ILMC Tool Box Series **2.3**

Battery Production and Recycling

Battery Design for Cleaner Production

1. Early Beginnings

The battery in automobiles today is far removed from the first lead-acid storage batteries developed in 1859 by Gaston Plante for use in telegraph equipment and I doubt that he could have envisaged the impact of his invention on society today. Simply put, 20th century life-style would not be possible without lead-acid batteries. The first cells to look like modern day batteries were invented in 1866 by G Leclanche of France. In his design and some of the latest modern batteries, there is no liquid acid. The first accumulator plates similar to those in the modern lead acid battery were conceived in 1881 by Henri Tudor. Interestingly, the experimental industrial version of the accumulator designed by Tudor worked for 16 years without interruption and only recharged from a waterwheel driven dynamo.

Whilst many will insist that the chemistry of the modern battery has changed little since the late 1890's, what has changed in the intervening years is the technology applied to the materials, the advanced production methods and the concern and care now shown for the environment and human health.

2. The Amazing Voltaic Battery

The industries' long association with the lead acid battery goes back to those pioneering mining companies of the late 1800's. At that time the most dangerous job in the mining industry was "Blasting". Fuses were somewhat unpredictable and often failed to ignite the charge of dynamite. Or worst still, seemed to fail to ignite the charge, and in a manner often fatal to miners, then exploded without warning, killing anyone in close proximity to the blast.

Salvation, however, was at hand with the application of "Voltaic" Battery technology. The introduction of electrical detonation of explosive charges truly revolutionized "blasting" practices throughout the mining industry. The lead acid battery brought about an "amazing" transformation in mining practices and probably saved the lives of many thousands of miners.

Nevertheless, it was the need to incorporate a lead acid battery into the automobile for "Starting", "Lights" and "Ignition", the "SLI" battery, that sealed the link between the lead industry and battery manufacture.

Indeed, today over 70% of World lead production goes into lead acid battery manufacturing.

3. Lead Acid Batteries

Lead-acid batteries either start or power cars, trucks, buses, boats, trains, rapid mass transit systems, recreational vehicles and electric wheelchairs all over the globe. The car battery also provides a stable electrical supply to a vehicle's electrical system.

During power outages, lead-acid batteries provide quiet, pollution-free emergency power for critical operations such as air traffic control towers, hospitals, railroad crossings, military installations, submarines, and weapons systems. In these situations the telephones stay on and this is because every major telephone company in the world uses lead-acid batteries as backup power to the telecommunications systems.

Were it not for standby lead-acid batteries, we probably would have power outages nearly every day because the electric utilities would not be able to handle rapid fluctuations in the demand for electricity. Lead-acid batteries come to the rescue, delivering large amounts of electricity for short periods of time until additional capacity is added to the grid. Lead-acid batteries power electric fork trucks used in warehouses, factories, mines, and ships. They also power the shuttle vehicles in airports, as well as wheelchairs and golf carts used. On the road, lead-acid batteries power electric law-enforcement vehicles, buses, shuttles at amusement parks and very soon mail delivery vans.

4. The Legacy

For many years lead acid battery manufacturing plants were regarded by many as sources of lead contamination of the workforce, the general population and the environment. In fact only a few years ago such a plant in Kosovo was shut down by the United Nations because environmental experts thought that the pollution levels around the site were so high that there was a real risk of lead poisoning. This incident and others has left the Lead Industry with an unenviable legacy.

5. Cleaner Battery Manufacturing

However, as more and more new and modernized plants attain ISO 9002 for quality control so we see a steady improvement in environmental awareness and accordingly an increasing number of battery manufacturers applying for and achieving ISO 14001 accreditation for their Environmental Management Systems.

Recently in the year 2000, for example, Philippine Recyclers Inc. based in Manila were awarded ISO 14001 certification to become the first Secondary Lead Plant in Asia to hold both ISO 9002 and 14001 accreditations.
But the key question for society today is why recycle the spent batteries?

6. Why Recycle?

Indeed, unless we recycle the spent batteries they will literally be falling about our ears, but apart from the inconvenience, recycling:

Saves Natural Resources:

By making products from recycled materials instead of virgin materials, we conserve land and reduce the need to mine for more minerals.

Saves Energy:

It takes less energy to make a recycled battery, in fact secondary lead bullion, for example, requires four times less energy to make than primary lead.

Saves Clean Air and Water:

In most cases, making products from recycled materials creates less air pollution and water pollution than making products from virgin materials.

Saves Landfill Space:

When the materials that you recycle go into new products, instead of landfills or incinerators, landfill space is conserved.

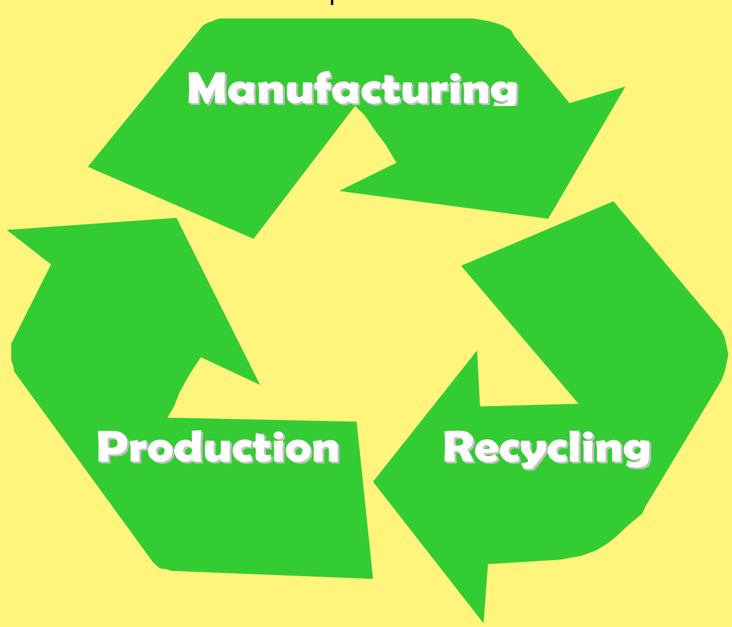
Saves Money and Creates Jobs:

The recycling industry and the associated processes create far more jobs than landfill sites or waste incinerators, and recycling is frequently the least expensive waste management option for cities and towns.

7. Recycling Loop

The earth's resources, no matter how abundant we think they are, are finite, and precious to all of us. It is essential that the food we eat, the water we drink and the air we breathe are free of toxins and keep us healthy. Maintaining a clean environment, reusing and reclaiming resources benefit us all. Moreover, sound environmental management will support sustainable development and growth.

It is therefore in everybody's interest to recycle as much scrap material as possible, especially lead acid batteries, because if they are not recycled the materials in the battery pose a serious environmental problem and a threat to human health.



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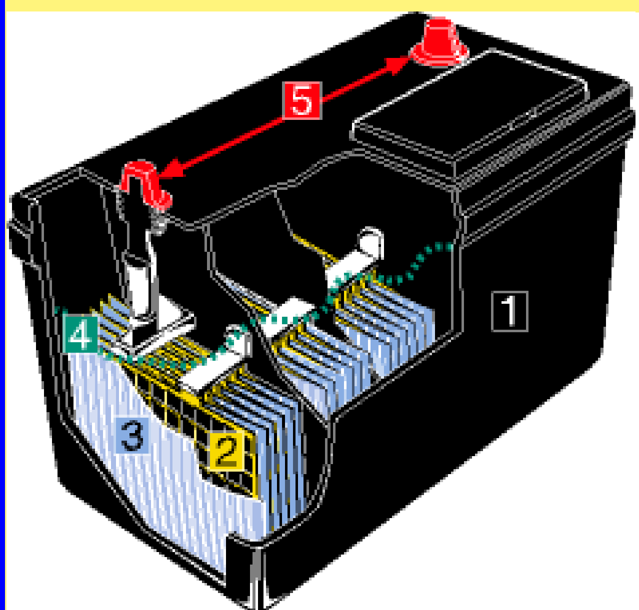
The ideal loop would be:

i Lead bullion production
ii Battery manufacture
iii Recovery and recycling of the battery materials

Lead acid batteries, in whatever form are all recyclable. This only means, however, that a battery can be recycled after it is spent. The battery itself does nothing to close the recycling loop if it is not recycled, but you, your governments and your industries can ensure that they enter the loop by creating an infrastructure that will promote and facilitate recycling.

8. Battery Components



Legend

1	**Plastic Container**
2	**Lead Plates**
3	**Plate Separators**
4	**Acid Electrolyte**
5	**Lead Terminals**

In order to ensure that the loop is closed we no only need the right infrastructure, but we also need a battery that is made up of recyclable materials.

The modern Lead acid battery is made up of:

A resilient Plastic container which is usually polyethylene, but the case mate rial can be metallic or a synthetic rubber.

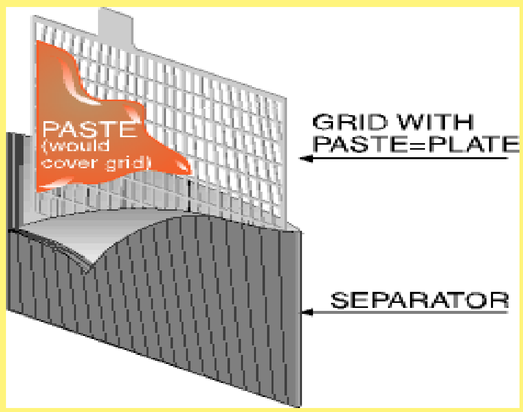
Positive and negative internal lead plates. The positive electrode (cathode) typically consists of pure lead dioxide, whereas the negative electrode (anode) consists of a grid of metallic lead alloy containing various elemental additives that may include one or more of the following, antimony, calcium, arsenic, copper, tin and selenium. These alloying elements are used to change density, hardness, porosity, and so on.

Porous synthetic plate separators that are increasingly made from rib rein forced polyethylene, but are also available in PVC and fiberglass.

The plates are immersed in a liquid electrolyte consisting of 35% sulfuric acid and 65% water. It is the electrolyte that promotes a chemical reaction in the battery that produces electrons and this energy is harnessed as electricity.

The positive and negative lead terminals used to connect the battery to the car.

8.1 Separator



Inside the battery, the pasted positive and negative plates must be separated to prevent short circuits. This separation is achieved using thin sheets of porous and synthetic insulating material used as spacers between the positive and negative plates. Fine pores in the separators allow electrical current to flow between the plates while preventing short circuits. The battery is made up so that a positive plate is paired with a negative plate and a separator. This unit is called an element, and there is one element per battery cell, or compartment inside the battery case.

The separator is a very important component of the modern lead acid battery and has been the subject of much intensive research.
The average lead battery consists of approximately 17% metallic lead, 50% lead sulfate/oxide, 24% acid, 5% plastics, 4% residuals (mainly silica used to bulk up the separators).

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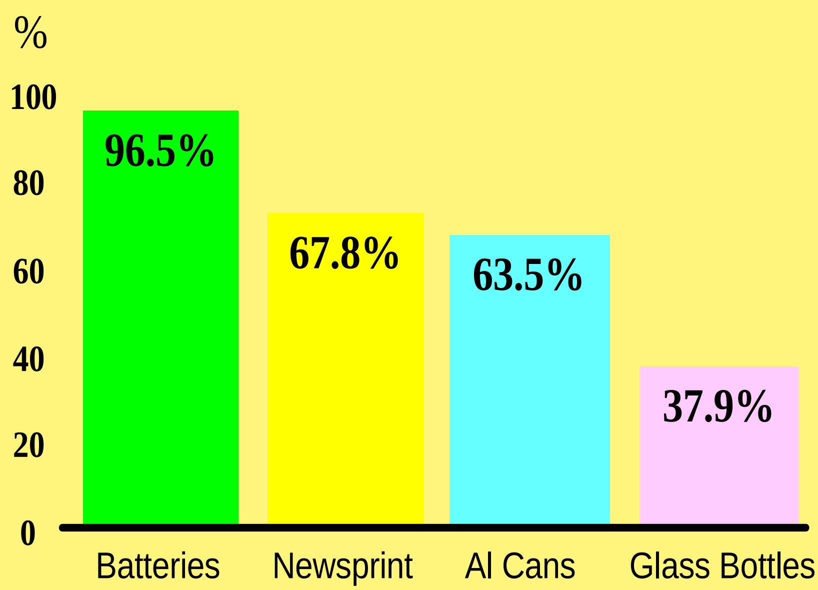
BCI - Recycling Rate Chart - for the latest annual recycling rates go to the BCI web site at: http://www.batterycouncil.org/

Recycling Rates



Typical Recycling Rates

All the components of the modern lead acid battery are recyclable and from an Industry perspective lead-acid batteries are an environmental success story because in most OECD countries approximately 96% of all battery lead is recycled. Compared to the usual "flagship" recycled products such as glass bottles at only 38%, aluminum cans at nearly 64% and newsprint at about 68%, lead acid batteries are the clear leaders in the field. In fact, used lead-acid batteries have topped the list of the most highly recycled consumer products for over a decade.

Unfortunately, battery recycling is not a public utility and scrap batteries are only recycled because it is profitable for the secondary non-ferrous industry to do so. In recent years, however, the introduction of essential and necessary environmental and occupational health regulations within the industry has cut profit margins to such an extent that most secondary lead smelters are barely breaking even and others have closed due to severe losses.

It is increasingly important therefore for the secondary lead industry to generate as much income from a spent battery as possible in order to improve margins and maintain profitability.

Modern secondary plants will take spent batteries and smash them in a mechanical hammer-mill. The broken battery pieces are usually gravity separated in a series water filled tanks.

9.1 Recycling Options

The washed and dry polypropylene pieces are sent to a plastic recycler, where the chips are melted and extruded to produce plastic pellets for use in the manufacture of battery cases.

The battery paste is fed to the smelting furnace to recover soft lead and the grids and terminals sent to the melting furnace for the production of hard lead. Lead bullion from both sources will be refined, cast into ingots sold to the battery manufacturer. The soft lead is suitable for battery paste and the hard lead bullion ideal for grids and terminals.

Polyethylene separators can be separated from the polypropylene waste stream and recycled, although in most secondary plants the current practice is to use this waste as a fuel supplement.

Used battery acid can be handled in four ways:

a. Neutralized, and the resulting effluent treated to meet clean water standards and then released into the public sewer system.

b. Converted to powered sodium sulfate for use in glass and textile manufacturing or as a filler or stabilizer in laundry detergent.

c. Converted to agricultural fertilizer using ammonia.

d. Converted to gypsum for use in the production of cement or by the construction industry in the manufacture of fiberboard.

9. The Ideal Design

With recycling rates for used batteries as high as 96% many people think that the industry has a consistent design that is ideal, but unfortunately this is not the case.

Plastic Case Material

Washed polypropylene chips from used battery cases are worth about US$300 per tonne and provide valuable additional income for the recycler. Increasingly, however, battery case material is being produced from a range of cheaper durable plastics that are impossible to separate economically from the polypropylene, thereby rending the plastic chips valueless and only fit to use as fuel. Ideally, all batteries should be made of the same plastic case material, but not necessarily polypropylene as long as there is a consistent use of the same material to maximize recovery and reuse. In his respect, rubber and metallic case material should be phased out except for instances where there is a specific need.

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Acid Electrolyte

Whilst certain industrial uses of lead acid batteries demand that the electrolyte is gelled to reduce the risk of spillage, for example in aircraft, the general introduction of gelled electrolyte should be discouraged as the gel is difficult to remove completely from the paste. Any acid gel that is not removed from the paste will generate sulfur dioxide gas in the smelting process and have to be removed from the waste gas stream prior to discharge to the atmosphere, thereby incurring additional operating costs.

Lead Plates

New battery designs that increase power, reliability and extend battery life, in particular the valve regulated battery designs, demand the use of soft very pure lead for the grids. Whilst the use of pure lead in this instance eases recycling, the vast majority of batteries consumed are standard automotive SLI batteries requiring harder lead grids that can only be made from lead alloys. Many of these alloys have traditionally been made from either toxic or environmentally undesirable elements or in some cases inert elements that contaminate the secondary bullion and are uneconomic to recover during the recycling process. In order for secondary lead producers to compete with primary lead and command the best premiums, the recycled lead must be of a quality suitable for the production of lead oxide, used in the production of battery paste.

Increasingly battery manufacturers moving towards the use of elements, such as calcium and tin, not only because they enhance performance, but they are either easy to recycle or remove from the lead bullion during the refining stage and also represent no particular toxic or environmental threat. Further research is required in this area to balance battery performance with sound environmental criteria.

Battery Paste

Current formulations for battery paste are ideal for the secondary industry and the likely changes on the horizons do not change this position.

Lead Terminals

The lead terminals are not critical to the chemical efficiency of the battery and only provide the link to complete the electrical circuit. Consequently the terminals are often made from a low quality lead bullion and while this might minimize costs, if the bullion used to produce the terminals contains other elements that are either toxic or undesirable, these elements will add a further refining burden to the recycler. Ideally, the terminals should be made from lead refined to the London Metals Exchange (LME) standard for 99.97% bullion to minimize contamination.

Plate Separators

In the early days of battery manufacturing the plate separators were made of wood. Today they are produced from a multitude of plastics, paper and glass fiber. Whilst glass fiber presents some separation problems in the mechanical battery breakers, it does not present an environmental threat apart from adding to the inert slag burden. Virtually all of the plastic and paper separators are impossible to recycle economically and are really only suitable as a fuel supplement.

Certain plastic separators, however, such as PVC (polyvinyl chloride) cannot be burnt as fuel because an acidic gas is generated and without an economic method to segregate PVC from the other separators, the whole of the separator waste stream is destined for landfill.

10. The Way Forward

In order to reduce the pollution caused by standing traffic, particularly in large cities, 36 volt electrical systems will shortly be installed as standard in all new cars. This higher voltage will enable instant start/stop motoring and automatically switch off the engine when the car is not moving. However, such a battery that enables an instance start when the accelerator is will weigh approximately 40 kilos, that is three times the weight of the average 12 volt automotive battery. With such an increase in battery size anticipated, battery design will be critical to maintaining sound environmental performance throughout the clean production life cycle.

As we see the way forward, there should be an improved dialogue between the battery manufacturers and the secondary lead industry; so that by sharing their respective experiences and needs lead acid batteries will be designed in way that not only improves the electrical performance of the battery, but throughout the recycling loop generates a real and sustainable improvement in environmental performance and consequently "Cleaner Production".

January 2001