

## LEAD SMELTER SURVEY

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### ABSTRACT

Continuing the series of periodic surveys, a global rundown of primary and secondary lead production and refining is presented. The aim is to provide information on technology and production trends for the benefit of all involved in the industry. Recent changes in the global lead industry include closure of several two-stage production processes (sintering and lead shaft furnaces or Imperial Smelting Furnaces), mainly in the Western world. New producers can treat secondary materials from the more and more dominating lead-acid battery scrap sector; this compensates for the loss of primary production in the Western world. Production in Asia has grown very fast and so the world production has grown to 8.5 Mt/y in 2008. However the impact of the recent global financial crisis may bring some changes. Summaries of production statistics and technologies used will help the lead industry to benchmark its operations.

Keywords: lead production, primary lead smelting, secondary lead smelting, lead refineries, pyrometallurgy,

## **INTRODUCTION**

The survey of primary lead smelters presented in this paper forms the latest of the series of surveys that have been undertaken for, and presented at, recent Lead/Zinc conferences. The data collected provides a useful oversight of the evolution of industrial practice. Previous surveys of primary and secondary lead production and refining were reported in 1987[1], 2000[2], and 2005[3]. A summary of the respondents to these surveys during this period are given in Table 1. It can be seen that a number of companies continue to provide information on a regular basis. Overall the number of companies participating in this exchange of information, is gradually increasing with time. This is an encouraging sign; however, there is still a considerable way to go before we can say we include all primary lead smelters.

In examining the trends in global primary lead production it was pointed [4] out that there has been an overall decline of production capacity in the Western world in excess of 800,000 tonnes per annum over the previous 20 years. Of this total capacity decrease 40% is from plants in Europe, 23% from USA, 13% South America, and 12.5% Japan. This significant restructuring of primary metal production is associated with the closure of smelters, particularly ISF furnaces in Western Europe, and the shutdown of plants using older process technologies that cannot meet increasingly stringent environmental requirements. In most cases this loss of primary metal capacity has been accompanied by the complete closure of the plant. However, there are some examples of companies changing from primary metal production to secondary lead production. For the first time the survey includes data from the new smelting technologies established in China as that country continues to develop increased production capacity across the whole of its metallurgical sector.

A summary of production outputs from primary lead processing technologies over the period in which the surveys have been carried out is provided in Table 2. The data provided in the present survey marked as 2010 in fact reflects production in the calendar year 2008. Total production reported by the respondents accounts for 1,429,000 tonnes primary lead metal, 496,300 tonnes secondary lead metal and 1,020,000 tonnes refined lead metal.

Despite strong metal prices in the preceding years, 2008 saw the onset of a global financial crisis that impacted production worldwide. This resulted in an uncharacteristic or atypical year for most operations, making it difficult to draw comparisons with previous surveys. However, it would appear that the crisis did not on its own lead directly to major plant closures, even though it affected profitability.

A detailed review of secondary smelters was provided in the previous conference of this series [5] and so will not be discussed here, however, those data that were provided by respondents to the present survey have been included in this paper.

## **LEAD SMELTING TECHNOLOGIES**

### **PRIMARY SMELTERS**

It can be seen from Table 3 that the range of technologies used in primary lead smelting have expanded; in addition to the classic lead concentrate sinter/lead blast furnace or zinc concentrate sinter/Imperial Smelting Furnace routes (see Figure 1), which themselves have been adapted to treat a variety of feedstocks, several alternative processes take in significant proportions of secondary materials.

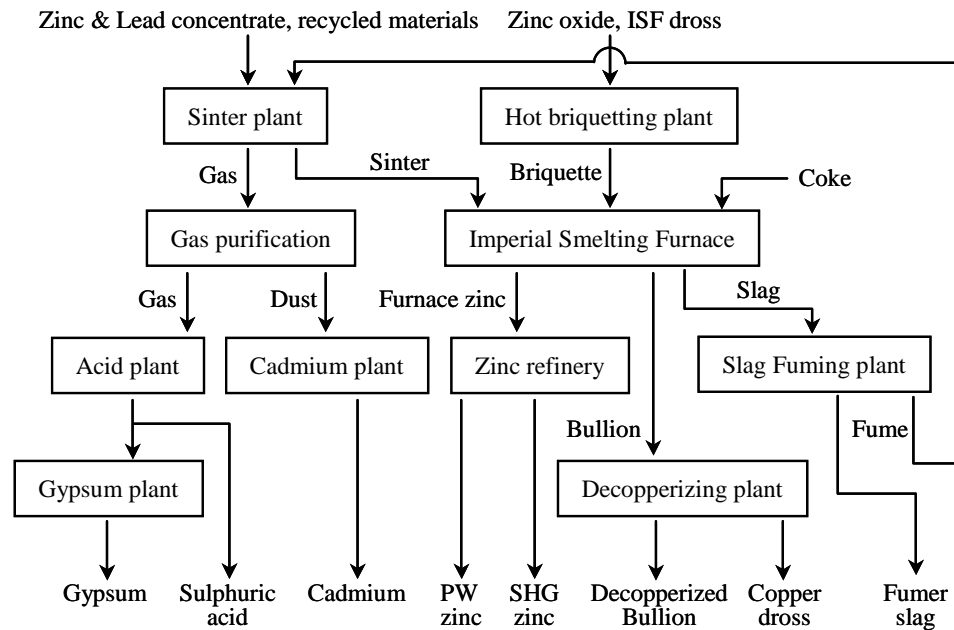


Figure 1 Process flowsheet for the Hachinohe plant

Recently implemented lead smelting technologies include:

Kivcet Furnace [6]

Dry and blended charge is submitted together with oxygen continuously through burners at the top of an oxidation shaft. The charge is ignited as it enters the reaction shaft. Temperatures up to 1400°C are reached and desulpherisation is achieved. Coarse coke breeze added at the same location forms a layer on the slag bath to reduce the majority of the PbO. Accretion management and the directly dependent performance of the coke checker is one of the most critical control parameters to the entire operation. Partly reduced slag and bullion flow under a partition wall into the electrically-heated reduction section of the furnace, where additional coke or coal is added for final reduction. Lead bullion is tapped from the furnace at one location in the reduction zone. Reaction gases from the oxidation and reduction zone are treated separately. Dust from the oxidation zone can be returned to the furnace, and dust from the reduction zone is used for zinc recovery.

QSL Furnace [7]

The furnace is a horizontal cylinder lined with chrome-magnesite bricks with an oxidation and a reduction zone. Tuyeres at the furnace bottom supply oxygen to the oxidation zone and a mixture of air and coal dust to the reduction zone. Feed, primary and secondary material and some coal, is introduced into the top of the furnace. The oxidation zone produces lead bullion, sulphur dioxide and a lead-rich slag. The lead-rich slag flows into the reduction zone where additional lead bullion is recovered. The Pb-bullion flows in the reverse direction to the lead tap hole in the oxidation zone. Slag is tapped from the opposite end of the furnace in the reduction zone. Exhaust gases containing high SO<sub>2</sub> levels are used for heat recovery and after dedusting for sulphuric acid production. The QSL process was designed to produce lead from primary materials and a wide range of secondary materials and to optimize energy recovery. One advantage is the ability to use materials that are moist and sized from fine materials to larger lumps.

TBRC Process [8]

This batchwise operating process consists of a rotary furnace, which is equipped with a top blowing lance. It is used by Boliden Rönnskär Smelter. It achieves high reaction efficiency by combining reagent blowing through the lance and the rotation of the furnace.

#### Doerschel Process [9]

The Doerschel process uses a rotary furnace and is used by KGHM Polska. Lead bearing dust and slimes in the adjacent copper smelter are treated as raw materials.

#### Electric furnace process [10]

This process is used at Kosaka Smelter in Japan. Zn leaching residues, lead dross, battery paste and other are charged into an arc type electric furnace. Raw materials are converted into bullion, matte and slag.

The Pb concentration in the bullion is 83%, while the matte contains 7,4% Pb and the slag 2,5%Pb.

#### Top Submerged Lance (Ausmelt, IsaSmelt) [11,12]

The top submerged lance designs, developed and refined by Ausmelt and IsaSmelt, are based on the original SIROSMELT concept. The vertical lance inserted into the slag bath is cooled on the inside by the incoming process gas. The lance is protected on the outside from attack by the bath material by the frozen slag layer formed on the outer lance surface. The furnaces typically use oxygen enrichment and lump coal or coke to control the bath conditions. The furnace shell is fixed and lined with refractory bricks or enhanced cooling systems. Waste heat boilers are used to recover heat from the process gases. The processes can be operated in batch or continuous mode. The application of these technologies has been reported in the literature for both primary and secondary smelting.

A variety of feeds including wet lead sulphide concentrates, leach residues, battery paste and lead scrap have been used with these furnaces to produce direct lead metal for secondary lead production. Direct lead smelting can also be achieved with high lead concentrate feeds.

The Isasmelt process has been used instead of a sinter plant at the YMG Qujing operation, Kunming China. The high lead sulphide concentrate feed is used to smelt direct lead and produce lead-rich slag. The slag is cast into molds and the solidified lump, together with supplementary limestone flux, is subsequently fed into the lead blast furnace.

#### SKS [13,14]

The Shui Kou Shan lead smelting process (SKS) is a bath smelting process consisting of a horizontal rotary furnace with enriched-oxygen injection through submerged tuyeres. The reactor has been developed to process lead sulfide concentrates, replacing existing sintering circuits, thereby reducing lead dust and SO<sub>2</sub> emissions to the environment and damage employee health. The process is used to produce lead metal and lead-rich slag. In the initial process concept the slag is charged to a lead blast furnace. A second generation of the process concept proposes the transfer of liquid slag into a slag reduction furnace with side blowing lances eliminating the blast furnace. The most recent technology adaptation a bottom blowing electrothermal furnace is applied for slag reduction. In China, a number of smelters have been built using the SKS process and are in commercial production. This new smelter design complies with current Chinese government requirements and is expected to replace some of the lead smelter capacity recently shut down due to environment concerns. An example of the integration of the SKS smelting process technology into the Yuguang plant in China is given in Figure 2.

A more detailed review of the advances in primary smelting technologies can be found elsewhere [15]

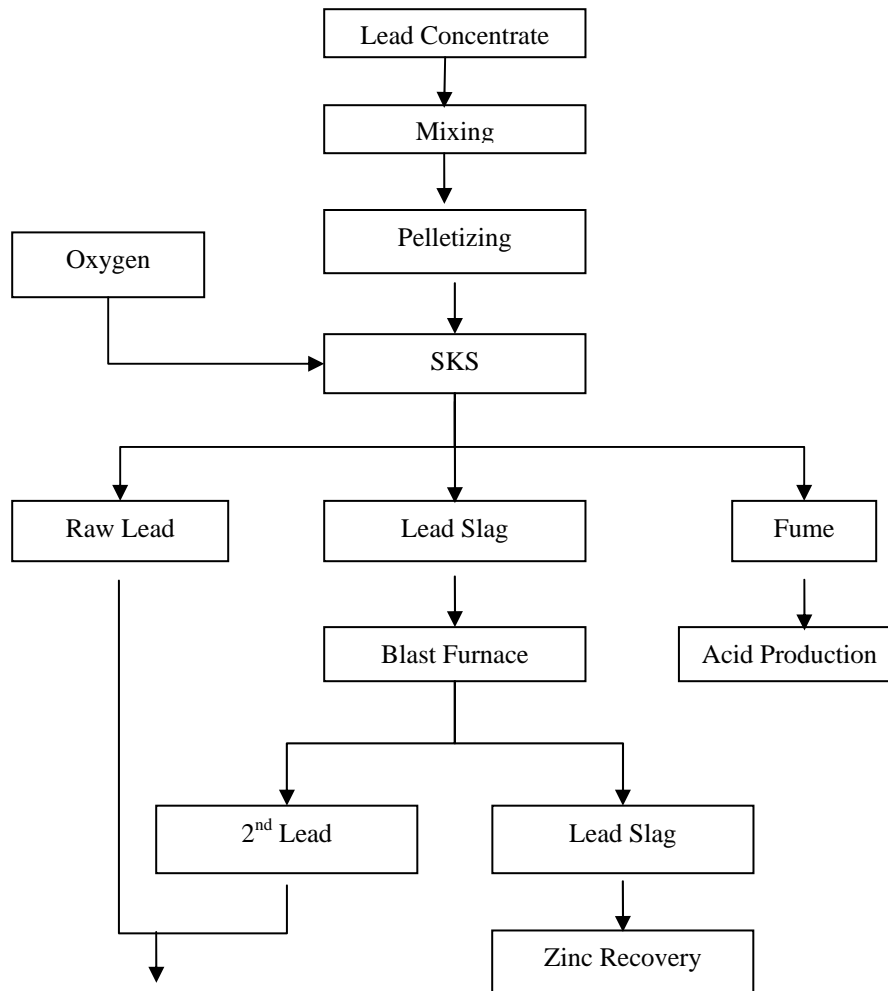


Figure 2 Flowsheet for primary lead smelter at Yuguang

## SECONDARY SMELTERS

The most important feed material for all secondary smelters is lead-acid battery scrap. Other materials, such as, leach residues, drosses, ashes, residues from lead chemicals production, lead glass residues, roofing lead, and lead scrap are also of interest. Battery scrap is mechanically processed before smelting the lead containing fractions. Some plants work with a feed of drained whole batteries for shaft furnaces or even rotary furnaces. Secondary smelters are typically smaller than primary smelters, and are located near the market of the battery scrap. Products of the simpler refining process of secondary smelters are Pb alloys according to customer demands. Worldwide approximately 170 secondary lead smelters are currently in operation.

### Shaft furnace process for whole batteries:

Drained and partly broken batteries are charged together with other feed materials and iron scrap, for the matte formation, to the furnace in layers with metallurgical coke. The latter ensures high bed permeability for gas flow. All plastic is destroyed. This requires an afterburner. Flue dust is recovered from the furnace gas and is

returned if needed after dechlorination by leaching. Sb-containing lead bullion and matte together with slag leave the furnace. Matte and slag are separated after cooling. Matte is given to a primary smelter able to handle the S-rich material for recovery of sulphur and lead. The shaft furnace process is a robust and simple process with the disadvantage of loss of the polypropylene, which has become more and more valuable with increasing oil prices.

Processing of batteries after separation:

Batteries are broken and separated in a sink-swim technology to recover metallic lead, lead paste, sulphuric acid, polypropylene and other waste plastic and rubber materials. Polypropylene can be sold. Sulphuric acid may find a further use in other applications. Metallic lead from the grids is melted with scrap to raw Sb-containing lead, whereas the lead paste can be processed as such or after desulphurisation with other suitable feed material to Sb free raw lead. Some plants sell the S-containing paste to primary smelters. Smelting furnaces for the metallics and the paste are short rotary furnaces, rotary furnaces, reverberatory furnaces, shaft furnaces or electric furnaces.

Some examples typical of the secondary lead smelters are given in Figures 3-5, illustrating the variety of processes and process combinations now being employed.

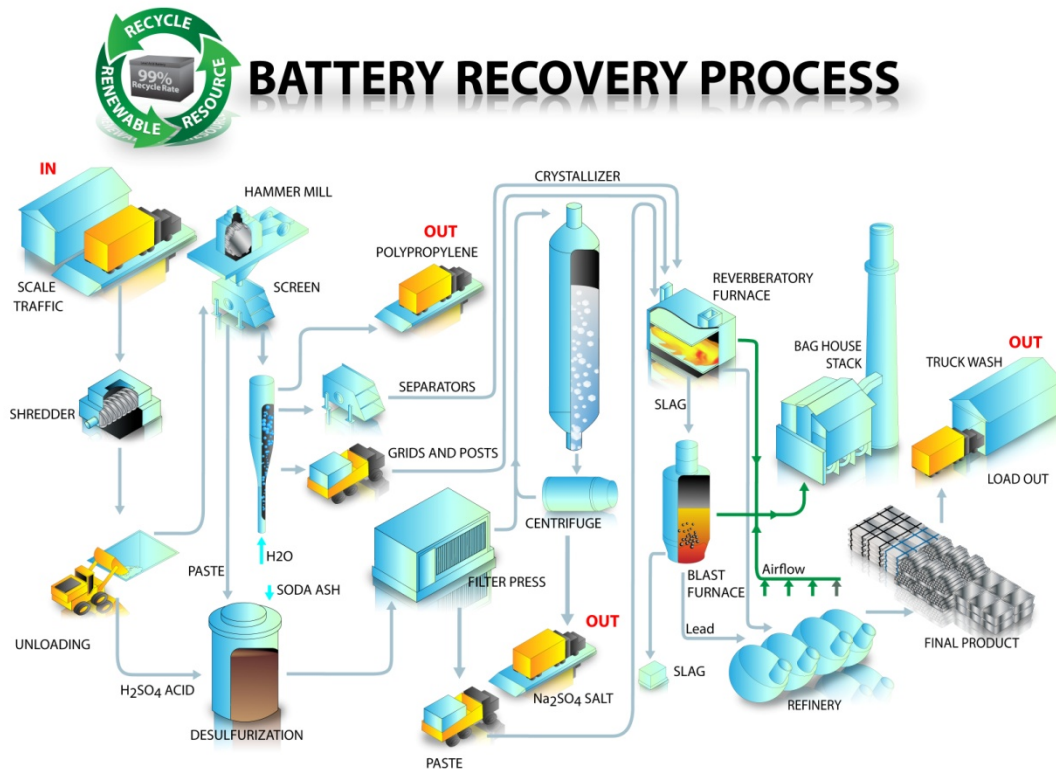


Figure 3. Process flowsheet for Doe Run Boss secondary lead smelter [16]

Figure 4. Process flowsheet for the Kovohute Plant

### **PLANT SURVEYS**

Details of the plant operations in 2008 are provided in Tables 4 - 7 for Primary Smelters, Secondary Smelters and Lead Refineries.

In relation to Primary Smelters (Table 4) it is apparent that the sinter plant/lead blast furnace plants have in many cases been adapted to treat a range of different feed materials; not only lead concentrates but also a range of secondary and waste materials are used.

As indicated above the principal feed to secondary smelting (Table 5) is lead acid batteries. For this reason the operations tend to be associated with the supply of these materials and in general tend to be smaller in capacity.

The details of lead refineries (Table 6) have been split into two categories i) pyrometallurgical processes (Table 6), and b) electrorefining using the Betts process (Table 7).

In some cases the refinery operations are linked to primary operations, in others secondary operations for clarity of presentation separate listings are provided in the tables.

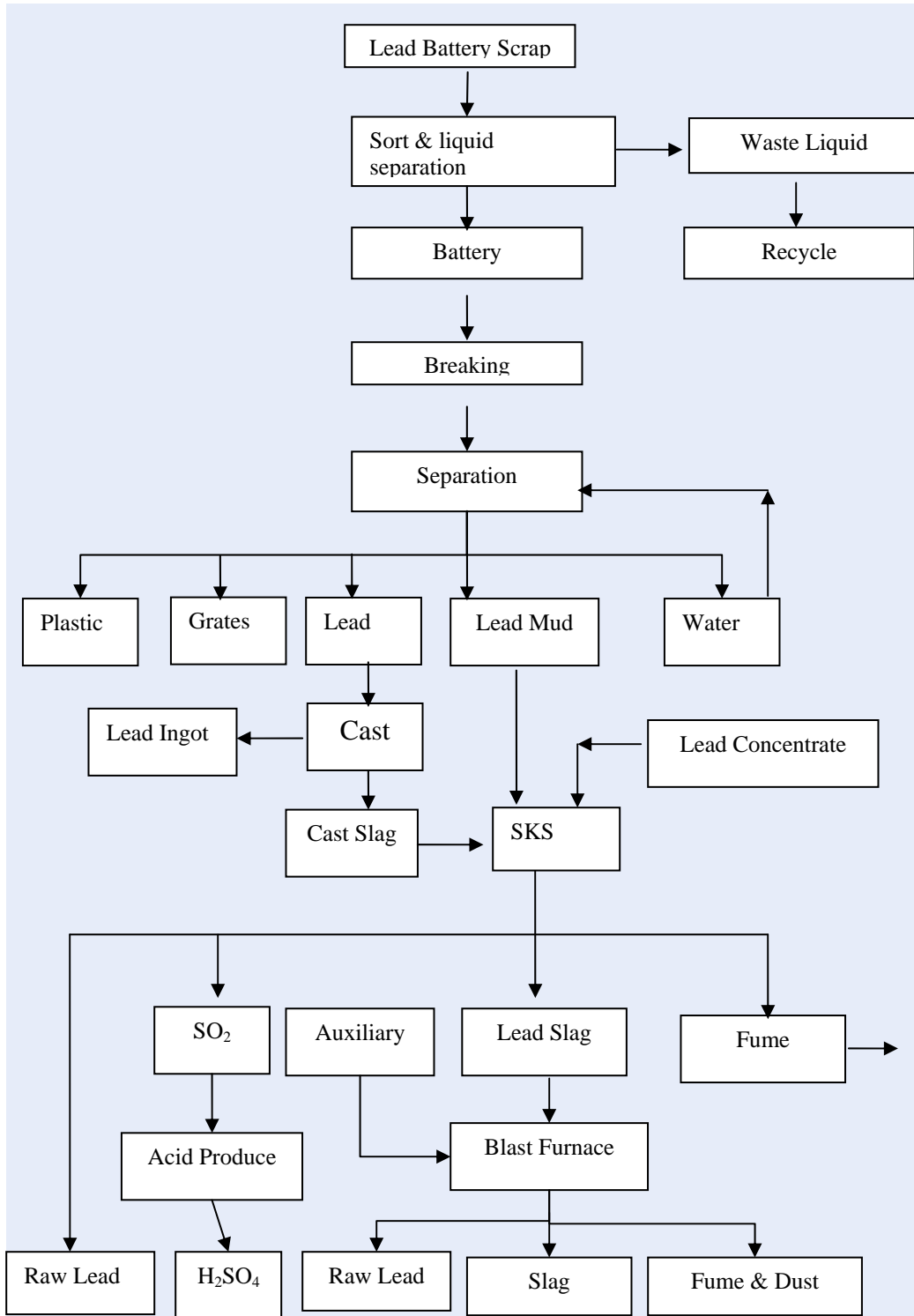


Figure 5. Process flowsheet for the Yuguang secondary lead plant



Table 1 Summary of respondents to primary lead surveys (P = Primary, S= Secondary, R = Refinery).

Primary Smelters Company/plant	1987	2000	2005	2010
Mt Isa, Xstrata Zn	P	P,R		P,R
Port Pirie, Nyrstar	P	P,R	P,R	P,R
Hachinohe		P	P	P
Harima, Sumitomo		P,R	P,R	P,R
Hosokura		P,R	S,R	
Kamioka	P	S,R	S,R	S,R
Chigirshima, Toho	P	P,S,R	R	P,S,R
Takehara, Mitsui	S		S, R	
Chanderiya, Hindustan		P,R		
Onsan, Korea Zinc/		P, R		
East Helena, Asarco		P,R		
Trail, TeckCominco/	P	P,R	P,R	
Herculaneum, DoeRun	P	P,R		P,R
Boss, DoeRun				S,R
Torreon, MetMex		P,R	P,R	P,R
Brunswick, Xstrata Zn	P	P,R	P,R	P,R
Berzelius Stolberg	P	P,R		
Ronnskar, Boliden	P	P,R	P,R	P,R
MHD Duisburg		P		
Portovesme		P,R		
KGHM Polska			P,R	P,R
Romplumb Baia Mare			P	
Kosaka			P,R	P,R
Chihong				P
East Penn				S,R
Newalta				S
Yuyuanguang				P,S,R
Olow, KGHM				S
Plovdiv, KCM				P,S,R
Northfleet, Britannia Refined Metals		R	S,R	
Norddeutsche Affinerie/Aurubis		R		R
Laverton, Alexandria Australian Refined Alloys			S	
Mutlu Izabe / Istanbul				S,R
EcoBat Indiana/West/NY			S	
Kovohute Pribram,			S	S,R
Hoboken	P			
Nordenham	P			
Boliden Begsoe	S			
Avonmouth	P			
Tsumeb	P			
Ecometal				S,R

Table 2 Summary of lead metal production from selected plants (,000 tonnes)

Primary Smelters Company/plant	1987	2000	2005	2010
Mt Isa, Xstrata Zn	160	156		167.3
Port Pirie, Nyrstar		215	231.6	220.8
Hachinohe		44.2	37.9	41.0
Harima, Sumitomo		22.0	23.7	30.0
Hosokura		20.5	22.2	
Kamioka	30.0	34.0	26.5	21.9
Chigirshima, Toho	72.0	90.0	91.0	80.0
Takehara, Mitsui	36.0		40.0	
Chanderiya, Hindustan		35.0		
Onsan, Korea Zinc/ East Helena, Asarco		121.0		
Trail, TeckCominco/ Herculaneum, DoeRun	140.0	120.0	93.0	Closed
Boss, DoeRun				180.0
Torreón, MetMex				134.0
Torreón, MetMex		180	180	139
Brunswick, Xstrata Zn	60.0	108.0	85.0	90.0
Berzelius Stolberg	92	100		
Ronnskar, Boliden	10.0	35.0	30.0	15.0
MHD Duisburg		31.0		Closed, 2005
Portovesme		125.0		Closed, 2005
KGHM Polska			21.0	20
Romplumb Baia Mare			8.0	
Kosaka			26.2	24.9
Chihong				80.0
East Penn			81.8	90.7
Newalta				62
Yuyuanguang				300.0
Olow, KGHM				20
Plovdiv, KCM				61.7
Northfleet, Britannia Refined Metals		225	163	Closed, 2002
Norddeutsche Affinerie/Aurubis		15		16.5
Laverton, Alexandria, Australian Refined Alloys			40	
Mutlu Izabe / Istanbul				18.7
EcoBat Indiana/West/NY			300	
Kovohute Pribram, Hoboken	50		29.3	36.1
Hoboken	50			Closed partly
Nordenham	102.3			
Boliden Bergoe	60.0			
Missouri, AMAX	130.0			
Avonmouth	36.0			Closed, 2002
Ecometal				10.6

## SUMMARY

The relatively rapid changes in lead primary and secondary lead smelting technologies continue to spread through operations world-wide reflecting changes to economic and environmental factors. Whilst primary smelter production continues after the departure of a number of major players those plants continuing operation have changed their processes so as to be able to treat a diversity of source materials including complex process wastes and recycled materials. New primary production has been installed in China using new smelting technologies.

Secondary smelter operations are focused on the treatment and recycling of materials from lead acid batteries. Where these changes have taken place they have flowed through to alterations in lead refineries to respond to changes in relative impurity levels.

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Table 3 Summary of lead metal production technologies from selected plants

Primary Smelters Plant, Company	Country	Primary Type	Refinery
Mt Isa, Xstrata Zn	Australia	S & B	Pyro
Port Pirie, Nyrstar	Australia	S & B	Pyro
Hachinohe	Japan	S & ISF	Pyro
Harima, Sumitomo	Japan	S & ISF	Betts
Hosokura	Japan	S & B	Betts
Kamioka	Japan	S & B	Betts
Chigirshima, Toho	Japan	S & ISF	Betts
Takehara, Mitsui	Japan	S&B(1987)	Betts
Chanderiya, Hindustan	India	S & ISF	Pyro
Onsan, Korea Zinc	Korea	QSL	Betts
East Helena, Asarco	USA	S&B	
Trail, TeckCominco/	Canada	KIVCET	Betts
Herculaneum, DoeRun	USA	S & B	Pyro
Boss, DoeRun	USA	Rev &B	Pyro
Torreón, MetMex	Mexico	S & B	Pyro
Brunswick, Xstrata	Canada	S & B	
Berzelius Stolberg	Germany	QSL	Pyro
Ronnskar, Boliden	Sweden	TBRC	Pyro
MHD Duisburg	Germany	S & ISF	
Portovesme	Italy	S & ISF	Pyro
KGHM Polska	Poland	Doers	Pyro
Romplumb Baia Mare	Romania	S & B	Pyro
Kosaka		Elect	Betts
Chihong	China	Isa & B	
East Penn	USA	Rev &B	
Newalta		Rot	
Yuyuang	China	SKS & B	Betts
Olow, KGHM	Poland	Rot	Pyro
Plovdiv, KCM	Poland	Rot	Pyro
Northfleet, Britannia	UK		Pyro
Norddeutsche Affin Aurubis	Germany		Pyro
EcoBat -Indiana/West/NY	USA		
Kovohute Pribram,	Romania		Pyro
Hoboken	Belgium	S&B	
Nordenham	Germany		Pyro
Binsfeldhammer, Bezelius	Germany	S&B	Pyro
Ronnskar Lead, Boliden	Sweden	Elect	Pyro
Missouri, AMAX	USA	S&B	
Kabwe, Zambia Copper	Zambia	S&B	
Avonmouth	UK	S&B	
Elswick, Associated Lead	UK	Rotary kiln	
Tsumbe	Numibia	S&B	
Ecometal			Pyro
Mutlu Izabe / Istanbul			Pyro

Table 4. Primary Lead Smelters.

<b>1.</b>	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Chihon	The Doe Run Company. Herculaneum Facility	Henan Yuguang Gold & Lead Co. Ltd.
<b>2.</b>	<b>Annual Production – Lead</b>	MTPY	90,000	80,000	163,000	300,000
	Cu-Dross	MTPY	0		10800	
	Sb-Slag	MTPY	0			
	Bi-crust	MTPY	0			
	Dore	MTPY	400			
	Copper Matte / Speiss	MTPY	3000			
<b>3.</b>	<b>Flowsheet</b>		Sinter / Blast Furnace / Refinery	Lead concentrate- pelletizing- ISA- raw lead- electro refining	Blast Furnace	Pelletising, SKS, Blast furnace, refining
<b>4.</b>	<b>Applied Technologies</b>					
4.1	Benefication / Separation		Crushing / Screening to -1.5 cm for selected feeds	Grinding/flotation selection		
4.2	Smelting		Blast Furnace	ISA-Blast furnace	Blast Furnace	SKS - Blast furnace
4.3	Refinery		Pyrometallurgical	Electrorefining	Pyrometallurgical	Electrorefining

Table 4. Primary Lead Smelters (continued)

1.	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Chihon	The Doe Run Company. Herculaneum	Henan Yuguang Gold & Lead Co. Ltd.
5.	<b>Raw Materials</b>	MTPY	260,000		220,000	600,000
5.1	<b>Concentrates</b>	%	50			
	% Pb		45	55-65	77	35—65
	% Zn		2	6	1	5-9
	% Fe			10	1.2	8-14
	% S		28	19	13.5	15-17
	% SiO <sub>2</sub>			1.55	0.6	3-7
	% H <sub>2</sub> O			6~10	7	6-8
5.2	<b>Secondaries</b>	%	50			
	Lead Paste	%	3			
	% Pb	%	70			72—78
	% S	%	3			5—7
	% H <sub>2</sub> O	%	20			11—15
	% Pb	%		20—30		
	% Zn	%		6—10		
	% Fe	%		2—3		
	% S	%		8—11		
	% SiO <sub>2</sub>	%		6—10		
	% H <sub>2</sub> O	%		5—13		
5.3	<b>Furnace Flux</b>					
	SiO <sub>2</sub>	kg / MT	0	113		25—35
	Lime	kg / MT	250	150		15—22
	Iron	kg / MT	20			38—47
	Coal	kg / MT	0	88		180—220
	Coke	kg / MT	100	163	260	171
	Other Type	kg / MT	0			

Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Chihon	The Doe Run Company. Herculanum Facility	Henan Yuguang Gold & Lead Co. Ltd.
6.	<b>Feed Preparation</b>					
6.1	<b>Blending System</b>		Feed bed followed by proportioning bins with individual weigh feeders			
6.1	<b>Dryer, if applicable</b>					
	Type					
	Number					
	Dimension	m				
	Feed Rate	MTPH		ISA20t/h,Blast Furnace10t/h		
	Inlet -H <sub>2</sub> O	%				
	Outlet -H <sub>2</sub> O	%				
	Fuel - Type			Solid, liquid		
	Calorific Value	kJ/kg				
	Gas Temperature			ISA : 990,Blast Furnace :350-450		
	Dryer Inlet	<sup>o</sup> C				
	Dryer Outlet	<sup>o</sup> C				
	Gas Volume	Nm <sup>3</sup> /hr		ISA : 3000,Blast Furnace :3000		
	Discharge Temperature	<sup>o</sup> C				



Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Chihon	The Doe Run Company. Herculaneum Facility	Henan Yuguang Gold & Lead Co. Ltd.
6.2	<b>Sinter Machine, if applicable</b>					
	Number		1		1	
	Dimensions, Hearth Area	m <sup>2</sup>	120		130	
	Nominal Capacity	MTPH	200		55	
	Sulfur Burning Rate	MT Sulfur/m <sup>2</sup> * day	1.4		0.057	
	Fuel - Type				Natural Gas	
	Cal. Value	kJ/kg	N/A		54000	
	Feed Moisture	% H <sub>2</sub> O	5		4 to 6	
	Sinter Composition					
	% Pb	%	38		45	
	% Fe	%	19		15.5	
	% S	%	1.5		< 2.2	
	Exhaust Gas - Volume	Nm <sup>3</sup> /hr	120,000		68,000	
	% SO <sub>2</sub>	%	4	8	3 to 5	

Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Chihon	The Doe Run Company. Herculanum	Henan Yuguang Gold & Lead Co. Ltd.
7.	<b>Smelting</b>					
	Number of Furnaces		1		2	3
	Type		Blast furnace	Blast furnace	Blast furnace	SKS 2 sets, Blast Furnace 1 set
	Nominal Capacity	MTPH	40		45	20
	Dimensions		1.8m x 7.3m			SKS 3.8*11.5m, blast furnace 8.6m <sup>2</sup>
7.1	<b>Smelting</b>					
	Auxiliary Fuel - Type		Coke	Coal, coke		Coke powder
	Amount	Kg (Nm <sup>3</sup> )/hr		ISA1.5t/h, Blast furnace300kg/h		700—900
	Calorific Value	kJ/kg				25000—27000
	Air Volume	Nm <sup>3</sup> /hr	14500	ISA:1300, Blast furnace 15000		0
	Oxygen Enrichment	%	27.5	30		0.99
	Oxygen Volume	Nm <sup>3</sup> /hr		2000		1900—2100
	Operating Temperature	<sup>o</sup> C	1240	1050		950—1050
	Flux as % of Feed	%	21	6.19		

Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Chihon	The Doe Run Company. Herculaneum Facility	Henan Yuguang Gold & Lead Co. Ltd.
	Refractory Lining - Type		Copper and steel water cooled jackets refractory hearth	Mg-Cr brick		Mg-Cr brick
	Campaign of Life	years	2	2		2—4
	Furnace Offgas					
	Volume	Nm <sup>3</sup> /hr	N/A	ISA : 3万Nm <sup>3</sup> /h, Blast Furnace : 3万Nm <sup>3</sup> /h		2*21000
	Temperature ex Furnace	<sup>0</sup> C	100	ISA : 990 <sup>0</sup> C, Blast Furnace : 350—450 <sup>0</sup> C		800—850
	% SO <sub>2</sub>	%	very low	8		6—10
	Gas Cooling by		none			Exhaust heat furnace
	Number of units					1
	Outlet Temperature	<sup>0</sup> C	60	200		400—430
	Dust Collection by			Environment Protection Collector	Baghouse	Vacuum and bagfilter
	Disposition of Dust		Re-process in sinter plant	Recycle	Recycled through sinter plant	return to feed
	Amount	TPH		ISA3t/h, Blast Furnace 0.4t/h	3	6

Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Chihon	The Doe Run Company. Herculeum Facility	Henan Yuguang Gold & Lead Co. Ltd.
7.2	<b>Slag Reduction</b>					
	Reducing Agent - Type			Coke		Coke
	Amount	Kg (Nm <sup>3</sup> )/hr		300kg/batch		3000—3500
	Calorific Value	kJ/kg				28000—32000
	Air Volume	Nm <sup>3</sup> /hr		15000		15000
	Oxygen Enrichment	%		23		25
	Oxygen Volume	Nm <sup>3</sup> /hr		720		550—650
	Operating Temperature	°C		1200—1300		1150—1250
	Refractory Lining - Type			Cr-Mg Brick		water jacket
	Campaign of Life	years		2		2—3

Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Chihon	The Doe Run Company. Herculeum Facility	Henan Yuguang Gold & Lead Co. Ltd.
	Furnace Offgas					
	Volume	Nm <sup>3</sup> /hr		ISA 30KNm <sup>3</sup> /h, Blast Furnace 30K Nm <sup>3</sup> /h		
	Temperature ex Furnace	<sup>o</sup> C		ISA 1000 <sup>o</sup> C, Blast Furnace 350—450 <sup>o</sup> C		550—640
	% SO <sub>2</sub>	%				
	Gas Cooling by					Cooling water tower, surface cooling
	Number of units					1
	Outlet Temperature	<sup>o</sup> C		200		
	Dust Collection by			Environment protection collector		Bag filter
	Disposition of Dust			Return to recover		Return to feed
	Amount	TPH				1.7

Table 4. Primary Lead Smelters (continued).

<b>1.</b>	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Chihon	The Doe Run Company. Herculaneum Facility	Henan Yuguang Gold & Lead Co. Ltd.
7.3	<b>Furnace Products (average)</b>					
7.3.1	Lead Bullion	MTPD	360	200	446	972
	% Pb	%		98	95	98
	% S	%		0.4		0.1
	% Cu	%		0.075		0.6
	% Sb	%		4t/a		0.2
	% Ag	%		60t/a		0.25
	Temperature	<sup>o</sup> C	1200			
7.3.2	Matte	MTPD		10		
	% Pb	%		60		
	% As	%				
	% Cu	%		15		
	% Fe	%				
	% S	%		6		
	Temperature	<sup>o</sup> C				
7.3.3	Slag	MTPD	400	246		300
	% Pb	%	1.5	50	2	3—4
	% FeO	%	33	13.62	30	31—35
	% SiO <sub>2</sub>	%	21	10.8	23	20—24
	% CaO	%	20	1.9	14	10—14
	% Zn	%	5.5	8.8	7	13—17
	Temperature	<sup>o</sup> C	1200	1200		

Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Chihon	The Doe Run Company. Herculaneum Facility	Henan Yuguang Gold & Lead Co. Ltd.
7.4	<b>Slag Cleaning / Fuming</b>					
	Number of Furnaces					2
	Type					Fume treatment furnace
	Slag Treated	MTPH				15
	Dimensions					8m <sup>2</sup>
	Reductant Type					Fume reduction
	Final Slag	MTPH				25
	% Pb	%				0.5—1.5
	% Cu	%				
	% Zn	%				2.5—4.0
	% Na	%				
	Fume Production	MTPH				
	% Pb	%				
	% Zn	%				

Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Chihon	The Doe Run Company. Herculaneum Facility	Henan Yuguang Gold & Lead Co. Ltd.
8.	<b>Sulfur Fixation</b>					
	Source of Gas		Sinter machine 100% off gas to acid plant	fume	Sinter machine	Recovered fume
	Plant - Type		Single absorber		Single absorption	
	Rated Capacity	MTPD	500	1.8tZn/a 18K tZn/a	250	550
	Gas Volume	Nm <sup>3</sup> /hr	120000	18000	68000	
	Average SO <sub>2</sub> in inlet gas	%	4	0.51	3 to 5	7—11
	Average Conversion Efficiency	%	95		90	
	Product Grade	% H <sub>2</sub> SO <sub>4</sub>	93.5	98	93	98
	Energy Requirement	KWh/MT Sulfur	0			
	Auxiliary Fuel					
	Tailgas Scrubbing			Amino acid to remove sulphide		Alkaline absorption



Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Xstrata Zinc Mount Isa Lead Smelter	KCM SA, Plovdiv	Toho Zinc Co.,Ltd. Chigirishima	Hachinohe Smelting	Sumitomo, Harima Smelter
2.	<b>Annual Production – Lead</b>	MTPY	167,304	61,770	80,000	41,027	30,000
	Cu-Dross	MTPY	6434		13500	3859	
	Sb-Slag	MTPY	0	28500 fume slag	–		
	Bi-crust	MTPY	0	780	–		
	Dore	MTPY	0	41.8	–		
	Copper Matte / Speiss	MTPY	Silver in crude lead 313	400 as matte	–		
				830 as speiss			
3.	<b>Flowsheet</b>		Sinter Plant, Blast Furnace, Partial Refining	Sinter Plant, Blast Furnace	Sinter Plant, Blast Furnace, Refining	Sinter, ISF, refining	Sinter , ISF, Refining
4.	<b>Applied Technologies</b>						
4.1	Benefication / Separation		-				
4.2	Smelting		Updraught sinter machine and blast furnace	Sinter Machine, Blast Furnace	Updraught Sinter Machine/ Blast Furnace	Updraught Sinter Machine / Imperial Smelting Furnace	Updraught Sinter Machine / Imperial Smelting Furnace
4.3	Refinery		Pyrometallurgical	Pyrometallurgical	Electrorefining		Electrorefining

Table 4. Primary Lead Smelters (continued).

1.	Company Name		Xstrata Zinc Mount Isa Lead Smelter	KCM SA, Plovdiv	Toho Zinc Co.,Ltd. Chigirishima	Hachinohe Smelting	Sumitomo, Harima Smelter
5.	<b>Raw Materials</b>	MTPY	330,413	92,800	94,000	235,200	
5.1	<b>Concentrates</b>	%	99.7	73	86	66.2	70
	% Pb		54.1	74	64.1	19.9	15.8
	% Zn		6.2	3	5.58	37.5	39.9
	% Fe		10.1	5	4.33	7.1	7.7
	% S		21.4	16	16.49	27.5	28.5
	% SiO <sub>2</sub>		1.1	2	2.83	2.7	3
	% H <sub>2</sub> O		10 - 30	7	5		
5.2	<b>Secondaries</b>	%	0.3	27	14	33.8	30
	Lead Paste	%	100	Lead Batrs13%	1.9		
	% Pb	%	70 - 90	60	72		
	% S	%	5	2.4	8.5		
	% H <sub>2</sub> O	%		17	20		
				Lead Cake 9 %			
	% Pb	%		36.8	24.56	11	6.2
	% Zn	%		12	4.04	30.3	60.8
	% Fe	%		Others 3	1.21	12.53	5.7
	% S	%		98 % Pb	11.61		
	% SiO <sub>2</sub>	%			12.96	3.49	0.8
	% H <sub>2</sub> O	%			5		
5.3	<b>Furnace Flux</b>						
	SiO <sub>2</sub>	kg / MT	119	90	50		
	Lime	kg / MT	464.7	110	240		
	Iron	kg / MT	0	250	80		
	Coal	kg / MT	0	n/a			
	Coke	kg / MT	197		218		
	Other Type	kg / MT	0.12				

Table 4. Primary Lead Smelters (continued).

<b>1.</b>	<b>Company Name</b>		Xstrata Zinc Mount Isa Lead Smelter	KCM SA, Plovdiv	Toho Zinc Co.,Ltd. Chigirishima	Hachinohe Smelting	Sumitomo, Harima Smelter
<b>6.</b>	<b>Feed Preparation</b>						
6.1	<b>Blending System</b>		Paddle mixer and disk pelletiser	Bedding	Pelletizing disc		
6.1	<b>Dryer, if applicable</b>						
	Type		Concentrate drum filters		—		
	Number		2		—		
	Dimension	m			—		
	Feed Rate	MTPH	60		—		
	Inlet -H <sub>2</sub> O	%	30		—		
	Outlet -H <sub>2</sub> O	%	13		—		
	Fuel - Type				—		
	Calorific Value	kJ/kg			—		
	Gas Temperature				—		
	Dryer Inlet	°C			—		
	Dryer Outlet	°C			—		
	Gas Volume	Nm <sup>3</sup> /hr			—		
	Discharge Temperature	°C			—		

Table 4. Primary Lead Smelters (continued).

1.	Company Name		Xstrata Zinc Mount Isa Lead Smelter	KCM SA, Plovdiv	Toho Zinc Co.,Ltd. Chigirishima	Hachinohe Smelting	Sumitomo, Harima Smelter
6.2	<b>Sinter Machine, if applicable</b>						
	Number		1	1	1	1	1
	Dimensions, Hearth Area	m <sup>2</sup>	96	48	33	90	75
	Nominal Capacity	MTPH	52	22	20	34	26
	Sulfur Burning Rate	MT Sulfur/m <sup>2</sup> * day	2.6	0.04	0.05	1.63	1.7
	Fuel - Type		Diesel	Heavy fuel oil	Heavy Fuel Oil	Heavy Fuel Oil	LPG
	Cal. Value	kJ/kg	45000	39800	39800	39100	
	Feed Moisture	% H <sub>2</sub> O	5	1	4.5	6.36	
	Sinter Composition						
	% Pb	%	48.4	41	40	19.57	17~19
	% Fe	%	9.51	15	10.5	9.75	8.5
	% S	%	1.9	2	2.5	0.7	0.5
	Exhaust Gas - Volume	Nm <sup>3</sup> /hr		180,000	18,600	60,500	53,000
	% SO <sub>2</sub>	%	4	0.5	5	7.43	6.5

Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Xstrata Zinc Mount Isa Lead Smelter	KCM SA, Plovdiv	Toho Zinc Co.,Ltd. Chigirishima	Hachinohe Smelting	Sumitomo, Harima Smelter
7.	<b>Smelting</b>						
	Number of Furnaces		1	1	1	1	1
	Type		Mount Isa Type Blast Furnace	Blast Furnace	Blast Furnace	Imperial Smelting Furnace	Imperial Smelting Furnace
	Nominal Capacity	MTPH	23	8	10	15	12 (Zinc), 4 (Lead)
	Dimensions		1.8m wide x 7m long at tuyeres	8,96 m <sup>2</sup>	5.5m×1.7m×4.2mH	27.3 m <sup>2</sup> Shaft Area	19.4m <sup>2</sup> Shaft Area
7.1	<b>Smelting</b>						
	Auxiliary Fuel - Type		Coke	Coke	Heavy Fuel Oil	Metallurgical Coke	Metallurgical Coke
	Amount	Kg (Nm <sup>3</sup> )/hr	6000	3600	60		
	Calorific Value	kJ/kg	26896		39600		
	Air Volume	Nm <sup>3</sup> /hr	25200	17500	7500	44600	36000
	Oxygen Enrichment	%	22.2		1.2	no	
	Oxygen Volume	Nm <sup>3</sup> /hr	450	300	90		
	Operating Temperature	<sup>o</sup> C	1200	1300	1200-1300		
	Flux as % of Feed	%		0	—		

Table 4. Primary Lead Smelters (continued).

<b>1.</b>	<b>Company Name</b>		Xstrata Zinc Mount Isa Lead Smelter	KCM SA, Plovdiv	Toho Zinc Co.,Ltd. Chigirishima	Hachinohe Smelting	Sumitomo, Harima Smelter
	Refractory Lining - Type		Crucible - Cookson Pimlico 7047 alumina chrome monolithic	Water Jacket, Chamot, chrome magnesite	Chrome-Magnesite-Brick		
	Campaign of Life	years	Approx 10	3	20		
	Furnace Offgas						
	Volume	Nm <sup>3</sup> /hr	95000	25000	25000	68100	47600
	Temperature ex Furnace	<sup>o</sup> C	190	500	250	450	460
	% SO <sub>2</sub>	%	0.005	0.04	0.5		
	Gas Cooling by		Air infiltration	Water Sprays	Scrubber	Gas Cooling Tower	Gas Cooling Tower
	Number of units		N/A	1	1	1	1
	Outlet Temperature	<sup>o</sup> C	N/A	120	120	35.7	35~45
	Dust Collection by		Flue dropout and baghouse	Baghouse	Bagfilter	Theisen Disintegrator	Theisen Disintegrator
	Disposition of Dust		Slurried and recycled	Recycle	Recycle		
	Amount	TPH	Approx 0.5	1.5	0.2	1.49	

Table 4. Primary Lead Smelters (continued).

1.	Company Name		Xstrata Zinc Mount Isa Lead Smelter	KCM SA, Plovdiv	Toho Zinc Co.,Ltd. Chigirishima	Hachinohe Smelting	Sumitomo, Harima Smelter
7.2	<b>Slag Reduction</b>		In furnace			In Imperial Smelting Furnace	
	Reducing Agent - Type		Coke		-	Coke	Coke
	Amount	Kg (Nm <sup>3</sup> )/hr			-		
	Calorific Value	kJ/kg			-		
	Air Volume	Nm <sup>3</sup> /hr			-		
	Oxygen Enrichment	%			-		
	Oxygen Volume	Nm <sup>3</sup> /hr			-		
	Operating Temperature	°C			-		
	Refractory Lining - Type				-		
	Campaign of Life	years			-		

Table 4. Primary Lead Smelters (continued).

1.	Company Name		Xstrata Zinc Mount Isa Lead Smelter	KCM SA, Plovdiv	Toho Zinc Co.,Ltd. Chigirishima	Hachinohe Smelting	Sumitomo, Harima Smelter
	Furnace Offgas				-		
	Volume	Nm <sup>3</sup> /hr			-		
	Temperature ex Furnace	<sup>0</sup> C			-		
	% SO <sub>2</sub>	%			-		
	Gas Cooling by				-		
	Number of units				-		
	Outlet Temperature	<sup>0</sup> C			-		
	Dust Collection by				-		
	Disposition of Dust				-		
	Amount	TPH			-		



Table 4. Primary Lead Smelters (continued).

1.	Company Name		Xstrata Zinc Mount Isa Lead Smelter	KCM SA, Plovdiv	Toho Zinc Co.,Ltd. Chigirishima	Hachinohe Smelting	Sumitomo, Harima Smelter
7.3	<b>Furnace Products (average)</b>						
7.3.1	Lead Bullion	MTPD	542.7	180	185	168.3	83
	% Pb	%	98.73	96.5	97.4	94.8	97.5
	% S	%	0.3	0.4			
	% Cu	%	0.5	1.5	0.04	3.2	1-2
	% Sb	%	0.2	0.7	1.6		0.5-1.0
	% Ag	%	0.2	0.1	0.45	0.2	
	Temperature	<sup>0</sup> C		900	1030	1000	1250-1350
7.3.2	Matte	MTPD	High Grade Export Dross 6000		None		
	% Pb	%	55				
	% As	%	0.3				
	% Cu	%	20				
	% Fe	%	0.5				
	% S	%	10				
	Temperature	<sup>0</sup> C					
7.3.3	Slag	MTPD	572.4	270	205	289	173
	% Pb	%	2.36	1.5	2.8	0.73	≤1.5
	% FeO	%	27.9	38	25	37.19	36~40
	% SiO <sub>2</sub>	%	20.91	22	21	17.98	18~22
	% CaO	%	23.81	14	18	14.04	12~17
	% Zn	%	12.63	11	12	8.25	7~9
	Temperature	<sup>0</sup> C	1200	1250	1205	1300	1250-1350

Table 4. Primary Lead Smelters (continued).

1.	Company Name		Xstrata Zinc Mount Isa Lead Smelter	KCM SA, Plovdiv	Toho Zinc Co.,Ltd. Chigirishima	Hachinohe Smelting	Sumitomo, Harima Smelter
7.4	<b>Slag Cleaning / Fuming</b>						
	Number of Furnaces			1	-	2	1
	Type			Continuous process	-	Ausmelt	Electric Furnace
						No.1 // No.2	
	Slag Treated	MTPH		12	-	12.05 // 11.2	7
	Dimensions			5,85 m <sup>2</sup>	-	3m dia×10 m high // 2.4m dia×6m high	5.6m (O.D.)
	Reductant Type			Heavy fuel oil	-	Oil Injection //Oil Injection	Metallurgical Coke
	Final Slag	MTPH		11	-	11.21 // 10.9	7
	% Pb	%		0.05	-	0.14 // 0.1	0.5
	% Cu	%		0.3	-	0.48 // 0.5	
	% Zn	%		3	-	5.0 // 3.0	5
	% Na	%			-		
	Fume Production	MTPH			-	0.84 // 0.3	0.5
	% Pb	%		8	-	9.75 // 3.9	8
	% Zn	%		65	-	63.93 // 68.3	60

Table 4. Primary Lead Smelters (continued).

<b>1.</b>	<b>Company Name</b>		Xstrata Zinc Mount Isa Lead Smelter	KCM SA, Plovdiv	Toho Zinc Co.,Ltd. Chigirishima	Hachinohe Smelting	Sumitomo, Harima Smelter
<b>8.</b>	<b>Sulfur Fixation</b>						
	Source of Gas		Sinter Plant / Blast Furnace		Sintering Machine	Sinter Plant	Sinter Plant
						Sulfuric Acid	
	Plant - Type		Nil		Sulfuric Acid Monsanto Single Contact	Lurgi Double Contact	Sulfuric Acid Single Contact
	Rated Capacity	MTPD			110	550	350
	Gas Volume	Nm <sup>3</sup> /hr			19000	62400	53000
	Average SO <sub>2</sub> in inlet gas	%			5	7.43	6.5
	Average Conversion Efficiency	%			94	99.5	97.5
	Product Grade	% H <sub>2</sub> SO <sub>4</sub>			98.3	77 & 98	98
	Energy Requirement	KWh/MT Sulfur			800		
	Auxiliary Fuel				Heater		
	Tailgas Scrubbing				SOx removal apparatus	Caustic soda	Ammonia or Caustic Soda

Table 4. Primary Lead Smelters (continued).

<b>1.</b>	<b>Company Name</b>		Kosaka Smelting & Refining Co	Torreon Smelter Met-Mex Peñoles S.A.	Nyrstar Port Pirie	Aurubis Hamburg	Boliden Rönnskär smelter
<b>2.</b>	<b>Annual Production – Lead</b>	MTPY	24,880	139,000	220,801	16,500	15,000
	Cu-Dross	MTPY	3836		12109	see refinery	1500
	Sb-Slag	MTPY	-		4146	see refinery	300
	Bi-crust	MTPY	174 ( electrolytic Bi)			see refinery	200
	Dore	MTPY	226			refined silver: 1200	0
	Copper Matte / Speiss	MTPY	-			-	300
<b>3.</b>	<b>Flowsheet</b>		Electric, refining	Sinter, Blast Furnace	Sinter, Blast Furnace	Breaker, Electric furnace, Casting, Matte converting	TBRC
<b>4.</b>	<b>Applied Technologies</b>						
4.1	Benefication / Separation		-			-	
4.2	Smelting		Electric Furnace	Sinter, Blast Furnace	Updraught Sinter Machine Blast Furnace	Electric furnace	TBRC Kaldor
4.3	Refinery		Electrorefining	Pyrometallurgical	Pyrometallurgical	Pyrometallurgical	Pyrometallurgical

Table 4. Primary Lead Smelters (continued).

1.	Company Name		Kosaka Smelting & Refining Co	Torreón Smelter Met-Mex Peñoles S.A.	Nyrstar Port Pirie	Aurubis Hamburg	Boliden Rönnskär smelter
5.	<b>Raw Materials</b>	MTPY	35,241	312,000	661,384	150,000	
5.1	<b>Concentrates</b>	%	0		77.6	no lead concentrates	100
	% Pb		-	41.45	60		70
	% Zn		-	7.48	5		7
	% Fe		-	8.53	8		3
	% S		-	18.14	16		15
	% SiO <sub>2</sub>		-	9.48	1.5		3
	% H <sub>2</sub> O		-	8.5	8		2
5.2	<b>Secondaries</b>	%	100		22.4	100	
			Zinc refinery residues, Drosses, Battery Paste, Dust, Residues, Lead Bullions			<u>Input materials:</u> copper lead matte copper dross copper silver dross flue dusts copper smelting slags dusts copper smelting flue dusts PM smelter slags dusts Pm smelter various recycled materials	
	Lead Paste	%					
	% Pb	%					
	% S	%					
	% H <sub>2</sub> O	%					
	% Pb	%	10-78		5		
	% Zn	%	0-11		12		
	% Fe	%	0-60		18		
	% S	%	0-20		4		
	% SiO <sub>2</sub>	%	0-60		13		
	% H <sub>2</sub> O	%	0-65		30		

Table 4. Primary Lead Smelters (continued).

1.	Company Name		Kosaka Smelting & Refining Co	Torreon Smelter Met-Mex Peñoles S.A.	Nyrstar Port Pirie	Aurubis Hamburg	Boliden Rönnskär smelter
5.3	<b>Furnace Flux</b>						
	SiO <sub>2</sub>	kg / MT	0	0		4000 t/a	50
	Lime	kg / MT	0	370		6000 kg/a	100
	Iron	kg / MT	853	169			50
	Coal	kg / MT	0	0		no	
	Coke	kg / MT	189	0		5000 kg/a	30
	Other Type	kg / MT	0	0		Iron oxide	

Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Kosaka Smelting & Refining Co	Torreon Smelter Met-Mex Peñoles S.A.	Nyrstar Port Pirie	Aurubis Hamburg	Boliden Rönnskär smelter
						6000 kg/a	
6.	<b>Feed Preparation</b>						
6.1	<b>Blending System</b>		Bedding, Proportioning Bins	Conveyor, car	Mixing Plant / Conditioning Drum		
6.1	<b>Dryer, if applicable</b>						
	Type		Rotary			Belt drying system	Rotary
	Number		1			1	1
	Dimension	m	7.314mL × 1.930mD			15	
	Feed Rate	MTPH	9			2 - 10	
	Inlet -H <sub>2</sub> O	%	18			< 5 - 30	
	Outlet -H <sub>2</sub> O	%	3			< 3	
	Fuel - Type		Crude oil			Natural gas	
	Calorific Value	kJ/kg	45300				
	Gas Temperature						
	Dryer Inlet	<sup>0</sup> C	650			200	
	Dryer Outlet	<sup>0</sup> C	120			< 120	
	Gas Volume	Nm <sup>3</sup> /hr	15000			30000	
	Discharge Temperature	<sup>0</sup> C	85			80-100	

Table 4. Primary Lead Smelters (continued).

1.	Company Name		Kosaka Smelting & Refining Co	Torreon Smelter Met-Mex Peñoles S.A.	Nyrstar Port Pirie	Aurubis Hamburg	Boliden Rönnskär smelter
6.2	<b>Sinter Machine, if applicable</b>						
	Number			2	1		
	Dimensions, Hearth Area	m <sup>2</sup>		120 // 40	83.6		
	Nominal Capacity	MTPH		52 // 12	90		
	Sulfur Burning Rate	MT Sulfur/m <sup>2</sup> * day		1.4	2.2		
	Fuel - Type			Sulphur / air	Natural Gas		
	Cal. Value	kJ/kg		700	38000		
	Feed Moisture	% H <sub>2</sub> O		6.5	11.5		
	Sinter Composition						
	% Pb	%		37 // 38	48		
	% Fe	%		10 // 11.5	13		
	% S	%		2.2 // 2.8	1.5		
	Exhaust Gas - Volume	Nm <sup>3</sup> /hr		90,000	108,000		
	% SO <sub>2</sub>	%		6.0 % (120 m2 ) // 2.0 % (40 m2 )	0.4		



Table 4. Primary Lead Smelters (continued).

1.	<b>Company Name</b>		Kosaka Smelting & Refining Co	Torreón Smelter Met-Mex Peñoles S.A.	Nyrstar Port Pirie	Aurubis Hamburg	Boliden Rönnskär smelter
7.	<b>Smelting</b>						
	Number of Furnaces		1	3	1	1	1
	Type		Electric Furnace	Blast Furnace	Open Top Lead Blast Furnace	Electric furnace	TBRC
	Nominal Capacity	MTPH	10	22 / horno	27	25	12
	Dimensions		6.3md × 2.97mH	9.8m2 area x7.9m high	18.8m3 hearth Area	round shape, diameter:7.5 m	11 m3 working volume
7.1	<b>Smelting</b>						
	Auxiliary Fuel - Type		not applied	Metallurgical Coke	Metallurgical Coke	Electricity	
	Amount	Kg (Nm <sup>3</sup> )/hr	-	105 kg coke / ton c.c.h.	6561	65	
	Calorific Value	kJ/kg	-	5500	28000		
	Air Volume	Nm <sup>3</sup> /hr	not applied	15290	26000	0	600
	Oxygen Enrichment	%	not applied		6.5	0	90
	Oxygen Volume	Nm <sup>3</sup> /hr	not applied		1800	0	5500
	Operating Temperature	<sup>o</sup> C	1050-1150	1200	1180 - 1250	1250	
	Flux as % of Feed	%	20	0		< 20	

Table 4. Primary Lead Smelters (continued).

<b>1.</b>	<b>Company Name</b>		Kosaka Smelting & Refining Co	Torreon Smelter Met-Mex Peñoles S.A.	Nyrstar Port Pirie	Aurubis Hamburg	Boliden Rönnskär smelter
	Refractory Lining - Type		Chrome, Magnesite-bricks	Basic bricks	Chrome Magnesite with water cooled steel jackets	various refractory types	Cr-Mg
	Campaign of Life	years	9	0.17	1.5	2	0.2
	Furnace Offgas						
	Volume	Nm <sup>3</sup> /hr	8000	60000	184000	25000	30000
	Temperature ex Furnace	<sup>o</sup> C	400-700	250	325	1300	
	% SO <sub>2</sub>	%	3-7	0.025	0.2	0.2	15
	Gas Cooling by		Air dilution and water cooled jacket	Water jacket	Direct Air Cooling	1 cooler	Scrubber
	Number of units		1	1		5 sections	1
	Outlet Temperature	<sup>o</sup> C	200	55		100	70
	Dust Collection by		Electrostatic Precipitater	Baghouse	Baghouse (3)	Cooler, bagfilter	
	Disposition of Dust		Return to furnace	Recycle	Slurry Recycling		Slurry recycled
	Amount	TPH	0.5	1.7	2	1 to 2	

Table 4. Primary Lead Smelters (continued).

1.	Company Name		Kosaka Smelting & Refining Co	Torreon Smelter Met-Mex Peñoles S.A.	Nyrstar Port Pirie	Aurubis Hamburg	Boliden Rönnskär smelter
7.2	<b>Slag Reduction</b>					no special reduction	
	Reducing Agent - Type					Coke breeze in electric furnace	
	Amount	Kg (Nm <sup>3</sup> )/hr					
	Calorific Value	kJ/kg					
	Air Volume	Nm <sup>3</sup> /hr					
	Oxygen Enrichment	%					
	Oxygen Volume	Nm <sup>3</sup> /hr					
	Operating Temperature	°C					
	Refractory Lining - Type						
	Campaign of Life	years					

Table 4. Primary Lead Smelters (continued).

1.	Company Name		Kosaka Smelting & Refining Co	Torreon Smelter Met-Mex Peñoles S.A.	Nyrstar Port Pirie	Aurubis Hamburg	Boliden Rönnskär smelter
	Furnace Offgas						
	Volume	Nm <sup>3</sup> /hr					
	Temperature ex Furnace	<sup>0</sup> C					
	% SO <sub>2</sub>	%					
	Gas Cooling by						
	Number of units						
	Outlet Temperature	<sup>0</sup> C					
	Dust Collection by						
	Disposition of Dust						
	Amount	TPH					

Table 4. Primary Lead Smelters (continued).

1.	Company Name		Kosaka Smelting & Refining Co	Torreon Smelter Met-Mex Peñoles S.A.	Nyrstar Port Pirie	Aurubis Hamburg	Boliden Rönnskär smelter
7.3	<b>Furnace Products (average)</b>						
7.3.1	Lead Bullion	MTPD	34.4	442	680	20 - 100	41
	% Pb	%	80.5	97	0.955	90	96
	% S	%	-	0	0.63	1	0.2
	% Cu	%	2.7	0.006	2.14	2	0.2
	% Sb	%	2.5	1.2	0.39	1,0-5	1.5
	% Ag	%	1.8	1.6	0.3	1,0-5	0.5
	Temperature	<sup>o</sup> C	800-900			1250	1000
7.3.2	Matte	MTPD	14	45	34	0 - 50	
	% Pb	%	7.3	18	40.3	15	35
	% As	%	1	5.5	0.94	2	
	% Cu	%	6.7	43.5	40.4	30-50	35
	% Fe	%	50	5.5	0.19	15	
	% S	%	19.5	7.5	15.1	20	20
	Temperature	<sup>o</sup> C	1000-1100			1250	
7.3.3	Slag	MTPD	57	630	635	100 - 200	
	% Pb	%	2.4	1.34	2.5	< 3	4
	% FeO	%	41	22.5	27.8	25-30	20
	% SiO <sub>2</sub>	%	24.8	18.5	21.5	25-30	19
	% CaO	%	6.9	18.8	15.4	43070	25
	% Zn	%	4.8	12.5	16.3	< 10	18
	Temperature	<sup>o</sup> C	1050-1150			1250	1200



Table 4. Primary Lead Smelters (continued).

<b>1.</b>	<b>Company Name</b>		Kosaka Smelting & Refining Co	Torreon Smelter Met-Mex Peñoles S.A.	Nyrstar Port Pirie	Aurubis Hamburg	Boliden Rönnskär smelter
<b>8.</b>	<b>Sulfur Fixation</b>						
	Source of Gas			Sinter Plant	Sinter Plant	Electric furnace	
				Sulfuric Acid		SO <sub>2</sub> -containing offgas is treated in	
	Plant - Type			Sulfuric Acid Single Contact	Sulphuric Acid Lurgi Single Contact	Acid plant of copper smelter	
	Rated Capacity	MTPD		550	230		
	Gas Volume	Nm <sup>3</sup> /hr		90000	48240		
	Average SO <sub>2</sub> in inlet gas	%		6	4.4		
	Average Conversion Efficiency	%		98.5	98		
	Product Grade	% H <sub>2</sub> SO <sub>4</sub>		98.5	98.5		97
	Energy Requirement	KWh/MT Sulfur		190	None		
	Auxiliary Fuel			Natural gas	Natural Gas		
	Tailgas Scrubbing			Absorption	None		

Table 5. Secondary Lead Smelters.

<b>1.</b>	<b>Company Name</b>		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
<b>2.</b>	<b>Annual Production – Lead</b>			145152	90719	62388
	Pb-Paste	MTPY		90720		
	Cu-Dross	MTPY		internal recycle		
	Pb-Cu-matte	MTPY		none		
	Sb-Slag	MTPY		internal recycle		
	Pb-Fe-Matte	MTPY		none		
	Other Type	MTPY		none		
<b>3.</b>	<b>Flowsheet</b>					
<b>4.</b>	<b>Applied Technologies</b>					
4.1						
4.2	Benefication / Separation			Engitech, hammermill, hydoseparator	MA 61 Battery Breaker	MA battery breaker plant
4.3	Smelting			Blast furnace, reverb	Reverberatory/ Blast combination	Long rotary kiln (2)
	Refinery			Pyrometallurgical	Pyrometallurgical	Pyrometallurgical



Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
5.						
	<b>Raw Materials</b>	MTPY			158000	
5.1						
	<b>Battery Scrap</b>	MTPY		217730	130000	
	Automotive Batteries	%		80	65	88
	Industrial Batteries	%		20	15	12
	Average Battery Weight	Kg		33.6	16.8	18.6
	% Paste	%		40	49	53
	% Grids	%		25	11	17
	% Electrolyte	%		17	27	20
	% Plastic	%		9	1	4
	% Hard Rubber	%		4.2	0	included with separators
	% Separators	%		4.8	12	6
	% Pb	%		53	58	
	% Sb	%		0.24	1.2	
	% Sn	%		0.07	0.6	
	% Ca	%		0.075		
	% Ag	%		0.025		
	% S	%		2.9		
	% Si	%		1.9		

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
5.2						
	<b>Other Scrap Material</b>	MTPY		42640	28000	
	Type of Secondaries			Sn dross, glass, flux replacements, lead scrap, hazardous material	Battery Plant factory scrap	
				dross, battery plant scrap, metallic lead, paint chips, wheel weights,		
				radiation shielding		
				hazardous waste manifested, drosses, plates, waste water, treatment,  WWT, stationary cells, locomotive cells		
				scrap trucks, scrap Pb, cable stripping, wheel weights,  linotype		
	% Pb	%		70	72	
	% Fe	%		3		
	% S	%		0.8		
	% SiO <sub>2</sub>	%		3		
	% Ca	%		0.3		
	% H <sub>2</sub> O	%		6		

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
5.3						
	<b>Furnace Flux</b>				Blast Furnace Additions Only	
	SiO <sub>2</sub>	kg / MT - bullion		0.23	16	
	Lime	kg / MT - bullion		0.15	24	
	Iron	kg / MT - bullion		0.42	89	
	- Type				Broken cast	
	Coal	kg / MT - bullion		0		
	Coke	kg / MT - bullion		0.42	123	
	Other Type	kg / MT - bullion				

Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
6.	<b>Feed Preparation</b>					
6.1	<b>Battery Breaking / Separation</b>					
	Flowsheet					
	Breaker Type			Hammer mill	MA Industries 61	
	Number			1	1	
	Capacity	MTPH		45	60	
	Paste Classifier - Type			Hydroseparator	Filter press	
	Metal Classifier - Type			plate and frame press	screw	
	Acid Collection	MTPY		17% of battery weight	3600 as Vitriol	
	Gypsum Production	MTPY		no	none all to acid reclaim	
	Water Consumption	Nm <sup>3</sup> /T Battery Scrap		0	0.042	
	Power Consumption	KWh/T Battery Scrap		0.003	21.5	
	Flocculant - Type					
	Amount	Kg/T Battery Scrap				

Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
6.2						
	<b>Desulfurization</b>					
	Capacity	MTPH	98.38	217730		
	%S content inlet paste	%		6		
	Reagent - Type			soda ash		
	- Amount	Kg/hr		1000 tpm		
	Temperature	<sup>o</sup> C	1050			
6.3						
	<b>Crystallizer</b>					
	Type			Engitec		
	Capacity	MTPH		1063.3 TPM		
	Auxiliary Fuel - Type			propane		
	Amount	Kg (Nm <sup>3</sup> )/T Na <sub>2</sub> SO <sub>4</sub>				
	Calorific Value	kJ/kg				
	Water evaporation rate	TPH		steam		
	Density of Salt Solution	g/l		31 % Na <sub>2</sub> SO <sub>4</sub>		
	Power Consumption	KWh/T Na <sub>2</sub> SO <sub>4</sub>				

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
6.4						
6.4.1	<b>Products</b>					
	Metallics	MTPD	223	136	78	
	% Pb	%	98	98	98	
	% Sb	%		1	1	
	% S	%	0.4	0.3		
	% Polyprop., Ebonite, Separators	%		14000		
6.4.2						
	Paste	MTPD		254	348	
	% Pb	%		75	67	
	% S	%		3		
	% Sb	%		0.02		
	Metallics, incl. Pb	%		<5%		
	Polyprop., Ebonite, Separators	%		<5%		
6.4.3						
	Polypropylene	MTPD			6	
	% Metallics	%		<1%	0	
	% Ebonite, Separators	%		<1%	6	
6.4.4						
	Ebonite, Separators	MTPD		Consumed reverb	88	
	Polypropylene	%				
	% Metallics	%				
6.4.5						
	Sodium Sulfate	MTPD		590		
	Purity	%		99.9		
	Other sulphates:	MTPD		None as products		

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
6.5	<b>Blending System</b>					
6.6	<b>Dryer, if applicable</b>				On the reverb furnace	
	Type				Heyl Patterson rotary kiln	
	Number				1	
	Dimension	m			2.13 diameter X 12	
	Feed Rate	MTPH			21.7	
	Inlet -H <sub>2</sub> O	%			12	
	Outlet -H <sub>2</sub> O	%			<1	
	Fuel - Type				Natural Gas	
	Calorific Value	kJ/kg			50	
	Gas Temperature					
	Dryer Inlet	<sup>0</sup> C			Ambient	
	Dryer Outlet	<sup>0</sup> C			>100	
	Gas Volume	Nm <sup>3</sup> /hr				
	Discharge Temperature	<sup>0</sup> C				

Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
7.	<b>Smelting</b>					
7.1	<b>Smelting - Furnace Type</b>		Pyrometallurgy	Blast Blast Furnace ,// Reverb.	Reverberatory // Cupola (Blast Furnace)	Long rotary kiln
	<b>Number</b>			1 // 1	1 // 1	
	Nominal Capacity	MTPH			225 // 115	2 x 164
	Dimensions			19 // 23	8.5X2.6 // 0.97X1.57 m	2 x (2.9 m x 40m)
	Auxiliary Fuel - Type				Natural gas // Coke	natural gas + used oil
	Amount	Kg (Nm <sup>3</sup> )/hr		coke // propane		150 + 300 (Nm <sup>3</sup> )/hr + l/hr
	Calorific Value	kJ/kg			50 // 29.5	
	Air Volume	Nm <sup>3</sup> /hr			ne=noentry // 2380	
	Oxygen Enrichment	%	30	5 // 95	ne // 3	0
	Oxygen Volume	Nm <sup>3</sup> /hr	1800	306 // 2605	ne // 72	
	Operating Temperature	<sup>o</sup> C	1050	1260 // 1093	1300 // 650	
	Flux as % of Feed	%	6.19	25 // 7	0 // ne	13



Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
	Refractory Lining - Type		Cr-Mg brick		Basic brick // water jacket	Magnesia chrome + high alumina bricks
	Campaign of Life	years	2	as needed // 13 months	1 // 10	0.5-25 years depending sections
	Furnace Offgas					
	Volume	Nm <sup>3</sup> /hr	ISA 32769; Blast Furnace 29251	67970 // 50980	39000 // ne	14000
	Temperature ex Furnace	<sup>o</sup> C	ISA 990 Blast Furnace 350—450□	149 // 1038	1000 // 200	350
	% SO <sub>2</sub>	%		0.08 // 0.19	715 // ne	0
	Gas Cooling by			na // Sonic	Evaporative followed by radiant // Gases are comingled with reverb furnace gases	Water + air
	Number of units			ne=no entry // 1	1 // ne	
	Outlet Temperature	<sup>o</sup> C		ne // 343	135 //ne	250
	Dust Collection by		Environment protection collector	ne // Baghouse	Baghouse //ne	Teflon filterbags
	Disposition of Dust		Return to recover	ne // to reverb	Returned to reverb //ne	Closed loop system
	Amount	TPH		ne // 40		1

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
	Lead Bullion	MTPD	223	127 // 272	200 //100	
	% Pb	%	98			> 99
	% S	%	0.4			0.05
	% Cu	%	0.075	0.5 // 0.1	0.02 //0.12	0.04
	% Sb	%	3.72t/a	4.5 // 0.1	0.1 //1.4	0.6
	% Ag	%	59.38t/a	0.004 // 0.005	0.01 //ne	0.0035
	Temperature	<sup>o</sup> C		982 // 732	450 //600	850
	Slag	MTPD	247	163 // 90	70 //29	
	% Pb	%	50	0.5 // 55	73 //1.5	3
	% Sb	%	1.28t/a	0.1 // 3	1.8 // ne	0.2
	% FeO	%	13.62	27 // 1	ne // 52	15-20
	% SiO <sub>2</sub>	%	10.8	30 // 10	ne // 30	3
	% CaO	%	1.9	10 // 1	ne // 15	1
	% Na	%		10 // depends		15-20
	Temperature	<sup>o</sup> C		1177 // 927		
	Pb-Fe-Matte					0
	% Pb	%			ne // 8	
	% As	%				
	% Cu	%				
	% Fe	%			ne // 62	
	% S	%			ne // 12	
	Temperature	<sup>o</sup> C				

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
7.2	Reducing Agent - Type		Coal, coke		Coke Fines	Coke + shredded tires
	Amount	Kg (Nm <sup>3</sup> )/hr	ISA 1.5t/h, Blast furnace 270kg/h	11 // 1 Coke	300	0.7
	Calorific Value	kJ/kg		27888 // 23240	29.5	6300 kcal/kg
	Air Volume	Nm <sup>3</sup> /hr	ISA 12600; BF 15000	8000 // ne scfm		
	Oxygen Enrichment	%	30	6 // 95		
	Oxygen Volume	Nm <sup>3</sup> /hr	1800	ne // 91000 scfh		
	Operating Temperature	<sup>0</sup> C	1050	same as above // ne		
	Refractory Lining - Type		Cr-Mg brick	Water jacket // Mg-Cr brick		
	Campaign Life	years	2	not much lately // same as above		
	Furnace Offgas					
	Volume	Nm <sup>3</sup> /hr	ISA 32760, Blast Furnace 29251	Rest is duplicate request for info		
	Temperature ex Furnace	<sup>0</sup> C	ISA 990, Blast Furnace 350-450			
	% SO <sub>2</sub>	%	8.21			
	Gas Cooling by					
	Number units					
	Outlet Temp.	<sup>0</sup> C	200			
	Dust Collection		Environment protection collector			

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
	Disposition of Dust		Return to recover			
	Amount	TPH	ISA 2.9t/h, Blast Furnace 0.4t/h			
	Lead Bullion	MTPD	223			
	% Pb	%	98			
	% S	%	0.4			
	% Cu	%	0.075			
	% Sb	%	3.72t/a			
	% Ag	%	59.38t/a			
	Temperature	<sup>0</sup> C				
	Matte	MTPD	10			
	% Pb	%	60			
	% As	%				
	% Cu	%	15			
	% Fe	%				
	% S	%	6			
	Temperature	<sup>0</sup> C				
	Slag	MTPD	247			
	% Pb	%	50			
	% FeO	%	13.62			
	% SiO <sub>2</sub>	%	10.8			
	% CaO	%	1.9			
	% Zn	%	8.8			
	Temperature	<sup>0</sup> C				

Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Chihong	Doe Run Resource Recycling Division	East Penn Manufacturing Co., Inc.	Newalta
8.	<b>Sulfur Fixation</b>			see desulfurization above		
	Source of Gas		Fume		Furnaces	
	Plant - Type					
	Rated Capacity	MTPD	49			
	Gas Volume	Nm <sup>3</sup> /hr	18000			
	Average SO <sub>2</sub> in inlet gas	%	0.51			
	Average Conversion Efficiency	%				
	Product Grade	% H <sub>2</sub> SO <sub>4</sub>				
	Energy Requirement	KWh/MT Sulfur				
	Auxiliary Fuel					
	Tailgas Scrubbing		Amino acid to remove sulphide		Scrub with ammonia	
					Ammonium Bisulfite	

Table 5. Secondary Lead Smelters (continued).

<b>1.</b>	<b>Company Name</b>		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
						2009
<b>2.</b>	<b>Annual Production – Lead</b>		70000		24104	18000
	Pb-Paste	MTPY	45000			
	Cu-Dross	MTPY				
	Pb-Cu-matte	MTPY				
	Sb-Slag	MTPY				
	Pb-Fe-Matte	MTPY				
	Other Type	MTPY	25000t			
<b>3.</b>	<b>Flowsheet</b>					
<b>4.</b>	<b>Applied Technologies</b>					
4.1			Hydro seperating, SKS smelter	Engitec		
4.2	Benefication / Separation		Separation			
4.3	Smelting		SKS	Short rotary furnace	Rotary-tilting Furnace	Cupola
	Refinery		Electrorefining			Electrorefining

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
5.	<b>Raw Materials</b>	MTPY	Lead Battery Scrap		69 692	28000
5.1	<b>Battery Scrap</b>	MTPY		11620		26000
	Automotive Batteries	%	75—85	90		100
	Industrial Batteries	%	15—25	10		-
	Average Battery Weight	Kg	20—30	16.5		-
	% Paste	%	55—65	41		-
	% Grids	%	25—30	32		-
	% Electrolyte	%	10—20	16		-
	% Plastic	%	4—8	6		-
	% Hard Rubber	%	1.5—2.5			-
	% Separators	%		5		-
	% Pb	%		60		78
	% Sb	%		0.5		
	% Sn	%				
	% Ca	%				
	% Ag	%				
	% S	%		2.4		4
	% Si	%				

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
5.2						
	<b>Other Scrap Material</b>	MTPY		3250		2000
	Type of Secondaries			Bullion	Lead bearing dust and slime from	Lead Residues
					Copper production	
	% Pb	%		97.9	~41	
	% Fe	%			~1	
	% S	%			~8	
	% SiO <sub>2</sub>	%			~2	
	% Ca	%			~1.5	
	% H <sub>2</sub> O	%			~12.3	



Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
5.3						
	<b>Furnace Flux</b>					
	SiO <sub>2</sub>	kg / MT - bullion	25—35			0
	Lime	kg / MT - bullion	15—22			0
	Iron	kg / MT - bullion	38—47	18	64	70
	- Type		Iron Ore			Waste Iron
	Coal	kg / MT - bullion	180—220			0
	Coke	kg / MT - bullion	171	38		190
	Other Type	kg / MT - bullion		25 as Na <sub>2</sub> CO <sub>3</sub>	2286	
					900	
					947	

Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
					Filter Press	
6.	<b>Feed Preparation</b>					
6.1						
	<b>Battery Breaking / Separation</b>					
	Flowsheet					
	Breaker Type		Hammer grinding machine	Hammermill		
	Number		1	1		
	Capacity	MTPH	20	3		
	Paste Classifier - Type		Vibration filter	Vibrator Screen		
	Metal Classifier - Type			Hydrodynamic		
	Acid Collection	MTPY		1860		
	Gypsum Production	MTPY	0			
	Water Consumption	Nm <sup>3</sup> /T Battery Scrap	0.79方	0.3		
	Power Consumption	KWh/T Battery Scrap	30	25		
	Flocculant - Type		VN934SH			
	- Amount	Kg/T Battery Scrap	0.05			

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
6.2	<b>Desulfurization</b>					
	Capacity	MTPH				
	%S content inlet paste	%				
	Reagent - Type					
	- Amount	Kg/hr				
	Temperature	°C				
6.3	<b>Crystallizer</b>					
	Type					
	Capacity	MTPH				
	Auxiliary Fuel - Type					
	Amount	Kg (Nm <sup>3</sup> )/T Na <sub>2</sub> SO <sub>4</sub>				
	Calorific Value	kJ/kg				
	Water evaporation rate	TPH				
	Density of Salt Solution	g/l				
	Power Consumption	KWh/T Na <sub>2</sub> SO <sub>4</sub>				

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
6.4						
6.4.1	<b>Products</b>					
	Metallics	MTPD	30—35	16		
	% Pb	%	97—98	97		
	% Sb	%	2—3	1.5		
	% S	%				
	% Polyprop., Ebonite, Separators	%				
6.4.2						
	Paste	MTPD		20		
	% Pb	%	74	72		
	% S	%	6	6		
	% Sb	%	0.1—0.8	0.4		
	% Metallics, incl. Pb	%		2		
	% Polyprop., Ebonite, Separators	%		1		
6.4.3						
	Polypropylene	MTPD	5—7	3		
	% Metallics	%	0.0008	0.04		
	% Ebonite, Separators	%		0.8		
6.4.4						
	Ebonite, Separators	MTPD		2.8		
	% Polypropylene	%		1		
	% Metallics	%		0.5		
6.4.5						
	Sodium Sulfate	MTPD				
	Purity	%				
	Other sulphates:	MTPD				

Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
6.5	<b>Blending System</b>			moulds	Yes	
6.6	<b>Dryer, if applicable</b>					
	Type					
	Number					
	Dimension	m				
	Feed Rate	MTPH				
	Inlet -H <sub>2</sub> O	%				
	Outlet -H <sub>2</sub> O	%				
	Fuel - Type					
	Calorific Value	kJ/kg				
	Gas Temperature					
	Dryer Inlet	<sup>0</sup> C				
	Dryer Outlet	<sup>0</sup> C				
	Gas Volume	Nm <sup>3</sup> /hr				
	Discharge Temperature	<sup>0</sup> C				

Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
7.	<b>Smelting</b>					
7.1	<b>Smelting - Furnace Type</b>		SKS, Blast Furnace	Short rotary furnace	Rotary-tilting furnace	Cupola
	<b>Number</b>		2	1	3	1
	Nominal Capacity			1,3 (metallic 85% + paste 15%)	24	3.3
	Dimensions	MTPH	SKS 3.8*11.5m, Blast Furnace 8.6m <sup>2</sup>	3m x 4m	2.8 (inside dia) x 5.95 (length)	1m×2m×2.5mH
	Auxiliary Fuel - Type		Coke Powder	Heavy fuel oil	Natural Gas	Coke
	Amount	Kg (Nm <sup>3</sup> )/hr	700—900	100	100-540	-
	Calorific Value	kJ/kg	25000—27000	39800	28657	-
	Air Volume	Nm <sup>3</sup> /hr	0	900	270-2000	1850
	Oxygen Enrichment	%	99%		up to 45	0.4
	Oxygen Volume	Nm <sup>3</sup> /hr	1900—2100	30	120-600	7
	Operating Temperature	<sup>o</sup> C	950—1050	1000	950-1200	1,100 - 1,200
	Flux as % of Feed	%		4	40210	

Table 5. Secondary Lead Smelters (continued).

<b>1.</b>	<b>Company Name</b>		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
	Refractory Lining - Type		Mg-Cr brick	Chrome Magnesite	Chrome-Magnesite	Chrome-Magnesite-Brick
	Campaign of Life	years	2—4	1.5	about 500 batches	1
	Furnace Offgas					
	Volume	Nm <sup>3</sup> /hr	21000	8000	5000-30000	9000
	Temperature ex Furnace	<sup>o</sup> C	800—850	600	950-1250	480
	% SO <sub>2</sub>	%	6—10	0.03		0.5
	Gas Cooling by		Exhaust heat furnace	Water Sprays	Water sprays/air cooling	Spray Tower (sent to the primary process)
	Number of units		1	1		1
	Outlet Temperature	<sup>o</sup> C	400—430	120	200-300	70
	Dust Collection by		Vacuum and bagfilter	Baghouse	Baghouse	Baghouse
	Disposition of Dust		Return to feed	Direct Feed Back	Reverted to smelting	Recycle
	Amount	TPH	6	0.1	about 9000 TPY	0.05

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
	Lead Bullion	MTPD	100	24	66	52
	% Pb	%	98—99	97.5	99	99.5
	% S	%	0.08—0.12			
	% Cu	%	0.5—0.7	0.05	0.2	0.05
	% Sb	%	0.15—0.25	1.5	0.26	0.4
	% Ag	%	0.20—0.30	0.006	0.05	
	Temperature	<sup>o</sup> C		850	950-1150	910
	Slag	MTPD	190		83	9
	% Pb	%	42—50		40-56	4
	% Sb	%			0.1	
	% FeO	%	10—18			53
	% SiO <sub>2</sub>	%	7—15		0.2-17.7	19
	% CaO	%	4—12		1.0-15.6	2
	% Na	%			950-1150	
	Temperature	<sup>o</sup> C				1150
	Pb-Fe-Matte					
	% Pb	%		5		
	% As	%				
	% Cu	%				
	% Fe	%		20		
	% S	%		15		
	Temperature	<sup>o</sup> C		950		



Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
7.2	Reducing Agent - Type		Coke	Coke		
	Amount	Kg (Nm <sup>3</sup> )/hr	3000—3500	40		
	Calorific Value	kJ/kg	28000—32000			
	Air Volume	Nm <sup>3</sup> /hr	15000			
	Oxygen Enrichment	%	25			
	Oxygen Volume	Nm <sup>3</sup> /hr	550—650			
	Operating Temperature	<sup>o</sup> C	1150—1250			
	Refractory Lining - Type					
	Campaign of Life	years	2—3			
	Furnace Offgas Volume	Nm <sup>3</sup> /hr				
	Temperature ex Furnace	<sup>o</sup> C	550—640			
	% SO <sub>2</sub>	%				
	Gas Cooling by					
	Number of units					
	Outlet Temp.	<sup>o</sup> C				
	Dust Collection by		Bag filter			

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
	Disposition of Dust		Return to feed			
	Amount	TPH	1.7			
	Lead Bullion	MTPD	972			
	% Pb	%	98—99			
	% S	%	0.1—0.2			
	% Cu	%	0.4—0.7			
	% Sb	%	0.15—0.25			
	% Ag	%	0.20—0.25			
	Temperature	<sup>0</sup> C				
	Matte	MTPD				
	% Pb	%				
	% As	%				
	% Cu	%				
	% Fe	%				
	% S	%				
	Temperature	<sup>0</sup> C				
	Slag	MTPD	300			
	% Pb	%	3—4			
	% FeO	%	31—35			
	% SiO <sub>2</sub>	%	20—24			
	% CaO	%	10—14			
	% Zn	%	13—17			
	Temperature	<sup>0</sup> C				

Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Yuguang	KCM SA, Plovdiv	KGHM Olow HMG	Toho Zinc Co.,Ltd. Chigirishima
8.	<b>Sulfur Fixation</b>				Off gas to desulphurization plant	
	Source of Gas		Fume recovery		Rotary-tilting Furnace	Cupola off gas
	Plant - Type				Semi-dry using lime milk	Absorbed by using magnesium hydroxide
	Rated Capacity	MTPD	4.5			
	Gas Volume	Nm <sup>3</sup> /hr				
	Average SO <sub>2</sub> in inlet gas	%	7—11			
	Average Conversion Efficiency	%				
	Product Grade	% H <sub>2</sub> SO <sub>4</sub>	98			
	Energy Requirement	KWh/MT Sulfur				
	Auxiliary Fuel					
	Tailgas Scrubbing		Alkaline absorption			

Table 5. Secondary Lead Smelters (continued)..

<b>1.</b>	<b>Company Name</b>		Kamioka Mining & Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
<b>2.</b>	<b>Annual Production – Lead</b>		21900	36077	17400	10600
	Pb-Paste	MTPY		none		8540
	Cu-Dross	MTPY		own treatment	621	-
	Pb-Cu-matte	MTPY		none		-
	Sb-Slag	MTPY		own treatment	516	-
	Pb-Fe-Matte	MTPY		6,085		-
	Other Type	MTPY				-
<b>3.</b>	<b>Flowsheet</b>					
<b>4.</b>	<b>Applied Technologies</b>					
4.1						
4.2	Benefication / Separation			not applied yet	MA Battery Breaker+Separation	Battery breaker, hydroseparation
4.3	Smelting		Blast Furnace	blast furnace Varta type, two rotary furnaces (only temporary)	Rotary	Gas/air fired rotary furnace
	Refinery		Electrorefining	Pyrometallurgical	Pyrometallurgical	Pyrometallurgical

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Kamioka Mining & Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
5.						
	<b>Raw Materials</b>	MTPY	47500	65925		
5.1						
	<b>Battery Scrap</b>	MTPY	33400	35554	21408	17600
	Automotive Batteries	%	90	ca 95		>90
	Industrial Batteries	%	10	ca 5		<10
	Average Battery Weight	Kg	12	16	17	20
	% Paste	%	70		36	48
	% Grids	%			26	28
	% Electrolyte	%	21	11	30	15
	% Plastic	%	6	5	5	4
	% Hard Rubber	%	1		none	-
	% Separators	%	2	5	3	5
	% Pb	%	60	59		60
	% Sb	%	0.5	0.8		-
	% Sn	%	0.01	0.1		-
	% Ca	%	0.2	0		-
	% Ag	%		0.004		-
	% S	%		3		-
	% Si	%	0.9	0		-

Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Kamioka Mining & Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
5.2						
	<b>Other Scrap Material</b>	MTPY	14100		3574	45
	Type of Secondaries					Lead scrap
				Battery Plates 8088 MTPY // 72%Pb		
				Metallic scrap 5451 MTPY // 98%Pb		
				Own returning materoial - drosses,3.475 MTPY //74%Pb		
				Ext. Sludges, oxides 3.154 MTPY //75%Pb		
	% Pb	%				90
	% Fe	%				-
	% S	%				-
	% SiO <sub>2</sub>	%				-
	% Ca	%				-
	% H <sub>2</sub> O	%				-

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Kamioka Mining & Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
5.3						
	<b>Furnace Flux</b>					
	SiO <sub>2</sub>	kg / MT - bullion	70	5		-
	Lime	kg / MT - bullion	200	7		-
	Iron	kg / MT - bullion	240	142	2049 MTPY	19
	- Type		Waste can	Turnings =42, and oxides =100 kg/MT		Iron turnings
	Coal	kg / MT - bullion		0	1664 MTPY	-
	Coke	kg / MT - bullion	310	111	26,5 MTPY	-
	Other Type	kg / MT - bullion		none		48 (anthracite)

Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Kamioka Mining & Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
6.						
	<b>Feed Preparation</b>					
6.1						
	<b>Battery Breaking / Separation</b>			not yet in operation (started 2010)		Engitec CX system
	Flowsheet					
	Breaker Type		Crusher			CX
	Number		5			1
	Capacity	MTPH	25			2.5
	Paste Classifier - Type		Filtration			Vibrator screen
	Metal Classifier - Type		Spiral Classifier			Hydrodynamic
	Acid Collection	MTPY				2640
	Gypsum Production	MTPY				-
	Water Consumption	Nm <sup>3</sup> /T Battery Scrap	4			0.6
	Power Consumption	KWh/T Battery Scrap	60			
	Flocculant - Type					Fennopol A 321
	- Amount	Kg/T Battery Scrap				0.04



Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Kamioka Mining Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
6.2	<b>Desulfurization</b>					
	Capacity	MTPH	6			1.2
	%S content inlet paste	%				6
	Reagent - Type		Slaked lime			soda ash
	- Amount	Kg/hr	350			290
	Temperature	<sup>o</sup> C				40
6.3	<b>Crystallizer</b>					
	Type					
	Capacity	MTPH				
	Auxiliary Fuel - Type					
	Amount	Kg (Nm <sup>3</sup> )/T Na <sub>2</sub> SO <sub>4</sub>				
	Calorific Value	kJ/kg				
	Water evaporation rate	TPH				
	Density of Salt Solution	g/l				
	Power Consumption	KWh/T Na <sub>2</sub> SO <sub>4</sub>				

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Kamioka Mining & Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
6.4						
6.4.1	<b>Products</b>					
	Metallics	MTPD	30			16
	% Pb	%	80			90
	% Sb	%	0.6			2
	% S	%	5			1
	% Polyprop., Ebonite, Separators	%	5			1
6.4.2						
	Paste	MTPD	55			29
	% Pb	%	70			70
	% S	%	8			1
	% Sb	%	0.6			0.5
	% Metallics,Pb	%				
	% Polyprop., Ebonite, Separators	%				
6.4.3						
	Polypropylene	MTPD	5			2.5
	% Metallics	%				
	% Ebonite, Separators	%				
6.4.4						
	Ebonite, Separators	MTPD				3
	% Polypropylene	%				
	% Metallics	%				
6.4.5						
	Sodium Sulfate	MTPD				
	Purity	%				

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Kamioka Mining & Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
6.5	<b>Blending System</b>					
6.6	<b>Dryer, if applicable</b>					
	Type					
	Number					
	Dimension	m				
	Feed Rate	MTPH				
	Inlet -H <sub>2</sub> O	%				
	Outlet -H <sub>2</sub> O	%				
	Fuel - Type					
	Calorific Value	kJ/kg				
	Gas Temperature					
	Dryer Inlet	<sup>0</sup> C				
	Dryer Outlet	°C				
	Gas Volume	Nm <sup>3</sup> /hr				
	Discharge Temperature	<sup>0</sup> C				

Table 5. Secondary Lead Smelters (continued).

<b>1.</b>	<b>Company Name</b>		Kamioka Mining Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
<b>7.</b>	<b>Smelting</b>					
7.1	<b>Smelting - Furnace Type</b>		Blast Furnace	Blast Furnace, Varta System		Gas/air fired rotary furnace
	<b>Number</b>		1	1		1
	Nominal Capacity	MTPH	3.5-bullion	5		2.3
	Dimensions	m	5.21m <sup>2</sup> Hearth Area	4.00 x1.20 m		4.3 x 2.8 m
	Auxiliary Fuel - Type			Natural gas		Natural gas
	Amount	Kg (Nm <sup>3</sup> )/hr		89		
	Calorific Value	kJ/kg		34000		33.6 MJ/Nm <sup>3</sup>
	Air Volume	Nm <sup>3</sup> /hr	4900	3100		
	Oxygen Enrichment	%		3.4		
	Oxygen Volume	Nm <sup>3</sup> /hr		110		
	Operating Temperature	<sup>0</sup> C	1250	1200		1100
	Flux as % of Feed	%	19	20		5

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Kamioka Mining Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
	Refractory Lining - Type		The sides of the furnace are water cooled jackets.	chamot		Chrome-Magnesia
	Campaign of Life	years	10	1		>1
	Furnace Offgas					
	Volume	Nm <sup>3</sup> /hr	12000	52200		20000
	Temperature ex Furnace	<sup>o</sup> C	480	250		400
	% SO <sub>2</sub>	%	0.2	0.0146		<1
	Gas Cooling by		Gas Cooling Tower	Quench		
	Number of units		1	1		
	Outlet Temperature	<sup>o</sup> C	120	195		
	Dust Collection by		Baghouse	Baghouse		Bag house
	Disposition of Dust		Recycle	Leaching, direct smelting		Dry fine
	Amount	TPH	0.75	0.184		0.04

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Kamioka Mining Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
	Lead Bullion	MTPD	70	37		42
	% Pb	%	97.5	98.1		95
	% S	%		not analysed		-
	% Cu	%	0.4	0.06		0.05
	% Sb	%	1	0.75		1.5
	% Ag	%	0.2	0.055		-
	Temperature	<sup>o</sup> C	850	1.050		700
	Slag	MTPD	80	2.93		3.8
	% Pb	%	2	2.1		<5
	% Sb	%		0		-
	% FeO	%	35	42.8		-
	% SiO <sub>2</sub>	%	23	24.9		-
	% CaO	%	14	7.4		-
	% Na	%		<1		-
	Temperature	<sup>o</sup> C	1250	1150		800
	Pb-Fe-Matte			6.085		-
	% Pb	%		6.1		-
	% As	%		<0,1		-
	% Cu	%		0.7		-
	% Fe	%		59.1		-
	% S	%		24		-
	Temperature	<sup>o</sup> C		1150		-

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Kamioka Mining Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
7.2	Reducing Agent - Type			Coke		
	Amount	Kg (Nm <sup>3</sup> )/hr		4.124		
	Calorific Value	kJ/kg		33500		
	Air Volume	Nm <sup>3</sup> /hr		3100		
	Oxygen Enrichment	%		3.4		
	Oxygen Volume	Nm <sup>3</sup> /hr		110		
	Operating Temperature	<sup>o</sup> C		above		
	Refractory Lining - Type					
	Campaign of Life	years				
	Furnace Offgas Volume	Nm <sup>3</sup> /hr		above		
	Temperature ex Furnace	<sup>o</sup> C				
	% SO <sub>2</sub>	%				
	Gas Cooling by					
	Number of units					
	Outlet Temperature	<sup>o</sup> C				
	Dust Collection					

Table 5. Secondary Lead Smelters (continued).

1.	Company Name		Kamioka Mining &	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
	Disposition of Dust					
	Amount	TPH				
	Lead Bullion	MTPD		above		
	% Pb	%				
	% S	%				
	% Cu	%				
	% Sb	%				
	% Ag	%				
	Temperature	<sup>o</sup> C				
	Matte	MTPD				
	% Pb	%				
	% As	%				
	% Cu	%				
	% Fe	%				
	% S	%				
	Temperature	<sup>o</sup> C				
	Slag	MTPD				
	% Pb	%				
	% FeO	%				
	% SiO <sub>2</sub>	%				
	% CaO	%				
	% Zn	%				
	Temperature	<sup>o</sup> C				



Table 5. Secondary Lead Smelters (continued).

1.	<b>Company Name</b>		Kamioka Mining & Smelting Co.Ltd.	Kovohute Pribram nastupnicka, a.s.	Mutlu Izabe / Istanbul Turkey	Ecometal Ltd
8.	<b>Sulfur Fixation</b>					
	Source of Gas			Blast furnace		
	Plant - Type			Alcalic water spraying		
	Rated Capacity	MTPD		3		
	Gas Volume	Nm <sup>3</sup> /hr		52200		
	Average SO <sub>2</sub> in inlet gas	%				
	Average Conversion Efficiency	%				
	Product Grade	% H <sub>2</sub> SO <sub>4</sub>				
	Energy Requirement	KWh/MT Sulfur				
	Auxiliary Fuel					
	Tailgas Scrubbing					

Table 6. Lead Smelter Refineries.

<b>1.</b>	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Doe Run Resource Recycling Division	The Doe Run Company	East Penn Manufacturing Co.
<b>2.</b>	<b>Refinery - Type</b>		Pyrometallurgical	Pyrometallurgical	Pyrometallurgical	Pyrometallurgical
<b>3.</b>	<b>Annual Production - Lead</b>	MTPY	90000	145152	180000	90744
	Soft Lead	%	75	37	39	46
	Hard Lead	%	5	33		42
	Pb-Ca-Alloys	%	20	30	61	12
<b>4.</b>	<b>Flowsheet</b>					
<b>5.</b>	<b>Pyrometallurgical Refinery</b>					
<b>5.1</b>	<b>Decopperizing</b>					
	Method		Drossing Kettles & CSD	Phosphorous and pyrite sulfur	Iron pyrite/sulfer	Pyrite & sulfur
	Kettle Size	T	230	204 & 245	226.75	72.5
	Number of Kettles		3	12	4	2
	Treated Bullion	MTPY	108000	160000	186842	52632
	Inlet Cu-content	%	1.5	0.5 % Inlet Cu-content reverb 0.1		
	Temperature	<sup>0</sup> C	1000	360C, Temperature reverb decopper 365C	450 - 480	

Table 6. Lead Smelter Refineries (continued).

<b>1.</b>	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Doe Run Resource Recycling Division	The Doe Run Company	East Penn Manufacturing Co.
	Reaction Agent(s)		Sulfur, shredded rubber			
	Amount	Kg/T Bullion	Sulfur 0.7	depends on copper level	Iron pyrite/sulfur - 11.0	
		Kg/T Bullion	Shredded rubber 0.01			
	Final Bullion	MTPY	105000	145152	177772	
	Final Cu-content	%	0.005	depends on alloy down to <0.0002	<.009	
	Duration of Treatment	HR/Kettle		less then 2 hours	1	
	Amount of Dross	MTPY		<5%	Kettle Dross Only - 10,800	
	Treatment of Cu-dross		Reverb furnace	Blast furnace	Cu dross is sold.	Resmelt
				no Cu by product		
	Final By-Product		Copper matte // Copper Speiss	Copper goes to matte and slag	Kettle Dross	
	Amount	MTPY	1500 // 1800			
	% Pb	%	10 // 18		64	
	% Cu	%	25 // 39		12	
	% S	%	17 // n/a		2.5	

Table 6. Lead Smelter Refineries (continued).

<b>1.</b>	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Doe Run Resource Recycling Division	The Doe Run Company	East Penn Manufacturing Co.
<b>5.2</b>	<b>Softening</b>					
	Method		Oxygen lances in kettle	Lead oxide to 0.15 then caustic to clean up		
	Kettle Size	T	230	204		
	Number of Kettles		2	up to 4		
	Treated Bullion	MTPY	105000	9072-22680		
	Inlet Sb-content	%	1.7	4.50%		
	Temperature Start	<sup>o</sup> C	620	593		
	Temperature End	<sup>o</sup> C	680	649		
	Reaction Agent(s)		Oxygen	Lead oxide		
	Amount	Kg/T Bullion	5	5		
		Kg/T Bullion				
	Final Bullion	MTPY	100000			
	Final Sb-content	%	0.06	10000-25000		
	Duration of Treatment	HR/Ket tle	13	0.1		
	Amount of Dross/Slag	MTPY	8000	2		
	Treatment of Sb- Dross/Slag		Sb dross to sinter plant	Depends on oxide needed but roughly equals oxide use		
			Sb slag to SRF	Blast furnace		
	Final By-Product			Antimony slag		
	Amount	MTPY		Depends on sales		
	% Pb	%	80	60		
	% Sb	%	15	23		
	% Na	%	n/a	<.0001		

Table 6. Lead Smelter Refineries (continued).

<b>1.</b>	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Doe Run Resource Recycling Division	The Doe Run Company	East Penn Manufacturing Co.
<b>5.3</b>	<b>Detinning</b>					
	Method		Agitation and/or oxygen lances in bullion	Proprietary		
	Kettle Size	T	230			
	Number of Kettles		2			
	Treated Bullion	MTPY	105000			
	Inlet Sn-content	%	0.01 - 0.30%			
	Temperature Start	<sup>o</sup> C	Agitation 500 - Lances 580			
	Temperature End	<sup>o</sup> C	600			
	Reaction Agent(s)		Air / oxygen			
	Amount	Kg/T Bullion	n/a			
		Kg/T Bullion	n/a			
	Final Bullion	MTPY	100000			
	Final Sn-content	%	0.0005			
	Duration of Treatment	HR/Kettle	2			
	Amount of Dross/Slag	MTPY	1000			
	Treatment of Sn-Dross/Slag		Sinter plant			
			Eventually comes out in blast furnace slag			
	Final By-Product					
	Amount	MTPY				
	% Pb	%				
	% Sn	%				
	% Na	%				

Table 6. Lead Smelter Refineries (continued).

<b>1.</b>	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Doe Run Resource Recycling Division	The Doe Run Company	East Penn Manufacturing Co.
<b>5.4</b>	<b>Desilverizing</b>					
	Method		Parkes		Parkes	
	Kettle Size	T	230		227	
	Number of Kettles		4		6	
	Amount of Steps		2		2	
	Treated Bullion	MTPY	100000		166888	
	Inlet Ag-content	%	0.6		0.03	
	Temperature Start	<sup>o</sup> C	480		450	
	Temperature End	<sup>o</sup> C	319		330	
	Reaction Agent(s)		Zinc SHG		Zinc	
	Amount	Kg/T Bullion	5.7		7.3	
		Kg/T Bullion				
	Final Bullion	MTPY	98000		165074	
	Final Ag-content	%	0.00%		0.15	
	Duration of Treatment	HR/Kettle	18		8	
	Amount of Dross/Crust	MTPY	4500		4081.5	
	Treatment of Ag- Dross/Crust		Liquation - VIR - BBOC		Recycled	
	Final By-Product		Silver doré			
	Amount	MTPY	360			
	% Pb	%	0.09		99.33	
	% Ag	%	99.5		0.15	
	% Cu	%	0.36		0.0001	
	% Zn	%	0		0.52	

Table 6. Lead Smelter Refineries (continued).

1.	Company Name		Xstrata Zinc Brunswick Smelter	Doe Run Resource Recycling Division	The Doe Run Company	East Penn Manufacturing Co.
5.5	<b>Dezincing, if applicable</b>					
	Method		Water cooled vacuum bell			
	Kettle Size	T	200		226.75	
	Number of Kettles				2	
	Treated Bullion	MTPY	98000		165074	
	Inlet Zn-content	%	0.48		0.0052	
	Temperature	<sup>o</sup> C	585-600		565	
	Reaction Agent(s)				None	
	Amount	Kg/T Bullion				
	Applied Vacuum	mbar	0.1 (estimated)		13.3	
	Final Bullion	MTPY	96000			
	Final Zn-content	%	0.06		0.0005	
	Duration of Treatment	HR/Kettle	5		5	
	Amount of Dross/Metal	MTPY			Not tracked	
	% Pb	%				
	% Zn	%				

Table 6. Lead Smelter Refineries (continued).

<b>1.</b>	<b>Company Name</b>		Xstrata Zinc Brunswick Smelter	Doe Run Resource Recycling Division	The Doe Run Company	East Penn Manufacturing Co.
<b>5.6</b>	<b>Debismuthizing</b>					
	Method		Kroll-Betterton			
	Kettle Size	T	260			
	Number of Kettles		2			
	Amount of Steps		1			
	Treated Bullion	MTPY	96000			
	Inlet Bi-content	%	0.3-0.5			
	Temperature Start	<sup>0</sup> C	500			
	Temperature End	<sup>0</sup> C	320			
	Reaction Agent(s)		Ca/Mg alloy (70/30)			
	Amount	Kg/T Bullion	2.8			
		Kg/T Bullion				
	Final Bullion	MTPY	94000			
	Final Bi-content	%	0.012			
	Duration of Treatment	HR/Kettle	20			
	Amount of Dross/Crust	MTPY	3000			
	Treatment of Bi- Dross/Crust		Melting, agitation, oxidation			
	Final By-Product		PbBi metal			
	Amount	MTPY	2000			
	% Pb	%	92			
	% Bi	%	8			
	% Ca	%	0			
	% Mg	%	0			



Table 6. Lead Smelter Refineries (continued).

1.	Company Name		Xstrata Zinc Brunswick Smelter	Doe Run Resource Recycling Division	The Doe Run Company	East Penn Manufacturing Co.
5.7	<b>Final Refining</b>					
	Method		Oxidation	Caustic + sodium metal	Caustic	Caustic
	Kettle Size	T	230	204	226.75	72.5
	Number of Kettles		1		3	2
	Amount of Steps		1		1	2
	Treated Bullion	MTPY	94000	145152	164167	90744
	Temperature Start	<sup>o</sup> C	320	399	480	
	Temperature End	<sup>o</sup> C	600	454	450	
	Reaction Agent(s)		NaOH + NaNO <sub>3</sub>	NaOH	NaNO <sub>3</sub>	NaOH
	Amount	Kg/T Bullion	Caustic 0.6	44kg caustic , more or less depending on impurities	2.2	
		Kg/T Bullion	Nitre 0.4	3.6 sodium, more or less depending on impurities		
	Final Bullion	MTPY	90000	145152, all bullion treated	163260	
	Duration of Treatment	HR/Kettle	8	2 HR/Kettle	1	
	Amount of Dross	MTPY	4000	4.5 T/kettle	6300	
	Treatment of Dross		Recycle to sinter plant	Blast furnace	Recycle through blast furnace	

Table 6. Lead Smelter Refineries (continued).

1.	Company Name		Xstrata Zinc Brunswick Smelter	Doe Run Resource Recycling Division	The Doe Run Company	East Penn Manufacturing Co.
5.8	<b>Casting</b>					
	Casting Machine - Type		Ingots: Shepard, // Jumbos: in-house system	0.9 T, billet, 27kg and 45.4kg pig machines	Inline	Wirtz
	Number of Moulds		150 (approx)// 20		600 on 60 lb line, 800 on 100 lb line	225
	Rate	MTPH	28 // 20	30	31.745	18
	Casting Temperature	<sup>0</sup> C	500 // 500	427-510	425 - 510	427
	Cast Product			0.9T billet, 27kg and 45.4kg pig machines	45.4kg bars, 0.9T ingots	
	Ingot Size	mm	530x100x70 // 591x591x303		610x610 Top x 280 tall x 432 square on bottom	
	Ingot Weight	Kg	35 // 1100	0.9T, billet, 27kg and 45.4kg	910	30
	Rejects as % of New Material	%	5	1	5	1

Table 6. Lead Smelter Refineries (continued).

<b>1.</b>	<b>Company Name</b>		Torreon Pb Refinery, Met Mex Peñoles S.A	Xstrata Zinc - Mount Isa Lead Smelter	KCM SA, Plovdiv	KGHM, Olow	Nyrstar Port Pirie
						2009	
<b>2.</b>	<b>Refinery - Type</b>		Pyromet. Lead & Silver	Drossing Aisle	Pyrometallurgica	Pyrometallurgica	Pyrometallurgica
<b>3.</b>	<b>Annual Production - Lead</b>	MTPY	113771	0	61770	21590	220801
	Soft Lead	%	NA	100	94	100	94.1
	Hard Lead	%	NA	0	1		
	Pb-Ca-Alloys	%	NA	0	5		5.9
<b>4.</b>	<b>Flowsheet</b>						
<b>5.</b>	<b>Pyrometallurgical Refinery</b>						
<b>5.1</b>	<b>Decopperizing Method</b>			Removal of primary dross & sulphur drossing	Drossing and Sulphur Addition	Liquation	Continuous Drossing Furnace (CDF)
	Kettle Size	T		80	250	120	Not Applicable
	Number of Kettles			2	4	2	Not Applicable
	Treated Bullion	MTPY			67000	26180	241251
	Inlet Cu-content	%		0	1.5	0,05 - 0,4	2.8
	Temperature	<sup>0</sup> C		600 & 326	450 - 320	330	450



Table 6. Lead Smelter Refineries (continued).

1.	Company Name		Torreon Pb Refinery, Met Mex Peñoles	Xstrata Zn - Mount Isa Lead	KCM SA, Plovdiv	KGHM, Olow	Nyrstar Port Pirie
5.2	<b>Softening</b>						
	Method		Kettle Softening with Oxygen	Caustic Soda Drossing	Caustic + Nitre Drossing	Oxygen injection, caustic soda	Batch Oxygen Softening
	Kettle Size	T	280-300	80	250	120	400
	Number of Kettles		4	4	2	2	2
	Treated Bullion	MTPY	131645		63000	25000	230453
	Inlet Sb-content	%	1	0	0.6	0,2-1,0% (As); 0,15-0,3 (Sn); 0,1-0,4 (Sb)	0.35
	Temperature Start	<sup>o</sup> C		600	420	580	460
	Temperature End	<sup>o</sup> C		480	520	650	655
	Reaction Agent(s)		Oxygen	Caustic Soda			Oxygen
	Amount	Kg/T	5	0.34	NaOH 7.5	3.5	2.6m <sup>3</sup> O <sub>2</sub> / t Bullion
		Kg/T			NaNO <sub>3</sub> 7		
	Final Bullion	MTPY		0	62000	23890	226307
	Final Sb-content	%	0.07	0.052	0	<0,001As; <0,001%Sn; <0,1%Sb	<0.005%
	Duration of Treatment	HR/Kettle		2	7	8 ÷ 16	18.2
	Amount of Dross/Slag	MTPY		Not measured	1300	1480 (estimated)	8500
	Treatment of Sb-Dross/Slag			1) see note below	Rotary Furnace	Blast Furnace	2) see note below
	Final By-Product						Softener Slag
	Amount	MTPY					4146
	% Pb	%				78	67.5
	% Sb	%					6
1) Blended with high grade copper sale dross							
2) Rotary furnace to produce high Sb/Pb but used in production of antimonial alloys.							

Table 6. Lead Smelter Refineries (continued).

<b>1.</b>	<b>Company Name</b>		Torreon Pb Refinery, Met Mex Peñoles S.A	Xstrata Zinc - Mount Isa Lead Smelter	KCM SA, Plovdiv	KGHM, Olow	Nyrstar Port Pirie
<b>5.3</b>	<b>Detinning</b>						
	Method						
	Kettle Size	T					
	Number of Kettles						
	Treated Bullion	MTPY					
	Inlet Sn-content	%					
	Temperature Start	<sup>o</sup> C					
	Temperature End	<sup>o</sup> C					
	Reaction Agent(s)						
	Amount	Kg/T Bullion					
		Kg/T Bullion					
	Final Bullion	MTPY					
	Final Sn-content	%					
	Duration of Treatment	HR/Kettle					
	Amount of Dross/Slag	MTPY					
	Treatment of Sn-Dross/Slag						
	Final By-Product						
	Amount	MTPY					
	% Pb	%					
	% Sn	%					
	% Na	%					

Table 6. Lead Smelter Refineries (continued).

1.	Company Name		TorreonPbRefinery, Met Mex Peñoles S.A	Xstrata Zinc - Mount Isa Lead Smelter	KCM SA, Plovdiv	KGHM, Olow	Nyrstar Port Pirie
<b>5.4</b>	<b>Desilverizing</b>						
	Method		Parkes		2-Stage Parkes Process	Parkes	2-Stage Parkes
	Kettle Size	T	280-300		250	120	400
	Number of Kettles		6		3	1	3
	Amount of Steps		2		2		2
	Treated Bullion	MTPY	127000		62000	23890	2400
	Inlet Ag-content	%			0.15	0.04 - 0.4	0.33
	Temperature Start	<sup>o</sup> C			480	500	455
	Temperature End	<sup>o</sup> C			317	330	325
	Reaction Agent(s)		Zinc		Zinc	Zinc	Zinc
	Amount	Kg/T Bullion	0.67		8.8	11.8	8
		Kg/T Bullion					
	Final Bullion	MTPY			61500	23550	221652
	Final Ag-content	%	0.001		0.0005	<0,001	0.0005
	Duration of Treatment	HR/Kettle			16	22	18 (2nd stage) 8.5 (1st stage)
	Amount of Dross/Crust	MTPY			3000	1540	9000
	Treatment of Ag-Dross/Crust				Liquation	Liquation	Liquation
	Final By-Product				Dore	Silver Rich Crust	Silver
	Amount	MTPY			42		
	% Pb	%				3.6	73
	% Ag	%			98.8	9.7	6.5
	% Cu	%			0.9	0.73	0.5
	% Zn	%				82	20





Table 6. Lead Smelter Refineries (continued).

1.	Company Name		TorreónPbRefinery, Met Mex Peñoles	Xstrata Zn - Mount Isa Lead	KCM SA, Plovdiv	KGHM, Olow	Nyrstar Port Pirie
<b>5.6</b>	<b>Debismuthizing</b>						
	Method		Kroll Betterton		Kroll Betterton	Kroll Betterton	Kroll - Betterton
	Kettle Size	T	280-300		250	120	200
	Number of Kettles		6		3	1	2
	Amount of Steps				2	1	2
	Treated Bullion	MTPY	118000		62000	23550	
	Inlet Bi-content	%			0.25	0,05 ÷ 0,2	0.035, 0.070
	Temperature Start	<sup>o</sup> C			335	500	410
	Temperature End	<sup>o</sup> C			318	330	Crude 326°C, Full 321°C
	Reaction Agent(s)		Ca / Mg alloy		Ca 0.62	Mg/Ca	Ca (0.4 - Crude, 0.7 - Full)
	Amount	Kg/T	0.42		Mg 2.25	3.1	Mg (1.3 - Crude, 3.0 - Full)
		Kg/T			Sb 0.6		
	Final Bullion	MTPY			61500	22685	
	Final Bi-content	%	≤ 0.025		0.005	<0,01	Crude 0.015, Full 0.005
	Duration of Treatment	HR/Kettle			8	20	1
	Amount of Dross/Crust	MTPY			800	960 (estimated)	150
	Treatment of Bi-Dross/Crust				Liquation		Oxidising at Ca/Mg dross smeltered in rotary furnace with borax to form Bi/Pb alloy
	Final By-Product				PbBi	2.0%Bi Pb Alloy	30% Bi / Pb Alloy
	Amount	MTPY			780	715	100
	% Pb	%			89.5	98	70
	% Bi	%			10.5	2	30
	% Ca	%			0		
	% Mg	%			0		





Table 6. Lead Smelter Refineries (continued).

<b>1.</b>	<b>Company Name</b>		Kovohute Pribram nastupnicka	Mutlu Akü/ Istanbul Turkey	Aurubis Hamburg	Boliden Rönnskär smelter	Ecometal Ltd
<b>2.</b>	<b>Refinery - Type</b>		Pyrometallurgical	Pyrometallurgical	Pyrometallurgical	Pyrometallurgical	Pyrometallurgical
<b>3.</b>	<b>Annual Production - Lead</b>	MTPY	36077	18700		15000	10600
	Soft Lead	%	33		16500	100	60
	Hard Lead	%	45	43	0		39
	Pb-Ca-Alloys	%	22	57	0		<1
<b>4.</b>	<b>Flowsheet</b>						
<b>5.</b>	<b>Pyrometallurgical Refinery</b>						
<b>5.1</b>	<b>Decopperizing</b>						
	Method		1 step liquation		Colcord	Drossing	Red phosphorus
			2.step sulfur + pyrite				
	Kettle Size	T	150		200	200	30
	Number of Kettles		2		1	1	1
	Treated Bullion	MTPY	42.465	5000	23500	17000	7900
	Inlet Cu-content	%	0.065	0.01	0.15	0.2	0.05
	Temperature	°C	340			500	400



Table 6. Lead Smelter Refineries (continued).

1.	Company Name		Kovohute Pribram nastupnicka	Mutlu Akü/ Istanbul Turkey	Aurubis Hamburg	Boliden Rönnskär smelter	Ecometal Ltd
5.2	<b>Softening</b>						
	Method		Oxygen		Oxygen	Oxygen injection / lance + Air	Oxygen
	Kettle Size	T	120		200	120	30
	Number of Kettles		2	5	1	2	1
	Treated Bullion	MTPY	ca 40100	19400	21500	16000	8900
	Inlet Sb-content	%	0.2 - 0.7	0.03	0.5 - 2.5	1.5	1.5
	Temperature Start	<sup>0</sup> C	550		650	600	600
	Temperature End	<sup>0</sup> C	600		650	630	450
	Reaction Agent(s)		Oxygen		Oxygen	Oxygen + Air	Oxygen
	Amount	Kg/T	0.8				20
		Kg/T					
	Final Bullion	MTPY	39600	18870	20000	15500	8000
	Final Sb-content	%	<0.1	0.0009	0.01	0.15 / 0.01	0.05
	Duration of Treatment	HR/Kettle	8		30	24	4
	Amount of Dross/Slag	MTPY	640	530	500	500	900
	Treatment of Sb- Dross/Slag		Own smelting in rotary furnaces		Selling	Slag to production of Sb-Pb alloys	Recycled through rotary furnace
						Dross: Recycled TBRC	Pb-Sb-As-Sn alloys
	Final By-Product		PbSnSb alloy			Antimony slag	
	Amount	MTPY	106		500		
	% Pb	%	53		55-65	60	
	% Sb	%	34		25-35	25	
	% Na	%	12		0		

Table 6. Lead Smelter Refineries (continued).

<b>1.</b>	<b>Company Name</b>		Kovohute Pribram nastupnicka	Mutlu Akü/ Istanbul Turkey	Aurubis Hamburg	Boliden Rönnskär smelter	Ecometal Ltd
<b>5.3</b>	<b>Detinning</b>						Same as 5.2
	Method		Oxygen till 0.1%, balance caustic		Oxygen or Harris	Stirring	
	Kettle Size	T	120		200	200	
	Number of Kettles		2		1		
	Treated Bullion	MTPY	20800	18870	22000	16000	
	Inlet Sn-content	%	0.7	0.003	0.01 - 0.5	0.2	
	Temperature Start	<sup>o</sup> C	600		420	450	
	Temperature End	<sup>o</sup> C	<700		420	450	
	Reaction Agent(s)		Oxygen		Oxygen or NaOH	Air	
	Amount	Kg/T	1.8				
		Kg/T					
	Final Bullion	MTPY	20100	18600	21500		
	Final Sn-content	%	0.2-0.1 O <sub>2</sub> , bal. till 0.001 NaOH.	<0.001	0.01	0.01	
	Duration of Treatment	HR/Kettle	8		16	24	
	Amount of Dross/Slag	MTPY	854	170		500	
	Treatment of Sn-Dross/Slag		Own smelting in BF or rotary furnaces		Recycled to lead smelter	TBRC	
					Electric furnace		
	Final By-Product						
	Amount	MTPY					
	% Pb	%					
	% Sn	%					
	% Na	%					

Table 6. Lead Smelter Refineries (continued).

1.	Company Name		Kovohute Pribram nastupnicka	Mutlu Akü/ Istanbul Turkey	Aurubis Hamburg	Boliden Rönnskär smelter	Ecometal Ltd
5.4	<b>Desilverizing</b>						
	Method		Parkes		Parkes	Parkes	
	Kettle Size	T	120		200	150	
	Number of Kettles		1		1	1	
	Amount of Steps		2		1	2	
	Treated Bullion	MTPY	12,500		25000		
	Inlet Ag-content	%	0,04-0,10		1.5	0.5	
	Temperature Start	<sup>0</sup> C	530		480	500	
	Temperature End	<sup>0</sup> C	340		320	325	
	Reaction Agent(s)		Zinc		Zinc	Zinc	
	Amount	Kg/T Bullion	5		40	20	
		Kg/T			-		
	Final Bullion	MTPY	12,400		20000		
	Final Ag-content	%	0,0002-0,0009		< 0,001	0.001	
	Duration of Treatment	HR/Kettle	16		36	24	
	Amount of Dross/Crust	MTPY	39		5000		
	Treatment of Ag-Dross/Crust		Distillation, cupullation		Liquation, dezincing		
	Final By-Product		Crust			Triple alloy	
	Amount	MTPY			350		
	% Pb	%	78		15	5	
	% Ag	%	2.8		70	20	
	% Cu	%	0.7		5	5	
	% Zn	%	17.6		10	70	











Table 7. Lead Smelter Refineries (Electrorefining).

<b>1.</b>	<b>Company Name</b>		Yuguang	Toho Zinc Co.,Ltd. Chigirishima	Sumitomo Metal Mining Harima Smelter	Kamioka Mining & Smelting	Kosaka Smelting & Refining Co.
<b>2.</b>	<b>Refinery - Type</b>		Betts Electrorefining	Betts Electrorefining	Betts Electrorefining	Betts Electrorefining	Betts Electrorefining
<b>3.</b>	<b>Annual Production - Lead</b>	MTPY	30000	77000	30000	18700	24880
	Soft Lead	%	91.5	0			100
	Hard Lead	%		0			0
	Pb-Ca-Alloys	%	8.5	13			0
<b>4.</b>	<b>Flowsheet</b>						
<b>5.</b>	<b>Pyrometallurgical Refinery</b>						
<b>5.1</b>	<b>Decopperizing</b>						
	Method			Continuous Decopperizing By kettle			Liquation
	Kettle Size	T		80			110
	Number of Kettles			3			1
	Treated Bullion	MTPY		82000			11800.38712
	Inlet Cu-content	%		0.6			3.5
	Temperature	<sup>o</sup> C		340			500



Table 7. Lead Smelter Refineries (Electrorefining) (Continued)

1.	Company Name		Yuguang	Toho Zinc Co.,Ltd. Chigirishima	Sumitomo Metal Mining Harima Smltr	Kamioka Mining & Smelting	Kosaka Smelting & Refining Co.
5.2	<b>Softening</b>						
	Method						<b>not applied</b>
	Kettle Size	T					
	Number of Kettles						
	Treated Bullion	MTPY					
	Inlet Sb-content	%					
	Temperature Start	<sup>o</sup> C					
	Temperature End	<sup>o</sup> C					
	Reaction Agent(s)						
	Amount	Kg/T Bullion					
		Kg/T Bullion					
	Final Bullion	MTPY					
	Final Sb-content	%					
	Duration of Treatment	HR/Kettle					
	Amount of Dross/Slag	MTPY					
	Treatment of Sb-Dross/Slag						
	Final By-Product						
	Amount	MTPY					
	% Pb	%					
	% Sb	%					

Table 7. Lead Smelter Refineries (Electrorefining) (Continued)

1.	Company Name		Yuguang	Toho Zinc Co.,Ltd. Chigirishima	Sumitomo Metal Mining Harima Smltr	Kamioka Mining & Smelting	Kosaka Smelting & Refining Co.
<b>5.3</b>	<b>Detinning</b>						
	Method						Oxidation
	Kettle Size	T					180
	Number of Kettles						1
	Treated Bullion	MTPY					10804
	Inlet Sn-content	%					2
	Temperature Start	<sup>o</sup> C					500
	Temperature End	<sup>o</sup> C					600
	Reaction Agent(s)						
	Amount	Kg/T Bullion					
		Kg/T Bullion					
	Final Bullion	MTPY					8144
	Final Sn-content	%					0.1
	Duration of Treatment	HR/Kettle					8
	Amount of Dross/Slag	MTPY					2487
	Treatment of Sn-Dross/Slag						self-recycle
	Final By-Product						
	Amount	MTPY					2487
	% Pb	%					56.3
	% Sn	%					15
	% Na	%					-



Table 7. Lead Smelter Refineries (Electrorefining) (Continued)

1.	Company Name		Yuguang	Toho Zinc Co.,Ltd. Chigirishima	Sumitomo Metal Mining Harima Smltr	Kamioka Mining & Smelting	Kosaka Smelting & Refining Co.
5.4	<b>Desilverizing</b>						
	Method						
	Kettle Size	T					
	Number of Kettles						
	Amount of Steps						
	Treated Bullion	MTPY					
	Inlet Ag-content	%					
	Temperature Start	<sup>0</sup> C					
	Temperature End	<sup>0</sup> C					
	Reaction Agent(s)						
	Amount	Kg/T					
		Kg/T					
	Final Bullion	MTPY					
	Final Ag-content	%					
	Duration of Treatment	HR/Kettle					
	Amount of Dross/Crust	MTPY					
	Treatment of Ag-Dross/Crust						
	Final By-Product						
	Amount	MTPY					
	% Pb	%					
	% Ag	%					
	% Cu	%					
	% Zn	%					



Table 7. Lead Smelter Refineries (Electrorefining) (Continued)

1.	Company Name		Yuguang	Toho Zinc Co.,Ltd. Chigirishima	Sumitomo Metal Mining Harima Smltr	Kamioka Mining & Smelting	Kosaka Smelting & Refining Co.
5.6	<b>Debismuthizing</b>						
	Method						
	Kettle Size	T					
	Number of Kettles						
	Amount of Steps						
	Treated Bullion	MTPY					
	Inlet Bi-content	%					
	Temperature Start	<sup>o</sup> C					
	Temperature End	<sup>o</sup> C					
	Reaction Agent(s)						
	Amount	Kg/T Bullion					
		Kg/T					
	Final Bullion	MTPY					
	Final Bi-content	%					
	Duration of Treatment	HR/Kettle					
	Amount of Dross/Crust	MTPY					
	Treatment of Bi-Dross/Crust						
	Final By-Product						
	Amount	MTPY					
	% Pb	%					
	% Bi	%					
	% Ca	%					
	% Mg	%					













Table 7. Lead Smelter Refineries (Electrorefining) (Continued)

1.	Company Name		Yuguang	Toho Zinc Co.,Ltd. Chigirishima	Sumitomo Metal Mining Harima Smelter	Kamioka Mining & Smelting	Kosaka Smelting & Refining Co.
<b>6.3</b>	<b>Anodes</b>						
	Casting Method		Slab continous cast	Vertical Automatic Casting Machine	Horizontal Casting Machine	Horizontal Casting Machine with Horizontal Mould	Casting wheel
	Composition						
	% Sb	%	0.4-1.2	1.58	0.15~0.45	1.2	1.56
	% As	%		0.24	≤0.05		0.05
	% Bi	%		0.38	0.10~0.30	0.3	1.11
	% Cu	%	0.02-0.04	0.04	≤0.15	0.1	0.09
	% Ag	%		0.45	0.10~0.35	0.2	0.84
	% Sn	%		0.18	≤0.10	0.3	0.02
	Total Dimension	mm	660×780	1390×800	1108×740×40		-
	Dimension Immersed Surface	mm	660×760	1240×840	1000	1,140×985×25	1000×640×31
	Mode of Suspension		Hook vertical hang	Shoulder	Shoulder	Shoulder	Cast lugs
	Anode Life	Days	3	7	8	6	8
	Scrap	%	30—40	37.2	32	50	38
	Anode Spacing	mm	95	100	110	110	110
	Weight	Kg	90—150	294	320	300	240

Table 7. Lead Smelter Refineries (Electrorefining) (Continued)

<b>1.</b>	<b>Company Name</b>		Yuguang	Toho Zinc Co.,Ltd. Chigirishima	Sumitomo Metal Mining Harima Smelter	Kamioka Mining & Smelting	Kosaka Smelting & Refining Co.
<b>6.4</b>	<b>Cathodes</b>						
	Starting Sheet		no	Refined Lead	Refined lead	Refined Lead	Refined lead
	Production Method		Continuous production in cooling cylinder	DM casting machine	Direct Machine	Cast	DM casting machine
	Thickness	mm	1.0-1.3	0.9	1	0.7	0.8
	Weight	Kg	18	15	10	12	7
	Life	Days	3	7	4	5	4
<b>6.5</b>	<b>Anode Slime</b>						
	Composition						
	% Sb	%	30-40	37.8	20-38	37	31.9
	% As	%	5-9	6.4	1-2	4	1.1
	% Pb	%	10-18	17.2	6-8	15	11.6
	% Cu	%	1-3	0.9	4-6	3	2.4
	% Bi	%	5-9	8.7	8-20	13	23.2
	% Ag	%	9-12	10.8	10-20	6	16.7
	Removed after	Days	1	1	8	6	4
	Percentage of Anodes	%	35	2.7	1.0~1.5		3.06
	Scrubbing Method		Water Scrubing	Rotating brush	Rotating Brush	Rotating brush	Scraper and rotary blush
	Method of Slime Treatment		Pyrometallurgy	Filtration	Filtration	Filtration	Filtration
	Products		Au, Ag Ingot	Pb-Sb Alloy Electrolytic Ag. Electrolytic Bi		Cake	Cake

Table 7. Lead Smelter Refineries (Electrorefining) (Continued)

<b>1.</b>	<b>Company Name</b>		Yuguang	Toho Zinc Co.,Ltd. Chigirishima	Sumitomo Metal Mining Harima Smelter	Kamioka Mining & Smelting	Kosaka Smelting & Refining Co.
<b>6.6</b>	<b>Casting</b>						
	Melting Furnace		Melting Furnace	Kettle	Kettle	Kettle	kettle
	Capacity	T	100	140	90	100	80
	Additives		NaOH	NaOH	NaOH, NaNO <sub>3</sub>	NaOH	NaOH
	Amount	Kg/T Bullion	0.37		0.3	1.05	0.31
	Amount of Dross	MTPY	4500		240	1400	560
	Treatment of Dross		Return to Cu removal	Recycle to Blast Furnace	Recycle to Short Rotary Furnace	Recycle to Blast Furnace	Return to smelting process
	Casting Machine - Type		Mould cast machine	Continuous	Endless Type		
	Number of Moulds			126	86	44	50
	Rate	MTPH	13t	28	25	15	15
	Casting Temperature	<sup>o</sup> C	400—450	500	400	470	440
	Cast Product		#1 primary lead	Ingots	Ingot	Ingot	ingot
	Ingot Size	mm		630×115×85H	117W x 640L x 85H		665 × 120 × 73
	Ingot Weight	Kg	48+3	50	50	50	48
	Rejects as % of New Material	%		1.7			-