

ALBION PROCESS™ SIMPLICITY IN LEACHING

ZINC APPLICATIONS



ALBION PROCESS™



xstrata
technology

1 General Albion Process™ Description

The Albion Process™ is a combination of ultrafine grinding and oxidative leaching at atmospheric pressure. The feed to the Albion Process™ is a concentrate containing base or precious metals, and the Albion Process™ is used to oxidise the sulphide minerals in the concentrate and liberate these metals for recovery by conventional means.

The Albion Process™ technology was developed in 1994 by Xstrata PLC and is patented worldwide. There are three Albion Process™ plants currently in operation. Two plants treat a zinc sulphide concentrate and are located in Spain (4,000 tpa zinc metal) and Germany (18,000 tpa zinc metal). A third Albion Process™ plant is operating in the Dominican Republic treating a refractory gold/silver concentrate, producing 80,000 ounces of gold annually. A photograph of the Las Lagunas IsaMill™ and oxidative leaching circuit is shown in Figure 1. Xstrata Technology is currently completing the design and supply of an Albion Process™ plant for the GPM Gold Project in Armenia. Procurement has begun for this project, with civil works on site advanced. The GPM Gold Project will commission in September, 2013.



Figure 1
Las Lagunas Albion Plant

The first stage of the Albion Process™ is fine grinding of the concentrate. Most sulphide minerals cannot be leached under normal atmospheric pressure conditions. The process of ultrafine grinding results in a high degree of strain being introduced into the sulphide mineral lattice. As a result, the number of grain boundary fractures and lattice defects in the mineral increases by several orders of magnitude, relative to un-ground minerals. The introduction of strain lowers the activation energy for the oxidation of the sulphides, and enables leaching under atmospheric conditions. The rate of leaching is also enhanced, due to the increased mineral surface area.

Fine grinding also prevents passivation of the leaching mineral by products of the leach reaction.

Passivation occurs when leach products, such as iron oxides and elemental sulphur, precipitate on the surface of the leaching mineral. These precipitates passivate the mineral by preventing the access of chemicals to the mineral surface.

Passivation is normally complete once the precipitated layer is 2 – 3 μm thick. Ultrafine grinding of a mineral to a particle size of 80% passing 10 – 12 μm will prevent passivation, as the leaching mineral will disintegrate prior to the precipitate layer becoming thick enough to passivate the mineral. This is illustrated in Figure 2.

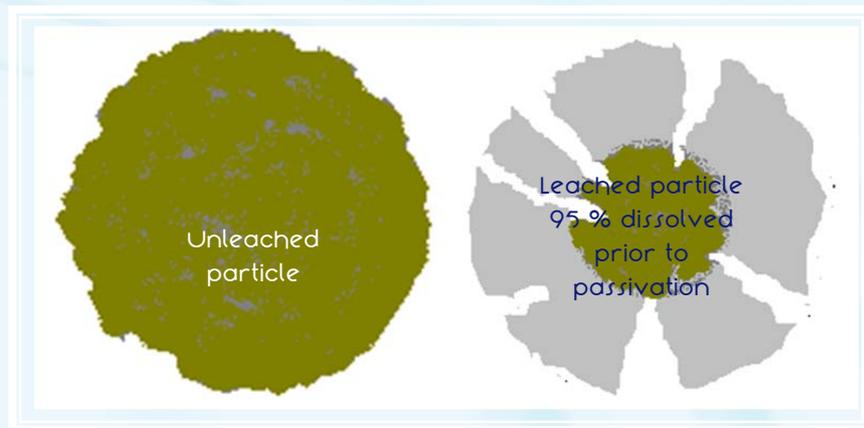


Figure 2
Mechanism of Passivation of Sulphide Minerals

After the concentrate has been finely ground, the slurry is then leached in agitated vessels, and oxygen is introduced to the leach slurry to oxidise the sulphide minerals. The agitated leaching vessels are designed by Xstrata and are known as the Albion Leach Reactor. The Albion Leach Reactor is agitated using dual hydrofoil impellers and oxygen is introduced to the leach slurry at supersonic velocity to improve mass transfer efficiency and ensure efficient oxidation of the sulphides. The Albion Leach Reactor is designed to operate at close to the boiling point of the slurry, and no cooling is required. Leaching is carried out autothermally, and the temperature of the leach slurry is set by the amount of heat released by the leaching reaction. Heat is not added to the leaching vessel from external sources, and excess heat generated from the oxidation process is removed through humidification of the vessel off gases.

2 Ultrafine Grinding and the IsaMill™ Technology

Ultrafine grinding requires a different milling action than found in a conventional ball mill, due to the fine nature of the grinding media required. In most ultrafine grinding mills, an impeller is used to impart momentum to the media charge. Media is agitated through stirring, and the resulting turbulent mixing overcomes the tendency of fine media to centrifuge. Abrasion is the major breakage mechanism in a stirred mill. The common aspects of a stirred mill are a central shaft and a series of impellers attached to the shaft. These impellers can be pins, spirals, or discs. In stirred mills, two configurations are common. In the first, the mill shaft and grinding elements are set up vertically within the mill. This type of configuration is limited in size to typically 750 kW of installed power or less. This limitation is brought about by the large break out torque imposed on the impeller located at the base of the media charge, due to the compressive load of media sitting vertically on the impeller.

In the second configuration the mill shaft is aligned horizontally within the mill chamber. This configuration, which is used in Xstrata's IsaMill™, is more cost efficient at motor sizes in excess of 500 kW. There is very little break out torque required to begin to agitate the media charge, which limits the motor size to that required for grinding only.

The IsaMill™ is a large-scale energy efficient continuous grinding technology specifically developed for rugged metalliferrous applications. Xstrata supplies the IsaMill™ technology to mining operations around the world, with over 100 mills installed in 9 countries worldwide. The IsaMill™ uses a very high energy intensity of 300kW/m³ in the grinding chamber, resulting in a small footprint and simple installation. The IsaMill™ can be scaled up directly from small scale laboratory tests. Xstrata's IsaMill™, is installed in more than two-thirds of the world's metalliferrous ultrafine grinding applications. The grinding media size for the IsaMill™ is within the size range 1.5 – 3.5 mm. Media can come from various sources, such as an autogenous media screened from the feed ore, silica sands or ceramic beads.

Xstrata will provide the IsaMill™ as a packaged Grinding Plant, consisting of the mill, slurry feed and discharge systems, media handling system, all instrumentation and control and all structural steel and platforms. Some of the IsaMill™ Grinding Plant components are shown in Figure 3 and 4. The IsaMill™ Grinding Plant incorporates all of Xstrata's operational and design experience gained from over 100 IsaMill™ installations, ensuring a trouble free commissioning.

The IsaMill™ will contain up to eight discs on the shaft, with each disc acting as a separate grinding element. The operating mechanism for the IsaMill™ is shown in Figure 5. This allows the IsaMill™ to be operated in open circuit without the need for cyclones. The IsaMill™ produces a sharp size distribution in open circuit, as the feed must pass through multiple distinct grinding zones in series before reaching the Product Separator. This plug flow action ensures no short circuiting, and efficiently directs energy to the coarser feed particles.

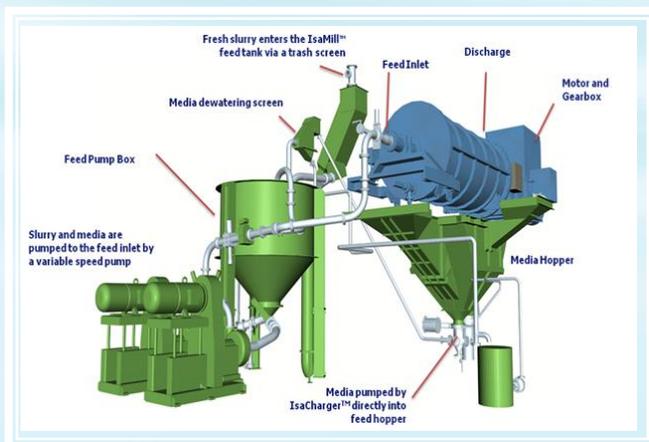


Figure 3
IsaMill™ Feed and Media Systems

passing size in the mill is typically less than 2.5 times the 80 % passing size, and very little coarse material enters the leaching circuit, resulting in very high leach recoveries.

The IsaMill™ is the highest intensity grinding technology available (>300kW/m³), meaning it is also the most compact, with a small footprint and low profile. The IsaMill™ is oriented horizontally, with the grinding plant accessed by a single platform at an elevation of approximately 3 m. Access to the mill and maintenance is simplified by the low operating aspect of the IsaMill™ and the associated grinding plant. Maintenance of the IsaMill™ is similar to routine maintenance for a slurry pump.

The Product Separator is a centrifugal separator at the end of the mill shaft that spins at sufficient rpm to generate over 20 "g" forces, and this action is responsible for the sharp classification within the mill. The IsaMill™ can be operated in open circuit at high slurry density, which is a key advantage for the leaching circuit, as the entry of water to the leach is limited, simplifying the water balance.

The IsaMill™ uses inert grinding media that produces clean, polished mineral surfaces resulting in improved leaching kinetics. A steep particle size distribution is produced in the mill. The 98 %

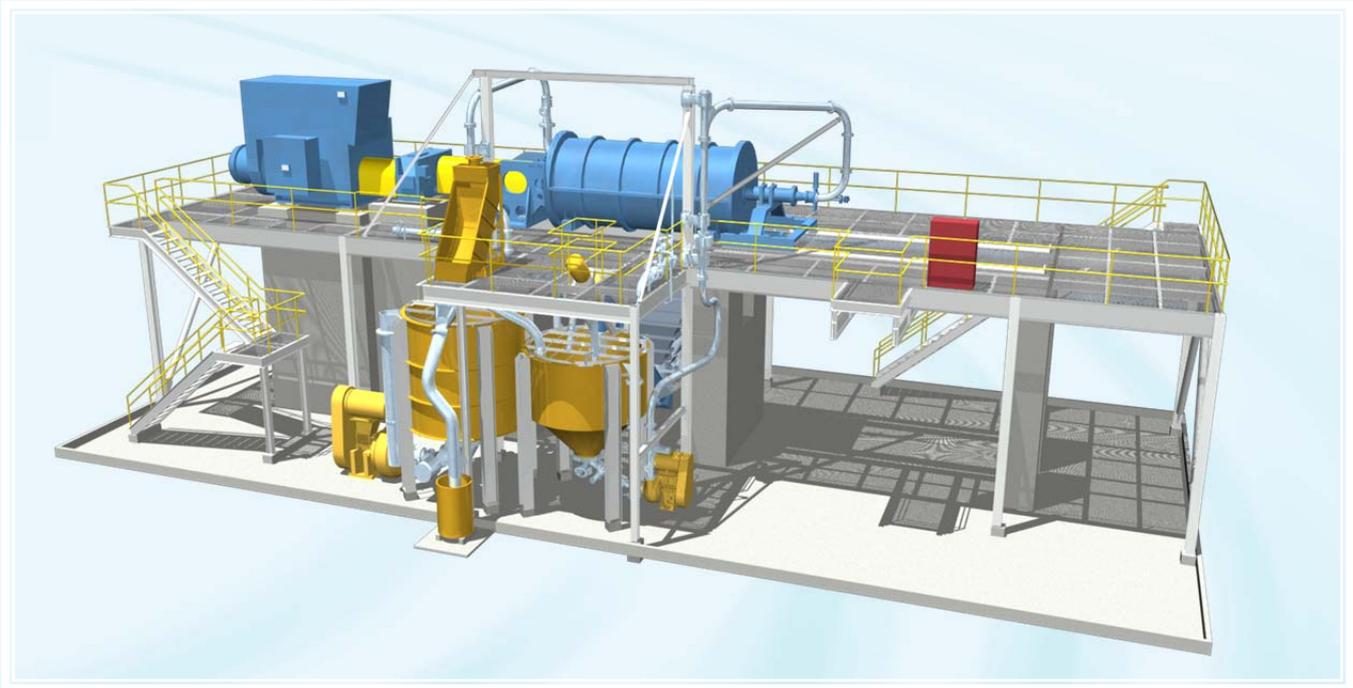


Figure 4
IsaMill™ Grinding Plant Layout

The internal rotating shaft in the IsaMill™ is counter-levered at the feed inlet end so the discharge end flange and grinding chamber can be simply unbolted and slid off using hydraulic rams. A shut down for inspection and replacement of internal wear parts takes less than 8 hours. Availability of 99% and utilisation of 96% are typical of the IsaMill™.

Scale-up of the IsaMill™ is straight forward. Laboratory test results are directly scaled to commercial size with 100% accuracy. The IsaMill™ has a proven 1:1 direct scale-up to reduce project risk.

The IsaMill™ is available in the following models:

- M500 (300 kW), capable of throughputs in the range 2 – 6 tonnes per hour
- M1000 (500 kW), capable of throughputs in the range 10 – 16 tonnes per hour
- M5000 (1200 and 1500kW), capable of throughputs in the range 20 – 60 tonnes per hour
- M10000 (3000kW), capable of throughputs in the range 60 – 100 tonnes per hour

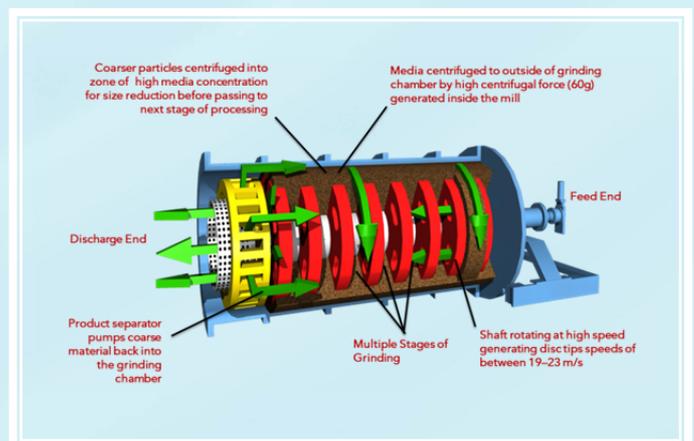


Figure 5
IsaMill™ Operating Mechanism

3 Oxidative Leaching

After the sulphide concentrate has been finely ground, it is then leached under atmospheric conditions in an oxidative leach consisting of interconnected Albion Leach Reactors. The Albion Leach Reactor is an atmospheric leaching vessel that has been designed by Xstrata Technology to achieve the oxygen mass transfer required for oxidation of the sulphide minerals at low capital and operating cost.

Oxygen is injected into the base of the Albion Leach Reactors using Xstrata's HyperSparge™ supersonic injection lances. The design of the HyperSparge™ injection system is carried out in conjunction with the design of the agitation system to ensure high oxygen mass transfer rates are achieved in the reactor. The agitator unit power is moderate, and the impeller tip speed is chosen in combination with the HyperSparge™ injection velocity to provide the required mass transfer rates.

The Albion Leach Reactor has a corrosion resistant alloy steel shell and base, supported on a ring beam or raft foundation. The tank aspect ratio is designed to achieve high oxygen transfer rates and capture efficiencies. Xstrata Technology has developed fully modular tank shell systems, which can be rapidly installed on site in one third the time of a field welded tank and at much lower costs. The Xstrata modular reactor designs require no site welding. The modular Albion Leach Reactor is shown in Figure 6.



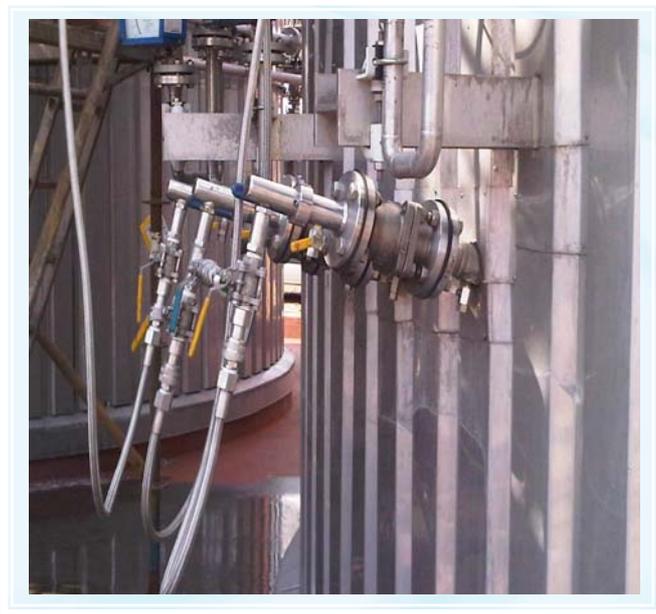
Figure 6
Albion Leach Reactor

sealing assemblies. This design ensures that no downtime is incurred for maintenance of the oxygen delivery system, as all HyperSparge™ units can be removed live for inspection.

The reactor is fitted with a centrally mounted agitator consisting of one or more hydrofoil impellers. The agitator sizing and impeller geometry is chosen by Xstrata Technology using in house correlations and testwork data to provide sufficient power to meet the oxygen mass transfer requirements in the leach vessel, as well as provide adequate solids suspension and gas dispersal. Impeller arrangements and spacing are also designed to assist in foam control within the vessel. The agitator is mounted off the tank shell, and modular maintenance platforms and structural supports are provided as part of the Albion Leach Reactor.

Key design aspects of the agitator, such as the solidity ratio, the impeller diameters and tip speeds and the overall pumping rate are determined in combination with the design of the oxygen delivery system to provide the optimum mass transfer rates in the reactor.

HyperSparge™ supersonic oxygen injection lances are mounted circumferentially around the reactor, close to the base. The HyperSparge™ is mounted externally to the tank, and penetrates through the tank wall using a series of



The HyperSparge™ injects oxygen at supersonic velocities in the range 450 – 550 m.s-1. The supersonic injection velocities result in a compressed gas jet at the tip of the sparger that incorporates slurry via shear resulting in very high mass transfer rates within the Albion Leach Reactors.

The unique design of the HyperSparge™ means that the agitator power required for the Albion Leach Reactors is much lower than is required in a conventional system. Oxygen capture efficiencies of 85 % or higher are achieved in Albion Plants within the Xstrata group using the HyperSparge™ system. A typical HyperSparge™ assembly is shown in Figure 7. The high jet velocities at the tip of the HyperSparge™ keep the nozzle clean and eliminate blockages.

The HyperSparge™ is incorporated in an overall oxygen addition and control system developed by Xstrata, consisting of in stack off gas monitoring and control of the HyperSparge™ delivery pressure. The oxygen control system is used to maintain high oxygen capture efficiencies within the Albion Leach Reactor.

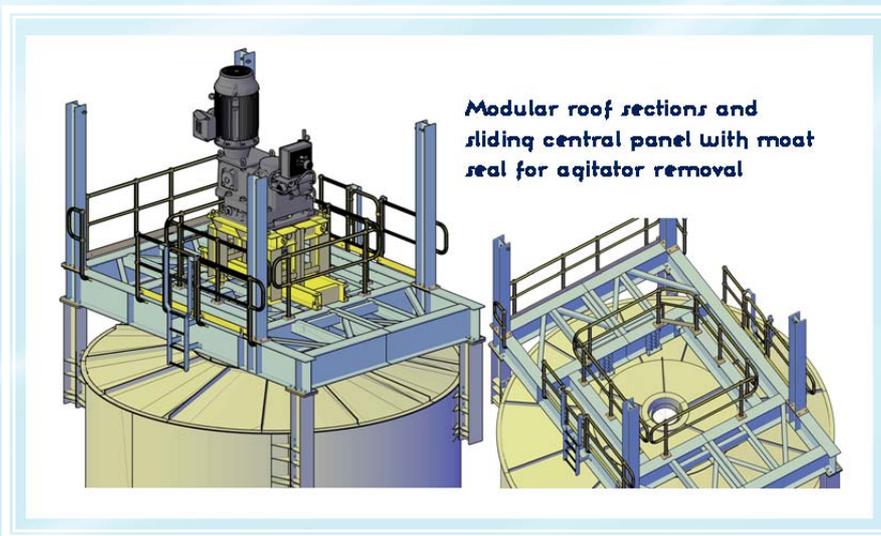


Figure 8
Albion Leach Reactor Roof Section

Exhaust gas from the oxidative leach is inert, and so the Albion Leach Reactor is fitted with sectional lids and an off gas stack to vent steam from the vessel to a safe working height. As the Albion Leach Reactors operate at close to the boiling point of the slurry, significant water vapour is released from the vessel with the exhaust gas, which assists in overall process water balance. The off gas stack is designed as a natural chimney to vent this exhaust gas to a safe working height. The exhaust gas is typically vented, however condensers can be fitted if required to recover the

evaporated water. The Albion Leach Reactor has a modular lid assembly, incorporating an agitator moat seal and sliding roof section to allow easy removal of the agitation mechanism for maintenance. This is shown in Figure 8.

Each Albion Leach Reactor has modular Internal baffles to assist mixing and prevent slurry vortexing, as well as a modular slurry riser to prevent slurry short-circuiting and assist in transport of coarser material through the leaching train.

The Albion Leach Reactors are connected in series with a launder system that allows gravity flow of the slurry through the leach train. All Albion Leach Reactors are fitted with bypass launders to allow any reactor to be removed from service for periodic maintenance. This is a low cost leaching system that is simple and flexible to operate, and the overall availability of the oxidative leach train is 99%. Xstrata Technology's launder design accommodates froth, preventing a build-up of foam in the leach train. The Launder Assembly is shown in Figure 9.

No internal heating or cooling systems are required in the Albion Leach Reactors. The vessel is allowed to operate at its equilibrium temperature, which is typically in the range 90 – 95 °C. Heat is provided by the oxidation of the sulphide minerals, with heat lost from the vessel by humidification of off gas. No direct or indirect temperature control is required, simplifying tank construction and maintenance. No external cooling towers or flash vessels are required.

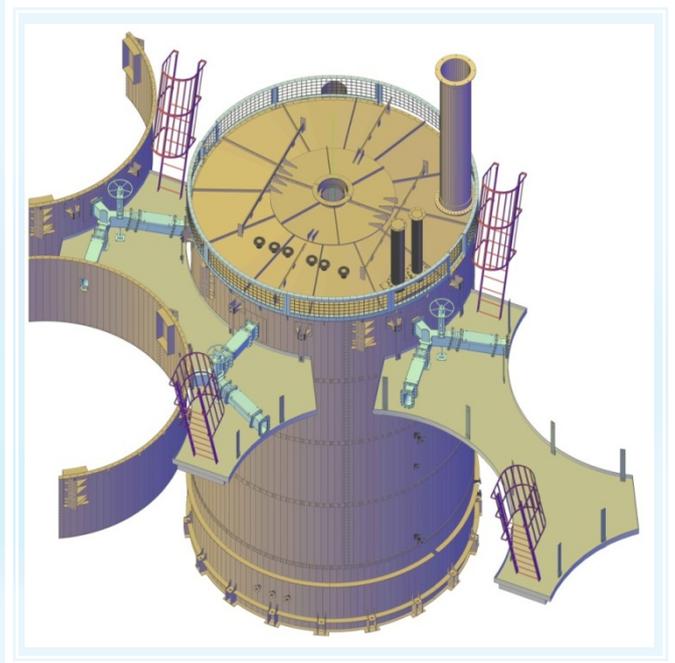


Figure 9
Launder System

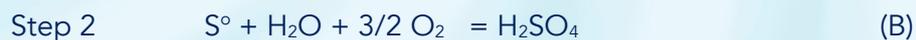
4 Oxidative Leach Chemistry

The Albion Process™ leach circuit oxidises sulphide minerals to either elemental sulphur or sulphate. This process liberates significant heat, and the oxidative leach operates at a temperature close to the boiling point of the slurry. Operating temperatures are in the range 93 – 98 °C.

At these operating temperatures, mineral leaching will occur in two steps. In the first step, the mineral sulphide is oxidised to a soluble sulphate and elemental sulphur.



In the second step, the elemental sulphur is then oxidised to form sulphuric acid.



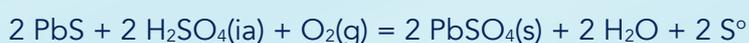
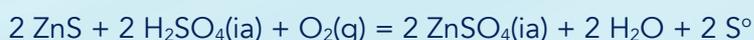
These reactions can be catalysed by the action of ferric iron under acidic conditions. The oxidative leach can be operated under a range of pH conditions, varying from acidic to neutral. The control pH will set the amount of elemental sulphur oxidation via reaction B. The extent of elemental sulphur oxidation can be varied from a few percent to full oxidation by control of the leach pH. This is the main control loop employed in the oxidative leach, with pH setpoints varied within the range 1 – 6.

For a zinc or bulk lead-zinc concentrate, the oxidative leach is operated under acidic conditions. In these systems, the background acidity is held in the range 5 – 15 gpl, and the leach acidity is maintained by either the addition of spent electrolyte from the zinc cellhouse or by allowing Reaction (B), the oxidation of elemental sulphur, to proceed. Zinc is recovered to the leach solution, and lead and silver remain in the oxidised residue for sale to a secondary lead smelter.

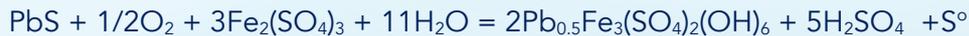
Elemental sulphur oxidation will proceed readily under the conditions found in the oxidative leach at acid levels below 10 gpl, and slows significantly as the acidity approaches 15 gpl. In this way the oxidative leach is self-regulating, oxidising elemental sulphur to maintain the required acid level.

The oxidative leach is a two stage process, where zinc and other metals are first leached in oxygenated acidic solution, with the leach slurry then neutralised to precipitate iron, aluminium, silicon and other deleterious elements such as arsenic, prior to separation of the solids and recovery of zinc from the neutralised solution. Neutralisation can be achieved by either goethite or jarosite precipitation.

Zinc concentrate would initially be ground to 80 % passing 18 - 25 microns and then leached in spent electrolyte from the zinc cellhouse or in raffinate from the zinc solvent extraction plant. Sphalerite and Galena would leach according to the reactions below.

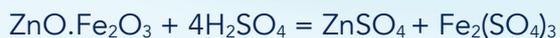


The oxidative leach would be controlled to a discharge acidity of 5 – 8 gpl, and the zinc recovery in the leach would be 98 - 99 %. Over 98 % of the galena would also be oxidised, and report to the leach residue as lead sulphate. In addition to lead sulphate, a significant amount of the lead would form plumbojarosite, according to the reaction:



Plumbojarosite is not thermally stable, and at temperatures in excess of 90 °C, would decompose to form lead sulphate. Over the duration of the oxidative leach, most of the plumbojarosite would breakdown, and the major lead bearing product would be lead sulphate.

Ferrites would also break down rapidly in the hot acidic conditions found in the oxidative leach circuit, according to the reaction:



Ferrites can act as an important iron source to the oxidative leach circuit, and the oxidative leach can be used to replace a Hot Acid Leach stage where the Albion Process™ plant is incorporated into an existing roast-leach-electrowin plant. Where ferrite leaching is desired, acid tenors at the start of the leach would be maintained at a higher level to assist in breakdown of the ferrites.

Pyrite is one of the major gangue minerals present in many zinc sulphide concentrates. The pyrite leach reaction would be:



Pyrite would not oxidise to form elemental sulphur at leach acidities below 25 gpl. Significant pyrite leaching would not occur until most of the base metal sulphides are leached to completion, due to galvanic effects, as pyrite is cathodically protected relative to these minerals. Pyrite leaching would only occur to a limited extent in the oxidative leaching circuit.

The oxidative leach would be a ferric leach, with ferric iron continuously regenerated in solution by reaction with dissolved oxygen. The oxygen would be supplied by the injection of oxygen gas into the slurry. The reaction for regeneration of ferrous iron would be:



In addition to the reactions outlined above, elemental sulphur would also be partially oxidised in the leach, according to the reaction:



In the oxidative leach circuit, the level of oxidation of elemental sulphur can be varied in the range 5 – 80 %, with control of key operating conditions. In a zinc concentrate leaching circuit, the level of oxidation of elemental sulphur would be low.

4.1 Neutralisation

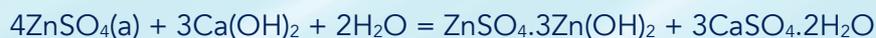
Both iron and sulphur, in the form of ferrous and ferric sulphate and acid would be liberated in the acidic leach, along with minor levels of other deleterious elements such as cobalt, cadmium, arsenic, aluminium and silicon. On completion of the leach, the oxidised slurry would be neutralised to separate these elements from the soluble zinc through precipitation.

Neutralisation can be achieved using one of two options, depending on the overall flowsheet employed for zinc recovery. Where the Albion Process™ plant forms an expansion to an existing zinc refinery, neutralisation can be carried out using calcine, and the oxidative leach discharge solution forwarded to the Neutral Leach circuit.

Where the Albion Process™ plant is a standalone facility, basic zinc sulphate would be used to neutralise the leached slurry.

When calcine is used to neutralise the oxidative leach discharge, the slurry would first be thickened and filtered. The filtrate would then be advanced to the Neutral Leach circuit and blended with other feed liquors to the Neutral Leach. Downstream processing of the oxidative leach liquor would then follow the conventional flowsheet used in a roast-leach-purification-electrowinning circuit.

When the Albion Process™ circuit is not incorporated within an existing refinery, a bleed of the rich leach liquor would be neutralised with either limestone or lime to form basic zinc sulphate slurry.



The basic zinc sulphate slurry would then be added to a Neutralisation circuit and the pH of the oxidative leach slurry would be increased progressively to oxidise and precipitate iron, aluminium, silicon and other impurities.

The Neutralisation circuit would be operated using the same Albion Leach Reactors as used in the oxidative leaching circuit, to ensure commonality of spares and simple maintenance. The inter tank launder system would be the same as employed in the oxidative leach, and all reagent mains would have dosing points extending through the interface between the leach and neutralisation stages. This would allow several tanks to be operated as either leach or neutralisation vessels, providing flexibility for differing concentrate compositions.

The following general control guidelines are applied when operating the Neutralisation circuit

- The pH profile across the neutralisation circuit would be staged to minimise super saturation of both iron and sulphate, to ensure a stable precipitate and minimise scale formation.
- Ferric levels in all tanks would be maintained at less than 1 g/L at all times and the temperature would be maintained at over 85 degrees. This would ensure that iron precipitates as goethite, and any arsenic as a stable ferric arsenate. Goethite would form a residue with good settling and filtration properties.
- The circuit would be operated with precipitated solids recycle to partially neutralise acid exiting the leach train and provide seed to the neutralisation circuit. This would enhance crystal growth at the expense of nucleation, and improve the settling and filtration properties of the precipitate.

The oxidative leach discharge slurry would initially be neutralised to a pH of 2.8 – 3.2 in the first Neutralisation Reactor, by adding calcine or basic zinc sulphate. The pH would then be increased in the subsequent Neutralisation Reactors to 3.5 - 4, with oxygen added to assist ferrous oxidation to ferric. Ferrous iron present in the leach discharge would be oxidised at the more neutral pH to ferric iron and precipitated as goethite:

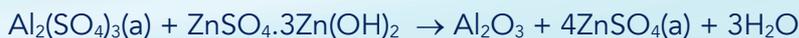


Goethite and the analogous phase, ferrihydrite, would be the favoured iron precipitates in the Neutralisation stage, due to the operating temperature of approximately 85-95°C. Minor hematite formation would also occur.

Arsenic would be fixed in the residue as a stable ferric arsenate.



Aluminium would be precipitated with goethite, along with significant amounts of other deleterious elements such as cadmium:



Some zinc losses to the goethite precipitate may occur, and this would be minimised by separating the Neutralisation circuit into two separate stages. In the first stage, the majority of the iron would be precipitated, and the residue thickened and removed by filtration. The filtrate from the first goethite stage would then be neutralised further to remove the remainder of the iron, and some zinc precipitation may occur in this stage. This precipitate would be thickened and returned to the oxidative leach for recovery of the zinc. Recycle of this precipitate would also supply ferric iron to the oxidative leach train.

Either oxygen or air can be used as the oxygen source in the Neutralisation stage. Oxygen is recommended to promote iron and arsenic oxidation kinetics and to prevent excess heat loss due to humidification of off-gas. High temperatures in the Neutralisation circuit are important in forming a stable arsenic precipitate.

As an alternative or supplement to goethite formation, and to reduce the limestone and lime demand of the Neutralisation stage, sodium can be added to the leach solution to facilitate precipitation of iron as jarosite:



Jarosite formation would occur at higher acidities than goethite, and would result in a significant reduction in limestone demand, and a reduction in operating costs for the neutralisation stage. The stability of the arsenic precipitate, however, can be lower than for a goethite precipitate. Jarosite formation may also occur in the oxidative leach due to the release of sodium and potassium ions from acid consuming gangue minerals such as albite.

5 Albion Process™ Flowsheets for Treating Zinc Concentrates

Two Albion Process™ flowsheets options for zinc recovery from zinc concentrates are shown in Figures 10 and 11. In both flowsheets, finely ground concentrate is leached in spent electrolyte from the electrowinning cellhouse. Oxygen is injected into the leach tanks to facilitate leaching. The zinc and iron bearing leach slurry is then neutralised to control iron and acid ahead of a conventional zinc dust purification and electrowinning cellhouse.

The two flowsheets differ in the method used to neutralise the oxidative leach slurry. In the first flowsheet, the neutralisation stage takes the form of a conventional neutral leach, with the oxidative leach slurry neutralised by contacting with calcine. Neutral leach residue would then be thickened and recycled to the oxidative leach circuit to recover zinc from ferrites. This flowsheet would be employed where the Albion Process™ plant is an expansion to an existing roast-leach-electrowin zinc refinery. The neutral leach stage may be preceded by a jarosite stage to reduce the total requirement of calcine in the neutral leach stage.

Where the Albion Process™ plant is to stand alone, neutralisation™ would be carried out with the use of basic zinc sulphate. This flowsheet is shown in Figure 11. The neutralisation circuit would be a two stage process, with residue from the second neutralisation stage recycled to the leach to minimise zinc losses. A jarosite stage would also be likely prior to neutralisation, again to minimise the amount of basic zinc sulphate required in the neutralisation stage.

Zinc recoveries in the Albion Process™ leach circuit are typically in the range 97 – 99 %. The capital cost of the plant is low relative to conventional roast-leach circuits, and pressure leaching, due to the simplicity of the circuit.

In the flowsheets shown in Figure 10 and 11, it has been assumed that the leaching circuit would be operated in conjunction with a conventional zinc dust purification and electrowinning circuit. Solvent extraction and electrowinning (SX/EW) is an alternative method to produce zinc metal, and the Albion Process™ circuit can be modified to suit an SX/EW circuit.

The Xstrata group of companies, through their subsidiary Austuriana de Zinc, are a supplier of zinc purification and cellhouse/casthouse technology. Xstrata operates the largest zinc refinery in the world in Spain. Xstrata can supply the entire plant necessary for the recovery of zinc from zinc concentrates through to final metal product.

Figure 10
Albion Process™ Flowsheet for Zinc Concentrates when Incorporated into an existing Roast-Leach-Electrowin Plant.

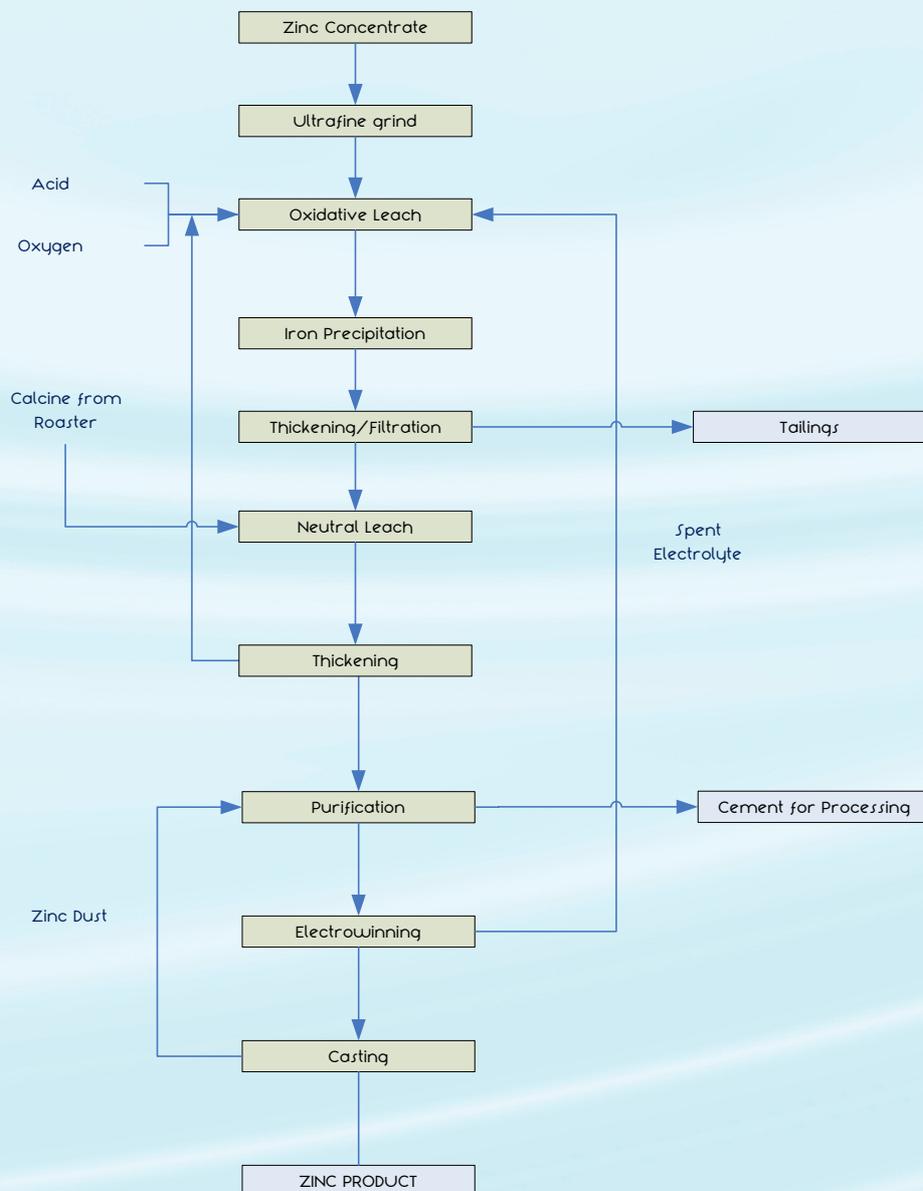
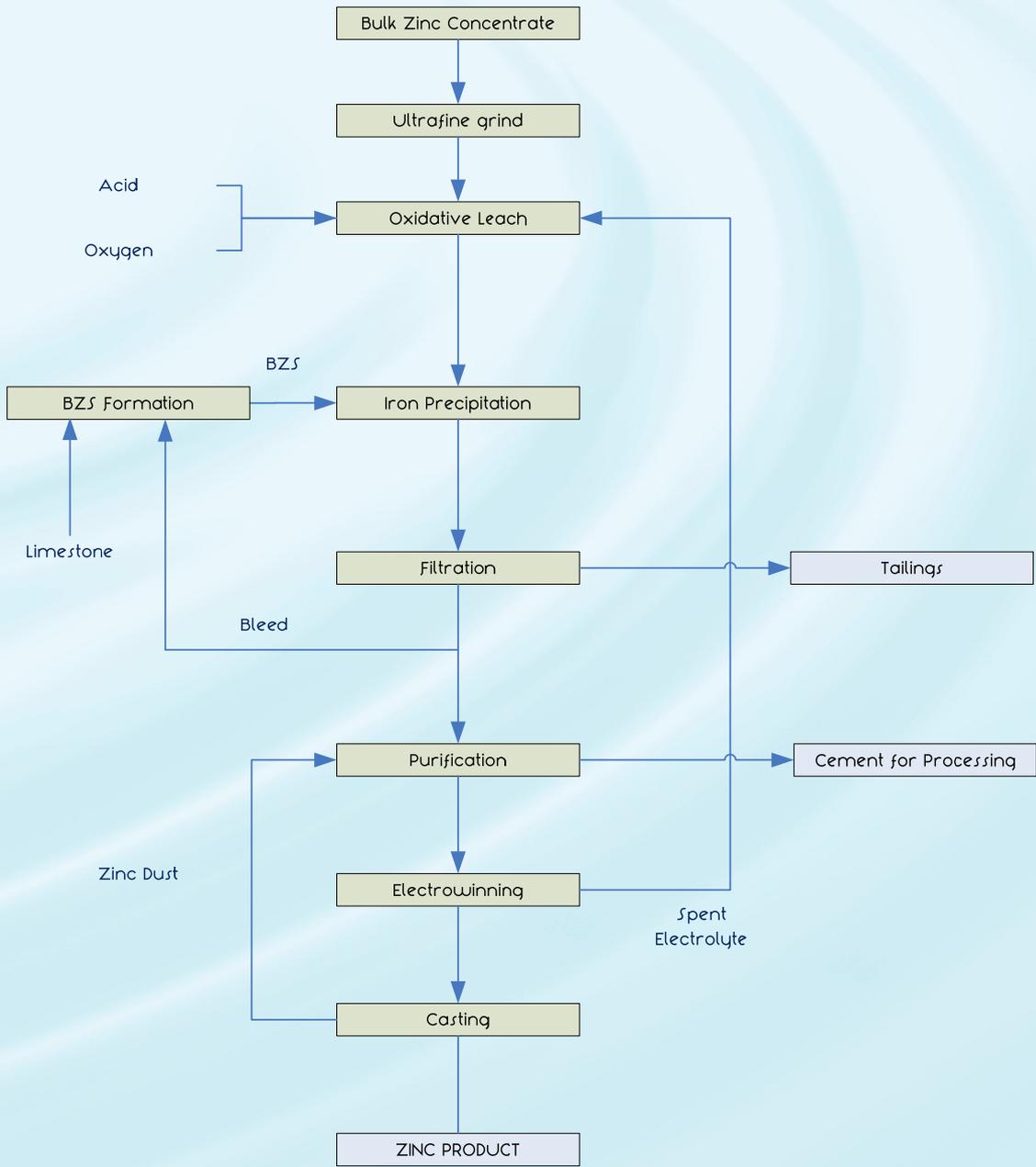


Figure 11
 Albion Process™ Flowsheet for Direct Leaching of Zinc Concentrates



6 Engineering and Project Development Services

Xstrata Technology is the developer and owner of the Albion Process™ technology and offers the technology to clients worldwide.

Xstrata Technology provides lump sum equipment design and supply packages to all Albion Process™ clients. The scope of supply includes the full Albion Process™ plant, inclusive of all structural steel, piping and launders, platforms, stairways and support structures. Full civil and foundation design can be included in the Xstrata Technology scope of work. Construction is supplied by the client, with supervisory labour provided by Xstrata.

The Albion Process plant package provided by Xstrata Technology is low cost and low risk, and incorporates all of Xstrata's knowhow in the 20 year development history of the IsaMill™ and Albion Process™ technologies. Xstrata Technology can work with our client's EPCM contractor to ensure that the Albion Process™ plant interfaces with all other plant areas in an efficient manner.

Xstrata Technology involvement in a project usually begins at the testwork stage, with a testwork and project development program designed for the client by Xstrata and our marketing partner Core Resources. All testwork is carried out at an approved testing facility. Xstrata can provide a range of Engineering Studies in support of the testwork programs to provide capital and operating cost data for the Albion Process™ plant. Xstrata Technology can also provide Feasibility Study services, ultimately leading to a lump sum equipment design and supply package, which is fully guaranteed by Xstrata.

As an introduction to the Albion Process™ technology, Xstrata can provide desktop capital and operating cost estimates for an Albion Process™ plant at no cost to our clients, once provided with a concentrate composition and planned throughput.

For more information on the Albion Process™, please refer all enquiries to:

Duncan W. Turner PhD
General Manager- Technology
Albion Process P/L
44 Corunna Street Albion, QLD 4010
Ph +61 7 3637 8105
Fax +61 7 3637 8199
Email: dturner@coreresources.com.au

Mike Hourn
Manager Hydrometallurgy
Xstrata Technology
Level 10, 160 Ann St, Brisbane, QLD 4001
Ph +61 7 3833 8539
Fax +61 7 3833 8555
Email: mhourn@xstratatech.com.au

Website www.albionprocess.com



Xstrata operates mines throughout the world.

Tough testing grounds that make our process technologies the best on earth.

**Xstrata Technology
Australia**

Level 10, 160 Ann St
Brisbane QLD 4000,
Australia

Tel +61 7 3833 8500
Fax +61 7 3833 8555
xstratatech@xstrata.com

**Xstrata Technology
Chile**

Alcántara 200, Of. 1202
Las Condes, Santiago
CP7550159 Chile

Tel +56 2 478 22 11
Fax +56 2 478 22 30
xstratatech@xstrata.com

**Xstrata Technology
Canada**

10th floor, 700 West Pender St,
Vancouver, British Columbia V6C
1G8 Canada

Tel +1 604 699 6400
Fax +1 604 689 4719
xstratatech@xstrata.com

**Xstrata Technology
South Africa**

Suite 19, Private Bag X1,
Melrose Arch 2076, South
Africa

Tel +27 82 441 7482
Fax +27 86 627 3099
xstratatech@xstrata.com

**Xstrata Technology
European Representative
United Kingdom**

Tel +44 (0) 207 746 2721
Mb +44 (0) 771 356 3353
xstratatech@xstrata.com