GALMOY Pb/Zn CONCENTRATOR

PROCESS DESIGN BASIS

FINAL - AS BUILT (06/98)

C7778 **1998**

DESIGN BASIS

The following specification outlines the design basis used for the Galmoy project.

1.0 General Design Data

1.1 Location and Climate

Location	Galmoy, Co Kilkenny Republic of Ireland
Altitude (above sea level)	nominally 130 m
Maximum temperature (design)	nominally 25 C
Minimum temperature (design)	nominally -5 C

Rainfall (Galmoy)		**References**
average annual	867 mm (Galmoy area)	10-3.1
effective rainfall	434 mm (Galmoy)	10-3.1

Rainfall (Kilkenny)

Monthly and annual averages for rainfall and potential evapotranspiration from Kilkenny (Met. Office (1960 - 1984))

Month	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**Total**
Rainfall (mm)	88	60	57	52	63	47	59	66	82	83	77	92	826
Pot. Evap. (mm)	2	13	30	55	73	83	77	64	39	16	3	1	456

Storm condition	50 mm in 24 hours	10-3.1
	22 mm in 1 hour	11-T1

2.0 Design Basis - Process Plant

All tonnages quoted are dry metric tonnes, unless otherwise stated.

2.1 Plant Capacity

Annual Plant Throughput	650,000 t	1A - 1
Daily Plant Throughput	1,900 t	1A - 1
Design Operating Rate	84 t/h	4
Operating Schedules	Continuous 24 h/day	1A - 1
	3 shifts/day	6 - 6.1
	8 hours/shift	

2.2 Run-of-Mine Ore Characteristics

Maximum Size	nominally 608 mm	2 - 7.4
Specific Gravity	3.1	2 - 7.4
Moisture Content (design)	10%	2 - 7.4
Abrasion Index	0.08	3

	CW	G	Design	
Zinc Grade (%)	11.85	10.37	11.31	1A - 6
Lead Grade (%)	0.68	1.9	1.12	1A - 1

(All figures are based on mineable figures and include dilution)

2.3 Crushing Plant

Operating Schedule		10 shifts/week	1A - 1b
		8 hours/shift	
		2 shifts/day	
Crushing Rate		235 t/h	2
Crusher Product	- P_{80}	150 mm	2
	- max lump	200 mm	

	Crushed Ore Stockpile	6,000 t (live)	1A - 1e	
	Crushed Ore Bulk Density	1.86 t/m^3 (Dry solids)	5a	
	Circuit Type	Open Circuit Jaw Crusher		

2.4 Grinding Circuit

	Circuit Type	2 stage milling. Closed circuit SAG mill incorporating a trommel recycle screw, closed circuit ball mill with cyclones	2	B

2.4.1 SAG Mill

	Number of Units	1		
	Mode of Operation	Closed circuit incorporating a trommel recycle screw, fixed speed	5	B
	Feed Rate	84 t/h (fresh feed)	2 - 7.4	
	Feed Size - F_{80}	150 mm	2 - 7.4	
	Feed Moisture Content	Up to 10%	2 - 7.4	B
	Autogenous Work Index	13.1 kWh/t (Design)	3	
	Product Size	Nominally 500 to 1,000 microns	5	B
	Mill Discharge Pulp % Solids	70% w/w	2 - 7.4	
	Make-Up Ball Diameter	125 mm	2 - 7.4	A
	Design Ball Loading	12% v/v	5	
	Design Mill Loading	35% v/v	5	
	Critical Size Removal/Treatment	Nil	2	

2.4.2 Ball Mill

	Number of Units	1		
	Mode of Operation	Closed-circuit with Cyclones	2 - 7.4	
	Circulating Load	nominally 250%	2 - 7.4	

Feed Rate	84 t/h (fresh feed to circuit)	2 - 7.4	
Feed Size F_{80} (Design)	500 microns (inc. safety factor)	2 - 7.4	
Bond Work Index (Design)	10.8 kWh/t (original design)	3	B
	13.5 kWh/t (actual mined)	14	B
Product Size P_{80}	95 microns	1A - 9.1	
Mill Discharge % Solids	65% w/w	2 - 7.4	
Make-up Ball Diameter	60 mm	9	A
Cyclone Overflow % Solids	35% w/w	5	
Design Ball Loading	40% v/v	9	

2.5 Flotation Circuit

2.5.1 Overall Metallurgical Performance 1A - 7

Zinc in Zinc Concentrate (CW)	94% recovery at 55% grade)	Original
Zinc in Zinc Concentrate (G)	94% recovery at 53% grade)	Design
Lead in Lead Concentrate (CW)	58% recovery at 45% grade)	
Lead in Lead Concentrate (G)	70% recovery at 55% grade)	

Zinc in Zinc Concentrate (CW)	90% recovery at 53.5 to 55% grade	15	B

Concentrate Production (Original Design) 4, 5b B

Zinc in feed	**% Zinc**	**% rec**	**% Grade**	**t/h**
CW	11.85	94	55	17.01
G	10.37	94	53	15.45
Average	11.31	94	53	16.85
Design	33% margin on average			22.45

Lead in feed	% Lead	% Rec	% Grade	t/h
CW	0.68	58	45	0.73
G	1.90	70	55	2.03
Average	1.12	64	45	1.34
Design	33% margin on average			1.80

2.5.2 **Lead Circuit**

Pb Rougher Flotation Cells

Number of Cells	4 off 16 m^3 cells	2	
Feed Rate	84 t/h		
Feed % Solids	35 % w/w	5b	
Retention Time (Actual)	20 mins	2	
Pb Rougher Concentrate (Design)	2.7 t/h	5	

Pb Cleaner Flotation

Number Off	1 flotation column	2	
Feed Rate (Original Design)	2.7 t/h	5b	B
Feed % Solids	21 % w/w	5b	
Pb Concentrate SG	5.0	5a	
Final Pb Concentrate (Design)	1.8 t/h	5b	
Final Pb Conc % Solids	15 - 20 % w/w, nominal	5a	B

Pb Cleaner Scavenger Flotation Cells

Number of Cells	2 off	2	
Pb Cleaner Scavenger Conc % Solids	25% w/w, nominal	5b	B

2.5.3 Zinc Circuit

Zn Flotation Conditioner

Number of Units	2		B
Feed Slurry % Solids	34 % w/w, nominal		
Retention Time	5 mins each	5a	B
Feed Rate (Design)	82.7 t/h	5b	

Zn Rougher Flotation Cells

Number of Cells	6 off 16 m^3 cells	2	
Feed Rate (Design)	82.7 t/h	5b	
Feed % Solids	34% w/w, nominal	5b	
Retention Time	30 mins	2	
Zinc Concentrate SG	4.0	5a	
Zn Rougher Concentrate Grade	28% Zinc	14	B
Zn Rougher Concentrate (Design)	28.1 t/h for Regrind design	5b	B
	42.4 t/h for Pump design	5/15	B
Zn Rougher Conc % Solids	30 % w/w	5b	

Zn Cleaner Flotation Columns

Number of Cells	4 column flotation cells	2	
Feed Rate (incl. recycles)	64.5 t/h	5/15	B
Feed % Solids	30% w/w, nominal	14/15	B
Final Zn Concentrate SG	4.0	5a	
Final Zn Concentrate (Design)	21.2 t/h	15	B
Final Zn Concentrate % Solids	16-18 % w/w, nominal	5b/9	B

Zn Rougher Scavenger Flotation Cells

Number of Cells	4 off 8m^3 cells	2	
Design Feed Rate & Feed % Solids	As for Zn Roughers		B

	Zn Cleaner Scavenger flotation Cells		B
	Number of Cells	6 x 16 m³ cells	B

2.5.4 **Pyrite Circuit**

Pyrite Conditioning

Number of Units	2	B
Retention Time	10 minutes each	B

Pyrite Flotation Cells

Number of Cells	3 off 21 m³ “Smart” cells	B
Feedrate (design)		
Retention Time	nominally 16 minutes	

2.5.5 Flotation Reagent Additions 2, 7

Reagent		Ore Type Addition, g/t CW	CW-1	G	Design g/t	
Primary Grind:	Na_2CO_3	2000	2000	2000	2000	
(SAG mill feed)	$ZnSO_4$	200	200	200	200	
Ball Mill	NaCN	100	100	100	100	
	AF242	20	20	20	20	
Pb Rougher Feed:	Na_2CO_3	670	1225	1300	1300	
	AF242	5	18	17	18	
	R343	25	38	37	38	
	MIBC	15	10	15	15	
Pb Cleaner Condition:	Na_2CO_3	500	500	500	500	
	$ZnSO_4$	100	100	100	100	
	NaCN	100	100	100	100	
	AF242	5	11	11	11	
	MIBC				Provision	
Zn Rougher Conditioner:	$Ca(OH)_2$	2020	3390	2350	3390	
	$CuSO_4$	1100	1250	1250	1250	
	AP3894	31	36	41	41	
	A350	31	36	41	41	
	MIBC				Provision	
Zn Regrind:	$Ca(OH)_2$	250	250	250	250	
	$CuSO_4$	100	100	100	100	
Zn Cleaner Feed:	$Ca(OH)_2$	455	295	200	455	
	AP3894	11	11	11	11	
	A350	11	11	11	11	
	MIBC				Provision	
Pyrite:	A350	-	-	-	100	
	$CuSO_4$	-	-	-	500	B
Flotation	MIBC	-	-	-	10	
	H_2SO_4	-	-	-	As required	B

2.6 Zn Concentrate Regrind Circuit

Type of Unit	Overflow Ball Mill		
Fresh Feed Rate	28.1 t/h (Original Design)	5b	B
Mill Discharge % Solids	65% w/w	2	
Feed Size F_{80} (Design)	95 microns	2	
Bond Work Index (Design)	9.0 kWh/t	5a	
Product Size P_{80} (Design)	20 microns	2, 7	
Make up Ball Diameter	25 mm	2, 5a	A
Design Ball Charge	27% v/v	9	A
Product % Solids	20% w/w, nominal	5b	
Circulating Load	200 - 300%	2	

2.7 Zinc Concentrate Leach

Number of Tanks	4	2
Residence Time per Tank	30 minutes	2
Feed Rate (Original Design)	22.45 t/h of zinc concentrate	5b	B
% Solids in Leach	20% w/w, nominal	5b
Sulphuric Acid Addition	7 kg per tonne ore (Approx 26 kg per tonne concentrate)	5a

2.8 Pb Concentrate Thickener

Type	Conventional	5a
Feed Rate (Design)	1.8 t/h	5b
Feed % Solids	20% w/w, nominal	5a
Underflow % Solids	60 - 70 % w/w	2
Thickener Size	6 m dia	5a, 9
Pb Concentrate SG	5.0	5a
Flocculant Dosage	10-20 g/t (of concentrate)	5a, 7
Specific Settling Rate	1.5 t/m²/day	

2.9 Zn Concentrate Thickener

Type	Conventional	5a	
Feed Rate (Original Design)	22.45 t/h	5b	B
Feed % Solids	20 % w/w	5b	
Underflow % Solids	60 - 65 % w/w	2	
Thickener Size	18 m dia	5a, 9	
Zinc Concentrate SG	4.0	5a	
Flocculant Dosage	10-20 g/t (of concentrate)	5a, 7	
Unit Area	2.1 t/m²/day		

2.10 Lead Concentrate Buffer Tank Storage

Pb Buffer Tank Working Volume	30 m³	
Maximum Holding Time	24 hours	2
Density of Contents	2.08 t/m³ slurry, nominal	5b

2.11 Zinc Concentrate Buffer Tank Storage

Zn Buffer Tank Working Volume	450 m³	4
Maximum Holding Time	24 hours	2
Density of Contents	1.95 t/m³ slurry, nominal	5b

2.12 Concentrate Filtration

Operation	7 days per week		A
Type	Recessed plate		

Pb Filters

Number of filters	1	
Operating Time	24 h/d	5a
Specific Filtration Rate	350 kg/m²/h	2, 5a
Concentrate Tonnage	44 t/day (design)	5b
Final Concentrate Moisture	8 % w/w	1A - 1K

Zn Filters

Number of filters	1	
Operating Time	24 h/d	5a
Specific Filtration Time	350 kg/m²/h	8
Zinc Concentrate Tonnage	540 t/day (design)	5b
Final Concentrate Moisture	8-10 % w/w	1A - 1K

Typical Concentrate Analysis 2

	Pb Conc.	Zn Conc. Unleache	Zn Conc Leached with H_2SO_4
Zn %	9.0	55.0	55.0
Pb %	50	0.4	0.4
Cu %	0.015	0.061	0.061
Au g/t	0.68	0.07	0.07
Ag g/t	27.5	18.0	18.0
MgO %	-	0.323	0.1
CaO %		1.63	0.3
SiO2 %		1.18	1.18
Cd %		0.077	0.077
Hg %		0.00026	0.00026
As %		0.31	0.31
Bi %		0.002	0.002
Sb %		0.002	0.002
Fe %		6.15	6.15

Note: "MgO" % in zinc final concentrate unleached typically 1.5 to 2.0%. Original leach circuit design based on figures in the table. 14 B

2.13 Concentrate Loadout

Pb Concentrate

Holding Time (Design)	8 days	1A - 9
Storage Capacity	376 t	5b
Storage Area Required	7 m x 16 m	5a
Concentrate Bulk Density	2.6 t/m³	5a

Zn Concentrate

Holding Time (Design)	4 days	1A - 9
Storage Capacity	2340 t	5b
Storage Area Required	25 m x 16 m	5a
Zn Concentrate Bulk Density	2.2 t/m³	5a
Capacity of Trucks	20-25 t	1A - 1g

2.14 Backfill

HIGH DENSITY BACKFILL PLANT			
Feed Size (P_{80})	95 microns	2	
Feed Tonnage	66 t/h (average) 74 t/h design	5b	
Thickener Area	0.5 m²/t/day	5a, 7	
Flocculant	45 g/t maximum		
Thickener % Solids	76% w/w (maximum)	5a	
Cement Addition	Surface		A
Cement Slurry Consistency	n.a.	5a, 9	A
Cement Pump Pressure	n.a.	9	A
Cement Silo	180 t	2	A
Percent of Backfill requiring Cement	60%	2	
Average Cement Addition	197 t week (at 5%)	5b	
Sand Requirement	Nil	5b	
Backfill Tonnages	1,315 tpd	5b	
Backfill Pulp Density	76% w/w nominal	5a (assumed)	
Backfill Operation	15 h/day, 5 days/week	5a	

2.15 Water Systems

2.15.1 Water Ponds

Wall slope	2:1, 26.5 degrees	5a
Storm water pond residence time	24 hours	
Treated water pond residence time	24 hours	
Well water pond residence time	24 hours	
Minimum freeboard	0.6 m	

Storm water pond capacity	nominally 2,300 m^3	5a
Mine water pond capacity	nominally 9,700 m^3	5a
Well water pond capacity	nominally 17,500 m^3	5a

2.15.2 Well Water (Dewatering)

Number of wells	5
Normal flowrate per well	162 m^3/hour
Number of wells on line	2 to 5
Maximum well water flowrate at equilibrium	729 m^3/h
Initial water flowrate per well	208 m^3/h (at start-up)

2.15.3 Mine Water Parameters

Normal flowrate	285 m^3/h		
Design flowrate	474 m^3/h (for underground pumping)		B
Solids Content (normal)	100 to 300 ppm	5a	
Design solids	less than 0.1% w/w	5a	

2.15.4 Water Treatment

2.15.4.1 Effluent Treatment (Reclaim water bleed)

Reclaim water bleed flowrate	70 m^3/h	14	B
Number of Oxidation tanks	3	2	
Residence time per tank	Oxidation 1 hour	2	
Neutralisation/Precipitation	15 minutes (Average 30 minutes per tank)		
Clarifier size	8 m		
Sand filters	2 on line	14	B
Discharge quality	less than 1 ppm TSS	9	
Carbon filters	1 (on line)		

Sand filter backwash flowrate 140 m^3/h instantaneous A

Carbon filter backwash flowrate 180 m^3/h instantaneous A

Reagent Addition

Hydrogen peroxide	up to 0.5 kg/m^3 of water	A
Lime	nominally 1 kg/m^3 of water	
Flocculant	up to 1 g/m^3 of water	A

Final discharge to mine water pond

2.15.4.2 **Mine Water Treatment**

Treatment plant flowrate (Excess water to tailings impoundment)	300 m^3/h		
Solids in feed water	100 to 300 ppm	5a	
Design	less than 0.1 % w/w		
Treatment tanks	1		
Residence time per tank	nominally 15 minutes		
Clarifier size	19 m diameter		
Underflow density	2 to 3% w/w solids		
Overflow clarity	less than 10 ppm solids		
Oil removal	by clarifier skimmer		
Reagent Addition			
Lime	up to 0.5 kg/m^3 of water	5a	
Flocculant	up to 1 g/m^3 of water	5a	A
Final treatment by settling pond			

2.15.5 **Goul Pipeline**

On line analysis of treated minewater	Dissolved O_2, pH, temperature, conductivity		
On line analysis of aerated well water	Dissolved O_2, pH, temperature, conductivity.		
All Ductile Iron - cement lined			
Maximum design flowrate	1,155 m^3/h (3 pumps)	5b	
Average monthly flowrate	637 m^3/h (1 pump)	5b	
Line/length/diameter	nominally 4,190 m, 453 mm id nominally 710 m, 403 mm id		

2.16 Reagents - Design Consumptions and Storage 2, 6-6.6, 5b

Name		Sodium Carbonate/Soda Ash
Design Consumption		3800 g/t milled, 7660 kg/day
Solution Strength		10 % w/w A
Delivered Form		Crystals, bulk
Storage		60 t silo

Name		Zinc Sulphate
Design Consumption		300 g/t milled, 605 kg/day
Solution Strength		10 % w/w
Delivered Form		Crystals, 25 kg bags
Storage		15 t outdoor

Name		Sodium Cyanide
Design Consumption		200 g/t milled, 403 kg/day
Solution Strength		10 % w/w
Delivered Form		Solid flake/Briquettes, 50 kg drums
Storage		10 t outdoor

Name		Lime (as $Ca(OH)_2$)
Design Consumption	}	4095 g/t milled 8260 kg/day (mill)
	}	3060 kg/day (water treatment)
Slurry Strength		20 % w/w
Delivered Form		Powder, bulk
Storage		60 t silo

Name	Copper Sulphate
Design Consumption	1350 g/t milled, 2720 kg/day
Solution Strength	15 % w/w
Delivered Form	Crystals, 25 kg bags/1 t bulk bags
Storage	30 t Indoor

A

Name	AF242
Design Consumption	49 g/t milled, 99 kg/day
Solution Strength	20% w/w
Delivered Form	Liquid, 200 l drum
Storage	3 t Outdoors

Name	R343 (SIPX)
Design Consumption	38 g/t milled, 77 kg/day
Solution Strength	5 % w/w
Delivered Form	Pellets, 125 kg drums
Storage	3 t Outdoors

Name	MIBC
Design Consumption	25 g/t milled, 50 kg/day (15 g/t milled, 30 kg day excl. pyrite)
Solution Strength	Undiluted
Delivered Form	Liquid, 200 l drum
Storage	3 t Outdoors

Name	AP3894
Design Consumption	52 g/t milled, 105 kg/day
Solution Strength	Undiluted
Delivered Form	Liquid, 200 l drum
Storage	3 t Outdoors

Name	A350 (PAX)	
Design Consumption	152 g/t milled, 306 kg/day, (52 g/t milled, 105 kg/day excl. pyrite)	
Solution Strength	10 % w/w	
Delivered Form	Pellets, 125 kg drum	
Storage	3 t Outdoors	
Name	Sulphuric Acid	
Design Consumption	Design 7 kg/t milled, 14 t/day	5a
Strength	96 - 98 %	
Delivered	Bulk road tanker	
Storage	50 t tank	
Name	Hydrogen Peroxide (Common Commercial Grade)	
Design Consumption	100 g/t milled, 202 kg/day	
Strength	27.5 - 35% w/w	9
Delivered	Bulk road tanker	
Storage	20 t tank	
Name	Flocculant (concentrate thickening)	
Design Consumption	20 g/t concentrate, 12 kg/day	
Strength	0.5 % w/w (mix)	
Delivered	Powder, bags	
Storage	1 t	
Name	Flocculant (water treatment)	
Design Consumption	10 to 20 g/m^3 of water (mine water, effluent treatment resp.) 96 kg/day, nominal	
Strength	0.5 % w/w (mix)	
Delivered	Powder, bags	
Storage	3 tonnes	

Name	Flocculant (backfill)	
Design Consumption	45 g/t solids, 50 kg/day	A
Strength	0.5% w/w (mix)	
Delivered	Powder, bags	
Storage	2 tonnes	

Name	Cement (backfill)	
Design Consumption	up to 40 tonnes per day	A
Strength	100% (dry)	
Delivered	Bulk road tanker	
Storage	80 tonne silo	

2.17 Plant Utilities

2.17.1 Plant Air

(For flotation column cells, concentrate filters, backfill line flush, general plant use)			B
Total Capacity:			
Consumed (Peak)	6,100 Nm^3/h design	5(a)	A
Installed	6,500 Nm^3/h		A
Operating Pressure	7.5 bar g nominal		A

2.17.2 Instrument Air

Dry Instrument Air	200 Nm^3
Operating Pressure	7.5 bar g nominal

2.17.3 Potable Water

From reservoir 5(a) B

2.17.4 Sewage Treatment

Population allowance	200 persons
Unit flowrate	250 litres/day/person
BOD	60 g/day/person (not containing excessive quantities of grease or detergent)

Discharge quality	BOD 20 mg/l TSS 30 mg/l Ammoniacal Nitrogen 20 mg/l
Daily volumetric capacity	50 m^3/day
Peak flowrate	4 m^3/hour

2.18 **Water Discharge Standards**

- Statutory Instrument SI 293 of 1988 - European Communities (Quality of Salmonid Water) Regulations 1988;

- Statutory Instrument SI 81 of 1988 - European Communities (Quality of Waters Intended for Human Consumption) Regulations 1988;

- Statutory Instrument SI 294 of 1989 - European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations 1989.

- Technical Memorandum No.1 (for spawning and salmonid freshwaters, estuaries and other coast waters), issued by the Department of the Environment for use by Local Authorities in relation to the Local Government Water Pollution Act of 1977.

2.19 Process Design Basis - References

The following sources have been used to develop the Process design basis for the Galmoy Project.

1 A, B, C, D, E, F Arcon Mines Ltd. Invitation to Bid document
volumes A, B, C, D, E and F

2 Kilborn Technical Study, Appendix 1 of documentation supplied by Arcon Mines Ltd.

3 Hazen Research, Appendix 5 of documentation supplied by Arcon Mines Ltd.

4 Derived from data referred elsewhere.

5a Davy In-house information.
5b Davy Mass Balance, generated from data referred elsewhere.
5c Davy/CML

6 Environmental Import Statement, Volume 1, Appendix 18 of documentation supplied by Arcon Mines Ltd.

7 Lakefield research testwork, Appendices 3 and 3a of documentation supplied by Arcon Mines Ltd.

8 Larox filtration testwork report, Appendix 6 of documentation supplied by Arcon Mines Ltd.

9 Vendor information

10 KTC Report November 1992

11 Golders Report 11/92, Appendix 9 of documentation supplied by Arcon Mines Ltd.

12 BeMRA report on mine dewatering

13 Golders Report 7/93, Hydrogeology Study of Galmoy Mine

14 Operating data B

15 Modification design data B

In the following section, references are noted in the form x-y, meaning section y in reference number x.