling and generally sold on the scrap metal market.

Some **nonferrous metal** can also be removed by electromagnetic separation and represents around **5% of the mass.**

SHREDDING – ALKALINE BATTERIES

Through vibration tables and/ or sieves, **plastics, and paper fractions, which represent around 2% of the mass** will be separated from the black mass, and sent to energy recovery as a best practice, or landfilled.

Finally, the black mass needs to find a final processor. The black mass is composed mainly of Zinc, **Manganese and Carbone** that are mixed, and represents around **65% of the mass of the battery.**

INNOVATIVE WAYS FOR ALKALINE BATTERIES RECYCLING- GOOD OPTIONS?

PREVENT

- Black Mass can be used for fertilizers production.
- Purchased at positive price by some societies:
  - http://cameronmicronutrients.com/index.html
  - https://www.tracegrow.com/
  - https://envirostream.com.au/

- Entire unprocessed batteries can be used for cast iron production in specific conditions.
- BAT'RING process, developed by ECO'RING, that generates cast iron brake pads, disks and motor parts for companies such as SCANIA, VOLVO and DAIMLER.
  - Done in France by FIDAY Gestion. http://www.fidaygestion.com/
  - https://www.youtube.com/watch?v=P21qe9y-PKU
  - https://www.youtube.com/watch?v=iJsKWz89QqE

OTHERWISE IN THE EU, PYROMETALLURGY

PREVENT

In WAELZ oven where entire alkaline batteries can also be fed with or without a pre-shredding step into a pyrolysis melting furnace at 700 °C.	Mercury is volatilized and recovered through condensation process.	Metal separation is carried out in an induction furnace by an oxidation-reduction reaction at 1500 °C.	Iron and manganese remain in liquid form.
The high temperature causes manganese to combine with the remaining iron components, producing ferromanganese.	The heat in the oven vaporizes organics, potassium, carbon, and zinc.	Zinc is contained in the flying ashes.	From it, are extracted a ferrous fraction and a nonferrous fraction that are recycled, and a slag that is used for fiber glass production or road aggregates.

OR WHAT ABOUT HYDROMETALLURGY?

PREVENT

- The black mass is subject to leaching which is a process aimed at extracting a solute from a solid with the aid of a suitable solvent and typically by acidic physicochemical treatment, to separate elements.
- Commonly used acids include sulfuric acid, hydrochloric acid or organic acids.
- Metals can be separated from one another by :
  - altering pH of the solution,
  - adding reaction agents to precipitate metallic salts,
  - electrolysis,
  - and liquid-liquid extraction steps

HYDROMETALLURGY

PREVENT

- The most probable reactions for manganese and zinc dissolved with sulfuric acid are the following:
  - $ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O$
  - $Mn_2O_3 + H_2SO_4 \rightarrow MnSO_4 + MnO_2 + H_2O$
  - When batteries are discharged, there is also presence if Mn_3O_4, which will also lead to an additional reaction possibility.
  - $Mn_3O_4 + 2H_2SO_4 \rightarrow 2MnSO_4 + MnO_2 + 2H_2O$
- There is not one defined hydrometallurgical process used but many possible processes with variations depending on local engineering teams decisions
- ZNSO4 -> Dye, fertilizers, synthetic textiles, medication, food for animals, metal treatment
- MNSO4-> By electrolysis, get MnO2 -> new batteries

HOW TO COPE WITH DAMAGED ALKALINE BATTERIES? WHAT TO DO WITH THEM?

PREVENT

Use gloves to handle them:

If batteries have a white or have rusty coloured powder on the terminals, handle them with latex or nitrile gloves, since this wet powder can burn your skin.

May I put them with all the other batteries? Yes

Do I need to isolate them? No, they will be shredded anyway.

Should I discharge them? Not necessarily .

What if I touch it? Chemical burn like caustic soda. Red skin. Irritation.

What needs to be at hand to avoid problems? Eye wash stations in case you put some in your eyes, gloves as mentioned above and a lavabo to wash hands.

AND FOR THE ONES WITH NICKEL, IN THE EU?

PREVENT

Generally for high level processes.

- **Nickel-Cadmium batteries** first are separated into metal and plastic components. The metals, such as iron, nickel, manganese, and chromium, get tossed into an essentially high melting point metal bath to separate from lower melting point metals like zinc and cadmium. Once separated the zinc and cadmium are then recycled with the plastics to be reused for new batteries.
- **Nickel Metal Hydride batteries** are removed from their cells. The cells go through a drying process to remove moisture (the potassium hydroxide electrolyte and H20) from the battery. During the drying process, the cells are heated in a time- and temperature-controlled manner. Once completely dried, the cells become valuable feedstock for stainless steel or alloy manufacturers.

COLLECTION AND HANDLING

- Batteries and any other types of waste that could potentially contribute chemicals to the environment should be handled with care.
- Use wooden pallets to keep the containers and batteries off the ground during transport.
- 4 drums per pallets, film wrapped or attached with plastic band.
- Mixed batteries in plastic drums.
- If only Lithium, liner bag 200 µm for metallic drums and vermiculite..

- Use containers that are sound, sealable and not damaged or leaking
- Label containers according to the local requirements.
- Keep the containers sealed or always closed.
- Protect from the weather and physical damage.

STORAGE BEST PRACTICES

PREVENT

- Establish a storage plan with identification of hazardous and risky waste.
- Share the storage plan with local fire brigade.
- Train personnel in the safe use, storage and shipping procedures for waste batteries. Only trained persons should have access to the storage area.

- Storage should be in a secure area with controlled access.
- Stock of waste batteries and accumulators should not exceed local limits
- **Reusing drums.** If you reuse drums that contained hazardous materials, they need to be cleaned, dried, and decontaminated.
- Rusty and damaged drums should not be used.
- If you clean drums on site, manage adequately the wastewater. This cannot be poured down a drain or disposed of with regular waste. You need to store the waste safely and have it taken away by environmental experts.

Questions on portable batteries?

GENERAL TOPICS - TRANSFER

PREVENT

CONDITIONING FOR TRANSFER

PREVENT

You can use 60 l drums, 120 l or 220 l.

For distance transport, the 220 l are the best.

Metal drums are usually 200-220 l, class II.

For lithium, as discussed, you also need vermiculite and an internal plastic bag.

Other containers are possible, see ADR packaging conditions. Depends of batteries capacities.

For NiMH and alkaline (only if sorted), the big bag is sufficient.

LEGAL ASPECTS FOR TRANSFER

Transfer of batteries must follow the control procedure based on Basel convention

The transportation of waste batteries to a recycling, treatment, disposal or management facility requires the proper classification packaging, labeling and manifests for the specific transport authority (air, marine, rail, road).

Mixed batteries are considered hazardous wastes.

Sorted batteries, it depends on the EWC number of the battery (see next slide).

Lithium ones are considered non-hazardous but need to be shipped by strict ADR rules

Please refer to: https://unece.org/transportdangerous-goods/adr-2021-files

ADR is the “Accord européen relatif au transport international des marchandises par route” in connection with “UN Recommendations on the Transport of Dangerous Goods”. These rules are law in the EU, and should be met if waste is transferred in the EU.

EUROPEAN WASTE CODES (EWC)

- **Before sorting:** 20 01 33* Mixed batteries with potential presence of hazardous waste
- **After sorting:** Batteries and accumulators
- **16 06 01*** Lead acid
- **16 06 02*** Nickel cadmium
- **16 06 03*** batteries containing mercury (Hg)
- **16 06 04** alkalines (other than 16 06 03*)
- **16 06 05** other batteries and accumulators (including NiMH and lithium ones)
- Note: more are under development

- Note: Batteries may also be classified as per local rules and ID codes. But if exported to EU, knowledge and use of EWC is necessary, for transfer documentation associated to procedures..

ANNEX VII FOR NON-HAZARDOUS WASTE

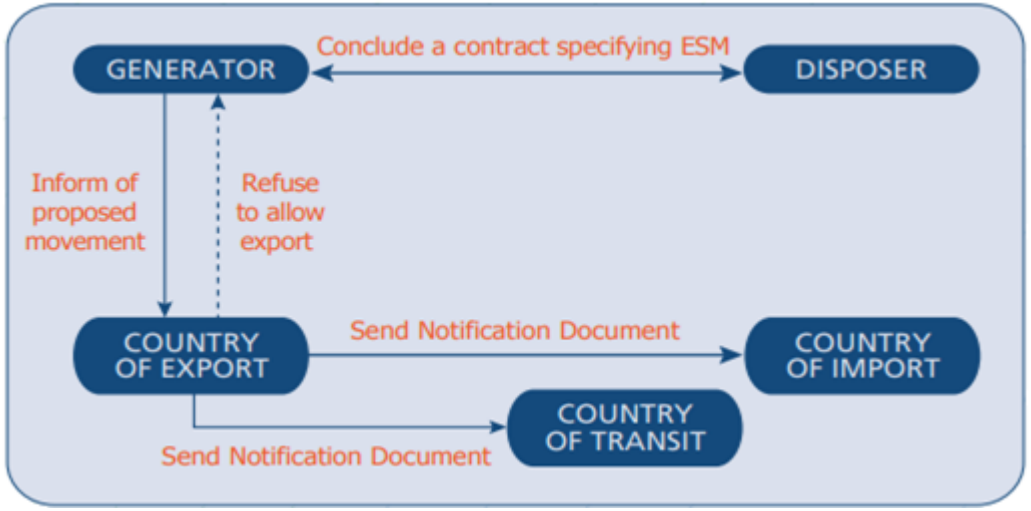
- For green listed EWC – non-hazardous waste
- Lithium batteries being non- hazardous by EWC 16 06 05.

- See Form: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32007R1379

LEGAL ASPECTS FOR TRANSFER

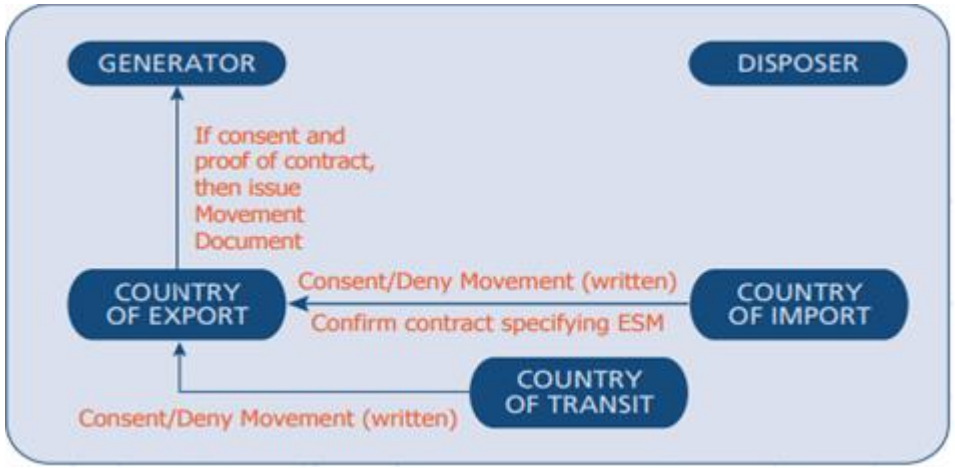
PREVENT

- Stage 1: Notification



- ✓ Exporter formally informs the disposer of the intended shipment
- ✓ A binding contract according to ESM between exporter and disposer must be enlisted
- ✓ The exporter is thereafter tasked to notify the authorities in the waste generated country of the intended shipment
- ✓ The authorities can approve or disregard the request in accordance with national laws and internationally binding obligations

- Stage 2: Consent and according of movement document

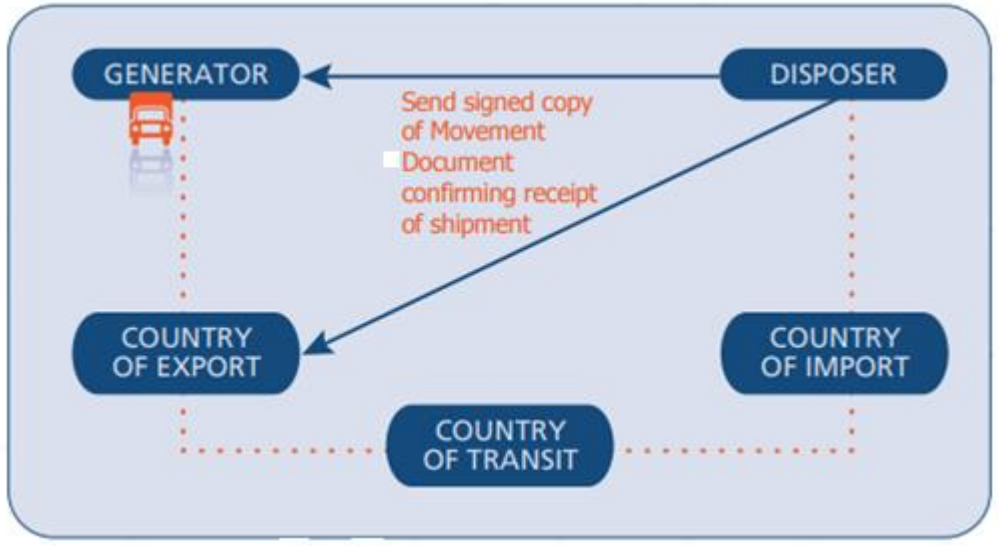


- ✓ The authorities in the exporting country issue a document after verifying that the disposer is committed and competent to receive the consignment
- ✓ Information in the document include; type of waste, carrier, exporter, importer

Source: UNEP/SBC: http://www.basel.int/Portals/4/Basel%20Convention/docs/pub/leaflets/leaflet-control-procedures-en.pdf

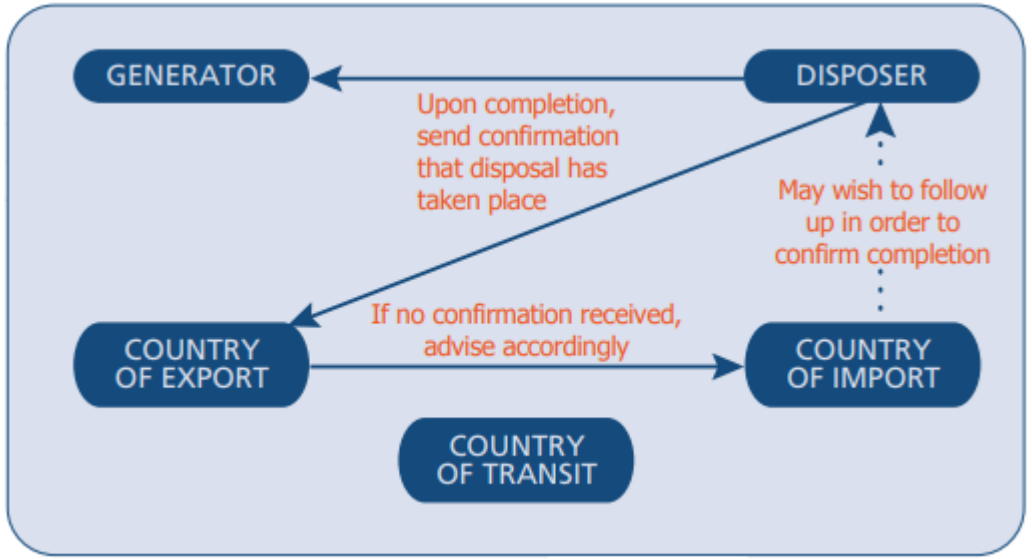
LEGAL ASPECTS FOR TRANSFER

- Stage 3: Transboundary movement



- ✓ The issued document must travel with the consignment at all time until the waste reaches the disposer
- ✓ The disposer confirmed receipt of waste by notifying the authorities in the exporting country
- ✓ Some countries accept copies of the same document. In this case, the authorities from the disposing countries send copies of the document.

- Stage 4: Confirmation of disposal

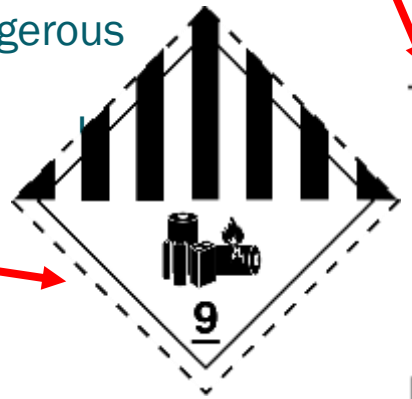


- ✓ At this stage, disposal is completed
- ✓ The exporter and exporting authorities are informed of the completed disposal of the consignment
- ✓ In the confirmation document. It must be affirmed that the disposal was according to the contractual terms between exporter and disposer in relation to the consignment

Source: UNEP/SBC: http://www.basel.int/Portals/4/Basel%20Convention/docs/pub/leaflets/leaflet-control-procedures-en.pdf

LEGAL ASPECTS FOR TRANSFER - LITHIUM

- ADR 2021 extraction. FYI only.
- https://unece.org/transportdangerous-goods/adr-2021-files
- Class 9 Miscellaneous dangerous substances and articles –
- Classification code M4 ion battery Label 9A



UN No.	Name and description	Class	Classification code	Packing group	Labels	Special provisions	Limited and excepted quantities		Packing instructions
3090	LITHIUM METAL BATTERIES (including lithium alloy batteries)	9	M4		9A	188 230 310 376 377 387 636	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906
3480	LITHIUM ION BATTERIES (including lithium ion polymer batteries)	9	M4		9A	188 230 310 348 376 377 387 636	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906

- But Also need to check rules for sea — the International Maritime Dangerous Goods Code (IMDG Code): https://www.imo.org/en/publications/Pages/IMDG%20Code.aspx

Source:ADR 2021- Please, always refer to the otiginal documentation to get process.

LEGAL ASPECTS FOR TRANSFER- LITHIUM

- https://unece.org/transport/documents/2021/01/standards/adr-2021-volume-1

Special provisions	188	Exceptions...
	230	Full regulations if...
	310	Prototypes
	360	Battery powered vehicles
	376	Damaged or defective lithium batteries
	377	Lithium batteries for disposal or recycling
	387	Hybrid batteries special devision188
	636	Used batteries
	670	Lithium batteries in household appliances

Special Provision 377

Lithium ion and lithium metal cells and batteries and equipment containing such cells and batteries carried for disposal or recycling, either packed together with or packed without non-lithium batteries, may be packaged in accordance with packing instruction P909 of 4.1.4.1.

These cells and batteries are not subject to the provisions of 2.2.9.1.7 (a) to (g).

Packages shall be marked "LITHIUM BATTERIES FOR DISPOSAL" or "LITHIUM BATTERIES FOR RECYCLING".

Identified damaged or defective batteries shall be carried in accordance with special provision 376.

LEGAL ASPECTS FOR TRANSFER - LITHIUM

P903	PACKING INSTRUCTION	P903
This instruction applies to UN Nos. 3090 , 3091, 3480 and 3481.		
For the purpose of this packing instruction, "equipment" means apparatus for which the lithium cells or batteries will provide electrical power for its operation. The following packagings are authorized provided that the general provisions of **4.1.1** and **4.1.3** are met:		

P908	PACKING INSTRUCTION	P908
This instruction applies to damaged or defective lithium ion cells and batteries and damaged or defective lithium metal cells and batteries, including those contained in equipment, of UN Nos. 3090, 3091, 3480 and 3481.		

P909	PACKING INSTRUCTION	P909
This instruction applies to UN Nos. 3090, 3091, 3480 and 3481 carried for disposal or recycling, either packed together with or packed without non-lithium batteries.		

P910	PACKING INSTRUCTION	P910
This instruction applies to UN Nos. 3090, 3091, 3480 and 3481 production runs consisting of not more than 100 cells or batteries and to pre-production prototypes of cells or batteries when these prototypes are carried for testing.		

P911	PACKING INSTRUCTION	P911
This instruction applies to damaged or defective cells and batteries of UN Nos. 3090, 3091, 3480 and 3481 liable to rapidly disassemble, dangerously react, produce a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours under normal conditions of carriage.		

LP903	PACKING INSTRUCTION	LP903
This instruction applies to UN Nos. 3090, 3091, 3480 and 3481.		

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Page 156, etc...

Packaging instructions available in ADR 2021 **Volume 2.** https://unece.org/sites/default/files/2021-01/ADR2021_Vol2e.pdf

Technical specifications of containers and packaging aspects/ information.

Please, discuss with the end receiver for details.

Source:ADR 2021- Please, always refer to the otiginal documentation to get process.

E.U. RECYCLING FACILITIES REFERENCES

- France

Erasteel : alkaline

Eurodieuze : alkaline, Li

Fiday Gestion : alkaline

Metal Blanc : Lead

Recupyl: Li

SNAM : Li, NiCd, NiMH

- Italy

Seval : alkaline, Li

- Germany

Accurec : Li, NiCd, NiMH

Promesa : Li

Redux : alkaline, Li

- Belgium

Revatech : alkaline

Umicore: Li

Campine Recycling: Lead

- Spain

Envirobat : alkaline

Exide: Lead

Metalurgica de Medina SA : Lead

Recobat: Lead

Recypilas : alkaline, Hg cells

- Finland

Akkuser : alkaline, Li

- Poland
- ENERIS Recupyl Sp. z o.o: alkaline

- Switzerland

Batrec : alkaline, Hg cells

PREVENT Waste Alliance E-Waste Working Group

PREVENT
Waste Alliance

www.prevent-waste.net

contact@prevent-waste.net