Lead-Acid Battery Management

Executive Summary

Lead-acid batteries are imported into PICs and are widely used in cars, trucks, boats, motorcycles, tractors and a range of other mechanical equipment requiring power, including solar energy systems.

Lead-acid batteries contain sulphuric acid and large amounts of lead. The acid is extremely corrosive and is also a good carrier for soluble lead and lead particulate. Lead is a highly toxic metal that produces a range of adverse health effects particularly in young children. Exposure to excessive levels of lead can cause brain damage; affect a child's growth; damage kidneys; impair hearing; and lead to numerous other associated problems. Refer section - Health and Environmental Impacts.

Although the acid can be cleaned and reused, the lead is the valuable component in the battery to be recovered by Pacific Island Countries. The appropriate controls are often not taken by Pacific Island recyclers, thus putting themselves and their environment at risk of contamination.

Batteries can be shipped to Australia or New Zealand, either containing acid or without acid. Personal Protection Equipment including coveralls, splash shields, protective glasses and gloves should be worn when opening batteries to remove the acid. The acid must be neutralised and filtered properly. The filter medium must be encapsulated in concrete to prevent migration of lead. Refer section – Battery Separation and Acid Handling.

If disposing batteries to a dumpsite or landfill, the acid should be removed and treated, and the casings should be sealed in plastic and encapsulated in concrete. Refer section – Landfill Disposal.

International legislation places restrictions on the movement of hazardous waste. The transboundary movement of batteries by ship requires special permits to be issued to the importing and exporting parties. Refer section – Export and Import Permits.

The funds paid for batteries in Australia and New Zealand may be adequate to recover the costs of shipping. Refer section – Case study of Fees.

Introduction

Lead-acid batteries contain components that have the ability to cause serious environmental contamination. In those PICs without private recyclers or even in areas of countries that do have recycling, batteries are left abandoned or disposed inappropriately to the environment.

The lead in old lead acid batteries should be recovered and reused. There are secondary smelters in New Zealand and Australia that accept old batteries for recycling, and the purchase price should usually be sufficient to cover the costs of shipping from PICs.

Conditions are harsh in most PICs hence life of batteries are lower than in more industrialised countries. A battery may only last 2 months in buses on poor quality roads.

Battery Types

There are many types of batteries and are categorized as primary or secondary cells. The primary batteries include, carbon-zinc, alkaline-manganese, lithium, zinc air, silver and mercury-oxide. The secondary cell batteries include lead-acid, nickel-cadmium, rechargeable alkaline, nickel-metal hydride, lithium and zinc-air.

This guideline sheet primarily refers to the lead-acid battery. Lead-acid batteries are imported into PICs and are widely used in cars, trucks, boats, motorcycles, tractors and a range of other mechanical equipment requiring power.

Health and Environmental Impacts

Lead-acid batteries contain sulphuric acid and large amounts of lead. The acid is extremely corrosive and also a good carrier for soluble lead and lead particulate. If the acid leaks onto the ground, it may contaminate the soil and then the soil will become a source of lead particulate as the solution dries out and the lead becomes incorporated into soil particles which may be blown by wind or raised by vehicle transit.

Lead is a highly toxic metal that produces a range of adverse health effects particularly in young children. Exposure to excessive levels of lead can cause brain damage; affect a child's growth; damage kidneys; impair hearing; cause vomiting, headaches, and appetite loss; and cause learning and behavioural problems. In adults, elevated lead levels can increase blood pressure and

can cause digestive problems, kidney damage, nerve disorders, sleep problems, muscle and joint pains.

Fetuses, infants, and children are especially vulnerable to lead exposure compared with adults, since lead is more easily absorbed into growing bodies. Also, the tissues of small children are more sensitive to the damaging effects of lead.

Present Situation

Recyclers in the Pacific are often not taking adequate precautions to protect themselves or the environment from lead contamination.

Lead recovery is also practiced at a domestic level in some PICs e.g. for making fishing sinkers and weights for diving belts. However, this practice should not be encouraged because of the potential environmental and human health hazards.

Shipments of lead-acid batteries have been made on a periodic basis to New Zealand for recycling in a number of Pacific Island Countries (PICs). These have included Cook Islands, Tahiti and Noumea. The cost of recycling has not always been recovered by these shipments. Due to the hazardous nature of waste batteries, battery recycling should be encouraged in all PICs.

In Tonga, Atenisi University collects batteries and sends the lead component for recycling. The batteries are drained of acid in soil ditches behind the university in close proximity to a low lying tidal area and the plastic casing is discarded.

Scrap Metals Fiji have been operating in Fiji since 1994 and collect batteries. The company sends whole batteries for recycling after draining the acid and also melts down lead taken from batteries to form ingots. The business will pay people for sending them batteries (The following prices are given for the different battery types N50 - $.50, N100 - $1, N70 - $0.70 each). Pacific Batteries Ltd in Fiji imports bulk lead for the manufacture of lead acid batteries. There is no recycling of lead acid batteries recovered in Fiji for their operations.

ASPA in American Samoa has collected a container of batteries for shipment to New Zealand. This operation was subsidised by the EPA to help cover costs.

It has been reported that Tahiti has been sending regular shipments of batteries for recycling to New Zealand over a number of years. This was not confirmed.

The Cook Islands have sent batteries to New Zealand for recycling previously.

Safe Handling

When handling batteries that still contain acid, appropriate Personal Protective Equipment (PPE) should be worn. This includes coveralls, protective glasses and gloves. This equipment can be purchased by specialist safety gear suppliers (refer to contacts list for suggested suppliers).

When lead plates are melted to form ingots for efficient shipping, extreme care needs to be taken to prevent inhalation of toxic lead fumes. A well fitted respirator with a cartridge suitable for lead must be worn around the heater and downwind, in addition to coveralls, glasses and gloves.

Undesirable Practices

- emptying of acid in batteries to the ground and waterways,
- lead recovery at a domestic level to make fishing sinkers and weights for diving belts,
- storage of batteries for any length of time while still connected,
- storage of batteries outside and uncovered.

Desirable Practices

- collecting batteries for either recycling or proper landfill disposal,
- reuse and recycling of as much of the battery as possible,
- shipping batteries to secure recycling facilities for recycling,
- storage of batteries in a safe storage facility as detailed below.

Terms

ULAB	Undrained Lead Acid Batteries also termed wet batteries.
DLAB	Drained Lead Acid Batteries also termed drained batteries.

Management Options

The entire process of recycling requires a co-ordinated approach and is outlined below.

Collection

Several different sectors of society need to be involved to ensure the collection system is effective, including scrap dealers, battery dealers and consumers. Collection centers should be located at retailers, service stations and other places where new batteries can be purchased. In this way disused batteries can be collected for forwarding to treatment. A collection point at landfill sites should also be considered.

At the collection center the disused batteries need to be stored so as to minimise leakage. Ideally, storage in an acid-resistant container is preferred, although this is often not possible due to cost.

- leaking batteries should be stored on a bunded pallet,
- the storage place should be sheltered from rain, water sources and away from heat,
- the ground of the storage place should have a ground cover, preferably plastic or any other acid-resistant material, that retains any leakage and directs it to a collection container for disposal,
- the storage place should have good ventilation to prevent hazardous gas accumulation,
- the storage place should have restricted access and be identified as a hazardous material storage place.

Any storage place should not accumulate large amounts of batteries (ie. over 100), and must not be considered as a permanent storage facility. Limiting the quantity of batteries decreases the chances of environmental and workplace safety accidents.

Collection points must not sell their batteries to unauthorised lead smelters. Unauthorised smelters are one of the biggest polluters of lead contamination, both to humans and the environment.

Transporting

Care is required when transporting batteries so that leakage from the battery is prevented.

- No matter what the transport method used (truck, boat, train) the batteries should be transported inside acid resistant containers, even if the batteries are in the vertical position. Batteries may be displaced from their original position, or the box may break or overturn, causing the electrolyte to leak.
- The containers should be well packed and tied <u>securely</u> during transportation.
- During transportation, labels should be used with the appropriate symbols and colours to identify the hazardous products. The symbols needed for battery transport are:

- Equipment which is suitable for cleaning battery spillage accidents should be carried on board the transportation vessel. The person(s) used to transport the equipment should be trained in use of the equipment, particularly in emergency preparedness procedures. This should also include PPE (personal protective equipment).

- A transportation schedule should be composed and the route picked to avoid environmentally sensitive areas (ie creeks, wetlands) and populated areas (ie. heavily urbanized areas).

The lead can be taken out from the battery casing before shipment and packed into containers. Although considerable care is needed in performing this operation (see below).

If there are any batteries that are leaking, these should be placed inside a containment box that is not reactive with acid, to prevent leakage.

Battery Separation

There are two hazardous components in lead-acid batteries, which need to be treated quite separately, the electrolytic solution and battery casing. The electrolytic solution is dilute sulphuric acid, which is a liquid and can leak from damaged batteries.

The battery casing contains lead that is connected to the casing and can be recovered by suitable professionals. The Technical Working Group of the Basel Convention adopted, in May 2002, the "Technical Guidelines for the Environmentally Sound Management of Waste Lead-Acid Batteries". The guidelines recommend that batteries should not be drained at collection points because the drainage of the sulfuric acid electrolyte may pose several threats to the human health and to the environment as: (a) it contains high lead levels, as soluble ions and particulate forms; (b) its acidity is very high and may cause burns and damage if accidentally spilled; (c) it requires special acid-resistant containers for storage; (d) its drainage requires workers to be protected in order to minimise any risk of injury, etc. Thus, battery drainage may be considered a potentially hazardous activity that demands, not only special tools, containers and safety equipment, but also trained personnel.

If separation of the contents is to be conducted, this should only be attempted by professional personnel, and undertaken in a safe storage facility as detailed below. Those islands that are particularly susceptible due to sensitive groundwaters, should not consider battery separation unless the alternative is dumpsite disposal.

Acid Handling

Great care should therefore be employed when removing acid by draining the casing. Once it is collected, it is important that the acid be neutralised to increase the pH (and hence reduce its corrosiveness) but also to remove the lead dissolved in the acid.

The acid should be diluted with an excess of water to give a 5 to 10-fold dilution. The liquid should then be neutralized by mixing with an equal volume of agricultural lime, or other alkaline material containing calcium carbonate, or sodium hydroxide. (Calcium carbonate can be ordered in from chemical manufacturing companies, and contact details are included later). Use of

hydrated lime has the advantage of lower cost per unit of neutralizing capacity when compared to sodium hydroxide

Coral rock may be an alternative in many PICs, although use of calcium carbonate or sodium hydroxide is preferred. The coral rock to be used should be dead coral, preferably washed ashore which can be crushed finely and added to the liquid requiring neutralization. If the rock is to be used, it should be crushed into very small particles to increase the surface area so that the neutralization reaction can proceed as fast as possible. If large particles are added to the acid it may take a lot longer for the same neutralization level to be reached.

After the additive has been mixed with the acid, universal paper is to be used to test the resulting pH of the liquid. (Universal paper can be purchased cheaply from chemical companies, again contact details are included later). Once the liquid has reached a pH of 7.5 it has been neutralised and is safe to discharge to the environment. It is important to ensure that the pH is within the range of pH 7-8, as outside of this range there will be levels of lead still dissolved into solution.

To remove the lead precipitates after neutralization, the solution must then be filtered. Soil can be used as an appropriate filter medium. A column of soil contained in a metal container ie. 44 gallon metal drum with each end removed, may be suitable for this purpose. The liquid once drained through this filter is ready for release to the environment.

The soil should be regularly replaced if large quantities of battery acid is being filtered. It is crucial that the soil must be encapsulated by mixing with wet concrete and can then be disposed to landfill as general waste. If the soil is not mixed with concrete, the lead will leach through the soil and become mobile in landfill leachate in high concentrations.

Another way to treat acid is to process it by reacting it with sodium hydroxide to convert it to sodium sulfate, an odorless white powder used in laundry detergent, glass and textile manufacturing. This process takes a material that would be discarded and turns it into a useful product.

Options

1. Recycling

There are recovery facilities in New Zealand and Australia which will purchase disused batteries. (Refer to the contacts list for details of facilities.) Lead recycling operations require a high degree of control because of the potential hazards from air emissions and wastewater discharges.

If it is too difficult to remove the acid from the batteries in the country before shipment, then the batteries can be shipped with acid still remaining in the battery. Exide in New Zealand will accept batteries still containing acid. If acid-containing batteries are going to be shipped then spillproof containers

need to be used, taking into consideration that sea conditions can be quite turbulent.

2. Landfill Disposal

If recycling of batteries is not chosen, disposal in a secure landfill is the next preferred option. Empty battery cases must be disposed carefully because they can still contain significant amounts of lead.

The acid should be removed from the casing and neutralised using the above detailed procedure. Batteries should then be wrapped in heavy duty plastic or encapsulated with concrete. The concrete and plastic serves the purpose of ensuring that lead will not leach out and become mobile in landfill leachate, thus reducing the environmental risk.

Safe Storage Facility

Batteries should be stored undercover and in a bunded area. A bund is a concrete wall built all around the area and designed to contain all the liquid likely to be spilled within the area. For battery containment, a bund wall at least 10cm high would be expected. All bunded areas should be covered to prevent rainfall intrusion.

Storage should preferably be in the temperature range specified by the batteries. Particularly in high humidity or temperatures common in the Pacific, batteries may deteriorate, causing leakage or corrosion of the metal parts.

Safe Handling

There are serious workplace health and safety risks to employees of facilities who undertake acid removal and battery management, and the following precautions are recommended.

- Personal Protection Equipment (PPE) - all workers must have their own PPE and must be trained on how to use them. The minimum PPE requirements is a respirator with lead filter, if undertaking acid removal. Extra protection is covered by wearing splash shields, safety glasses, gloves and overalls.

- Work Practices – it is important that the facility adopt some working policies to decrease the health contamination risks to employees. This includes
  a) Prohibiting smoking in the working place,
  b) segregation of the work and eating areas,
  c) enforcement of showering at the end of work,
  d) changing out of work clothes before going home,
  e) changing and laundering workwear daily,
  f) checking and cleaning respirators daily.

- Non covered areas – all areas that are not covered with roofs should ideally be of a hard and smooth surface, preferably paved with impermeable material. This is so that material can be swept easily.

Any swept materials may contain high concentrations of lead dust so the sweeper should take care to avoid inhalation of this dust by wearing a respirator and collected dirt should be disposed of in a bin that will go to landfill.

Refer to the contacts list for suppliers of PPE.

Export and Import Permits

For the movement of lead-acid batteries from any Pacific Island Countries to New Zealand or Australia there are certain import permits required, which could include:

- Basel Import Permit,
- Waigani Special Import Permit.

The processing of applications can take up to 2 months so adequate planning is important. A company from the importing country needs to make application for the permit.

Those countries who are not parties to any multilateral or regional agreements will not be permitted to transport batteries. Refer to the Export and Import Permits Fact Sheet as part of this series for more information.

Recycling Facilities

Recycling and disposal facilities are available in Australia and New Zealand as follows:

Small primary alkaline cells can be treated and disposed in NZ by Tredi. Exide have a large recycling plant in Wellington that takes car batteries.

In Australia, there is only one company that can accept, drain and smelt batteries, Australian Refined Alloys (ARA). ARA does not accept batteries straight from producers but works through another front company, Sims Metals, who will accept the batteries for processing with ARA later.

Economics

Mixed containers of scrap batteries and other lighter scrap material (eg pressed aluminium cans) have been shipped together to maximize the space versus weight ratio of the container (for example: 6 tonnes of cans, 14 tonnes of scrap batteries). This improves the financial return of each container.

A Fiji collector of batteries reports that weights between about 23 tonne and 26 tonne are achieved per container when filled with batteries. (An average is about 24.5 tonne).

Exide pay NZ $225 per metric tonne, for wet or dry (drained) scrap batteries delivered in to their store in Lower Hutt, Wellington. Exide only accepts full containers of batteries to their Wellington facilities and report that approximately 18 (dry) and 21 tonne (wet) is achieved in a 20ft container, palletised (10 pallets on the floor, 10 pallets as a second row). Scrap dealers in Auckland will need to be contacted if split shipments are made.

If a shipment is split with other materials, the scrap dealer in Auckland would need to unpack the container and ship the batteries to Exide by road. Freight could be arranged with Exide at a cost of $65 per tonne.

Case Study of fees

The cost of transporting a 20 foot container of batteries from Samoa to New Zealand is outlined in the following table. This economics analysis does not take into account collection costs, which can form a large component of resources and time. Capital costs of equipment are not included either.

Table 1: Outline of costs for transporting batteries from Samoa to New Zealand.

Fee	$ Value	Unit charge	Cost
Hire of container for two days to load	ST14 (US4)	Day	- ST28 (USD9)
Transport cost of container from company to wharf	ST150 (USD45)	For 20ft container	- ST150 (USD47)
Port Service charge in Samoa	ST30 (USD9)	Per container	- ST30 (USD9)
Wharfage fee in Samoa	ST2.5 (for 20ft cont.) (USD1)	Per m^3 (cont is 33m^3)	- ST82.5 (USD26)
Shipping cost from Samoa to NZ	NZD2200 (USD)	Per 20ft container	- NZD2200 (USD1,192)
BAF (as at 5/8/02)	12.1	%	- NZD266 (USD144)
CAF (as at 5/8/02)	18.7	%	- NZD411 (USD222)
Import service charge in NZ	NZD130 (USD65)		- NZD130 (USD70)
Customs Clearance	NZD85		- NZD85 (USD46)
GST	12.5	%	-NZD562.5 (USD305)
Transport to Company in Wellington's metro area	NZD165 (USD82)		- NZD165 (USD89)
Total cost to door of company			-NZD3,989 (USD2,162)
Income from Product	NZ$225	tonne	+NZD4,500 (USD2,248)

Income – Cost =	+NZD511 (USD277)

* 20 tonne has been taken as an average container weight of batteries
* Conversion rates used at 22/1/03 are: 1NZD = 0.542USD, 1WST = 0.583NZD
* Costs have been calculated in NZD and converted to USD after calculations
* Figures have been rounded to the nearest whole dollar

A permit issued under the Waigani Convention Regulations would be needed for this hazardous waste movement. OECD Regulations are not applicable as Samoa is not an OECD member, and the Waigani Regulations would be used rather than Basel, even though Samoa is a Party to Waigani and Basel. The code for Waigani would be Y31 on Annex I (for Basel it would also be Y31 with it further classified as A1160 on Annex VIII - this would correspond to the OECD amber code of AA170).