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International Lead Management Center Inc.

The International Lead Management Center

Battery Design for Cleaner Production

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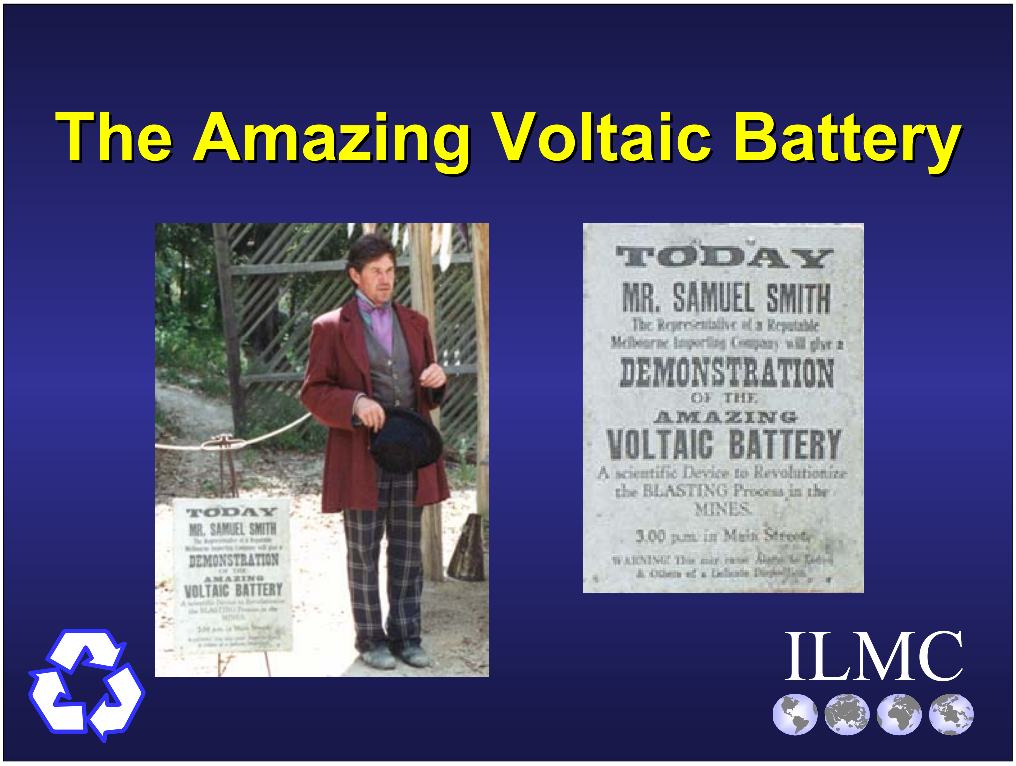
Early Beginnings

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 our lives today.

Simply put, our 20th century life-style would not be possible without lead-acid batteries. The first cells to look like our modern day batteries were invented in 1866 by G Leclanché 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.

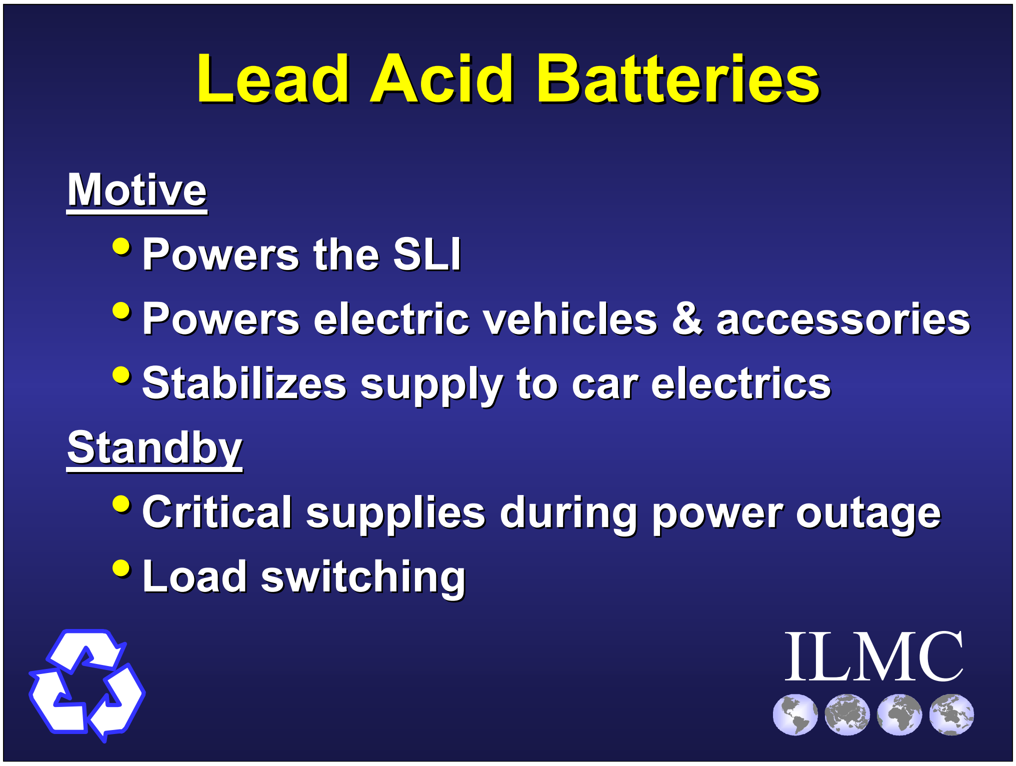
Whilst many will insist that the chemistry of the modern battery has changed little since the late 1890's, what has changed in the intervening years is the technology applied to the materials, the advanced production methods and our concern and care for the environment and human health, epitomized by the modern practices adopted by the major recyclers in the secondary lead industry.



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. As the graphic suggests, the lead acid battery brought about an "amazing" transformation in mining practices and probably saved the lives of many thousands of miners.



Lead Acid Batteries

Today, 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 couldn't 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.

But lead acid batteries really score because used lead acid batteries (ULAB) are easy to recycle.

Why Recycle?

Indeed, unless we recycle the spent batteries they will literally be falling about our ears, but apart from that recycling ULAB has enormous benefits.

- 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.

Recycling Loop

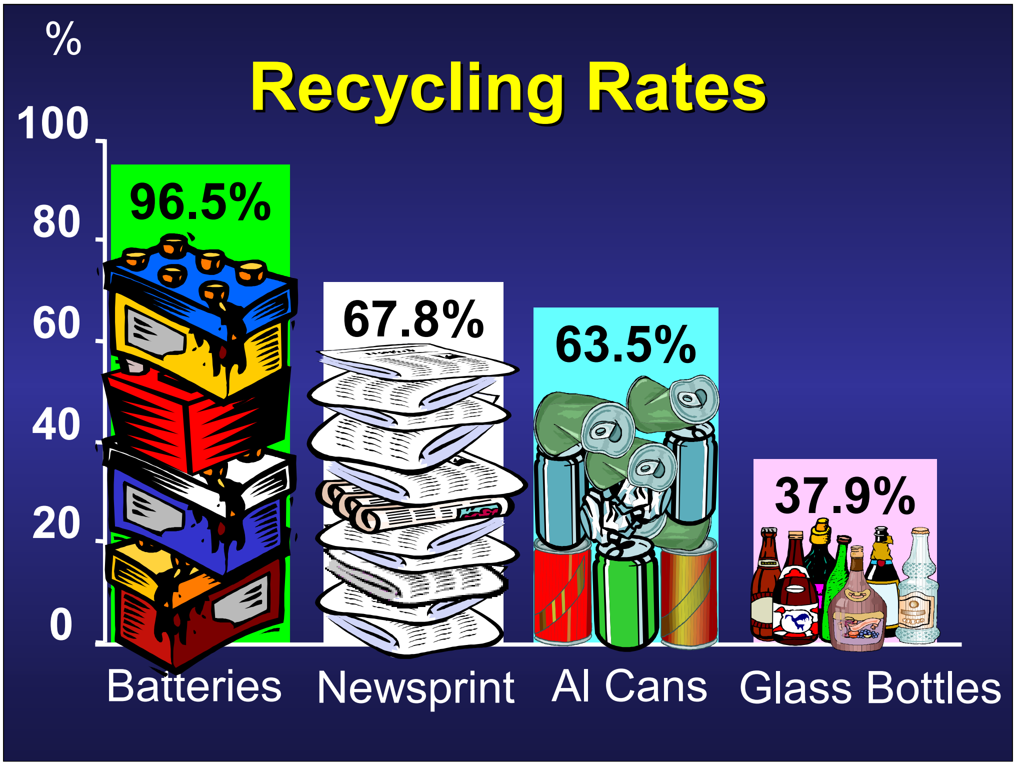
The earth's resources, no matter how abundant we think they are, are finite, and precious to all of us. It is essential that the food we eat, the water we drink and the air we breathe are free of toxins and keep us healthy. Maintaining a clean environment, reusing and reclaiming resources benefits us 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 used 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.

The ideal loop would be:

1. Lead bullion production
2. Battery manufacture
3. 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.



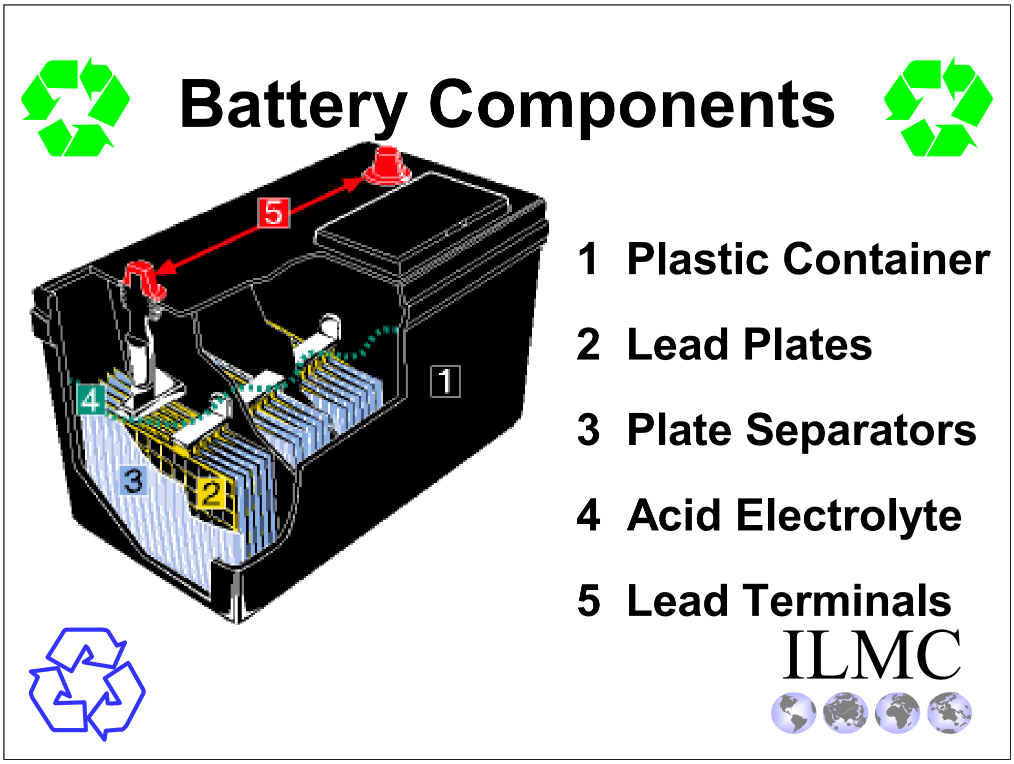
Recycling Rates

As the components of the modern lead acid battery are recyclable, lead-acid batteries should be 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, despite a developed infrastructure for collecting ULAB, battery recycling is not a public utility and ULAB are only recycled because it is profitable for the secondary lead industry to do so.

In recent years, the introduction of essential, but necessary environmental and occupational health regulations in 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 recycle ULAB in the most cost effective way and generate as much income from a spent battery as possible in order to improve margins and maintain profitability.



Battery Components

In order to ensure that the loop is closed we not 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:

1. A resilient Plastic container which is usually polypropylene, but the case material can be metallic, synthetic rubber or a co-polymer.
2. 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.
3. Porous synthetic plate separators which are increasingly made from rib reinforced polyethylene, but are also available in PVC and fiber glass.
4. 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.
5. The positive and negative lead terminals used to connect the battery to the car.

Ideal Recycling Criteria

However, from an environmental perspective there are a number of criteria that are key elements in the design of the ideal battery.

Firstly, the materials used should be reusable or easily recycled for use in a new battery in order to conserve natural resources.

It is essential that the materials chosen have been obtained from sources that have little or no environmental impact on the surrounding flora and fauna in order to protect plant and animal species.

The recycling operation should use a minimal amount of energy. In this context it is important that recycling operations use less energy than primary sources so that there is less impact on global warming and valuable energy resources are conserved.

The process should not produce any toxic or inert solid waste, to eliminate the need for landfill waste sites. Ideally the only solid material produced should be a saleable product.

Finally, the process should not cause any adverse occupational or population exposures. Certain lead compounds and metals used in grid alloys are toxic and must be subject to stringent environmental controls to ensure that the social benefits that come with recycling operations are not undermined by poisoning the workforce or the local population.

The Ideal Design

With recycling rates for used batteries as high as 96% you might think that the industry already 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 ton and provide valuable additional income for the recycler. Increasingly, however, battery case material is being produced from a range of cheaper durable co-polymer plastics that are impossible to separate economically from the polypropylene, thereby rending the plastic chips of little value 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.

Acid Electrolyte

Increasingly over the years the users of lead acid batteries are demanding gelled electrolyte to reduce the risk of acid leakage and spillage. Furthermore, spirally wound and valve regulated batteries require the gelled electrolyte. The gelled electrolyte is difficult to remove from the battery paste prior to smelting and those secondary plants that delsulfurize prior to smelting will have to re-equip themselves to deal with the increase in sulfur dioxide production and remove it from the waste gas stream prior to discharge to the atmosphere.

The Ideal Design

<u>Lead Plates</u>

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 and calcium alloys for modern battery grids. Increasingly battery certain manufacturers are 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.

<u>Battery Paste</u>

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

The Ideal Design

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.

Design Myth

Campaigners of sustainable development and promoters of cleaner production advocate that manufactured products should be easy to disassemble so that they are easy to recycle or reuse.

However, lead acid batteries are the exception to this rule. Every effort should be made to design and manufacture batteries that are difficult to disassemble to discourage and prevent the proliferation of unregulated battery reconditioning. As I am sure most of you are aware reconditioning involves the cannibalisation of used batteries to select components with some useful “life” in order to made a battery that will take a charge. Reconditioning is invariably undertaken in small workshops with little or no regard for sound environmental practices, occupational safety of the health of those working on the premises. Indeed, in every case battery reconditioning causes environmental contamination and population lead exposure.

Of course, the valve regulated battery is ideal as it cannot be reconditioned because the battery will not function once the integrity of the factory seal is broken.

Eco Label

Finally, prior to leaving the manufacturing plant, all lead-acid batteries should be labeled in accordance with prevailing national and international regulations and with the international recycling symbol ISO 7000-1135, better known as the Mobeus loop.

Furthermore, there should be instructions for the recycling of the battery when it is at the end of its useful life or a point of contact clearly displayed.

Each label should state, “lead-acid battery”, "Pb" or the words "LEAD", "RETURN and RECYCLE."

If possible the label should also have a bar code containing information about the place of manufacture, the date of production, the battery type and its components.

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 engaged will weigh approximately 40 kilos, that is three times the weight of the average 12 volt SLI battery. With such an increase in battery size anticipated, battery design will be critical to maintaining sound environmental performance throughout the 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 recycling and environmental performance. Indeed, many of you already benefit from established schemes that perpetuate high rates of recycling, competitive pricing and lower energy consumption by the secondary industries. Furthermore, if batteries are designed to maximize recycling as well as energy storage and power output, then a sustainable philosophy can be realized and lead acid batteries will look a very attractive proposition compared with all other battery technologies.