Metal compounds used as intermediates in the battery industry

The objective of this paper is to document examples of metal compounds used in the battery industry and assessing their status as intermediates.

1- BATTERY FUNDAMENTALS

Batteries are electrochemical devices which store energy in chemical form and release it as electricity into a circuit (commonly referred as "the load")
They all have the same structure: two electrodes containing active material immersed/embedded within an ion-friendly media (electrolyte)
Battery operation follows one single pattern:

- Ions (of atoms or molecules) are exchanged between the two electrodes through the electrolyte <u>within the battery</u>
- electrons are exchanged between the two electrodes through the external circuit <u>outside of the battery</u>

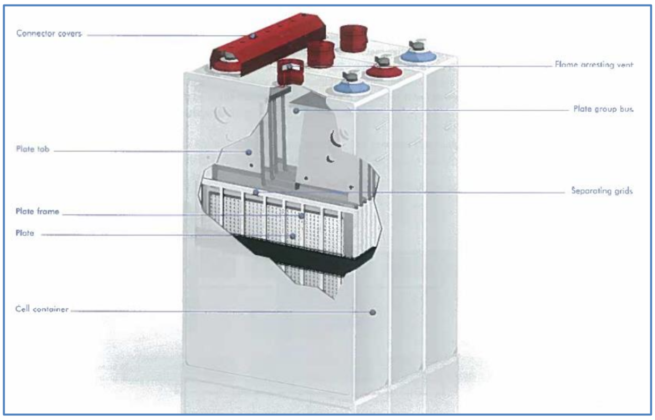
There are dozens of battery technologies on the market, main ones are:

- <u>Portable</u>: Saline, Alkaline, Li-MnO_2, Ni-MH, Li-Ion (LCO, LFP, LMO…),
- <u>Automotive</u>: Pb/acid,
- <u>Industrial</u>: Pb/acid, Ni-Cd, Li-Ion, Na-$NiCl_2$, LMP, Li-$SOCl_2$, Li-SO_2

Electrodes are articles which are contained in the battery, which itself is also an article, as was determined in the technical document "Electrodes are articles" (see attachment).

2- BATTERIES PRODUCTION PROCESS

In all battery technologies, substances are used to manufacture the « active material » of the cathode (the positive electrode) and anode (the negative electrode). The active material is embedded in a mechanical substrate to form an electrode. These electrodes are then further assembled with the other battery components (including electronics) to obtain a finished battery.

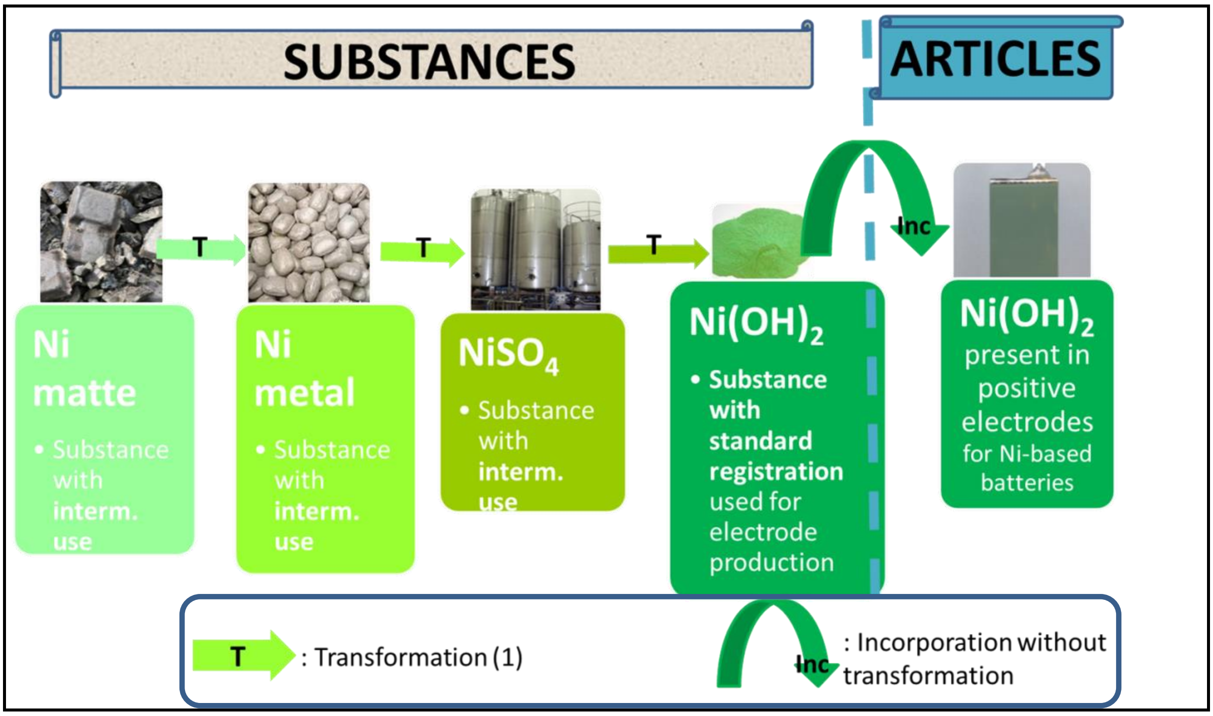


3- INTERMEDIATE USE OF SUBSTANCES IN BATTERIES

In the course of batteries production, substances are used in the production of (and are incorporated in) the electrodes (an article): these substances are registered with a "standard registration" (along with their uses).
In several instances, these substances are transformed into "*Other substances*" within the article in the course of the article production: these *"Other substances"* formed are not subject to the registration requirement as they are formed within an article.
If these substances are the outcome of the conversion (a synthesis) of other "*Previous substances*" on an industrial site: these *"Previous substances"* are intermediates for that use, (and these intermediate uses are listed in the registration dossier of these "*Previous substances*").

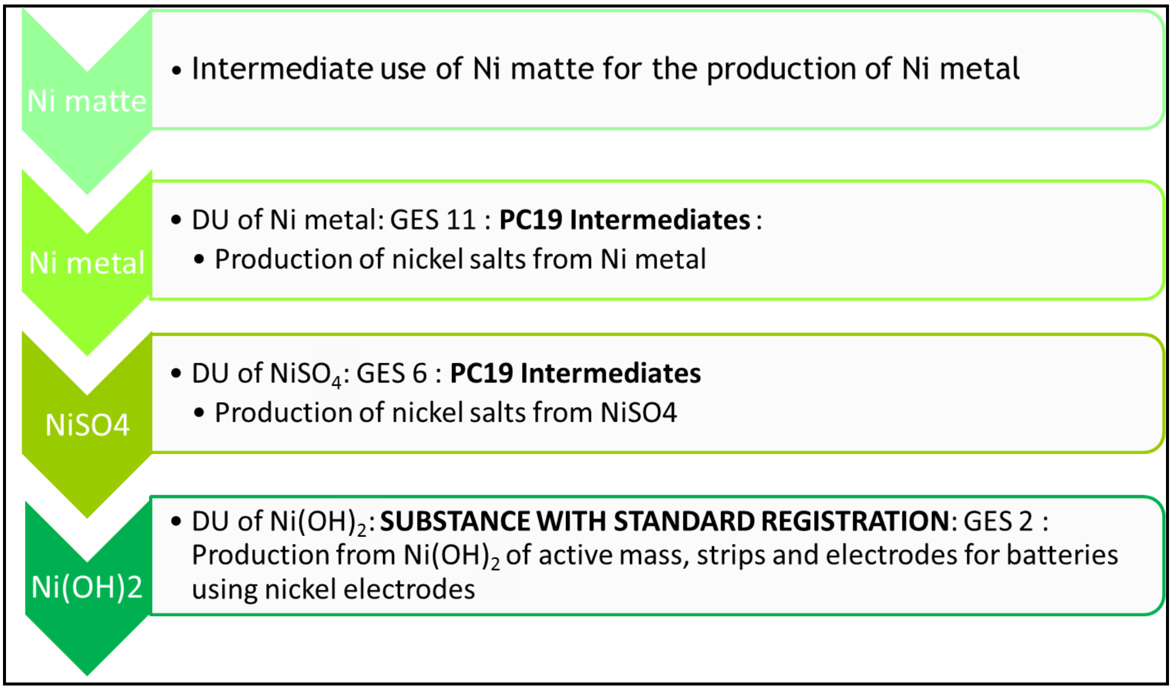
A. PRODUCTION OF NI-MH BATTERIES

The steps of positive electrodes production for Ni-MH batteries are depicted below:



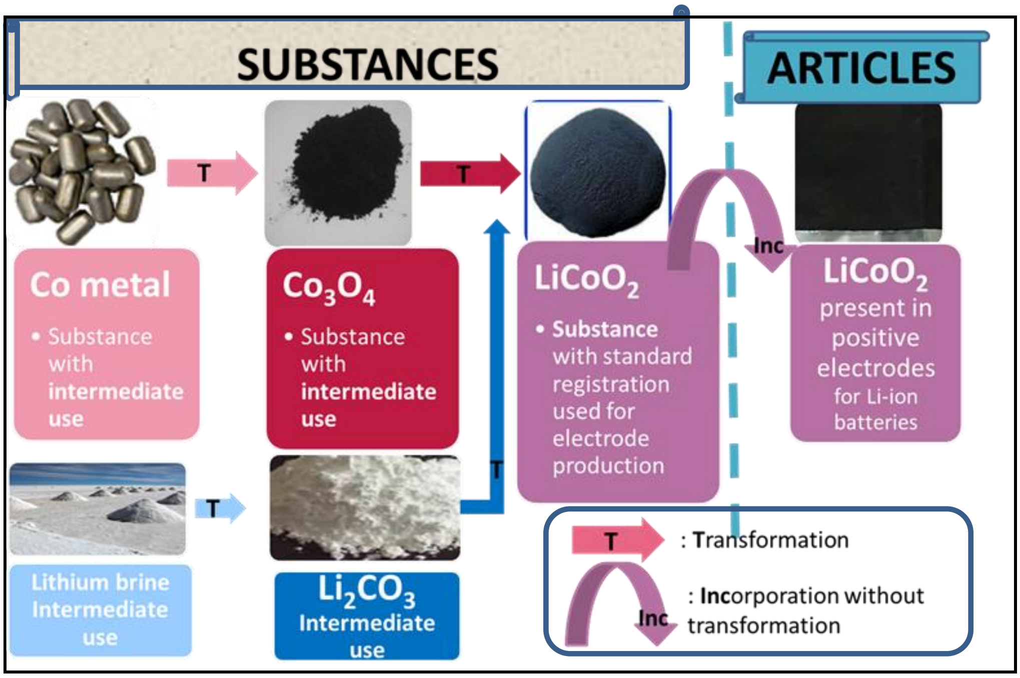
(1) Transformation: means full transformation into other substance(s), within the limits of chemical reaction equilibrium (typically with less than 0,1% of initial substance remaining).

The registration dossiers of these substances developed by the Nickel REACH consortia (http://www.nickelconsortia.eu/exposure-scenario-library.html) reflect these intermediate uses. They are summarized in the graph hereafter.



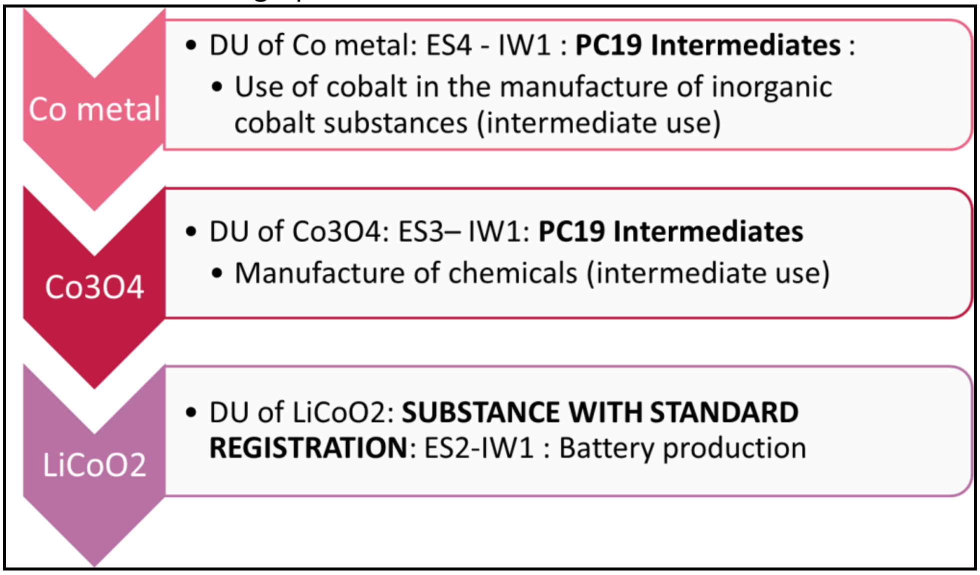
B. PRODUCTION OF LI-ION BATTERIES

The steps of positive electrodes production for Li-ion batteries are depicted below:



The registration dossiers of these substances developed by the Cobalt REACH consortia (http://www.cobaltreachconsortium.org) reflect these intermediate uses.

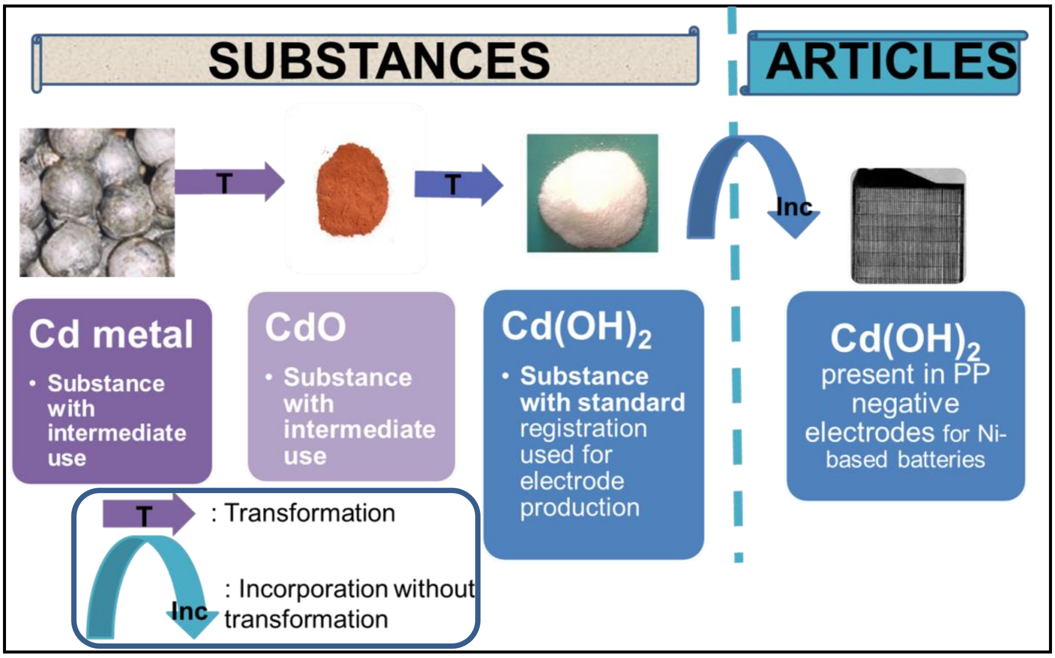
They are summarized in the graph below:



C. PRODUCTION OF NI-CD BATTERIES

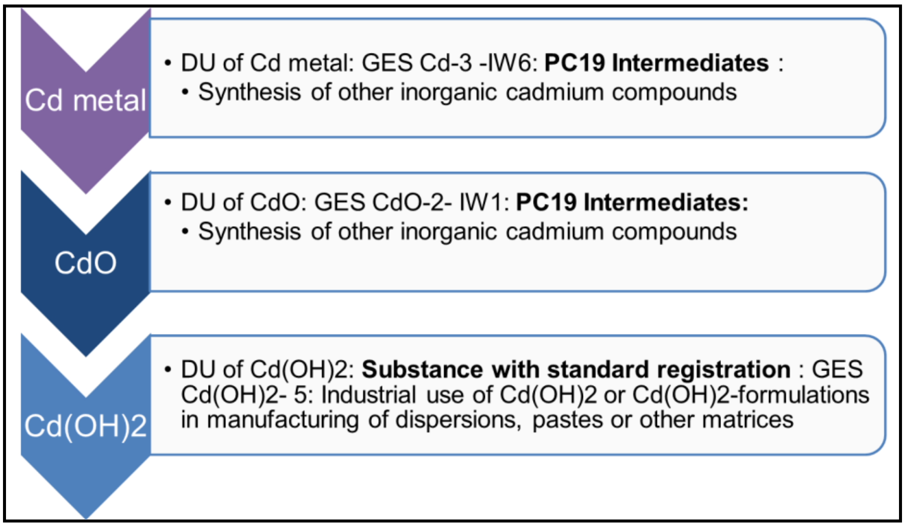
C.1 - PRODUCTION OF POCKET PLATE NEGATIVE ELECTRODES (PP)

The steps of the production of Pocket Plate negative electrodes for Ni-Cd batteries are depicted below:



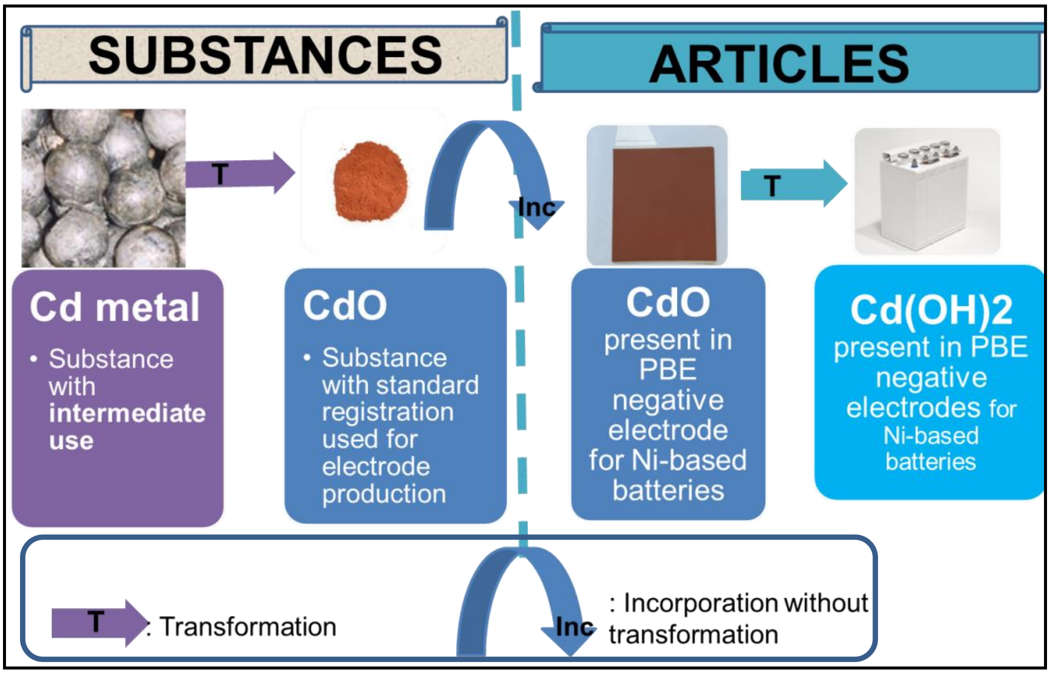
The information regarding the uses supported by the Cadmium REACH consortium, including the intermediate status described above, the can be found at http://reach-cadmium.eu.

They are summarized in the graph below:

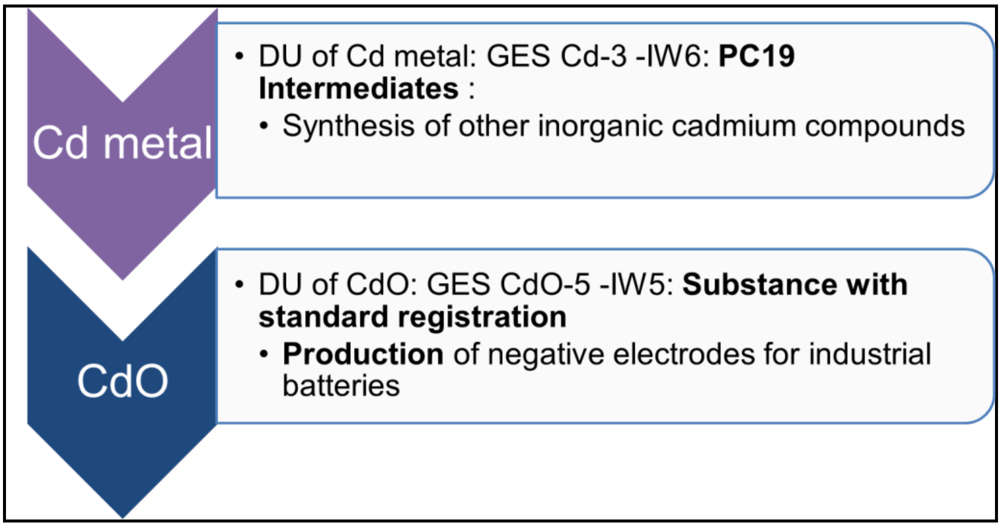


C.2 - PRODUCTION OF PLASTIC BONDED NEGATIVE ELECTRODES (PBE)

The steps of Plastic Bonded negative electrodes (PBE) manufacturing for Ni-Cd batteries are depicted below:



In this example, **Cd(OH)2 is not subject to registration requirement** and the downstream use of CdO is described with another Exposure Scenario as explained hereafter:



D. CONCLUSION

An assessment methodology can be applied for the identification of intermediate uses of substances in the batteries production.

- **The REACH definition of intermediate is fulfilled by several substances used in the multiple upstream process steps which lead to the manufacture of the active materials. These active materials are then incorporated into battery electrodes.**
- **Conversely, substances incorporated into battery electrodes (whether transformed into other substances after this incorporation or not) are registered with a "standard registration" (along with this use).**

ATTACHEMENT:
Battery electrodes are articles

The objective of this document is to explain why battery electrodes meet the definition of articles in the REACH regulation.

1. Shape, surface and design of battery electrodes

An article is defined in Article 3.3 of the REACH Regulation as *"an object which during production is given a special shape, surface or design which determines its function to a greater degree than does its chemical composition*".

In all battery technologies, the positive and negative battery electrodes are produced with mixtures of chemical substances either pasted on or integrated in a mechanical support.

There are no further changes in electrode shape or design after the production stage. The positive and negative battery electrodes are then assembled into battery boxes/cells (either before or after they are charged). In some instances they are sold directly to a limited number of industrial customers which specialize in cell manufacturing. Size, shape and design are adapted to specific customer requirements.

2. Function of battery electrodes

The function of a battery electrode is to carry energy for a given application. Although the chemical composition of a generic battery electrode determines its fundamental ability to carry the energy, it is the plate shape, surface and manufacturing design (flat or tubular plates, dimensions, the thickness of the active material) that define whether it is able to deliver the performance required for different automotive and industrial applications (SLI, stand-by, motive power etc.). Examples of different battery plate designs are given in Annex.

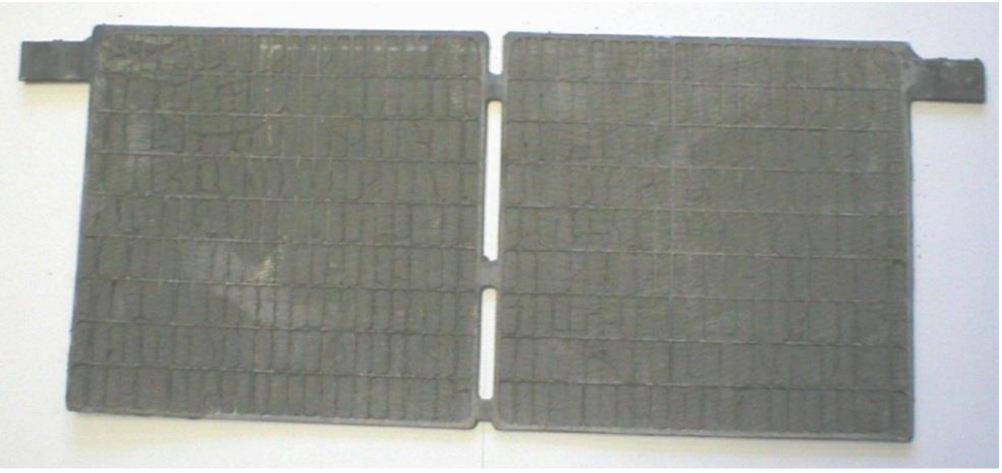
3. Battery electrodes are articles

The functionality of the battery electrode, which acts as an energy carrier within the battery, is determined more by its special shape, surface and design than by its chemical composition, therefore EUROBAT and RECHARGE conclude that an electrode is an article according to the REACH Regulation.

Annex: Different designs of Battery Electrodes

The pictures below show several different shapes and designs used in battery electrodes and tailored to specific applications.

A/. Flat Plates (Positive and Negative)

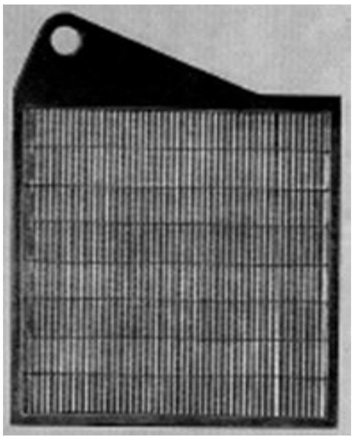


Lead-acid flat plates

B/. Tubular Plates

Lead-acid tubular plates

C/. Pocket Plate Electrodes



Pocket plate electrode for Ni-Cd batteries

D/. Plastic Bonded Electrodes

PBE electrode for Ni-Cd batteries

E/. Sintered Electrodes

Sintered Electrode for Ni-Cd batteries

F/. Difference in Battery Plate Structures

This diagram outlines how plate thickness and structure is adapted to influence battery performance. Thick plates allow for improved lifetime and cycling behavior, while thin plates allow for high current discharge.