

# **A Review of the Options for Restructuring the Secondary Lead Acid Battery Industry, in Particular the Smaller Battery Recyclers and Secondary Lead Smelters and the Informal Sector, with a View to Enhancing Their Environmental Performance and Improving Health Standards.**

## **Background and objective of the study**

The ban on the export of used lead-acid batteries (ULAB) from Annex VII (OECD, EC, Liechtenstein) to non-Annex VII countries pursuant to decision III/1 of the Basel Convention will reduce the availability of imported scrap feedstock for battery recycling in the Philippines. As ULAB supply from other developing countries will become scarcer and scarcer, the ban is likely to encourage and enhance collection and recuperation of domestically generated scrap batteries. This leads to a situation within which, the limits of justifiable collection and transport costs, the principal secondary lead smelter in the country, Philippine Recyclers Inc.(PRI), siphons off domestically generated ULAB from the smaller battery recyclers and secondary lead smelters, and unlicensed battery reconditioners/melters in the informal sector of the Philippine economy. Although this development is desirable from an environmental and health point of view, it might generate adverse social problems and hardship.

From a short-term perspective, this study explores the technological and managerial opportunities for improving the environmental and occupational health performance of the smaller battery recyclers and secondary smelters and unregulated reconditioning and melting activities in the informal part of the economy. The analysis has been conducted on the basis of site visits of typical production units, a brief survey questionnaire completed by the site managers and assessment of regional availability of scrap feedstock and lead demand (in the form of reconditioned batteries and refined lead for non-battery uses).

From a medium- and long-term point of view, the study investigates the pros and cons of restructuring the informal ULABs collection and recycling sector in the Philippines. The objective has been to make the smaller battery recyclers and secondary smelters, battery reconditioners and inefficient recyclers in the informal sector part of an effective and efficient collection infrastructure supporting an environmentally sound secondary lead sector for the recycling of battery scrap. This approach gradually phases out uncontrolled, inefficient and environmentally unacceptable methods of partial lead recovery, and in particular practices employed outside the formal sector by an unknown, but somewhat significant number of people. It would also spare Government agencies the eventual need to address this problem at a financial and social cost, most likely out of proportion to the amount of lead recovered during any decontamination procedure or through the provision of a (publicly managed or subsidized) scrap battery collection system.

In this regard, due attention has been paid to the logistic peculiarities of an archipelago, in particular the regional spread of collection infrastructure, collection and shipment costs as well as the assurance of environmentally safe transport. It is not unlikely that the Government might have to provide some support and assistance in making parts of the remote collection and transport system viable.

### **Scope of the study**

- Brief characterization of the size, employed technology, feedstock material and output of (i) battery reconditioners; (ii) cottage melters; and (iii) the smaller battery recyclers and secondary smelters (Asia Pacific, Silver King, Guevarra/Magsuet, Celica Batteries, Tower Lead, Honest Parts, and any others that are identified and located). Furthermore, the inter-relationship between these three different commercial groups regarding the supply of feedstock and demand for recovered lead are briefly reviewed.
- Short characterization of the main environmental and occupational health problems of the three groups: battery reconditioners; cottage melters; and smaller battery recyclers and secondary smelters
- Assessment of options for short-term upgrading of environmental and occupational health performance in the three groups. The options are practical, feasible and affordable.
- Analysis of the long-term restructuring options of the three target groups with a view to
  - (i) increasing collection of domestically generated ULAB for the unregulated battery recyclers which meet acceptable environmental standards;
  - (ii) gradually reducing uncontrolled, partial lead recovery in the country in a socially tolerable way.

## **Section 1. Characterization of the size, technology, feedstock material, output and inter-relationship between these groups: Battery Reconditioners, Cottage Melters, Smaller battery recyclers and secondary lead smelters.**

### **Section 1.1 Battery Reconditioners**

Throughout the major cities of the Philippines, and in particular the capital Manila, there are hundreds, possibly thousands of small battery reconditioners. The typical battery reconditioner occupies small shop premises located along main city roadways with street access and is usually found amongst other shops selling a variety of provisions, fast foods, and domestic and consumer goods.

Each battery reconditioner seems to employ about 4 other Filipinos engaged in a number of manual tasks associated with dismantling and re-assembling batteries. One person in each of the premises is responsible for the commercial transactions, that is, the purchase or acquisition of "spent" batteries and the sale of reconditioned batteries and surplus battery parts, i.e. rubber and polypropylene cases, and battery plates.

Some of the reconditioners also rented or leased commercial batteries for daily, weekly and monthly periods to self employed truck, "Jeepneys" and taxi drivers.

It is likely from observations made during a field trip to the Philippines in June of 1998 that as many as 6,000 Filipinos could be employed in the battery reconditioning industry.

Battery reconditioners test "spent" batteries delivered to their premise to ascertain whether the battery can be reconditioned by just recharging the cells or whether one or more of the batteries cells requires replacing due the build up of sulfates on the surface of the active materials. If the battery merely requires recharging, it is quickly resold after a quick "boost" overnight charge and the electrolyte topped up with either distilled or de-ionized water.

Batteries with defective cells require those cells to be replaced or the sulfate layers on the active surfaces of the lead acid battery to be removed. There are chemicals that certain reconditioners will add to the battery electrolyte to remove the lead sulfate layer from the active surface on the battery plates. In some cases removal of the inactive sulfate layer will allow the battery to be recharged and effectively reconditioned. When chemicals are ineffective, recyclers will usually break open the battery by cutting through the rubber or polypropylene weld at the top of the battery case and removing the top complete with the positive and negative terminal connections. Using simple measuring and observation techniques the battery cell or cells that are "spent" are identified and replaced by cannibalizing another battery with some "good" cells. The positive plates are often reused up to three times. The top will then be replaced, glued to the base section and the battery recharged prior to resale.

The expected battery life from these reconditioning methods will vary tremendously as some or all of the cells will fail shortly after resale. Experience has shown that some reconditioned batteries will fail after about three months, although many will last for five or six months, but useful life is very short compared to the expected two years life of a new battery in the hot climate of the Philippines.

Those cells that are "spent" and batteries that are beyond "reconditioning" will be broken open and the acid "dumped" by washing down the street drain or allowed to percolate into the soil at the rear of the premises. No evidence was observed for the safe collection and neutralization of battery acid in the reconditioning shops. The battery electrolyte is disposed of because it has no value. The rubber or polypropylene cases are sold to either a plastic recycling plant or directly to a battery manufacturer for reuse. The battery plates will be set aside, usually at the rear of the premises and allowed to dry. The dried plates will then be placed in large clear heavy duty plastic bags and sold by weight to one or more of the dozen or so smaller secondary smelters or backyard melters in the Philippines. Philippine Recyclers Inc. secondary plant at Bulacan does not purchase battery plates for smelting.

## **Section 1.2 Cottage Melters**

The small Cottage Melters typically work from the backyard of domestic premises or on a larger scale from abandoned industrial premises. None of these cottage businesses are licensed lead recyclers and it is also probable that lead melting is not the only metal recovery activity. Very often lead melters primary source of income will be derived from lead metal recovery from the collection of industrial and automotive battery scrap, because they can obtain a better price for the separated metallic lead content than the whole scrap battery or the plates if sold separately.

Cottage Melters break open the scrap batteries with an axe or a circular saw. The dilute sulfuric acid is disposed of by either tipping it into drains or rivers, or allowing it to percolate through the soil into the surrounding groundwater. The rubber and polypropylene cases are sold to plastic recyclers for eventual resale to the battery manufacturers. The lead battery plates, complete with the lead oxide and sulfate pastes still embedded in the battery plate grids are melted in large open kilns or cast iron "pots" of various sizes. The metallic lead grids melt easily and the metal is tapped from the kilns or pots and cast in moulds to produce unrefined lead ingots. It is most unlikely that any backyard melter will have a furnace capable of recovering the lead from the paste. The most likely scenario is that once the metallic lead in the battery grids has melted and been cast into metallic ingots the melting pot or kettle will be emptied ready for the next batch.

The waste paste tipped from the pot will be in the form of a heavy slag or residue with a lead content of over 90%. The most profitable method for disposal of this lead rich slag would be to sell it to a small or large smelter, but the most likely fate for this waste material is either the river, the rear of the melter's dwelling housing or some remote part of the countryside. There was no evidence at any of the small scale smelters that were inspected that these residues are sold for further processing. Backyard recovery rates are therefore, at best, 40% of the available lead in a scrap battery, including lugs and bridges, and consequently there will always be a serious pollution problem caused by the lead rich slag disposal.

The number of backyard melters in the Philippines has proven impossible to estimate, as the melting operations tend to be spasmodic rendering the task of tracking down these clandestine activities extremely difficult. The author of this paper did not find and witness any small scale melting operations in Manila, despite many hours of searching.

### **Section 1.3 Smaller Battery Recyclers and Secondary Lead Smelters**

A Smaller Battery Recycler or Secondary Smelter can be described as a lead recycler producing less than 5,000 tonnes of lead ingots per annum.

There are 9 known Smaller Battery Recyclers and Secondary Lead Smelters in the Philippines, six on the main island located close to Manila, and three on the smaller islands. The owners and managers of four of the smaller smelters cooperated with the Author in the preparation of this study<sup>1</sup>, in return for anonymity in the final report.

The smaller battery recyclers and secondary lead smelters produce between them approximately 12,000 tonnes of secondary unrefined lead ingots per annum. The raw materials are mainly acid drained and dry battery plates. Only one secondary plant was breaking and processing a small quantity of whole case batteries.

An estimated 150 Filipinos are directly employed in the small lead smelting plants.

All the smaller battery recyclers and secondary lead smelting plants employ "short" 1 to 3 tonne reverberatory furnaces using diesel or waste oil fired burners as the main lead smelting furnace.

Reverberatory furnaces average approximately 2.4 meters wide X 10m long at the slag line, but the reverberatory furnaces favored by the small recyclers in the Philippines are approximately one third of this size. Two burners normally fire the furnaces, although the small furnaces used in the Philippines have only one air enriched diesel/waste oil burner.

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<sup>1</sup> Appendix IV, UNCTAD / ILMC Philippine Project, Field Study Report, Small Battery Recycling Plants, Environmental and Occupational Health Assessment, August 1998.

The standard furnace construction uses magnesite brick below the slag line, chrome magnesite brick at the slag line, and high alumina brick on the upper walls. The suspended arch roof is constructed using basic brick in areas where slag may splash and high alumina brick elsewhere.

The floor arch is heavy-duty fireclay brick. It was not possible to determine or confirm which refractories have been installed in the small Filipino reverberatory furnaces. Carbon is usually added to the charge material as a reducing agent in the form of coke breeze, but in one Filipino plant waste coconut shells are used, in an amount up to about 5% by weight of the total charge. (About the same as coke breeze)

The mixed dry charges are fed manually to the small furnaces and pushed into the reaction area using a variety of hand-made tools. Radiation and convection from the hot furnace gases and walls heat the charge. The lead alloy grids melt, and the carbon reacts with the lead oxides and sulfates reducing these compounds to metallic lead and a variety of gaseous and solid oxides and sulfides. Most of the reactions take place in the first half of the furnace. The remaining portion of the furnace is mainly a settling area for separation of the slag from the metal, although some smelting is done in this zone.

The slag consists of a thin, fluid layer floating on top of the heavier molten lead layer. Both the molten slag and metal are tapped at the end of each smelt from the furnace into cast steel pots.

During the smelting of battery plates, the furnace produces low (0.2- 0.7%) antimony bullion (soft lead) and a furnace slag containing 80% lead and antimonial oxides.

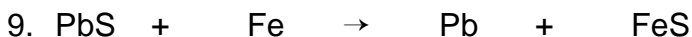
The furnace slag is stored and reprocessed in the reverberatory furnace in a separate slag campaign. The campaigned slag charge is blended with up to 5% reducing agent and is fed back to the furnace in the same manner as the battery plate material. Normally this slag smelt will recover about 50% of the lead contained in the slag as a low (.8-2.5%) antimony bullion. The residual slag from the slag charge is typically rich in antimonial oxides and low in lead oxides and ideally should be processed further in an oxygen blast furnace. As none of the smaller battery recyclers and secondary lead smelters own a blast furnace the lead recovery rate during the slag campaigns is not optimized and some of the residual lead in the slag is not recovered.

Reverberatory furnace smelting, at approximately 1400 to 1500 degrees centigrade, reduces the lead compounds to metallic lead bullion, and at the same time oxides the alloying elements in the battery grids, posts, straps, and connectors to produce a slag containing virtually all the alloying elements.

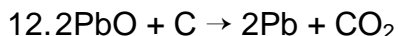
The following reverberatory furnace reactions are typically the most common:

1.  $\text{PbSO}_4 + \text{C} \rightarrow \text{Pb} + \text{CO}_2 + \text{SO}_2$
2.  $2\text{PbO} + \text{C} \rightarrow 2\text{Pb} + \text{CO}_2$
3.  $4\text{Sb(m)} + 3\text{PbSO}_4 \rightarrow 3\text{Pb} + 3\text{SO}_2 + 2\text{Sb}_2\text{O}_3$
4.  $2\text{Sb(m)} + 3\text{PbO} \rightarrow 3\text{Pb} + \text{Sb}_2\text{O}_3$
5.  $\text{Sn(m)} + \text{PbSO}_4 \rightarrow \text{Pb} + \text{SO}_2 + \text{SnO}_2$
6.  $\text{Sn(m)} + 2\text{PbO} \rightarrow 2\text{Pb} + \text{SnO}_2$
7.  $3\text{As(m)} + 3\text{PbSO}_4 \rightarrow 3\text{Pb} + 3\text{SO}_2 + 2\text{As}_2\text{O}_3$
8.  $2\text{As(m)} + 3\text{PbO} \rightarrow 3\text{Pb} + \text{As}_2\text{O}_3$

Carbon and/or carbon monoxide reduces some of the lead sulfate to metallic lead evolving carbon dioxide and sulfur dioxide as shown in reaction #1. To reduce the sulfur dioxide emissions metallic iron is added to the furnace charge to combine with the free sulfur to form iron sulfides as shown in equation # 9.



Most of the lead sulfate is reduced by the molten grid metallic according to equation # 9. In this reaction one mole of lead sulfate reacts with 4 moles of molten lead to produce 4 moles of lead oxide and one mole of lead sulfide, which enter the slag. Antimony and any arsenic and tin contained in the grid metal are also oxidized in a similar manner. Reaction # 10 is responsible for the lead sulfide, most of which is oxidized in the highly oxidizing slag by the lead oxide to produce molten lead and sulfur dioxide as shown in # 11. Any residual lead sulfide remains in the slag. The remaining two moles of lead oxide are reduced to lead by carbon in reaction # 12.



The lead sulfate and the lead oxide generated in the furnace reactions produce conditions that are reducing to lead, but oxidizing to all other battery grid alloying elements and impurities. Thus the furnace bullion contains very low levels of antimony and almost no arsenic or tin. The free flowing lead oxide or litharge slag contains virtually all the alloying elements as oxides.

At the four sites inspected internally the operators were adding scrap steel to the furnace charges. The iron in the steel reduces the lead sulfate to lead oxide during the smelting process and the iron is oxidized to iron sulfide. The lead oxide is then further reduced to metallic lead by the action of the carbon in the coke, producing carbon dioxide as the eventual by-product.

The iron, by reducing the lead sulfate to the oxide, effectively de-sulfurizes the charge, but this desulfurization process is futile unless the slag is eventually removed from the process circuit.

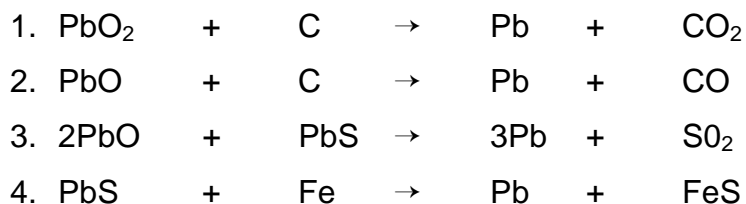
All but one of the small smelters continuously returns the slag to the reverberatory furnace, thereby saturating the molten slag in the furnace bath with iron sulfides. At saturation point any further desulfurization is only achieved with the liberation of the sulfur from the melt and the emission of sulfur dioxide gas into the atmosphere.

One of the secondary plants also utilized a small 2 to 3 tonne Rotary furnace with a deisel oil fired burner for campaign smelting of drosses and by-products. The rotary kiln is a 3 metre steel cylinder probably lined with chrome magnesite refractory bricks (79% MgO and 9% Cr<sub>2</sub>O<sub>3</sub>), as most rotary furnaces are. Heat is transferred from the burner flame to both the charge and the refractory lining by radiation.

These batch kilns are rotated during four hours of smelting thereby mixing the charge, exposing fresh material and increasing the rate of heat transfer as the hot refractories transfer heat to the material by conduction as the drum constantly rotates the refractories under the charge. The smelting temperature is approximately 1000 degrees celcius with conditions and reagent requirements usually based on the ternary phase oxide system of silica, iron and sodium. The reagents used in the Filipino rotary normally consists of 5% scrap iron (scrap construction rods) for sulfur removal and 5% sodium carbonate; the reducing agents are usually 5% coal fines and sand is added as required for the silica content in order to maintain fluidity in the tertiary slag phase.

The Filipino rotary had an diesel oil fired air enriched burner located in a refractory lined door at one end of the furnace. At the opposite end the furnace wall was tapered to an exhaust flue of about 400 millimetres in diameter. The furnace is charged through the open door housing the burner and tapped from a plugged hole in the located center of the rotary drum. There is no afterburner installed in the Filipino rotary system, but in the absence of combustibles, is acceptable.

This manually charged Filipino rotary furnace smelts product drosses, that is, lead oxides and complex metallic salts where lead is combined with other impurities. The chemical reactions occurring in the rotary furnace will depend on the composition of the drosses. Essentially, however, oxides and other compounds in the drosses are reduced to remove any sulfur and other non-metallics, disposing of the waste material in the form of a slag that melts at a relatively low temperature. The basic lead compounds react as follows:



The carbon reduces the lead oxides to metallic lead and carbon dioxide and monoxide as described in 1 and 2. Redox reactions with lead oxide and the active iron liberate metallic lead, sulfur dioxide and iron sulfide.

The dust collected in the filter bags is removed by manually shaking the bags after each furnace charge. The dust dislodged from the inside of the bags, falls to the bottom of the bag housing and is collected via a rotary valve (sealed non-return valve to prevent leaks to atmosphere) and returned to the furnace.

Two of the small smelters visited ventilated furnace gases and the fume generated in the furnace tapping areas to baghouses with polyester bag filters. One of the smelters passes furnace exhaust gasses and the ventilation from the tapping area through an aerosol mist in a small water-cooling tower. The fume dust adheres to the water droplets in the aerosol, and forms a wet sludge that collects in a reservoir at the base of the tower. The sludge is manually removed each week, dried and the fume returned to the process.

The feed for the aerosol is water circulated by a water pump in a closed unfiltered loop. The efficiency of the aerosol will be adversely affected as fine colloidal fume particles collected by the fine aerosol are re-circulated and block up the small holes in the aerosol nozzles. Furthermore, the water will gradually become acidic as some of the sulfur dioxide produced in the smelting process dissolves in the water. This innovative dust and fume collection system would be greatly improved if:

- (i) water re-circulated to the pump was filtered to remove nozzle blocking particles
- (ii) the re-circulating liquid was alkaline

An alkaline aerosol would remove more of the sulfur dioxide gas to form a neutral salt that could be returned to the furnace. Under relatively easily controlled conditions during smelting the sulfur in the salt can be removed by iron addition to the charge material and tapped from the furnace a slag that would need to be discarded.

One of the plants visited appeared to vent the furnace fumes to the atmosphere. Three other plants visited without gaining access to the process areas did not appear to have ventilation plants on the premises and “white smoke” typical of unfiltered lead fume was clearly visible from the furnace stacks.

## **Section 1.4 The Inter-relationship between the different Lead Recyclers**

Lead acid batteries that the reconditioners cannot resell are opened and the battery acid disposed of. There is considerable speculation about the methods for disposing of the acid electrolyte and regrettably the author could not ascertain precisely the most common methods of disposal. In the absence of any acid neutralization ponds, it is most likely to be disposed of by either tipping it down the local storm drain or sewer, or into a nearby stream or river or allowing it to percolate into the water table through the soil around the reconditioners premises. The lead containing plates with the metallic grids and the lead paste are separated, air dried, packed into heavy duty plastic bags, sealed and sold to the small secondary lead plants. Philippine Recyclers Inc. (PRI), the largest secondary smelter in the Philippines have a policy of purchasing and recycling only whole case batteries and the company does not purchase battery plates.

The small recyclers compete with each other for scrap battery plates in a market driven supply/demand situation. There was no evidence of any collusion between the small smelters to depress scrap prices, but there was ample evidence to suggest that there was a chronic shortage of scrap materials and all the small smelters visited during the field trip appeared to be vying with each other for supplies and operating their plants under capacity.

The small recyclers smelt the plates and probably recover at least 90% of the available lead in the grids and the paste. The unrefined lead ingots produced by the small recyclers are for the most part sold to PRI. PRI add the unrefined ingots to their own furnace metal during the lead refining process for the removal of impurities.

A minority of the small recycling plants ship their unrefined lead to producers of other small lead products such as wheel weights, lead solder or fishing sinkers.

The policy of PRI to purchase whole case batteries only serves to secure the small recyclers with an unrestricted supply of battery plates from the reconditioners. While the reconditioners have a ready market for the battery plates, they will continue to dispose of the acid in “environmentally unfriendly” ways. The market for battery plates and oxide is being sustained because PRI purchase most of the unrefined lead from the small recyclers. Acid disposal into the environment will only cease when all the recyclers, large and small, decide to recycle only whole case batteries and neutralize the acid electrolyte in the recycling process. Such a policy has, however, other implications, which are discussed later.

## **Section 2. Environmental and Occupational Health problems.**

A recent study of non-exposed adult women in Manila to lead<sup>2</sup> from dietary sources concluded that the blood lead levels of the study group was low at less than 4 mg/dl of Hemoglobin, indicating that the levels of lead exposure, including respiratory lead particulates, might be low. Data published by the Philippine Environmental Management Bureau (EMB) in 1990<sup>3</sup> and 1996<sup>4</sup> shows that lead in air values in Manila from 1987 to 1995 were not excessively high. Indeed, recorded lead in air values have fallen slightly from a geometric mean value of 0.52  $\mu\text{g}/\text{m}^3$  in 1987 to 0.45  $\mu\text{g}/\text{m}^3$  in 1995.

Information detailing environmental exposure to lead in the Philippines from the EMB is not readily available.

Pre-employment blood lead levels for employees of the RAMCAR Corporation<sup>5</sup> (appendix III) recruited from the Metro Manila area during the last two years show, however, a very different picture. The average blood lead level from those recruited in the Metro Manila area is 16.52 mg/dl of lead in blood. The number of new employees sampled in the survey was 176 from as far south as Imus and as far north as Plaridel. The average blood lead level for employees living in the Marilao area was 21.58. The lowest result was from Meycauayan employee and the highest was from an employee recruited in Marilao.

This survey of Metro Manila residents recruited to PRI or RAMCAR demonstrates that there is population exposure in and around the whole of the Metro Manila area. It is most unlikely that any emissions from the regulated site at Bulacan would be solely responsible for such widespread pollution. It is, however, more likely that the elevated blood lead levels amongst the Manila residents is due to a number of point sources scattered around the city, including unregulated smelters and battery reconditioners.

### **Section 2.1 Battery Reconditioners**

The most immediate problem posed by the battery reconditioners is the disposal of battery electrolyte, that is, dilute sulfuric acid. Acid tipped into the drainage and municipal sewer system will be neutralized at one of the many city water treatment plants. Such treatment is, however, an unnecessary financial penalty against a town's or city's municipal budget.

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<sup>2</sup> Non-occupational exposure of adult women in Manila, the Philippines, to lead and cadmium. Z.-W. Zhang et al, January 5<sup>th</sup> 1998. *The Science of the Total Environment* 215 (1998) 157 – 165.

In total 45 female non –smoking clerical workers from a large medical complex were sampled to determine levels of dietary exposure.

<sup>3</sup> Philippine EMB, Department of Environment and Natural Resources, the Government of the Philippines. *Philippine environment in the eighties*, Environmental Management Bureau, 1990:6.

<sup>4</sup> Philippine EMB, Department of Environment and Natural Resources, the Government of the Philippines. *Philippine environmental quality report 1990 - 95 in the eighties*, Environmental Management Bureau 1996:9.

<sup>5</sup> RAMCAR Corporation 1999.

Acid that is allowed to percolate into the ground at the rear of the battery reconditioners' shop will render the surrounding soil infertile and probably contaminate the groundwater. Acid tipped into streams and rivers will, depending on the extent of the dilution, lower the pH of the water and adversely affect the local ecosystem.

Sulfuric acid will also attack and dissolve most concrete mixtures and mortar. This is important in Manila, where riverbank erosion on certain sections of the river is prevented by stone and mortar retaining walls.

Personnel observed working in the reconditioning shops were not wearing any protective clothing, gloves or safety goggles. Some of the personnel working in the shops wore only shorts, no shirts or shoes, and others who were wearing tee shirts wore only sandals on their feet. The procedure to open the "spent" batteries and either change the plates or remove certain cells rendered the person undertaking the task at risk from acid splashes, and hence burns, to the skin and face, particularly the hands feet and eyes.

Battery plates removed from "spent" batteries and individual cells are air dried prior for sale to the small smelters. There is a risk that when the dried plates are collected and packed into the heavy duty plastic bags that the lead paste on the metallic grids will be disturbed and the lead bearing dust generated disperse into the atmosphere and contaminate those in the immediate vicinity. If inhaled or ingested the lead in such fine colloidal size particles will be readily absorbed into the blood stream.

It should be noted that all of the battery reconditioners observed were located in busy streets and adjacent to other general food stores including outdoor "fast food" vendors. People were observed eating meals outdoors either adjacent to or close by battery reconditioning shops and young children were seen playing in the adjoining streets.

## **Section 2.1 Smaller Battery Recyclers and Secondary Lead Smelters**

The four small smelting facilities visited had changing rooms and lockers for clean clothes. Only one of the proprietors issued their employees with protective footwear and none of them issued any protective clothing. One of the sites had a manual laundry for employees to wash their working clothes. At the other three sites employees were expected to launder their own work clothes at home. It was not possible to observe employees working at the smelters where access was not gained due to high perimeter walls.

Two of the smelters had showers for the operators to use at the end of their shifts and all four plants had hand washing facilities for use prior to meals and refreshment breaks. One of the proprietors had issued his employees with rubber dust respirators and the other three had paper masks available on request. Regrettably at only one of the Sites were any of the operators observed wearing respirators tapping slag and metal from the furnace. Some of the operators were seen to be wearing wet towels or scarves around the face during furnace tapping periods.

The vast majority of operators at the four sites wore shorts, light tee shirts and open toed sandals. Only a few maintenance personnel were observed wearing hard hats. Nobody was observed wearing eye protection, not even when tapping the furnaces.

Battery plates are delivered to the small recyclers in heavy-duty plastic bags and at all four sites were stored unopened until the material was charged to the furnace. Whilst a few of the plastic bags at one of the locations were torn open, this method of storage did adversely contribute to the lead in air levels.

Breaking the bags open prior to charging, however, does pose a serious problem. The bags are opened manually and the contents tipped onto the unventilated charge preparation area adjacent to the furnace. Clouds of dust are clearly visible during this activity and undoubtedly contribute to elevated lead levels.

One of the plants had just installed a new micro-pulsed cyclone assisted baghouse with an automated cleaning cycle for removing fume from the inside of the cloth bags. Unfortunately, this Taiwanese baghouse was still awaiting full commissioning and was not operational during the field trip. It did, however, appear to be a well designed and engineered unit, appropriate to the size of the smelter.

The furnace extraction systems employed at two of the sites and connected to manually maintained baghouses did appear to ventilate smelting fume. During smelting there were few fume emissions from the furnaces observed and the operators seemed to understand how to balance the burner exhaust gases and fume extraction systems. Nevertheless, hygiene extraction was poor on all of the furnaces. This was particularly apparent after firing a new charge and during the tapping phase of the end of the smelting cycle.

Baghouse fume and dust filters require frequent shaking to remove the build up of fume on the inside of the bags to maintain ventilation velocities in the flue system. Without frequent shaking, particularly during the first phase of smelting, the fume adheres to the inside of the filter bag and “blinds” the filter medium, severely limiting extraction and reducing ventilation at the furnace to virtually zero. Furthermore if there is a heavy accumulation of fume, it is subsequently more difficult to remove completely, even with vigorous shaking. Regular, automated and engineered mechanical shaking will minimize the risk of fume building up on the inside of the filter bags.

The exhaust stack from the smelter that contained fume with an aerosol in a 3.0 by 0.3 metre cooling tower was fume free during smelting. Nevertheless, hygiene extraction at the furnace was inadequate and failed to contain all the fume emissions during the tapping phases.

All the furnace stacks at the five sites inspected externally were observed to be fuming white smoke, typical of unfiltered furnace exhaust gases containing lead fume. It is unknown whether these sites have any hygiene or environmental controls. Two of these sites were in heavily populated areas, thereby exposing residents to lead fume. Three of

the four sites inspected internally are located in industrial zones and at least 400 metres from designated housing areas. One of the sites inspected internally has a private residence adjacent to the entrance to the property and appears to be located in a mixed zone, that is, industrial premises and private properties.

The hygiene and smelting flue ducting from all the furnaces converged at various points prior to entry to the baghouse. No mechanical dampers were observed in the respective ducting to optimize either hygiene or smelting extraction. The installation of simple manually controlled dampers located in the furnace and hygiene ducting would allow furnace operators to direct ventilation to maximize extraction to either the furnace during smelting or for hygiene during the slag and tapping periods.

External perimeter inspections at all nine sites did not reveal evidence of liquid effluent pollution, although it is feasible that wastewater from the laundries and the showers will pollute the municipal drainage system with lead bearing dusts. The absence of liquid effluent contamination is because the main feed material for the small smelters are dry battery plates and lead oxide paste.

Only one of the owners of the four smelters inspected admitted landfill disposal of furnace slag. The other three claimed that the slags and residues were continuously re-circulated in the furnaces. It is common and good metallurgical practice to return the slag tapped from reverberatory furnaces to the smelting process. The metallurgy of the reverberatory furnace is such that the slag tapped from the furnace will be rich in antimony, if present in the scrap feedstock, and lead oxides. Returning the slag to the furnace permits a second reduction phase to recover the lead in the slag residue. There is a point, however, when the slag is so rich in antimony, that re-circulation via the reverberatory furnace fails to reduce the lead content of the slag tapped from the furnace.

The traditional metallurgical solution to this dichotomy is to process this high antimonial lead bearing slag through a high temperature oxygen blast furnace. This additional furnace procedure reduces the lead content in the final residues to less than 5% (and usually < 0.5%) and produces a stable inert disposable slag suitable for either landfill or sale as road hardcore or sandblast material.

Whilst all the furnaces at the sites inspected were either housed in separate buildings or under cover, the solid waste residues were sorted and stored outside and exposed to the elements. It is important to sort through the slag because it is common practice amongst experienced operators who want to ensure that all the slag is tapped from the furnace to allow the slag to flow into the collection pot until molten metal is observed flowing into the pot. This molten lead will sink to the bottom of the slag pot during the cooling phase and solidify. Sorting through the cooled and upturned slag buttons allows operators to recover the valuable metal and return it to the process for ingot casting.

It was noted during the field trip that the slags exposed to the elements for a week or so at all the sites had degraded and were breaking down into a dusty residue. The production of these degradable slags is in part due to the use of soda ash as a fluxing agent in the furnace, thereby producing soluble sodium salts in the slags. During periods of heavy rain there exists the potential for the lead bearing slags to wash away as slurry.

The small recycler with the five tonne Rotary smelter was not operating this furnace during the site inspection. This Rotary furnace is utilized to toll smelt lead-bearing industrial drosses unsuited to the reverberatory furnaces. Rotary furnaces, unless operated at high temperatures using calcium silicate based fluxes, will produce leachable lead bearing residues unsuitable for landfill or any other industrial application. Leachable rotary furnace slags require further metallurgical treatment, which may include solvent extraction of toxic metals, to render the residues inert and safe for landfill disposal.

### **Section 3 Short Term Upgrading of Environmental and Occupational Health Performance**

#### **Section 3.1 Battery Reconditioners**

The unauthorized disposal of battery electrolyte must cease. The problem for these reconditioning shops will be where to store and how to dispose of the dilute sulfuric acid. The simple solution is not expensive, but does require education of the battery reconditioners and distribution of materials and reagents.

The Philippine Government must consider suitable legislation and monitoring to ensure that the battery reconditioners do not dispose of untreated battery electrolyte into the environment. The Government should also consider distributing to the reconditioning shops 100 litre heavy-duty plastic drums to facilitate storage of electrolyte drained from the discarded batteries.

Once the dilute sulfuric acid is contained it can either be neutralized with lime prior to discharge or collected by the municipal authorities and neutralized at a central treatment plant. Lime is a cheap neutralizing agent, but the government may have to consider free distribution of the lime to the reconditioners, otherwise the owners of the shops might consider the expense unnecessary. Lime treatment of the battery acid is not an ideal environmental solution because it does not remove any dissolved lead or lead sulfate in the discharge effluent. Of the two “environmentally unfriendly” problems and as “*a first step*”, it is preferable to neutralize the acid and discharge the effluent with some dissolved lead and entrained lead sulfate than discharge untreated raw dilute sulfuric acid to the waterways and municipal drainage system. As an alternative the municipal authorities might consider entering into a contract with PRI to treat the battery electrolyte collected from the reconditioners.

The battery reconditioning shops operate on a “shoestring budget” and the provision of any form of safety equipment represents an “unwanted” overhead. The government must educate and encourage owners to follow simple safety precautions. The employees at the battery reconditioning shops should be observing a minimum level of precautions and wear rubber acid resistant gloves, a body apron, boots and goggles. In addition when battery plates are prepared for sale to the smelters the employees should be wearing facemasks, especially when the dried plates are placed in the heavy-duty plastic bags, because this activity will generate a fine lead bearing dust which is easily inhaled.

Hand and face washing facilities should be available as a safety feature to wash away any battery acid that might splash onto the skin or into the eyes. In addition the owners of the shops should be educated to insist that employees wash their hands before eating or drinking.

In a country where smoking cigarettes appears to be almost endemic amongst the working population a smoking ban is unlikely to be observed, but a smoking ban in the reconditioning shops would reduce considerably the risk of ingestion of lead from hand mouth contact.

Reconditioning shops should reinforce any education program with inexpensive signs clearly visible in the place of work. Typically examples of two such signs would read:

**“WARNING – LEAD/ACID WORK AREA – NO SMOKING, EATING OR DRINKING”**  
**“LEAD/ACID WORK AREA – WEAR GLOVES, GOGGLES, BOOTS AND APRON”**

### **Section 3.1 Smaller Battery Recyclers and Secondary Lead Smelters**

Although most of the owners of the small secondary smelters visited had respiratory and safety equipment available at the smelting sites, few operators wore any propriety personal protective equipment. A thorough education program for the secondary lead smelting workers detailing the potential dangers and hazards associated with lead recycling should be a priority. Such a program should include the simple precautions that can be taken to minimize the risks of lead exposure and furnace related accidents, namely these “*Ten Commandments*”:

1. Wear respiratory protection during charging, smelting and tapping operations
2. Segregate work and home clothes
3. Only wear lead smelting clothing at work
4. Do not wear contaminated clothing at home
5. Wash and change work clothing every day or shift
6. Wash hands and face prior to eating or drinking
7. Eat and drink away from the smelting operations in a segregated area
8. Shower thoroughly at the end of the work day
9. Shower thoroughly immediately following a high level lead exposure
10. Do not smoke in the smelting areas

Following such education the owners should enforce the wearing of personal protective equipment. This is not a large additional cost to the owners as much of the basic equipment is already available. The minimum standards for personal protection should be hard hat, respirator, goggles, acid resistant rubber boots and a fire resistant apron when tapping the furnace.

Whilst eating and drinking areas were segregated at all the premises inspected during the field visit, large, but inexpensive signs would serve to reinforce personal hygiene. These signs would remind personnel to wash their hands prior to eating or drinking.

Two of the sites inspected had employee changing, laundry and shower facilities for employees. Nevertheless, there was little evidence that the laundry and showers were actually used to any extent, if at all. The employees at the two sites with showers should be given every encouragement to use the facilities and wash thoroughly at the end of their designated shift. Soap and clean towels should be made available and space provided to hang washed work clothes and any personal towels.

Secondary smelters without showers should consider installing at least one unit, which would at least provide a dousing point in the event that an employee is accidentally badly burned. Such an installation is not inexpensive, but is essential for both hygiene and safety reasons.

As stated in the previous section in a country where smoking cigarettes is almost endemic amongst the working population a smoking ban is unlikely to be observed. Nevertheless, a smoking ban in the smelting areas would virtually eliminate hand to mouth contact and considerably reduce the risk of ingestion of lead.

The introduction of simple manually operated dampers into the extraction ducting from the furnaces to the baghouses would enable the ventilation to be optimized for either smelting or tapping and considerably improve fume capture during slag and metal tapping. Fume capture during tapping would also be improved if the hooding on all the furnaces inspected was lowered closer to the slag and metal pots.

The risk of lead contamination during furnace charge preparation would be reduced if the bags containing the battery plates were cut open and the contents tipped into dust retaining skips specially designed with angle iron lids (see appendix II). These skips can be designed to be lifted by either an overhead crane or mobile or hand fork truck so that the charge can be deposited in or close to the furnace with the minimum of dust dissipated into the work areas. Alternatively the bags could be of a designated size that can be charged to the furnace unopened so that the risk of lead bearing dust emissions from the battery plates is eliminated.

Slag sorting and storage, prior to returning the slags to the process should be under cover to minimize weathering and the degradation of the slag into a dusty residue. Additional buildings are expensive and the only inexpensive solution would be for the owners to manage the undercover space available more efficiently and construct small storage and sorting bays with simple partitions.

#### **Section 4 Long-term restructuring options which:**

- **Reduce lead recovery in the informal sector**
- **Increase collection rates of domestically generated lead scrap**
- **Define a role for the small recycler**

#### **Section 4.1 Reduce lead recovery in the informal sector**

The long-term options for restructuring the recycling of used lead acid batteries (ULAB) in the Philippines will inevitably involve the country's major secondary lead producer, Philippine Recyclers Inc. The emphasis for this discussion paper is, however, the battery reconditioners and the small smelters.

Information and data collated by the International Lead Zinc Study Group (ILZSG) and the United Nations Conference on Trade and Development (UNCTAD) suggests that the number of ULAB recycled in the formal licensed sector of the secondary lead industry in the Philippines approaches one million units per annum.

This figure, however, represents only 50% of the replacement batteries sold in the Philippines each year. The remaining 50% of ULAB are either reconditioned or smelted in the informal unlicensed and unregulated sector or dumped and "lost" to the environment.

To discuss long term restructuring also requires an understanding of the reasons why the Philippines' has such a proliferation of battery reconditioners. By Filipino standards a new lead acid battery is equivalent to one weeks wages and represents a very expensive commodity. Furthermore because of the climate in the Philippines the average life of a new lead acid battery is approximately two years.

Heat is the number one "*killer*" of a battery; although it increases the performance of the battery in the short-term, life is drastically reduced over time. Heat increases the rate of evaporation, which causes a loss of water from the electrolyte. Extreme heat also increases the rate of self-discharge and promotes the corrosion of the positive plate grids. Antimonial battery alloys are resistant to grid "creep" and "deformation", but are prone to higher gassing rates during charging and the consequent loss of electrolyte. Calcium alloys are not ideally suited to use in hot climates and are subject to grid "creep" and "deformation".

The automotive batteries manufactured in most OECD countries, even those with hot climates, have much longer useful lifespan of between 5 and 10 years. This is because most battery manufacturers use either tin rich antimonial battery alloys to increase grid mechanical strength, reduce “creep” and improve corrosion resistance or special silver enriched alloys, which reduce corrosion and extend battery life up to twice as long as standard grid alloys.

It should be noted, however, that silver rich alloys are not, however, conducive to producing competitive high-grade secondary lead because silver is expensive to remove during the recycling process<sup>6</sup>. Recent studies by the Advanced Lead Acid Battery Consortium (ALABC)<sup>7</sup> have shown that the material strength and corrosion resistance of the positive grids can be improved considerably in calcium lead alloys if the calcium content is reduced to less than 0.08% and tin is added to the alloy to levels between 1.5 and 2%. In addition MetalEurope have been developing special barium lead alloys for use in high temperature applications and early indications are that these grid alloys might extend battery life.<sup>8</sup>

Understandably Filipinos reject paying up to a weeks salary for a battery with a limited life and will seek to purchase or lease a reconditioned unit for under half the cost of a new battery. For as long as lead acid battery life in the Philippines is so poor compared to OECD countries, there will be a market for reconditioned batteries.

The first stage of any major restructuring must be the introduction of long life batteries that provide up to 5 years useful life thereby rendering the reconditioned battery poor value for money and an uneconomic purchase. Additional research may be required to determine the optimum grid alloy composition for lead acid batteries in the Philippines. This could be undertaken in conjunction with a Philippine University, on the basis of South-South co-operation (for instance with India), or with one of the major OECD companies already supporting this area of research.

The size of the battery reconditioning industry in the Philippines will place an enormous resource demand on the EMB if these premises are to be officially inspected, monitored and regulated. If the EMB cannot acquire the necessary resources, then the presence of so many uncontrolled sources of potential lead and sulfuric acid contamination will undermine any environmental improvements made in the formal recycling sector. A change in battery grid technology that extends battery life affords the most socially acceptable way forward. In this context the Government might consider a research grant to a suitable Philippine university to explore existing technologies for battery designs and grid formulations to optimize the construction of a “long life” battery. Such a grant should be a good investment, bearing in mind the advances already made and published. It should also be possible to seek additional funding from the major recycler, PRI.

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<sup>6</sup> P. Frost, ALABC conference Prague 1998

<sup>7</sup> D. Prengemen, ALABC conference Prague 1998

<sup>8</sup> L. Albert, LABC conference Prague 1998

Because the battery reconditioning industry supports the livelihoods of so many Filipinos, any legislative program by the Philippine government to displace those employed in this sector will have serious social consequences. It is unlikely, however, that regulation alone would eliminate the trade. As long as there remains a strong demand for cheap automotive batteries this unregulated trade will continue to prosper, albeit “underground” and possibly illegal.

New grid technology that dramatically increases the life of a battery reduces the number of batteries in the recycle loop and encourages the purchase of new batteries, and not reconditioned units, apart from those that just need recharging. The retail market in “long life” lead acid batteries would therefore be the driving force to displace “cannibalized” reconditioned batteries. Moreover, this would be a slow transition over a number of years, effective only as the new units become available and confidence in the new technology grows. Over say a five-year period the demand for so many reconditioning shops will reduce and the number of premises decline. The process of change should be sufficiently slow as to allow those engaged in the trade to seek new ventures and alternative employment.

During this period it is imperative that the Philippine government and the secondary lead producers extend battery collection incentives to encourage some of the reconditioners to become scrap ULAB collectors. The Government should consider legislation that requires whole scrap batteries complete with electrolyte to be collected and stored prior to delivery to a secondary smelter.

Ideally the batteries should be palletized, shrink-wrapped and delivered unbroken to the secondary recyclers. While this might be impractical in the near future, this is the standard in the best recycling regimes and at PRI, and should become general practice in the Philippines.

In return the reconditioners should be given the opportunity to retail and lease new inexpensive batteries in exchange for scrap ULAB. This opportunity will provide a further incentive to dispense with the reconditioning trade and accelerate the integration of the reconditioning sector into the mainstream recycling sector, which has an excellent record of collecting ULAB with the licensed secondary smelters.

#### **Section 4.2 Increase collection rates of domestically generated lead scrap**

The gradual decline of battery reconditioners will not necessarily increase the percentage of scrap batteries in the Philippines collected and recycled at the licensed smelters. At present, whether “spent” batteries are sent directly to the major smelter, PRI, or are exchanged for a reconditioned battery, and “spent” cells sold to the smaller smelters, virtually all the lead in both recycling circuits is recovered. A small quantity might be sold to the backyard melters, although no evidence of this activity was found in Manila during the field, but even if this is the case, the quantity will be small.

Any change in the plate grid technology that increases the working life of the lead acid battery reduces environmental contamination from the dilute sulfuric acid and lowers the risk of population exposure from lead oxide dusts. Essentially the tonnage of lead recovered from ULAB within the current recycling circuit or PRI, the small recyclers and the battery reconditioners is the same, although environmental and population lead exposure is dramatically reduced. Improvements in collection and recycling rates for ULAB in the Philippines must, and can only come from new sources of ULAB, as yet not collected and possibly dumped in the environment.

The Republic of the Philippines consists of about 7,100 islands, but fortunately for the battery smelters over 50% of vehicle registrations are in the Metro Manila area and most of the remaining registrations are on the main island Luzon and the islands of Negros, Mindanao, and Cebu. RAMCAR, the parent company of PRI and the owner of Motolite Batteries has over 800 retail outlets in the Philippines (the Map in appendix I) including the largest islands. The RAMCAR “Balik Bateria<sup>9</sup>” collection scheme guarantees a discount on a new Motolite battery if the ULAB is returned and traded in at the time of purchase. Thus PRI has effectively a nationwide network of 800 ULAB collection points.

Philippine new battery sales suggest that there are at least another 500 independent battery retailers. The independent retailers do not necessarily collect ULAB when a new battery is sold and even if they do, they might not sell the ULAB to PRI or any other small recycler for recovery. Furthermore it is doubtful whether it is profitable for retailers not located on the main island to economically return small quantities the ULAB to the PRI site, bearing in mind that ULAB have to be shipped to the main island of Luzon in an environmentally sound manner.

The options for battery retailers who collect ULAB and wish to arrange for them to be recycled are limited. None of the small recyclers have the necessary plant and equipment to receive and process whole case batteries in an environmentally acceptable manner. Those retailers who might be environmentally conscientious and want to ensure that the whole ULAB are recycled to the highest environmental standards can only sell the batteries to PRI, because the Bulacan plant is the only site at present with the necessary equipment to contain and neutralize the battery acid.

The price offered by PRI for such batteries is lower than the current price offered by the battery reconditioners, because transporting and shipping ULAB safely is comparatively expensive, especially if they have to be shipped to the mainland by boat. This gives the small recycler, without shipping costs, a competitive advantage and consequently they are in a position to offer higher prices for the scrap materials.

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<sup>9</sup> Appendix 1

There was no evidence that the small recyclers are processing whole case batteries in any large numbers. Nevertheless, if the battery reconditioners are likely to decline over the next 5 years or so, the owners of these sites will be forced to consider whole ULAB as a feedstock in the absence of readily available battery plates. Under current licensing regulations none of the small recyclers are likely to obtain accreditation from the EMB to process whole ULAB unless they install facilities to contain and neutralize the battery acid.

There are virtually no small battery recyclers in OECD countries, because over the last twenty years the enormous cost of complying with environmental and occupational health standards could only be met by those companies with high capacity recycling plants. The smaller recyclers became uneconomic and ceased to operate.

New technologies developed in the last 10 years could, however, improve the prospects for small recyclers. Environmentally sound pyro-metallurgical and hydro-metallurgical battery reprocessing plants can be designed on a smaller scale to receive whole ULAB, break them, separate the components and smelt the lead bearing scrap. In line computer control systems enable processes to be controlled in real time. Process engineers do not have to rely on vast waste storage bunkers to contain effluent for retrospective treatment prior to discharge. Furnaces do not have to be large for economic batch processing, as certain modern designs facilitate continuous charging and tapping. Such designs enable the design engineers to scale the furnaces to suit the anticipated demand, large or small.

It is therefore feasible for some of the owners of the small recycling plants in the Philippines to consider upgrading their processes over the next five years to include those items of plant that would enable them to comply with the licensing requirements of the EMB. Existing reverberatory furnaces could be either integrated into the upgraded site or replaced with similar sized furnaces, but not necessarily the same technology.

To ensure a return on investment in new process equipment it is important for the owners of the small smelters to secure a supply of ULAB. As outlined above PRI will dominate the market for ULAB in the Metro Manila area and attract additional supplies from their retail outlets on the other main islands. There are, however, areas of the Philippines where PRI does not collect many batteries because it is either uneconomic or the retail outlets to collect ULAB do not exist (see appendix I, retail map of the Philippines).

It would be beneficial to both the owners of the small recyclers and the environment of the Philippines if small recyclers could be located in these areas. Indeed, some already are and would be ideal candidates for upgrading their facilities.

Those small smelters that are located in the heavily populated areas of Manila should either: -

- cease operating due to a lack of supply of battery plates;
- be closed by the EMB for failing to possess valid environmental compliance certificates or adequately contain battery acid or control the discharge of battery acid
- relocate outside Manila to an area with a potential supply of ULAB scrap.

From an environmental perspective it would be most desirable for those smelters located in populated areas to move to either remote locations or industrial zones. Certainly those located in the populated areas of Metro Manila should be closed.

Such a strategy will undoubtedly improve overall collection rates of ULAB in the Philippines as the small recyclers relocate to other ULAB catchment areas and seek to maximize scrap feedstock.

### **Section 4.3 Define a role for the small recycler**

In those areas of the Philippines where PRI do not have retail outlets and by previous definition a collection center for ULAB, have an obvious role. Their role and any incentive to upgrade their facilities is somewhat unclear in those areas of the Philippines close to the Bulacan smelter or where PRI have retail outlets and collection centers. As the number of battery reconditioners declines, PRI and the Smaller Battery Recyclers will be competing for the same raw materials.

It is, however, expensive for PRI to ship ULAB from the many islands in the Philippines to Luzon in compliance with the statutory environmental requirements.

Consideration should therefore be given to setting up regional secondary lead consortiums between PRI the Smaller Battery Recyclers. The basis for such an arrangement would be as follows:

- PRI would send all the ULAB collected in the outlying islands, that is apart from Luzon, under the RAMCAR “Balik Baterya<sup>10</sup>” collection scheme to local Small Battery Recyclers and Secondary Lead Smelters for processing under a consortium toll contract. In this way PRI would avoid the high shipping and transport cost associated with returning the ULAB to Bulacan.
- The Smaller Battery Recyclers and Secondary Lead Smelters would break and segregate all the recoverable materials in the ULAB.

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<sup>10</sup> Appendix 1

- PRI would assist Smaller Battery Recyclers and Secondary Lead Smelters on the islands of Negros, Mindanao, and Cebu to set up neutralization plants for the treatment of the battery electrolyte.
- The polypropylene battery case material would be crushed or shredded and resold to PRI at “fair” prevailing market prices to be cast into new battery cases at the RAMCAR battery manufacturing plant.
- The lead in the battery grids and the lead oxide and sulfates should be recovered, cast into ingots and sold to PRI as crude lead bullion. Transporting lead bullion does not pose any environmental hazards and considerably reduces the shipping costs per tonne of lead recovered.

The remaining question is the technology that the smaller smelters could consider and afford.

There are essentially two competing technologies that can be “tailored” to be suitable for the smaller recycler, one is based on the CSIRO/ISASMELT submersible lance furnace and the others are hydro-metallurgical processes.

Both have problems associated with operating overheads and ancillary costs.

The submersible lance technology generates high temperatures and requires expensive furnace refractories and automated baghouse systems that are energy intensive. This type of furnace requires the minimum of reagents and produces an inert slag that can be granulated and used as hardcore for roads or landfill.

This is, nevertheless, an established technology with plants in the UK, Belgium and a new one under construction in Malaya. A Company in Melbourne, Australia, specializes in designing and delivering purpose built furnaces. The predominant product from this furnace is “soft” lead, that is antimony free, which would suit the demand of the RAMCAR battery plant.

The hydro-metallurgical processes are difficult to assess, as there are so few operating commercially. The main drawback seems to be the high cost of electricity associated with the electrolytic production of pure lead and the disposal of highly toxic slimes that accumulate as residues in the bottom of the electrolytic tanks.

In theory, the hydro-metallurgical processes offer a new way forward to environmentally friendly recycling. All the hydro-metallurgical processes dissolve the grid metallics and the lead oxide and sulfate paste in an acid or base solution. The process is therefore free of lead bearing fumes and emissions. The lead salts are then passed to an electrolytic cell for purification by electrolysis. Installation costs for turn-key projects would be high.

One of the proposed hydro-metallurgical processes, the PLACID process, employs a technology that could be adapted favorably to suit the circumstances in the Philippines. Such an approach is already under consideration in India and is basically as follows:

- a) Dissolve the grid metallics, oxides and sulfates in a the PLACID acid/brine solution
- b) Adjust the PLACID process to partially refine the lead without proceeding to the final electrolytic stage
- c) Process the partially refined lead in a conventional low temperature melting furnace, such as a small Rotary furnace, at about 500-600° Celsius to produce a cast lead bullion suitable for refining at the PRI Bulacan plant.
- d) Careful control of the process should result in the production of gypsum (calcium sulfate) as the only waste product. Gypsum can be sold as a useful raw material to the cement industry and plaster board manufacturers.

The PLACID process is patented and more information is available, but only with the permission of the owner of the license<sup>11</sup>.

Such a mix of new and conventional technology should provide an environmentally friendly option that has potential as a viable alternative to either pure pyro-metallurgy or electrochemistry. Certainly the ability to utilize a low temperature melting furnace will minimize fume problems, baghouse requirements, and reduce fuel consumption.

Under the above scheme the smaller recyclers would have a role in the future growth of the secondary lead industry in the Philippines and would therefore be more receptive to change and cooperate with the Government in the implementation of this program.

## **Section 5. The Role of the Government of the Philippines**

It is imperative throughout the period of adjustment following the introduction of both short and long term improvements that the EMB remain vigilant in their pursuit of those recyclers that do not meet the minimum standards of environmental control. The EMB should consider penalties against those recyclers that consistently fail to meet the standard required, including revoking the operating license of persistent offenders. It is also important to locate new, but unlicensed, smelters in remote and populated areas and ensure that uniform standards are applied throughout the Philippines.

This strategy should not represent an undue strain on the manpower resources of the EMB and it would certainly be more desirable to monitor 8 or 9 small smelters than a thousand or so battery reconditioners.

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<sup>11</sup> David Andrews Projects Limited, UK.

The Government and the EMB have a key role in these strategies to ensure that every assistance is available to provide relocation incentives and facilitating technology transfer to those small recyclers receptive to environmental improvements. The benefits to the Government for adopting this strategy are fivefold:

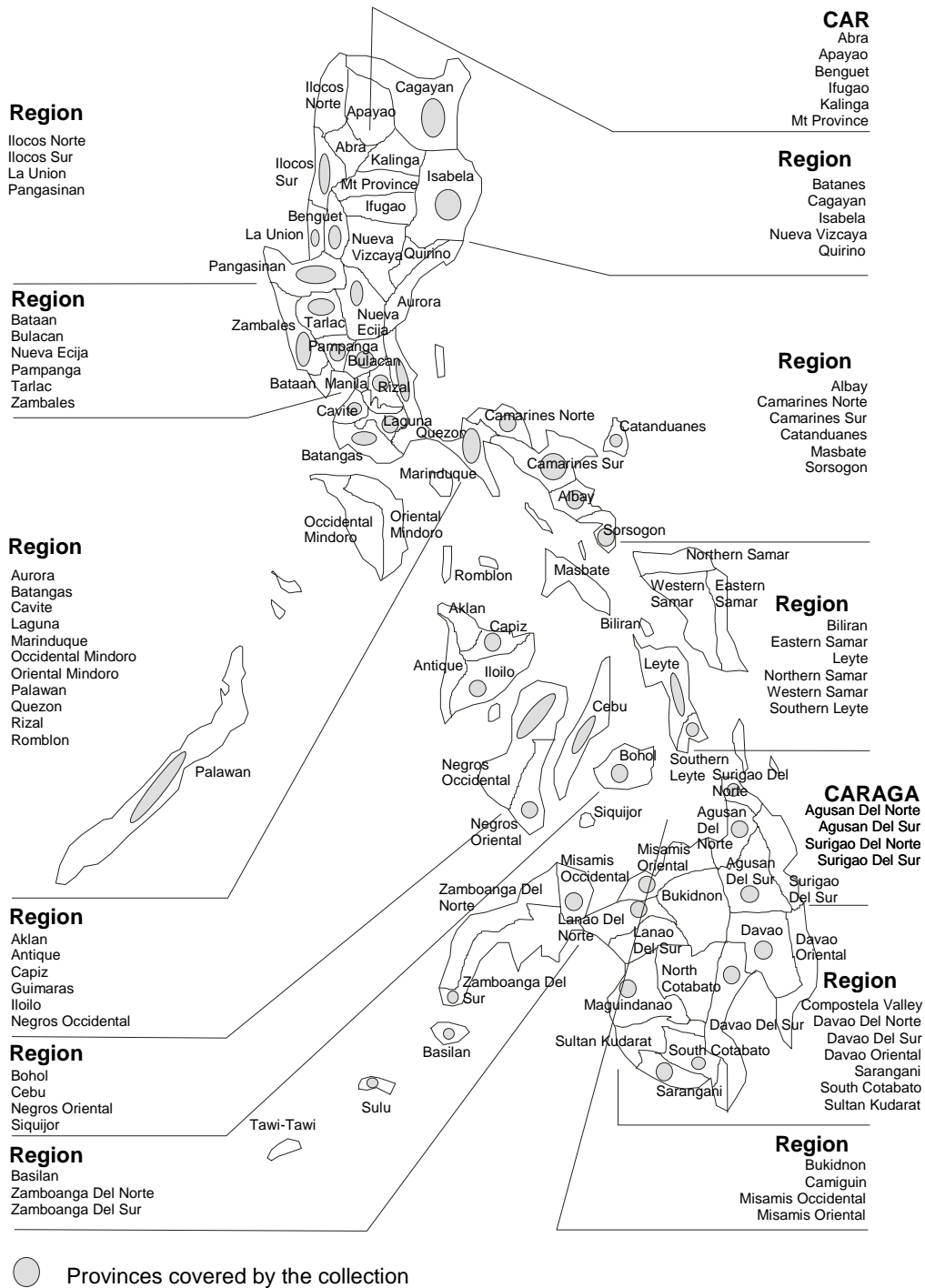
- the environment will be protected from the adverse effects of ULAB recycling
- occupational and population lead exposure will be reduced
- immediate and severe financial hardship will not be inflicted on those in the local population involved in battery recycling and who might economically and socially be adversely affected by improved environmental performance
- sound environmental performance in the secondary lead industry will considerably enhance the prospects of concluding Article 11 Agreements for the import of ULAB to meet the increasing demand for secondary lead
- the Philippine economy will be less reliant on the import of primary lead to meet the shortfall of secondary lead

The Philippines has a prosperous lead acid battery industry exporting 350,000 production units annually. This industry is an important contributor to the wealth of the nation, but unless the demand for lead for the battery industry can be met from secondary materials, the manufacturers will have no alternative but to import primary lead. There is usually little added value in manufacturing batteries from primary lead at the London Metal Exchange (LME) world prices, although in the current market the price differential is small. Nevertheless, there is still a considerable scope for adding value when lead is imported at scrap prices, recycled and resold, effectively at primary lead prices, in new batteries.

The above strategies encompass both short and long term improvements. The social disruption that might be caused by a short-term strategy that eliminates those employed in the reconditioning and informal battery recovery sectors would be so severe that it can be anticipated that the activities would be driven underground. Consequently, only the essential improvements to occupational health and the environment can be considered short term. All other strategies can be considered long term and aim to integrate all those parties involved in the recycling sector into an environmentally sound and cohesive industry in a socially acceptable manner.

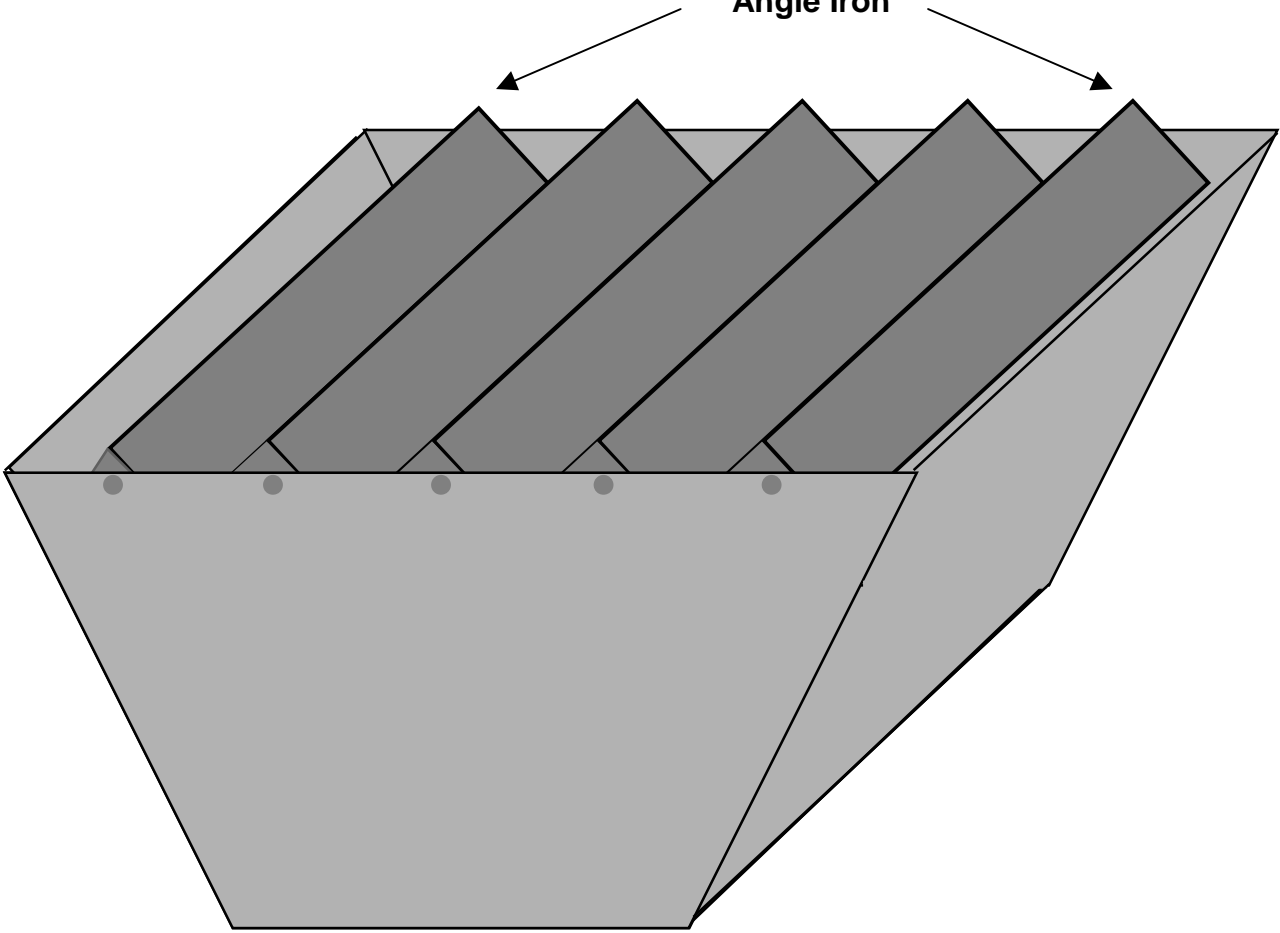
Brian Wilson  
March 10, 1999

## Provincial Catchment Area of Scrap Battery Collection within The Balik Baterya Program of Philippine Recyclers, Inc.

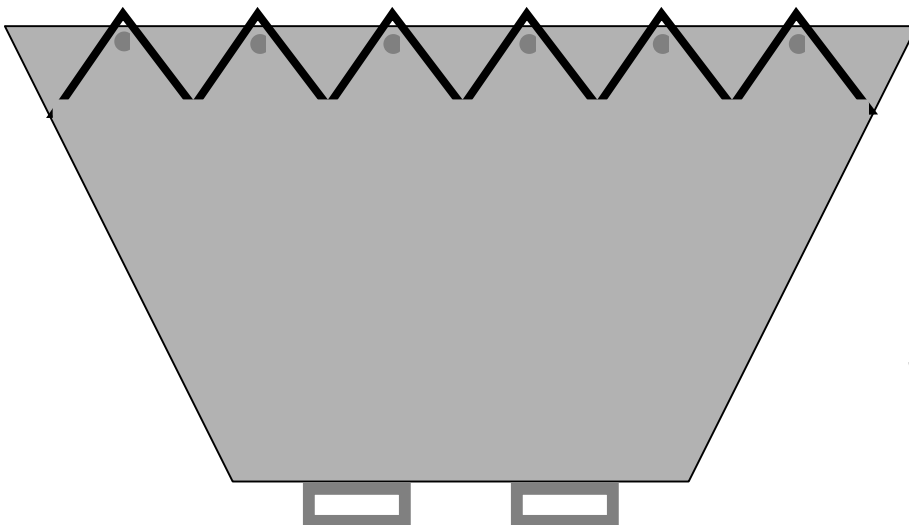


**Dust Reducing Skip**

Angle Iron



Drosses and fume “dumped” onto the skip open the swivel lids of “angle iron” to pass down into the skip. The angle iron lids swivel back into position and seal the skip.



Side elevation

# PRI Employee Baseline Lead in Blood Averages

Appendix III



Metro Manila Towns	sample size	average	Metro Manila Towns	sample size	average
Sta Maria	2	11.3	San lidefonso	1	18.21
Plaridel	4	13.49	San Jose del Monte	2	9.89
Meycauayan	45	15.94	San Miguel	1	15.15
Marilao	23	21.58	Navotas	1	9.79
Bocaue	14	23.06	Quezon City	3	18.28
Hagonoy	4	12.53	Valenzuela	34	15.32
Obando	6	14.08	Malabon	4	12.57
Baliuag	2	14.37	Calocan	4	16.7
Calumpit	4	13.21	Novaliches	1	19.55
Pandi	5	14.05	Sta Cruz	1	17.39
Paombong	1	22.22	Guagua	1	8.93
Balagtas	4	12.04	Imus	1	20.42
Malolos	7	15.02	Mandalutong	1	11
			weighted average		16.52

# **UNCTAD / ILMC Philippine Project**

## **Field Study Report**

### **Small Battery Recycling Plants Environmental and Occupational Health Assessment**

August 1998

## 1. Process

LEAD RECYCLING PLANT	1	2	3	4
1. Lead bearing materials recycled	Battery Plates drosses	Battery Plates	Drained batteries & plates	Battery Plates
2. Annual tonnage of recycled materials	1,400	1,200	1,200	1,800
3. Procedures for material collection	Delivered by truck	Reconditioners deliver by truck	Purchased & collected by truck	Purchased & collected by truck
4. Facilities for the reception of materials	Concrete bay in plastic sacks	Undercover bins	Plastic sacks in the yard	Under cover concrete bay in plastic sacks
5. Procedures for sorting scrap materials	N/A	N/A	Manual	N/A
6. Mechanically or manual battery breaking	N/A	N/A	Manual	N/A
7. Battery component separation process	N/A	N/A	Manual	N/A
8. Separate component transport system	N/A	Fork truck	Fork truck	N/A
9. Scrap smelting process and furnaces	2 x reverberatory 1 x rotary	Reverberatory	Reverberatory	Reverberatory
10. Furnace charging system	Manual by shovel	Manual by shovel	Manual by shovel	Manual by shovel
11. Furnace combustion conditions	Diesel / waste oil & air	Diesel oil & air	Diesel oil & air	Diesel oil & air
12. Furnace hygiene regimes	furnace extraction hoods to 2 baghouses	Surgical face masks	Extraction to water scrubbing tower	Extraction hood to baghouse
13. Baghouse ventilation & extraction systems	2 cyclones to baghouse	None	Extraction to water scrubbing tower	Manually shaken bags
14. Furnace lead and slag tapping regimes	Metal & slag tapped to separate pots	Metal & slag tapped to separate pots	Metal & slag tapped to separate pots	Metal & slag tapped to separate pots
15. Slag treatment, storage & disposal	Weathered on open ground & recycled	Open compound	Land fill	Recycled
16. By-products treatment	Baghouse fume recycled	N/A	Baghouse fume recycled	Recycled
17. Ingot casting procedures & process	By ladle from metal pot	By ladle from metal pot	By ladle from metal pot	By ladle from metal pot

## 2. Environment

	1	2	3	4
1. Chemical composition of typical discard	N/K	N/K	N/K	N/K
2. Atmospheric discharge limits	N/K	N/K	Results with EMB	N/K
3. Ranges and the mean atmospheric discharge results for the smelter	N/K	N/K	Results with EMB	N/K
4. Discharge standards for liquid effluent discharge	N/A	N/K	EMB	N/K
5. Raw material storage prior to furnace charging	Storage bin	Covered bin	Plastic sacks	Storage bin
6. Process area extraction and ventilation systems	Extraction hood to a baghouse	Exhaust ventilation	Extraction hood to a baghouse	Extraction hood to a baghouse
7. Baghouse cleaning and maintenance regimes	Automatic pulsed	N/A	Manually as required	Manually shaken
8. Baghouse cleaning and maintenance procedures	Maintained when stack is smoking	N/A	Top up water and remove fume sludge	Damaged bags changed as required
9. Chemical composition of the return slag	N/K	Iron matte, Na <sub>2</sub> SO <sub>4</sub> , FeO, SiO <sub>2</sub> , FeSi <sub>2</sub>	N/K	N/K
10. By-product storage areas	No	No	Sealed solid concrete	No
11. Disposal method of the discard slag	Landfill	Recycled	Landfill	N/A
12. Proximity of local population to the plant	300 meters	100 meters	Adjacent	Approx. 2.5 meters
13. Person responsible for environmental performance	Plant Manager	Plant supervisor	Owner	Owner

### 3. Occupational Exposure

	1	2	3	4
1. Number of employees and contract personnel working at the plant	25	20	10	16
2. Age and service profiles	N/K	Average age 35 years	5 years service	Average age 35 years 1.5 years service
3. Labor turnover rates	Low	Low	Nil	Nil
4. Hours of work, shift system and working patterns	3 x 8 hours continuous rotating pattern	3 x 8 hours continuous rotating pattern	7 x 8 hour day shift 2 x 15 hour rotating night shift	2 x 12 hour rotating shifts
5. Plant changing facilities and regime prior to starting work	Changing room, lockers for personal clothing	Changing room, lockers for personal clothing	Changing room, lockers for personal clothing	Changing room, lockers for personal clothing
6. Plant changing facilities and regime at the end of the working day	Changing room, lockers for personal clothing	Changing room, lockers for personal clothing & laundry	Changing room, showers, lockers for personal clothing	Changing room, showers, lockers for personal clothing
7. Protective process clothing	none	None	Personal issue	Personal choice
8. Process clothing changing & washing regime	none	Daily clean set	Daily clean set	Plant laundry facilities
9. What is the regime to ensure that process workers wear clean clothes?	None	Inspection	Inspection	Inspection
10. Segregation of eating, drinking & process areas	Segregation	Segregation	Segregation	Segregation
11. Washing or showering facilities prior to consuming food and drink	Hand wash	Hand wash	Hand wash & shower	Hand wash & shower
12. Hygiene surveillance program	None	None	None	None
13. Respirator policy for process areas	Respirators issued	Respirators issued	Respirators issued	Respirators worn to tap & charge furnace
14. Occupational exposure training	Initial instruction	Initial instruction	Initial instruction	Induction training
15. Person responsible for hygiene & occupational health	Plant Manager	Plant supervisor	Owner	Owner

