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COMALCO LIMITED

**MICROFILMED**

SILICON SMELTER AT  
CAPE SORELL, TASMANIA

TECHNICAL DESCRIPTION

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A. INTRODUCTION

The discovery by A.H. Bartlett's Exploration Services Group of a major high-grade quartzite deposit at Cape Sorell, Tasmania, drew Comalco's attention to the possibility of establishing a Silicon Smelter for the production of metallic silicon. Economy of scale made it essential to consider the establishment of such a venture on the basis of a yearly production much in excess of Australian, not to mention Comalco's, requirements. Discussions with Japanese consumers were encouraging, and interest has been shown in 10-year contracts for substantial quantities. European companies have also shown interest to the extent of visiting the site of the quartzite deposit, and contacts have been made by U.S.A. buyers.

A plant sized to product initially 30,000 to 35,000 tonnes of silicon metal per year was therefore selected for study.

In addition to the production of silicon metal a quarrying operation necessary to supply raw quartzite to the smelter will need to be established. This operation has been considered as a separate entity and is designed to supply not only the raw material to the smelter, but also to produce silicon-grade quartzite for export should the demand and price warrant it.

Preliminary discussions with the Hydro-Electric Commission of Tasmania have indicated that a total of 200 MW, in stages of 68 ± 5%, 130 and 200 MW, could be secured. This would allow the development, in three major steps, of a total production capacity of 100 000 tonnes. Our market studies indicate that sales of this order, on a long term basis, could possibly be achieved, but our studies were confined, at this stage, to the immediate prospect of producing 33 000 to 34 000 tonnes/year.

## B. ENVIRONMENT

First environmental studies, which have included a vegetation survey by the University of Tasmania, Botany Department, have been completed.

Preliminary information from the Vegetation Survey suggests that the area is not atypical or environmentally unique in the Tasmanian scene and contains no rare or endangered species.

Informal discussion has been held with the Tasmanian Lands Department, on matters of landscape planning and conservation on crown lands.

Anticipated future work will be concerned with aspects of roads and access, plant site selection and effluent control.

## C. PLANT DESCRIPTION

### 1.0 Plant Size

The present study has been based on practically standard 20 MW rated furnaces; three of these, of a total of 60 MW, were chosen to obtain the desired production rate in the order of 34 000 tonnes per year.

The advantages of this concept are :-

- 1.1 Furnaces can be installed at intervals, if the market proves to be unable to absorb the full initial output.
- 1.2 Operating difficulties affect only part of the production capacity.
- 1.3 The design output is obtained using practically standard, well proven furnaces.
- 1.4 Furnace delivery and start-up is less of a problem than

with higher rated units operating at the limit of present technology.

1.5 There is greater choice of experienced furnace manufacturers.

1.6 Due to the lower weight, handling problems for installation of furnaces and furnace transformers are reduced.

## 2.0 Siteworks

The site for the works has been chosen to satisfy the demands of minimal transportation of raw and finished materials, the engineering of the site itself and visual environmental aspects. Consequently, a location has been selected lying adjacent to and west of the initial mining area, and within 2km of the wharf site. The site slopes downwards from the mine area towards the Pilot Bay lagoon, should have an average R.L. of about 16m and should be effectively hidden from view from Macquarie Harbour by the 50 to 70m R.L. contours.

It is anticipated that a plant site, sized for the ultimate plant, will be prepared in the initial construction, with the surplus area being available as a construction site for the initial plant. The site will be constructed on a cut to fill basis and use will be made of the sloping site to minimise the vertical lifts of process materials from storage areas to blending and furnace feed bins.

The site will be well drained and all run-off will be channelled back to the Pilot Bay lagoon after being passed through a sand/rock filter or other treatment as required.

Roads within the plant site and to the wharf will be sealed.

The plant site will be fenced to secure it from entry by unauthorised people and both wild and domesticated animals.

### 3.0 Buildings

#### 3.1 Raw Material Storage

The raw material storage building will be wide span and low profile and will support the incoming raw materials distributing conveyor system. The various raw materials will be separated by concrete retaining walls.

#### 3.2 Blending Building

The blending building structure will be basically a number of steel bins, suitably weatherproofed at the top for the infeed of raw materials and at the bottom for the outfeed.

#### 3.3 Furnace Building

The furnace building structure will be substantial as it will support three furnaces with the exception of their rotating hearths. The furnace transformers will be located as near as practical to the electrical connection points on the electrodes and thus will be located on the floor of the building at furnace hood level.

#### 3.4 Cooling/Crushing Building

This building will be simply a weather cover and will support no machinery.

#### 3.5 Screening/Packing Building

This building will be simply a weather cover and will support no machinery.

#### 3.6 Administration/Laboratory/Amenity Building

This building will be designed to suit availability of materials in Strahan and thus will probably be of brick veneer

construction. To economise in its construction it is considered that plant administration, laboratory operations and staff and daily paid amenities should be under the one roof.

### 3.7 Workshops/Store Building

A single building incorporating the maintenance and covered storage functions will be provided. A fenced yard will be provided for storage of items that need not be under cover.

### 3.8 Other Buildings

All buildings required for operation of the factory will be provided, including air compressor building sub-station building and gatehouse.

## 4.0 Raw Materials Receival and Storage

### 4.1 Imported Raw Materials

Petroleum coke and bituminous coal will be shipped to Cape Sorell where it will be unloaded. From the wharf these materials will be transported to the plant by road truck on contract.

A total storage capacity of ninety (90) days usage of these materials will be provided with about one third or thirty (30) days usage being stored under cover.

### 4.2 Quartzite

Quartzite will be delivered to the plant from the mine stockpile in road trucks. Thirty (30) days usage will be held in open storage and incoming materials will be delivered to the stockpile via the above truck tipping station and conveying system.

#### 4.3 Woodchips - Mill offcuts

Wood reductant will probably be delivered by road, as waste material from local sawmills or as woodchips from Bell Bay. Ninety (90) days usage will be stored with about thirty (30) days usage being in the covered storage. The same unloading and distributing system as above will be used.

### 5.0 Raw Material Control

#### 5.1 Storage

It is proposed that the raw material handling will be controlled from local stop-start push button stations only, with one operator who will continually supervise the raw material conveyor system. The system will conform with all electrical safety and mining regulations within the State of Tasmania.

#### 5.2 Reclaiming

Raw materials will be reclaimed from storage by front end loader, elevated and distributed to bins by conveyor.

Each bin will be fitted with level measuring equipment which will indicate the condition of all bins to the reclaim front end loader operator.

### 6.0 Furnaces

6.1 On top of each of the three furnaces will be a number (probably 12) of charging bins with level control, into each of which the blended raw materials will be fed on demand.

The furnace hearth is separate from the body and is rotated at very slow speed (variable - 100 to 400 hours per revolution), in order to make energy distribution more uniform

and to increase the furnace melting area. A stoking machine will be incorporated to break up surface crusts and to cover gas blow holes.

The furnace hearth and body are lined with insulating and fire bricks and finally with car on blocks to prevent contamination of the silicon product.

Each furnace has a hood and is thus semi-enclosed, avoiding the use of excess air for effective and economical environmental control.

The electrodes will be of pre-baked type and will be lowered and lifted hydraulically.

7.0 Metal Handling

7.1 Silicon metal will be tapped out of the bottom of each furnace at about two-hourly intervals, discharged into ladles and transported by crane to the casting area.

The molten silicon will be held for as long as possible in ladles to allow the segregation of any contained slag. At the appropriate time and after removal of the slag the silicon will be poured into floor moulds formed out of silicon fines separated from the finished product during screening.

7.2 When the cast silicon ingot has cooled sufficiently it will be recovered from the floor mould by front end loader and transported to the cooling stockpile.

The large lump silicon product will be taken from the stockpile by front end loader, crushed in a jaw crusher

and passed over a vibrating screen. The product from the screen will discharge into two separate size ranges onto flat, slow-moving conveyors to allow inspection and hand removal of any reject material. Reject material will be product lumps containing slag. The screen underflow fines will be collected and stockpiled for recirculation to the furnace (together with reject material) for remelting.

From the inspection conveyors the products will each discharge into open-topped containers which, after filling, will be weighed, sealed and stored for shipment.

Additional weighing equipment will be installed for shipping purposes.

## 8.0 Services

### 8.1 Water

#### a) Potable Water

If potable water is not available from either of the two proposed underground sources, fresh water will be collected from the plant roofs and stored in an underground tank from whence it will be distributed. It is envisaged that a water treatment plant will be required to make this water suitable for drinking.

#### b) Process Water

The furnaces, furnace transformers and various other items of plant will be water cooled. This will be achieved by closed-circuit systems with cooling tower and ancillary equipment. Make-up water and that for other purposes e.g. washdown etc. will be provided from whichever of the two likely underground sources is proven to be most suitable.

c) Fire Fighting Water

From the same source as the process supply, fire water will be pumped through a fire fighting ring main which will distribute it as necessary around the plant.

Under normal circumstances this water will be pumped by an electrically driven pump but a diesel driven unit will be provided for emergency purposes.

8.2 Compressed Air

An air compressor will be provided and air will be distributed to the appropriate points in the plant.

8.3 Sewerage System

A sewerage system will be provided for the plant area.

8.4 Other

Storages for fuel and lubricants will be provided as required.

Potable, mobile and fixed fire extinguishing systems will be provided as and where necessary.

9.0 Workshop Equipment

Consistent with the relative remoteness of the plant workshop equipment will be provided to allow all but major maintenance works to be carried out.

10.0 Office & Amenities Equipment

All the necessary office furniture, fixings and equipment will be provided.

Amenity equipment will include toilet and shower facilities, lockers and a suitably furnished lunch room complete with food warming oven and hot water urn. It is considered that no canteen facilities should be provided. Shift workers will have their own separate facilities located in the furnace building and in this

case provision will be made to allow operators to prepare their own hot meals.

#### 11.0 Site Laboratory

The silicon plant will have a laboratory facility on site to handle the following principal assignments :-

1. Check analysis of raw material, quartzite and reductants.
2. Routine analysis of silicon and slag as tapped from the furnace.
3. Check analysis of shipment batches of product silicon.
4. Routine analysis of gaseous and liquid effluents for particulates and chemical impurities.
5. Analyse samples of quartzite taken from prospective future quartzite mining areas.
6. Analyse quartzite shipments for export.

#### 12.0 Staff Houses

Five houses will be provided for the senior staff.

#### 13.0 Electrical Services

##### 13.1 H.E.C. Sub-Station

The H.E.C. will install a 220 kV sub-station which will be located along the north-west boundary of the plant area. This location ensures minimum insulator pollution from stack effluent. The H.E.C. will provide one 85 MVA transformer to supply the site and they will make provision for one spare unit. The 85 MVA unit will probably be a standard step down transformer common to the H.E.C. system. This fact, together with the availability of spare transformer capacity, has obvious advantages.

### 13.2 Comalco Sub-station

Comalco will take power from the H.E.C. at 33 kV. There will be two distribution voltages, one at 6.6 kV to feed the 1500 kW motors for the bag filter equipment and the main distribution feeders and 240/415 V for general plant auxiliaries and supplies.

Comalco will install 2 x 33/6.6 kV, 5 MVA transformers in the main switchyard and 6 x 6.6 kV/415 V transformers distributed around the plant. The 33 kV switchgear will be either outdoor gear or alternatively metal clad indoor gear located in the sub-station control room.

### 13.3 Furnace Transformers

There will be nine single phase, 10 MVA furnace transformers (3 per furnace) each having on-load tap changing on the 33 kV side. The transport weight of the furnace transformers will be of the order of 22 tonnes each and it is proposed that the port facility will handle these units. The transformers will be located approximately 16 m above ground level and on this account, coupled with wharf handling problems, all efforts to reduce weight will be investigated, including the maximum use of aluminium.

The furnace transformers will receive power at 33 kV and transform down to furnace voltage which will be in the range of 200-328 V. The transformer range will cover 33 stepped taps and this should be suitable for both silicon production and ferro-silicon production.

### 13.4 Furnace Supply

Proprietary methods for feeding the electrodes are designed to minimise reactance and to maintain optimal current balance in the furnace. Current is conducted from the

step-down transformers by means of water cooled copper tubes, and is transferred to the electrode via flexible bus.

#### 14.0 Manning

The manning that is envisaged is as follows :

##### a) Staff

Works Manager	1
Production Manager	1
Production Supt.	1
General Services Supt.	1
Shift Supervisors	4
Shift Foremen	4
Laboratory Supervisor	1
Laboratory Assistants	2
Yard Gang Foremen	1
Engineering Manager	1
Mechanical Engineer	1
Mechanical Foremen	2
Electrical Engineer	1
Instrument Technician	1
Electrical Foreman	1
Draughtsman	1
Accounts Manager	1
Paymaster	1
Purchasing Officer	1
Store Attendants	1
Personnel Manager	1
Safety Officer	1
First Aid Attendant	1
Gatehouse Attendants	4
Clerks	5
Secretaries	3
Total Staff -	<u>43</u>

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b) Plant Operations

	<u>Men</u>	<u>Shifts</u>	<u>Total</u>
1. Raw Material Receival			
Weighbridge	1	1	1
Store	1	1	1
Total -			2
2. Raw Material Handling			
Reclaiming	1	1	1
Blending	1	4	4
Total -			5
3. Furnace			
Furnace control and charging	5	4	20
Tapping & casting	4	4	16
Crane driver	1	4	4
Total -			40
4. Product Crushing & Shipping			
FE loader driver	1	1	1
Crushing & sorting	4	1	4
Weighing packing and shipping	3	1	3
Total -			8
5. Yard Gang and General			
Yard Gang	10	1	10
Amenities attendant	1	1	1
General cleaners	4	1	4
Truck driver	1	1	1
FL truck/crane driver	1	1	1
Total -			18
<u>Total plant operations</u>			

c) Plant Maintenance

Shift fitters	1	4	4
Fitters	4	1	4
Shift electricians	1	4	4
Electricians	2	1	2
Instrument fitters	1	1	1
Boiler makers	3	1	3
Others	2	1	2
Trades assistants	6	1	6

Total maintenance 26

TOTAL LABOUR 142

D. QUARTZITE MINING

1.0 Quartzite Production

The silicon plant will require approximately 100 000 tonnes per year of quartzite for production of 34 000 tonnes per year of silicon.

The opportunity also exists for the mining and export of further quantities of quartzite to silicon and ferro silicon producers in Japan and elsewhere.

2.0 Mine Sites

The three major deposits at Mount Antill, Mount Obvious and the North Escarpment area will be worked simultaneously to enable blending of ore going to the silicon plant.

3.0 Mining Method

Crawler mounted percussion drills will be used to drill the deposits in 10m benches to a maximum depth of 30m below sea level. Drill hole spacing and explosive used will be selected to give optimum production of shattered quartzite.

Run of mine quartzite will be delivered to the centrally located crushing plant, using front end loaders and 35 tonne rear dump trucks.

It is anticipated that the production of 100 000 tonnes per year of -120 mm +40 mm quartzite will require mining of some 160 000 tonnes of in-situ rock.

4.0 Crushing and Screening Plant

Run of mine ore will be fed to the primary 42" x 30" double toggle jaw crusher by a 42" x 30' feeder and scalper. Material under 40 mm will be discarded at the scalper for use as road material.

Primary crushed ore will be conveyed to a secondary gyratory crusher installed in closed circuit to deliver -120 mm + 40 mm quartzite to a slewing stockpile conveyor.

A 100 m<sup>3</sup> truck loading bin will be provided and an area allotted for outdoor storage of 50 000 tonnes of sized quartzite.

5.0 Delivery of Quartzite to Silicon Plant

Blended and sized quartzite will be delivered to the silicon plant in 35 tonne rear dump trucks.

6.0 For the production of 100 000 tonnes of quartzite the drilling and crushing plant manning is assumed as follows :

Manager	1
Drillers	2
Drillers offsider	1
Crusher & Screen Operators	2
F.E.L. operators	2
In-mine truck drivers	4
Maintenance (Mechanical)	1
Electrician	1
Total	<u>14</u>

E. OTHER RAW MATERIALS1.0 Reductants

1.1 For the Cape Sorell operation a number of alternative reduction mixtures have been computed. Apart from the electrical conductivity and reactivity aspects noted earlier, chemical purity of the reductants is of paramount importance since most of the impurities are retained in the product silicon, i.e. 90% of the iron is retained, and 80% of most other impurities.

The alternative local reductants considered included :-

Victorian brown coal char, Coalcliffe, Moura, Baralaba and Blackwater coals, Yarrabee anthracite and Collie char, besides green petroleum coke and carbon electrodes.

Typical reductant mixes and the impurity level which these are anticipated to provide in the product silicon are:-

1.2 Using Victorian brown coal char, the mix per kilo of product would be :-

quartzite	2.7 kilo
green petroleum coke	0.6 kilo
brown coal char	0.51 kilo
woodchips	0.3 kilo
carbon electrode	0.1 kilo

Product silicon would contain impurities

$\text{Fe}_2\text{O}_3$	0.7
$\text{Al}_2\text{O}_3$	0.6
$\text{TiO}_2$	0.03
CaO	0.1
Mgo	0.2

1.3 Using Moura coal the mix would be :-

quartzite	2.7
green petroleum coke	0.6
coal	0.55
woodchips	0.3
carbon electrode	0.1

Impurities would be :-

$Fe_2O_3$	0.4
$Al_2O_3$	1.4
$TiO_2$	0.07
CaO	0.1
MgO	0.06

1.4 The desirable impurity levels for silicon metal suitable for alloying with aluminium, as set out in KACC's specification, are as follows :-

$Fe_2O_3$	0.67% max
CaO	0.07% "
$Al_2O_3$	0.95% "
$TiO_2$	0.17% "
(Si	98.5% min)

## 2.0 Woodchips

For a Cape Sorell silicon plant location, it is probable that woodchips and hog wood could be supplied from local sawmill operations at Strahan and Queenstown.

An alternative supply would be from the APPM and Northern Woodchips plants located near Comalco, Bell Bay.

## 3.0 Electrodes

Pre-bake electrodes are used for production of silicon because of the need to minimise iron and other impurities in the

product. The majority of other electrometallurgical furnaces utilise Soderberg self-bake type electrodes contained in steel electrode "cans".

Pre-bake electrodes would be fully machined high purity units of 55" diameter and approximately 7 feet in length. These are likely to be supplied by Union Carbide (USA) or Elettro-carbonium (Italy).

#### 4.0 Power

The normal power requirements suggested for silicon metal production are :-

Net (furnace) power usage	12 000 kWh per tonne silicon metal
Gross power usage	12 620 kWh per tonne silicon metal
Power factor (after capacitor correction)	80%
Furnace utilisation	90%
Maintenance down time	10%

Some manufacturers quote power consumption figures 10-15% lower.