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ENCORE METALS NL

CONFIDENTIAL

TASMELT

Tasmania Regional Smelting Project

STAGE 2

PREFEASIBILITY STUDY PROPOSAL

AMG REFERENCE POINTS ADDED

February 1999

487002

TASMELT

Tasmania Regional Smelting Project

Stage 2 Prefeasibility Study Proposal

Sirosmelt is a high intensity, low capital cost, hollow submerged lance smelting technology. It was originally developed by the CSIRO. A single plant can be used to treat one or a variety of feeds. Some twenty commercial plants have been installed worldwide.

A 1998 Scoping Study by Encore Metals NL evaluated and confirmed the commercial merits of constructing a Sirosmelt based regional smelting facility at Zeehan, Western Tasmania - **TASMELT**.

The study examined the recovery of zinc and other valuable metals from the 450,750 tonne 13.4% zinc Zeehan slag dumps and thereafter from a variety of other potential feeds sourced from the West Coast of Tasmania.

The study concluded that:

1. TASMELT was a viable value-adding project with relatively low technical and commercial risks if feeds additional to the Zeehan slags could be secured to ensure a minimum 10 year life.

2. there is a high probability that additional feeds could be obtained.

3. the Zeehan slags fully underwrite project capital costs and provide an excellent commissioning and back-up feed between treatment campaigns on other West Coast sourced materials.

4. an operation could be established for a relatively low initial capital cost, with incremental capital additions justified on a feed-by-feed basis.

5. the infrastructure, political and commercial environment in Tasmania and its West Coast region was extremely conducive to establishing the project.

Exclusivity - Renison Bell Tin Tailings and Middlings

The West Coast of Tasmania is a world ranking mining province hosting several major, mature working base and precious mines. There are also several undeveloped sub-economic mineral deposits a number of which would benefit greatly from a regional smelter.

Of particular interest to TASMELT as potential feeds are:

- reconcentrating tailings dams at operating or closed mines
- reconcentrating current tailings arisings at operating mines
- removing recirculating middling streams from concentrators
- marginal in-situ tin resources

The Murchison United NL owned Renison Bell tin mine tailings resource has been ranked first of several resources that would double project life to more than 10 years.

A Letter of Agreement between Encore and Murchison United NL provides Encore with exclusive rights to evaluate the Renison Bell tin tailings and middling concentrate streams.

There are three tailings dams at Renison Bell. Dams A and B contain a combined 5.2 million tonnes of tailings and 23,000 tonnes of tin metal. Dam C is operational and contains some 10 million tonnes of tailings and 40,000 tonnes of tin metal.

Differentiating Technical and Commercial Advantages

A differentiating and fundamental advantage of TASMELT is that it requires the delivery of only 'rough' or 'dirty' concentrates for processing in its smelter. These are much easier and considerably cheaper to produce.

Without TASMELT, the only option available to mine operators wishing to recover metals from tailings is to produce a high-grade concentrate for direct sale. The inherent nature of the tailings means that a high grade is almost impossible to achieve and, if it were, would entail considerable metal loss rendering the exercise uneconomic.

Financial Returns

A preliminary financial model has been constructed to provide a framework for an evaluation of the combined Zeehan and Renison Bell materials. The input of current available data shows that for an initial **capital cost of $18.0 million** (with additional incremental capital requirements funded from cash flow) and LME zinc and tin prices of US$970 and US$5,200 respectively, TASMELT has a **pre-tax NPV of $25.6 million** and an **IRR of 35%** over its initial 12 year operating life. This is inclusive of the smelter running at significantly less than full capacity following the depletion of the Zeehan slags resource in year 6. The options for utilising this available capacity will be developed during Stage 2.

Proposed Operating Regime

Commissioning material and first year's production will be sourced from the Zeehan slags. This will be treated in a 112,500 tonnes per annum smelter designed to fume Zeehan slags and Renison Bell tin concentrates. A three-month tin fuming campaign will then follow. This will treat the first stockpile of tin concentrates accumulated by a dedicated 500,000 tonnes per annum concentrator using current Renison Bell tailings arisings. Alternating zinc and tin fuming campaigns will then take place.

In year three the tailings concentrator will be upgraded to 1,000,000 tonnes per annum to take a mixed feed of current tailings arisings and material from A and B dams. Campaigns will continue until the zinc slags are fully depleted in year six whereupon tin only fuming will continue. The available smelter capacity can be taken up by a third feed material and/or by bringing forward a year nine scheduled increase in tin tailings concentration capacity to 1,500,000 tonnes per annum.

The preliminary financial model takes a conservative view. It defers the use of excess capacity until year nine to coincide with the current planned end of life of the Renison Bell mining operations and the availability of C dam material.

Site Options

The preferred site for the smelter is currently at the Zeehan slags site, 3 kilometres south of the Zeehan township.

Basing a regional Sirosmelt plant at Zeehan has a number of advantages:

- feed slag does not have to be transported or stockpiled
- it is only twelve kilometres from Renison Bell
- discard slag does not have to be transported to a dump site
- minimum infrastructure is required
- water is readily available
- there is no requirement to purchase or lease land for the plant
- environmental impact is minimised

Stage 2 – Prefeasibility Study

Stage 2 implementation will advance the project at a cost of $400,000 over a period of 6 months through to a decision to commence Stage 3 – a full feasibility and implementation study.

It will address optimisation of the zinc slag smelter models, preliminary concentration and smelter testwork on Renison Bell tailings, plant design and process optimisation, operating and capital costs to +/- 20%, zinc and tin fume marketing options, commercial, environmental and regulatory issues.

Conclusion

Stage 1 has confirmed that TASMELT presents a viable opportunity to build a regional smelting facility on Tasmania's West Coast.

In addition to the benefits accumulating to Encore, TASMELT:

- will provide attractive additional revenue and operational benefits to owners of West Coast resources targeted for processing,

- provide new options for integration into active and proposed environmental management plans including the re-establishment of tailings dams in accordance with current best practise.

- will create 45 new skilled and semi-skilled jobs.

- will provide an accessible Australia based showcase for Sirosmelt technology.

- allow several marginal in-situ and secondary resources to be reconsidered for mining and re-treatment.

The securing of an exclusive right to evaluate the Renison Bell tailings and middlings as an additional project feed completes the criteria for progressing to Stage 2.

Stage 2 will address in detail a majority of the technical and commercial issues associated with project implementation. This work will enable a decision to commence Stage 3, a full feasibility and implementation study, to be made.

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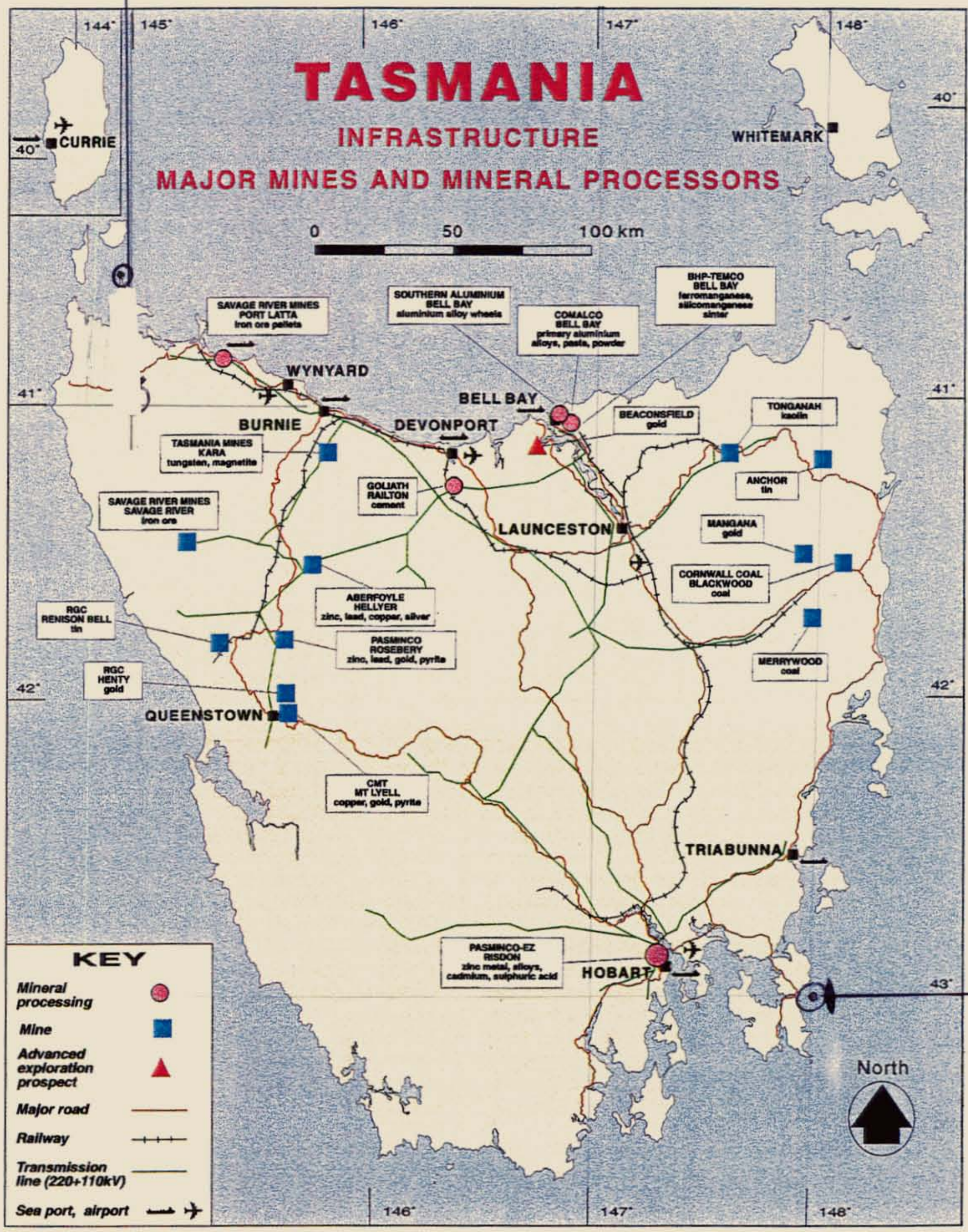

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SECTION A

CORPORATE INFORMATION

ENCORE METALS NL

CORPORATE DIRECTORY

Directors:

Stephen Stone *B.Sc.(Hons), M.Aus.IMM, MIMM, C.Eng., FAICD*
Steven Kent Gilman *B.App.Sc., FAusIMM, MAIME.*
Gerrard Tonks *CA*

Company Secretary

Stephen Stone

Registered and Principal Office

7 Chester Street,
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ACN 084 358 814

SHARE CAPITAL

Issued:

10,100,000 ordinary shares of $0.001 each, fully paid

Share Register:

Stephen Stone	ATF The Pearlstone Family Trust	5,100,000
Steven Gilman	ATF The Gilman family Trust	2,500,000
Baracus P/L	ATF The Brooks Family Trust	2,500,000

KEY PERSONNEL

Stephen Stone

Mr. Stone (43) is the originator and initial seed financier of the TASMELT concept. He is primarily responsible for the long term direction and day-to-day management of the company.

He trained as a mining geologist and has over twenty years varied international hands-on operating and management experience in the mining industry. The last 12 years have been spent in Australia where he has been particularly involved and successful in the formation, financing, management and development of junior resource companies and their projects. In this capacity he has held a number of chief executive positions at public companies including Dragon Mining NL (11 years) and Marlborough Gold Mines NL (3 years).

In addition to Encore he is currently involved in the reorganisation and development into an industrial minerals company of Talon Resources NL, where he is Executive Chairman.

Steven Gilman

Mr. Gilman (43) is a major shareholder in and director of Encore and is primarily responsible for the technical development of TASMELT.

He has over 20 years international hands-on operating and management experience in the mining industry. He was most recently Group Operations Manager – Australia RGC Mineral Sands Limited and was responsible for the management and continual development of several large Australian mining operations. He has managed mining and extraction operations in the USA and Australia and in Africa gained broad experience at large copper smelters and acid plants. In addition to his valuable smelting and operations experience he also brings to the company experience in dredging operations which will be important in tailings dam operations.

SECTION B

PROJECT BACKGROUND AND CONCEPT

Project Background and Concept

A 1991 prefeasibility study by Pyrosmelt NL and BHP Engineering Consultants Pty Ltd considered on a stand-alone basis the reprocessing of the old Zeehan slag dumps. These are a legacy of lead-silver smelting from the turn of the century.

A financial optimisation model selected a 15 tonnes per hour (112,500 tonnes per annum) single furnace plant producing 20,650 tonnes per annum of raw fume as the base case.

The prefeasibility study cost over $300,000 and comprised:

- Dump surveying, extensive drilling, sampling and assaying.
- Resource estimates by Resource Services Group Pty Ltd of Perth.
- A preliminary Environmental Scoping Study by BHP Engineering Consultants Pty Ltd, Perth for submission to the Tasmania Office of Environment (now called Dept. of Environment and Land Management - DELM).
- Slag fuming optimisation models by Ausmelt Pty Ltd, plus mass and energy balances for the process, operating and capital costs estimates to +/-30% for a variety of plant throughputs and furnace configurations.
- Independent checks on these by BHP, including detailed plant description and engineering design.
- Preliminary cost estimation and market studies by Pyrosmelt NL for leach processing of raw zinc oxide fume.
- Financial modelling, optimisation studies and base case derivation.

The Zeehan project was placed on hold when the zinc price and exchange rate moved unfavourably.

1998 Integrated Zeehan Slags Prefeasibility and TASMELT Scoping Study

This study re-examined, updated and extended the 1991 study to account for the treatment of additional feed materials sourced from the West Coast of Tasmania.

It concluded that it was now more likely that a commitment to a long term, viable, regional smelting facility could be justified. Its key points were:

1. TASMELT was a viable value-adding project with relatively low technical and commercial risks if feeds additional to the Zeehan slags could be secured to ensure a minimum 10-year life.

2. there is a high probability that additional feeds could be obtained.

3. the Zeehan slags fully underwrite project capital costs and provide an excellent commissioning and back-up feed between treatment campaigns on other West Coast sourced materials.

4. an operation could be established for a relatively low initial capital cost, with incremental capital additions justified on a feed-by-feed basis.

5. the infrastructure, political and commercial environment in Tasmania and its West Coast region was extremely conducive to establishing the project. There is strong State Government and community support for responsible development on the West Coast.

In addition to these points TASMELT:

- will provide attractive additional revenue and operational benefits to owners of West Coast resources targeted for processing,

- provides new options for integration into active and proposed environmental management plans including the re-establishment of tailings dams in accordance with current best practise.

- will create some 35 new skilled and semi-skilled direct jobs.

- will provide an accessible Australia based showcase for Sirosmelt technology.

- may be replicated in other mining regions of the world.

It also confirmed that basing a regional Sirosmelt plant at Zeehan has a number of advantages:

- Feed slag does not have to be transported or stockpiled
- Discard slag does not have to be transported to a dump site
- Minimum infrastructure requirements are required
- Water is readily available
- There is no requirement to purchase or lease land for the plant
- There will be minimal impact on the environment
- The site is relatively remote from major settlement

Differentiating Technical and Commercial Advantages

A differentiating and fundamental advantage of TASMELT is that it requires the delivery of only 'rough' or 'dirty' concentrates for processing in its smelter. These are much easier and considerably cheaper to produce.

Without TASMELT, the only option available to mine operators wishing to recover metals from tailings is to produce a high-grade concentrate for direct sale. The inherent nature of the tailings means that this is almost impossible to achieve without a considerable metal loss occurring and rendering the exercise uneconomic.

Rights to Renison Bell Tailings.

Obtaining a second material for TASMELT was critical to Stage 2 proceeding.

In this regard Encore has obtained exclusive access to evaluate the Renison Bell tailings and middlings stream. This arrangement also includes exclusivity in negotiating commercial terms for the reprocessing of these materials.

It was not appropriate for either Murchison or Encore to formalise any terms for the taking and reprocessing of Renison Bell tailings or middlings as the value of these materials and the relative benefits accruing to either party have not yet been determined

TASMELT will not only generate additional revenue for Renison Bell but will enable it, amongst other things, to:

- enhance its environmental management plan in respect of tailings dams A and B by providing it with an opportunity to replace any retreated tailings in a manner according to current best practice.
- Consider the removal of recirculating middling streams and the simplification of the existing concentrator circuit.
- Consider the use of spent tailings and/or slag for use as mine fill.

Site Data

Location

Tasmania Smelting Co. Site, Zeehan, West Coast of Tasmania
2.5km SSE of Zeehan township
Latitude 41.53S
Longitude 145.20

Elevation

150 – 200m AHD

Nearest Principal Town Sites

Rosebery 24km NE
Queenstown 40km SE
Burnie 150km NNE
Hobart 295km SE

Communications

Post at Zeehan
Courier via local agents
Telecom at Zeehan
No service at site

Road Access

Adjoins Zeehan to Strahan sealed roadway

Rail Access

Emu Bay railway from Burnie terminates at Melba Flats 12km NW of site

Air Services

Infrequently used strip at Zeehan
Scheduled services to Burnie, Launceston and Hobart
Charter flights from these and into Strahan

Power

None at site
Can be lined in

Water

No town water at site
Austral Creek adjacent
Little Henty River 1.5km east

Temperature Range

–2°C in June, to 25°C in February

Rainfall

17mm in January to 265mm in July. Total mean per year of 2446mm

SECTION C

TECHNICAL OVERVIEW

Zinc and Tin Fuming Using Sirosmelt Technology

'Fuming' is a common and well-established smelting practice where valuable metals are volatilised and collected outside of the furnace, usually as an oxide.

Sirosmelt is a furnace technology that has particular application to fuming. It is a submerged combustion process where process air and fuel are injected under pressure below the surface of a liquid bath via a specially designed hollow steel lance.

The injection lance is cooled by the process air flowing down through it. A protective coating of solid slag is allowed to build up on the end of the lance. This allows it to be inserted deep into the molten material without damage.

Process gases are delivered deep into the slag to create active turbulence that promotes rapid chemical reactions, good fuel efficiency and a high throughput capacity relative to the furnace size.

Combustion of the fuel within the molten material provides the heat for the reduction reactions and encourages fast, efficient and very controllable reactions. New feed and reductant are added in lump form through a port in the top of the furnace. These additions are rapidly consumed in the slag bath due to the intense stirring of the bath by the submerged injection of air.

TASMELT Application

Some 25 Sirosmelt based operations now operate worldwide. It is regarded as a well proven, relatively low capital cost versatile smelting technology. Its advantages include high thermal efficiency, high productivity and the ability to accept a wide range of feed materials. Smelting takes place in highly controlled conditions and in a relatively clean, hygienic and compact environment.

Commercial smelters have been installed using Sirosmelt for copper, zinc, lead and tin production. The basic furnace and support infrastructure is sufficiently common across these applications that campaign smelting a variety of different metal feedstocks is feasible.

Zinc fuming is a well-established industrial process and the suitability of Sirosmelt has been demonstrated on a large commercial scale.

Furnaces can be configured to work on a batch or continuous basis and in parallel with another furnace. Coal, diesel or gas can power the furnace. TASMELT is using a coal-powered facility.

Sirosmelt plants range in size from a few tonnes per hour throughput up to 30 tonnes per hour. Commercial plants have been operating since 1978.

TASMELT Phased Smelter Development Concept

A key difference from previous smelter proposals is that TASMELT intends to put this versatility into practice. It will alternate campaigns of zinc fuming using the Zeehan slag material and tin fuming using Renison Bell reconcentrated tailings.

In order to avoid cross contamination of the metal products, campaigns will be constructed around the normal refractory maintenance cycles, and there will be two fume cooling and collection circuits.

Because the tin fuming will be accompanied by a more significant sulphur content in the feed, it will also be essential to install gas cleaning sulphur recovery equipment prior to the first tin campaign.

The modular nature of the proposed furnace will enable multiple units to be installed around a common infrastructure in the event sufficient volumes of feedstock eventuate from the large number of potential sources identified in the region.

Technology Licensing

Sirosmelt is marketed by two companies who pay a licence fee to the CSIRO, the original developer. These are MIM Limited under the name Isasmelt and Ausmelt Limited under the name Ausmelt. Ausmelt has recently sold its rights to market the technology in respect of zinc smelting and fuming to Korea Zinc Limited which operates two zinc fuming plants

The technology is made available to users on a sub-licensing basis, generally in the form of an upfront cash fee. In addition the licensees provide a package to the client that generally comprises:

- process design
- basic and detailed engineering design
- certain prefabricated equipment specific to the technology such as lances and lance handling equipment, control systems and instrumentation
- site supervision during construction and refractory installation
- cold and hot commissioning services

Encore has not entered into an arrangement with either of the providers. As part of Stage 2 it will evaluate these alternatives.

The Zeehan Resource

Ownership

The Zeehan dumps are situated on Retention Licence 9603 now held by Dragon Mining NL wholly owned subsidiary, Pyrosmelt NL.

Pasminco Limited, the original owner of the dumps, by virtue of a Licence Agreement between it and Pyrosmelt NL, has a 5% net smelter return interest in the project.

Encore Metals NL has extended to March 18th 1999 at a cost of $50,000 a 6 month $100,000 option to purchase from Pyrosmelt NL its interest in the dumps (inclusive of the option extension fee). It is also required to pay a 5% net profits interest. This NPI is only payable after the repayment of all capital and direct finance costs.

Origin

There are two adjacent slag dumps at Zeehan on the West Coast of Tasmania.

These contain a combined 450,750 tonnes of slab and granular form slag averaging 13.4% zinc, 1.7% lead and 54 grammes per tonne silver.

The slags are residual materials from turn of the century lead-silver ore smelting. In those days no process was available for the removal of any zinc present in the ore feed. It therefore reported to the slag.

Production occurred first between 1898 and 1914 when the greatest amount of ore was smelted. It continued intermittently until 1946. Only remnant site foundations, rusted boilers and the residual slag dumps now remain.

Resource Estimation

The Zeehan dumps comprise two distinct adjacent resources called the North and South Dumps.

The smaller north dump comprises a platey slag whilst the larger south dump contains platey slag on top of a smaller volume of finer grained granular slag. Both materials are suitable for feed into a Sirosmelt furnace

The dumps have been surveyed by Pasminco and drilled to bedrock in order to generate an accurate volumetric estimation. This is stored on Surpac and Micromine software.

Thirty-six air core holes were drilled in September 1990 by Wallis Drilling on two 20 metre x 20 metre grids.

One metre samples (375) and duplicates (10%) were collected and assayed for zinc, lead and silver.

Selected samples (16) were assayed for an extensive range of other elements

All samples remain stored in a shed at Zeehan.

Specific gravity measurements averaged 3.65 but a bulk density of 3.00 was used to estimate tonnage. This allows for possible cavities but is considered conservative.

Resource Services Group of Perth completed an estimation of the resources in each dump. This extended to grade contouring and block modelling to facilitate the construction of optimum production schedules.

	Tonnes	**Zinc %**	**Lead %**	**Silver g/t**
South Dump	369,600	13.92	1.69	52
North Dump	81,150	10.83	1.85	62
Total	**450,750**	**13.36**	**1.71**	**54**

No further drilling is considered necessary at Zeehan. Subject to the project being shown to be economic, the resources can be transferred into the reserve category as defined by the AusIMM Code for the Reporting of Ore Reserves and Resources.

Slag Analysis

Element	Level
Zn	13.64%
Pb	1.72%
Ag	54ppm
Cu	2238ppm
Bi	100ppm
Ni	81ppm
Co	63ppm
Au	0.138ppm
Cd	4.9ppm
S	3.33%
Ge	9.51ppm
CaO	11.35%
SiO_2	19.96%
FeO_2	32.08%
Al_2O_3	3.78%
MgO	1.30%
LOI	4.74%
As	350ppm
Sb	380ppm
Sn	384ppm
Na_2O	0.07ppm
K_2O	0.56%
MnO	7.46%
P_2O_5	0.12%
TiO_2	0.17%

Additional Feed Materials

The West Coast of Tasmania is a world ranking mining province hosting several major mature working and dormant mines within a belt of less than 100 kilometres.

A number of potential and suitable feed materials especially suited for integration into the project are located on the West Coast. These include:

- Re-concentrated Renison Bell tin tailings (A and B historical dams. Possibly part or eventually whole of live C dam)
- Current mill tailings arisings
- Renison Bell concentrator middlings
- Renison Bell primary tin concentrates

- Re-concentrated Rosebery zinc tailings
- Rosebery concentrator middlings and other circuit by-products

- Re-concentrated Hellyer tailings

- The in-situ Zeehan and Queen Hill tin deposits.

- Several other in-situ West Coast tin deposits such as Mt. Bishof, alluvial deposits such as Lafferty's and various tailings stockpiles.

- Several in-situ zinc-lead-silver resources such as Oceana and Comstock.

Phased Smelter Development

The initial smelter operation will produce a raw fume containing zinc and other volatile metal oxides. It also provides the majority of the hardware required for the introduction of campaign smelting of a variety of feeds.

The initial smelter can be easily adapted to new feeds in a modular fashion as these opportunities present themselves.

Tailings Resources

These present some of the preferred material sources for processing, as they are readily accessible.

Most of these types of resources have been fully evaluated by previous or current owners. Much of this evaluation has focussed on the need to produce a high-grade concentrate. Metal recoveries have consequently been low and revenues inadequate.

The Sirosmelt based TASMELT concept enables tailings derived concentrates of much lower metal content and specification to be produced. Metal recoveries are high and much greater revenues are ultimately realised. This is not an option currently available to mine owners and is a fundamental and differentiating feature of TASMELT.

TASMELT will provide an opportunity for mine owners to:

- realise value for tailings resources,

- consider using by-products as mine fill,
- reduce the potential for and liabilities arising from acid water drainage, and
- re-establish selected dams in accordance with current best practice.

Primary and Middling Concentrator Streams

Concentrators at working mines such as Renison Bell and Rosebery also create and have to contend with difficult and costly middling streams. This material continually re-circulates in concentrator circuits and reduces effective throughput capacity. TASMELT may enable a proportion of these middling streams to be removed.

In the case of tin, middlings and primary concentrates can contain high iron and sulphur that lower tin recovery ahead of the traditional smelting process. The strict quality control required to reduce iron and sulphur in tin concentrates inevitably causes metal loss.

Tin sulphide matte fuming by Sirosmelt can produce high-grade tin oxide suitable for further refining and importantly without the inherent concentrator metal losses due to the presence of iron and sulphur.

Raw Zinc Fume Production

Raw zinc oxide fume is produced by the continuous smelting and reduction of zinc furnace slag using the top submerged lance based Sirosmelt technology.

The 1991 study considered single and dual furnace configurations. A single furnace configuration was recommended and is also the preferred configuration for the Stage 2 study. Smelting and reduction are carried out in the same furnace. This simple configuration reduces commissioning risk and, with appropriate design accommodation, still provides for future expansion.

Further modification can be made in a staged approach to cater for other feed materials. Partitioning of zinc and lead may be accomplished with relatively minor additional capital expense. The nature of future feed materials may dictate that a second parallel furnace is added whereby smelting and reduction can take place separately.

The proposed plant will be designed in modular form. The furnace will operate at 15 tonnes per hour to treat 112,500 dry tonnes of feed per annum.

Process Description

There are six essential stages in the production of the raw zinc oxide fume:

- Slag preparation
- Slag smelting
- Slag reduction
- After burning
- Gas handling
- Slag handling
- Furnace stand-by

These will be implemented at Zeehan as follows:

Slag Preparation

Slag will be recovered from the dumps by front-end loader and delivered to the dump hopper along with the required coal. A grizzly will remove lumps over 300mm and a crusher will reduce the slag to –40mm

The slag than passes to the crushed slag bin via a conveyor, bucket elevator and another conveyor. Crushed slag and reductant coal will be weighed and apportioned onto the feed conveyor on the basis of slag zinc content.

The ore and coal (+1mm to 10mm) with a moisture content of approximately 2% is directly fed into a porthole at the top of the water cooled cylindrical shaped Sirosmelt furnace, via a bucket elevator.

Slag Smelting

This step removes most of the zinc from the slag.

The lance consists of two annular tubes. Finely ground coal is pneumatically conveyed down the inner tube. Combustion air is carried in the annulus between the inner and outer tube. The combustion air acts as a coolant for the lance and is assisted by swirlers located in the annulus between the inner and outer tube.

A bed of molten slag remaining from the previous batch helps maintain the necessary temperatures in the furnace for the commencement of the next smelt cycle. Additional energy is provided by the combustion of fuel with air in the lance with smelting taking place at around 1300°C.

As the lance is lowered above the molten slag a solidified layer of slag encrusts and builds up on the outer surface of the lance. This layer provides the protection required from the molten slag.

At the top of the lance there is a third concentric tube that extends only part way down the lance. This allows the entry of the after burner air to the furnace. This air cools the top portion of the lance and also provides oxygen for the after burner reactions.

Slag Reduction

Combustion conditions are finely controllable. The lump coal provides reducing conditions in the slag.

Zinc oxides, lead oxides and silver are reduced and volatilised.

The reduced metals are removed from the bath by the intense stirring and flushing action of the process gas.

After Burning

Immediately above the bath the metals are rapidly oxidised by supplementary air added through the top of the lance. The oxidised fume then passes out of the top of the furnace, into a cooler and is collected in a baghouse.

Gas Handling and Fume Collection

The fume and off gases are drawn off the furnace through a refractory lined duct. This gas can have a temperature of up to 1700°C and is cooled by water in a gas cooler. The cooling water is sprayed into the gas stream at the top of the cooler, the evaporation of the water providing the cooling to reduce the temperature to about 200°C.

The baghouse will collect the metal oxide fume at its bottom. The off-gas exiting the baghouse will comprise mainly N_2, CO_2 and water vapour and will be discharged into the atmosphere via a stack.

The fume can then be agglomerated in a pug mill by mixing it with a controlled amount of water to form between 1mm and 6mm diameter pellets. It is then discharged into a bagging station ready for transport.

Most of the fume is collected in the baghouse but some will also report to the base of the evaporative cooler.

Slag Handling

Final slag is tapped via a water-cooled tapping block or weir into a launder and into a water granulation system.

Furnace Stand-by

This occurs when the furnace for various reasons is not smelting or reducing such as during slag tapping or during minor disruptions. The furnace is kept at the required operating temperature by the addition of coal.

Process Inputs

The key process inputs are:

Coal

Coal is the preferred fuel source and is also required as a reductant. The alternative of diesel is more costly. Gas is not currently an option at Zeehan.

There is a requirement for 32,000 tonnes of coal per annum of which 24,000 is for fuel and the balance for reductant. The size fraction required is +10mm – 25mm. It is the single largest operating cost. Several sources within and outside of Tasmania are available. The base case has considered Merrywood Coal.

Proximate Analysis	***Ad Wt%***
Moisture	5.0
Ash	23.2
VM	28.8
Fixed Carbon	48.0
Sulphur	0.43
Phosphorous	-

Ash Analysis	***Wt%***
SiO_2	60.9
Al_2O_3	32.6
Fe_2O_3	3.14
CaO	0.99
MgO	0.72
TiO_2	1.32
Na_2O	0.11
K2O	0.89
P_2O5	0.12
Mn_3O_4	0.05
SO_3	0.31

Oxygen Enrichment

Oxygen enrichment generally increases the efficiency of the fuel combustion process so that throughput can be increased. Alternately it may allow a smaller furnace to be built with a commensurate saving in capital cost.

The possibility of oxygen enrichment at Zeehan was dismissed by the 1991 Pre-feasibility Study. However, recent commercial scale experience and advances in this area warrant that it should be reconsidered in any new study as a means of reducing operating costs for only a relatively small increase in capital.

Power

The planned facility is not a large power user although this is an important input.

Power would be run in through a dedicated line from the Zeehan township.

Other Operating Issues

Central Services

The region is well serviced by contracting companies able to take on a wide range of maintenance, site, transport activities, assay and laboratory services. This will enable a significant reduction in capital and labour costs to be made.

Compressed Air

Compressed air at 300kPa from the compressor is required by the lance for combustion of the fuel and for afterburning.

Plant Availability

Availability is expected to be about 85% and allows 7,500 hours per annum operating time on a continuous 3 x 8-hour shift, 7 days per week. The balance is accounted for by general maintenance, unplanned breakdowns and stoppages plus annual refractory relining.

Manning

The total personnel requirement for a smelter operating 24 hours per day, 7 days per week will total 33:

- Plant manager x 1,
- Senior metallurgist x1
- Shift leaders x 4
- Plant operators x 12
- Electricians x 2
- Mechanics x 4 (one per shift crew)
- Laboratory technicians x 2
- Senior chemist x 1
- Instruments engineer x 1
- Boilermaker x 2
- Administration Manager x 1
- Support staff x 2

Given the availability of a skilled permanently housed workforce at Zeehan and generally on the West Coast it is most likely that many of the above will be contracted in on a more cost effective basis. The total permanent dedicated smelter work force is therefore expected to be and has been costed at 25. This will increase to 35 when the tin tailings concentrator becomes operational.

Water

The plant will require some 400,000 tonnes per annum of process water for furnace cooling, slag granulation, evaporative gas cooling and site dust control.

There will be a recirculating water load for slag granulation and furnace cooling which will pass through a cooling water pond to reduce make up requirements from other sources.

A weir, headworks and power will be required.

There is expected to be a net loss of water in the order of $55m^3$/hr with the major consumer being gas cooling.

Water will be abstracted from Austral Creek, which flows adjacent to the site. An alternative is the larger Little Henty River, 1.5km to the east.

Austral Creek was the water source for the original smelters, which used three steam driven pumps to lift water to head tanks above the smelter complex.

Refractory Reline

Under normal operation a full refractory reline will be required every year with a partial reline possibly every six months. Smelting campaigns will be scheduled to coincide with these events although stockpile accumulation rates will have some impact on reline timing.

Stage 2 – Zeehan Slags Technical Programme

Stage 2 work proposed on and specific to the Zeehan slags comprises:

- Final process flow sheets and mass balances.
- Energy balances.
- Updating and optimisation of Zeehan slags smelting model, operating and capital costs.

No pilot plant smelting testwork is proposed during Stage 2. To the extent that any smelting testwork is required, this will be undertaken during Stage 3 and will primarily be for the purpose of product marketing and process environmental certification.

Major Equipment List

(Zeehan dedicated smelter only)

			Qty	Capacity	Power (kW)
1	**CIVIL/SITE WORKS**				
1.01		Earthworks			
1.02		Drainage			
1.03		Concreting			
2	**FEED HANDLING**				
2.01	F1	Slag Crushing Plant		50 t/h	50.0
2.02	F1	Slag Transfer Conveyor	10 m	25 t/h	7.5
2.03	F1	Slag Feed Bin/Feeder	50 t	25 t/h	12.0
2.04	F1	Reductant Coal Feed Bin/Feeder	10 t	2 t/h	7.5
2.05	F1	Elevator Conveyor	20 m	25 t/h	10.0
2.06	F1	Rotary Valve		25 t/h	1.0
2.07	F1	Feed Chute		25 t/h	
3	**SIROSMELT FURNACE(S)**				
3.01	F1	Furnace Shell & Gas Offtake			
3.02	F1	Furnace & Gas Offtake Refractories	2 sets		
3.03	F1	Water Cooled Copper Blocks			
3.04	F1	Sirosmelt Lances	1 + 3		
3.05	F1	Lance Flexibles	3 + 3		
3.06	F1	Lance Hoist		2 t	5.0
3.07	F1	Lance Maintenance Hoist		1 t	2.0
3.08	F1	Stand-by Burner		8 GJ/h	
3.09	F1	Over Flow Weir			
3.10	F1	Launder/Weir Burners	4	2 GJ/h	
3.11		Operating Decks			
3.12		Support Structure			
3.13		Slag Granulation Launder	10 m		
3.14		Slag Granulation Pit	36 m^3		
3.15		Tapping Equipment			
4	**GAS HANDLING**				
4.01	F1	Gas Cooler		44000 Nm^3/h	7.5
4.02	F1	Baghouse		85000 Nm^3/h	
4.03	F1	ID Fan		85000 Nm^3/h	180.0
4.04	F1	Stack	25 m	85000 Nm^3/h	
5	**BUILDINGS**				
5.01		Control Room	6x3 m		1.0
5.02		MCC	6x3 m		
5.03		Laboratory	12x6 m		3.0
5.04		Offices	12x6 m		3.0
5.05		Furnace	20x20 m		
5.06		Ablutions	6x3 m		1.5
5.07		Lunch room	6x3 m		1.0
5.08		Workshop	12x12 m		5.0
5.09		Compressor House	6x3 m		

6	**SERVICES**				
6.01		Compressed Air Supply 100 kPa		15000 Nm^3/h	70.0
6.02		Compressed Air Supply 230 kPa		43000 Nm^3/h	2400.0
6.03		Compressed Air Supply 700 kPa		1000 Nm^3/h	100.0
6.04		Air Piping 100 kPa	10 m		
6.05		Air Piping 230 kPa	50 m		
6.06		Air Piping 700 kPa	50 m		
6.07	F1	Fuel Coal Feed Bin/Feeder	20 t	6 t/h	12.0
6.08	F1	Fuel Coal Hammer Mill		6 t/h	40.0
6.09	F1	Fuel Coal Fuller Kinyon Pump		6 t/h	30.0
6.10	F1	Fuel Coal Piping	20 m		
6.11		Water Storage – Slag Granulation	100 t		
6.12		Water Pump – Slag Granulation		500 t/h	40.0
6.13		Water Piping – Slag Granulation	50 m		
6.14		Water Sump Pump – Slag Granulation		100 t/h	11.0
6.15		Water Cooling Tower – Slag Granulation		20 GJ/h	
6.16		Water Storage – Furnace/Gas Cooling	100 t		
6.17		Water Pump – Furnace Cooling	1+1	120 t/h	20.0
6.18		Water Piping – Furnace Cooling	50 m		
6.19		Water Sump – Furnace Cooling			
6.20		Water Sump Pump – Furnace Cooling	1+1	120 t/h	15.0
6.21		Water Cooling Tower – Furnace Cooling		12 GJ/h	
6.22		Water Pump – Gas Cooling	1+1	32 t/h	10.0
6.23		Water Piping – Gas Cooling	100 m		
6.24		Workshop Equipment			
6.25		Safety Equipment			
6.26		Laboratory Equipment			
6.27		Front End Loader		5 t	
6.28		4WD Plant Vehicle		1 t	
6.29		Electricals	3.1 MW		
6.30		Instrumentation	18 loops		

Energy Balance

Heat In	GJ/h	Heat Out	GJ/h
Combustion	-89.85	Combustion Products	49.74
Combustion Preheat	-8.11	Smelt Products	8.25
Smelt Preheat	0.00	Slag Heat	25.58
Reactions	5.04	Furnace Losses	9.50
Liquid Slag	0.00	Fume	4.82
A'burn Recup.	-4.79		
TOTAL	**-97.89**	**TOTAL**	**97.89**

MASS BALANCE

INPUT:		Wgt	Zn	Pb	Fe	SiO_2	CaO	S	Cu	As	Al_2O_3	MgO	Resid.	H_2O		Ag
Zeehan Slag	%		13.4	1.7	22.4	20.0	11.4	3.3	0.2	0.0	3.7	1.3	12.4	5.0	g/t	54
	kg/h	15000	2004.0	258.0	3357.1	2994.0	1702.5	499.5	33.6	5.3	555.0	195.0	1857.0	750.0	g/h	810
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		11.5		
(Reductant)	kg/h	969			7.8	112.2	5.2	4.0			37.8	3.5		111.4		
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		5.1		
(Fuel)	kg/h	3483			28.1	403.4	18.5	14.3			135.8	12.6		177.6		
Total Feed	kg/h	19452	2004.0	258.0	3393.0	3509.7	1726.2	517.8	33.6	5.3	728.5	211.0	1857.0	1039.0	g/h	810

OUTPUT:		Wgt	Zn	Pb	Fe	SiO_2	CaO	S	Cu	As	Al_2O_3	MgO	Resid.	H_2O		Ag
Slag	%		3.1	0.3	26.0	26.9	13.3	0.2	0.3	0.0	5.6	1.6	14.4		g/t	19
	kg/h	12897	400.8	38.7	3359.1	3474.6	1708.9	25.9	33.2	0.3	721.2	208.9	1857.0		g/h	243
	Rec		20.0	15.0	99.0	99.0	99.0	5.0	99.0	5.0	99.0	99.0	100.0			39
Fume	%		67.6	9.3	1.4	1.5	0.7	1.1	0.0	0.2	0.3	0.1	0.0		g/t	239
	kg/h	2371	1603.2	219.3	33.9	35.1	17.3	25.9	0.3	5.0	7.3	2.1	0.0		g/h	567
	Rec		80.0	85.0	1.0	1.0	1.0	5.0	1.0	95.0	1.0	1.0	0.0			70
Total Output	Kg/h	15267	2004.0	258.0	3393.0	3509.7	1726.2	51.8	33.6	5.3	728.5	211.0	1857.0		g/h	810

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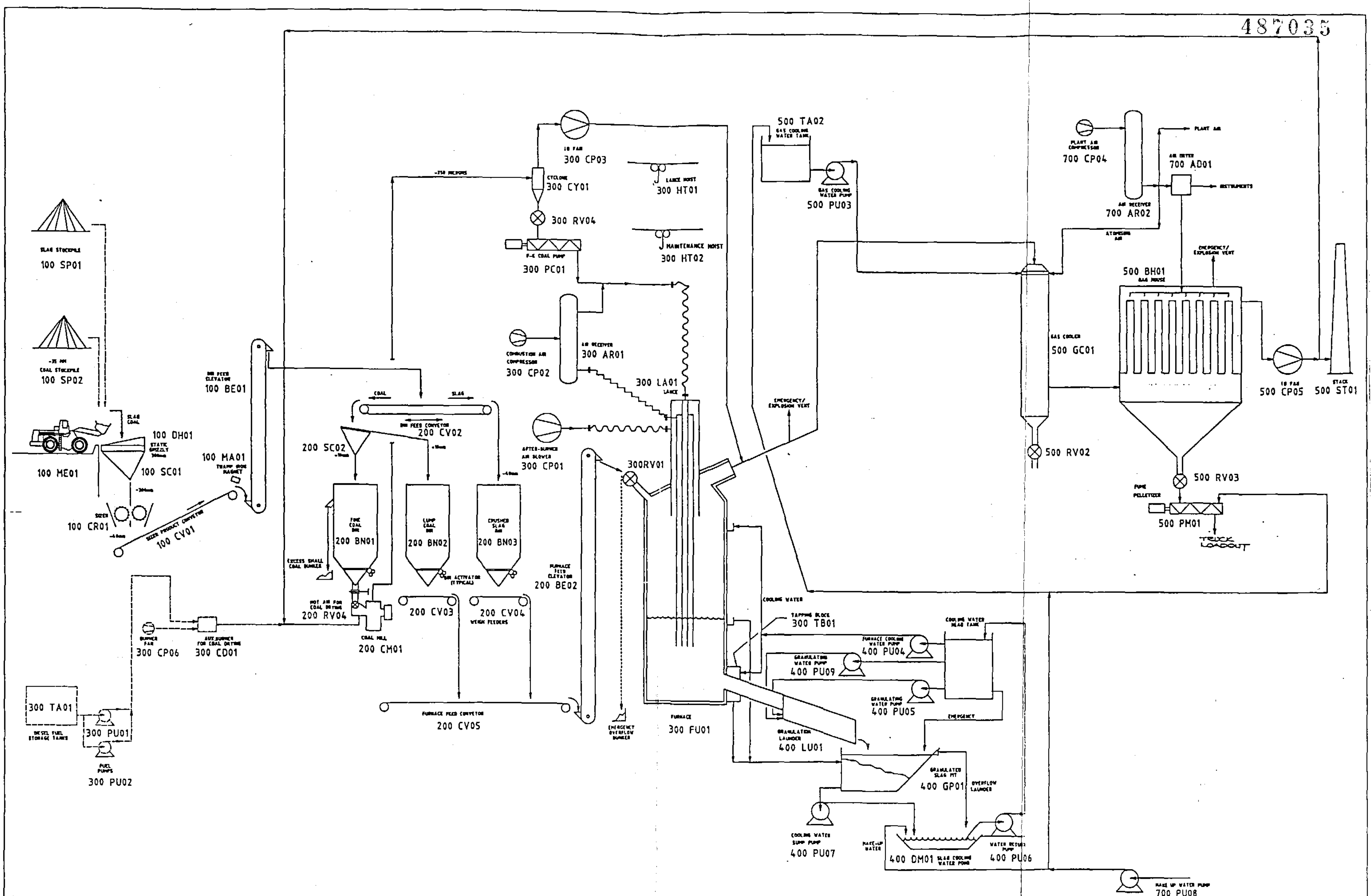

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REVISIONS | APPROVAL | REFERENCE DRAWINGS

BHP Engineering - PERTH

PYROSMELT N.L.
ZEEHAN SLAG RETREATMENT
CONCEPTUAL PROCESS DIAGRAM

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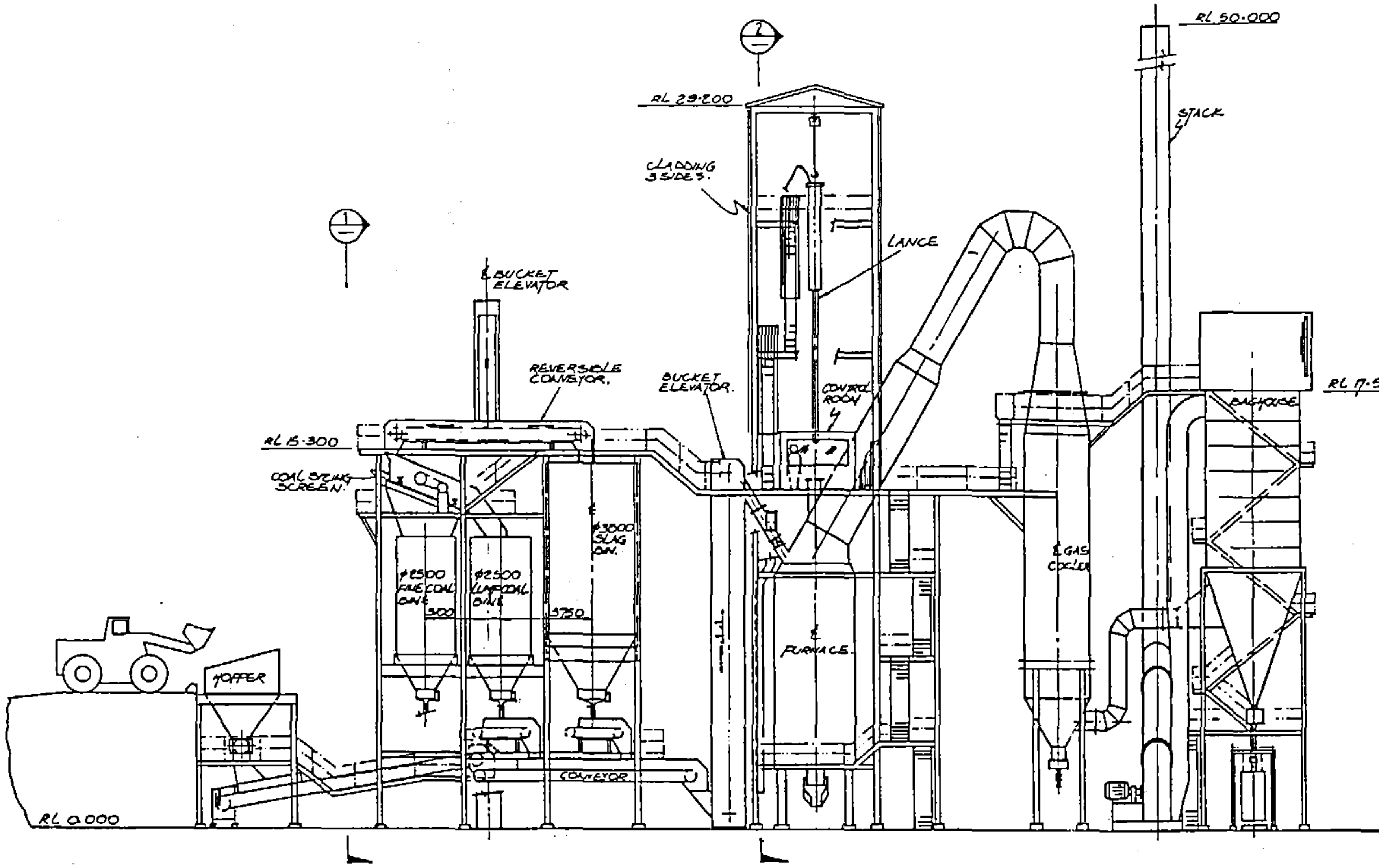

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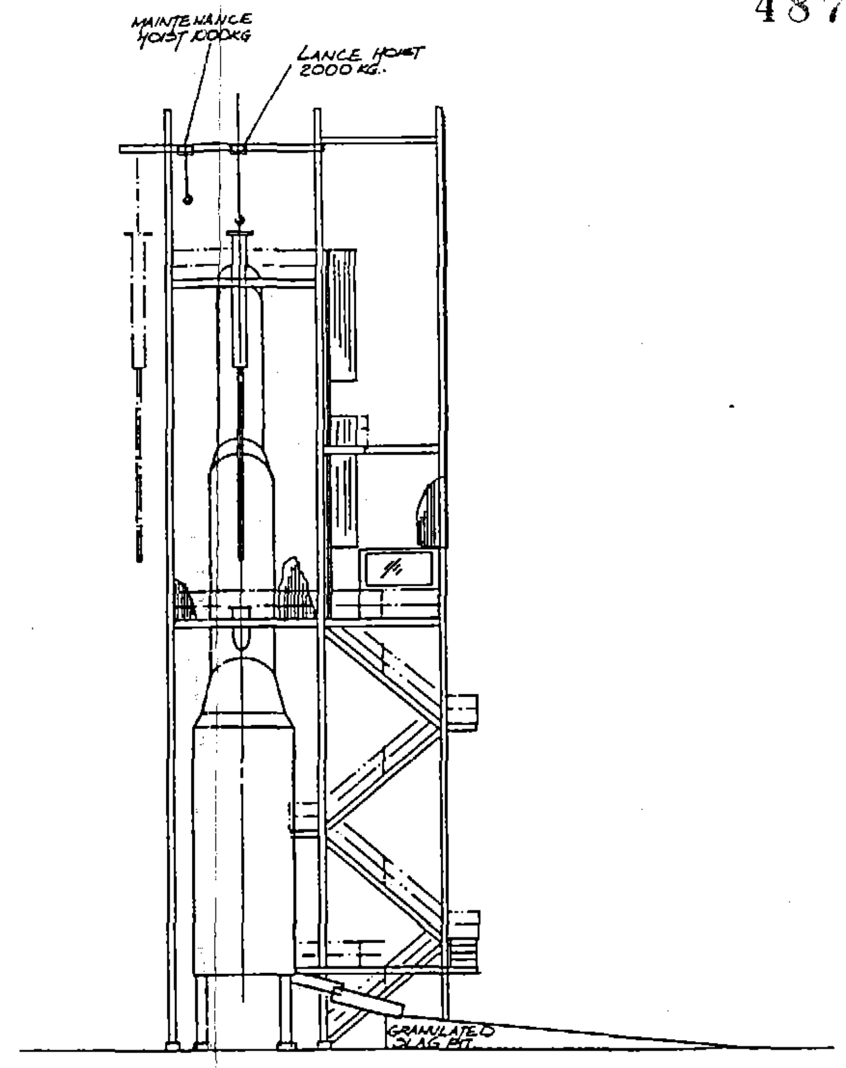

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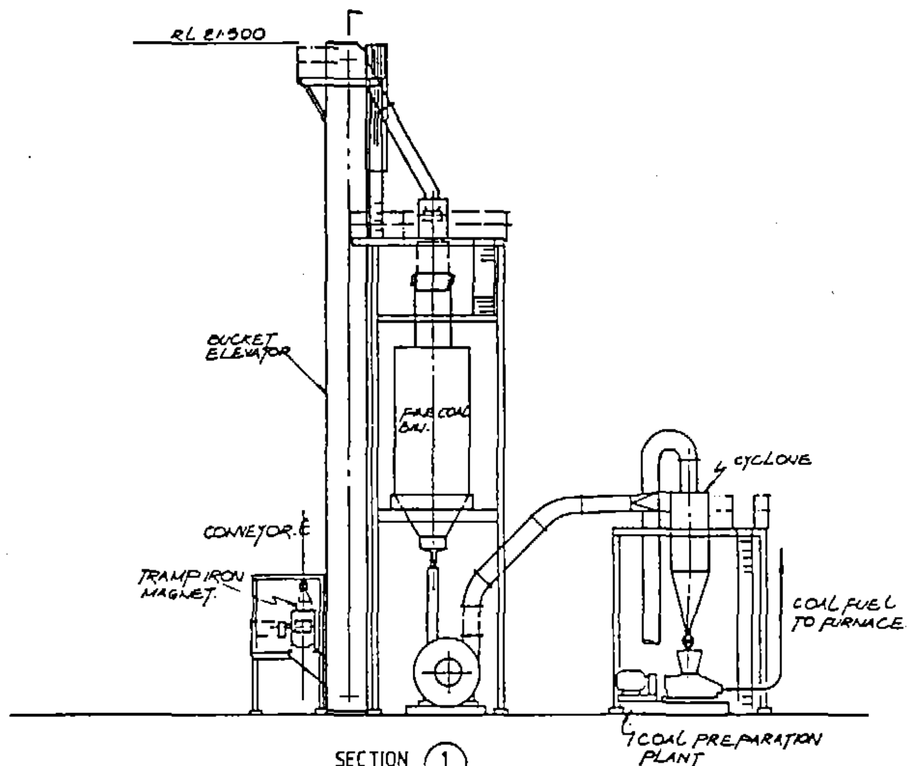

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SIGNED .... DATE ....

DRAWN E.H. 17.10.90

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PYROSMELT N.L.
ZEEHAN SLAG RETREATMENT
GENERAL ARRANGEMENT
ELEVATION & SECTIONS

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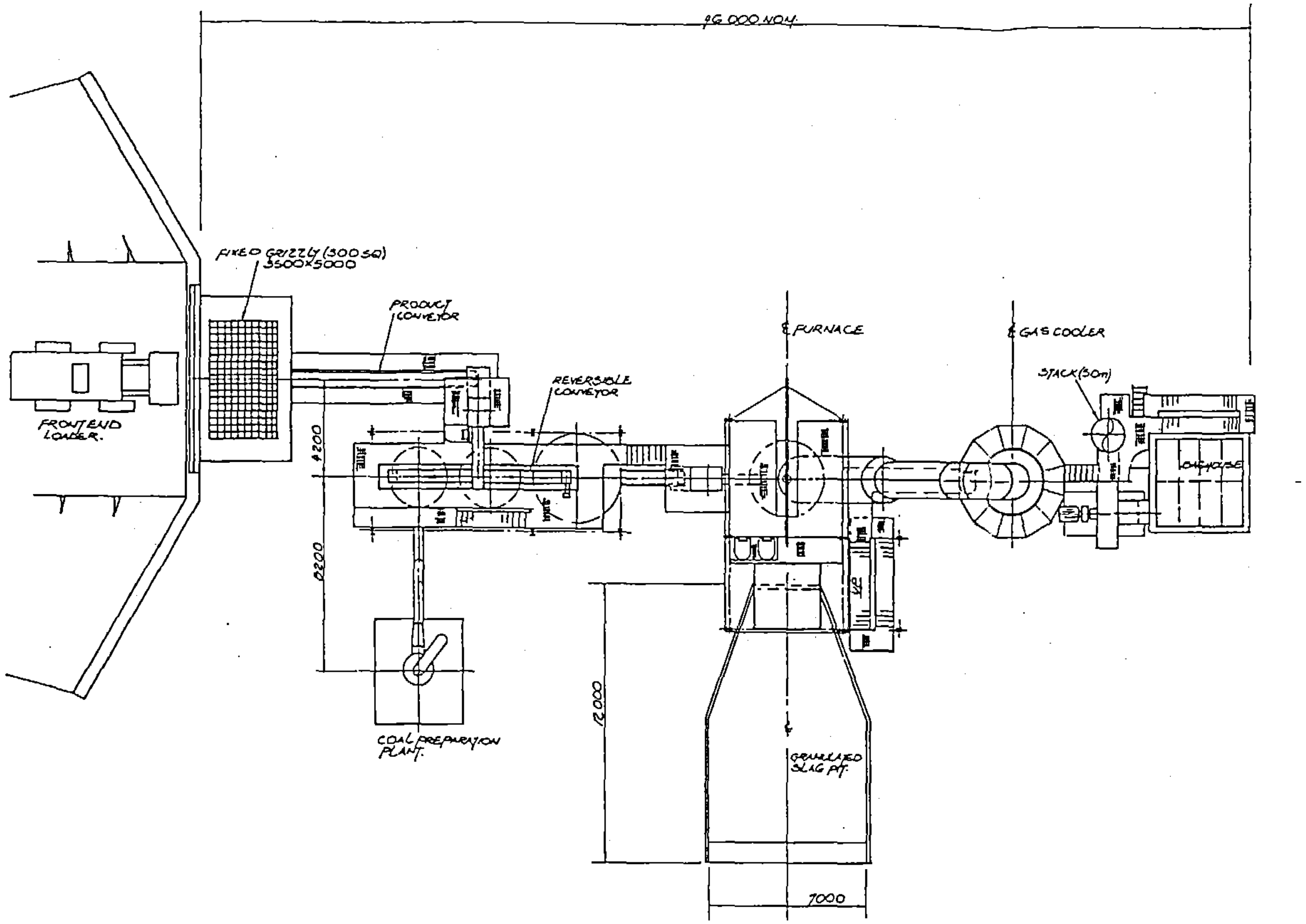

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REVISIONS | APPROVAL | REFERENCE DRAWINGS

BHP Engineering – PERTH

PYROSMELT N.L.
ZEEHAN SLAG RETREATMENT
GENERAL ARRANGEMENT
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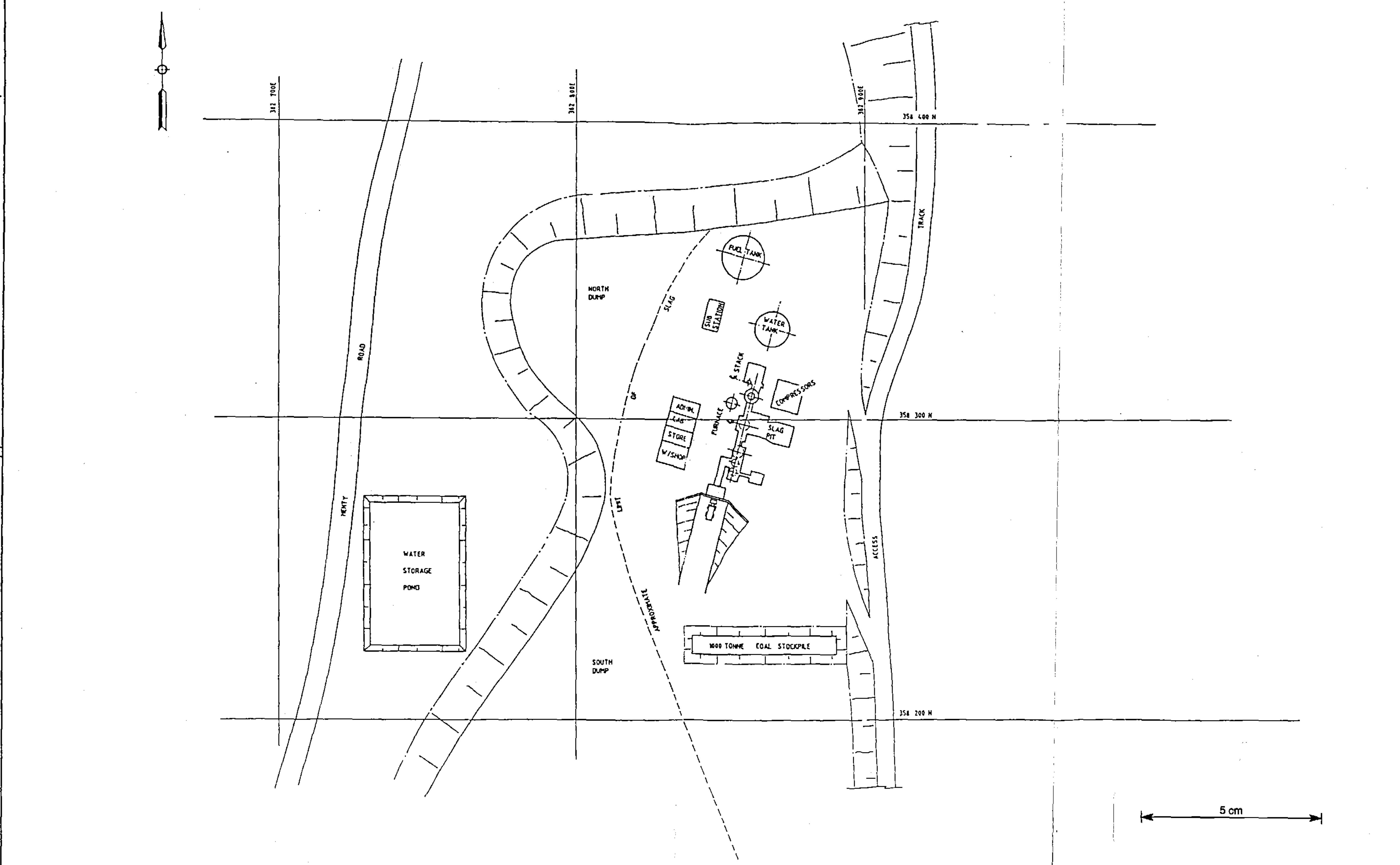

B	NOV '90	P.D.	SITE PLAN REDRAWN

REVISIONS | APPROVAL | REFERENCE DRAWINGS

DRAWN P.J.D. NOV '90

BHP Engineering – PERTH

PYROSMELT N.L.
ZEEHAN SLAG RETREATMENT
SITE PLAN

SCALE 1:500 | DATE NOV. 90 | B1 | DRG Nº E 200 - 400 - 004 / B

Tin Fume Production

Tin fume production relies upon the relatively high volatility of tin sulphide in order to separate tin from other impurities, particularly iron. Classical tin smelting has great difficulty dealing with even moderate levels of iron. This is because the reduced metals tend to form an iron-tin alloy known as *hardhead* that requires re-smelting and usually multiple furnaces.

In the tin fuming process, low-grade concentrate is smelted and reduced in a similar manner to the Zeehan slag. It is important to provide sufficient sulphur in the smelted liquid to ensure that tin sulphide, and not tin metal, is formed.

To maintain the right amount of sulphur in the furnace, a metal sulphide phase, or *matte* will be maintained. This is quite dense, and will sit below the slag formed from the other material in the concentrate. Matte will also act as a collector for any precious metals or base metals, and can be periodically tapped if necessary. Slag is formed continuously and is handled in the same manner as the discard slag in the zinc fuming operation.

At the smelting temperature, tin sulphide is volatile and boils out of the molten bath. Excess air is added above the melt to re-oxidise the tin, forming a tin oxide fume and sulphur dioxide gas. The addition of air, and subsequent cooling of fume employs the same process as the zinc fume operation; however, to avoid cross- contamination of the two metal oxides, there will be a second fume cooler and product handling train for tin production.

Due to the increased amount of sulphur dioxide produced during tin fuming, it will be necessary to install additional gas cleaning equipment to either scrub and neutralise or convert the gas to sulphuric acid.

The product of this tin fuming will be a high-grade tin oxide, approximately 65% tin, with low (< 1%) iron. This is ideal as a conventional smelter feed, and can either be sold along with Renison Bell concentrate, or contracted as separate parcels to a commercial smelter.

Sulphide or *matte* smelting of tin has been practiced in the Aberfoyle demonstration plant in Kalgoorlie during the 1980's, and does not present a technical risk to the project.

Testwork Focus

Issues requiring testwork in Stage 2 include tin fume quality and sulphur requirement. It may be necessary to add sulphur in the form of pyrrhotite (available from the Renison Bell reject streams). The amount of arsenic in concentrate will be important, as this also forms volatiles during smelting and needs to be controlled in the fume product.

Once the Renison Bell concentrator flowsheet has been selected, bench scale samples representing future plant production can be processed in a crucible smelting trial to determine these parameters.

Stage 2 - Renison Bell Tailings and Middlings Technical Programme

There are three tailings dams at Renison Bell. Dams A and B contain a combined 5.2 million tonnes of tailings and 23,000 tonnes of tin metal. Dam C is operational and contains some 10 million tonnes of tailings and 40,000 tonnes of tin metal.

Current arisings of tailings are 750,000 tonnes per annum (including slimes) grading between 0.4 and 0.5% tin.

Encore has already completed a detailed review of an extensive resource of Renison Bell generated testwork and evaluation data on Dams A and B. On the basis of this work, a portion of which is also relevant to TASMELT objectives, a detailed testwork programme has been devised and indicative quotes obtained.

Sirosmelt technology is well proven on various tin concentrates from around the world and has been considered on at least two occasions for Renison Bell. A number of commercial size plants have been installed and there is considerable confidence to be had in its application by TASMELT on a Renison Bell based concentrate.

Stage 2 Renison Bell tailings testwork has two key components:

1. **Tailings Concentrates Production**

   Benchscale development of a viable concentrate production flowsheet and preliminary costing of an optimal concentrate.

2. **Tin Fuming**

   Development and modelling of concentrate smelting regime and costing to +/- 20%.

Tailings Concentrate Production

Renison tailings comprise mainly iron and other sulphides together with minor amounts of oxides, carbonates and silicates. Tin occurs mainly as tin oxide (cassiterite) with approximately 10% as sulphide (stannite)

The most significant advantage Tasmelt provides a Renison Bell tailings recovery plant is its ability to handle low-grade concentrates with high levels of iron and sulphur.

Renison Bell has conducted several extensive campaigns of research on extracting tin from its historic tailings dams "A and B".

The key objectives of this historical recovery work was to produce a concentrate of sufficient tin grade to integrate with current run-of-mine concentrate production ie. to strive for >60% tin content whilst attempting to maintain decent levels of recovery.

This work has been reviewed by Encore. A preliminary testwork programme has been prepared to look at producing a low cost, low grade but acceptable metal recovery concentrate feed for TASMELT.

Dam C is still active and practical access to some 50% of it is difficult whilst the mine is operational. However, it is feasible that current tailings arisings can not only provide a source of material for preliminary testwork but also a possible feed for commissioning the first tin smelting campaign. Thereafter, it could be blended with concentrates from A and B dams. Current arisings are already devoid of slimes and are separated into the sulphide and non-sulphide streams that require separate treatments.

Recovery Issues

Tin, as cassiterite, is present in tailings for a number of reasons:

- fine tin (slimes) is lost because it is too fine to respond properly during gravity concentration.

- other fine material has a high reagent consumption on flotation, so is physically removed (along with the fine cassiterite) before flotation.

- some tin is carried off in the sulphide flotation concentrate.

  This stream removes the bulk of the plant feed impurities such as sulphur, iron and arsenic. Some cassiterite is lost here, because it is joined to the sulphide minerals that are intended to be removed. Regrinding will liberate some of this tin. It will also make some of it too fine to recover. Regrinding is practiced extensively in the current Renison Bell circuit, and there is some opinion this could be overdone, as current plant tailings lose over 40% of tin as slimes.

- in cassiterite flotation tailings.

  Like any metallurgical process, cassiterite flotation is somewhat imprecise, so some "gets away". A factor exacerbating this loss is the prohibition of a collecting reagent (PSA) in 1995. Synthetic replacements for this now environmentally unsuitable reagent have been produced but are less effective.

- In both sulphide and cassiterite flotation circuits, there is also a phenomenon of misreporting by entrainment.

  Some free tin oxide will be swept along with the sulphides in the former, and the gangue tailings in latter. Given sufficient stages of recovery, these losses would reduce to almost nothing, however economics limit the extent of this.

Slimes

Slimes contents of tailings is an important consideration. During liberation of tin values by grinding, an unavoidable loss of brittle cassiterite occurs when it is reduced below a recoverable size (nominally 6 microns). None of the commercially demonstrated equipment is suitable for recovering such fine material.

Slimes has been measured at between 20% and 40% of the total tin content in the mill tailings, and presents an automatic barrier to reported recovery if included in the tin content of any process scheme. In any proposed or previously tested recovery plant, de-sliming is a critical step, so an important element of proposed testwork will be to analyse tin feedstocks "post de-sliming" to determine a realistic recoverable tin.

Recovery Circuit and Testwork

The retrieval of tin values from tailings will encompass the use of techniques found in the present Renison Bell plant, as well as those employed in previous test work. Due to the low levels of tin values present in the tailings, it is imperative to employ low unit costs stages to remove the bulk of unwanted material prior to any more expensive concentration stages.

Fine material does not contain recoverable tin, and can be separated from the remaining material using hydrocyclones or hydrosizers.

Much of the sulphur and iron is present as pyrrhotite, which is a weakly magnetic mineral, amenable to removal using modern high intensity rare-earth magnetic separators.

Previous testwork has shown that moderate grinding followed by sulphide and cassiterite flotation is effective in recovering tin at this stage.

It is also proposed that a gravity concentration stage using spirals on selectively sized streams should be tested. Free cassiterite that had previously reported to tailings due to entrainment may prove to be recoverable using this inexpensive technique.

Sulphide Tin

Renison Bell primary ore also contains minor amounts of sulphide tin representing approximately 3% of total tin. This material is currently rejected in the concentrator circuit along with other sulphides. Encore testwork will examine the viability of recovering these values.

Marketing of Raw Zinc Oxide and Tin Fumes

Marketing studies for both zinc and tin fume products will be an integral and critical component of Stage 2.

Specialist marketing expertise will be employed to build on the preliminary investigations made.

This work will be undertaken using indicative product specifications arising from early stage testwork on the Renison Bell tailings and more advanced information on the Zeehan slags.

Zinc Fume

The raw fume produced at Zeehan is in effect a high grade, low sulphur, low iron concentrate.

As for conventional zinc concentrates, it is marketed to the world's custom zinc smelters. Integrated smelters may also make some custom purchases.

In turn, zinc smelters sell zinc metal to fabricators, galvanisers and other users. Hence demand for zinc concentrates is a derived demand based on demand for zinc metal and zinc smelting capacity and utilisation.

Smelter Technology

Zinc concentrates are processed into zinc metal and other by-products by two predominant technologies:

- the electrolytic process (roast – acid leach – electrowinning from sulphate solution).

  Due to the high purity requirements for the electrolyte in the electrolytic process, only high grade concentrates (Zn >50%) with combined Cu+Pb <3% are acceptable. Other elements such as antimony, arsenic, chlorine, cobalt, fluorine, nickel, selenium, tellurium and tin can be deleterious to electrolysis, even in trace amounts in the electrolytes, and may therefore attract significant penalties or outright rejection of concentrates by the smelter.

- the Imperial Smelting Process (ISP smelters) which treats mixed lead/zinc concentrates.

  While ISP smelters can accept clean high grade concentrates, they require a certain proportion of lead in their feedstock and can recover copper and other payable metals. ISP smelters therefore usually purchase bulk zinc-lead concentrates. Penalties and rejection may be imposed if the arsenic, antimony or tin concentrates are too high.

The Zeehan derived fume will be most suited for sale to an ISP smelter.

Major Zinc Smelters in the Asia Pacific Region

Country	*Plant*	*Production Capacity ('000tpa zinc metal)*	*Company*
Electrolytic			
Australia	Risdon	220	Pasminco
	Port Pirie	40	Pasminco
Japan	Annaka	143	Toho Zinc
	Kamioka	63	Mitsui
	Hikoshima	84	Mitsui
	Akita	106	Mitsubishi
	Ijima	156	Akita Zinc
	Mikkaichi	100	Nippon
Korea	*Onsan*	190	Korea Zinc
ISF			
Australia	Cockle Creek	81	Pasminco
Japan	Harlma	85	Sumiko ISP
	Hachinohe	101	Hachinohe Smelting

Smelting Contracts

Historically, the Net Smelter Return for zinc concentrates has usually been 40%-60% of the value of the total zinc metal contained in the concentrate. This excludes concentrates with unusually high precious metals or penalty element payments.

Contracts are structured to contain pricing payments, treatment charges, escalators, de-escalators, price participation and penalty charges

Pricing

The pricing of delivered zinc concentrates is generally as follows:

- Pay 85% of the value of the zinc content subject to a minimum deduction of 8 percentage points.
- Pay 60% for lead subject to a minimum deduction of 3 percentage points.
- Pay 65% for silver subject to a minimum deduction of 3.5 ounces.

Treatment Charges

A treatment charge expressed as a fixed deduction per tonne concentrate is applied. This includes the cost of refining the zinc. A price participation is also included.

For high grade concentrates (>54% Zn), the treatment charge (including price participation) can be roughly estimated by correlation to the zinc price using the following formula (Vogel and Grey, 1990):

Treatment Charge = zinc price x 17.5%

Treatment charges for ISP smelters normally attract additional treatment charges of around US$15-US35 per tonne concentrate.

Treatment charges are generally in the range US$185 to US$220 and are presently US$190.

The fume produced at Zeehan has the advantage over conventional zinc concentrates of having:

- Generally higher grade
- Very low sulphur content which is in the form of sulphate that does not require roasting and acid production
- Very low levels of iron that avoids the need for production and handling of toxic waste such as jarosite.

Treatment Escalators

Treatment escalators are applied for fluctuations in the zinc price about a base price currently around US$1000.

Typically, they may be reduced 20 cents per tonne for each dollar below that base price and escalated a similar amount above that price.

Penalties

Penalties are imposed for undesirable elements that increase the smelter's costs.

Smelters may reject some concentrates because they contain a high level of penalty elements. There are no standard "rejection limits" for the penalty elements as any concentrate is potentially saleable depending on its quantity and the availability of other more favourable concentrates. Clearly, "dirtier" concentrates can only be sold for lower returns than cleaner concentrates or at times when cleaner concentrates are in short supply.

The Zeehan slags and their fume product will be low in other metals.

Other Markets

The fume may alternatively be directly sold to manufactures of reagents used in the automotive rubber tyre industry and agricultural products such as animal feed supplements and fertiliser additives.

The latter represent small markets relative to the former and both require a relatively high purity zinc oxide.

Raw Fume Upgrading Options

Some 55% of the value of the zinc contained in the Zeehan raw fume is realised when sold as described above.

It is possible and could be desirable to further process the fume to produce a range of marketable added value products. These are:

- **Zinc Enriched Fume**

  By roasting, containing 77% zinc and low lead.

  This process also produces a lead rich material, for sale separately. Plant accommodating this procedure will also enable treatment of zinc refinery residues, and tin tailings re-concentrate, and could be established relatively soon after the initial commissioning establishes stable smelting operations.

  This option will be evaluated during full feasibility.

- **Basic Zinc Sulphate**

  by leaching in sulphuric acid followed by precipitation from the leach liquor using sodium hydroxide

- **Zinc Sulphate Monohydrate**

  by leaching in sulphuric acid followed by precipitation by pressure crystallisation

- **High Purity Zinc Oxide**

  by leaching in sulphuric acid and spray roasting in a reactor

Slag Marketing

The slag by-product has several uses. It is relatively inert and has good mechanical characteristics. These allow it to be sold as mine fill, for road base and for use in cement manufacture.

Tin Fume Marketing

Tin fume, or oxide, may be likened to a very high-grade tin concentrate, and is ideal feed to a conventional tin smelter.

There are commercial smelters in the Asia-Pacific region that purchase concentrates in small and large parcels, with varying smelter terms depending upon the size and impurity content of the supply.

Contract terms are not too dissimilar in structure to those for zinc concentrates but with specific pricing differences.

Net revenue after all treatment charges, penalties etc is generally in the order of 75% to 85% depending on concentrate quality.

There are some synergistic advantages to Renison Bell and Encore in blending the products from Renison Bell concentrator and Encore smelter. These will be considered as part of Stage 2.

Emissions and Environmental Issues

The project will have minimum overall and readily managed environmental impact, which will be limited to the duration of the project.

Some aspects of the project are expected to lead to a long-term improvement in the environmental status of the Zeehan slags dumpsite such as the removal of residual metal values from the slag. The granulated slag is expected to rehabilitate more successfully than the platey slag.

External consultants in compliance with operating licence conditions will undertake routine environmental monitoring. Of particular interest will be the various emissions:

Solid Emissions

The major solid waste will be new slag, which is a relatively inert glass-like siliceous material, highly resistant to degradation.

Any slag remaining at site will be granulated and landscaped to soften the appearance of the site and to promote revegetation.

General solid waste from the operation can be disposed of in the municipal waste dump 1km north of the smelter. This dump takes a variety of domestic and light industrial wastes.

Drainage from the residual Zeehan slag dumps is not expected to contain metals above the background level. It will be low in zinc and other metals and is virtually inert.

Similar product from zinc slag fuming has passed US EPA and Dutch environmental leaching tests.

The existing slag does not appear to be leaching to any appreciable extent and there is no evidence of vegetation damage immediately down toe of the dumps.

Air Emissions

Emissions to the atmosphere from the process comprise the off gases from the furnace after passing through the baghouse. The main constituents will be N_2, O_2, CO_2, H_2O, and SO_2, emitted at a volume of 120,000Nm^3/hr with an elevated temperature of approximately 150°C.

Emissions of SO_2 are of major concern to regulatory authorities. Sulphur in the slag and coal and the retention rate in the new slag and product determine the amount of SO2. It is expected that 70% of the sulphur will be retained in the discard slag. The SO_2 emission levels produced by the furnace stack are likely to be below 1.5g/m^3, which is within current acceptable levels.

When tin fuming commences there will be a requirement for the installation of an SO_2 scrubbing facility.

Noise Emissions

The fans, compressors and lance, will generate noise when it is removed from the bath.

The smelter will not be a significant source of noise.

The nearest residence is approximately 1500 metres from the site and is shielded by two hills.

Site Issues

Zeehan is currently the preferred site for the regional smelter although an open mind will be maintained subject to the sourcing of other feed materials.

The Zeehan site is close to excellent infrastructure and is adjacent to the Zeehan Strahan road. There is also a clear and levelled site available.

SECTION D

FINANCIAL OVERVIEW

Financial Modelling and Material Smelting Schedule Optimisation

A preliminary financial model in respect of the Zeehan slags and Renison Bell tailings has been constructed to provide a framework for continuous project evaluation.

It envisages a twelve-year operating life and is conservative in not assuming full capacity smelter utilisation after depletion of zinc slags in year six. It also conservatively inputs a 15% tin concentrate.

The attached summary tables set out the main capital and operating cost components of the proposed initial Sirosmelt facility. These have been adapted and updated from the 1991 Dragon-BHP Prefeasibility Study

Its main operational assumptions are:

- *Initial modular plant installation for zinc and tin fuming ($15.0M)*
  Installation and commissioning of 0.5 million tonne per annum tin tailings concentration circuit ($3.0M)
- *Commence year one of zinc fuming at 15 tonnes per hour (112,000 tpa)*
  Commence concentration and stockpile build-up from current tailings arisings of 0.5Mtpa (0.75Mtpa including unwanted slimes).
- *Cease zinc fuming. Commence 3-month tin fuming campaign.*
- *Complete tin fuming campaign and reconfigure smelter for zinc fuming*
- *Commence second zinc fuming campaign*
  Upgrade tin concentrator to 1,000,000 tpa ($4.0M) and accumulate tin concentrates from 0.5Mtpa tailings arisings and 0.5Mtpa from A and B dams.
- *Alternating zinc and tin campaigns to total slag exhaustion in year six*
- *Continuous tin campaign until Renison Bell mine reaches end of current planned operating life.*
- *Treat Dam C tailings using existing 1.0Mtpa mill and 'redundant' Renison Bell mill.*
- *Reconfigure smelter for next generation feeds*

Capital Costs

Based on 1991 Scoping Study costs (Zeehan dedicated smelter only) with total adjusted for inflation and incremental plant additions to treat tin fume ($1.0M gas handling upgrade and $1.0M SO_2 scrubbing facility.

Item	Cost
Civil and Site Works	199,000
Feed Handling	212,000
Sirosmelt Furnace	1,260,000
Gas Handing	2,780,000
SO_2 Scrubbing	1,000,000
Buildings	1,027,000
Services	2,766,000
TOTAL CAPITAL EQUIPMENT	**9,244,000**
Installation	1,055,000
Spares	362,000
Shipping/Handling	181,000
Insurance	145,000
Pre-Commissioning	38,000
Commissioning & Training	226,000
EPCM	1,659,000
Royalties	638,000
Contingency	1,235,000
Site Rehabilitation	217,000
TOTAL OTHER	***5,756,000***
TOTAL INSTALLED COST	**15,000,000**

Operating Costs

Based on 1991 Prefeasibility Study costs adjusted for inflation and inclusion of a gas scrubbing facility.

Labour on costs	27%	2,280,000
Coal fuel and reductant	30%	2,540,000
Power	14%	1,160,000
Gas scrubbing	7%	560,000
Maintenance	7%	630,000
Packaging and transport	13%	1,150,000
Other costs	3%	250,000
TOTAL		**$8,570,000**

TASMELT PRELIMINARY FINANCIAL MODEL Zeehan Slags & Renison Tailings (A, B and C Dams)

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	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Renison tailings operations																	
capital spent $000's		$3,000	$100	$4,000	$100	$100	$100	$100	$100	$100	$100						
capacity tpa		0	500,000	500,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,500,000	1,500,000	1,500,000	0	0	0
treatment feedstock		nil	CFT&FSC	CFT&FSC	plus "A"	plus "A"	plus"B"	plus"B"	plus"B"	plus"C"	plus"C"	"C" dam	"C" dam	"C" dam	nil	nil	nil
dredging cost per tonne/cost $000's	$1.00	$0	$0	$0	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,500	$1,500	$1,500	$0	$0	$0
milling cost per tonne/cost $000's	$6.00	$0	$3,000	$3,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$9,000	$9,000	$9,000	$0	$0	$0
tails placement cost per tonne/cost $000's	$1.00	$0	$500	$500	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,500	$1,500	$1,500	$0	$0	$0
feed grade %Sn		0.50%	0.50%	0.50%	0.45%	0.45%	0.45%	0.45%	0.45%	0.45%	0.45%	0.45%	0.45%	0.45%	0.45%	0.45%	0.45%
concentrate grade %Sn	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Sn recovery %	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
concentrate produced tonnes		0	8,333	8,333	15,000	15,000	15,000	15,000	15,000	15,000	15,000	22,500	22,500	22,500	0	0	0
Pelletising cost per tonne/ cost $000's	$5.00	$0	$42	$42	$75	$75	$75	$75	$75	$75	$75	$113	$113	$113	$0	$0	$0
Transport cost per tonne/ cost $000's	$3.00	$0	$25	$25	$45	$45	$45	$45	$45	$45	$45	$68	$68	$68	$0	$0	$0
Total costs $000's		$0	$3,567	$3,567	$8,120	$8,120	$8,120	$8,120	$8,120	$8,120	$8,120	$12,180	$12,180	$12,180	$0	$0	$0
cost per tonne concentrate		$0	$428	$428	$541	$541	$541	$541	$541	$541	$541	$541	$541	$541	$1,008	$1,008	$1,008
cost per tonne contained tin in conc		$0	$2,853	$2,853	$3,609	$3,609	$3,609	$3,609	$3,609	$3,609	$3,609	$3,609	$3,609	$3,609	$6,720	$6,720	$6,720
Smelter Operations																	
capital spent $000's		$15,000	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$0	$0	
Tin concentrates take precedence	⇒	⇒	minimum campaign tonnage of tin cons			15,000	⇒	tin cons smelting rate tph		10							
Opening stocks tin concentrate tonnes		0	0	8,333	1,667	1,667	1,667	1,667	1,667	1,667	1,667	1,667	9,167	1,667	9,167	0	0
tin concentrates produced tonnes		0	8,333	8,333	15,000	15,000	15,000	15,000	15,000	15,000	15,000	22,500	22,500	22,500	0	0	0
concentrates available for smelting tonnes		0	8,333	16,667	16,667	16,667	16,667	16,667	16,667	16,667	16,667	24,167	31,667	24,167	9,167	0	0
Tin fuming campaigns																	
tin concentrates consumed tonnes		0	0	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	30,000	15,000	9,167	0	0
smelter recovery	95%																
tin content of fume	65%																
tin fume produced tonnes		0	0	3288	3288	3288	3288	3288	3288	3288	3288	3288	6577	3288	2010	0	0
Slag campaigns		⇒	changeover number of days			28	⇒	slag smelting rate tph		15							
opening stock tonnes		450,000	450,000	338,310	257,688	177,066	96,444	15,822	0	0	0	0	0	0	0	0	0
slag operating days available		0	365	263	263	263	263	263	263	263	263	263	162	263	303	365	365
smelter availability during slag campaign %	85%																
smelter capacity for slag		0	111,690	80,622	80,622	80,622	80,622	80,622	80,622	80,622	80,622	80,622	49,554	80,622	92,704	111,690	111,690
slag smelted tonnes			111,690	80,622	80,622	80,622	80,622	15,822	0	0	0	0	0	0	0	0	0
slag composition	zinc	lead	ppm Ag														
	13.4%	1.7%	54														
smelter recovery	94%	95%	95%														
fume zinc content	65%																
tonnes fume		0	23,025	16,621	16,621	16,621	16,621	3,262	0	0	0	0	0	0	0	0	0
Smelter costs																	
operating hours per year		0	7,446	6,875	6,875	6,875	6,875	2,555	1,500	1,500	1,500	1,500	3,000	1,500	917	0	0
reline& overhaul hours per year		0	672	672	672	672	672	672	672	672	672	672	672	672	672	0	0
standby hours per year			642	1,213	1,213	1,213	1,213	5,533	6,588	6,588	6,588	6,588	5,088	6,588	7,171	0	0
coal rates kg per hour	standby hours	700	smelting hours	4,200													

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	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Financials																	
depreciation schedule $000's																	
value at start		$0	$16,200	$14,760	$16,974	$15,288	$13,602	$11,916	$10,230	$8,544	$6,858	$5,172	$3,386	$1,600	-$186	-$478	-$478
new capex		$18,000	$200	$4,100	$200	$200	$200	$200	$200	$200	$200	$100	$100	$100	$0	$0	$0
value for depreciation		$18,000	$16,400	$18,860	$17,174	$15,488	$13,802	$12,116	$10,430	$8,744	$7,058	$5,272	$3,486	$1,700	-$186	-$478	-$478
10 year straight line depr		$1,800	$1,640	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$292	$0	-$48
Renison costs		$0	$3,567	$3,567	$8,120	$8,120	$8,120	$8,120	$8,120	$8,120	$8,120	$12,180	$12,180	$12,180	$0	$0	$0
Smelter costs		$0	$9,233	$9,311	$9,311	$9,311	$9,311	$4,597	$3,992	$3,992	$3,992	$3,992	$5,424	$3,992	$2,810	$490	$0
NPI costs		$0	$548	$396	$396	$396	$396	$78	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Operating costs		$0	$13,348	$13,274	$17,827	$17,827	$17,827	$12,794	$12,112	$12,112	$12,112	$16,172	$17,604	$16,172	$2,810	$490	$0
Revenue from tin		$0	$0	$15,511	$15,511	$15,511	$15,511	$15,511	$15,511	$15,511	$15,511	$15,511	$31,021	$15,511	$9,479	$0	$0
Revenue from slag		$0	$22,155	$15,992	$15,992	$15,992	$15,992	$3,138	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total revenue		$0	$22,155	$31,503	$31,503	$31,503	$31,503	$18,649	$15,511	$15,511	$15,511	$15,511	$31,021	$15,511	$9,479	$0	$0
Operating profit		$0	$8,807	$18,229	$13,676	$13,676	$13,676	$5,855	$3,399	$3,399	$3,399	-$661	$13,417	-$661	$6,669	-$490	-$0
depreciation		$1,800	$1,640	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$1,886	$292	$0	-$48
profit before tax		-$1,800	$7,167	$16,343	$11,790	$11,790	$11,790	$3,969	$1,513	$1,513	$1,513	-$2,547	$11,531	-$2,547	$6,377	-$490	$48
tax rate ….tax	39%	-$702	$2,795	$6,374	$4,598	$4,598	$4,598	$1,548	$590	$590	$590	-$993	$4,497	-$993	$2,487	-$191	$19
cashflow from operations		$702	$6,012	$11,855	$9,078	$9,078	$9,078	$4,307	$2,809	$2,809	$2,809	$332	$8,920	$332	$4,182	-$299	-$19
capital expense		$18,000	$200	$4,100	$200	$200	$200	$200	$200	$200	$200	$100	$100	$100	$0	$0	$0
net cash		-$17,298	$5,812	$7,755	$8,878	$8,878	$8,878	$4,107	$2,609	$2,609	$2,609	$232	$8,820	$232	$4,182	-$299	-$19
NPV discount rate	10%	**$20,912**															
IRR		**38%**															

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	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
coal consumption tonnes per year		0	31,723	29,723	29,723	29,723	29,723	14,603	10,912	10,912	10,912	10,912	16,162	10,912	8,870	0	0
coal cost per tonne/ cost $000's	$70	$0	$2,221	$2,081	$2,081	$2,081	$2,081	$1,022	$764	$764	$764	$764	$1,131	$764	$621	$0	$0
Power draw online / standby / shutdown kW		2,500	1,000	200													
Power unit cost c/kWhr....cost $000's	$0.06	$0	$1,163	$1,112	$1,112	$1,112	$1,112	$723	$628	$628	$628	$628	$763	$628	$576	$0	$0
fuel oil cost per tonne / tonnes used	$650	0	500	500	500	500	500	400	300	300	300	300	300	300	300	100	0
liquid fuel cost $000's		*$0*	*$325*	*$325*	*$325*	*$325*	*$325*	*$260*	$195	$195	$195	$195	$195	$195	$195	$65	$0
smelter people cost / numbers	$65,000	0	35	35	35	35	35	15	15	15	15	15	15	15	10	5	
people costs $000's		$0	$2,275	$2,275	$2,275	$2,275	$2,275	$975	$975	$975	$975	$975	$975	$975	$650	$325	$0
relines $000's per year		$0	$375	$375	$375	$375	$375	$150	$150	$150	$150	$150	$150	$150	$0		
other maintenance per year $000's		$0	$250	$250	*$250*	*$250*	*$250*	*$100*	*$250*	*$250*	*$250*	*$250*	*$250*	*$250*	*$150*	$100	$0
SO2 stabilisation		$0	$558	$703	$703	$703	$703	$379	$300	$300	$300	$300	$600	$300	$183	$0	$0
product packaging cost/t .... Cost $000's	$20	$0	$461	$398	$398	$398	$398	$131	$66	$66	$66	$66	$132	$66	$40	$0	$0
Transport to Burnie/t... cost $000's	$30	$0	$691	$597	$597	$597	$597	$197	$99	$99	$99	$99	$197	$99	$60	$0	$0
other costs $000's			$250	$250	$250	$250	$250	$100	$100	$100	$100	$100	$100	$100	$50	$0	$0
State Govt royalty..cost $000's	3%	$0	$665	$945	$945	$945	$945	$559	$465	$465	$465	$465	$931	$465	$284	$0	$0
Smelter costs incl.royalty $000's		**$0**	**$9,233**	**$9,311**	**$9,311**	**$9,311**	**$9,311**	**$4,597**	**$3,992**	**$3,992**	**$3,992**	**$3,992**	**$5,424**	**$3,992**	**$2,810**	**$490**	**$0**
Calculate Renison NPI	average concentrate cost=		**$522**	average smelter cost on tin		**$242**	revenue per tonne conc less royalty			**$1,003**	net profit on tin before tax per tonne conc				**$239**		
Calculate Pasminco NPI	smelter cost on slag=		**$83**	revenue per tonne slag net of royalty=			**$181**				net profit on slag before tax per tonne conc				**$98**		
Renison NPI	0%	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pasminco NPI	5%	$0	$548	$396	$396	$396	$396	$78	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total costs		**$0**	**$13,348**	**$13,274**	**$17,827**	**$17,827**	**$17,827**	**$12,794**	**$12,112**	**$12,112**	**$12,112**	**$16,172**	**$17,604**	**$16,172**	**$2,810**	**$490**	**$0**

Product price calculation

Exchange rate US$/Au$ 0.60

per tonne bulk zinc fume		US$ prices	Zinc/tonne	Lead/tonne	Silver/Tr.Oz	Use This ▼
			$970	$480	$5.00	
Zinc	pay zinc value	$536	or deduct MTU's		$553	$536
Lead	pay lead value	$38	or deduct MTU's		$26	$26
Silver	deduct 4 Tr Oz from	8.5	pay 70% of	4.5	Troy Oz	$16
Total price						$577

per tonne bulk tin fume	US$ prices		
LME Sn	$5,200		
refinery realisation costs per tonne fume	$500		
transport cost per tonne fume to refinery	*$50*		
fume tin content	65%	**US$/t fume net**	**$2,830**

Revenue

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Slag fume tonnes produced	0	23,025	*16,621*	*16,621*	*16,621*	*16,621*	*3,262*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Australian price FOR	$962	$962	$962	$962	$962	$962	$962	$962	$962	$962	$962	$962	$962	$962	$962	$962
Revenue A$000's	$0	$22,155	$15,992	$15,992	$15,992	$15,992	$3,138	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tin fume tonnes produced	0	0	3,288	3,288	3,288	3,288	3,288	3,288	3,288	3,288	3,288	6,577	3,288	2,010	0	0
Australian price FOR	$4,717	$4,717	$4,717	$4,717	$4,717	$4,717	$4,717	$4,717	$4,717	$4,717	$4,717	$4,717	$4,717	$4,717	$4,717	$4,717
Revenue A$000's	$0	$0	$15,511	$15,511	$15,511	$15,511	$15,511	$15,511	$15,511	$15,511	$15,511	$31,021	$15,511	$9,479	$0	$0
Total revenue A$000's	**$0**	**$22,155**	**$31,503**	**$31,503**	**$31,503**	**$31,503**	**$18,649**	**$15,511**	**$15,511**	**$15,511**	**$15,511**	**$31,021**	**$15,511**	**$9,479**	**$0**	**$0**

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SECTION E

STAGE 2 PREFEASIBILITY STUDY

DEVELOPMENT PLAN AND BUDGET

Stage 2 Prefeasibility Study Development Plan and Budget

Work on Stage 1 of TASMELT has cost in excess of $500,000. Pyrosmelt and Encore have funded this.

Encore funding has been provided by its principals and includes the first option payment of $50,000 on the Zeehan Slag Dumps to Dragon Mining NL and $150,000 on development work leading to the preparation of the Stage 1 scoping report and the proposal for Stage 2.

Stage 2 – Prefeasibility

Stage 2 of TASMELT is the phased advance of the project over 6 months through to the commencement of a feasibility study. The cost will be approximately $400,000.

With extensive work having already been undertaken of the Zeehan slags most work and expense will relate to development work on the Renison Bell tailings.

Stage 2 will comprise:

• Process optimisation and updating of Zeehan slags smelter costs	$ 50,000
• Prefeasibility evaluation of Renison Bell tin tailings	
• Confirmatory testwork, process development and costing (+/-20%)	$100,000
• Smelter modelling, confirmatory testwork and costing (+/-20%)	$ 25,000
• Campaign optimisation and financial modelling	$ 25,000
• Preliminary plant design – concentrator and smelter	$ 50,000
• Product marketing	$ 20,000
• Environmental Scoping Study	$ 20,000
• Technology Licensing	$ 10,000
• Preliminary evaluation of additional feeds	$ 10,000
• Dragon Mining NL Option Payment	$ 50,000
• Project management and administration	$ 40,000
Total	**$400,000**

Appendix One

Zeehan Dump Block Model

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Resource Service Group PTY. LTD. Inc. in W.A.

MEMORANDUM

TO : STEVEN STONE - JOINT MANAGING DIRECTOR
DRAGON MINING LTD

FROM : JULIAN BARNES

DATE : 14 DECEMBER 1990

SUBJECT : ZEEHAN DUMPS BLOCK MODELLING

Block modelling has been undertaken on both the north and south dumps at Zeehan. Table 1 displays the modelling parameters used.

Variography was carried out on both dumps using uncomposited data. Variography was principally undertaken on the zinc assay data and was used to determine ranges. Statistical analysis (summarised in Table 2) has indicated that cutting of higher grades does not appear to be warranted (namely the close similarity between the arithmetic mean and Sichels T). No compositing of the data was carried out prior to block modelling.

An inverse distance squared weighting algorithm has been used rather than kriging due to time limitations. Given the smooth distribution of all three elements, it is believed that the inverse distance squared estimate will give a good approximation of the grade distribution within the dumps.

Table 3 displays a comparison between the digital terrain modelled volume with mean grade data from the raw data set compared to the block modelling volumes and grades. A density of 3 tonnes per cubic metre has been used to calculate the tonnages. As is evident, the block sizes used (10 metres northing, 10 metres easting and 2 metres RL for the south dump, and 5 metres northing, 5 metres easting and 2 metres RL for the north dump) have enabled close approximations to the DTM volumes.

Table 4 displays the grade tonnage breakdown for the north and south dumps using zinc percentage as the category element.

An antipathetic relationship between lead and zinc is evident in the south dump (and to a lesser extent in the north dump).

The block modelling exercise is believed to have produced a good estimation of the tonnage and grade within the Zeehan dumps, however, the brief study has a number of limitations which should be rectified for a full feasibility analysis:-

(i) The granular and platey slags in the south dump have not been modelled separately.

(ii) Variography was not carried out extensively on lead and silver, and hence the precise ranges of influence for these two elements are not known in detail.

(iii) The ranges determined for zinc have been used to model all three elements.

(iv) Kriging has not been carried out to date.

(v) Sub-blocking has not been used (and would allow greater accuracy in volume determination, although the technique cannot be used in kriging).

(vi) Density data has not been modelled and density has been assigned using a conservative factor of 3 g/t.

(vii) The effect of compositing has not been determined.

(viii) Block value plots have not been produced yet (although they can be created quickly).

Notwithstanding these limitations, it is believed that the fourteen level plans included with this memorandum will allow Dragon Mining Ltd to build a greater understanding of the grade distribution within the Zeehan dumps. It is evident that the dumps have high grade zones of which exploitation would clearly benefit early cash flow.

If you require it, I can compile all work carried out to date into a formal report.

Please do not hesitate to contact me if you have any queries.

With best regards,

Julian

Julian

TABLE 1

ZEEHAN DUMPS
BLOCK MODELLING PARAMETERS

	SOUTH DUMP	NORTH DUMP
Easting Origin	362705	362780
Northing Origin	358080	358280
RL Origin	153	165
Easting Block Size	10	5
Easting Blocks	18	25
Northing Block Size	10	5
Northing Blocks	18	25
RL Block Size	2	2
RL Blocks	10	5
East Search Radius	50	30
North Search Radius	50	30
RL Search Radius	5	2
Horizontal Skew	Ø	Ø
Vertical Dip	Ø	Ø
Inverse Power	2	2
Calculate No. of Points	Yes	Yes
Calculate Standard Deviation	Yes	Yes
Constrained by DTM Volume	Yes	Yes

ZEEHAN STATISTICAL SUMMARY TABLE 2
WHOLE DATA SET

Dump	Element	No. Of Samples	Min	Max	Mean	95% Confidence Limits	Standard Deviation	Variance	Coefficient of Variation	Geometric Mean	LNSD	LNVAR	Sichels t
Sth Dump	Pb	324	0.00	4.50	1.63	0.09	0.7854	0.6168	0.48	1.66	0.3257	0.1061	1.75
Sth Dump	Zn	324	0.00	29.50	12.68	0.50	4.5952	21.1159	0.36	13.35	0.2429	0.0590	13.75
Sth Dump	Ag	324	0.00	109	49	2.00	20.7100	429.0500	0.42	51	0.3000	0.0900	53
Nth Dump	Pb	84	0.00	3.54	1.64	0.15	0.6716	0.4511	0.41	1.80	0.1965	0.0386	1.84
Nth Dump	Zn	84	0.00	17.04	9.82	0.89	4.0796	16.6428	0.42	10.75	0.2173	0.0472	10.97
Nth Dump	Ag	84	0.00	100	55	5.00	22.4100	502.3000	0.41	61	0.2000	0.0400	61

ZEEHAN STATISTICAL SUMMARY
MINERALISED INTERVAL SAMPLES ONLY

Dump	Element	No. Of Samples	Min	Max	Mean	95% Confidence Limits	Standard Deviation	Variance	Coefficient of Variation	Geometric Mean	LNSD	LNVAR	Sichels t
Nth Dump	Pb	75	1.00	3.54	1.84	0.09	0.3739	0.1398	0.20	1.80	0.1965	0.0386	1.84
Nth Dump	Zn	75	6.23	17.04	11.00	0.54	2.3499	5.5220	0.21	10.75	0.2173	0.0472	10.97
Nth Dump	Ag	75	35	100	62	3	12.23	149.55	0.20	61	0.20	0.04	62
Sth Dump	Pb	300	0.51	4.50	1.76	0.07	0.6600	0.4356	0.25	1.66	0.3257	0.1061	1.75
Sth Dump	Zn	300	1.75	29.50	13.70	0.34	2.9775	8.8658	0.22	13.35	0.2429	0.0590	13.75
Sth Dump	Ag	300	17	109	53	2	15.86	251.45	0.30	51	0.30	0.09	53
Sth Dump	Pb	280	0.51	4.20	1.70	0.70	0.6028	0.3634	0.35	1.62	0.3067	0.0941	1.70
Platey Slag	Zn	280	1.75	29.50	13.89	0.35	2.9556	8.7356	0.21	13.54	0.2404	0.0578	13.95
	Ag	280	17	109	53	2	15.70	246.49	0.30	51	0.29	0.08	53
Sth Dump	Pb	20	1.30	4.50	2.56	0.42	0.8942	0.7996	0.35	2.41	0.3650	0.1332	2.55
Granular	Zn	20	7.10	14.00	11.08	0.87	1.8693	3.4943	0.17	10.91	0.1836	0.0337	11.13
Slag	Ag	20	17	84	53	9	18.37	337.62	0.35	50	0.40	0.16	54

Note: All populations approximate lognormal distribution.
Statistics calculated on uncomposited and uncut data

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TABLE 3

ZEEHAN DUMPS
GRADE AND TONNAGE COMPARISONS

Dump	DTM/Section Volume	Density	Tonnes	Stats Grades			Block Model Volume	Density	Tonnes	Block Model Grades		
				Zn%	Pb%	Ag (ppm)				Zn%	Pb%	Ag (ppm)
South Dump	125333	3.0	375999	13.70	1.76	53	123200	3	369600	13.92	1.69	52
North Dump	26381	3.0	79143	11.00	1.84	62	27050	3	81150	10.83	1.85	62

TABLE 4

ZEEHAN DUMPS
GRADE TONNAGE DATA

SOUTH DUMP

From	To	Volume	Tonnes	Zn	Pb	Ag	Cum. Vol	Cum. Tonnes	Zn	Pb	Ag
10	11	1800	5400	10.60	1.91	47	1800	5400	10.60	1.91	47
11	12	10400	31200	11.66	2.08	57	12200	36600	11.50	2.06	55
12	14	49400	148200	12.98	1.86	56	61600	184800	12.68	1.90	52
14	16	56400	169200	14.98	1.49	48	118000	354000	13.78	1.70	52
16	18	4400	13200	16.56	1.39	50	122400	367200	13.88	1.69	52
>18		800	2400	20.17	1.44	45	123200	369600	13.92	1.69	52

NORTH DUMP

From	To	Volume	Tonnes	Zn	Pb	Ag	Cum. Vol	Cum. Tonnes	Zn	Pb	Ag
0	10	7100	21300	9.33	1.86	59	7100	21300	9.33	1.86	59
10	11	8000	24000	10.54	1.88	65	15100	45300	9.97	1.87	62
11	12	7850	23550	11.46	1.88	64	22950	68850	10.48	1.88	63
12	14	3850	11550	12.73	1.72	55	26800	80400	10.80	1.85	62
14	16	250	750	14.24	1.69	50	27050	81150	10.83	1.85	62

Note: Zn% used as Grade Tonnage category control. Block modelled by inverse distance squared.

Appendix Two

Preliminary Information for the Office of Environment

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BHP Engineering

ZEEHAN RETREATMENT PROJECT

PRELIMINARY INFORMATION

FOR THE

OFFICE OF ENVIRONMENT

Ref: PS:VH:E200/391
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CONTENTS

1.0 INTRODUCTION

To assist the Office of Environment in fulfilling its obligations in setting guidelines for the preparation of a Development Proposal and Environmental Management Plan (DPEMP), BHP Engineering has prepared the following information, on behalf of Pyrosmelt NL.

The information is, of necessity, preliminary as the project has not yet advanced beyond the prefeasibility stage. However it is recognised by Pyrosmelt NL that the environmental aspects need to be examined as part of the prefeasibility study to provide the necessary input to the plant design, layout and operating parameters.

Data presented is the best available to the project at this stage and is not expected to change significantly for the final plant though it will be refined during the detailed design phases of the project. Layouts shown in the sketch maps are indicative only and are not based on detailed engineering data so may need to be altered. However given the nature of the equipment the limiting factors in the layout of the site are access to the existing slag dumps, suitable areas for stockpiling of raw materials and new waste dump locations.

The information and interpretations presented in this report are based on data gathered from a variety of sources including:

Pyrosmelt NL
Dragon Resources
Ausmelt Pty Ltd
BHP Engineering Pty Ltd
Zeehan Municipal Council
HEC (& RWSC)
School of Mines Museum (Zeehan)
Pasminco Limited - Roseberry
Mt Lyell Mining Company - Queenstown
Bureau of Meteorology
Site Visits

This information is provided to enable the Office of Environment and associated Government agencies to base the requirements for a DP & EMP on the latest information available to the proponents.

2.0 PROJECT DESCRIPTION

2.1 BACKGROUND

Pyrosmelt NL intends to reprocess the waste slag dumps at the 'Zeehan Smelter Site' which accumulated over three distinct operating periods during the period 1898 to 1946. Most of the slag was probably produced during the period 1898 to 1914 with lesser quantities during the second period of operations from 1924 to 1930 during which it appears that roasting was the main activity followed by flotation.

The process proposed to recover the zinc and lead is 'Sirosmelt' which is a small scale submerged combustion process originally developed by the CSIRO and now marketed by Ausmelt Pty Ltd and MIM Limited. Various plants have operated over the past ten or so years on materials ranging from tin, lead, zinc and copper concentrates to residual slags from traditional smelting processes. Plants are currently operated at:

- Mt Isa (3 plants)
- Port Pirie, SA
- Newcastle, NSW
- Arhnem, Netherlands

The scale of these plants range from a few tonne per hour to 24 tonne per hour. A plant was also operated in Sydney processing tin ores in the late 70's until poor economics forced its closure. Commercial plants have operated since 1978 and a number of plants are planned or being constructed worldwide.

The smelter site is covered by a mining lease held by Pasminco Mining who have entered into the appropriate agreements with Dragon Resources to allow Dragon Resources Limited and Pyrosmelt NL access to the slag dumps.

2.2 PROCESS TECHNOLOGY

The Sirosmelt process is a submerged combustion process where air and fuel are injected below the surface of a liquid slag via a hollow lance. Combustion of the fuel within the slag provides both the heat to melt more slag and the heat required for the reduction reactions. Cold feed and reductant (coal) are added in lump form through a feed port in the top of the furnace with the lump material rapidly consumed in the slag bath due to the intense stirring of the bath by the injected air.

The zinc oxide together with the oxides of lead and other minor elements are reduced and volatilised. The intense stirring and flushing action of the process gas removes the reduced metals from the bath. Above the bath the metals are rapidly reoxidised by supplementary air entry through the top of the lance. The oxidised fume produced is then collected in a baghouse.

Zinc in its metallic form has a boiling point of 907°C. The operating temperature for melting the slag is 1200°C and this provides the mechanism for the fuming of zinc metal. The zinc oxide in the slag has first to be reduced before fuming and this is achieved by the addition of coal to the molten slag bath. Reduction of zinc is thought to occur by a number of mechanisms, the most important being:

$$ZnO + C - Zn + CO$$

The vaporised zinc metal is oxidised with air above the bath and the resultant fume is collected by a baghouse after the gas cooler. The fume is then bagged, ready for sale to the market.

The plant can be run in either batch mode or continuously, however a decision has not yet been made as to the mode of operation for this project. There are no significant differences in emissions or plant design between the continuous and batch modes. The final selection is more dependent on parameters such as ease of winning the slag and arrangements for plant operators, however it is expected that the plant will run 24 hours a day, seven days a week.

2.3 PROCESS STEPS

To describe the individual steps in converting the waste slag to zinc oxide it is easier to consider the batch method. There are six steps in the process:

- slag smelting
- slag reduction
- after burning
- gas handling
- slag handling
- furnace standby

2.3.1 Slag Smelting

At the beginning of each cycle a bed of molten slag is present from the previous batch which helps maintain the necessary temperatures in the furnace. Fine coal is fed through the lance with air to provide the energy source and lump slag is added and melted together with lump coal which acts as the reductant.

This step removes most of the zinc from the slag typically reducing the zinc content below 5% and typically takes 4 to 5 hours at the scale of operation considered here.

3.0 INFRASTRUCTURE REQUIREMENTS

3.1 RAW MATERIALS SUPPLY

Coal and slag are the two major raw materials required for the process. The slag is obviously available on site whilst the coal is expected to be obtained from the east Tasmanian coal field.

Slag will be won by front end loader or a large backhoe. A dozer may also be required. Due to a comparatively small scale of operation the equipment required will be smaller than that normally associated with mining type procedures. It is unclear what pretreatment (crushing, screening) will be required to prepare the slag for feeding to the furnace.

Coal will be stockpiled on site to the extent required to ensure the furnace is kept supplied. A nominal one week stockpile of 1500 tonne is envisaged. Some treatment of the coal will be required to produce the fine and lump coal fractions. Sizing and pulverising equipment will be required for this process. All runoff from the stockpile area will be directed to the site water dam and used in the process to lessen the requirement for make up water. Dust control will be exercised through normal handling practices and also by keeping the coal damp if stored for extended periods.

3.2 Water Supply

Water is required for three principle functions in the plant being:

- gas cooling
- furnace cooling
- slag granulation

An additional quantity is also required for general housekeeping and dust control around the site.

There is expected to be a net loss of water in the order of 55 m^3/hr or 1320 m^3/day with the major consumption being for gas cooling. There will be a recirculating water load for slag granulation and furnace cooling which will pass though a cooling water pond to settle out solids. Runoff from the site will also be directed to this pond to reduce make up requirements from other sources. Should there be an excess of water it will overflow the settling pond and be directed to the natural drainage systems.

The required water is expected to be obtained from either Austral Creek which passes just below the site or from the Little Henty River which is 1 km to the east. Austral Creek was the water source for the original smelters which used three steam driven pumps to lift the water to head tanks above the smelter complex. Initial calculations based on catchment area, rainfall and runoff estimates indicate that the required quantity of water can be supplied from either stream.

Abstraction of water will require the permission of the Rivers and Water Supply Commission. The discussions with the RWSC to date have been to determine whether streamflow data exists for the Little Henty and Austral Creeks.

3.3 Power Requirements

A plant of the size anticipated will require approximately 2 MW with the primary use being the fan, air compressors, crushing and screening plant and the various pumps. No power is available at the site, the closest connection point being Zeehan.

3.4 Air Supply

One of the key aspects of the process is the injection of air to combust the coal and provide the intense agitation required. The air requirements are met by compressors located near the furnace which supply both high pressure air (250 kPa) for the lance and low pressure (20 kPa) for the after burner. It is expected that a number of smaller compressors will be used rather than one large unit for reliability.

3.5 Workforce

The anticipated workforce is in the range of 15 to 25 but cannot be determined more definitely at this stage. Most of the workforce is expected to reside in Zeehan.

3.6 Transport

Transport options for coal supply and product shipment have not been investigated in any detail as yet. However adequate transportation infrastructure is apparently available according to discussions with Zeehan contacts.

4.0 ENVIRONMENTAL FACTORS

4.1 EXISTING SITE

This site has seen intermittent use as a mineral processing site since the late 1890's. First as a roaster and blast furnace and later as a roaster and concentrator. During the construction and operation of the site extensive changes occurred to the surrounding environment as a result of physical disturbance during building, the extraction of limerock, disposal of waste solids and the emissions from the roasters. Natural revegetation of the site has been slow, due in part to the coarse nature of the weathered siltstone and sandstones on the hills.

The vegetation bordering Austral Creek is considerably more diverse than that on the hillsides with a variety of tall shrubs and trees including Eucalypts, Banksias and Acacias. Also present are blackberry and other introduced species. The project is not expected to infringe on this area except as may be required to install pumping equipment. The tailings encroach on to this area and appear to be slowly smothering vegetation as the tailings are eroded.

The existing physical and biological environment of the site has been degraded and the site is basically unstable and would require time and effort to stabilise the site. This project can provide some measure of improvement through the appropriate layout and operation of the plant which will remove potential long term pollution sources. The new slag will have lower metal levels, be effectively inert and a potentially useful product in its own right.

Factors which have the potential to impact the environment are discussed below. It is the proponents view that each of these can be managed to provide adequate protection of the environment. It is also important to recognise that the project life is about 3 to 4 years at which time the plant is expected to be relocated.

4.2 EMISSIONS – WATER

Under normal operating conditions no water will leave the site as there is a net water loss due to cooling requirements. Site runoff will be directed to the cooling water pond which also acts as a sediment trap. During heavy rainfall events, especially when the plant is not operating, the cooling pond will overflow to the creek. As the process adds no metals to the water and the runoff would otherwise report to the creek in an uncontrolled manner, this arrangement is likely to improve water management on the site from the existing uncontrolled drainage.

Drainage from the new slag dumps is not expected to contain metals above the background as the slag is virtually inert. Similar Sirosmelt product from zinc slag has passed both the US EPA and Dutch leaching tests. The existing slag does not appear to be leaching to an appreciable extent with no evidence of vegetation damage immediately downtoe of the dumps. Some gypsum crystal growth is evident in the southern dump which may be due to the presence of other material (tailings, untreated ore) in the dump. Subsurface samples have been collected from beneath slag and these will provide additional data on contamination from leaching of the slag.

4.3 EMISSIONS – SOLIDS

The major solid waste will be the new slag which is a glass like siliceous material that is highly resistant to degradation making it a good material for sand blasting, road fill and similar construction purposes. The new slag dump could be placed so as to facilitate access to the material by potential consumers with ready access from the main road.

Alternatively the dumps can be located and managed for an end goal of a rehabilitated landform. The obvious locations for the new dumps are either immediately north or south of the existing dumps. In both cases the new dumps would be battered to a nominal three to one slope to facilitate rehabilitation. This activity would also soften the appearance of the site which has numerous high benches facing the main road.

Whilst the existing dumps have minimal vegetation this is apparently due to the lack of fine material to hold moisture and permit the development of root systems. In those locations where fine, granulated, slag has had eroded material washed over the surface, grasses have established voluntarily.

General solid wastes from the operation would best be disposed of in a controlled municipal waste dump. The Zeehan Municipal dump is approximately 1 km north of the smelter site and appears to take a wide variety of residential and light industrial wastes.

4.4 EMISSIONS – NOISE

The smelter itself is not expected to be a significant source of noise with the fan and compressors being the major sources together with the lance when it is just removed from the bath. However these factors have been effectively controlled by appropriate design as evidenced by the operating plants in Arhnem and the plant that used to operate in Sydney. General noise will also be emitted by the equipment used to recover the slag.

The nearest residence is approximately 1500 m from the site and shielded by two hills so should not be appreciably affected.

4.5 EMISSIONS – AIR

Emissions to the atmosphere from the process comprise the off gases from the furnace after passing through the baghouse. The main constituents will be N_2, O_2, CO_2, H_2O and SO_2 emitted in an air stream of 120,000 Nm^3/hr with an elevated temperature of approximately 150°C.

Emissions of sulphur dioxide are recognised to be of concern to the regulatory agencies and preliminary calculations have been prepared to show the likely ambient concentrations. The calculations are based on conservative data and use recognised formulae for the prediction of ground level concentrations and plume rise.

The ground level concentrations have been predicted for the nearest residence which is 1500 m north of the site. A range of atmospheric stability classes have been used following the approach of Turner (1969). Class A is the most unstable, Class D is neutral and Class F strongly stable. With the general climatic conditions of Zeehan the dominant class is expected to be neutral (Class D) with stable conditions also common (Classes E & F). The unstable conditions are expected to be infrequent probably occurring for less than 5% of the time.

The high frequency of neutral conditions (Class D) are the result of overcast and/or windy conditions. Unstable conditions are principally the result of thermally driven turbulence and these conditions are not expected to be common occurrences.

The results of the calculations are presented in Table 2 and show that for an emission rate of 40 g/s of SO_2, the concentrations are all below the annual average of 50 ug/m^3. The actual concentrations experienced at the residence would be considerably less due to the variability of the wind direction. The predicted concentrations approximate a 10 minute sampling period.

The sulphur dioxide emission rate depends on the amount of sulphur in the slag and coal and the retention rate in the new slag and product. Ausmelt have advised that they expect 70% of the sulphur to be retained. This is based on their extensive experience in testing of similar slags for treatment.

Due to the use of water for cooling the gas there will be a visible plume from the stack.

Minor constituents of the slag (As, Sb etc) are expected to report to the fume and will not present an environmental hazard.

5.0 HERITAGE VALUES

Three locations near the site have been nominated for the Register of the National Estate as items of geological importance. One of the locations is immediately south of the slag dumps and encroaches on the southern dump and includes most of the tailings. The nomination information indicates that the item of significance is the rock formation on the ridge running south of the old smelter where past activity has exposed geological stratigraphy of interest.

This issue is being addressed through the AHC however the proponents consider that the item of apparent interest is unlikely to be disturbed. Some of the area nominated would be disturbed in winning the slag but would not impact on the geological setting.

6.0 CONCLUSIONS

The information presented is the latest available to the proponents and is considered to be conservative in those areas where detailed data is unavailable. The proponents are committed to the responsible management of the site and recognise the need to incorporate environmental factors in the design of the project.

The proponents believe that the project will have a minimal and readily managed environmental impact which will be limited to the duration of the project. Some aspects of the project are expected to lead to a long term improvement in the environmental status of the site such as the removal of residual metal values from the slag and the granulated slag is expected to rehabilitate more successfully than the platey slag.

A prefeasibility study has recently been commissioned and will be prepared in conjunction with the DPEMP for the project to ensure environmental factors are incorporated in the design and layout of the plant.

Of the anticipated impacts, sulphur dioxide emissions in particular, have been evaluated in a preliminary manner and have been shown to be well within he appropriate standards. The proponents do not consider that modelling is required beyond the approach presented in this preliminary report.

TABLE 1

Key to Stability Classes for Calculations

Windspeed (m/s)	Day: Incoming Solar Radiation — Strong (1)	Moderate (2)	Slight (3)	Night: Cloud Cover — Mostly Overcast (4)	Mostly Clear
<2	A	A-B	B	E	F
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

After D.B.Turner. "Workbook of Atmospheric Dispersion Estimates." Washington, D.C. HEW, 1969.

(1) Clear skies, solar altitude greater than 60 degrees above the horizontal, typical of a sunny summer afternoon. Very convective atmosphere.
(2) Summer day with a few broken clouds.
(3) Typical of a sunny autumn afternoon, summer day with broken low clouds, or a summer day with clear skies and a solar altitude of 15 to 35 degrees above horizontal.
(4) Can also be used for a winter day.

TABLE 2

Typical Ground Level Sulphur Dioxide Concentrations for Stability Classes Listed in Table 1.

Windspeed (m/s)	Ground Level SO2 Concentration (g/m^3) SO2 emission rate 40 g/s				
1.5	22.6	0.8	0.8	0.0	0.1
2.5	14.0	14.0	0.1	0.0	2.3
4.0	29.5	4.9	4.9	0.0	0.0
5.5	15.9	0.0	0.0	0.0	0.0
6.5	22.6	0.1	0.1	0.1	0.1

Note: Where a range of stabilities is listed in Table 1, the class resulting in the higher concentration was used.

TABLE 3

Data for Calculation of Ground Level Concentrations

Emission Rate (g/s)	40
Distance to Receptor (m)	1500
Physical Stack Height (m)	50
Exhaust Temperature (C)	150
Ambient Temperature (C)	10
Stack Diameter (m)	1.75
Exit Velocity (m/s)	20
Gas Volume (Nm^3/s)	33

Standard Deviations for 1500m

Class	A	B	C	D	E	F
Sigma y	306	224	149	98	73	49
Sigma z	1065	171	88	42	29	19

TABLE 4

Wind Speed and Direction Summary - Zeehan (seven years of records)

	Calm	N	NE	E	SE	S	SW	W	NW
% Average of all observations	8	11	8	3	11	5	15	7	32

	Calm	0.3 to 1.4	1.7 2.8	3.1 5.6	5.8 8.3	8.6 11.1	11.4 13.9	14.2 +
% Average of all observations	8	18	30	25	9	5	3	1

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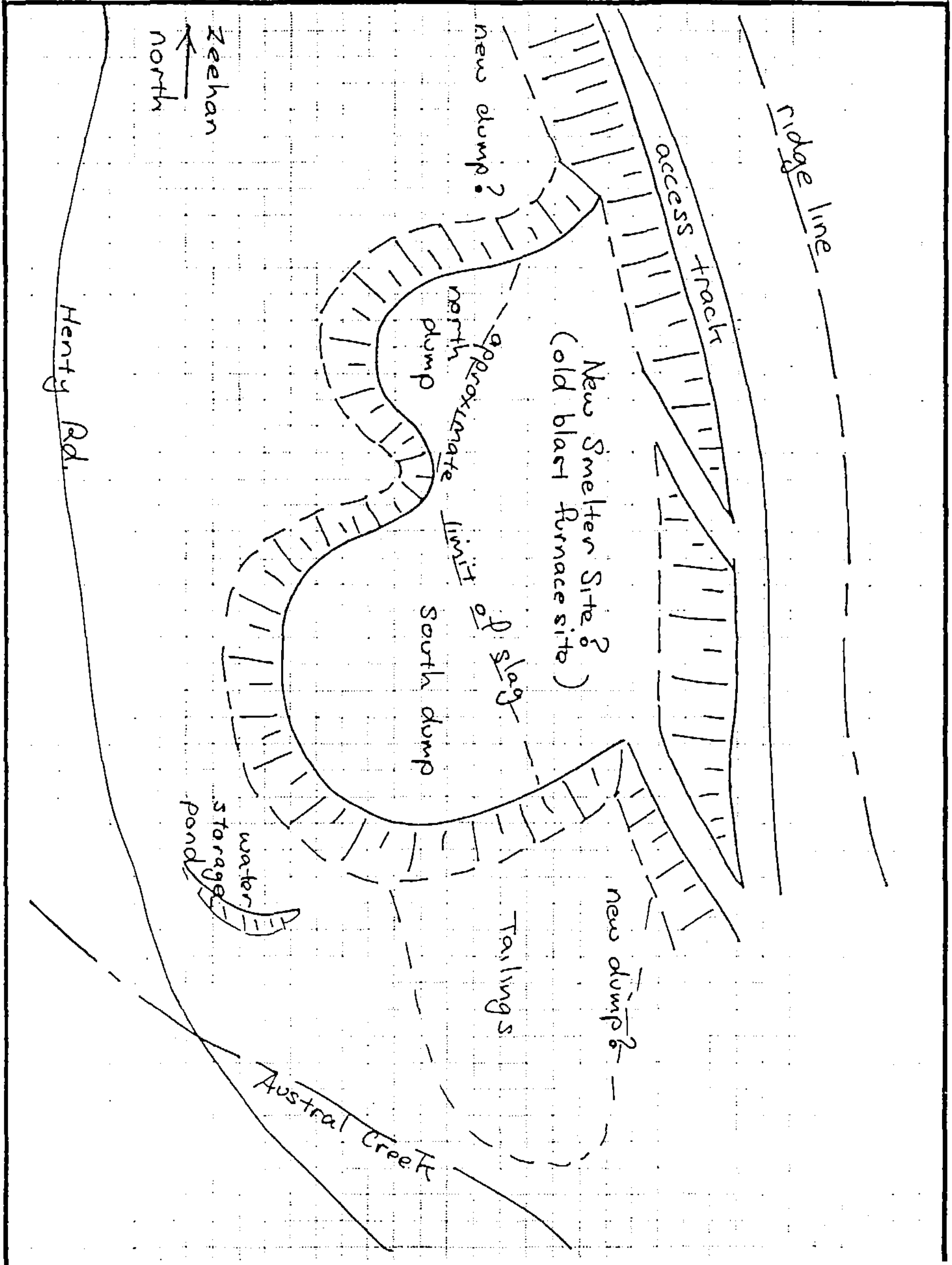
CALCULATION SHEET

PROJECT Zeehan Retreatment Project	SHEET No. 1	AMDT
PROJECT UNIT Sketch Map	DATE 2/10/90	
DEPARTMENT	AUTH JOB No.	PREPARED BY P.S.



Appendix Three

Ausmelt brochure

AUSMELT

A Cleaner, Less Expensive Way to Recover and Recycle Metal and Inorganic Wastes

Initially developed for processing metallurgical ores, Ausmelt Technology has been successfully applied to the recovery of copper, nickel, lead, zinc, tin, precious metals and iron. Ausmelt has now extended the technology to process wastes and residues including lead and zinc slags, EAF dust, mixed organic and heavy metal wastes, incinerator ash and aluminium spent potlining.

Many commercial applications are proving that the Ausmelt process is a cleaner, safer, less expensive way to recover and recycle metals and other organics from wastes.

Ausmelt Technology is in commercial use at Broken Hill Associated Smelters Australia (silver doré production), Rio Tinto Zimbabwe (nickel copper leach residue smelting), Korea Zinc (lead and zinc recovery from QSL slag and a separate electrolytic zinc residue treatment plant) and Bindura Nickel Corporation, Zimbabwe (copper leach residue processing).

Ausmelt is currently involved in the design, construction or commissioning of smelters for Hindustan Copper Limited, India (anode slimes processing), Metaleurop Weser Blei, Germany (lead concentrates and wastes smelting), Tsumeb Corporation, Namibia (primary and secondary lead materials smelting), Funsur, Peru (tin concentrates smelting and refining), Zhong Tiao Shan Nonferrous Metals Corp, China (copper concentrates smelting and converting) and Portland Aluminium, Australia (processing spent potlining from aluminium production). Plant throughputs range from 72 tpa (anode slimes processing) to 200,000 tpa (copper concentrates smelting).

A major factor in Metaleurop's decision to choose Ausmelt Technology for smelter modernisation was the technology's ability to meet strict German environmental standards.

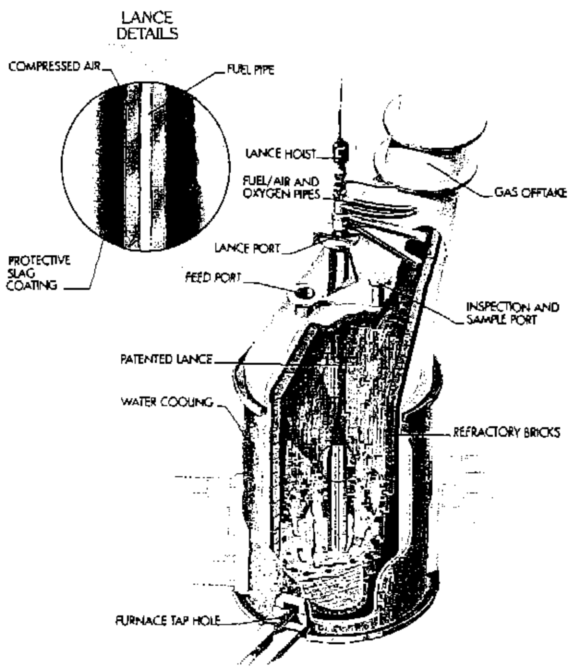
The Ausmelt furnace is a high-intensity bath reactor in which metals can be separated and recovered, leaving an inert slag that meets the most stringent environmental regulations. Recovered metals or compounds can be recycled or sold to mainstream production.

The Ausmelt furnace system is flexible and easy to operate and control. The system is compact and closed, virtually eliminating gas emissions. Dust carry-over from the feed is low, simplifying the design and operation of the gas cleaning system. Low capital and operating costs provide further advantages over other process routes.

Ausmelt provides the technology as a design and supply package or on a full project management basis. A variety of services are available from Ausmelt to develop and evaluate specific projects before plant construction, including laboratory testwork, pilot plant trials and feasibility studies. Pilot plant facilities are now available in Australia, USA and France.

Ausmelt is dedicated to developing applications for the technology throughout the world, and has been building plants for recovering metals and treating wastes for more than ten years.

CUTAWAY DIAGRAM OF AN AUSMELT FURNACE



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INCINERATOR ASH PROCESSING

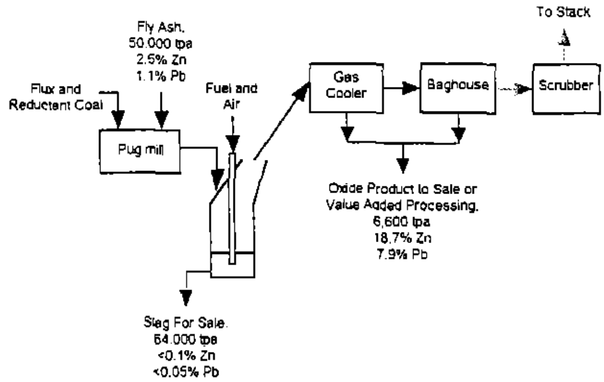
Toxic waste and municipal incinerator ash contain a range of materials including unburnt carbon, glass and metals. The levels of zinc, lead, cadmium and other heavy metals cause concern when disposing of the ash. In many cases ash is currently being sent to hazardous or monitored landfills, however in the future this may not be an option. A means of treating the toxic ash before disposal is therefore required.

Toxic waste incinerator ash treatment has been piloted in the Ausmelt pilot plant in Colorado, USA. The Ausmelt process for incinerator ash smelts the ash in a molten slag. The volatile metals in the ash will fume and are collected in the gas handling system as oxides for recycling and sale. The process uses the combustible organic components of the ash as part of the fuel requirement. Any residual metals will dissolve in the slag and will be fixed in the crystal structure when the slag solidifies. Slag can be granulated or cast into moulds for disposal or sale.

SPENT POTLINING

Spent potlining (SPL) is a hazardous waste produced by aluminium smelters. SPL contains carbon, refractory materials, fluoride, and cyanide from reactions in the pot. SPL can cause severe pollution by contaminating ground water or releasing toxic gases when wet. Many processes have been proposed in the past for treating SPL, but few have reached commercialisation, and none have been widely accepted.

Ausmelt Technology offers a low cost, simple and effective method of processing SPL, destroying the cyanide and separating the contained fluoride. The Ausmelt furnace relies on the slag bath for heat and mass transfer, and in a single step separates the fluoride, destroys the cyanide and produces a discardable slag. Slag produced in pilot plant trials has easily passed USA EPA Toxicity Characteristic Leaching Procedure (TCLP) tests for fluoride.



Incinerator Ash Treatment,
50,000 tpa capacity

EAF DUST PROCESSING

Reprocessing scrap steel in electric arc furnace (EAF) mini mills produces a dust by-product containing the volatile metals such as zinc, lead, cadmium and arsenic from the scrap steel. The high levels of heavy metals mean that the dusts are listed hazardous wastes in the USA and elsewhere, and disposal is restricted.

Ausmelt Technology offers an economic, environmentally sound method of recovering these metals from the EAF dusts, leaving an inert slag. The heavy metals are concentrated in an oxide fume. After further processing using conventional sodium carbonate washing technology to remove the halides, the fume can be recycled to a zinc producer for recovery of the metals.

Ausmelt Technology is a proven means of separating toxic metals from wastes. The technology is also able to accept materials containing organic components that are combusted. The levels of toxic metals in the final slag product will be low enough to pass leach tests such as the USA EPA TCLP test. Metals are recovered to a fume for recycle to mainstream metal production.

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INTRODUCTION

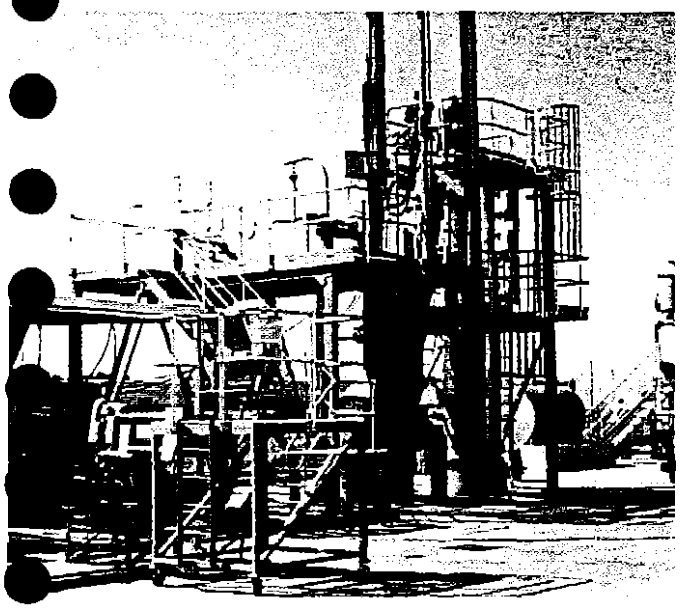
Ausmelt was founded in 1981 to commercialise Sirosmelt Technology, a revolutionary smelting method invented by Dr Floyd and developed over the previous ten years with the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO).

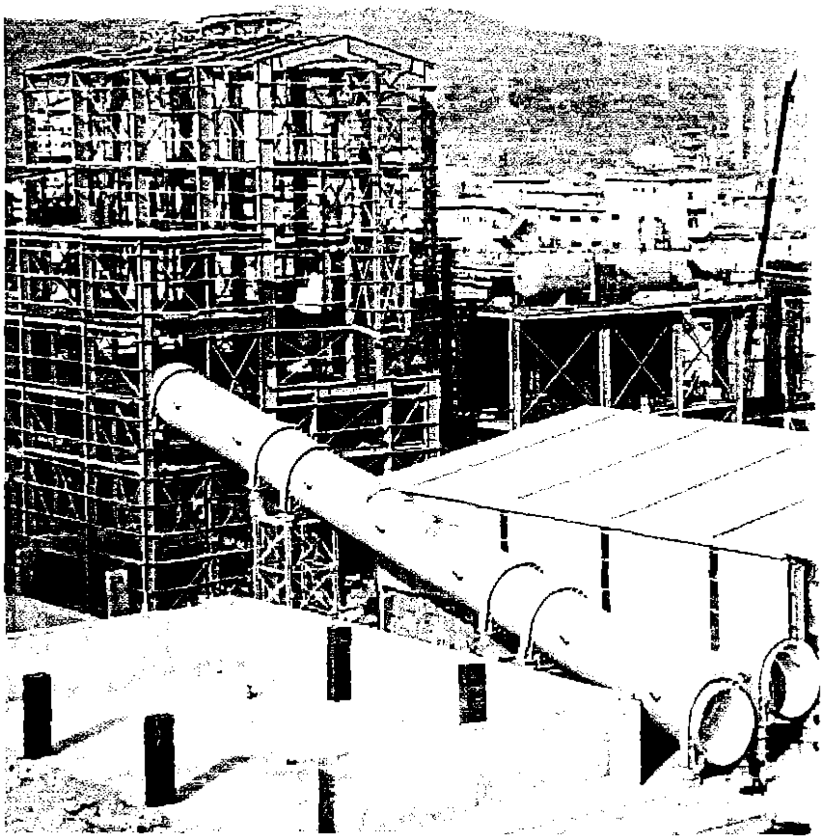
The technology offers industry a low cost, high intensity system for smelting base metal ores and concentrates and for winning valuable materials from waste or discarded materials.

Operating as an independent company under Dr Floyd, Ausmelt has made extensive improvements to the technology, extending its application widely into non-ferrous metal production processes. It is now known as Ausmelt Technology and the development of equipment and processes continues.

Ausmelt's experience with this technology is unique, having designed and supplied commercial plants for clients over a broad range of scales and processes. For example, the Korea Zinc Residue smelter processing 125,000 tonnes a year of zinc residues is the largest Ausmelt plant yet constructed while the Hindustan Copper Limited Precious Metals Plant treats less than 100 tonnes a year of very high value anode slimes.

Ausmelt's pyrometallurgical processing skills and knowledge have resulted in development of a great number of processes, the most recent of which is the AusIron pig iron process. A joint venture has been formed, including Ausmelt, to construct a prototype plant as the next step in the commercialisation of the AusIron process.





Ausmelt Technology is accepted around the world as offering high intensity reactions, processing flexibility and simplicity of design.

Ausmelt Technology offers many potential benefits over alternate technologies including improved overall and direct metal recovery, lower capital and operating costs, improved environmental performance and the flexibility to handle wide variations in feed type.

Ausmelt Technology is simple to operate, innovative and versatile, making it appropriate to use in modernising existing smelters. Ausmelt furnaces may be retro-fitted to existing plants to replace furnaces of older design, or added to increase plant production by treating process streams that might otherwise be discharged as waste, or by providing additional process capability not available using other systems.

Ausmelt furnaces can be designed to treat small quantities of materials, and may find application in isolated areas, treating material that would otherwise require transport to a central plant.

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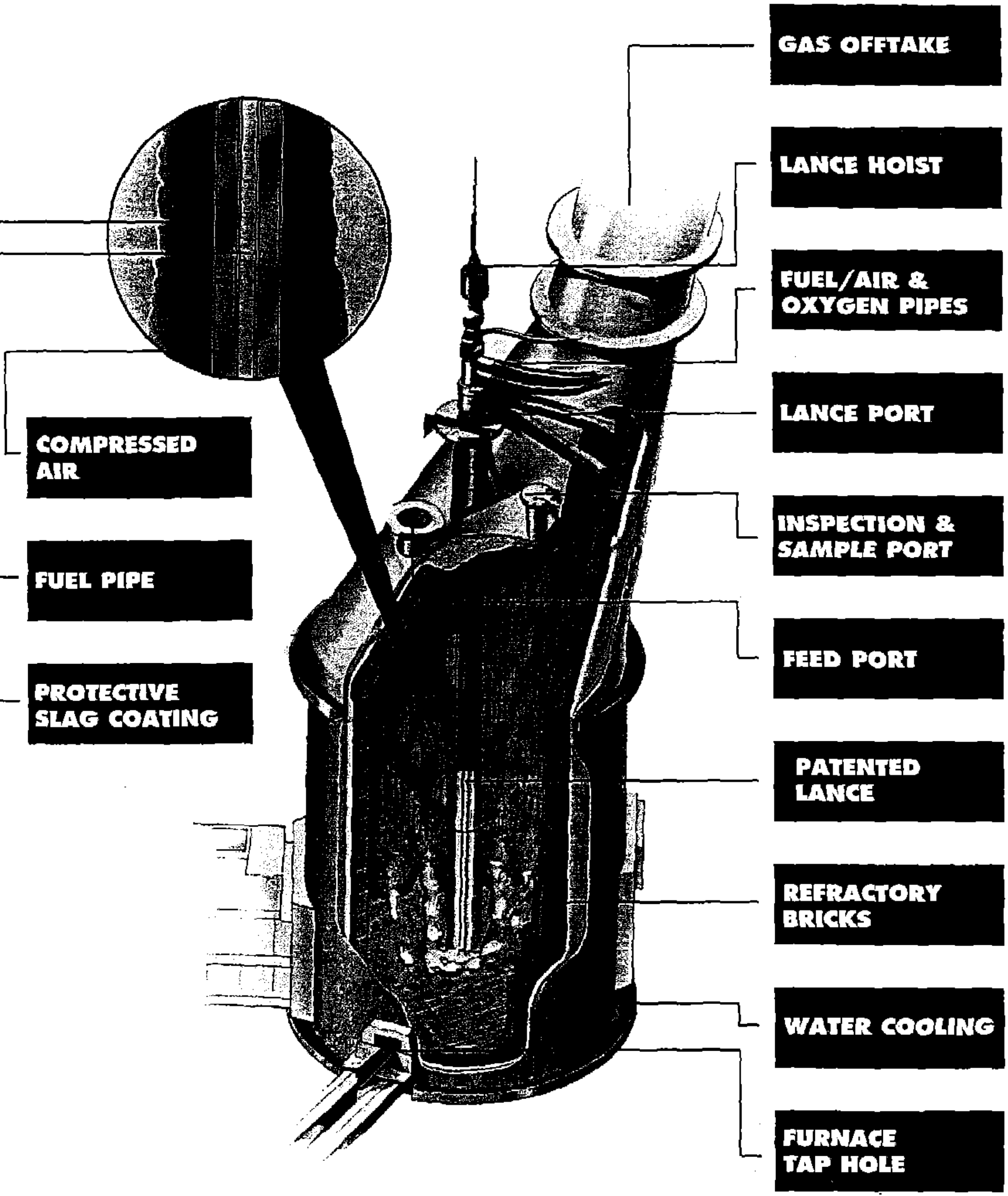
AUSMELT PROCESS



The Ausmelt furnace is a totally enclosed refractory lined vessel which uses a lance to inject fuel and air into the bath. The fuel combusts at the tip of the lance, thereby heating the furnace contents, while the injected gases cause vigorous agitation and rapid process reactions. Feed and fluxes are dropped into the furnace through a feed port in the roof and off gases are ducted from the top of the furnace.

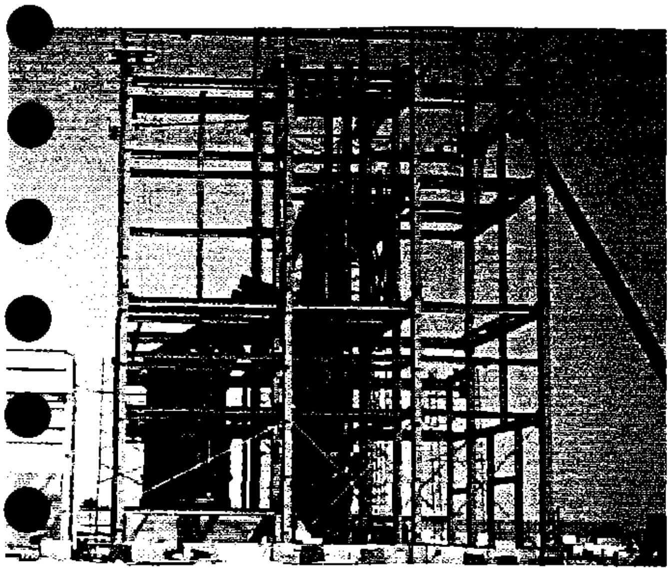
Because the reactions in the furnace are rapid, only a short residence time is required to process most materials. This means furnaces can be much smaller than more conventional designs, leading to specific operating and cost advantages.

Conditions in the furnace can be controlled precisely by adjusting feed, fuel and air flow rates.

PROJECT DEVELOPMENT SERVICES

Ausmelt's background in developing this technology provides the knowledge and experience to take a project from conception through to construction and commissioning of commercial smelters.

Ausmelt supplies a package incorporating the core plant required for any application. This includes supply of the furnace, lances, lance lifting system, and instrumentation and controls. Also included are process and basic design, supervision of installation of the core plant, supervision of detailed design and installation of associated feed, product and gas handling systems. Specific additional facilities may also be supplied for certain auxiliary equipment, such as coal preparation plant, gas cooler and baghouse systems. This approach ensures optimum application of the technology, integration of the total smelter equipment and maximum project continuity.



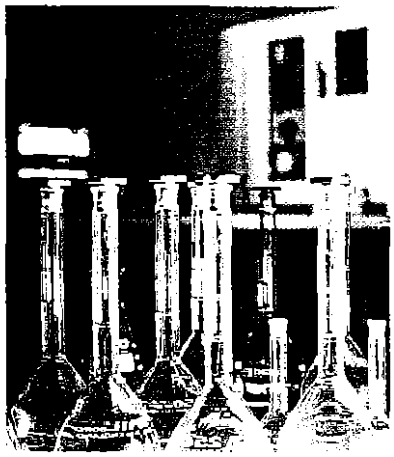
Ausmelt can also provide turn key plants or EPCM services for the complete plant.

Ausmelt Technology is provided to clients together with a Technology Licence. Where appropriate Ausmelt is prepared to take an ownership share in plants.

Where necessary in developing projects through to the construction stage Ausmelt offers services as follows.

PROCESS DESIGN

Resource assessment through process development and modelling, mass and energy balances and process flow diagram development..

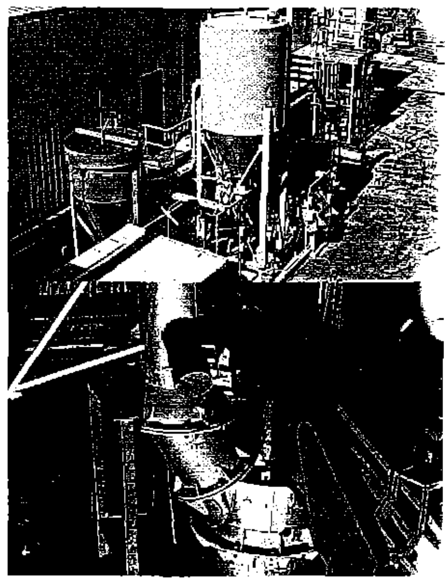


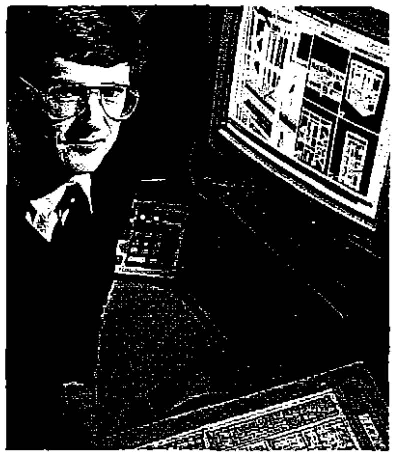
LABORATORY STUDIES

Smelting is simulated in laboratory tests to determine process conditions best suited to metal recovery from a client's material and to provide a basic flowsheet.

PILOT PLANT TESTWORK

Pilot plant facilities are available in Australia, the United States and France for development and demonstration trials. Data obtained in pilot plant testwork is used in smelter detailed design as well as studies aimed at obtaining regulatory approvals and project finance. Client staff are encouraged to attend the trials to improve familiarity with the technology and as preliminary training for the smelter's commissioning and operation.





FEASIBILITY STUDIES

Feasibility studies are tailored to suit client requirements. A preliminary feasibility study typically defines the metallurgical process, provides preliminary engineering and costing of capital and operating requirements.

A full feasibility study provides details of the metallurgical design, engineering design and specifies capital and operating costs to a 10% accuracy level.

AUSMELT TECHNOLOGY BENEFITS

Operational flexibility including batch or continuous operation provides economic operation at large and small scales

Multiple batch processes can be performed in one furnace

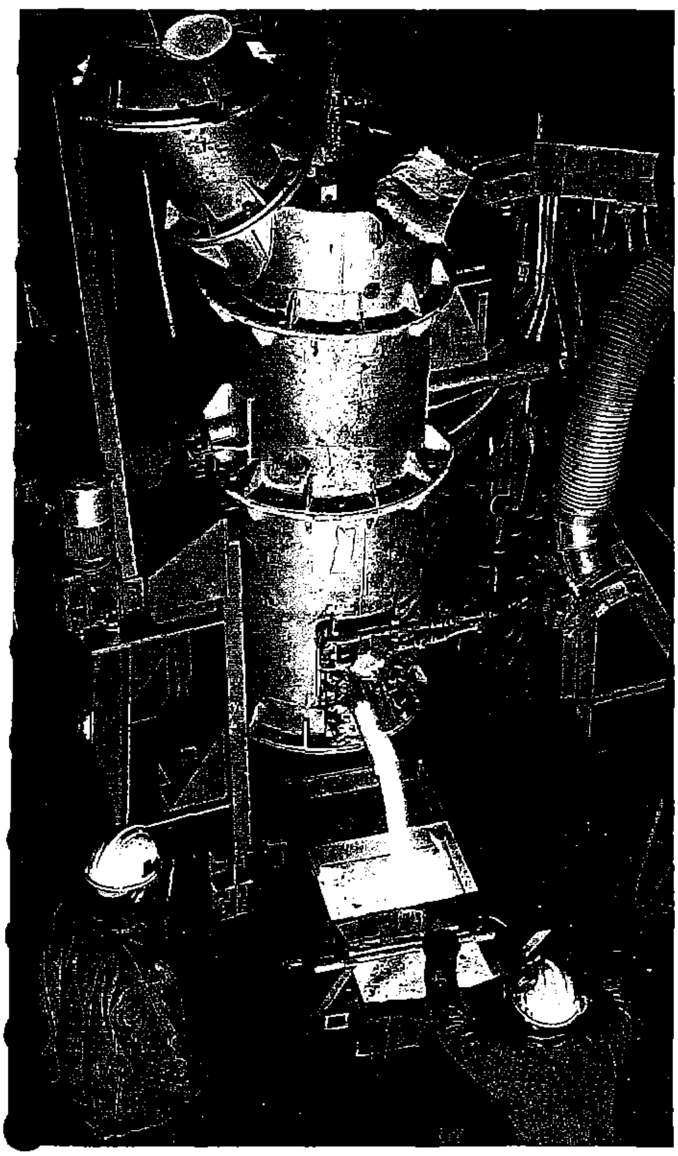
Well sealed furnace minimises fugitive emissions and improves environmental compliance

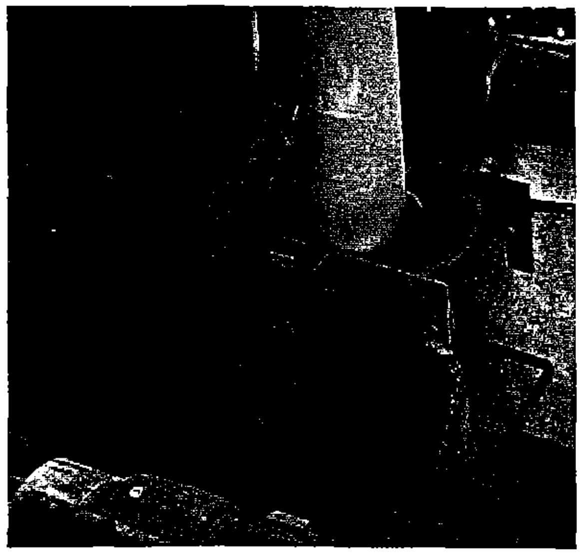
Coal, fuel oil or natural gas may be used as fuel for the furnace

High fuel efficiency

Low power, water, land and labour requirements

Low capital and operating costs





Effective removal of volatile metals to fume allows high purity metal products

Low dust carry over into the flue gases

Clean, environmentally compliant, discardable slags

High metal recovery to marketable products

Product quality can be controlled to meet market or downstream processing requirements

Flexible in accepting ranges and variations in feed composition and type

Minimal feed preparation is required as the system accepts variations from run-of-mine crushed ore to fine concentrates and powders.

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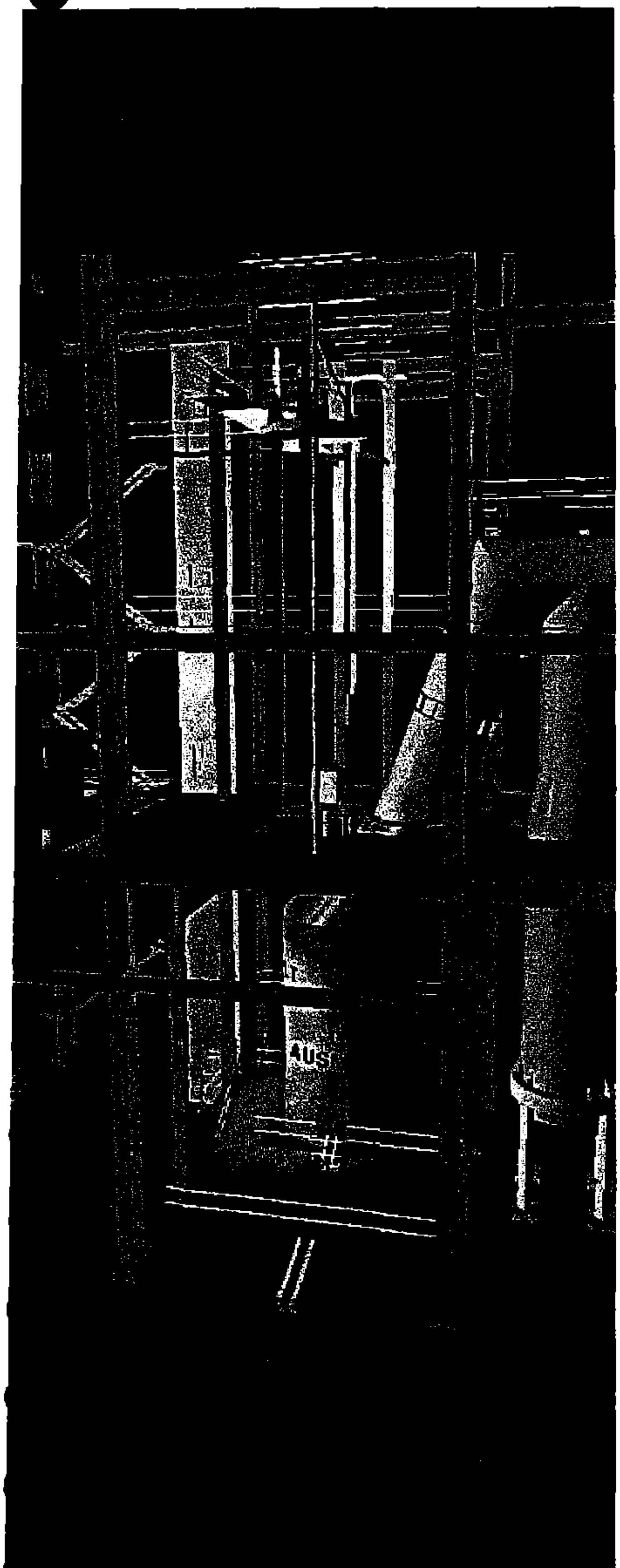

WASTE TREATMENT SOLUTIONS

As the world moves towards improving environmental standards and industrial practices, new processes are required to avoid the production of environmental problem materials, and deal effectively with existing problems.

Ausmelt Technology has made a major impact in this area.

Ausmelt Technology has been proven to be extremely effective for treating metallurgical wastes, separating toxic and potentially valuable components for recycling.

Wastes successfully processed using Ausmelt Tecnology in either pilot or commercial scale plants include;

- zinc/lead residues including jarosite and goethite,
- electric arc furnace dust,
- lead slags,
- flue dusts
- leach residues,
- SPL (spent potliner) from aluminium production, and
- toxic waste and municipal incinerator ash, and speiss and other metallurgical intermediates.

These and many other wastes can be processed using Ausmelt Technology, to produce environmentally acceptable products, often with significant economic returns from the recycle of valuable products.

The capacity of Ausmelt Technology to recover heavy metals to the gas phase, and precious metals to a metal phase while producing a benign glass or slag that can meet TCLP test requirements places Ausmelt Technology in the forefront of waste material recovery systems.

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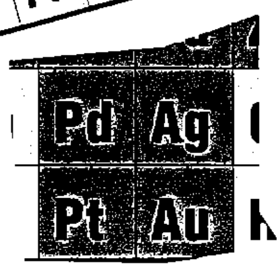
AUSMELT APPLICATION IN NON-FERROUS AND PRECIOUS METAL PROCESSING

LEAD
Lead concentrate smelting
Secondary lead smelting
Lead furnace slag processing
Processing copper dross from lead refining
Lead softener slag reduction
Recovery from lead residues and fumes
Lead retort bullion cupellation.

TIN
Tin concentrate smelting
Tin slag reduction
Sulphide fuming of refractory tin ore
Tin fume smelting
Tin oxide fuming

NICKEL
Nickel laterite smelting
Nickel concentrate smelting
Nickel recovery from slag
Nickel copper residue smelting
Nickel matte converting

ZINC
Zinc fuming from Imperial smelting Furnace slags
Recovery of zinc from leach residues
Zinc sulphide smelting and fuming
Recovery from Electric Arc Furnace dusts



WASTES
Spent potliner
Incinerator Ash
Chemical and
Industrial wastes

COPPER
Copper concentrate smelting
Copper matte converting
Copper/gold ore smelting
Copper recovery from slag
Copper anode furnace slag reduction
Copper scrap smelting

IRON
Ausmelt has successfully produced good quality pig iron from a range of iron ore and various qualities of coal. Specific process advantages include use of medium grade iron ore and coal, not metallurgical coke, for processing.
Converter, Blast Furnace and Electric Furnace dusts can also be processed to produce valuable by products.

PLATINUM GROUP AND PRECIOUS METALS
Silver retort cupellation
Anode slimes processing
Leach residue processing
Precious metals concentrate smelting
Refractory gold concentrates
Recovery from complex intermediates

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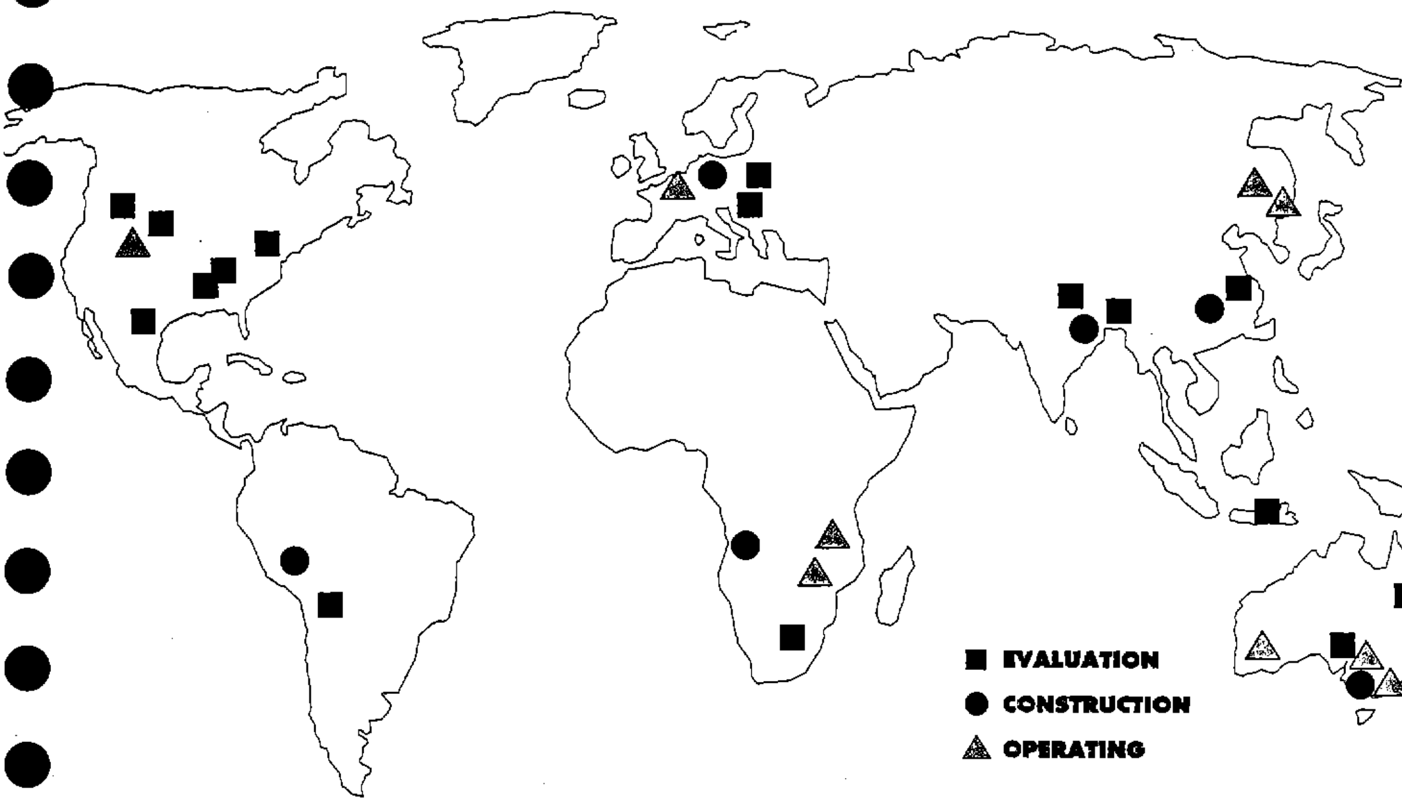
GLOBAL ACTIVITIES



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MAJOR PROCESS AND EQUIPMENT DEVELOPMENTS BY AUSMELT

1.	Furnace design and construction methods including, lance handling facilities, material transfer systems for feed to the furnace, tapping facilities and arrangements as well as control systems and sensors.
2.	Improvements and modifications in refractory and furnace shell design.
3.	Liquid material transfer between furnaces by simple weir system.
4.	Smelting copper concentrates and ores.
5.	Batch and continuous converting of copper and nickel matte.
6.	Stibnite smelting and fuming for gold and antimony separation and recovery (Patented).
7.	Gold and silver recovery from a range of primary and secondary materials.
8.	Lance system redesigned using shroud air for improved performance as well as process advantages. (This lance system has been patented by Ausmelt and is a major extension of the original Sirosmelt system.)
9.	Zinc-lead-silver concentrate smelting. (Patented).
10.	Smelting zinc plant wastes, including jarosite and goethite, and similar materials. (Patented).
11.	Zinc slag smelting and fuming. (Patented).
12.	Lance design for high levels of oxygen enrichment of combustion and process gases.
13.	Ferro-nickel production from laterites. (Patented).
14.	A new lance and furnace system for iron production from low grade as well as high grade resources. (Patented).
15.	Desulphurising nickel matte.
16.	Processing complex lead-zinc-copper-precious metals concentrates and other materials.
17.	Processing "dirty" or complex copper concentrates and other materials for multi-metal recovery.
18.	Smelting of various fumes and dusts including copper smelter dusts and EAF dust.
19.	Special lance design for powder and dust injection using an injector. (Patented).
20.	Processing of spent potlining from aluminium smelters jointly developed with Alcoa of Australia. (Patented).
21.	Processing of toxic and heavy metal containing wastes to recover metal values and produce a benign slag. (Patented).
22.	Processing of cobalt bearing materials to recover cobalt usually together with copper or nickel to a higher value metal product. (Patented).

AUSMELT DESIGNED SMELTERS

TPA AND FEED TYPE	OPERATION	LOCATION	PURPOSE	COMMISSIONED BY	OPERATOR
10,000 Cu concentrates	1984	Roxby Downs AUSTRALIA	Smelting copper concentrates (35 to 40% Cu) to produce blister copper and slag. Slag used in leach testing.	Ausmelt, RMS	Ausmelt, RMS
1,000 Stibio-tantalite	1985	Greenbushes AUSTRALIA	Tantalum slag production from concentrates (25% Ta_2O_5, 22% Sn, 15% Sb), enriched by fuming tin and antimony.	Ausmelt, Greenbushes	Greenbushes
Various	1986	Dandenong AUSTRALIA	Multi-purpose pilot plant facility. Used for Fe, Zn, Pb, Cu, Ni, Au, Ag and others.	Ausmelt	Ausmelt
Flash Furnace Accretion Removal	1987	Kalgoorlie AUSTRALIA	Ausmelt Lance injected into the Flash Furnace to remove accretions.	Ausmelt	Western Mining Corp.
10,000 Sn Concentrates	1989	Arnhem HOLLAND	Smelting combined tin concentrates (35 to 42% Sn) and slags (≈15% Sn) to produce tin metal.	Ausmelt, HMIB	HMIB
90,000 Zn Slag	1990	Cockle Creek AUSTRALIA	Fuming ISF slag (6 to 10% Zn, $<1\%$ Pb) to produce a zinc/lead oxide fume product.	Ausmelt/Sulphide Corporation	Sulphide Corporation
1,200 Bullion	1990	Pt Pirie AUSTRALIA	Cupellation of retort metal to produce silver dore.	BHAS	BHAS
7,700 Ni Residue	1992	Eiffel Flats ZIMBABWE	Nickel leach residue smelter producing low sulphur matte for further processing on site.	Ausmelt, Rio Tinto Zimbabwe	Rio Tinto Zimbabwe
100,000 Pb/Zn Slag	1992	Onsan SOUTH KOREA	Fuming lead and zinc from QSL slag to produce lead/zinc oxide fume and discardable slag.	Ausmelt, Korea Zinc	Korea Zinc
Various	1993	Colorado	Pilot plant facility. Aimed at waste processing development/demonstration, and Fe, Zn, Pb, Cu, Ni, etc as required.	Ausmelt, Ausmelt Technology Corporation	Ausmelt, Colorado Mineral Research Institute.

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TPA AND FEED TYPE	OPERATION	LOCATION	PURPOSE	COMMISSIONED BY	OPERATOR
72 Anode Slimes	1995	Ghatsila INDIA	Ausmelt to design and supply a smelter to process anode slimes to silver-gold bullion at HCL's Ghatsila smelter.	Ausmelt/HCL	HCL
1,000 Primary & Secondary Lead	1996	Paris FRANCE	Pilot plant facility for Metaleurop in support of Nordenham project.	Ausmelt/Metaleurop	Metaleurop Recherche
10,500 Copper Leach Residue	1992	Bindura ZIMBABWE	Production of blister copper containing precious and platinum group metals, nickel/copper alloy and discardable slag. Multiple operations in a single furnace.	Ausmelt/BNC	BNC
120,000 Zinc Residues	1995	Onsan SOUTH KOREA	Processing current production and stockpiled goethite together with jarosite and primary leach residue to produce zinc and lead fume and discardable slag.	Korea Zinc	Korea Zinc
30,000 Sn Concentrates	1996	Pisco PERU	Smelting Minsur concentrates to produce tin metal.	Ausmelt	Funsur
120,000 Primary & Secondary Lead	1996	Nordenham GERMANY	Replacement of the traditional sinter plant and blast furnace with Ausmelt Technology for Metaleurop to produce lead bullion.	Ausmelt/Metaleurop	Metaleurop
120,000 Primary & Secondary Lead	1996	Tsumeb NAMIBIA	Replacement of the sinter plant and blast furnace with Ausmelt Technology for Tsumeb Corporation to produce lead bullion	Ausmelt	Tsumeb
12,000 Spent Potlining	1997	Portland Victoria AUSTRALIA	New process to treat spend potlining from aluminium smelters.	Ausmelt/Portland Aluminium/Alcoa	Portland Aluminium
170,000 Copper Concentrates	1998	Zhong Tiao Shan CHINA	New continuous smelt/convert Ausmelt copper smelter.	Ausmelt/ZTS	ZTS

487095

Ausmelt development of top-submerged lance technology

J. M. Floyd and W. E. Short

Ausmelt technology

The top-submerged lance, as state-of-the-art smelting technology, produces a cost-effective, efficient reactor that is applied to the complete range of smelting and processing operations currently performed for non-ferrous, ferrous and precious-metal materials. It also has the ability to open up new developments and opportunities in separating metals with processing stages that are not possible or readily achievable by use of other technologies. The origins of the process are described in previous papers.[1,2,3] Major process developments are listed in Table 1; a schematic section through an Ausmelt furnace is shown in Fig. 1.

Table 1 Major process developments by Ausmelt

Smelting copper concentrates and ores
Batch and continuous converting of copper and nickel matte
Stibnite smelting and fuming for gold and antimony separation and recovery (patented)
Gold and silver recovery from range of primary and secondary materials
Zinc–lead–silver concentrate smelting (patented)
Smelting zinc plant wastes and similar materials (patented)
Zinc slag smelting and fuming (patented)
Ferronickel production from laterites (patented)
Iron production from low-grade as well as high-grade resources (patented)
Desulphurizing nickel matte
Processing complex lead–zinc–copper–precious metals concentrates and other materials
Processing 'dirty' or complex copper concentrates and other materials
Smelting of various fumes and dusts

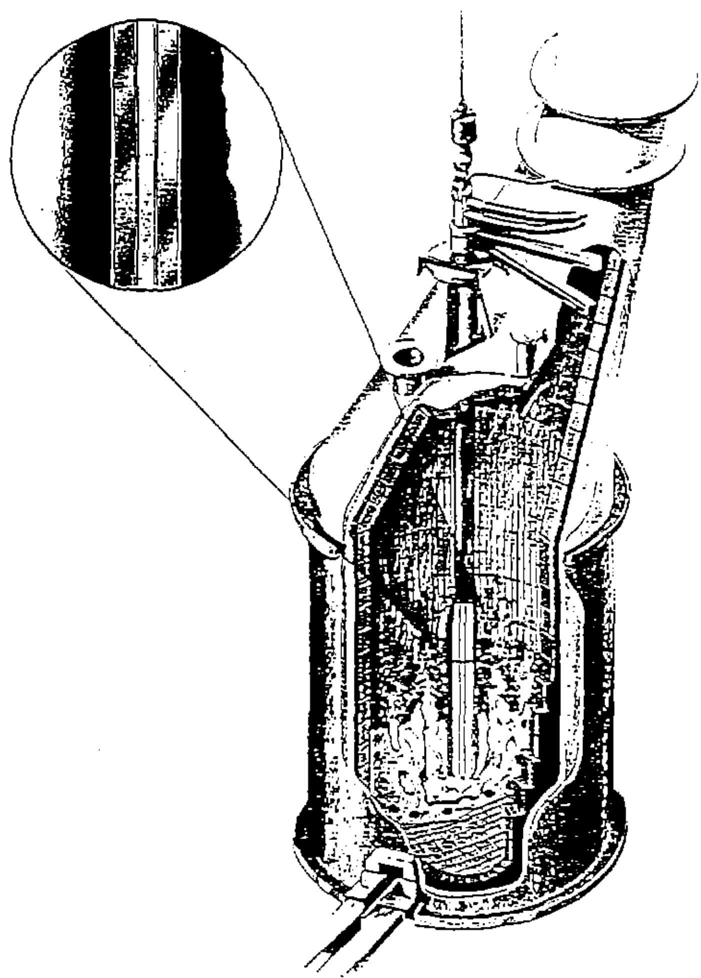

Fig. 1 Schematic section through Ausmelt furnace

The technology centres on a simple lance through which process air and fuel are delivered beneath the surface of a liquid slag bath. The steel lance is non-consumable and is protected from the furnace contents by a coating of frozen slag. The slag coating is established by carefully lowering the lance into the slag with a pause above the bath to allow splash to freeze on the lance. The tip of the lance is normally well below the static slag level of the furnace contents. The process gases are thus injected deeply into the slag and create very turbulent conditions in the bath. This turbulence promotes very rapid reactions and the smelting capacity is high for the furnace's small size. Excellent contact between the slag and the process gases also allows high fuel efficiency.[1]

The lance is located centrally in the furnace, which is constructed as a refractory-lined cylinder. Where very aggressive slags, mattes or metals are present or high temperatures are employed water cooling is required behind the refractories to ensure acceptable refractory life between vessel relines.

For specific applications specially designed lances can be used to achieve oxygen enrichment of process gases of up to 40–60%.[2,3] Fuel and fine materials are conveyed down the lance through inner tubes. Coarse materials are dropped into the furnace through a feed port and are rapidly incorporated into the bath on the cascading slag surface.

The simplicity of the system's operation and equipment requirements disguise the sophistication of the reaction regimes present within the furnace. There are several different regions, as shown in Fig. 2: the reaction zone in the immediate vicinity of the lance tip, which can be oxidizing, neutral or reducing; the slag surface, where smelting reactions occur under oxidizing, neutral or reducing conditions; the furnace bottom, which can be relatively quiescent, with the lance raised high in the bath, or well stirred, with the lance injected deep into the furnace contents; and the gas plume region, where reactions between the combustion gases and the slag bath occur.

The lance is readily lowered and raised in the furnace to control the stirring of the bath. If advantageous, it is possible to avoid stirring the bottom of the bath by adjusting the depth of injection. Lance position is an important operating

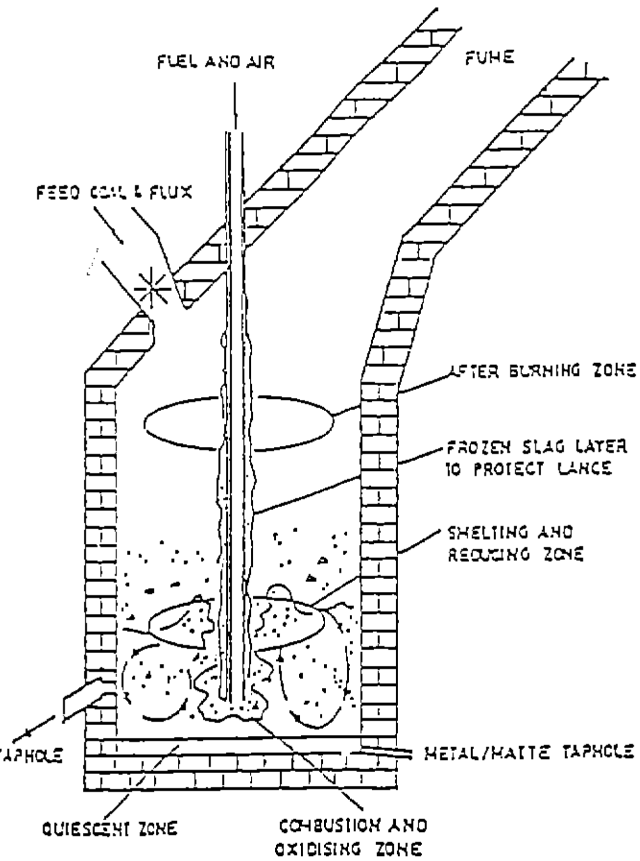

Fig. 2 Reaction regimes within Ausmelt furnace

parameter as it allows the slag to separate from metal or matte phases. In the process for producing tin metal described herein, the lance position is important in producing metal with a low iron content suitable for further processing in a tin refinery.

The process can be stopped to allow a reactant or collecting material to be added to the furnace or a product to be removed, thus allowing a series of operations to be carried out on a single charge. The furnace can be left on standby heat for long periods of time and the contents can be rapidly made fluid again by lowering the lance. Interruptions caused by labour or other problems do not cause major process difficulties.

Ausmelt lances have also been used in other furnaces, such as copper-smelting reverberatory furnaces, electric slag reduction furnaces and Outokumpu flash furnaces, to improve operating conditions in the bath.

The advantages of the technology include its intense and controllable stirring and its ability to accept a wide range of feeds, ranging from run-of-mine crushed ore, wet slimes, sludges and muds, which are fed through a feed port in the top of the furnace, to fine concentrates and dusts, which are injected via the lance. These features, together with the simple design of the furnace, allow plants to be built for lower capital costs than competing technologies. The technology is radically different from conventional technologies, and this has introduced an additional level of caution in its acceptance. A list of Ausmelt-designed smelters is included as Table 2. Commercial top-submerged lance technology smelters have been constructed and operated for a wide variety of feed materials. Further smelters are currently in the development and design stage.

Blister copper production

Ausmelt has developed a process for the production of blister copper (containing any precious-metal values) from the processing of copper concentrates. Either one or two furnaces are employed, depending on the scale of the operation. The process flowsheet is shown in Fig. 3. Submerged-lance combustion technology is particularly suitable to the process of copper concentrate smelting and

Table 2 Ausmelt smelters

Capacity, t/year, and feed type	Operational since	Location	Purpose	Commission	Operator	Comments and references
7500 Cu concs	1984	Roxby Downs Australia	Copper slag production	Ausmelt, RMS	Ausmelt, RMS	To produce slag from Cu concs.[5]
1500 Stibio-tantalite	1985	Greenbushes Australia	Enriching Ta slags	Ausmelt, Greenbushes	Greenbushes	Fumed Sn and Sb from Ta slags
	1986	Dandenong Australia	Multi-purpose pilot-plant facility	Ausmelt	Ausmelt	Used for Zn, Pb, Cu, Ni, Au and many more
Flash furnace accretion removal	1987	Kalgoorlie Australia	Lance in flash furnace	Ausmelt	Western Mining Corp.	Furnace accretion removal
15 000 Sn concs	1989	Arnhem Netherlands	Tin smelting	Ausmelt, HMIB	HMIB	Detailed design performed by HMIB[7]
105 000 Zn slag	1990	Cockle Creek Australia	Zn fuming from ISF slag	Sulphide Corporation	Sulphide Corporation	Fuming Zn and Pb from ISF slag[8]
1500 Bullion	1990	Pt Pirie Australia	Cupellation of Ag alloy	BHAS	BHAS	Cupel Ag from retort metal[9,10]
7500 Residue	1992	Zimbabwe	Leach residue smelter	Ausmelt, RTZ	Rio Tinto Zimbabwe	Ni–Cu residue desulphurization
90 000 Slag	1992	Onsan Korea	Zn fuming from QSL slag	Ausmelt, Korea Zinc	Korea Zinc	Fuming Pb and Zn from QSL slag

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matte converting because of the intense stirring and controllable oxidation of the sulphides in the bath.

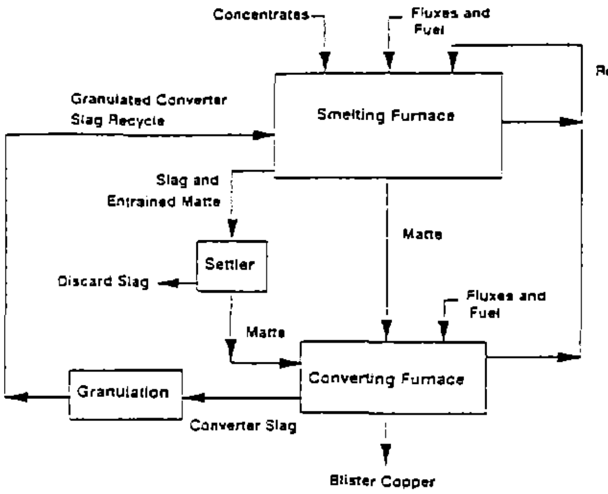

Fig. 3 Blister copper process flowsheet

In the two-furnace operation concentrates are fed continuously to the smelting furnace, with fluxes and recycled materials, to produce matte containing approximately 60% copper and discard slag containing less than 0.6% copper. Slag and entrained matte overflow to a settling furnace, where they are separated. The slag is tapped and granulated before being discarded as landfill or sold as aggregate to the construction industry. The small amount of entrained matte is batch-tapped and transferred to the converting furnace. The majority of the matte flows from the smelting furnace to the converting furnace via a weir and launder system. The converter operates continuously, producing blister copper that can be tapped either continuously or in batches without interrupting the converting operation. The metal product is suitable for further processing in an anode furnace and electrolytic refinery.

As a result of the high oxidation rates in the converter and the fact that the slag phase is in contact with the metal, high levels of copper are present in the converter slag. This slag, therefore, is batch-tapped, granulated and recycled to the main smelting furnace as feed.

Off-gases from the furnaces require SO_2 removal prior to discharge. Depending on the scale of the operation and local market requirements, sulphuric acid production from furnace off-gases is often economically justified.

Operating the process in two furnaces is appropriate for smelters with a concentrate intake of more than 100 000 t/year. At smaller scales a single-furnace, batch operation is required. During smelting discard slag is tapped as required while smelting of concentrates is continued until the furnace is full of matte. Once the furnace has reached capacity the matte is converted to blister copper. The converting-stage slag remains in the furnace after the blister copper has been tapped and is reprocessed in the subsequent smelting stage.[6] The oxidation level of this stage is controlled in the process by addition of coal.

The versatility of the furnace system allows the feeding of any quantity and most qualities of secondary copper materials, such as copper reverts, anode scrap copper metal and wire. It can also be used to process complex copper concentrates that contain elements normally considered undesirable in conventional copper circuits. Bismuth, lead and zinc can all be removed to very low levels by the appropriate choice of operating conditions and can be recovered in a fume that contains very little dust and which can be sold or further processed to produce marketable products.[11,12] The blister copper produced from the process will contain suitably low levels of these impurities, compatible with the requirements of the refinery. These results can be attributed to the ready control of process conditions and the low dust carryover that the technology facilitates; appropriate design and operating conditions allow dust carryover in the Ausmelt system to be consistently less than 1% of the feed rate.[5]

Complex concentrates are usually available at a lower price than clean, high-grade concentrates, so long-term contracts under favourable conditions are likely to be achievable. Plant design will need to include the process steps necessary to achieve separation of the different components to marketable products so as to provide the required capacity and product quality assurances.[13–16]

Nickel–copper–precious metals concentrates and residues

Like blister copper production from copper concentrates, the processing of nickel–copper concentrates comprises two stages. Ausmelt has demonstrated in its pilot-plant in Dandenong, Australia, the high recoveries and low copper and nickel levels in discard slag that can be achieved. Discard slag and matte are produced in the smelting stage. The product of the converting stage can be conventional high-grade matte, desulphurized nickel–copper matte or even desulphurized nickel matte.[17]

Ausmelt has commercialized a process for the treatment of copper–nickel leach residues at Empress Nickel Refinery, Eiffel Flats, Zimbabwe.[18] The commercial operation takes place in a single furnace. The process involves a smelting stage that produces matte containing 6% sulphur, which is tapped from the furnace and granulated for further refining in a leach circuit. The slag can be periodically reduced to minimize dissolved copper and nickel in slag. A figure of 1.0% combined nickel plus copper in slag can be achieved when the plant is operated to include an appropriate slag reduction stage.

Cupellation

Ausmelt technology has been successfully applied to cupellation.[9,10] The process allows for production of high-grade precious metal, of anode quality or similar, from various feed materials, including copper anode slimes and retort bullion. The furnace is a steel, water-cooled cylinder lined with refractories. The top-submerged lance provides for combustion, oxidation and reduction of the bath under turbulent conditions, thereby producing efficient heat and mass transfer for smelting, oxidizing and reducing operations. The lance design promotes good metal–gas contact, resulting in a high specific smelting rate. The efficiency of the lance allows the furnace to be static, requiring no mechanical drive or tilt mechanisms.

The Ausmelt cupellation system is well suited to smelting and cupelling retort bullion and copper anode slimes. A metal quality suitable for casting anodes for the separation of silver and gold is achievable and the process is rapid and efficient. Benefits lie in the high recovery, reduced precious-metals inventory and low process requirements for fuel and fluxes. The furnace is also capable of processing a variety of materials, including spent refractories, slag and fume.

Three alternatives to traditional cupellation technology have been tested and used on a commercial scale in recent times: the top-submerged lance system (Ausmelt), the top-blown rotary converter (TBRC) and bottom-blown oxygen cupellation. The strength of the Ausmelt cupellation system is its simplicity. The stationary design, flexibility of fuel type and ease of lance repair without interrupting the process are definite advantages of the Ausmelt system.

Iron smelting

In its pilot-plant in Dandenong Ausmelt has developed a new technology to produce pig iron by the smelting of low-grade iron sources unsuitable for treatment with traditional technologies.[3,19] The types of materials that can be smelted include beach sands, ilmenite, residues from smelting, zinc plant residue, red mud from alumina refining, fines from pellet handling operations, primary iron ore and intermediates containing high levels of zinc.

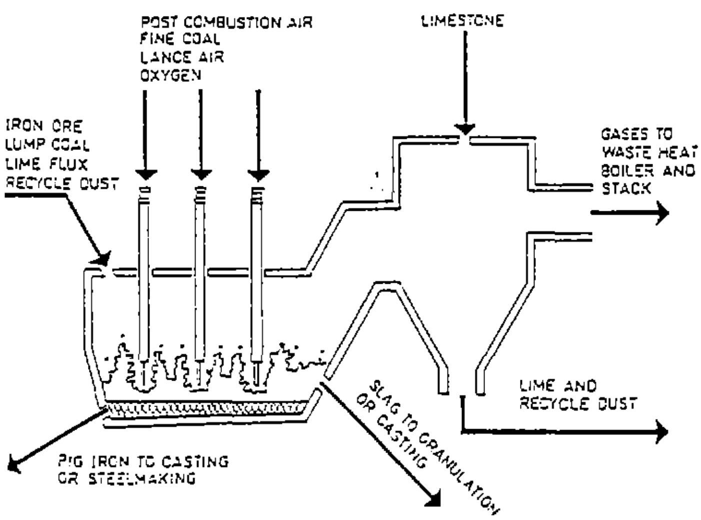

Fig. 4 Iron smelting technology

A schematic illustration of the process is presented as Fig. 4. The ore or fines, together with lump coal and flux, are fed to the furnace continuously through a sealed port system. Fine coal, oxygen and air are injected down the lance to provide efficient submerged combustion, generating the energy for the smelting reactions under strongly reducing conditions. The fuel used can be fine coal, natural gas or liquid hydrocarbons, the choice depending on the availability and cost at a particular location.

Carbon monoxide and unburnt volatiles from the coal that rise above the bath in the smelting and combustion gases are completely burnt in a controlled manner to ensure efficient heat recovery to the bath without reoxidation of the slag or metal. Post-combustion was demonstrated in the pilot-plant development.

Metal and slag are tapped from the furnace at regular intervals as the furnace reaches capacity. The slag will be tapped into ladles and either cast into moulds or granulated to suit market requirements.

The process has several advantages over other technologies. (1) The reactions take place in a slag bath that forms a barrier between the reactive metal and the relatively high oxygen levels required for efficient heat recovery. This compares favourably with other direct smelting processes, which involve injection into the iron bath. (2) A very important advantage is that the technology requires only one smelting reactor, with direct feed of ore or concentrates to the furnace. (3) The use of conventional facilities for waste-heat recovery makes it easier to operate, cheaper to build and very straightforward to implement by comparison with other technologies. (4) The furnace system is operated under negative pressure, which gives a safer and environmentally better operation than processes operating under positive pressure. (5) Low-grade (cheap) iron sources are acceptable, so the cost of feed material can be low. (6) Feed preparation is minimal since lump materials can be fed without grinding. Fine material can also be fed via a simple feed system. (7) All equipment, such as that for feed handling and gas handling, is conventional, apart from the furnace and lances. (8) Any grade of coal can be used as fuel. (9) The furnace is stationary and has no tuyères, so the maintenance of refractories and mechanical equipment is easier than in competing technologies. (10) Complete combustion of the volatiles and reaction products is achieved within the furnace under conditions that maximize the recovery of heat to the bath.

The system has other advantages in common with many new direct-smelting processes, including the capacity to produce electricity surplus to the plant's own requirements, which can be sold if appropriate marketing arrangements are possible, and the fact that small production units can be economic, allowing application to smaller resources.

Tin smelting

Ausmelt has significant experience in the area of processing tin concentrates to produce high-grade tin metal suitable for further refining in a conventional pyrometallurgical tin refinery. Also obtained from the process is discard slag containing less than 0.5% tin.[7]

The process flowsheet for smelting typical tin concentrates involves a single furnace (Fig. 5). The smelting of tin

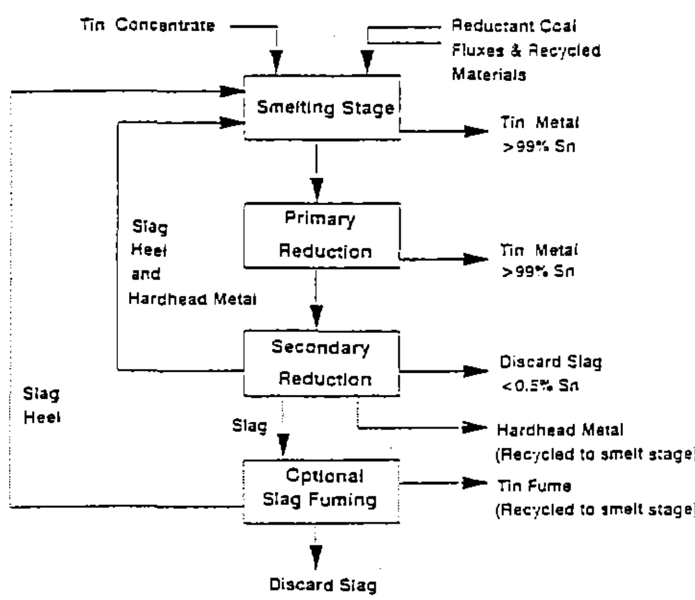

Fig. 5 Process flowsheet for typical tin concentrates

concentrates is carried out at approximately 1150°C under slightly reducing conditions, which are obtained by the addition of lump coal with the concentrates. To ensure high tin recoveries dust and fume from the smelting and reduction stages are recycled to the furnace with the concentrate feed. Fluxes are also fed to the furnace during smelting.

The metal produced during smelting collects in the quiescent zone in the furnace base and is periodically tapped into moulds. Smelting (i.e. with the lance submerged) can continue during tapping, so the latter does not cause plant downtime or production losses.

Once the level of slag in the furnace has reached design capacity concentrate smelting is halted and slag reduction is carried out in two sequential operations: mild, primary reduction followed by a strong, secondary reduction. The bath temperature is allowed to rise to 1200°C during primary reduction and lump coal is fed until the level of tin in slag drops to approximately 4%. Once this level is achieved the metal product is tapped from the furnace and secondary slag reduction commences. During secondary reduction the temperature is allowed to increase further to 1300°C, with continued lump coal addition. It is during this stage that hardhead (high tin–iron alloy) is produced. When the level of tin in the slag falls to below 1% most of the slag is tapped and granulated to be discarded. A small slag heel and the hardhead remain in the furnace for the next smelting cycle. Ausmelt has shown that as the next smelting cycle begins the iron contained in the hardhead metal phase is readily reoxidized and transferred to the slag phase.[20,21]

Slag fuming is a supplementary operation by which the level of tin in discard slag may be reduced to even lower levels. This stage requires temperatures in excess of 1400°C, necessitating special attention to furnace design and refractory maintenance. For the slag fuming process to occur effectively all the hardhead in the furnace at the end of the second-stage reduction must be tapped for recycle to the smelting stage.

Minor elements in the system behave much as in conventional tin smelters.[22]

In conventional tin-smelting processes a common problem is the co-reduction of iron with the tin. The iron–tin alloy produced is recycled to the smelting stage, which limits the recovery of tin because the iron recycle must be controlled to a manageable level. Consequently, the final slag cannot be reduced to very low levels of tin as that would involve the reduction of excessive amounts of iron. Ausmelt can diminish this problem substantially by control of the equilibration reactions and by taking advantage of the kinetics of the reduction/oxidation reactions. The main difference between the Ausmelt furnace and traditional furnaces is that slag reduction occurs very rapidly. By operating the lance in a high position in the slag bath it is possible to produce tin–iron alloy containing less iron than furnaces that operate under equilibrium conditions. Operation of the lance in a high position not only results in maximum slag agitation and slag–reductant contact in the upper slag region but also promotes coalescence of the reduced metal that collects in the relatively quiescent zone in the bottom of the furnace.

The recovery of tin to metal is determined by the degree of non-equilibrium that can be achieved in the Ausmelt furnace. This is dependent on a number of variables, including reductant addition rate, initial tin and iron levels in the slag, process interruptions and the required final tin levels in slag.[7]

Lead smelting

Three Ausmelt process routes are available for the smelting of lead sulphide concentrates or ores, depending on the grade of the feed and the other elements to be recovered.[2]

Low-grade concentrates

Experience has shown that it is very difficult to remove sulphur from low-grade materials (less than 40% lead) without fuming a large proportion of the lead. The treatment of low-grade materials, therefore, includes a fuming stage to produce a lead-rich fume. The fume product is then directly reduced to bullion and low-lead slag in a second stage.

High-grade concentrates

Direct smelting to produce lead metal under oxidizing conditions is possible if the concentrates are of sufficiently high grade (>55% lead). A flowsheet for the processing of high-grade lead concentrates is presented as Fig. 6.

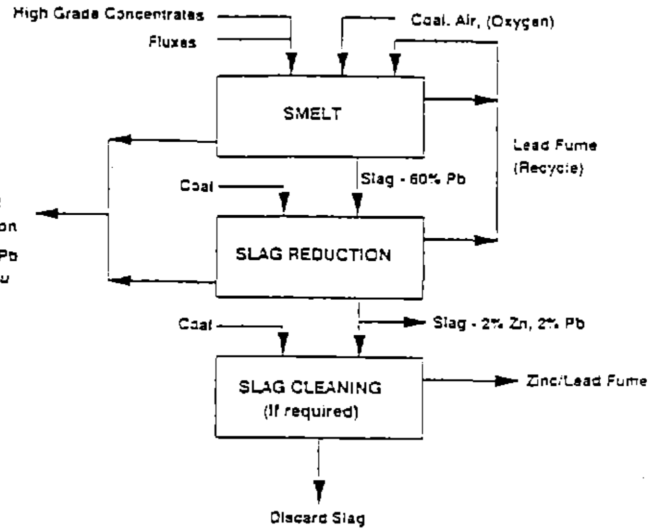

Fig. 6 Process flowsheet for high-grade lead concentrates

High-grade concentrates are fed with coal to the smelting stage to produce lead bullion and high-lead slag. The bullion is periodically tapped from the furnace and smelting continues until the furnace reaches capacity. Slag reduction is then commenced, which produces lead bullion and a slag containing approximately 2% lead and 2% zinc. If required, this slag may be cleaned under reducing conditions to produce a lead–zinc fume for sale and discard slag.

The fume products from the smelting and slag reduction stages are recycled to the smelting stage for increased lead recovery to bullion. Smelting is performed with high levels of oxygen enrichment to minimize the quantity of gas passing through the bath, so minimizing the amount of fume being recycled.

Complex concentrates

Ausmelt technology has been shown in pilot-plant and commercial operations to be suitable for separating the valuable metals in complex materials containing, for example, lead, copper, zinc and silver.[12,13,14] Crushed ore or concentrates are smelted with the appropriate fluxes to produce a slag containing most of the zinc, a matte containing most of the copper and silver and a fume containing most of the lead. The lead-rich fume is collected in a baghouse for subsequent treatment and the matte and slag are tapped through a forehearth, where they are separated. The slag is processed by reduction, either in batches in the same furnace or continuously in an additional furnace, to produce a zinc-rich fume suitable for sale or further processing for zinc production. The lead-rich fume is reduced in a separate furnace to produce lead metal, zinc-rich slag and a fume stream that is immediately recycled in this furnace. The slag product is returned to the main smelting furnace to recover zinc and lead further.

When used for slag cleaning operations the Ausmelt process has the capacity also to remove such toxic elements as arsenic, antimony and cadmium to very low levels. The discard slag can, therefore, be a very clean product, capable of meeting the most stringent environmental testing standards.

The choice of operating strategy for a particular feed material is an economic decision that can be made by the smelter operator. The process conditions can be altered to suit the feed composition without the need to modify the plant, provided that the appropriate facilities are included in the design and construction of the plant.

Zinc plant residue treatment

The disposal of waste products and the recovery of metal values from waste streams to improve process economics are significant concerns in modern metallurgical plants. Substantial value is contained in these wastes since in many cases they are stockpiled in considerable volume. If left untreated, the toxic elements contained in these materials, stored in an unstable condition, can create significant environmental problems. One particular subject that has been identified is the treatment of jarosite and goethite residues produced in the electrolytic zinc process. Typical analyses of zinc wastes are provided in Table 3.

Table 3 Typical analyses of zinc wastes

Material	Primary leach residue	Jarosite	Goethite
Zn, %	16.9	5	10
Pb, %	9.9	5.2	2
Fe, %	28.9	25	40
S, %	12.5	13	4
SiO_2, %	6.1	3	2.5
Cu, %	1.1	0.2	1.5
Cd, ppm	8100	200	500
As, ppm	1800	600	2000
Ag, ppm	1800	80	80
Sb, ppm	1700	100	10

Top-submerged lance technology is particularly suitable for processing zinc residues to produce a chemically inert slag and a marketable zinc oxide fume.[23] The further processing of this zinc fume will involve the separation, and recovery where appropriate, of other volatile elements, including arsenic, antimony, lead, cadmium and bismuth. The fume will generally contain 65–75% zinc; a separate lead bullion product is also producible. The slag product can be disposed of without posing an environmental hazard.[24] The fume is suitable as a low-iron feed to an electrolytic zinc plant or an Imperial Smelting Furnace for zinc recovery.

The technology is also suitable for processing the primary zinc residue produced at the neutral-leach stage of operation in an electrolytic zinc plant. Smelting would replace the hot acid-leach step for the recovery of zinc in the residue, thereby avoiding the large-scale production of jarosite or goethite residues, with their associated disposal problems. A continuous, two-furnace system is needed; Fig. 7 is the flowsheet for a typical operation producing zinc fume and discard slag. The two fume products will contain the metal values of zinc, lead and silver with other volatile metals.

Solid feed is introduced through the top of the smelting furnace and smelted at 1300–1350°C with the aid of a top-submerged lance. Solid reductant, such as lump coal, is added to maintain the low oxygen potential required for the reduction of zinc and lead oxides to metals. Fuel, combustion air and shroud air are injected into the furnace bath via the lance. The combustion air can be enriched to 40% oxygen to minimize fuel consumption as well as furnace and gas handling size.

Metallic zinc and lead have high vapour pressures at the temperature of operation. If appropriate operating conditions are chosen, zinc and lead metals will be removed with the flue gases from the slag bath and reoxidized in the gas phase with air to produce oxide or sulphate fumes. Most of the silver, cadmium, arsenic, halogens and other volatile chemical species will fume off simultaneously. The furnace off-gases, typically at a design temperature between 1250 and 1450°C, can be cooled in a waste-heat boiler or evaporative cooler. Fumes in the cooled gases are removed in a baghouse or electrostatic precipitator and the cleaned gases are scrubbed for SO_2 removal and discharged to atmosphere via a stack.

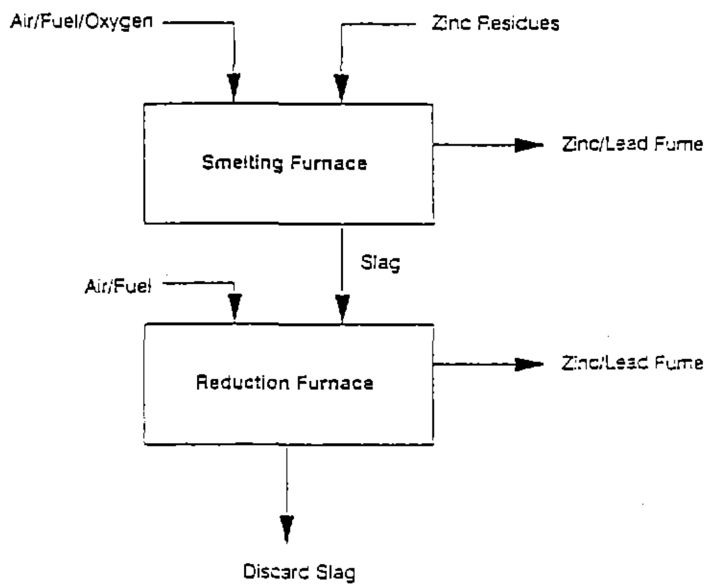

Fig. 7 Zinc residue process flowsheet

The smelting-stage slag is transferred continuously from the first furnace via a launder into the second Ausmelt furnace for further zinc removal from slag. The reduction furnace is designed to operate at 1350°C. No oxygen enrichment of the combustion air is required in the reduction stage. The handling of the reductant coal, fuel coal, combustion air and furnace gases of the second furnace is similar to that for the smelting furnace. A second zinc-lead fume product is generated. The final slag, containing less than 1% Zn and less than 0.1% Pb, is tapped continuously from the slag fuming furnace, granulated and discarded.

Conclusion

Ausmelt technology offers potential economic and environmental benefits in the treatment of numerous feed materials to recover most non-ferrous metals and iron to marketable products. The furnace system is the foundation for processes with high rates of heat and mass transfer in a well-sealed, compact vessel that have low capital and operating costs and satisfy in-plant and local environmental requirements.

The technology has been commercialized for a variety of feed materials and international interest continues to increase—both in processes already developed by Ausmelt and in other development areas, including waste treatment. *Several projects are currently proceeding towards commercialization in the near future.*

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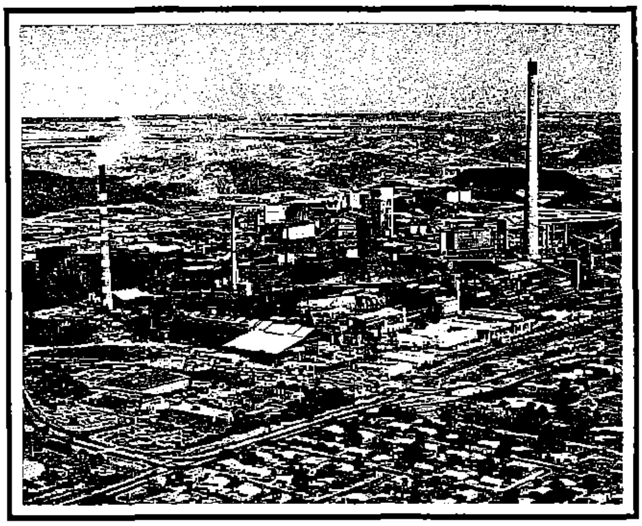
Appendix Four

Isasmelt brochure

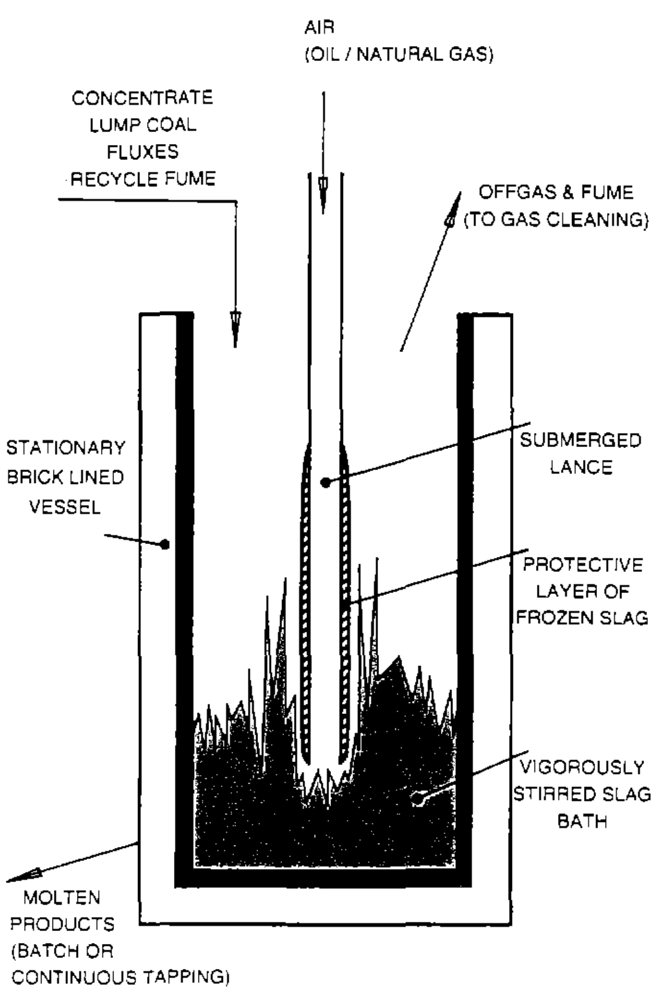
INTRODUCTION



Mount Isa Mines Limited (MIM) has been in the smelting business since 1931, when the first Lead Smelter was commissioned at Mount Isa, in Queensland, Australia. This smelter was temporarily converted to copper production in 1943 as a wartime measure. The MIM Copper Smelter was commissioned in 1953. MIM annually produces 170 000 tonnes of lead bullion and 180 000 tonnes of anode copper.

Faced with continuing pressure to reduce operating costs and to maintain or improve smelter hygiene standards, MIM developed the ISASMELT process jointly with the Australian government's "Commonwealth Scientific and Industrial Research Organization" (CSIRO).

THE ISASMELT PROCESS



THE ISASMELT CONCEPT

The ISASMELT process is based on the Sirosmelt lance which was developed by the CSIRO in 1973. The process requires a simple, refractory lined furnace and operates with a single submerged combustion lance to create a highly turbulent bath. The lance is coated with a protective layer of frozen slag. Internal swirlers enhance the heat transfer from the lance wall to the process air, promoting the formation of this slag coating.

Feed preparation requirements are minimal. An ISASMELT reactor can treat concentrate straight from an ordinary drum filter. The turbulence of the ISASMELT bath ensures rapid incorporation of feed materials and a high rate of reaction.

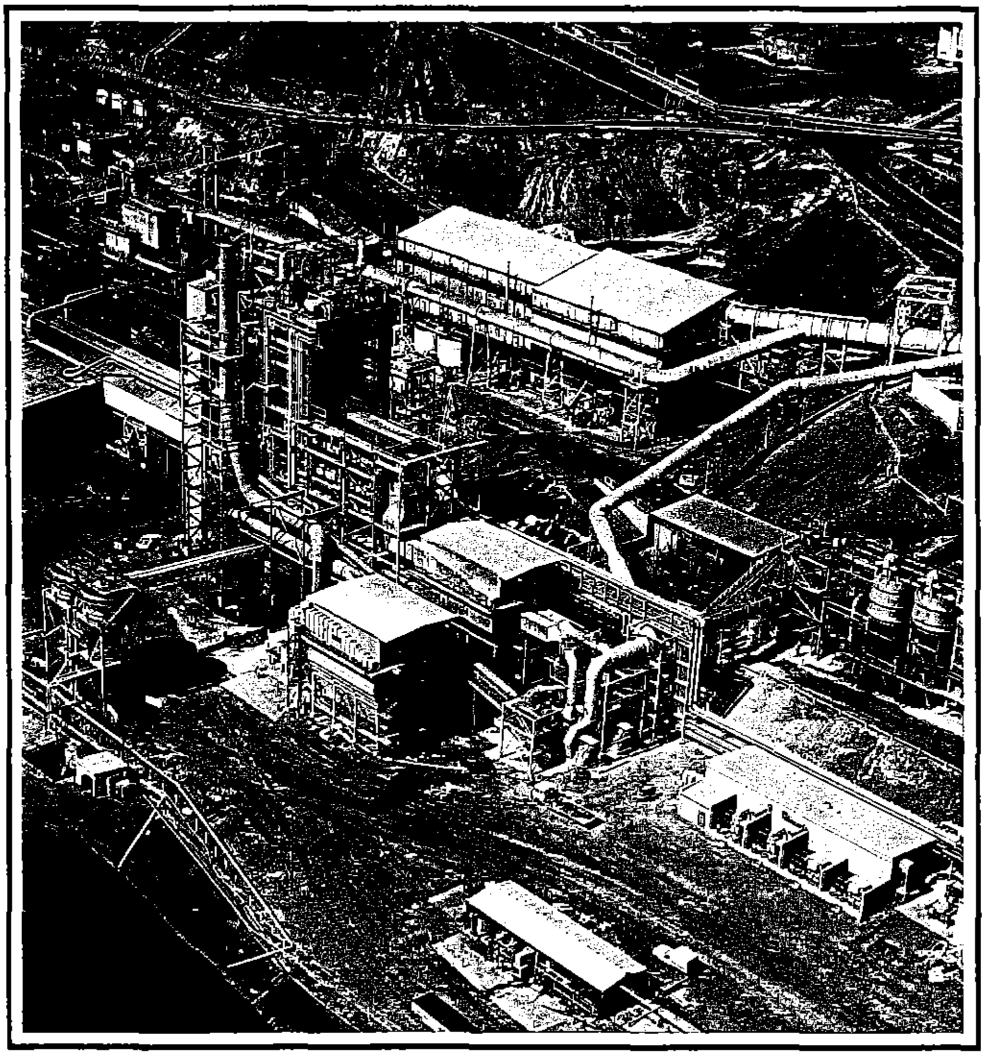
Since April 1987 MIM has been operating a Copper ISASMELT reactor treating 20 t/h of copper concentrate and, also at Mount Isa, a Copper ISASMELT plant to produce 180 000 t/y of copper is under construction.

During 1991 a Lead ISASMELT plant to produce 60 000 t/y of crude lead bullion was commissioned in the Mount Isa Lead Smelter. At Britannia Refined Metals in the United Kingdom, an ISASMELT plant to recover 40 000 t/y secondary lead has been successfully commissioned.

The Lead ISASMELT Process

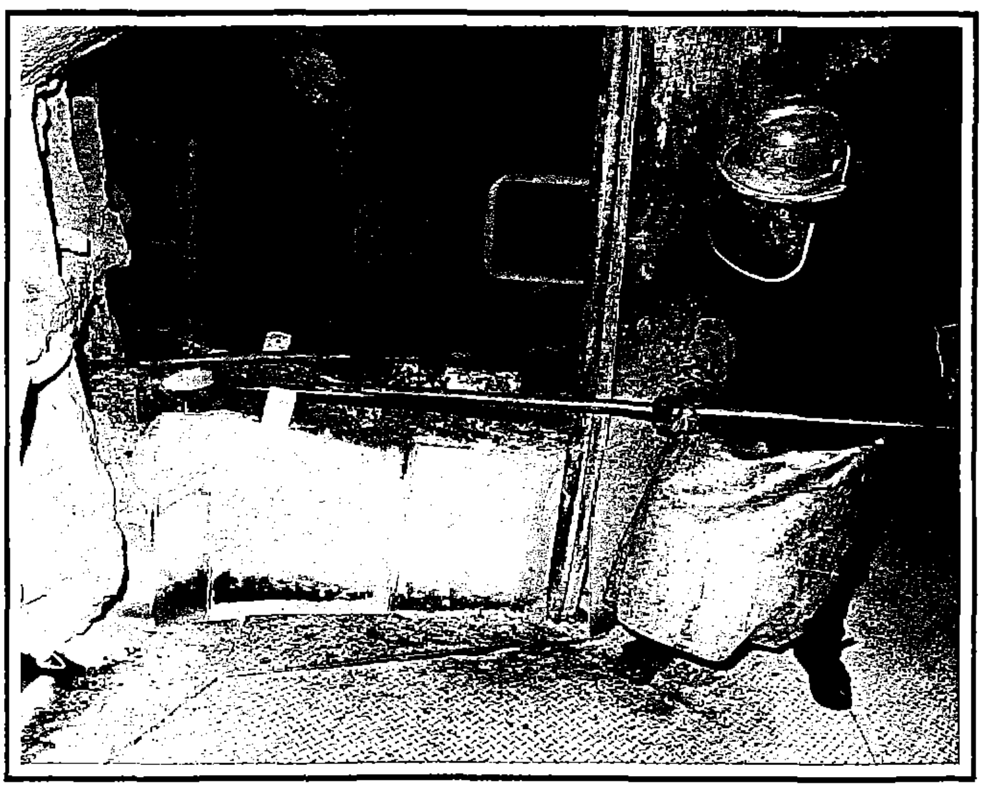
The **Lead ISASMELT** process is a two stage continuous lead process.

Lead concentrate is smelted in one furnace to produce a high lead slag which is transferred to the second furnace for reduction to produce a crude lead bullion.



The Lead ISASMELT Plant commissioned at Mount Isa in 1991.

Taking a sample tapped from the Copper ISASMELT furnace.



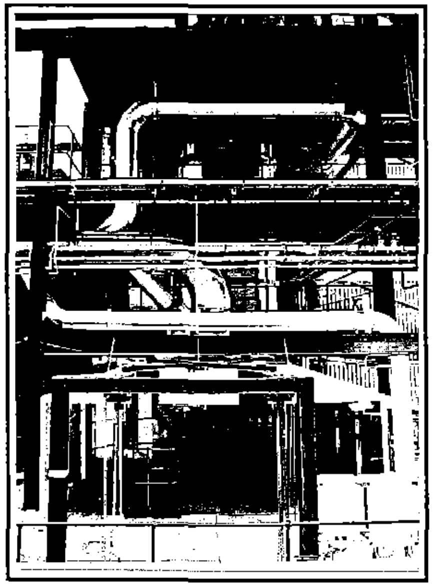
The Copper ISASMELT Process

The **Copper ISASMELT** process is a single stage concentrate smelting furnace which produces a matte and a discardable slag. The matte and slag are transferred to a holding furnace for complete separation.

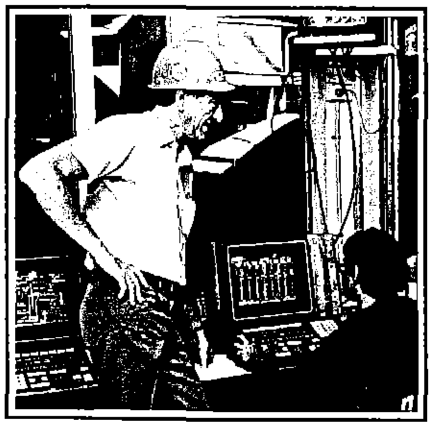
OPERATIONAL FEATURES

ISASMELT PROCESS ADVANTAGES:

Simple, low cost reactor.	The Lead ISASMELT plant at Mount Isa produces 60000 t/y of lead from concentrate and was constructed for $US 47.5 million. The new Copper ISASMELT furnace at Mount Isa (part of a $US 73 million smelter upgrade) will smelt 180000 t/y of copper.
Minimal feed preparation requirement.	The Lead ISASMELT reactor is fed a pelletised mix of filter cake, flux, coke breeze and recycled fume. The Copper ISASMELT furnace also receives pellets – containing filter cake, dry concentrate, flux and coal.
Can be incorporated at existing plants.	An ISASMELT reactor requires minimal floor space and is compatible with most existing smelting processes.
High specific smelting rate.	*The new Copper ISASMELT reactor will treat up to 125 t/h of concentrate.*
Low operating labour requirement.	An ISASMELT reactor can be operated by a crew of 4 - 6 operators per shift, depending on the scale and complexity of the plant.
Easy operation.	A high degree of automation features on-line computer control.
Low maintenance costs.	An ISASMELT plant is compact and has few moving parts to maintain. A refractory life in excess of 18 months can be expected in most installations.
Fuel type is flexible.	ISASMELT furnaces have been successfully operated using coal, coke breeze, oil and natural gas as fuel.
High turn down ratio.	The Copper demonstration ISASMELT reactor operates at 15 t/h using air only and has operated at up to 50 t/h with oxygen enrichment.
Good plant hygiene.	An ISASMELT reactor is fully sealed apart from the lance port and the feed port, so fugitive emissions can be easily contained.
High impurity removal.	*The Copper ISASMELT process eliminates 60 - 70 % of Pb, 90 - 95 % of As,* 90 - 93% of Bi, and 60 - 80 % of Sb from the concentrate feed into the discard slag or gas stream.



Used car batteries yield secondary lead in the Lead ISASMELT reactor at Northfleet, United Kingdom.



ISASMELT Marketing Manager Jim Pritchard with the operator in the Copper ISASMELT control room at Mount Isa.

THE ISASMELT PROCESS IS FLEXIBLE

The ISASMELT process can be applied to many non-ferrous metals, including:

Copper	- chalcopyrite concentrates - converter slag concentrates - gold bearing concentrates - concentrates containing high levels of impurities
Lead	- lead concentrates - dross treatment - battery paste - lead recycling - silver bearing concentrates
Zinc	- zinc bearing slags - zinc concentrates - lead/silver residues - steelworks EAF dust
Tin	- tin concentrates - tin ores - tin slag reduction - matte fuming
Nickel	- nickel concentrates - nickel copper concentrates - nickel PGM concentrates

Processes for the treatment of other materials may be developed after a program of testwork.

MIM's experience has shown that ISASMELT can be used for :

Expanding the capacity of existing plants

Treatment of difficult materials

Plant modernisation

New facilities

Small capacity plants

Large capacity plants

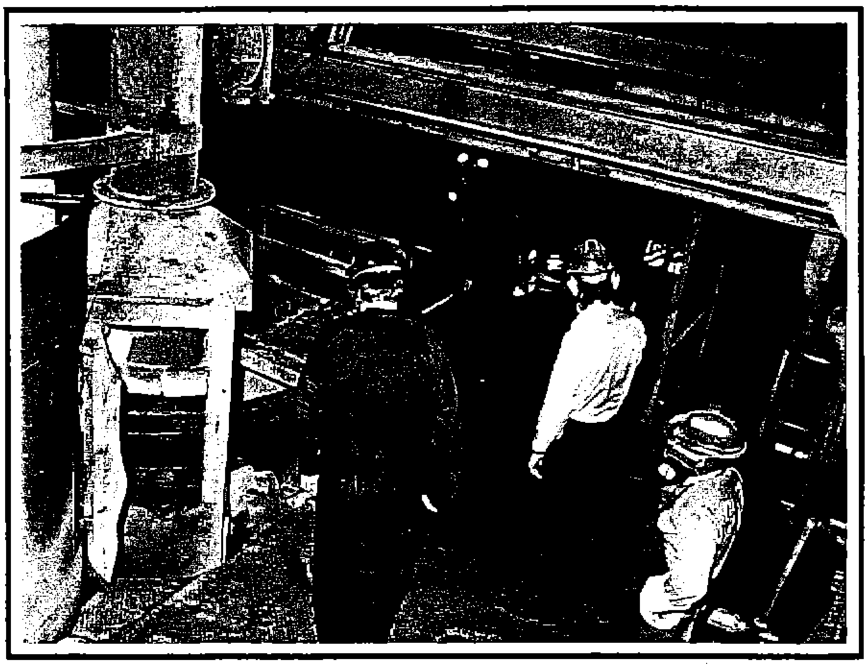
Recovery of metals from waste products.

'ISASMELT' LICENCE

MIM has a marketing agreement with CSIRO, the joint developers of the ISASMELT process. Companies wishing to install an ISASMELT furnace should contact MIM Holdings Limited Marketing of Technology Department in Brisbane.

MIM offers a licence agreement with the following features:

a) A grant to the licensee of a non-exclusive licence to use ISASMELT technology at its plant for an agreed licence fee.
b) Definition of services to be provided by MIM, including plant design, training for client operating personnel at Mount Isa, and commissioning assistance from experienced personnel from the Mount Isa smelters.
c) Provisions for continuing co-operation, collaboration, and confidentiality.



Familiarisation with ISASMELT operations at Mount Isa is included in pre-startup training. Here, Cyprus Miami Mining Company representatives inspect slag tapping from the reduction vessel in the Lead ISASMELT plant.

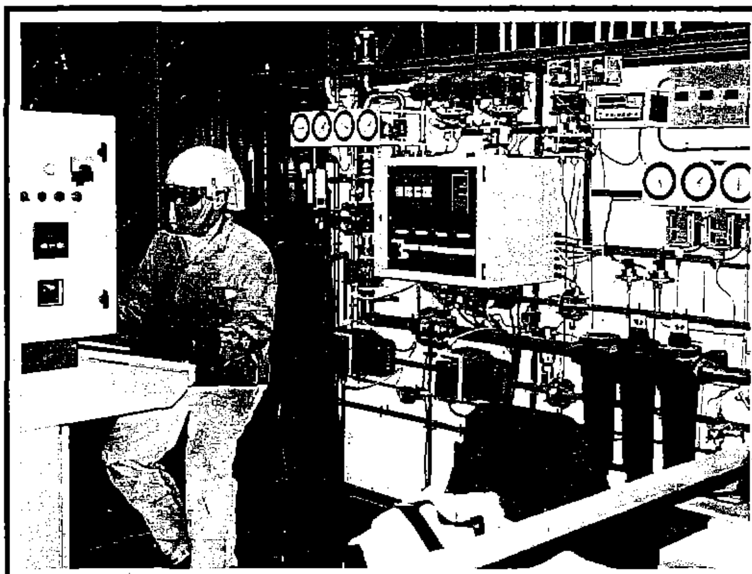
Recent ISASMELT licences have been confirmed with AGIP for their Nickel Plant in Western Australia and with Cyprus Miami Mining Company for a Copper ISASMELT Plant in Arizona, U.S.A.

The Secondary Lead ISASMELT Plant at Britannia Refined Metals in the United Kingdom will be the precursor of several such installations as worldwide environmental awareness points to increased recycling of lead from exhausted car batteries.

ISASMELT: ADDITIONAL SERVICES

MIM can offer the following services in addition to the Licence Agreement:

- Feasibility studies.
- Advice on the best process flow sheets for a particular material.
- Preliminary cost estimates and plant layouts.
- Pilot plant tests on 250 kg/h scale.
- Site visits to view the ISASMELT operations at Mount Isa.
- Discussions with development and operating personnel at Mount Isa.
- Demonstration treatment of copper concentrates at the 20 - 25 t/h scale.
- Basic engineering and assistance with plant design, including feed preparation, off-gas handling, and instrumentation.
- MIM will work closely with the engineering contractor selected by the licensee to ensure successful design, construction and startup.



The control panel of the 250 kg/h ISASMELT pilot plant at Northfleet which is used to carry out test smelting runs for potential clients. Another pilot plant operates at Mount Isa.

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MTM

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Federal and State Grant Funding

Encore has been advised that TASMELT Stage 2 may be eligible for a Commonwealth Feasibility Study Fund grant of up to $50,000 on a dollar-for-dollar matching basis.

There is also the possibility that an equivalent amount of funding on a similar basis might be forthcoming via the resources of the Tasmania State Government within the $50,000 limit.

A formal application for these funds is to be made.