ILMC

International Lead Management Center Inc.

The International Lead Management Center

Battery Design for Cleaner Production

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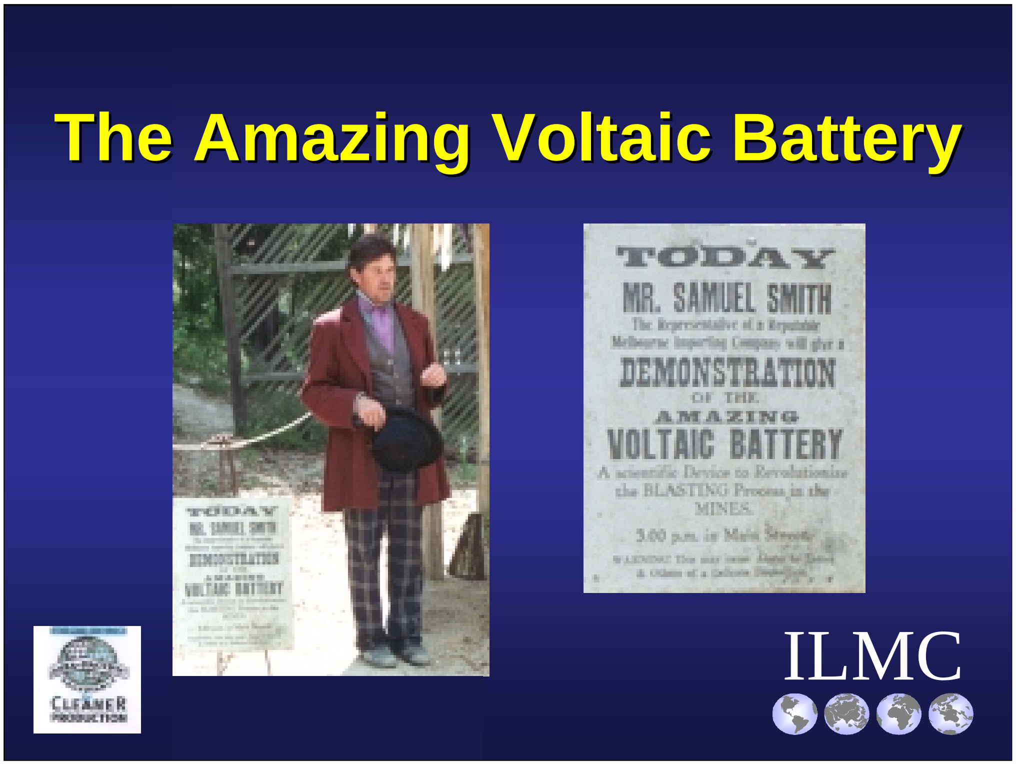
Early Beginnings

The International Lead Management Center is based in North Carolina, USA and is made up of a consortium of ten of the leading mining and smelting companies in the world. Its mission is to promote and implement lead risk reduction practices within the industry and amongst the general population worldwide through multi-stakeholder pilot program activities.

The battery in automobiles today is far removed from the first lead-acid storage batteries developed in 1859 by Gaston Planté 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 21st 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 most modern batteries, the electrolyte is "gelled". The first accumulator plates similar to type used 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 dynamo driven by a water-wheel.

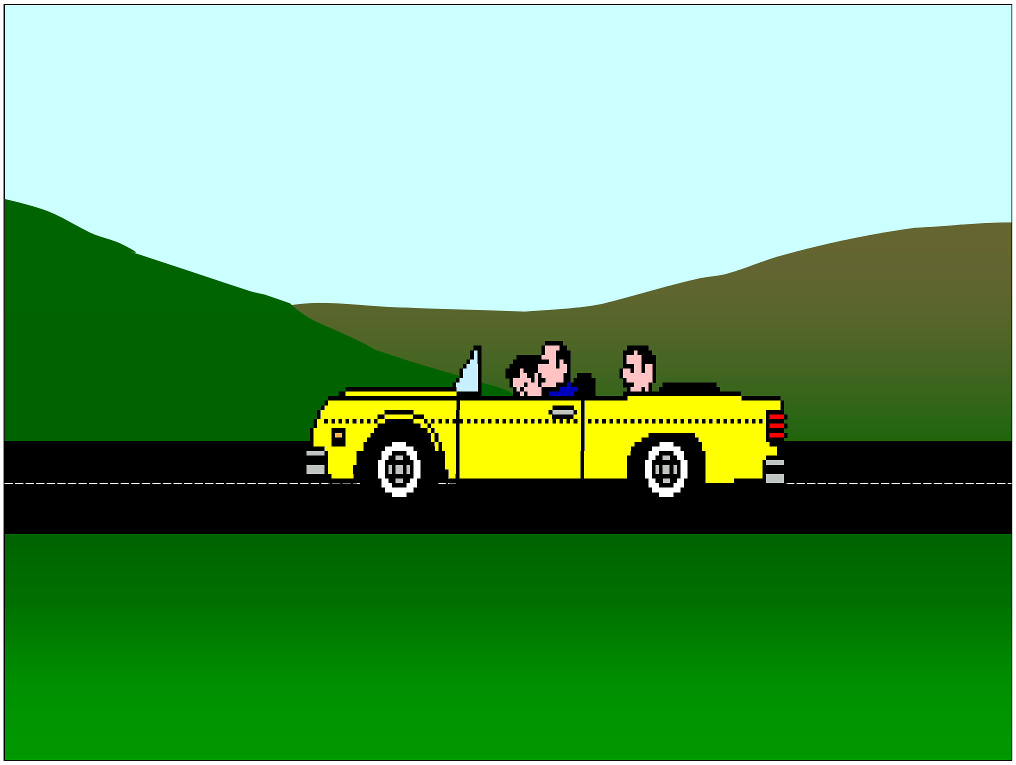
Whilst many will insist that the chemistry of the modern battery has changed little since the late 1890's, what has changed in the intervening years is the technology applied to the materials, the advanced production methods and our concern and care for the environment and human health. Indeed, the lead acid battery is likely to change more in the next decade than in the last 100 years.



The Amazing Voltaic Battery

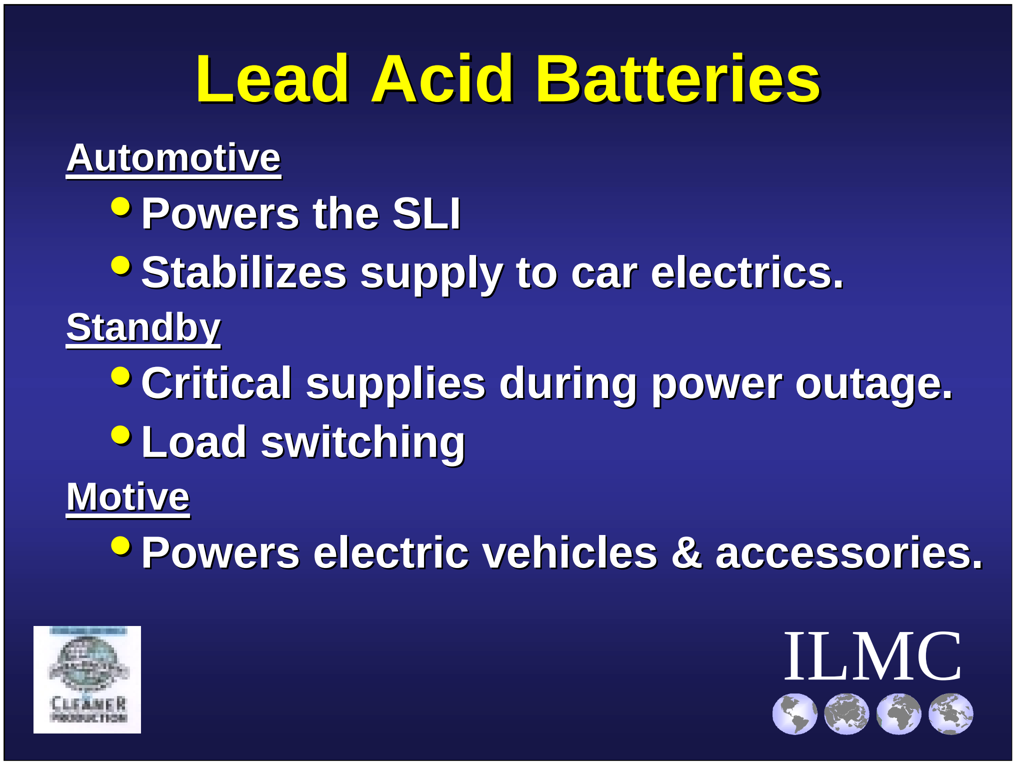
I suppose the industries' long association with the lead-acid battery goes back to those pioneering mining companies of the late 1800's. At that time the most dangerous job in the mining industry was "Blasting". Fuses were somewhat unpredictable and often failed to ignite the charge of dynamite. Or worse still, seemed to fail to ignite the charge, only to explode 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 for 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.



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.



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.

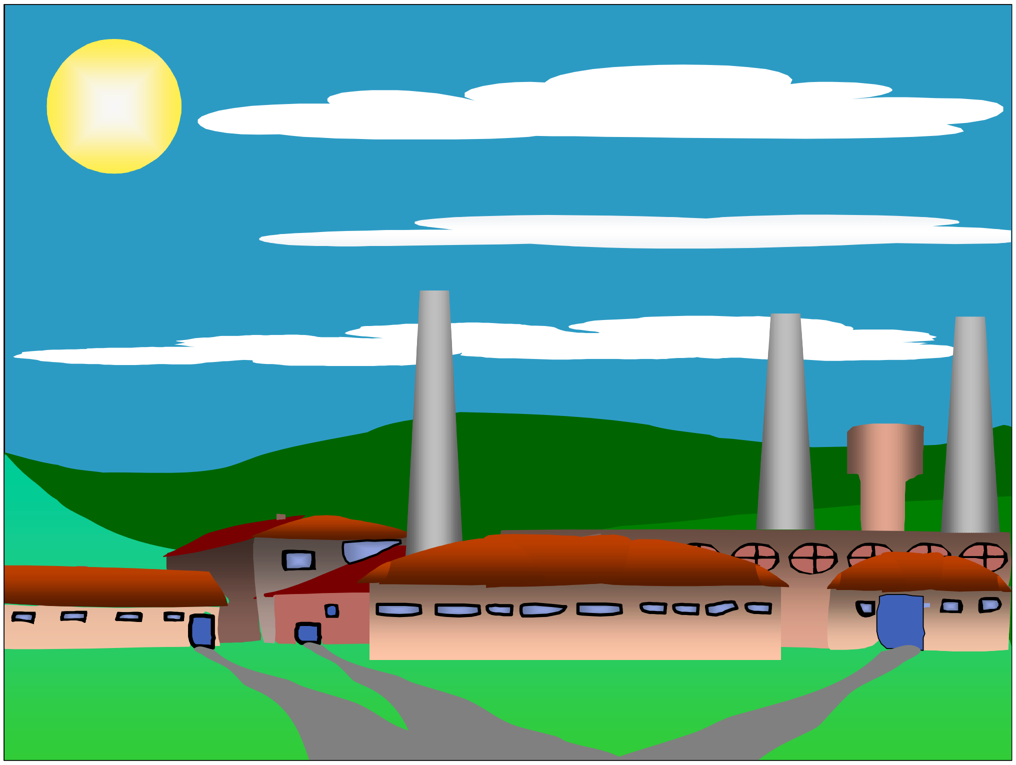
During power outages, lead-acid batteries provide quiet, pollution-free emergency power for critical operations such as air-traffic control towers, hospitals, railroad crossings, military installations, submarines, and weapons systems. In these situations the telephones stay on and this is because every major telephone company in the world, including mobile telephone service providers, 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. This is when lead-acid batteries come to the rescue, as enormous arrays of batteries 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, amusement park shuttles and golf carts. On the road, lead-acid batteries power electric law-enforcement vehicles, buses, and very soon mail delivery vans.

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 last year such a plant in Kosovo was shut down by the United Nations because environmental experts thought the pollution levels around the site were so high that there was a real risk of lead poisoning. This incident and others have left the lead industry with an unenviable legacy.



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.

Last year, 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 us today is why recycle the spent batteries?

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:

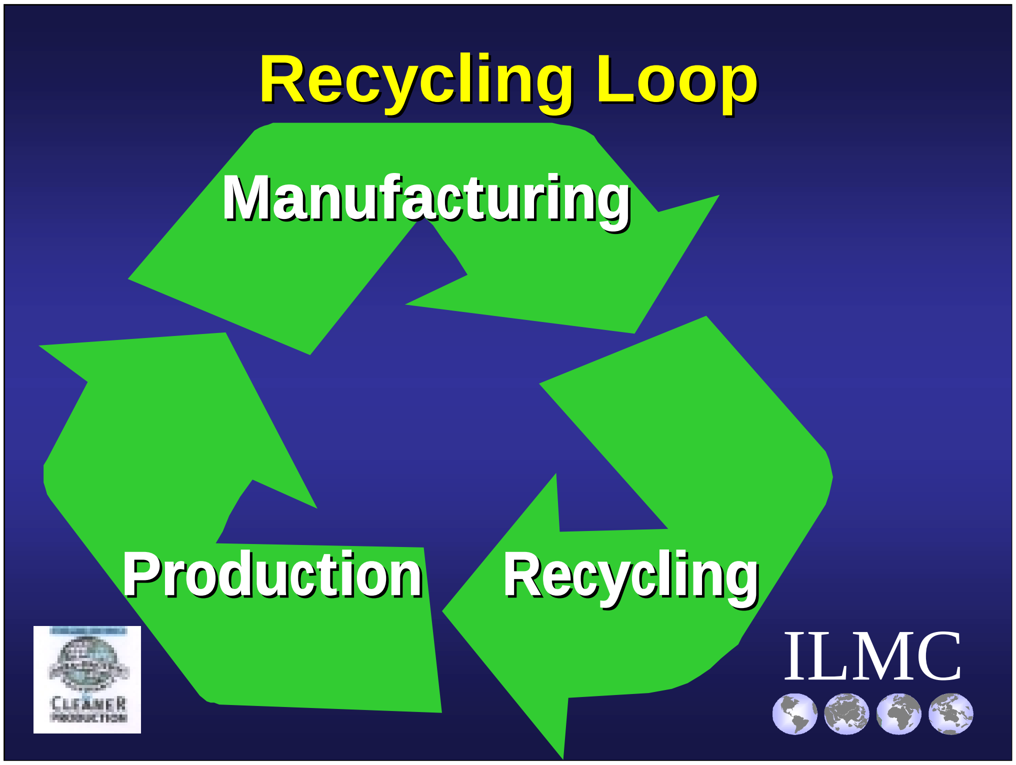
In most cases, making products from recycled materials creates less air pollution and water pollution than making products from virgin materials.

• 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.



Recycling Loop

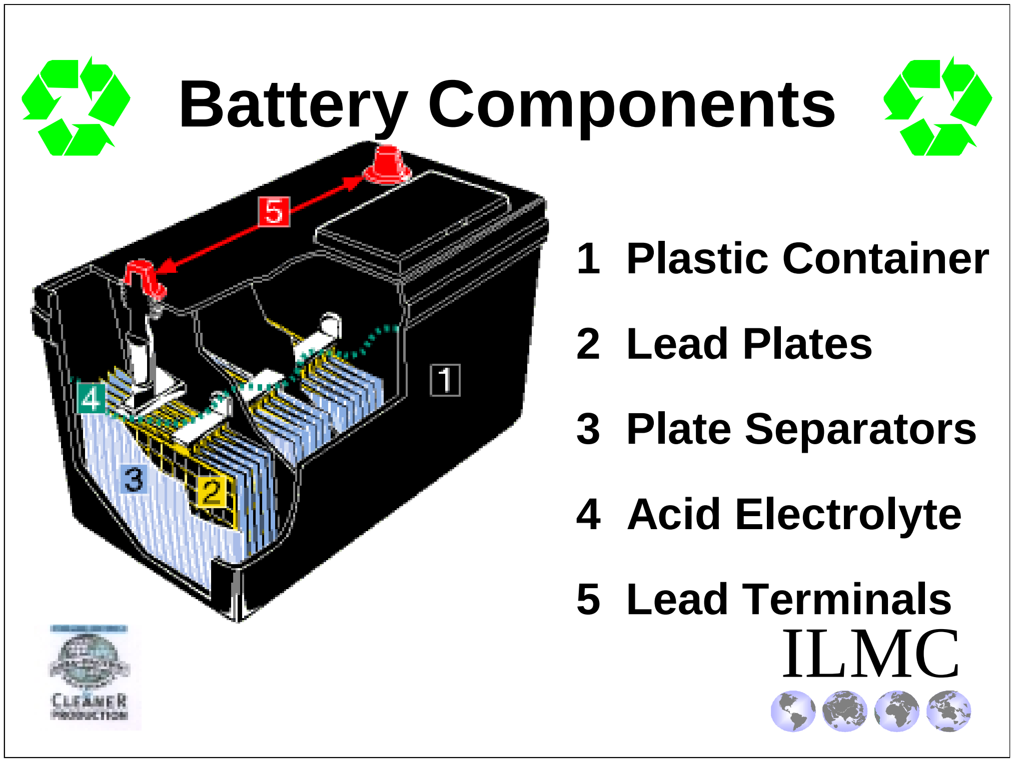
The earth's resources, no matter how abundant we think they are, are finite, and precious to all of us. It is essential that the food we eat, the water we drink and the air we breathe are free of toxins and keep us healthy. Maintaining a clean environment, re-using and reclaiming resources benefits us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

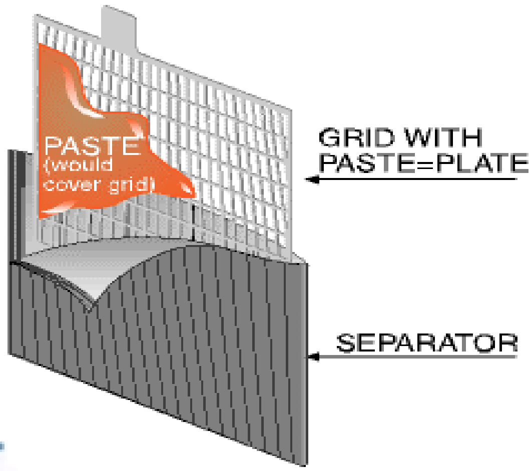


Battery Components

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 polyethylene, but increasingly is made from alternative co-polymers or reinforced, but the case material can also be metallic or a synthetic rubber.
2. Positive and negative internal lead plates. The positive electrode (cathode) typically consists of pure lead dioxide supported on a metallic grid, whereas the negative electrode (anode) consists of a grid of metallic lead alloy containing various elemental additives that includes one or more of the following and sometimes others not mentioned, antimony, calcium, arsenic, copper, tin, strontium, aluminum, selenium and more recently bismuth and silver. These alloying elements are used to change grid strength, corrosion resistance, reduce over-potential or maintenance, and internal resistance.
3. Porous synthetic plate separators 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 facilitates the chemical reactions that enable the storage and discharge of electrical energy and permit the passage of electrons that provide the current flow.
5. The positive and negative lead terminals used to connect the battery to the car and pass the current from the individual cells via a series of connecting lugs and bridges.

Separators



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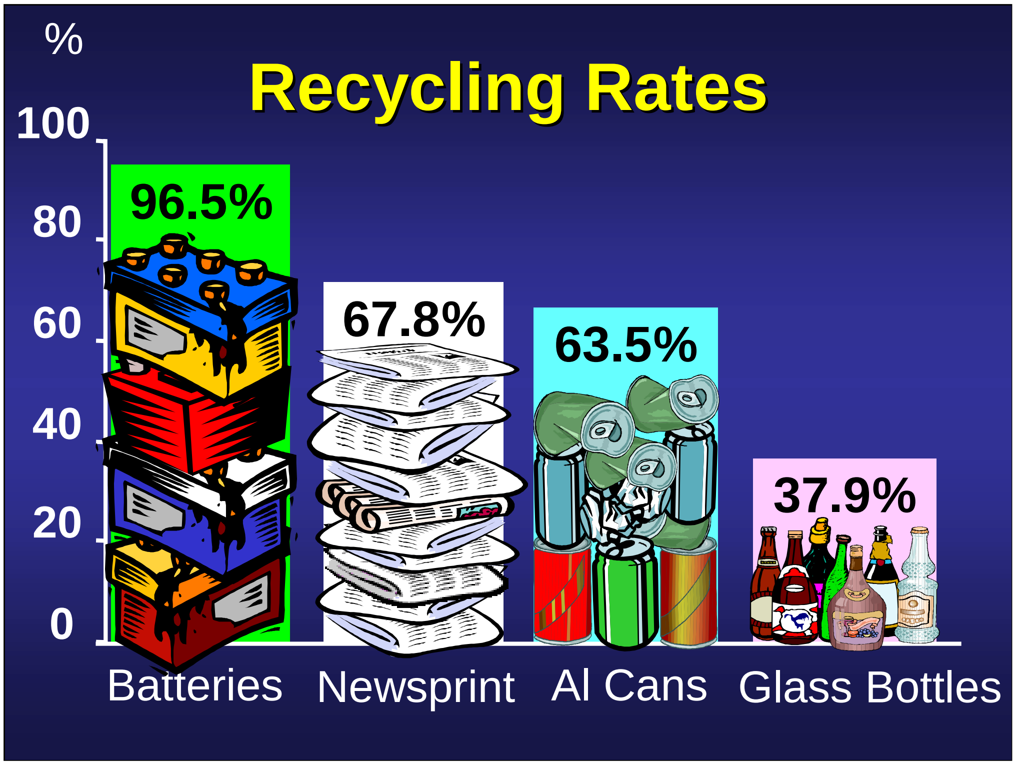
Separator

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 via the electrolyte and 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 composition of the lead battery varies around the world, but consists of approximately 25% metallic lead, 50% lead sulfate/oxide, 15% acid, 5% plastics, and the balance made up from other materials and residuals (mainly silica used to bulk up the separators).

All the components of the modern lead acid battery should be recyclable, but the design of some batteries means that certain components cannot be recovered for economic reasons or interfere with the recovery process.



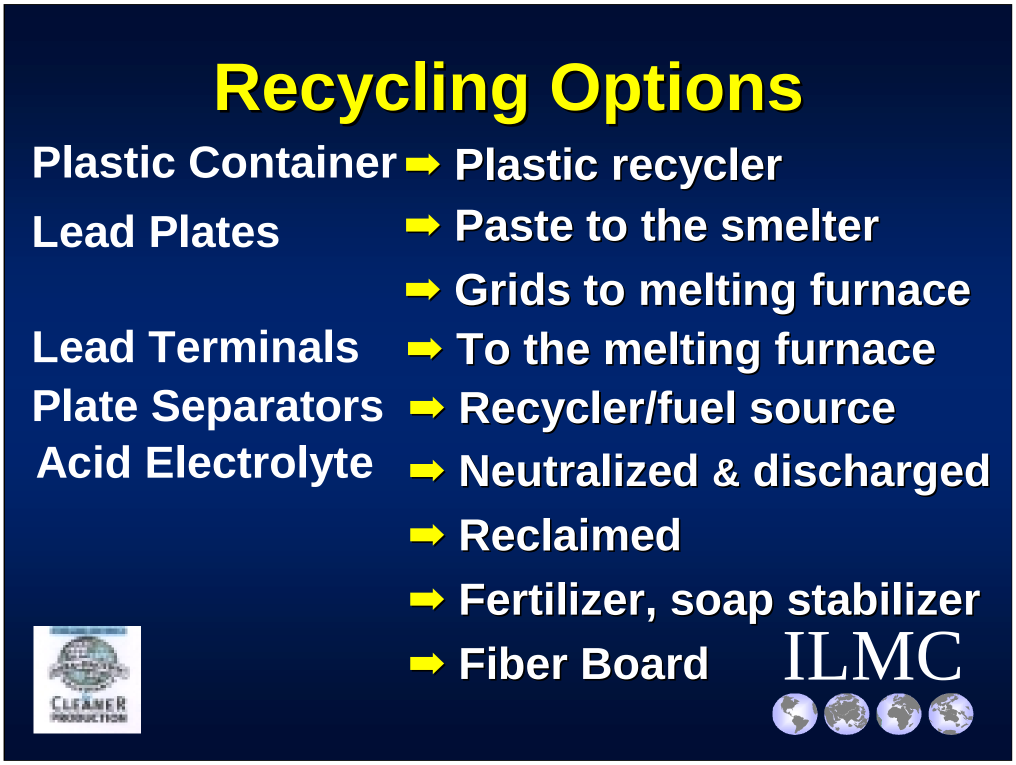
Recycling Rates

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 the United States just over 96% is recovered and in most of the G7 nations upwards of 95% 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 environmental and occupational health regulations, and an all time low lead price has cut profit margins to such an extent that most secondary lead smelters that are not the beneficiaries of government levies 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.

Although there are some BAT listed processes that smelt whole batteries most modern secondary plants break spent batteries in a mechanical hammer-mill and gravity separate the components in a series of water filled tanks.



Recycling Options

The washed and dried 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.

Although certain process with combine the waste lead streams, the most efficient plants feed the paste to the smelting furnace to recover soft lead and the grids and terminals are sent to a melting furnace for the production of hard lead. Lead bullion from both sources will be refined, cast into ingots and 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:

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

Reclaimed and after topping up with concentrated acid then used as the electrolyte in new batteries

Chemically treated and converted to either agricultural fertilizer using ammonia or to powered sodium sulfate for use in either glass and textile manufacturing or as a filler or stabilizer in household laundry detergent.

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

The Ideal Design

With recycling rates for used batteries as high as 96% you might think that 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 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. The next generation of batteries will demand a more rigid case material, so there is now an ideal opportunity for the industry to use the same plastic material in order to maximize recovery and reuse. Accordingly, rubber and metallic case material could be phased out except for instances where there is a specific need in which case the design should be such that it is easy to dismantle the battery.

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 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 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.

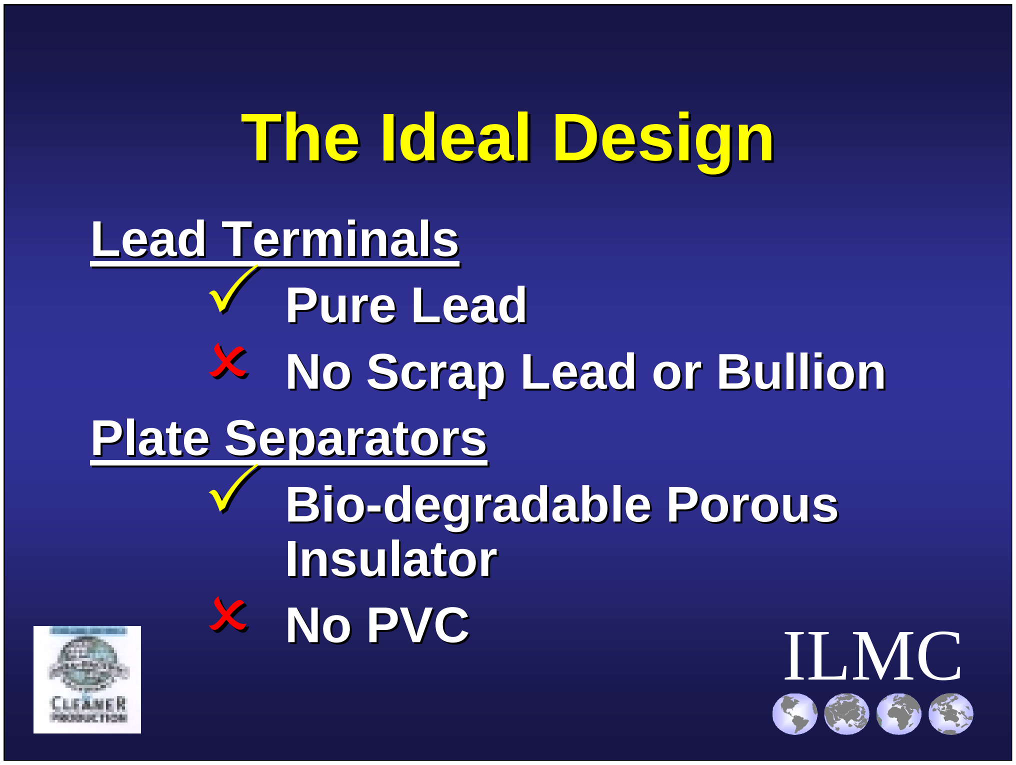
The Ideal Design

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 stronger grids that can only be made from lead alloys. Many of these alloys have traditionally been made from elements that are either toxic, environmentally undesirable or contaminate the secondary bullion. 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 are moving towards the use of elements, such as calcium and tin, not only because they enhance performance, but they are generally easier to recycle and remove from the lead bullion during the refining stage. Such elements are also desirable because they are not toxic and do not threaten the environment. Further research is required in this area, but is seems likely that a combination of traditional pyro-metallurgical smelting and the emerging hydro-metallurgical recycling will enable the secondary industry to produce a very pure lead bullion economically and with improved environmental performance due to lower emission levels and waste residues.

Battery Paste

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



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 and potential occupational safety hazard 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 and wear 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 there is the potential for the production of dioxins. Without an economic method to segregate PVC from the other separators, the whole of the separator waste stream is destined for landfill.

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 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 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 the “cradle to grave” philosophy can be realized and lead acid batteries will look a very attractive proposition compared with other technologies.

Information

For further information about Battery Recycling and/or Lead Risk Reduction programs please refer to the ILMC Web Site at:

http://www.ilmc.org

or

contact Brian Wilson by e-mail at bwilson@ilmc.org

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