Risk Management Pty Ltd

# PRELIMINARY HAZARD ANALYSIS,
# BATTERY RECYCLING FACILITY,
# 10 LANCASTER STREET, INGLEBURN, NSW

***Prepared by: Dean Shewring***

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Pinnacle Risk Management Pty Limited
ABN 83 098 666 703

PO Box 5024 Elanora Heights
NSW Australia 2101
Telephone: (02) 9913 7284
Facsimile: (02) 9913 7930

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# EXECUTIVE SUMMARY

Ledox Australia Pty Ltd (Ledox) is proposing use of an existing industrial building at 10 Lancaster Street, Ingleburn, NSW, as a battery recycling facility.

As part of the Secretary's Environmental Assessment Requirements from the NSW Department of Planning and Environment, a Preliminary Hazard Analysis is required. This report details the results from the analysis.

The risks associated with the proposed battery recycling facility at Ingleburn have been assessed and compared against the DoP risk criteria. The results are as follows and show compliance with all risk criteria.

| **Description** | **Risk Criteria** | **Risk Acceptable?** |
|---|---|---|
| Fatality risk to sensitive uses, including hospitals, schools, aged care | $0.5 \times 10^{-6}$ per year | Yes |
| Fatality risk to residential and hotels | $1 \times 10^{-6}$ per year | Yes |
| Fatality risk to commercial areas, including offices, retail centres, warehouses | $5 \times 10^{-6}$ per year | Yes |
| Fatality risk to sporting complexes and active open spaces | $10 \times 10^{-6}$ per year | Yes |
| Fatality risk to be contained within the boundary of an industrial site | $50 \times 10^{-6}$ per year | Yes |
| Injury risk – incident heat flux radiation at residential areas should not exceed 4.7 kW/m$^2$ at frequencies of more than 50 chances in a million per year or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year | $50 \times 10^{-6}$ per year | Yes |
| Toxic exposure - Toxic concentrations in residential areas which would be seriously injurious to sensitive members of the community following a relatively short period of exposure | $10 \times 10^{-6}$ per year | Yes |
| Toxic exposure - Toxic concentrations in residential areas which should cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community | $50 \times 10^{-6}$ per year | Yes |
| Propagation due to Fire and Explosion – exceed radiant heat levels of 23 kW/m$^2$ or explosion overpressures of 14 kPa in adjacent industrial facilities | $50 \times 10^{-6}$ per year | Yes |

Societal risk, area cumulative risk, transport risk and environmental risk are also concluded to be acceptable.

The primary reasons for the low risk levels from the facility are that the facility is a wet process where fires, explosions and toxic releases are either contained on-site or low in off-site impact.

The following recommendations are made from this review:

1. Provide roof ventilation in the building given the potential for hydrogen build-up over time and possible explosion.

2. Ensure the sulphuric acid tank is vented from the top point in the tank given the potential for hydrogen build-up over time and possible explosion.

3. Provide double-skin underground tanks and pipes to lower the risk of environmental impact from equipment failure, e.g. lead or sulphuric acid leaking into the ground.

4. Safety showers and eyewashes should be alarmed to expedite emergency response to a person exposed to harmful chemicals.

5. Comply with the WHS (Work Health and Safety) Regulations 2011, in particular, Part 7.2, for lead control.

6. The process should be reviewed via the HAZOP technique, in particular, the scrubber system and liquid systems.

7. Ensure that the building floor integrity is sound, e.g. no cracks, to avoid seepage and environmental impact. The floor surface is to be compatible with sulphuric acid.

8. Waste liquids need to be contained and analysed for lead prior to disposal. This includes Trade Waste.

9. Trip the process on scrubber failure.

10. The emergency response plan is to include actions to take for off-site people during a fire event, e.g. stay in-doors or evacuate.

11. Include in the facility design the need to contain the design quantity of firewater.

# GLOSSARY

| | |
|---|---|
| AEGL | Acute Exposure Guideline Level |
| CCTV | Closed Circuit Television |
| DoPE | NSW Department of Planning and Environment |
| ERPG | Environmental Response Planning Guideline |
| HAZAN | Hazard Analysis |
| HIPAP | Hazardous Industry Planning Advisory Paper |
| IDLH | Immediately Dangerous to Life and Health |
| OSHA | Occupational Safety and Health Administration |
| NOX | Nitrogen Oxides |
| PHA | Preliminary Hazard Analysis |
| PPE | Personal Protective Equipment |
| PVC | Polyvinyl Chloride |
| QRA | Quantitative Risk Assessment |
| SEAR | Secretary's Environmental Assessment Requirements |
| SOx | Sulphur Oxides |
| STEL | Short Term Exposure Limit |
| TLV | Threshold Limit Value |
| TWA | Time-Weighted Average |
| UN | United Nations |

# REPORT

## 1 INTRODUCTION

### 1.1 BACKGROUND

Ledox Australia Pty Ltd (Ledox) is proposing use of an existing industrial building at 10 Lancaster Street, Ingleburn, NSW, as a battery recycling facility.

The plant is proposed to be designed for an average production capacity of 8 ton/hr (including the battery acid). The facility will process only car batteries.

As part of the Secretary's Environmental Assessment Requirements (SEARs) from the NSW Department of Planning and Environment (DoPE), a Preliminary Hazard Analysis (PHA) is required.

This PHA has been prepared in accordance with the guidelines published by the DoPE Hazardous Industry Planning Advisory Paper (HIPAP) No 6 (Ref 1). JBA Planning (acting on behalf of Ledox) has appointed Pinnacle Risk Management Pty Ltd (Pinnacle Risk Management) to prepare this Preliminary Hazard Analysis report.

### 1.2 OBJECTIVES

The main aims of this PHA study are to:

- Identify the credible, potential hazardous events associated with the development with the potential for off-site impacts;
- Evaluate the level of risk associated with the identified potential hazardous events to surrounding land users and compare the calculated risk levels with the risk criteria published by the DoPE in HIPAP No 4 (Ref 2);
- Review the adequacy of the proposed safeguards to prevent and mitigate the potential hazardous events; and
- Where necessary, submit recommendations to Ledox to ensure the development is operated and maintained at acceptable levels of process safety and effective safety management systems are used.

### 1.3 SCOPE

This PHA assesses the credible, potential hazardous events and corresponding risks associated with the Ledox battery recycling facility at Ingleburn with the potential for off-site impacts.

## 1.4 METHODOLOGY

In accordance with the approach recommended by the DoPE in HIPAP 6 (Ref 1) the underlying methodology of the PHA is risk-based, that is, the risk of a particular potentially hazardous event is assessed as the outcome of its consequences and likelihood.

The PHA has been conducted as follows:

- Initially, the development and its location were reviewed to identify credible, potential hazardous events, their causes and consequences. Proposed safeguards were also included in this review;
- As the potential hazardous events are located at a significant distance from other sensitive land users, the consequences of each potential hazardous event were estimated to determine if there are any possible unacceptable off-site impacts;
- Included in the analysis is the risk of propagation between the proposed facility and adjacent properties; and
- If adverse off-site impacts could occur, the likelihood of each potential hazardous event was reviewed, using appropriate techniques / methods, to check if there is any significant risk to people and facilities off-site, and if the risk levels are within the criteria in HIPAP 4 (Ref 2).

# 2 SITE DESCRIPTION

The site at 10 Lancaster Street, Ingleburn (see Figure 1), is approximately 3,800 $m^2$ in area and is located within the Ingleburn Industrial Estate in the Campbelltown City Council Local Government Area.

The battery recycling facility will utilise the existing building on the site. The building on the site is single storey in height with an internal mezzanine level. Car parking is provided towards the southern end of the property. Two driveway accesses off Lancaster Street are provided to either edge of the southern frontage. The building contains a mezzanine office component at the front with the remainder being a double height warehouse. Roller doors at either end provide vehicle access into the building. The building covers approximately 52% of the total site area.

The site is surrounded on all sides by existing industrial development. The Ingleburn industrial estate continues to the south-west of the site for some 2.5 km.

West of the site is an existing metal fabricating facility, beyond which is the Bunbury Curan Creek canal, then further industrial development leading to the Hume Motorway (M31) approximately 1 km away.

South of the site, beyond the immediate industrial development, is the Ingleburn Memorial Park approximately 350 m away. Further afield is the Main South Railway connecting Campbelltown and Liverpool. Ingleburn Station is located approximately 700 m south of the site, with the retail centre of Ingleburn immediately east of the train station. There are a number of residential houses in Aero Road approximately 300 m south of the site.

South-east of the site are existing industrial facilities leading to the Main South Railway (some 400 m away), beyond which are the residential areas of Ingleburn. These residences east of the Main South Railway are located approximately 450 m southeast of the site.

East of the site are existing industrial facilities beyond which is located Milton Park. The closest residential area east of the site is located in Macquarie Fields some 850 m away.

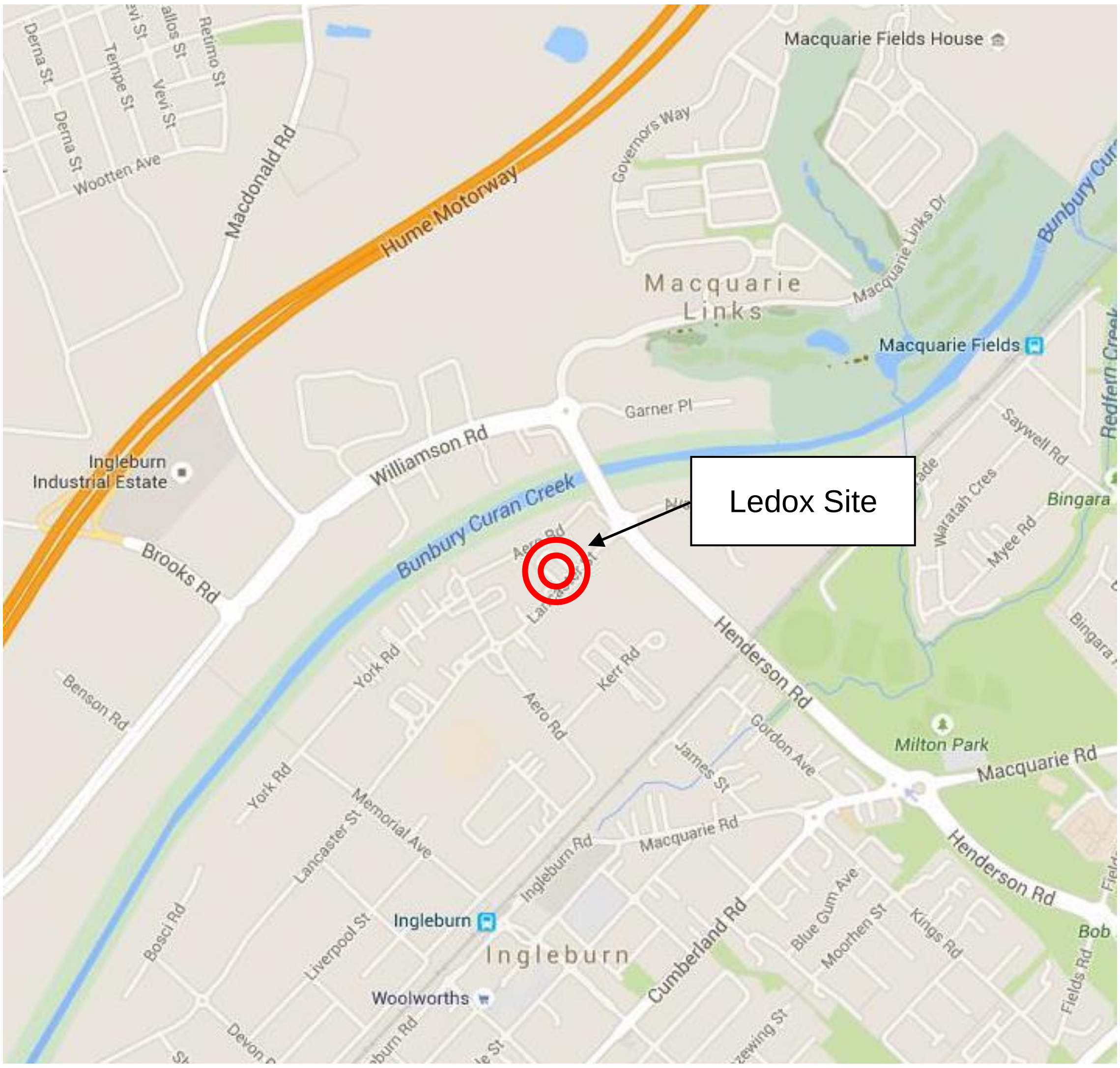
North of the site the closest residential area is Macquarie Links, some 750 m away.

The proposed trading hours are Monday-Friday (7am-7pm) and Saturday (9am-3pm). There will be approximately 7 people on-site.

Security of the site will be achieved by a number of means. This will include site personnel and security patrols by an external security company (this includes weekends and night patrols). Also, the site will be fully fenced and non-operating gates will be locked. Security cameras will be installed for staff to view visitors and site activities.

There are no known significant external events, e.g. flooding, that are considered high risk for this site.

**Figure 1 - Site Location**




Source: Ref 3

# 3 FACILITY DESCRIPTION

## 3.1 OVERVIEW

The proposed battery recycling facility will receive car batteries from distribution agents. The batteries will be broken down and the recoverable components will be extracted for recycling and/or re-use.

The facility intends to have the capacity to process up to 1,500 tonnes of per month. Each battery comprises of recoverable lead and plastics which will be collected for reuse and waste materials that will require disposal. The approximate breakdown of the components within batteries is shown in Table 1.

**Table 1 – Battery Composition**

| **Material:** | **Weight%** |
|---|---|
| Electrolyte (sulphuric acid) | 15 |
| Lead Sulphate | 10 |
| Lead Oxide | 40 |
| Lead Grid or Metal | 30 |
| Polypropylene | 3 |
| Heavy Plastics, Paper, Fibres etc | 2 |

It is intended to recover the lead plates and lead sludge and transport these to South Korea for re-processing into new car batteries.

The residual waste materials are the sulphuric acid, waste water and waste polyethylene (known as separators). These will be removed from site by a suitably licenced contractor for disposal. Residual plastics may also be recycled if appropriate recycling schemes are available.

The battery recycling machine will be almost entirely within the building. External components will be limited to a scrubber and a sodium carbonate tank (400 L capacity).

## 3.2 PROCESS DESCRIPTION

The overall process contains five main operational areas:

- Unit 100: Battery transportation, sulphuric acid collection;
- Unit 200: Shredding and separation unit;

- Unit 300: Lead paste desulfurization unit;
- Unit 400: Automated soda ash supply unit; and
- Unit 500 Scrubber System.

These areas are shown on the Site Layout (Figure 2) and Process Flow Diagram (Appendix 1).

### 3.2.1 Process Inputs and Outputs:

The following are the process inputs to the battery recycling facility:

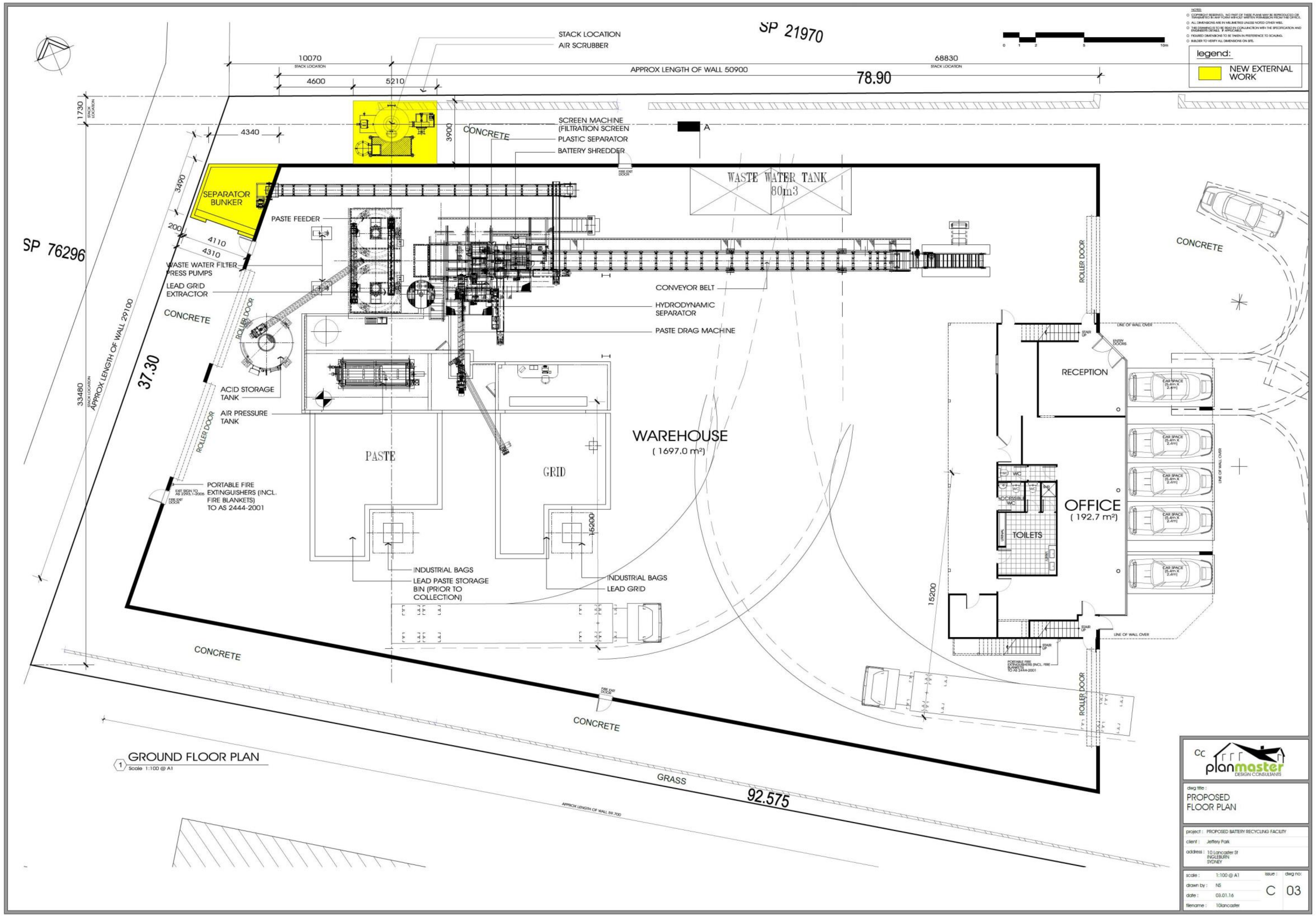
- The car batteries;
- Sodium carbonate (stored as a powder in a 50 te silo);
- Polymer (supplied in 20 kg or 25 kg bags);
- Potable water;
- Instrument air; and
- Power.

The following are the process outputs:

- Plastics, i.e. polyethylene and polypropylene. These will be cleaned and sold for recycling;
- Waste water. This is the water used for cleaning the warehouse plus some of the sulphuric acid. The pH is expected to be 3 to 4. The waste water is stored in the waste water tank (80 $m^3$). The waste water will be collected by a licenced waste water contractor in a tanker and taken for off-site re-processing;
- Sulphuric acid. This will be stored in a 30 $m^3$ tank;
- Lead carbonate ($PbCO_3$), i.e. the filter cake (sludge) or paste. The sludge will be collected in bins, loaded into containers and taken for re-processing into new batteries at another site; and
- The recovered lead plates, i.e. also known as grid or lead scrap (recycled to new batteries).

The solid outputs, i.e. lead plates, lead sludge and plastics, will be packaged into industrial bags ready to be exported in shipping containers.

**Figure 2 – Site Layout**



### 3.2.2 Unit 100: Battery Transportation and Sulphuric Acid Collection

The objective for Unit 100 is to ensure that Unit 200 is supplied with batteries that do not contain any electrolyte, i.e. sulphuric acid.

Waste storage batteries are unloaded inside of the factory from trucks. The batteries are transported by forklift truck onto BC-101 (belt conveyer) where they are fed to a cutting machine (CT-101). The cutting machine breaks open the batteries which allows the sulphuric acid to drain into a sump and trench. The sulphuric acid flows to an underground collection tank for either reuse or off-site disposal (i.e. by pumping into a road tanker). The sulphuric acid tank capacity is proposed to be 30 $m^3$.

### 3.2.3 Unit 200: Shredding and Separation Unit

The battery pieces from the cutting machine are then fed into the shredder machine. The battery pieces are then shredded prior to subsequent component separation and sorting.

The shredder machine is to be supplied with recycled water for cooling, screen cleaning and material transport purposes.

The battery scrap and the water spray from the shredder machine pass through the screen machine (VS-201) where the water and a fine powder paste of less than 0.2 mm (lead oxides and lead sulphate) discharge to the paste drag machine. Large pieces from the screen machine, i.e. the lead and plastics, are to be discharged into the hydrodynamic separator (H-200).

The hydrodynamic separator will separate the plastics and lead onto their respective conveyor belts. This water filled vessel uses the differences in weight and density for material separation. The three main outputs from the hydrodynamic separator are:

- The separators (e.g. polyethylene) and water from the hydrodynamic separator will be transported to the vibrating screen (VS-206) where they will be separated. The separators will be stored in a bin and the water is sent to the paste drag machine;
- The polypropylene and water from the hydrodynamic separator will be transported to screw conveyors SC-209 and SC-210 where they will be separated. The polypropylene will be washed and stored in a collection bin; and
- The lead (grid) from the hydrodynamic separator will be dried using air and then transported to screw conveyors SC-211 and SC-212 for storage in bins.

When the paste and metallic powder enter the paste drag machine (DG-230), it will be mixed with flocculant, i.e. polymer. This will create flocs, i.e. sludge in the water, for ease of neutralisation in Unit 300 and separation in the filter press.

### 3.2.4 Unit 300: Lead Paste Desulphurisation Unit and Filter Press

The lead sludge within the recycled batteries is sulphate based, primarily compromising lead sulphate ($PbSO_4$), which is a toxic substance. This requires treatment via chemical reaction to convert the sludge into a carbonate-based material, i.e. lead carbonate ($PbCO_3$), which is a more stable form of lead and more suitable for handling and shipment.

The sludge from the paste drag machine will be conveyed into one of two stirred neutralisation tanks (R-310 and R-320) and soda ash (sodium carbonate) added. This is to neutralise the sludge from lead sulphate to lead carbonate and also to neutralise sulphuric acid. The reactions in the stirred tanks are as follows:

$PbSO_4$ (s)+ $Na_2CO_3$ (aq) = $PbCO_3$ (s) + $Na_2SO_4$ (aq) + heat

$H_2SO_4$ (aq) + $Na_2CO_3$ (aq) = $Na_2SO_4$(aq) + $CO_2$(g) + heat

Once the sludge has been neutralized, it will be conveyed to a filter press where the majority of the water is removed to form the filter cake. The expected percentage in the filter cake for water is approximately 20% and approximately 80% for the lead. The sulphur content is likely to be less than 0.6%.

The water from the filter press flows to a recycling water tank (10 $m^3$) for subsequent reuse, i.e. in the neutralisation tanks. The recycled water tank will be an underground tank. The pH will typically be 7 to 8.

### 3.2.5 Unit 400: Automated Soda Ash Supply Unit

The storage tank capacity for soda ash (sodium carbonate) will be approximately 50 tonne in an atmospheric silo. When required for neutralisation, the soda ash will be automatically fed to the stirred neutralisation tanks via screw conveyers SC-403 and SC-404.

### 3.2.6 Unit 500: Scrubber System

The scrubber system will be designed to remove odours, particulates and vapours produced during the production process (primarily SOx and trace levels of lead dust). The ducting sources that capture these odours and vapours are shown in Table 2. There is a fan on the inlet to the scrubber so the ducting operates at slight negative pressures, i.e. to avoid emissions sources affecting people within the building.

**Table 2 – Odour Sources for Scrubber**

| Identifier: | Equipment Name: | Equipment Number: |
|---|---|---|
| A | Shredder Machine Inlet (Conveyor Belt Outlet) | HC-200 |
| B | Hydrodynamic Separator Upper Body (Vibrating Screen Outlet) | VS-201 |
| C | Paste Drag Machine | DG-230 |
| D | Stirred Neutralisation Tanks | R-310 and R-320 |
| E | Filter Press Upper Body | - |

The scrubber will contain packing which will be sprayed with water. The water will flow over the packing and absorb any SOx and lead dust as they travel up through the bed. The scrubber stack discharge is 600 mm diameter and 9 m above ground level.

# 4 HAZARD IDENTIFICATION

## 4.1 HAZARDOUS MATERIALS

The hazardous materials at the proposed facility are summarised as follows:

- Sulphuric acid and acidic mist / SOx to the scrubber;
- Lead, lead sulphate, lead oxides and lead carbonate;
- Sodium carbonate;
- Polymer; and
- Carbon dioxide.

The hazardous properties associated with these materials are discussed below.

***Sulphuric Acid***

Sulphuric acid is a Class 8 Dangerous Good (corrosive substance); Packing Group II. The typical strength for sulphuric acid in car batteries is between 30 to 50 wt%.

Sulphuric acid is a colourless, oily viscous liquid with a strong pungent odour. It is not flammable but is highly corrosive, toxic and poisonous. The threshold value limit for sulphuric acid is 0.2 $mg/m^3$ and the STEL (Short Term Exposure Limit) is 3 $mg/m^3$. The odour threshold is 0.6-1 $mg/m^3$ although pure acid does not have good warning properties.

In splash accidents involving sulphuric acid, the heat liberated by dilution with water (i.e. from the body) can add thermal burn to the chemical injury caused by the acid itself.

Sulphuric acid is a very powerful oxidiser that is incompatible with materials such as oxidising agents, organics, nitric acid, chlorates, carbides, metals (e.g. sodium, aluminium, potassium) and zinc oxide. Concentrations below 70% attack mild steel. Sulphuric acid may attack some forms of plastic, rubber and coatings.

In the presence of water, sulphuric acid is highly corrosive to most metals. It will strongly react with water at concentrations greater than 90%. Flammable hydrogen gas may evolve upon contact with metals. Care is therefore required when maintaining pipework etc containing sulphuric acid as hydrogen flash fires can occur, e.g. hot work in cutting through pipes.

The potential evolution of toxic gases requires handling of sulphuric acid only in well ventilated areas. The storage vessel and area must be secure, dry and removed from the incompatible materials listed above. Small containers must be adequately labelled, protected from physical damage and sealed when not in use.

Although not flammable, sulphuric acid may produce toxic gases when heated by a fire, e.g. sulphuric acid mist and sulphur dioxide. If fumes are inhaled, severe irritation to the throat will occur. Over exposure may result in mucous membrane irritation, coughing, bronchitis, ulceration, bloody nose, lung tissue damage, chemical pneumonitis, pulmonary oedema and death. Contact with skin may result in rash, dermatitis, blistering, severe burns and discolouration.

When spilt, sulphuric acid is very slippery.

Sulphuric acid reactions with iron, e.g. in metals, can produce iron sulphate. This sludge can cause blockages in equipment and possible equipment damage.

***Lead, Lead Sulphate, Lead Oxides and Lead Carbonate***

Inorganic lead is a malleable, blue-grey, heavy metal that occurs naturally in the Earth's crust.

Lead and its compounds enter the body primarily through inhalation and ingestion. Lead passes through the lungs into the blood where it can harm many of the body's organ systems. While inorganic lead does not readily enter the body through the skin, it can enter the body through accidental ingestion (eating, drinking and smoking) via contaminated hands, clothing and surfaces. Workers may develop a variety of ailments, such as neurological effects, gastrointestinal effects, anaemia and kidney disease.

OSHA's (Occupational Safety and Health Administration USA) general industry and construction lead standards include a medical removal protection provision for workers whose blood lead levels reach or exceed 50 µg/dL (construction) or 60 µg/dL (general industry). It is recommended that maintaining blood lead levels below 20 µg/dL over a twenty-year period, or below 10 µg/dL over a forty-year period, would be sufficient to prevent chronic effects associated with cumulative exposures.

Lead is a probable carcinogen and may be a teratogen (an agent or factor which causes malformation of an embryo). Repeated exposure to lead can cause lead poisoning with symptoms such as metallic taste, poor appetite, weight loss, colic, nausea, nerve damage, brain disorders and muscle cramps.

The airborne permissible exposure limit is 0.05 mg/m$^3$ averaged over an eight hour work shift. As above, air concentrations should be maintained so that the blood level is less than 0.06 mg per 100 g of blood. The Immediately Dangerous to Life and Health (IDLH) value is 100 mg/m$^3$.

Acute health effects include:

- Contact can irritate the eyes;

- Lead can cause headache, irritability, reduced memory, disturbed sleep and mood and personality changes; and

- Exposure can cause upset stomach, poor appetite, weakness and fatigue.

Lead sulphate with more than 3% free acid is a Class 8, Packing Group II, corrosive material. It is an odourless, white, crystalline powder. The threshold limit value (TLV) is 0.05 mg/m$^3$. In addition to the corrosive nature of lead sulphate, the above-mentioned effects for inhalation or ingestion of lead also apply.

Lead carbonate is a colourless, crystalline material. It can have the same toxic effects due to the presence of lead and hence it has the same permissible exposure levels, i.e. TLV = 0.05 mg/m$^3$ and the IDLH = 100 mg/m$^3$. Lead carbonate is a Class 6 Packing Group III material (UN Number 2291). This is also the Class and Packing Group for lead oxides (with similar hazards).

### *Sodium Carbonate*

Sodium carbonate ($Na_2CO_3$), or soda ash, is a white, odourless, granular solid which is non-combustible and not toxic. It reacts with acids to release carbon dioxide gas and heat. Sodium carbonate may irritate skin and eyes. The dust may also irritate the respiratory tract. Sodium carbonate is not expected to be toxic to the environment nor to aquatic organisms. In the presence of moisture the two materials combine to form caustic soda (NaOH) which may cause burns.

Excessive, long term contact may produce “soda ulcers” on hands and perforation of the nasal septum. Sensitivity reactions may occur from prolonged and repeated exposure.

Sodium carbonate is not a classified Dangerous Good but is classified as a hazardous material according to Safe Work Australia. Being a dust, the exposure limit is 10 mg/m$^3$ (workplace exposure standard for particulates).

### *Polymer*

Polymer is a Class 9 Dangerous Good (when transported in quantities exceeding 500 L or kg). It is not deemed to be a hazardous material according to Safe Work Australia. Irritation is the main impact on isolated exposure.

Carbon dioxide, and if combustion is incomplete, carbon monoxide and smoke are the main expected products from a fire. Fires involving polymer may also evolve oxides of nitrogen (NOx) under fire conditions.

Water in contact with polymer will cause slippery floor conditions.

Being a dust, the exposure limit is 10 mg/m$^3$ (workplace exposure standard for particulates).

***Carbon Dioxide:***

Carbon dioxide is a colourless gas with a slightly noticeable odour. It is not flammable or acutely toxic. At high concentrations, it can displace air and is therefore an asphyxiant.

It has a sublimation point of -78°C. In either a liquid or solid form, it has the potential for cold burns.

Carbon dioxide is slightly soluble in water and results in an acidic solution of approximate pH of 4. At elevated temperatures, this solution is corrosive towards some steels, e.g. carbon steel.

Carbon dioxide is a greenhouse gas. It is used in the food industry, e.g. bubbles in soft drinks and beer. The gas is heavier than air and hence may accumulate in confined spaces and pose asphyxiation risks.

**Table 3- Carbon Dioxide Health Impacts**

| $CO_2$ Concentration | Health Impacts |
|---|---|
| 0.5% | Long-term exposure limit in major jurisdictions |
| 1% | Slightly increased breathing rate |
| 2% | Doubled breathing rate, headache, tiredness |
| 5% | Very rapid breathing, confusion, vision impairment |
| 8 – 10% | Loss of consciousness after 5 to 10 minutes |
| >10% | More rapid loss of consciousness, death if not promptly rescued |

## 4.2 POTENTIAL HAZARDOUS INCIDENTS REVIEW

In accordance with the requirements of **Guidelines for Hazard Analysis**, (Ref 1), it is necessary to identify hazardous events associated with the facility's operations. As recommended in HIPAP 6, the PHA focuses on "atypical and abnormal events and conditions. It is not intended to apply to continuous or normal operating emissions to air or water".

In keeping with the principles of risk assessments, credible, hazardous events with the potential for off-site effects have been identified. That is, "slips, trips and falls" type events are not included nor are non-credible situations such as an aircraft crash occurring at the same time as an earthquake.

The identified credible, significant incidents with the potential for off-site impacts for the proposed facility are summarised in the Hazard Identification Word Diagram following (Table 4).

This diagram presents the causes and consequences of the events, together with major preventative and protective features that are included as part of the design.

A review of incidents involving battery recycling facilities shows significant harm from lead exposure to people and the environment in areas such as Asia, Africa and South America. These significant events are less common in the more advanced areas such as North America, Europe and Australia.

The process in the less advanced areas is typically as follows.

> The recycling process begins by removing the combustible material, such as plastics and insulation, with a gas-fired thermal oxidizer. Polluting particles created by a burning process are eliminated by the plant's scrubber (if installed) before release into the atmosphere. This leaves the clean and naked cells with metal content.
>
> The cells are then chopped into small pieces and heated until the metal liquefies. Non-metallic substances are burned off; leaving a black slag on top that a slag arm removes. The alloys settle according to weight and are skimmed off like cream from raw milk while still in liquid form.

The proposed process for the Ingleburn facility does not involve any gas-fired unit operations where toxic vapours can be evolved; it is a physical destruction process in a wet system. This limits the quantity of lead emitted and hence with the potential to affect people both on and off-site.

## Table 4 – Hazard Identification Word Diagram

| Event ID No. | Hazardous Event | Causes | Possible Consequences | Prevention and Mitigation Control Measures |
|---|---|---|---|---|
| 1. | Fire within the building | Conveyor belt fire.<br><br>Forklift truck fire.<br><br>Plastics fire.<br><br>Electrical fire.<br><br>Source of ignition include:<br><br>1. Hot work.<br>2. Smoking.<br>3. Electrical fault.<br>4. Conveyor belt slip. | Fire involving the lead compounds. Given the limited fire load in the building and the wet process, the fire is likely to be a local event. However, toxic products of combustion including lead oxides and SOx can be emitted. Also, batteries can explode in a fire.<br><br>Therefore, there can be impact to people (radiant heat and/or exposure to toxic combustion products), property (radiant heat) and the environment (toxic combustion products as well as contaminated fire water) | Control of ignition sources procedures, e.g. hot work permits.<br>Forklift trucks maintained annually.<br>Belt slip detection and trips.<br>Fire extinguishers inside the building.<br>Emergency plans.<br>Emergency warning system.<br>Spill kits |
| 2. | Fire within the building (due to malicious act) | Person trespasses on the property | Potential for a fire (arson) with the same consequences as above | Security Risk Assessment and Security Plan in place.<br>24 / 7 security presence at the site.<br>Routine security patrols.<br>Site is fully fenced.<br>Lighting for night observation.<br>CCTV cameras |
| 3. | Office fire | Electrical fault, sabotage, smoking | Damage to the office area and potential for propagation to the building (same consequences as Event No. 1 above). Otherwise, this will be a local event only | Fire protection includes hand-held hoses and extinguishers |

| Event ID No. | Hazardous Event | Causes | Possible Consequences | Prevention and Mitigation Control Measures |
|---|---|---|---|---|
| 4. | Exposure to lead | Loss of the scrubber extraction fan and lead dust accumulates within the building.<br><br>Manual handling of lead and its compounds, e.g. during operation or maintenance | Lead is a toxic metal as detailed in Section 4.1.<br><br>This event is local impact only, i.e. no significant off-site consequences likely | Operations to cease on loss of the scrubber fan.<br>PPE (personal protective equipment) for workers as per Regulations and Safety Data Sheets. |
| 5. | Scrubber fail | Loss of reflux water, e.g. pump failure or no make-up water | Emission of acidic mist, SOx and particulates containing lead to atmosphere. This may cause the health impacts detailed in Section 4.1 if the exposure is significant. These released materials can also impact the environment.<br><br>The carbon dioxide produced during sulphuric acid neutralisation may accumulate within the building, e.g. at low points, and hence become an asphyxiation hazard to on-site workers | Operation will cease once the scrubber unit fails to function. It is crucial for the scrubber unit to be functioning at all times.<br>Constant monitoring of the machine / scrubber before and after of every shift.<br>Maintenance will be completed regularly as instructed by the manufacturer of the machine |

| Event ID No. | Hazardous Event | Causes | Possible Consequences | Prevention and Mitigation Control Measures |
|---|---|---|---|---|
| 6. | Overfilling the sulphuric acid tank | Failure of the level control | Spilling sulphuric acid with the potential to cause corrosive burns to people and also impact the environment.<br><br>This event is local impact only, i.e. no significant off-site consequences likely | Close monitoring of the sulphuric tank.<br>The sulphuric acid tank will be enclosed and a pump will be installed to reduce the risk that the waste collector or workers will be exposed to the chemicals.<br>Appropriate PPE will be provided at all times to ensure safety and protection to staff |
| 7. | Battery explosion | Battery delivered to site that has been excessively charged.<br>Hydrogen and oxygen gas produced, i.e. ignition hazard | Spraying of the battery acid, e.g. onto people in the area.<br><br>Explosion could adversely impact people, e.g. projectiles.<br><br>This event is local impact only, i.e. no significant off-site consequences likely | Emergency response plans.<br>Battery inspections.<br>Fire protection includes hand-held hoses and extinguishers.<br>Safety showers and eyewash units |
| 8. | Environmental Impact | Releasing lead contaminated waste water, e.g. to stormwater or to Trade Waste | Potential for the lead to enter the aquatic environment leading to lead poisoning | Building is bunded to avoid spills entering the stormwater system |
| 9. | Off-site Vehicle Accident | Poor driving conditions, speed, unsafe driving, vehicle part failure | Injury to people involved in the accident.<br><br>Potential for the batteries or recycled lead and its compounds to be released. This can impact people or the environment | Ledox will be outsourcing truck delivery drivers and will ensure they have the appropriate documents and are from a reputable, licensed delivery company |

# 5 RISK ANALYSIS

The assessment of risks to both the public as well as to operating personnel around this industrial development requires the application of the basic steps outlined in Section 1. As per HIPAP 6 (Ref 1), the chosen analysis technique should be commensurate with the nature of the risks involved. Risk analysis could be qualitative, semi-quantitative or quantitative.

The typical risk analysis methodology attempts to take account of all credible hazardous situations that may arise from the operation of processing plants etc.

Having identified all credible, significant incidents, risk analysis requires the following general approach for individual incidents:

Risk = Likelihood x Consequence

The risks from all individual potential events are then summated to get cumulative risk.

For QRA and hazard analysis, the consequences of an incident are calculated using standard correlations and probit-type methods which assess the effect of fire radiation, explosion overpressure and toxicity to an individual, depending on the type of hazard.

In this PHA, however, the approach adopted to assess the risk of the identified hazardous events is scenario based risk assessment. The reasons for this approach are:

1. The distance to residential and other sensitive land users is large for this site; and

2. There are a limited number of events with off-site impact. The main events of off-site interest are building fires and scrubber failures. Therefore, these are analysed in detail in the remaining sections of this report.

As appropriate analysis of credible scenarios is performed in this PHA, initially the consequences of the potential fire and release events with off-site impact are assessed. For the events which do not contribute to off-site risk (as determined by the risk criteria in HIPAP No. 4 (Ref 2)) then no further risk analysis is warranted. When the consequence of an event does contribute to off-site, the likelihood and hence risk is then analysed as required.

The risk criteria applying to developments in NSW are summarised in Table 5 on the following page (from Ref 2).

## Table 5 - Risk Criteria, New Plants

| Description | Risk Criteria |
|---|---|
| Fatality risk to sensitive uses, including hospitals, schools, aged care | $0.5 \times 10^{-6}$ per year |
| Fatality risk to residential and hotels | $1 \times 10^{-6}$ per year |
| Fatality risk to commercial areas, including offices, retail centres, warehouses | $5 \times 10^{-6}$ per year |
| Fatality risk to sporting complexes and active open spaces | $10 \times 10^{-6}$ per year |
| Fatality risk to be contained within the boundary of an industrial site | $50 \times 10^{-6}$ per year |
| Injury risk – incident heat flux radiation at residential areas should not exceed 4.7 $kW/m^2$ at frequencies of more than 50 chances in a million per year or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year | $50 \times 10^{-6}$ per year |
| Toxic exposure - Toxic concentrations in residential areas which would be seriously injurious to sensitive members of the community following a relatively short period of exposure | $10 \times 10^{-6}$ per year |
| Toxic exposure - Toxic concentrations in residential areas which should cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community | $50 \times 10^{-6}$ per year |
| Propagation due to Fire and Explosion – exceed radiant heat levels of 23 $kW/m^2$ or explosion overpressures of 14 kPa in adjacent industrial facilities | $50 \times 10^{-6}$ per year |

As discussed above, the consequences of the potential hazardous events are initially analysed to determine if any events have the potential to contribute to the above-listed criteria and hence worthy of further analysis.

## 5.1 PRODUCTS OF COMBUSTION FROM A BUILDING FIRE

The fire load within the processing area is limited to the wooden pallets, vehicles, rubber conveyor belts, machine oils, electrical insulation and recycled plastics (normally wet from the process). The majority of the process involves liquids, i.e. sulphuric acid (not combustible), waste water and water, and hence fires initiating in these processing areas are not likely.

Burning materials generate combustion gases (Ref 4). Common materials such as wood, paper, natural and man-made fibres, plastics and chemicals generate a range of combustion gases that are asphyxiants or toxic to varying degrees. For a processing building, these gases include:

- Carbon monoxide and dioxide;
- Hydrogen chloride (from burning plastics such as PVC);
- Water vapour;
- Oxides of nitrogen; and
- Vapours or dusts of unburnt material (typically up to 10% of the total quantity involved in the fire, Ref 5) or lead and its compounds.

Smoke plume modelling has historically been performed via a number of methods. As stated in Lees (Ref 6):

"Impact from toxic products of combustion will only be significant, generally, local to the fire. The hot products of combustion rising from a fire typically have a temperature in the range 800-1200ºC and a density a quarter that of air."

Various approaches to smoke plume modelling can be used. One established methodology is the Brigg's Plume Model (Ref 7) for various combinations of weather / wind conditions and fire temperatures. The results for the fire scenario for the building fire case are shown in Table 6. An efflux velocity of 5 m/s for the products of combustion is taken for the fire event modelling. The results do not include the effects of local terrain wash and hence dilution. Therefore, these results will be conservative.

The area for the fire is taken to be 50% of the total building area given large sections of the process involve non-combustible liquids. The building area is approximately 1,840 $m^2$.

Given the wet process, there are no fired unit operations and the lack of flammable materials then the likelihood for this event is considered low, i.e. similar to a modern warehouse ($1.8 \times 10^{-4}$ per year for low fire risk materials – Ref 8).

**Table 6 – Fire Plume Rise Modelling**

| Scenario | Wind (m/s) / Weather | Initial Height of Plume, m | Initial Plume Radius, m | Comments |
|---|---|---|---|---|
| Building fire – 50% of total roof area (combustion gases approximately 900ºC) | F2<br>D5<br>D15 | 255<br>100<br>34 | 120<br>50<br>19 | For the F2 condition, the plume is predicted to be always above ground level by at least 15 m. The distances to achieve a plume height of more than 10 m above the ground for the D5 and D15 conditions are 100 and 370 m, respectively |

The results in Table 6 are indicative of previous warehouse and industrial building fires. Ref 9 also quotes modelled hazard ranges up to 400 m unless smouldering combustion (i.e. cooler combustion products) is taking place.

Given that lead could be in the smoke plume then emergency response for people downwind is required (for at least 400 m from the site).

## 5.2 Assessment of Scrubber Failures

Scrubber failure will lead to the inlet gas stream passes directly to atmosphere, i.e. without removal of the contaminants. The design conditions for the scrubber inlet stream are:

Flowrate = 250 $m^3$/min

Temperature = 30 C

Lead component = 13.53 mg/$Nm^3$ or 12.2 mg/$m^3$

Dust (total) = 29.09 mg/$Nm^3$ or 26.2 mg/$m^3$

SOx = 0.02435 ppm

The Emergency Response Planning Guidelines (ERPG) levels (Ref 10), the Acute Exposure Guideline Levels (AEGLs) (Ref 11) for SOx and the toxicity values for lead are shown in Table 7.

## Table 7 – Toxicity of SOx and Lead

| | **ERPG - 1 (ppm)**<br><br>At this level, there may be some odour but there should be no significant irritation for a 1 hour exposure | **ERPG - 2 (ppm)**<br><br>There is likely to be strong odour and some eye irritation at this level, but serious health effects are unlikely for a 1 hour exposure | **ERPG - 3 (ppm)**<br><br>This level may cause severe eye and nasal irritation, however lethality would not be expected for a 1 hour exposure |
|---|---|---|---|
| **$SO_2$** | 0.3 | 3 | 25 |
| **$H_2SO_4$** | 0.5 | 2.3 | 28 |
| | **AEGL – 1 (ppm) 10 minutes**<br><br>The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure | **AEGL – 2 (ppm) 10 minutes**<br><br>The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape | **AEGL – 3 (ppm) 10 minutes**<br><br>The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death |
| **$SO_2$** | 0.2 | 0.75 | 30 |
| **$H_2SO_4$** | 0.05 | 2 | 63 |
| | **IDLH** | **TWA (over an 8 hour shift)** | |
| **Lead** | 100 mg/m$^3$ (as lead) | 0.04 mg/m$^3$ (as lead) | |

For SOx (acid mist), the scrubber inlet value is very low, i.e. 0.02435 ppm. This is below the ERPG and AEGL values in Table 7 and hence failure of the scrubber is not expected to result in adverse impact (irritation, injury and fatality) off-site. Correspondingly, the HIPAP 4 risk criteria are satisfied.

There are no published irritation or injury values for lead for compliance purposes. As lead is a poisonous material, emissions need to be kept very low to avoid off-site impact, i.e. the scrubber must be operational when the process is on-line.

The design lead composition in the inlet stream is 12.2 mg/m$^3$ which is below the IDLH value of 100 mg/m$^3$. Hence, off-site fatality due to lead exposure is not expected.

The size of the dust particle is unknown at this stage. If the particle size is relatively large then dry deposition due to stokes settling will restrict the length of the plume. If the particle size is relatively small, e.g. $PM_{10}$ or less, then the dust plume length and characteristic may be similar to a vapour plume (Ref 12).

From the above discussion on lead, if the scrubber fails then the process should be tripped (see the recommendations in this report).

## 5.3 AIRCRAFT IMPACT AND OTHER EXTERNAL EVENTS

Previous risk assessments (e.g. Ref 13) have shown that the likelihood of an aircraft crash is acceptably low within Australia. Typical frequencies associated with aircraft crashes are:

- Scheduled aircraft $1 \times 10^{-8}$/year; and
- Unscheduled aircraft $4 \times 10^{-7}$/year.

The outcomes of any aircraft crash on this site will be dominated by the ensuing fire from the plane wreckage. This is an existing risk for all sites. Given the above frequencies, the likelihood of this type of event is acceptably low for a site of this size and location.

Other external events that may lead to propagation of incidents on any site include:

| | |
|---|---|
| Subsidence | Landslide |
| Burst Dam | Vermin/insect infestation |
| Storm and high winds | Forest fire |
| Storm surge | Rising water courses |
| Flood | Storm water runoff |
| Breach of security | Lightning |
| Tidal waves | Earthquake |

These events were reviewed and none of them were found to pose any significant risk to the new facility given the proposed safeguards.

## 5.4 CUMULATIVE RISK

As shown in this PHA, the facility will have negligible impact on the cumulative risk results for the local area as the significant fire, explosion and toxic impacts are retained on the site.

Therefore, it is reasonable to conclude that the development does not make a significant contribution to the existing cumulative risk in the area.

## 5.5 SOCIETAL RISK

The abovementioned criteria for individual risk do not necessarily reflect the overall risk associated with any proposal. In some cases, for instance, where the 1 pmpy contour approaches closely to residential areas or sensitive land uses, the potential may exist for multiple fatalities as the result of a single accident. One attempt to make comparative assessments of such cases involves the calculation of societal risk.

Societal risk results are usually presented as F-N curves, which show the frequency of events (F) resulting in N or more fatalities. To determine societal risk, it is necessary to quantify the population within each zone of risk surrounding a facility. By combining the results for different risk levels, a societal risk curve can be produced.

In this study of the Battery Recycling Facility facility at Ingleburn, the risk of fatality does not extend off the site and is well away from the residential areas. Societal risk is therefore acceptable.

## 5.6 RISK TO THE BIOPHYSICAL ENVIRONMENT

The main concern for risk to the biophysical environment is generally with effects on whole systems or populations.

The main causes for environmental impact from this facility are from lead contaminated waste water, e.g. firewater runoff, and releases to the atmosphere, in particular, from the scrubber.

All forms of waste liquids from the processing areas of this facility will need to be contained on-site and tested prior to disposal (see the recommendations in this report). This includes the design quantity for firewater.

As per Section 5.2, if the scrubber fails then the process should be tripped.

# 6 Conclusion and Recommendations

The risks associated with the proposed Battery Recycling Facility at Ingleside have been assessed and compared against the DoP risk criteria. The results are as follows and show compliance with all risk criteria.

| Description | Risk Criteria | Risk Acceptable? |
|---|---|---|
| Fatality risk to sensitive uses, including hospitals, schools, aged care | $0.5 \times 10^{-6}$ per year | Yes |
| Fatality risk to residential and hotels | $1 \times 10^{-6}$ per year | Yes |
| Fatality risk to commercial areas, including offices, retail centres, warehouses | $5 \times 10^{-6}$ per year | Yes |
| Fatality risk to sporting complexes and active open spaces | $10 \times 10^{-6}$ per year | Yes |
| Fatality risk to be contained within the boundary of an industrial site | $50 \times 10^{-6}$ per year | Yes |
| Injury risk – incident heat flux radiation at residential areas should not exceed 4.7 $kW/m^2$ at frequencies of more than 50 chances in a million per year or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year | $50 \times 10^{-6}$ per year | Yes |
| Toxic exposure - Toxic concentrations in residential areas which would be seriously injurious to sensitive members of the community following a relatively short period of exposure | $10 \times 10^{-6}$ per year | Yes |
| Toxic exposure - Toxic concentrations in residential areas which should cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community | $50 \times 10^{-6}$ per year | Yes |
| Propagation due to Fire and Explosion – exceed radiant heat levels of 23 $kW/m^2$ or explosion overpressures of 14 kPa in adjacent industrial facilities | $50 \times 10^{-6}$ per year | Yes |

Societal risk, area cumulative risk, transport risk and environmental risk are also concluded to be acceptable.

The primary reasons for the low risk levels from the facility are that the facility is a wet process where fires, explosions and toxic releases are either contained on-site or low in off-site impact.

The following recommendations are made from this review:

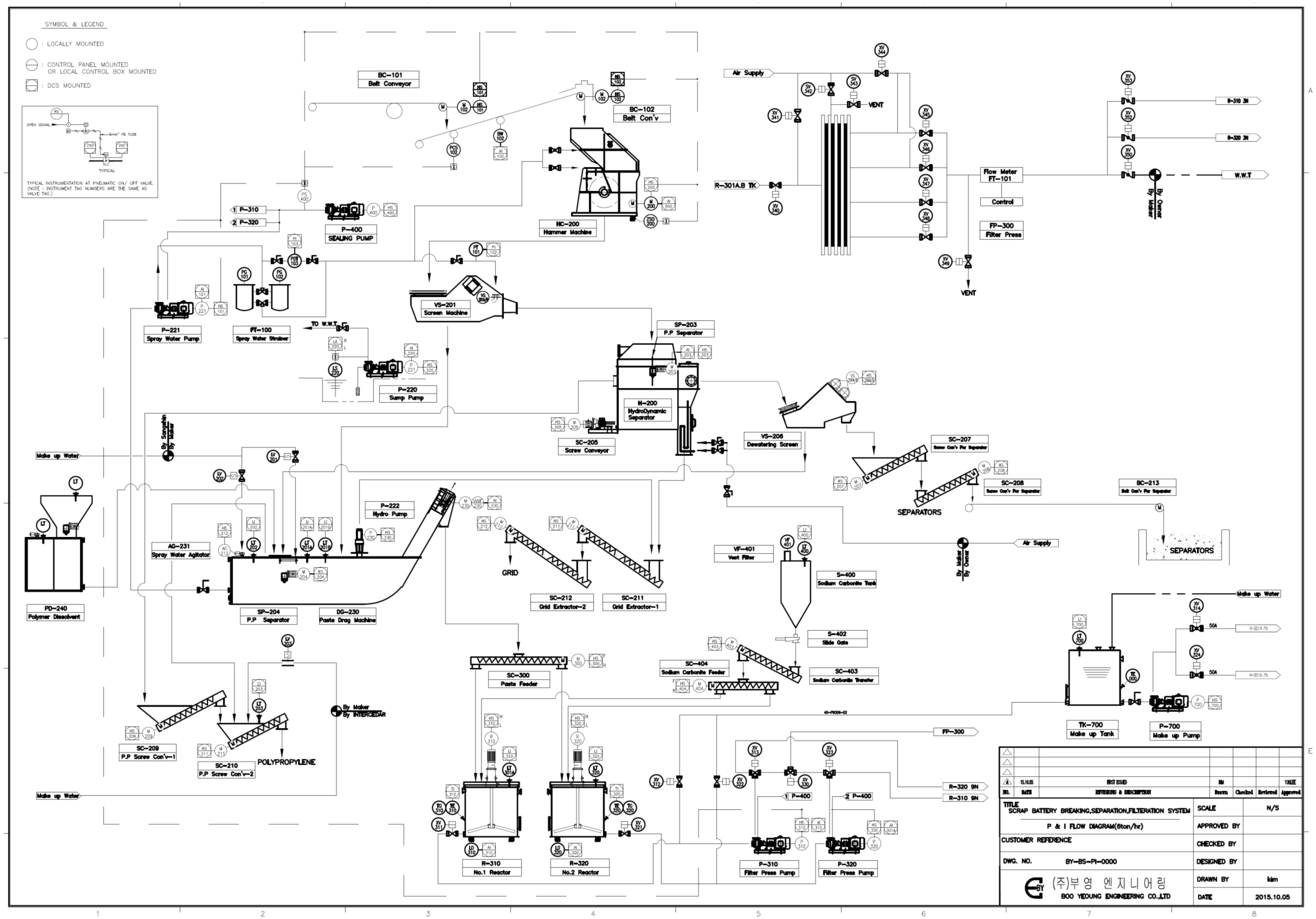
1. Provide roof ventilation in the building given the potential for hydrogen build-up over time and possible explosion.
2. Ensure the sulphuric acid tank is vented from the top point in the tank given the potential for hydrogen build-up over time and possible explosion.
3. Provide double-skin underground tanks and pipes to lower the risk of environmental impact from equipment failure, e.g. lead or sulphuric acid leaking into the ground.
4. Safety showers and eyewashes should be alarmed to expedite emergency response to a person exposed to harmful chemicals.
5. Comply with the WHS (Work Health and Safety) Regulations 2011, in particular, Part 7.2, for lead control.
6. The process should be reviewed via the HAZOP technique, in particular, the scrubber system and liquid systems.
7. Ensure that the building floor integrity is sound, e.g. no cracks, to avoid seepage and environmental impact. The floor surface is to be compatible with sulphuric acid.
8. Waste liquids need to be contained and analysed for lead prior to disposal. This includes Trade Waste.
9. Trip the process on scrubber failure.
10. The emergency response plan is to include actions to take for off-site people during a fire event, e.g. stay in-doors or evacuate.
11. Include in the facility design the need to contain the design quantity of firewater.

# Appendix 1

# Process Flow Diagram

**Preliminary Hazard Analysis, Battery Recycling Facility, Ingleburn**

## Appendix 1 – Process Flow Diagram.



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