6.7 Utilities

6.7.1 List and descriptions of the components

Natural gas, oxygen gas, nitrogen gas, plant air, industrial water, potable water, circulation water, sea water, sewerage water, and fire hydrant

The facilities are described as follows:

(1) Natural gas

Natural gas from the government gas control system located next to the Steel Complex will be received at the battery point in order to meet the requirements of the Steel Complex and will be supplied to each plant through a pipeline.

(2) Oxygen gas, nitrogen gas and plant air

Oxygen gas, nitrogen gas and plant air will be generated by an air separation plant and an air compressor plant installed in the Steel Complex.

(3) Industrial water and potable water

Industrial water and potable water will be supplied from the desalination plant. Potable water will be supplied directly through a pipeline to consumers by pumps which are installed in the desalination plant.

Industrial water will be received at the raw water reservoir and stored. Most of the industrial water will be supplied as make-up water for the cooling water system of each process.

Industrial water will also be supplied to the fire hydrant system from the reservoir.

(4) Cooling water system

Cooling water is used in the Steel Complex to cool the steel production process.

Two (2) types of cooling systems are used in the Steel Complex.

One is the indirect cooling water system (ICW system) which is not contaminated in the processes, because cooling water is cooled indirectly via a wall of equipment such as heat exchangers, tubes, water jackets.

The other one is the direct cooling water system (DCW system) which is contaminated in the process, and dust, scale and oils are included as contaminants.

Contaminants are separated by means of sedimentation, filtration, floatation, dehydration, etc.

Both cooling systems are re-circulated after being cooled down by the cooling system.

The closed type cooling system consists of plate type heat exchanger made of titanium plate and sea water used as a cooling medium.

(5) Sea water

Sea water will be fed from Sohar port. The sea water intake system to be located at the raw material berth will consist of a bar screen, a drum screen, circulation pumps, chlorination equipment and electrical equipment.

Sea water will be pumped by circulation pumps and delivered to the Steel Complex through a pipeline. Sea water will be used as a cooling medium in the Steel Complex and then discharged outside the breakwater.

(6) Waste water

Waste water from the water recirculation system will be quite little and waste water from the Steel Complex will be almost the same as sea water quantitatively and qualitatively.

(7) Sewerage water

Potable water is used for drinking, washing, in the canteen, etc. and discharged as live sewerage.

Live sewerage will be gathered by the pumping station located in each office and plant and transferred to the sewerage water treatment station in the Steel Complex.

The treated water will be re-used in the Steel Complex for plantation and slag cooling.

(8) Fire hydrant

The fire hydrant supply system located in the raw water receiving station will supply water to the outdoor fire hydrant system as per the requirements of NFPA.

(9) Yard piping system

A yard piping system is required to connect supply systems, plants, re-circulation system and discharge systems.

The pipeline will generally be installed on a pipe rack for easy maintenance.

Potable water, waste water and fire water main will be laid underground.

6.7.2 Natural gas

(1) Specifications

The specifications of the natural gas system in the Steel Complex is as follows:

- Receiving quantity	: Max. 66,000 Nm^3/hr, Av. 54,000 Nm^3/hr
- Receiving pressure	: 4.0 + 0.1 kg/cm^2
- Impurity	: None
- Other composition	: Heavy hydrocarbon (C5+) < 0.1 mol.% Sulfur (as H_2s) < 5 ~ 10 ppm
- L.H.V. (MJ/Sm^3)	: 36.4
- Pressure	: 4.0 kgf/cm^2
- Standards	: API recommended practice 521, 1990
- Instruments	: Explosion proof type

(2) Description of process and equipment

Natural gas from the government gas control system located next to the Steel Complex will be received at the battery point in order to meet the requirements of the Steel Complex and will be supplied to each plant through a pipeline.

A flow sheet of natural gas is shown in Figure 6-7-1.

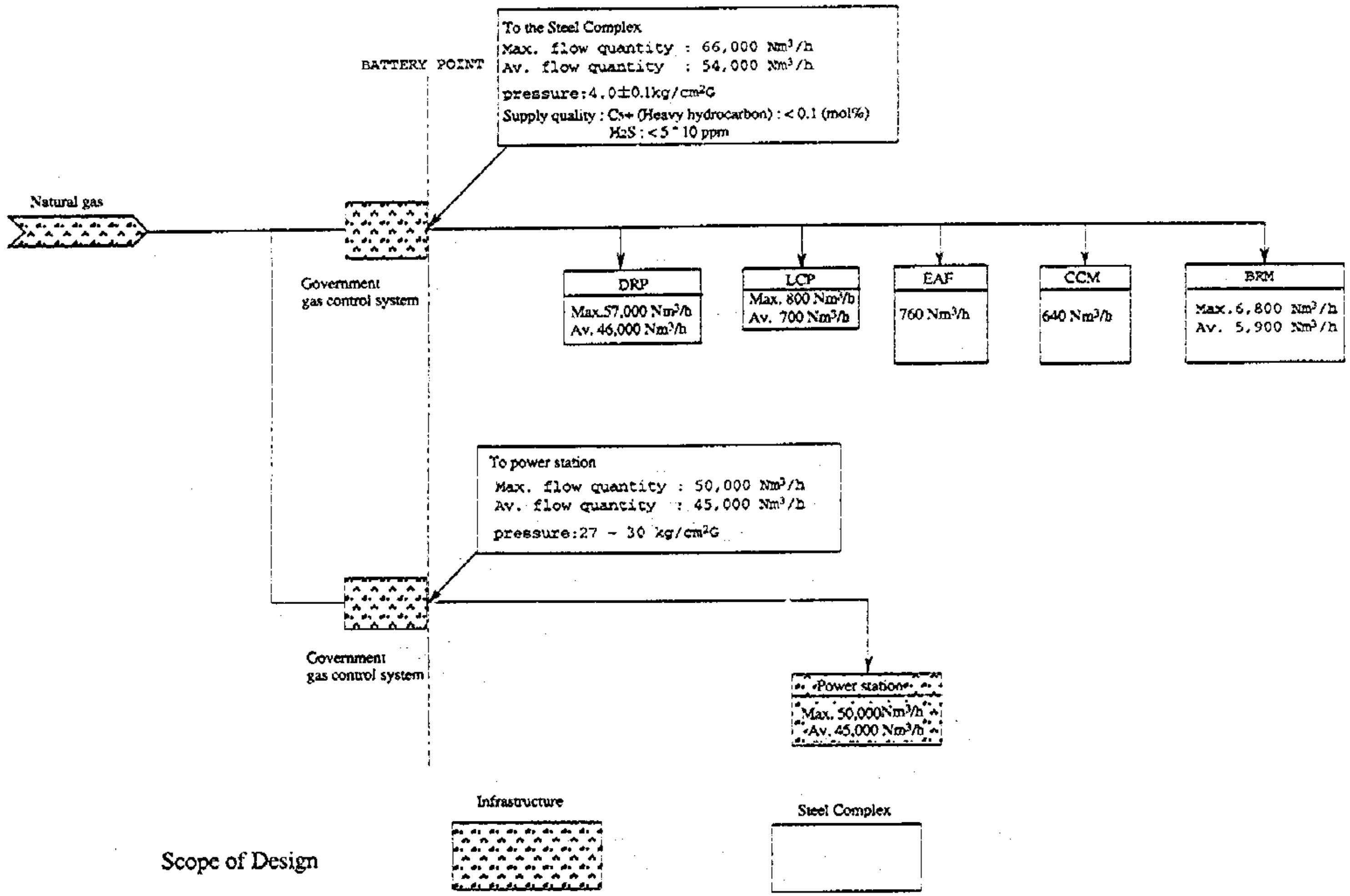


Figure 6-7-1 Natural Gas Flow Sheet

6.7.3 Gases (oxygen gas, nitrogen gas and plant air)

(1) Specifications

Oxygen gas, nitrogen gas and plant air will be generated in the Steel Complex.
The specifications for oxygen gas, nitrogen gas and plant air are as indicated in Table 6-7-1
Fluctuations of oxygen gas and nitrogen gas consumption will be absorbed by the liquid tanks.

Table 6-7-1 Specifications of Oxygen, Nitrogen and Plant Air

Item	Oxygen gas	Nitrogen gas	Plant air
Supply quantity (max.) (Nm^3/hr)	9,000	3,000	10,000
Generating capacity (Av.) (Nm^3/hr)	6,000	3,000	10,000
Generating pressure (kg/cm^2)	20.0	6.0	6.0
Supply pressure (kg/cm^2)	15.0	6.0	6.0
Purity (%)	99.5	99.99	oil free
Noise level of equipment	< 95 dB(A) at 1 m distance from machine side		

(2) Description of process and equipment

Oxygen gas and nitrogen gas will be generated by cryogenic type air separation plant.
Both gases will be produced as liquid gas and are stored in liquid tanks respectively.
Both gases are evaporated by vaporizers as per the requirements of each plant.
Plant air will be generated by air compressors and will be supplied to consumers in the steel complex.
The flow sheet of gas generation system is indicated in Figure 6-7-2.

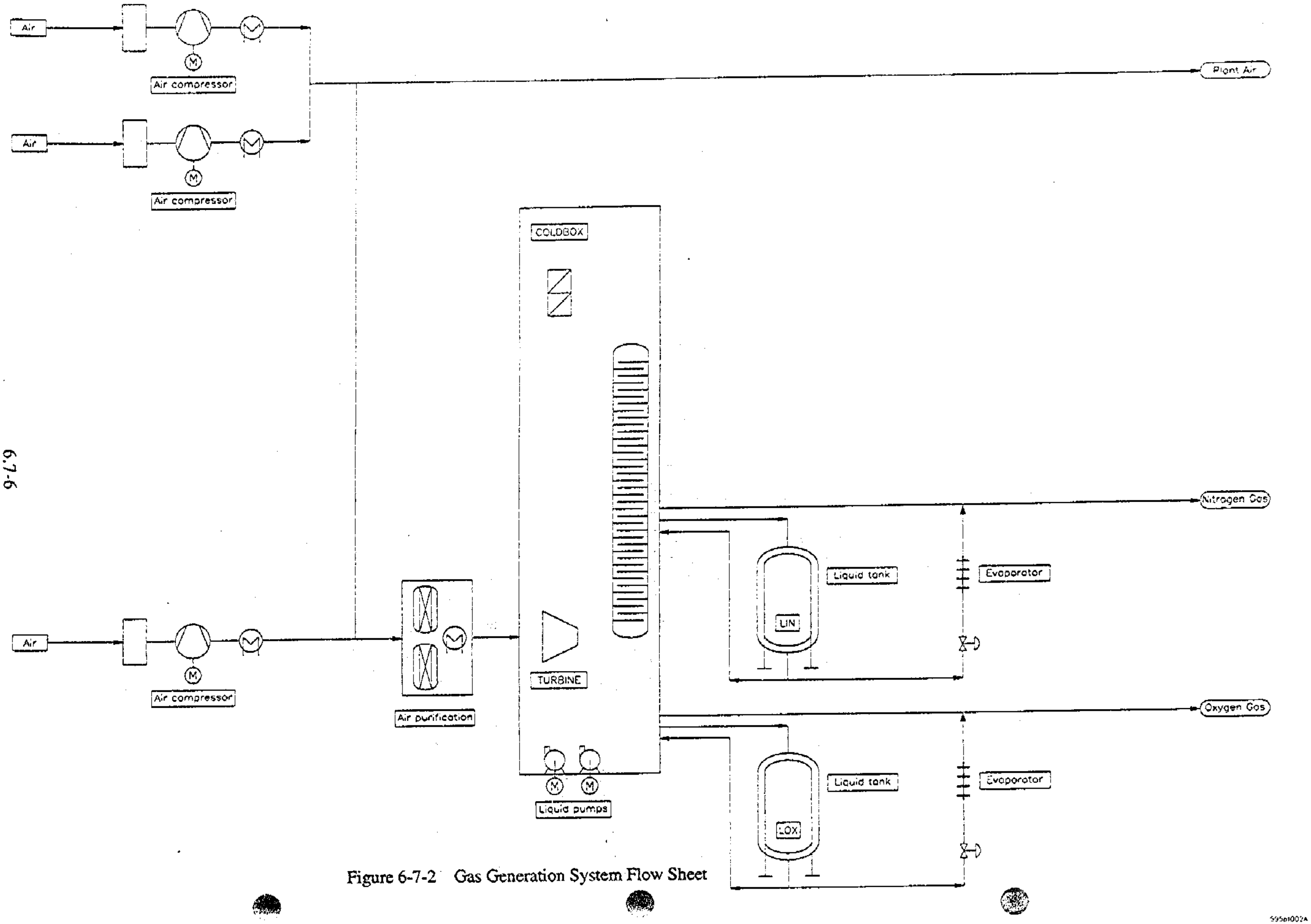


Figure 6-7-2 Gas Generation System Flow Sheet

6.7.4 Water

(1) Industrial water

1) Specifications

(a) Raw water receiving station

Industrial water is made by the desalination plant which is installed in the Steel Complex and is stored in the raw water receiving station and then supplied to the plants as make-up water.

The quality of make-up water will be same as that of product water from desalination plant and is indicated as follows:

-Make-up water quality and supply conditions to each plant.

pH: 7.

TDS : < 110 mg/litter

Total hardness : < 20 ppm as $CaCO_3$

Chloride iron : < 50 mg/l as $CaCO_3$

Turbidity: < 1.0 NTU

Supply capacity : 200 m^3/h

Supply pressure : 3.0 kg/cm^2

(b) Fire hydrant system

The fire hydrant system will be prepared as an out door hydrant system as per NFPA

2) Description of process and equipment

(a) Raw water receiving station

The raw water receiving station is indicated in Figure 6-7-3.

A reservoir in the raw water receiving station will have a capacity of 3,000 m^3 and this basin will hold about 20 hours consumption in case of water shortage.

Industrial water will be supplied to the each plant directly and chemical dosing will be done in each plant depending upon the required water quality.

(b) Fire hydrant system

The system will be supplied from the reservoir.

It is pressurized all the time as a system.

The fire hydrant system consists fire pumps (motor and engine driven with battery charger), a jockey pump, a pressure tank, fire hydrants, hoses and a fire water main pipe.

(2) Potable water

Potable water can be supplied from Sohar municipality pipeline, but a connecting pipeline of about 5~7 km is required between an existed pipeline and the Steel Complex.
Potable water will be made by the desalination plant together with industrial water which is installed in the Steel Complex and stored in the storage basin.
After chlorination, potable water will be supplied to the plants through a pipeline

(3) Cooling water system

In order to reduce consumption of industrial water, two counter measures are taken in the Steel Complex.
These are :

- Closed type re-circulation system

  Indirect cooling water (ICW) is not contaminated in the processes, so it is cooled down and treated chemically, then re-circulated.
  Direct cooling water (DCW) is contaminated in the process, and scale and oil are included as contaminants.
  Contaminants are separated by means of sedimentation, filtration, floatation, dehydration, etc.
  Cooling water for the above systems is cooled down by heat exchanger using sea water as a cooling medium instead of a cooling tower in order to reduce evaporation of cooling water.
  Blow down is needed in order to eliminate condensation of salinity of circulation water and the use of heat exchangers will serve this purpose.

- Change to other cooling medium
  - Sea water

    A part of the indirect cooling system will use sea water as cooling water directly.
    But corrosion and scale formation will happen in the cooling system due to higher salinity in the sea water. Material selection, application of cathodic protection, dosing scale inhibitors in the sea water etc. will be taken as countermeasures to eliminate these problems.
  - Air cooling

    All air conditioning system will be cooled by air.

1) Specifications

The ICW and DCW systems are as follows ; the flow sheet is indicated in Figure 6-7-4 :

(a) ICW system

The ICW will be used as a cooling medium for the plant and will require such characteristics as anti-corrosion, non-scaling and non-slime growth so that the system may be operated without any trouble.

- Chemical dosing is required for the ICW system to eliminate problems.
- A closed circuit using a heat exchanger will be employed instead of a cooling tower that may cause evaporation and condensation of circulation water.
- Sea water will be used as a cooling medium for heat exchangers.
  Temperature rise of sea water : < 7.0 deg.C
- Required cooling water quantity for each ICW system is indicated in Table 6-7-2.

Table 6-7-2 Required Cooling Water Quantity for Each ICW System

Plant name	Required Cooling Water Quantity (m^3/h)	Required Cooling Water Quantity (Emergency) (m^3/h)
Direct reduction plant	500	0
Lime calcining plant	8	0
Electric arc furnace	5,200	1,600
Ladle furnace	435	100
Continuous casting machine	1,363	288
Bar rolling mill	1,000	150
Air separation plant	600	0
Total	9,106	2,138

- The required make-up water quantity : 0.3% of circulation water (ICW).

(b) DCW system

- The same as ICW system
- In addition to the ICW system, water quality will be controlled as follows:

  Suspended solid : < 10 mg/l

  Oil : < 5 mg/l

- Required cooling water quantity for each DCW system is indicated in Table 6-7-3.

Table 6-7-3 Required Cooling Water Quantity for Each DCW System

Plant name	Required Cooling Water Quantity (m^3/h)	Required Cooling Water Quantity (Emergency) (m^3/h)
Direct reduction plant	2,500	0
Continuous casting machine	1,440	0
Bar rolling mill	1,200	0
Total	5,140	0

(c) Estimation of the required make-up water

The balance between raw water and circulation water are calculated as per make-up water ratio plus the water loss in the plant and indicated in Figure 6-7-4.

(d) Water recovery ratio

As an index to the technologically advanced situation for utilization of water, a water recovery ratio is employed.

Water recovery ratio (WRR)
= {(Recycled quantity - Make-up water quantity) /(Recycled quantity)} x 100

Water recovery ratio (WRR) in this conceptual plan is calculated as per Figure 6-7-4 and the result is as follows:

Circulation water=9,106(ICW)+5,140(DCW) =14,246 m^3/h
Make up water + potable water = 169 + 20 = 189 m^3/h
WRR = (14,246-189)/14,246 = 98.7 %

Some steelworks in Japan have maintained a WRR = 95 - 96 %.
The conceptual plan has already exceeded this advanced level.

2) Description of the process and equipment

(a) ICW system

- System selection

Five types of ICW system are mainly used in the steel industry and their features are indicated in Figure 6-7-5.

Type-4 is employed in GCC countries and North Africa to reduce the consumption of industrial water.
Type-4 is a closed circuit system and cooling water (re-circulation water) is subject to evaporation, condensation and contamination from particles in the air like open type cooling tower systems (Type-1 and Type-2).
So, Type-4 has lower consumption of industrial water than other Types and is applied in this project.

- Chemical dosing system
  - The chemical dosing system consists of corrosion inhibitors, scale inhibitors, and an inhibitor of bacteria growth and coagulation regent if required. All chemicals are dosed automatically.
  - Corrosion speed is monitored by an on line monitoring system.
    The target corrosion speed is less than 4 mill/year.
  - Monitoring of scaling speed and bacteria count will be done periodically.

- Emergency water system
  - Emergency water system during power shutdown will be required for furnaces and continuous casting machines so that equipment will not be damaged from higher temperatures.
  - Emergency water will be supplied from the head tank using gravity flow before the diesel driven pump is operated. It takes about 1 ~ 2 minutes to start the diesel driven pump after the power has shut down.
  - The holding capacity of the head tank will be a minimum 8.0 minutes.

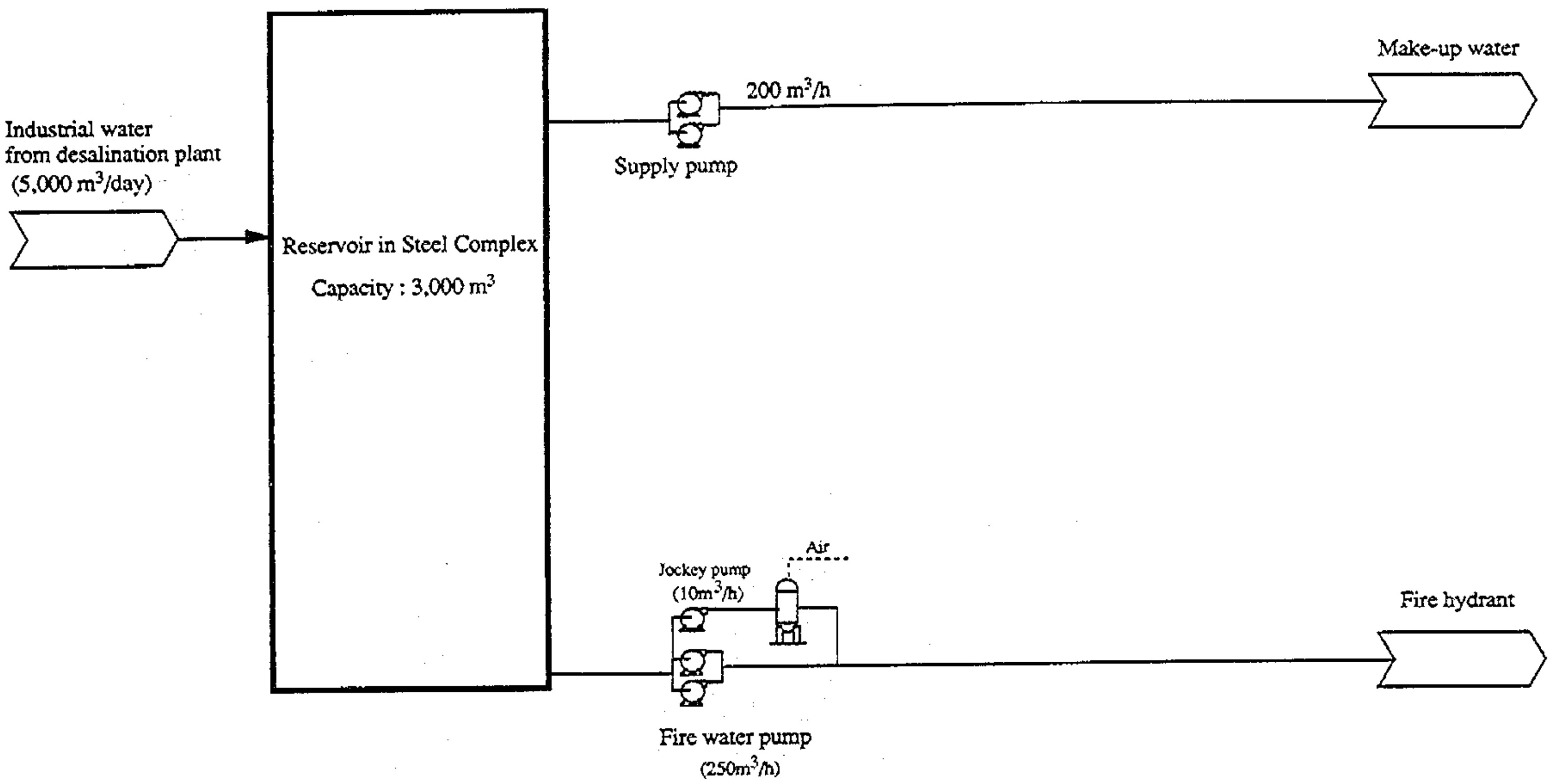


Figure 6-7-3 Raw Water Receiving Station Flow Sheet

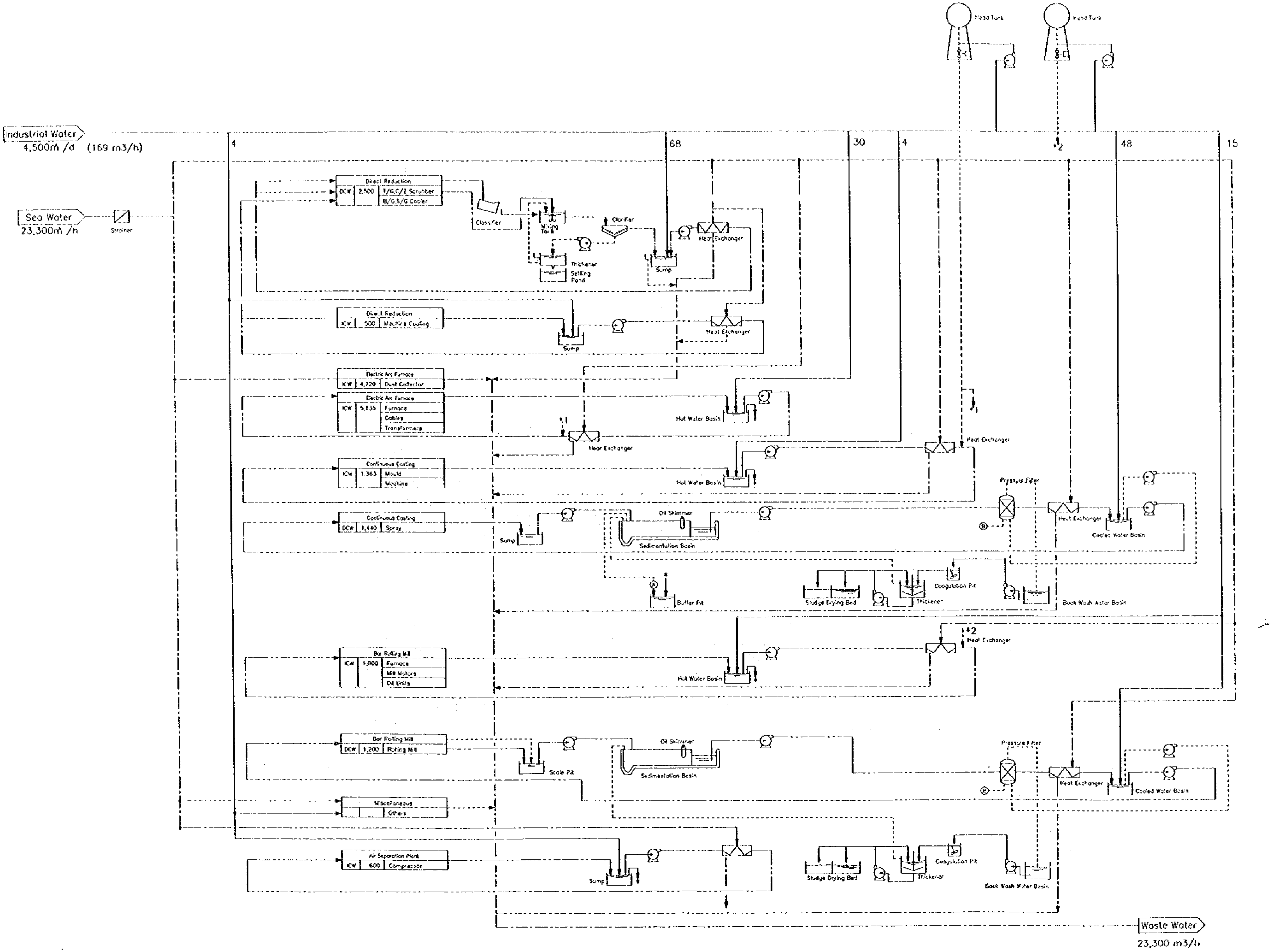


Figure 6-7-4 Cooling Water System

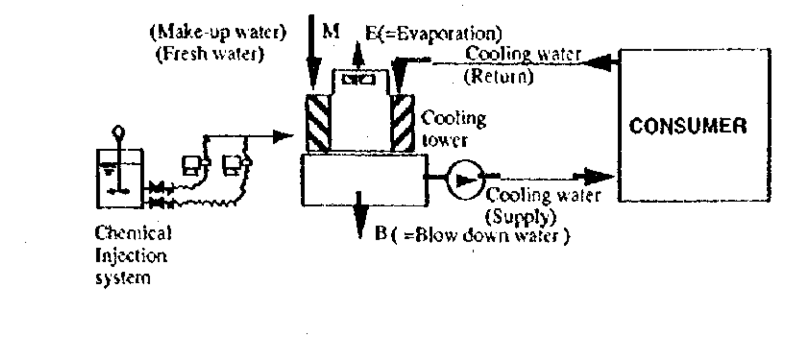
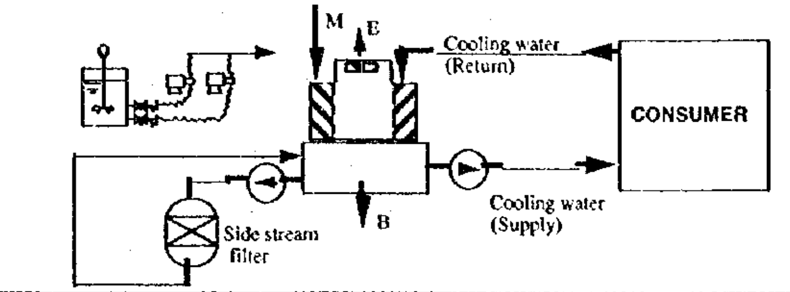
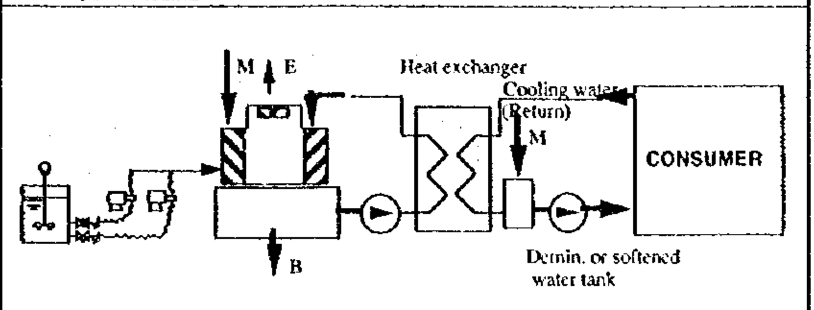
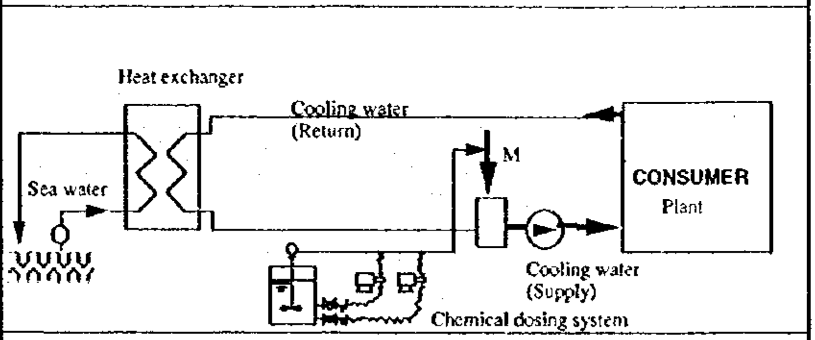
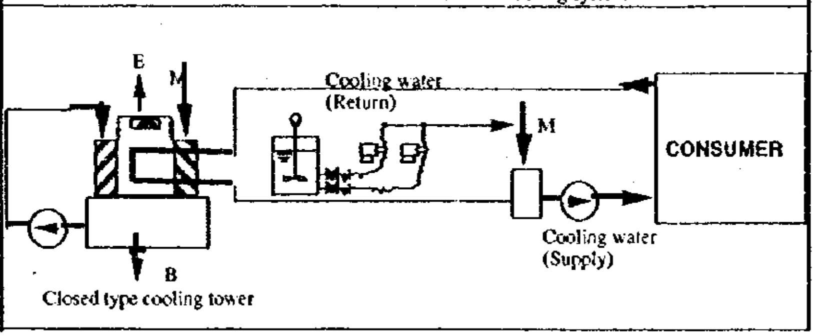
TYPE-1	The most common system. This system is used without contamination from ambient air. Water quality of recirculation water will be controled by the quality of makeup water and blow down quantity. Chemical dosing will be controled by monitoring corrosion speed, scaling speed and bacteria growth in the ICW system.	
TYPE-2	Added side stream filter to Type-1 for eliminating dust. (ANSDK, Nigeria, Japan and many other countries)	
TYPE-3	This type is used for higher thermal transfer area and complicated water channel so that trouble by water does not happen. Make-up water will be of demineralized or softened water. (Mostly for mold and machine cooling in CCM)	
TYPE-4	This type is used mainly where fresh water is made from sea water. Make-up water is less than that of above system. (Saudi Arabia, Qatar, Iran, Libya and also Blast furnaces around the world)	
TYPE-5	This type is a revision of Type-3. Closed type cooling tower is used instead of heat exchanger + cooling tower Disadvantage : maintenance of heat exchanger is difficult. (Used in many countries.)	

Figure 6-7-5 Types of ICW System in Operation mainly in the Steel Industry

(b) Direct cooling water system (DCW system)

DCW will be contaminated in plants during direct cooling by scale and oil.

Brief explanation of system is as follows:

(Refer to Figure 6-7-4.)

DCW is discharged to the scale pit and the coarse scale is separated by settling. Then, water is transferred to the sedimentation basin and scale and oil are separated so that water can be fed to the pressure filter.

After filtration, DCW is cooled in the heat exchanger and re-circulated.

In some arrangements, settled scale in the sedimentation basin is removed by crab bucket crane and is dried on a sludge drying bed. Dried sludge is removed periodically to the damping area.

Backwashed water from the pressure filter is stored in the washing pit for about 4 hours where floating suction pipes can suck only supernatant water, and then is transferred to the sedimentation basin.

The settled sludge is transferred to thickener and is allowed to thicken. Then, the thickened sludge is transferred to sludge drying bed.

Oil is collected by oil skimmer, thickened by the oil-water separation tank and then stored in the oil tank.

6.7.5 Sea water

(1) Sea water requirement for the Steel Complex

Estimates are as follows:

1) Flow quantity

Required flow quantity is estimated in Table 6-7-4.

Table 6-7-4 Required Quantity of Sea Water for the Steel Complex

	Steel Complex	Power station (In case of GT/ST combined cycle)
Flow quantity (m^3/h)	25,000 m^3/h 184,000,000 m^3/year	25,000 m^3/h
Unit consumption	153.0m^3/t-steel product	120 m^3/MWh

2) Sea water quality

Sea water temperature (max.) : < 35 deg.C

(2) Situation of sea water at plant site (Sohar)

1) Flow quantity

Sea water is available in Sohar port.

2) Sea water quality

Sea water sample was taken in Sohar port for analysis.

Marine pollution bulletin No. 27 was received from Ministry of Regional & Environment.

According to the above bulletin, data of sea water temperature around Sohar area in 1992 was indicated on map.

Sea water temperature in 1992 is read from map and is indicated in Table 6-7-5.

The maximum design temperature of sea water in Sohar will be 35 deg.C considering the maximum sea water temperature of Ghubrah power station.

Sea water around Sohar port can be used for the Steel Complex.

Table 6-7-5 Sea Water Temperature around Sohar in 1992

Sea water temperature from map	
Early summer	30 deg.C
Winter	22 deg.C

Source: Marine pollution bulletin No. 27

(3) Explanation of facility and clarification of scope of work

1) Explanation of facility

Sea water will be led from raw material berth through an underground water channel to the sea water pump station which will be located a part of material berth and then sea water will be pumped up to the Steel Complex,desalination plant and power station.

Hot sea water will be discharged to the outside of breakwater so that temperature of intake water does not rise due to mix with hot sea water.

Configuration of sea water intake system is indicated in Figure 6-7-6.

2) Clarification of scope of work

The required facilities will be divided into two parts, one is to be prepared as infrastructure and the other one is to be prepared by the Steel Complex.

If big projects have surplus electric power 'a', sea water intake system for power station would not be required in the Steel Complex. The facility which would be affected by infrastructure preparation is mentioned as Sea water intake system-II and the facility required for the Steel Complex is mentioned as Sea water intake system-I.

• The scope of work also is summarized in Figure 6-7-6.

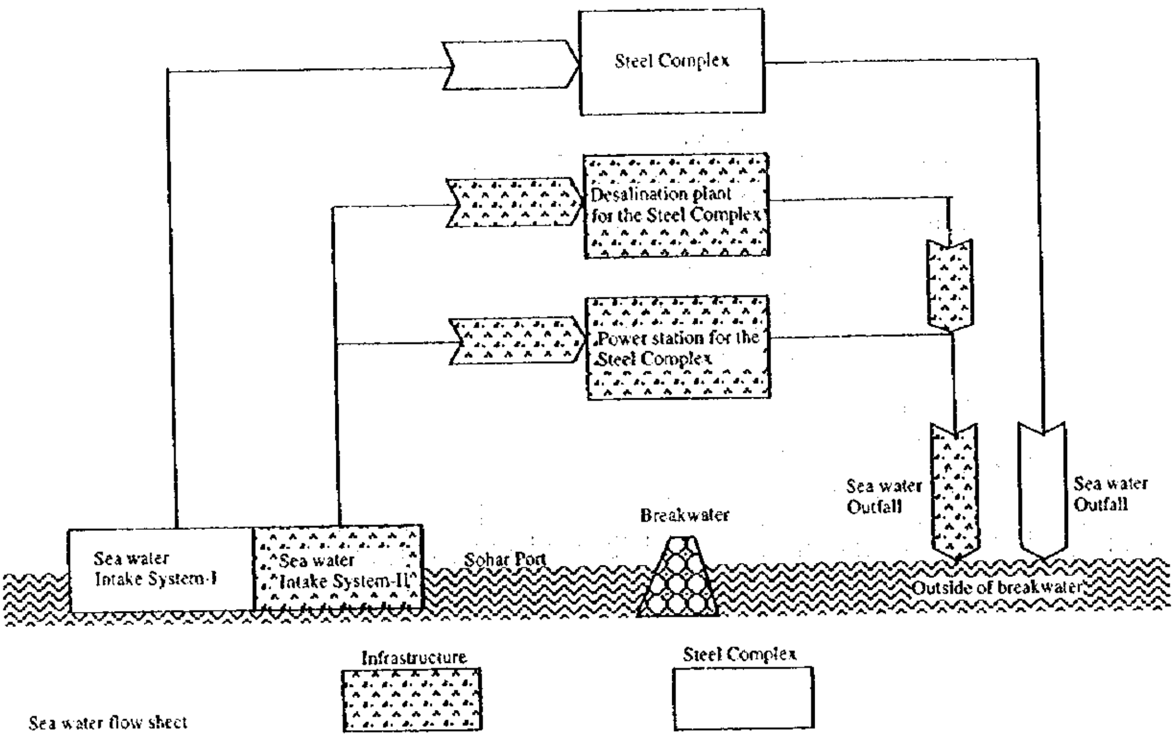


Figure 6-7-6 Sea Water Flow Sheet

(4) Conceptual design of the sea water intake system

The specifications of the sea water intake system to be installed in Sohar are as follows:

(a) Design criteria

- Raw sea water :
  - Design condition : 30 deg.C
  - Maximum allowable temperature : 32 deg.C
  - Suspended solids : < 5.0 mg/l

- Intake capacity
  - Intake capacity is indicated in Table 6-7-6 and the capacity of the civil structure for sea water intake system-I is designed as 50,000 m^3/h considering future expansion.

Table 6-7-6 Intake Capacity of Sea Water

	Sea water intake system-I	Sea water intake system-II
	Steel Complex	Power station (In case of GT/ST combined cycle)
Intake capacity (m^3/h)	25,000	25,000

- Intake sea water quality
  - The quality of sea water affects the pretreatment efficiency of the R-O type desalination plant and is closely related to the membrane degradation, it also creates biofouling of plate type heat exchanger in the Steel Complex.
  - Jellyfish, oil balls, sea weed, etc., will be removed by mechanical equipment such as curtain walls and screens.
  - Biological growth shall be chlorinated in order to free from biofouling.
  - Inflow of suspended solid shall be minimized.

(b) Type of sea water intake system

Since the sea water intake system will be equipped within a breakwater in Sohar port, a curtain wall type is selected as per Table 6-7-7 and a drum type screen is selected from Table 6-7-8 respectively.

In this conceptual design, the structure of the suction basin and pump chambers which are located after the screen will apply the structure of identical ones which are operating in good condition in other countries. But at the execution stage, a physical model test or hydraulic simulation shall be done in order to optimize the intake structure so that the best flow approach to the pumps will be obtained. If such optimization is not made, abnormal flow such as swirling flow, surface vortices, submerged vortices, etc. may happen and may cause trouble for the pumps and the intake system.

The sea water intake system is shown in Figure 6-7-7.

Table 6-7-7 Comparison of Water Intake System in Sohar Port

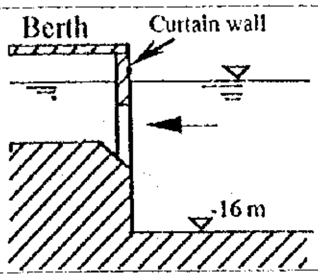
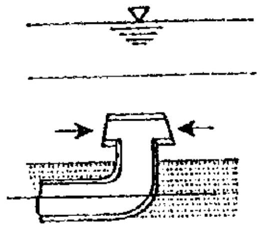
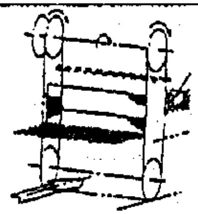
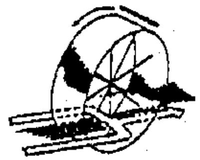
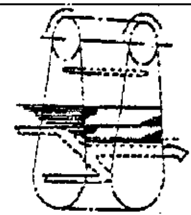
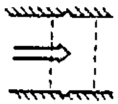
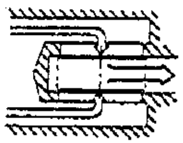
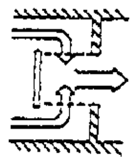
Type	Curtain wall	Buried pipeline
Outline		
1. Occupied area	Small	Small
2. Water intake	Sohar port will have sufficient depth and width at the mouth to be secured to avoid an inflow of surface water	Possible to take clean and low temperature water from a depth below a layer of discontinuity.
3. Wave	Breakwater will be available surround port. There is no influence of wave.	Breakwater will be available surround the port. There is no influence of wave.
4. Inflow of suspended solids (sand)	Since the inflow velocity is low (approx. 25 cm/s), sedimentation in the channel and pump pit will be small.	Since the inflow velocity is low (approx. 20 cm/s). the inflow rate of SS is small.
5. Volume of intake water	Easy to accommodate a large volume of water.	Easy to accommodate a large volume of water.
6. Environment a. Aquatic biota b. Scenery	Since the construction in Sohar port, no impact are expected.	Since the construction in Sohar port, no impact is expected.
7. Obstruction for boats	Not possible to stop in front of intake facility.	The intake head is an obstacle for passing boats in Sohar port.
9. Maintenance	Maintenance is done easily.	Maintenance of the intake head is very difficult due the location.
10. Construction	Construction cost is small.	Construction cost is high.
11. Others		

Table 6-7-8 Screen Comparison

Type	Single flow type	Drum type	Double flow type
Sketch			
Capability of treatment of debris	There is a possibility of return over	There is no possibility of return over.	There is no possibility of return over.
Raking efficiency	100 %	40 ~ 50 %	60 ~ 70 %
Raking quantity	1	0.4 ~ 0.5	0.6 ~ 0.7
Limitation of treated debris.	No	Available	Available
Foundation	Simple	Complicated	Complicated
Head loss due to shape of foundation	Small	Little (100 ~ 200 mm)	Little (200 ~ 300 mm)
Construction of screen	Simple	Simple	Complicated
Foundation			

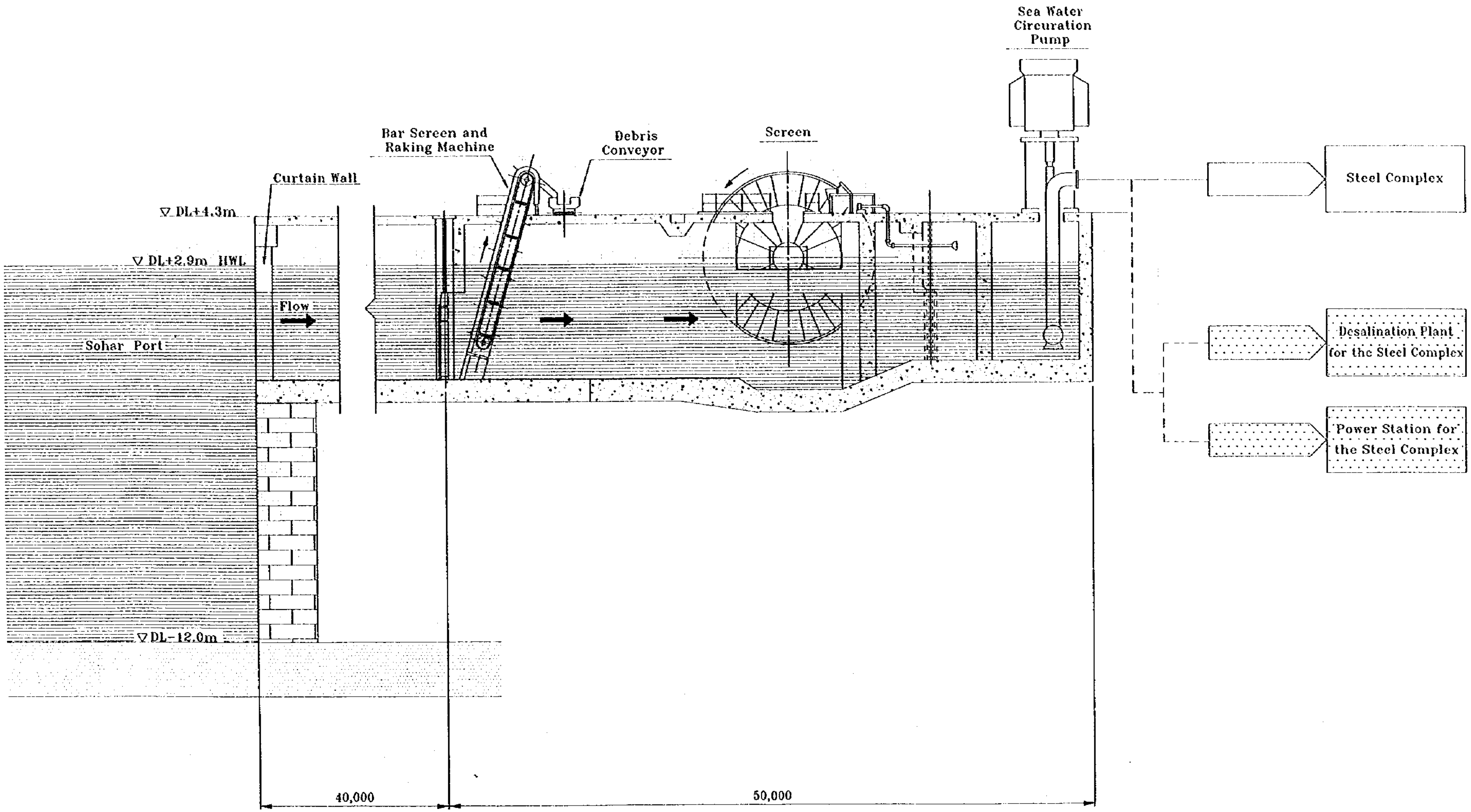


Figure 6-7-7 Flow Sheet of Sea Water Intake System-I in Sohar

6.7.6 Waste water

(1) Specifications

1) Drainage quantity and quality of waste water

Waste water is divided into two types and the details are as follows:

(a) Hot sea water

Sea water after passing through the cooling system will be discharged as hot sea water.

- Quantity:

The maximum discharge quantity : 25,000 m^3/h

- Quality

There is no contamination in the steel complex.

The maximum temperature rise is less than 7.0 deg.C.

(b) Live sewage

Potable water is used for live purposes in the Steel Complex such as for drinking, washing, in the canteen, etc. and discharged as live sewerage.

- Quantity:

The maximum discharge quantity : 20 m^3/h

- Quality

Quality of sewerage water is specified as follows:

Item	Quality	
	Before treatment	Treated water
BOD_5(mg/l)	200	20
SS (mg/l)	250	50

(2) Description of equipment

(a) Hot sea water

Hot sea water is discharged from cooling system and is gathered in the underground pipe which is made of steel and tar epoxy coated. Then, the hot sea water will be discharged outside of the breakwater by its own pressure.

(b) Live sewage

Live sewerage will be gathered by the pumping station located in each office and plant and will be transferred to the sewerage water treatment station in the Steel Complex.

Live sewage is treated by the activated sludge process as shown in Figure 6-7-8.

Waste water is removed from suspended solids, which are easy to separate using a grit chamber and flow control basin and is introduced into the aeration basin.

The aeration basin is the heart of the activated sludge process.

The waste water is mixed with the activated sludge returned from the sedimentation basin and is aerated.

The waste water is separated into supernatant treated water and settled sludge in the sedimentation basin.

While some of the settled sludge is returned for reuse in the aeration basin, the excess sludge is discharged to the sludge storage basin and will be disposed.

The supernatant treated water will be re-used for plantation and slag cooling in the Steel Complex.

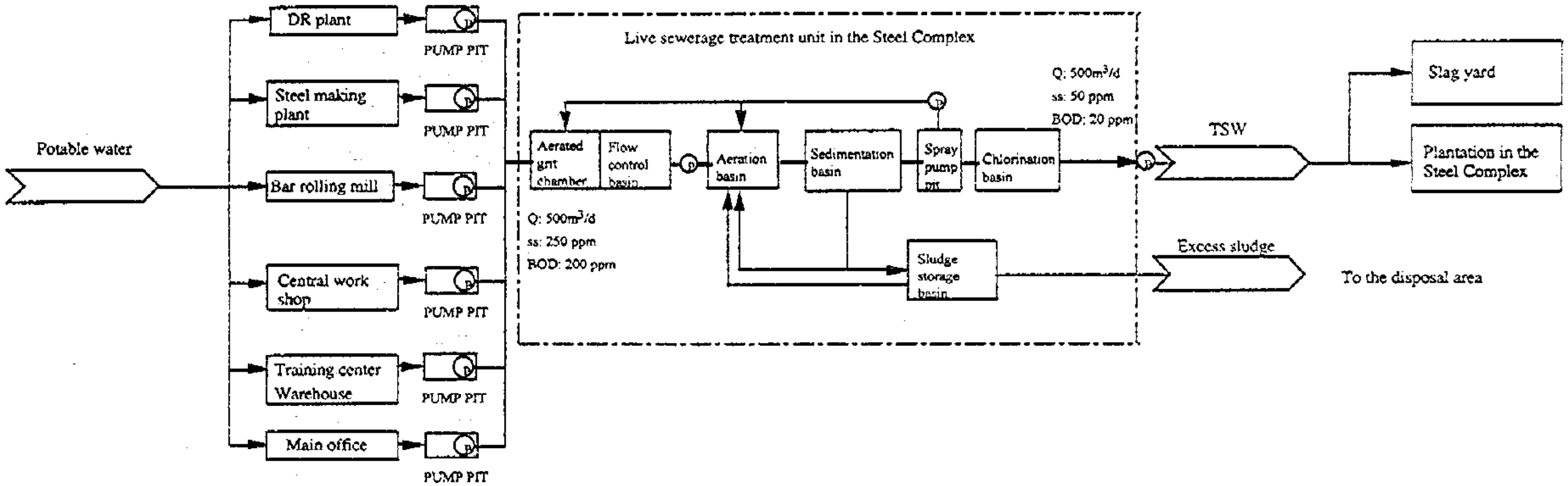


Figure 6-7-8 Flow Sheet of Live Sewerage Treatment System

6.7.7 Organization and personnel

Organization of the utility section is one of the sections in the maintenance and utilities department.

Maintenance of utilities requires specific knowledge and understanding about systems as a whole and the phenomenon of various gases and chemicals, therefore maintenance persons for daily maintenance are included in the utility section.

A total of fifty eight (58) persons are required for the utility facilities and the details are indicated in Table 6-7-9.

Table 6-7-9 Organization and Personnel of Utility Facilities

Utility	Section Manager	Assistant Section Manager	Engineer	Foreman	Assistant Foreman	Worker
Operation (shift) (day)	 1	 1	 1	 2	 2*4 0	 8*4 0
Maintenance	0	0	1	1	2	9
Total	1	1	2	3	10	41

6.7.8 Equipment list and drawings

(1) Equipment list

Major equipment for utility facilities are shown in Appendix A6-7-1.

(2) Drawings

Layout drawings of utility facilities are enclosed in Appendix A6-7-2.

1) Figure A6-7-1 Layout of Air Separation Plant and Plant Air
2) Figure A6-7-2 Layout of Desalination Plant and Water Receiving Station
3) Figure A6-7-3 Layout of Water Treatment Station-I for SMP and CCM
4) Figure A6-7-4 Layout of Water Treatment Station-II for BRM
5) Figure A6-7-5 Layout of Sea Water Intake System-I
6) Figure A6-7-6 Layout of Live Sewerage Treatment Station

6.8 Maintenance Shop

6.8.1 Outline

Maintenance should be so planned that operation work in each plant will be kept smooth and be able to perform their production plan without equipment trouble.
The study team visited in the 1st field survey, Raysut Cement Co., Oman Mining Co., Sharq Sohar Steel Rolling Mills, Ghubrah Power and Desalination Plant. All of them told us that they had enough maintenance capability as well as necessary staff.
In this project, the maintenance shop with the necessary number of engineers and skilled workers will be also indispensable for smooth and steady production activities.

6.8.2 Organization and manpower

For the purpose of smoothly achieving maintenance work, a department consisting of the following 4 sections would better be organized to take charge of all the maintenance work as the Maintenance and Utilities department.

Maintenance & Utilities Dept.
- Maintenance coordination
- Mechanical maintenance
- Electrical maintenance
- Utilities

- Maintenance coordination section takes charge of overall coordination among sections concerned about shutdown schedule, maintenance budget control, etc. In addition, this section is responsible for drawings, lubricating oil and overall coordination of repair work.
- Mechanical maintenance and Electrical maintenance sections take charge of maintaining on plant equipment with close contact with each plant. Budgeting for spare parts and consumables, and all kinds of repair work are important jobs. In addition, the job of electric power distribution is included in the Electrical maintenance section.
  Repair shops including the car repair shop will mainly come under the control of these sections.
- Utilities section takes charge of smoothly supplying necessary power for each production plant. At the same time this section performs not only monitoring of operations but planning the maintenance of equipment including budgeting.

Table 6-8-1 Organization and Personnel of Maintenance Shop

SM	ASM	Engineer	Foreman	Assistant foreman	Worker	Remarks
Maintenance coordination 1	1	3	-	1	2	Drawing control
1	1	3	-	1	2	
Mechanical maintenance 1	Port 1 DRP 1 SMP 1 BMP 1 M. Repair 1	- 1 2 2 3	1x1 1x1 1x1 1x1 1x1 1x1	1x4 1x4 1x4+2x1 1x4+1x1 1x1 2x1	1x4 2x4+1x1 3x4+4x1 3x4+3x1 4x1 15x1	Hydraulic unit Machining and Steel fabrication
1	5	8	6	24	63	
Electrical maintenance 1	Port 1 DRP 1 SMP 1 BMP 1 Power 1 E. Repair 1 Instru. 1	- 1 2 1 1 2 2	1x1 1x1 1x1 1x1 1x1 1x1 1x1 1x1	1x4 1x4 1x4 1x4 1x4 2x1 1x1 3x1	1x4 2x4+1x1 3x4+4x1 3x4+3x1 3x4 10x1 5x1 7x1	Overhaul at maintenance shop Cable, Communication
1	7	9	8	26	78	
Utilities 1	1	Water 1 Gas 1	1x1 1x1 Maintenance 1x1	1x4 1x4 2x1	4x4 4x4 5+4	Water treatment Gases
1	1	2	3	10	41	

6.8.3 Maintenance shop equipment

In order to maintain all the plant equipment, periodical repairs, major repairs and sometimes emergency repairs are required. These repairs chiefly involve replacement of worn or broken parts. The removed parts shall be sent to the repair shop for welding, machining, etc. and then stored again as spare parts.

The equipment in the maintenance shop shall then comprise the following in order to respond to the serving cycle.

- Machinery
- Equipment to assemble and disassemble machines
- Equipment for steel structure, piping and welding
- Equipment for repairing and testing electrical equipment and instrumentation equipment
- Equipment for minor repairs and the checking of vehicles

(1) Machine shop

Main equipment will be as follows:

1)	Lathe 1m	: 1
2)	Lathe 2.5m	: 1
3)	Lathe 5m	: 1
4)	Milling machine	: 1
5)	Slotting machine	: 1
6)	Shaping machine	: 1
7)	Boring machine	: 1
8)	Radial drilling machine	: 1

(2) Overhaul and assembling shop

This shop will be provided with a 200t horizontal press, assembly surface plate, etc.

(3) Steel frame shop

The steel frame shop shall be equipped with ending rolls, radial drilling machines and various types of welding machines.

(4) Electrical repair shop

Machines such as a winding machine will be capable of repairing 100kW DC motor and 200 kW AC motor. Testing devices which would be purchased by each plant shall be centrally controlled.

(5) Vehicle repair shop

Repair equipment will be capable of carrying out inspection and minor repairs. Medium and major repairs will be carried out by outside companies specializing of in car repair.

(6) Maintenance service vehicles

Some double cab trucks and crane trucks will be provided for common use for the maintenance work in all sections.

6.8.4 Equipment list

Equipment list is shown in Appendix A6-8-1.

6.9 Analysis and Inspection Facilities

6.9.1 Outline

Analysis and inspection facilities will be installed for the Steel Complex and be used for carrying out quality control work including routine analysis of DRI, molten steel, cast billets, and finished products.

The analysis and inspection facilities will consist of two groups of equipment: one for analysis needed for the steel making process and raw materials and the other for physical and metallurgical inspection of semi-finished and finished products. The first group of equipment will be installed in a building (called the analysis center) to be constructed beside the Steel Making plant. The other group of equipment will be installed in a building (called the material testing center) to be constructed beside the BRM building.

6.9.2 Basic plan

(1) Quick analysis is needed for the steel making process, an analysis of materials such as DRI, iron ore, ferroalloy, burnt lime, slag, natural gas, water, and refractories, and analysis of semi-finished and finished products will be conducted by the equipment installed in the analysis center.

(2) Physical and metallurgical inspection of semi-finished and finished products, DRI, iron oxide pellets, lump ore, burnt lime, and refractories will be conducted in the material testing center.

(3) Samples for quick analysis will be sent to the analysis center by the pneumatic transportation tube from the EAF, LF and CCM shops.

(4) Gas cutting of cast billets will be conducted in the CCM shop in order to provide the analysis and inspection facilities with specimens for sulfur print and macrostructure inspection.

(5) Bars for specimens in designated dimensions and quantity will be provided from the BRM.

6.9.3 Facility plan

(1) Equipment for analysis

A vacuum emission spectrometer, a fluorescent x-ray analyzer, carbon & sulfur and nitrogen & oxygen determinators, an inductively coupled plasma analyzer, and equipment needed for preparation of specimens such as automatic sample preparation equipment for quick analysis and an abrasive cut-off machine will be installed for analysis in the analysis center.

(2) Equipment for physical and metallurgical inspection

Equipment for physical and metallurgical tests and sample preparation equipment will be installed in the material testing center.

6.9.4 Description of system and equipment

The system and equipment will be installed to eliminate individual differences among operators and also to avoid, as much as possible, complicated manual measuring so that stable analysis and inspection results will be obtained.

6.9.5 Organization and personnel

The organization and personnel are charted below.

Table 6-9-1 Organization and Personnel for Analysis and Inspection

Section Manager	Assist. Sec. Mgr.	Engineer	Foreman	Assistant Foreman	Worker	Remarks
1	Lab			1 x 4	2 x 4	OES * & x-ray
	1 x 1	2 x 1	2 x 1		1 x 4	Chemical Analysis
					1 x 4	Sample Preparation
				1 x 1	4 x 1	Chemical Analysis
					1 x 1	Gas Analysis
					6 x 1	Mechanical Tests
				1 x 1	2 x 1	Physical Tests
					4 x 1	Inventory & Data Control
1	1	2	2	6	33	Total 45

* Optical Emission Spectrometer

6.9.6 Equipment list

Appendix A6-9-1 attached hereto shows Equipment List of Analysis and Inspection Facilities.

6.10 Transportation Facilities in the Steel Complex

6.10.1 Outline

Transportation facilities in the steel works include transporting and storing of scrap, limestone, additives, refractories, electrodes, slag, mill scale, waste materials and others required for keeping the production of approximate 1,200,000 tons per year of bar products.
Equipment on intra-works transportation will be independently provided as follows.

- Movable equipment such as mobile cranes, forklifts, shovels, etc. for unloading and loading.
- Transportation equipment such as slag pot carriers, dump trucks, trailers, flat deck trucks, etc.
- Warehouses and storage yard for incoming raw and other materials.
- Truck weighing equipment required to weigh purchased materials and rolled products.
- Special purpose vehicles, automobiles, etc. required in the works.

6.10.2 Intra-works transportation flow

Main routes of material transportation flow and amount of handling in the steel works are shown in Table 6.10-1. Scrap will be imported, and unloaded at Sohar port. Transportation from the port to the scrap yard is assumed to be done by company dump trucks when a scrap carrier arrives. As for all other purchased materials such as limestone, ferro-alloys, refractories, etc., their transportation is carried out from each storage place to required points.
Most bar products are planned to be shipped from the port by ship, therefore cooled bars will be transported by trailers from BMP to the port.

Table 6-10-1 Materials to be transported in the Plant

Materials	Route	Vehicle	t/y
Purchased scrap	Port-Scrap yard	Dump truck	100,000
Charging scrap	Scrap yard-SMP	-do-	147,000
SMP home scrap	SMP-Scrap yard	-do-	21,700
BRM home scrap	BRM-Scrap yard	-do-	26,400
Slag yard scrap	Slag yard-Scrap yard	-do-	1,300
Limestone	Storage yard-LCP hopper	-do-	100,800
Additives	Warehouse/Storage yard-SMP	-do-	59,740
SMP refractories	Warehouse-SMP	Flat body truck	15,200
Electrode	Warehouse-SMP	-do-	2,300
BRM mill scale	BRM-Disposal area	Dump truck	9,600
SMP slag (hot)	SMP-Slag yard	Slag pot carrier	204,000
SMP slag (cold)	Slag yard-Disposal area	Dump truck	202,700
SMP scale	SMP-Disposal area	Dump truck	6,000
Oxide fines	DRP Oxide bin-Storage yard	Dump truck	48,000
Lime stone fines	LCP hopper-Storage yard	Dump truck	9,900
Burnt lime fines	LCP hopper- DRP	Fork lift	610
DRP sludge cake	DRP-Disposal area	Dump truck	45,000
DRP classified sludge	DRP-Disposal area	-do-	8,500
SMP dust	SMP-Disposal area	-do-	20,800
SMP waste brick	SMP-Disposal area	-do-	1,600
Water treated sludge	Water treatment plant-Disposal area	Vacuum dumper	2,000
Separated oil	Water treatment plant-Oil company	-do-	600

6.10.3 Description of system and equipment

(1) Intra-works transportation facilities

Imported scrap will be unloaded by gantry cranes with lifting magnet, and some of them will be directly loaded onto dump truck and transported to the scrap yard. Remaining scraps will be temporarily unloaded on the ground and then loaded onto dump trucks and transported to the scrap yard.

Scrap in the scrap yard will be loaded onto dump trucks by crawler cranes with lifting-magnet and transported by dump trucks to SMP after weighing at the truck weighing scale and dumped into a scrap bucket in the SMP.

Returned home scrap from the SMP, the BRM and the slag yard will be transported to the scrap yard by dump trucks.

Hot slag poured into slag pots from the electric arc furnaces or ladles in the SMP will be self-loaded by hot slag pot carriers, transported to the slag yard and self-dumped into the slag yard.

Limestone will be loaded onto dump trucks by wheel shovels transported from the limestone storage yard to the limestone receiving hopper.

Additives for the SMP will be loaded onto dump trucks by wheel shovels in the additive warehouse, transported and dumped into the receiving hopper in SMP.

Refractories and electrode will be loaded onto a flat deck truck by a forklift in the warehouse and transported to the SMP.

Major transportation facilities are as follows.

1) 35t crawler crane	:	2
2) 2m^3 crawler shovel	:	4
3) 1.5m^3 wheel shovel	:	6
4) 1.5t forklift truck	:	2
5) 14t dump truck	:	10
6) 11t flat deck truck	:	2
7) 30t semi-trailer	:	2
8) 60t slag pot carrier	:	2
9) Power breaker	:	1
10) Bulldozer	:	1
11) Crane truck	:	2
12) Double cab truck	:	5
13) Truck weighing station	:	3

Crane trucks and double cab trucks are mainly utilized for maintenance work.

(2) Warehouse

Refractories, electrodes, additives and spare parts for this project will be stored at warehouses in the plant.

Warehouses will be as follows:

1) Warehouse for bricks and electrodes	:	30 m x 140 m x 1 bay
2) Warehouse for additives	:	30 m x 80 m x 1 bay

3) Warehouse for spare parts : 30 m x 80 m x 1 bay

(3) Scrap yard

Scrap is purchased at regular intervals and 20,000 to 30,000 tons will be delivered every two months or so by vessels. Around 10,000m2 is set aside for the storage and preparation work.

(4) Storage yard for limestone, fluorspar and Fe-Mn

As these materials can be exposed to rain, a 3,000m2 yard is planned outdoors.

(5) Slag yard

204,000 tons/year of hot slag will be dumped by self-loading slag pot carriers. To protect the vehicle from hot slag heat, the slag dumping mount shall be elevated from the slag yard by one step. A metal reclamation work area after cooling, and a temporary stockyard for metal and slag shall be also necessary.

(6) Disposal area

As shown in Table 6.10-1, a large amount of waste will be generated from each process in the steel works, and must be disposed of somewhere outside the works but as close to the works as possible.

(7) Truck weighing equipment

3 weighing stations will be installed for purchased scrap, charging scrap, shipping products, etc.

6.10.4 Organization and personnel

Manpower requirements will be determined in accordance with the transportation work. A 3-shift job will consist of scrap handling and hot slag handling in the SMP operation, and product transportation from BRM to storage area in berth. Other operations will basically be done by one shift.

The transportation section will be included as one section in the Purchase and Transportation department (PTD). The warehouse job will not be included in the transportation section but in other sections in the PTD.

The organization and personnel of the Transportation section is shown in Table 6-10-2.

Table 6-10-2 Organization and Personnel of the Transportation Section

SM	ASM	Specialist	Foreman	Assistant foreman	Worker	Remarks
1	1	3	3x1	3x4+2x1	7x4+16	

6.10.5 Equipment list

The equipment list is shown in Appendix A6-10-1.

6.11 Administration Facilities

6.11.1 Outline

The construction and installation of such administration facilities listed below shall be considered.

(1) Main office
(2) Training center
(3) First aid
(4) Security office
(5) Fire station
(6) Site offices for;
- Direct Reduction Plant
- Steel Making Plant
- Bar Rolling Mill Plant
- Maintenance Shop

(7) Parking area
(8) Other

6.11.2 Basic design

The basic design and system of each facility shall be made in accordance with the international codes and requirements of local practice and regulation.

6.12 Civil and Building Work

6.12.1 Outline

Civil and building work will cover land preparation and all foundations and building items required for the construction and installation of such steel plant facilities including utilities, roads, drainage and administration facilities as are specified in General Layout of Direct Reduction Based Steel Complex. The contents of the work is summarized as follows:

(1) Civil work

1) Land preparation
2) Foundations for buildings and structures
3) Foundations for equipment and machinery
4) Pits and culverts for piping and cable
5) Cellars
6) Slabs on grades
7) Yard preparation for scrap and slag storage, and waste disposal
8) Roads and paving
9) Drainage systems for rain water, waste water and sanitary sewage

(2) Building work

1) Provision, fabrication and erection of structural steel
2) Reinforced concrete structural building
3) Roofing and siding
4) Floor and wall finishings and ceilings
5) Doors and windows
6) Mechanical and electrical work for building, such as
   (a) Potable water supply system
   (b) Hot water supply system
   (c) Sanitation system
   (d) Fire fighting system
   (e) Ventilation and air conditioning
   (f) Power distribution system
   (g) Lighting system
   (h) Fire alarm system
   (i) Lightning proofing system

(j) Internal communication system

6.12.2 Design basis

The design basis for foundations and buildings shall be established in accordance with the relevant clause of the latest issue of international codes and standards and their equivalents.

6.12.3 Description of foundations and buildings

Items of foundation and building work for the following plant facilities shall be considered.

(1) Land preparation including gate and perimeter fence
(2) Raw material handling facility
(3) Direct reduction plant facility
(4) Steel making plant facility
(5) Bar rolling mill plant facility
(6) Lime calcining plant facility
(7) Electric power and distribution facility
(8) Utilities
    1) Water treatment station
    2) Natural gas receiving station
    3) Water intake and discharge
    4) Sewage treatment station
    5) Desalination plant
(9) Maintenance shop
(10) Analysis and Inspection facility
(11) Transportation facility
(12) Administration Facility
(13) Road and paving
(14) Drainage systems for storm water, waste water and sanitary sewage

6.12.4 Foundation and building lists

The foundation and building for each plant facility and administration facility shall be listed in Appendix 6A-12-1.

Chapter 7. PRESENT SITUATION AND FUTURE INFRASTRUCTURE PLAN

7.1 Port and Port Facilities

The present situation and future plans for Sohar port are investigated as follows:
Sohar port is planned to be one of the most important parts of the infrastructure for the industrialization of northern Oman. According to the master plan, the construction work will be completed in the year 2002. As electric power station, a petroleum chemical plant, and an aluminum refinery are also planned to be constructed behind the port.

In the original plan of Sohar port, the approach channel and the turning basin were planned to have same depth of -15 m. However, in the present plan, the depth has been changed to -16.5 m for the approach channel and -16 m for the turning basin due to the condition changed to that the Steel Complex will be constructed at the back of the port as shown in Figure 7-1-1.

At the back of the phase 1 port area, an exclusive quay wall for the Steel Complex, one war material berth for 100,000 DWT and one product berth for 20,000 DWT and one product berth for 10,000 DWT are planned to be constructed along 700-m long waterfront line. The location of berth would ensure a very efficient handling of cargoes to/from the Steel Complex.

It is not confirmed yet whether there is a plan to provide tag boat services, oil supply services and other services. However, it is naturally expected that there services will be available at the time of opening of the port.

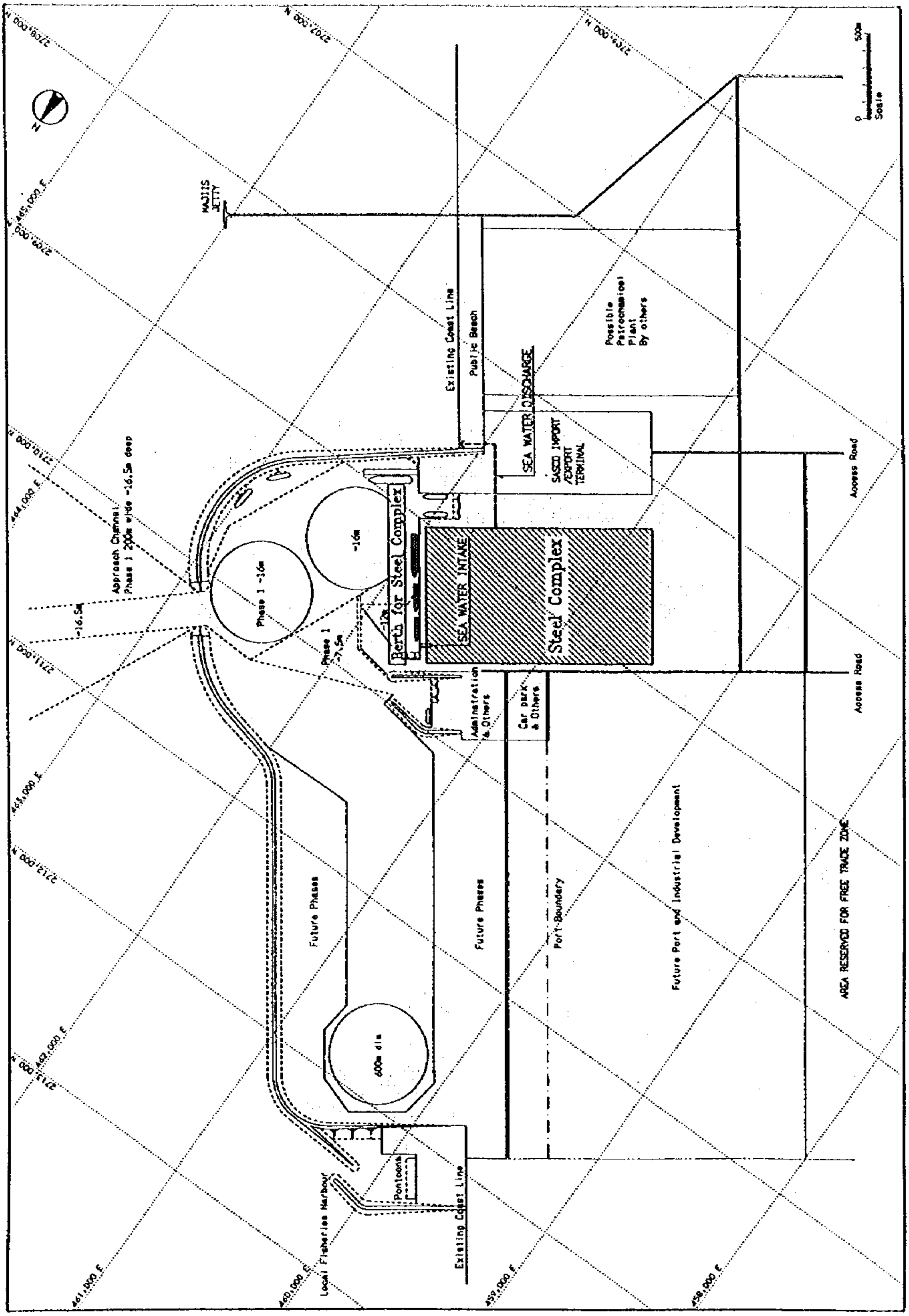


Figure 7-1-1 Proposed Site Location

7.2 Road

The existing road condition is investigated as follows:
Trunk road (Route 1) runs about 4 km southwest of Sohar port, connecting Muscat and GCC. However, access from Route 1 to the Sohar Port construction site is a potential problem. Though a two-lane paved road is available from Route 1 up to existing Majis jetty (which is about 2 km south of the proposed Steel Complex Site), there is no road between the Majis jetty and the Steel Complex. Nevertheless, it is naturally expected that an access road will be also constructed as part of the port development plan. At the Complex side, a connection road from an access road to the Steel Complex would be considered.

7.3 Electrical Power Supply

(1) Power capacity in Sohar region

1) After a site investigation it was concluded that the power capacity in Sohar region is not sufficient for the Steel Complex. MOEW does not have plan to provide the required power to the Steel Complex.
2) A power generation plant for the Steel Complex needs to be constructed by the Steel Complex or byt the private sector with a capacity greater than 200 MW.
3) In Sohar, other big projects concerning petrochemicals, an oil refineries and an aluminum smelters are planned and there is a possibility that one of the big projects would have surplus electricity.
4) In addition to the above, this power generation plant would be connected to the power supply grid between Muscat and Sohar (including Wadi Jizzi power station) with at 132 kV line within a couple of years by the Government. If it is connected, the Steel Complex would be able to overcome the difficulties for normal operations of the Steel Complex, and to have a higher short circuit level (fault level). Total power generation capacity supplied by the network will be more than 2240 MW by the year 2004.
5) With the above measures, a short circuit capacity of a min. 3,000 MVA - max. 6,000 MVA could be obtained, and flicker compensation equipment to minimize voltage fluctuation could be reduced.

(2) Connections at 132 kV between Muscat and Sohar (including Wadi Jizzi power station) at present are as follows;

1) Wadi Jizzi P/S to Sohar S/S : in operation
2) Sohar S/S to Khaburah S/S (about 60 km): tender will be issued by July in 1998
3) Khaburah S/S to Masanaah S/S (about 60 km) : under design
4) Masanaah S/S to Muscat System : in operation

(3) Wadi Jizzi power station

1) Total generation capacity : 278 MW, 334 MW by end of year 1999
2) Demand : Max. 300 MW (in Summer) min. 90 MW (in Winter)
3) Fuel : Natural gas (and oil for emergency)
4) Type and GT frame size : Gas turbine frame No-5 x 3 sets and No-6 x 8 sets
5) Fault level at 132 kV : Max.1283 MVA , min. 397 MVA at present. 2500 MVA in 2015
6) Generation cost : 7.6 baiza / kWh

(4) Sohar sub-station

1) Total transformer capacity : 2 x 125 MVA
2) Average demand : 100 MVA
3) Max. demand : 124 MW (in Summer)
4) Voltage variation : 132 kV to 126 kV
5) Frequency variation : 50 Hz to 49.8 Hz
6) Frequency stoppage (power failure) : twice a year (in past 3 years)

(5) Applicable tariff structure

1) Domestic and government consumers

Slab (kWh)	Rate Baiza / kWh
00000-03000	10
03001-05000	15
05001-07000	20
07001-10000	25
above 10000	30

2) Commercial consumers
Flat rate of 20 baiza / kWh

3) Industrial consumers
(a) Within specified industrial areas

Summer months (May, June, July and August)	24 baiza / kWh
Winter months (Sept. to April)	12 baiza / kWh

(b) In other areas

Summer months	24 baiza / kWh
Winter months	16 baiza / kWh

In Dhofar region : Summer months (April to July)
Winter months (August to March)

4) Agricultural and fisheries

Up to 7000 kWh	10 baiza / kWh
above 7000 kWh	20 baiza / kWh

5) Hotel / tourism

00000-03000	10 baiza / kWh
03001-05000	15 baiza / kWh
above 5000	20 baiza / kWh

(6) Master Plan Study for the Electric Power Sector

Maximum demand for electricity and plans for future generation are shown in Table 7-3-1.

Table 7-3-1 After Modification by Actual Data - 1997

Unit : MW

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Peak demand	1373	1447	1521	1688	1790	1890	1987	2061	2134	2206	2277
Net supply capacity	1406	1551	1645	1833	1928	2022	2157	2241	2241	2335	2411
Reserve margin	1406	1551	1645	1833	1928	2022	2157	2241	2241	2335	2411
Firm generation	1311	1456	1550	1738	1833	1927	2062	2146	2146	2240	2316
Balance of firm generation to peak demand	-62	9	29	50	43	37	75	85	12	34	39
Rusail P/S	500.4	594.5	688.6	782.7	782.7	782.7	782.7	782.7	783	783	782.7
Future expansion		94.1	94.1	94.1							
		(GT-7)	(GT-8)	(GT-9)							
Ghubra P/S	537	537	537	537	537	537	484.5	473.6	474	474	473.6
Future expansion							-52.5	-105			
								94.1			
Manah P/S	86.4	86.4	86.4	86.4	86.4	86.4	180.5	180.5	181	181	180.5
Future expansion							94.1				
							(GT-4)				
Barka P/S	0	0	0	0	94.1	188.2	282.3	376.4	376	376	470.5
Future expansion					94.1	94.1	94.1	94.1			94.1
					(GT-1)	(GT-2)	(GT-3)	(GT-4)			(GT-5)
Wadi Jizzi P/S	281.8	281.8	333.2	333.2	427.3	427.3	427.3	427.3	427	521	503.6
Future expansion			51.4		94.1					94.1	-17.8
			(GT-12/13)		(GT-14)					(GT15)	(GT-1)
Expansion total		94.1	145.5	94.1	188.2	94.1	94.1	83.2		94.1	76.3

Source : MOEW

7.4 Water

7.4.1 History of development

In Oman, the habitants share in the benefit of many wells for water supply as well as the Faraj Systems, a kind of intake system from ground water zone, which are in service even now to supply water to rural areas.

Water consumption in the Muscat area is increasing year by year, an advanced desalination project was established to construct the first desalination unit at Ghubrah due to increasing demand for water, which was completed in 1976. The total capacity is now 35 MIGPD.

In 1989, the Government of Oman started to take an active interest to control water resources to restrict both new well drilling and free intake of water from existing wells.

Recent Government policy on water can be seen in the Fifth Five-Year Development Plan (1996-2000) summarized in the following section.

7.4.2 Government policy

The Plan aims towards the provision of potable water for all residential areas by the year 2005.

The Plan objectives regarding the potable water sector are as follows:

- Increasing the production of water in order to meet the requirements and demand of various regions and ensure the balanced distribution of water.
- Furthering the private sector role in the field of potable water through its participation in the operation, maintenance and implementation of water projects and related works.
- Providing new sources of water from ground water reserves or by establishing water desalination plants.
- Rationalizing water consumption through media campaigns.
- Reducing water loss to 15% the following years.

The main objectives of the Plan concerning the water resources sector are summarized as follows:

- Balancing water uses and renewable resources, and conserving water resources from being depleted and polluted.
- Providing water for industrial, commercial and agricultural uses within the limits of the available resources so as to achieve sustainable development.
- Enhancing the role of the private sector in developing water resources.

The privatization program in the Fifth Five-Year Development Plan includes the following water projects out of 11 projects :

- Muscat waste water project
- Salalah wastewater project
- Water desalination and power generation plant at Barka
- Water desalination project in Al Ashkara (First phase)
- Utilization of the water of Al Masarrat Basin

7.4.3 Water resources

Compared with the other Gulf Coast Countries, Oman has mountains in the central part of the country providing comparatively large amounts of rainfall, and there are many well fields for natural water supply.

In the Muscat area, however, water demand has increased in recent years along with modernization of the area, and Ghubrah Desalination Plant is now operating with 35 MIGPD water production in a total of 6 units which were commissioned in 1997. Well water is restricted to 20,000 m^3/d for resources conservation.

In the Sohar area, well water is supplied to the residential area and also Sohar Industrial Estate.

Total amount of well water is 8,000 m^3/d (8 wells x 1,000 m^3/d) at present and a desalination plant will be constructed in future along with area industrialization.

An expanded potable water distribution network is planned to reach most residential areas by 2002.

7.5 Natural gas

7.5.1 Natural gas reserves

Gas fields are located at Yibal, Barik, Saih Nihayda, Saih Rawl and Fahud
Total natural gas reserves in Sultanate of Oman is as follows :

Expected	25.4 TCF (non-associated gas)
Proven	17.7 TCF (non-associated gas)

The net balance of Associated gas over next 25 years is approximately zero.
Source : Sohar and Salalah gas supply study , (Long term gas supply plan for Sultanate of Oman) : Revision 2, February 1998

[Definition]: Expected: (50% chance ,50% chance will be lower)
Proven: (85% chance, 15% chance will be less)
Natural gas exists under ground but needs to be recovered economically.
A 50% chance means that 50% of the reserves could be recovered economically.

A natural gas exploration program is in progress which seeks to confirm if the reserves are more than 35 TCF.

7.5.2 Natural gas production and its uses

(1) Historical production and utilization of Non-associated gas

Historical production and utilization of Non-associated gas is indicated in Table-7-5-1.

Table-7-5-1 Historical Production and Utilization of Non-associated Gas

(Unit: Million scf/d)

	Production	Utilization	
	Non-associated gas	Domestic & industry	Oil field injection
1991	166	146	20
1992	179	170	9
1993	201	192	9
1994	219	198	21
1995	222	205	17
1996	243	226	17

Source: PDO -as supplied to MOG 30/11/97 Ref:AEG/126/97

(2) Natural gas and forecast

The forecast for natural gas demand from 2000 to 2020 excluding the Steel complex is indicated in Table-7-5-2

Compared with past production amount, demand for natural gas will increase significantly. The forecast includes major projects for LNG, urea, the aluminum smelter, poly-olefin and others.

The LNG project represents one of the basic foundations of the economic diversification strategy from oil to gas and the export of LNG will start from 2000.

However, the steel complex project which uses about 90 Million scf/d of natural gas is not included due to the F/S stage.

As per the forecast, natural gas production(expected) could be supplied on demand by the year 2011, after that the shortage of gas could be covered by new reserves developed by the natural gas exploration program .

Table-7-5-2 Natural Gas Demand Forecast

(Unit: Million scf/d)

Year	2000	2005	2010	2015	2020
Power	411	603	795	904	1014
LNG	712	959	959	959	959
Industry/Others	82	493	575	575	466
Total	1205	2027	2301	2411	2438

Source: PDO

7.5.3 Natural gas pipeline status

(1) Present

The existing Government Gas System provides gas to the Sohar area through a combined 20" and 36" pipe line from Yibal to Murayrat and a 16" pipeline from Murayrat to Sohar. (Refer to Figure 7-5-1)
The South Oman Gas Line (northern part :16", southern part: 10") is dedicated to PDO operations and connects Saih Nihayda to Marmul. It is fully utilized.
The supply pressure from Saih Nihayda is 7.0 Mpa.

(2) Future

A new gas pipeline project is included in the Fifth Five-Year plan, the outline is summarized as follows:

- LNG project pipeline

In 1999, two new gas pipelines will be commissioned. A 48" pipeline from Saih Rawl to Sur and a 28" pipeline link from Saih Rawl to the Government Gas System at Fahud.

- Sohar pipeline

The supply capacity of the existing transmission system to Sohar is fully utilized.
A new pipeline is proposed from Fahud to Sohar to meet long term domestic and industrial demand requirements for the region.
The distance from Fahud to Sohar is approximately 300 km.
Front end design for the planned pipeline is based on a 32" diameter and design work has already been completed.
The construction of new pipeline is scheduled to be completed by the summer in 2001.

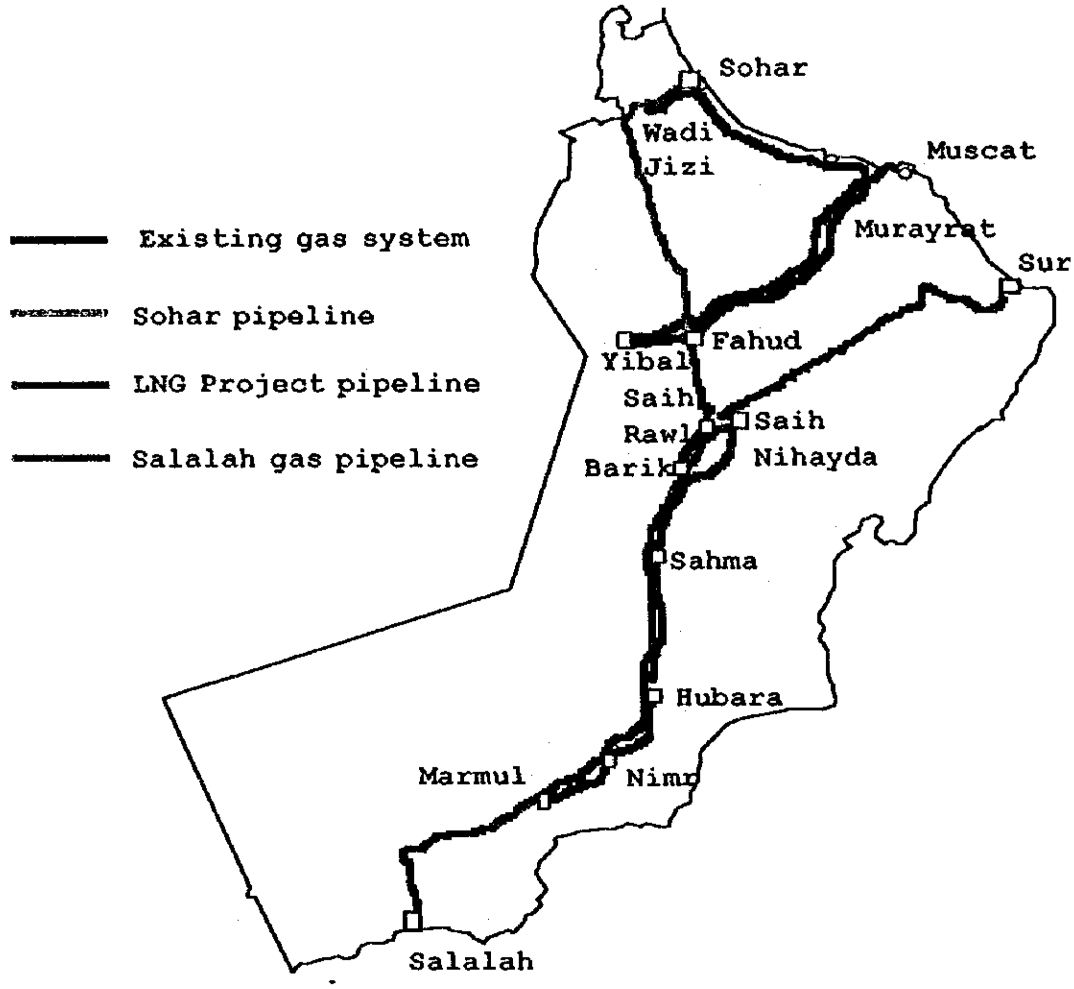


Figure 7-5-1 Natural Gas Pipeline Project

7.6 Telecommunication

(1) Telephone and facsimile requirements

Approximate requirements for normal telephone, facsimile and cellular telephone for the Steel Complex will be as follows;

- Telephone : 25 lines
- Facsimile : 10 lines
- Cellular telephone : 20 lines

(2) Telephone (including cellular) and facsimile services by GTO will be sufficient for the Steel Complex.

Chapter 8. CONCEPTUAL STUDY FOR INFRASTRUCTURE AND UTILITIES

8.1 Port and Port Facilities

8.1.1 Port

As mentioned in section 7.1.1, the government would be responsible for the construction of the new Sohar port, of which a construction project plan has been established on the condition that the Steel Complex will be constructed in the nearby area. However, it is not necessary to construct the port solely as a part of the Steel Complex construction project as the port facilities would also serve as support infrastructure for other industries.

8.1.2 Berth and berth facilities

It is assumed that the port facilities such as quay walls would be constructed by the government and that loading facilities such as unloaders and gantry cranes would be erected as a part of the Steel Complex construction project.

(1) Cargo volume and ship type

1) Raw materials

There will be two types of raw materials, namely: main materials (e.g. Iron oxide, Cokes) and auxiliary materials (e.g. mineral ores, silicon). Main raw materials would require different unloading cranes. On the other hand, auxiliary raw materials would be handled by the same cranes used for handling products and are unloaded at the products berth.

Table 8-1-1 shows cargo volume, ship type, ship size, the number of ships, and berth for each item.

Table 8-1-1 Cargo Volume of the Raw Material

Item	Cargo Volume.(t/y)	Ship Type	Ship Size (D.W.T.)	Cargo Volume per Ship(ton)	Total No. of Ships per Year	Berth Used
Iron oxide	1,885,000	Ore carrier	100,000	80,000	24	Raw material
Scrap	98,900	Cargo ship	20,000	10,000	10	Product
Coke lump	42,000	Cargo ship	20,000	3,000	14	Raw material
Fettling materials	18,400	Cargo ship	10,000	2,000	10	Product
Ferro-manganese	12,000	Cargo ship	10,000	2,000	6	Product
Ferro-silicon	5,300	Cargo ship	10,000	1,000	6	Product
Others	2,600	Cargo ship	10,000	1,000	3	Product

2) Products

The products consist of steel bars only. As a result of marketing study, export destination, cargo volume, and ship type are summarized in Table 8-1-2.

Table 8-1-2 Cargo Volume of the Products

Export Destination	Cargo Volume (t/y)	Ship Type	Ship Size (D.W.T.)	Cargo Volume per Ship (ton)	No. of Ship Entry/Arrival to Port(/y)
Domestic	39,000	Cargo ship	20,000	2,000	20
Kuwait	34,000	Cargo ship	20,000	2,000	17
Bahrain	10,000	Cargo ship	20,000	2,000	5
Saudi Arabia	30,000	Cargo ship	20,000	2,000	15
Yemen	130,000	Cargo ship	20,000	2,000	65
Jordan	5,000	Cargo ship	20,000	2,000	3
Syria	10,000	Cargo ship	20,000	2,000	5
Kenya	1,000	Cargo ship	20,000	1,000	1
Tanzania	1,000	Cargo ship	20,000	1,000	1
Pakistan	3,000	Cargo ship	20,000	1,000	3
ASEAN	70,000	Cargo ship	20,000	3,000	24

(2) Berth arrangement

Judging from the expected volume of cargo, ship type, and the number of ship arrivals, it would be desirable to provide one berth for handling main raw materials and two berths for handling the products and auxiliary raw materials.

1) Ship dimensions

Table 8-1-3 Ship Dimensions

Ship Type	Ship Size (DWT)	Overall Length (m)	Moulded Breadth (m)	Full Draft (m)	Applicable Berth
Ore carrier	100,000	250	40.0	14.5	Raw material
Cargo ship	20,000	165	25.0	10.0	Product
Cargo ship	10,000	137	19.9	8.5	Product

2) Water depth of berths

Using the formula "Full draft x 1.1", water depth of the berths will be as follows:

Raw material berth : water depth - 16 meters

Product berth : water depth - 12 meters (for 30,000 DWT cargo ship)

3) Berth length

Single berth : Overall ship length + 2 times moulded ship breadth (Result to be rounded off)

Continuous berth : Overall ship length + moulded ship breadth (Result to be rounded off) However, when the ships are of different breadths, the in-between distance of the two ships shall not be less than the breadth of the larger ship.

4) Arrangement plan

The berth length for Steel Complex is about 700 m. Figure 8-1-1 shows the arrangement plan for one raw material berth and two product berths.

BERTH ARRANGEMENT PLAN

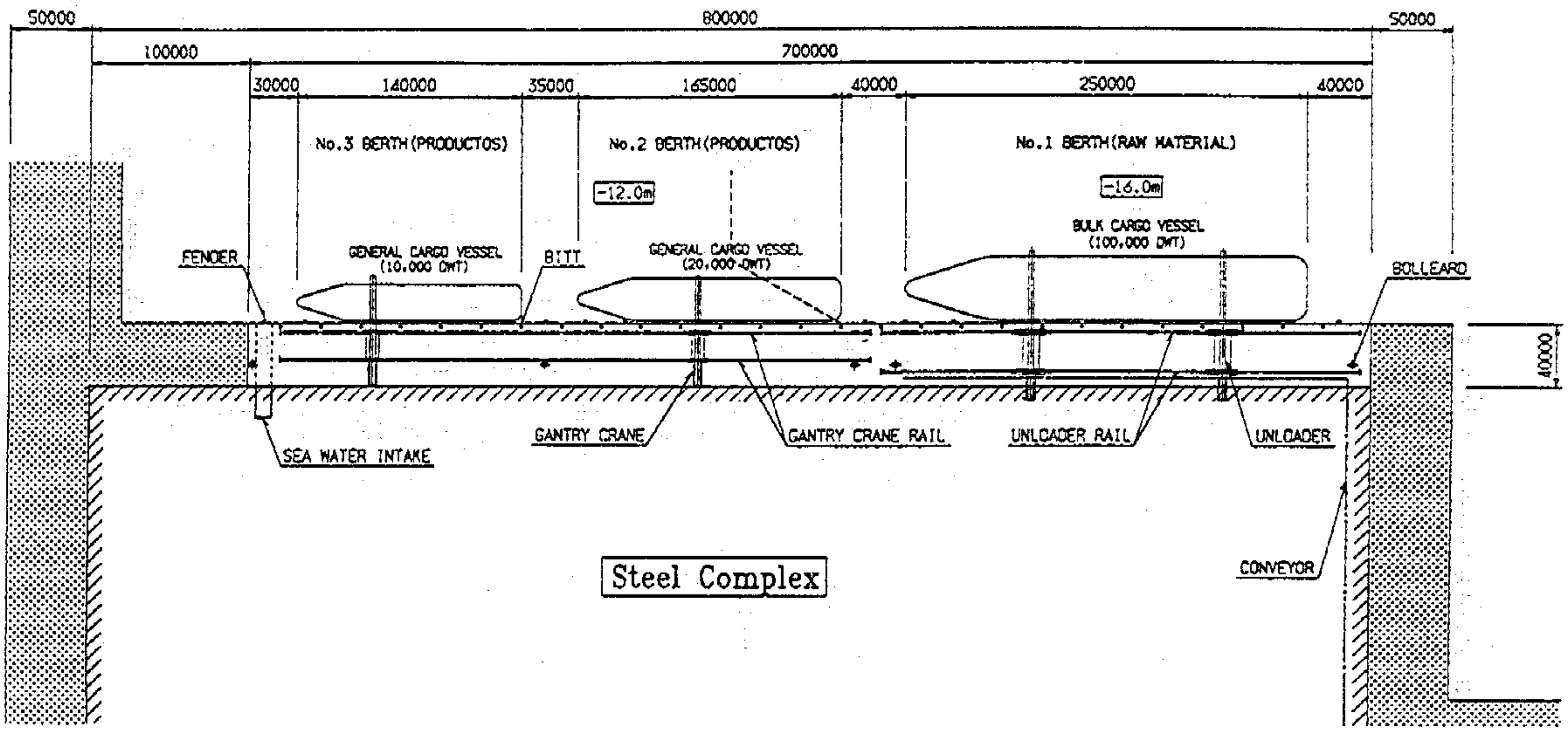


Fig 8-1-1 Berth Arrangement Plan

(3) Berth facilities

Unloaders would be provided purposely at the raw material berth to handle the unloading of Iron oxide and Coke lump. The number of unloaders to be provided will be two (2) to shorten the time for unloading, thus saving transportation cost, and to take into account the difficulty in finding measures to cope with the malfunctioning of the unloader(s). At the product berth, gantry cranes would be provided for the purpose of loading products and unloading auxiliary materials. One crane can be used both as a loader and unloader. A total of two cranes will be provided, of which two berths can share one crane.

The specifications of the cranes are as follows:

Unloader

There are two types of unloader; the rope trolley grab bucket type and the continuous bucket conveyer type. The rope trolley grab bucket was selected because the continuous bucket conveyer though productivity is high, is more expensive and repair of damaged parts is very difficult in Oman.

Type	: grab bucket unloader
Capacity	: 1,000 t/h.
Rail gauge	: 25 m

Gantry crane

Type	: Bridge type crane
Capacity (Max. lifting load)	: 20 t
Rail gauge	: 20 m

(4) Calculation of berth occupancy rate

1) Target occupancy rate

Less than 60%

2) Annual operation days of berth

Annual operation days of berth is taken to be 345 days in consideration to operation stoppage due to strong wind and waves.

3) Cargo distribution to each berth.

The items among the cargoes listed in the Table 8-1-1 and 8-1-2 will be distributed as shown Table 8-1-4.

Table 8-1-4 Cargo Volume of each Berth

Berth No. 1 (Raw material berth)

Items	Type of Ship	Ship Size (DWT)	Cargo Volume per Ship(ton)	No. of Ships per Year
Iron oxide	Ore carrier	100,000	80,000	24
Coke lump	Cargo ship	20,000	3,000	14

Berth No. 2 (Product berth)

Item	Ship Type	Ship Size (DWT)	Cargo Volume per Ship (ton)	No. of Ships per Year
Steel bar	Cargo ship	20,000	3,000	24
Steel bar	Cargo ship	20,000	2,000	130
Steel bar	Cargo ship	10,000	1,000	5

Berth No. 3 (Product berth)

Item	Ship Type	Ship Size (DWT)	Cargo Volume per Ship (ton)	No. of Ships per Year
Scrap	Cargo ship	20,000	10,000	10
Fettling materials	Cargo ship	10,000	2,000	10
Ferro-manganese	Cargo ship	10,000	2,000	6
Ferro-silicon	Cargo ship	10,000	1,000	6
Others	Cargo ship	10,000	1,000	3

4) Productivity of cargo handling

According to the data obtained in Japan, the productivity of cargo handling for different items is taken from Table 8-1-5.

Table 8-1-5 Productivity of Cargo Handling

Item	Productivity (t/h/crane)
Iron oxide	600
Scrap	60
Coke lamp	200
Fettling materials	30
Ferromanganese	30
Steel bars	100

5) Calculation of occupancy rate

$$\text{Occupancy rate} = \frac{\text{No. of occupying days per ship} \times \text{No. of ships per year}}{\text{Operation days per year}}$$

$$\text{No. of occupying days} = \frac{W}{P \times N \times Tw} + \frac{Tp}{24 \text{ hours}}$$

W : Cargo volume per ship (ton)

P : Productivity of cargo handling (ton)

N : No. of crane

Tw : Working hours per day (21 hours)

Tp : Preparation time (the total time between ship entry the port and starting operation, and between completion of operation and leaving the port) – 4 hours

The calculated results as indicated in Table 8-1-6 below are within the target occupancy rate for all berths.

Table 8-1-6 Berth Occupancy Rate

	Items	Cargo volume(ton)	Productivity (ton/hr/crane)	No. of crane	Necessary operation time (hours)	Necessary operation time (days)	Occupying days per ship	No. of ships per year	Total occupying days per year		Occupancy rate
No.1 Berth	Iron oxide	80,000	600	2	66.7	3.2	3.4	24		82	
	Coke lump	3,000	200	1	15.0	0.7	0.9	14		13	
									Berth Total	94	27%
No.2 Berth	Scrap	10,000	60	1	166.7	7.9	8.2	10		82	
	Fettling materials	2,000	30	1	66.7	3.2	3.4	10		34	
	Ferromanganese	2,000	30	1	66.7	3.2	3.4	6		20	
	Ferro-silicon	1,000	30	1	33.3	1.6	1.8	6		11	
	Graphic - electrode	1,000	30	1	33.3	1.6	1.8	3		5	
									Berth Total	153	44%
No.3 Berth	Steel bars	2,000	100	1	20.0	1.0	1.2	130		156	
	Steel bars	3,000	100	1	30.0	1.4	1.6	24		38	
	Steel bars	1,000	100	1	10.0	0.5	0.7	5		4	
									Berth Total	198	57%

Table 8-1-6 Berth Occupancy Rate

	Items	Cargo volume(ton)	Productivity (ton/hr/crane)	No. of crane	Necessary operation time		Occupying days per ship	No. of ships per year	Total occupying days per year		Occupancy rate
					(hours)	(days)					
No.1 Berth	Iron oxide	80,000	600	2	66.7	3.2	3.4	24		82	
	Coke lump	3,000	200	1	15.0	0.7	0.9	14		13	
									Berth Total	94	27%
No.2 Berth	Scrap	10,000	60	1	166.7	7.9	8.2	10		82	
	Fettling materials	2,000	30	1	66.7	3.2	3.4	10		34	
	Ferromanganese	2,000	30	1	66.7	3.2	3.4	6		20	
	Ferro-silicon	1,000	30	1	33.3	1.6	1.8	6		11	
	Graphic - electrode	1,000	30	1	33.3	1.6	1.8	3		5	
									Berth Total	153	44%
No.3 Berth	Steel bars	2,000	100	1	20.0	1.0	1.2	130		156	
	Steel bars	3,000	100	1	30.0	1.4	1.6	24		38	
	Steel bars	1,000	100	1	10.0	0.5	0.7	5		4	
									Berth Total	198	57%

(5) Preliminary Design of Quay Wall and Crane Foundation

1) Design Conditions

Design conditions will be given in Table 8-1-7.

Table 8-1-7 Design Conditions

	Raw Material Berth	Products Berth
Design Ship Size	100,000D.W.T	30,000D.W.T
Water Depth	-16.0m	-12.0m
Quay Cope Level	+4.3m	+4.3m
Tidal Level		
H.W.L	+2.4m	+2.4m
M.S.L	+1.5m	+1.5m
L.W.L	+0.8m	+0.8m
D.L	+0.0m	+0.0m
Surcharge	3.0t/m2	5.0t/m2
Seismic Force	not considered	not considered
Berthing Velocity	12 cm/sec	15 cm/sec
Tractive Force		
Bollard:	200t	100t
Bit:	100t	70t
Crane Type	Unloader	Gantry crane

2) Structural Design

In order to ensure an economical, easy and safe construction work, concrete block construction will be adopted as the structural system for the quay wall, and steel pipe foundation will be adopted as crane foundation. Fig. 8-1-2 shows the typical section of the raw materials berth construction while Fig. 8-1-3 shows the typical section of the products berth construction.

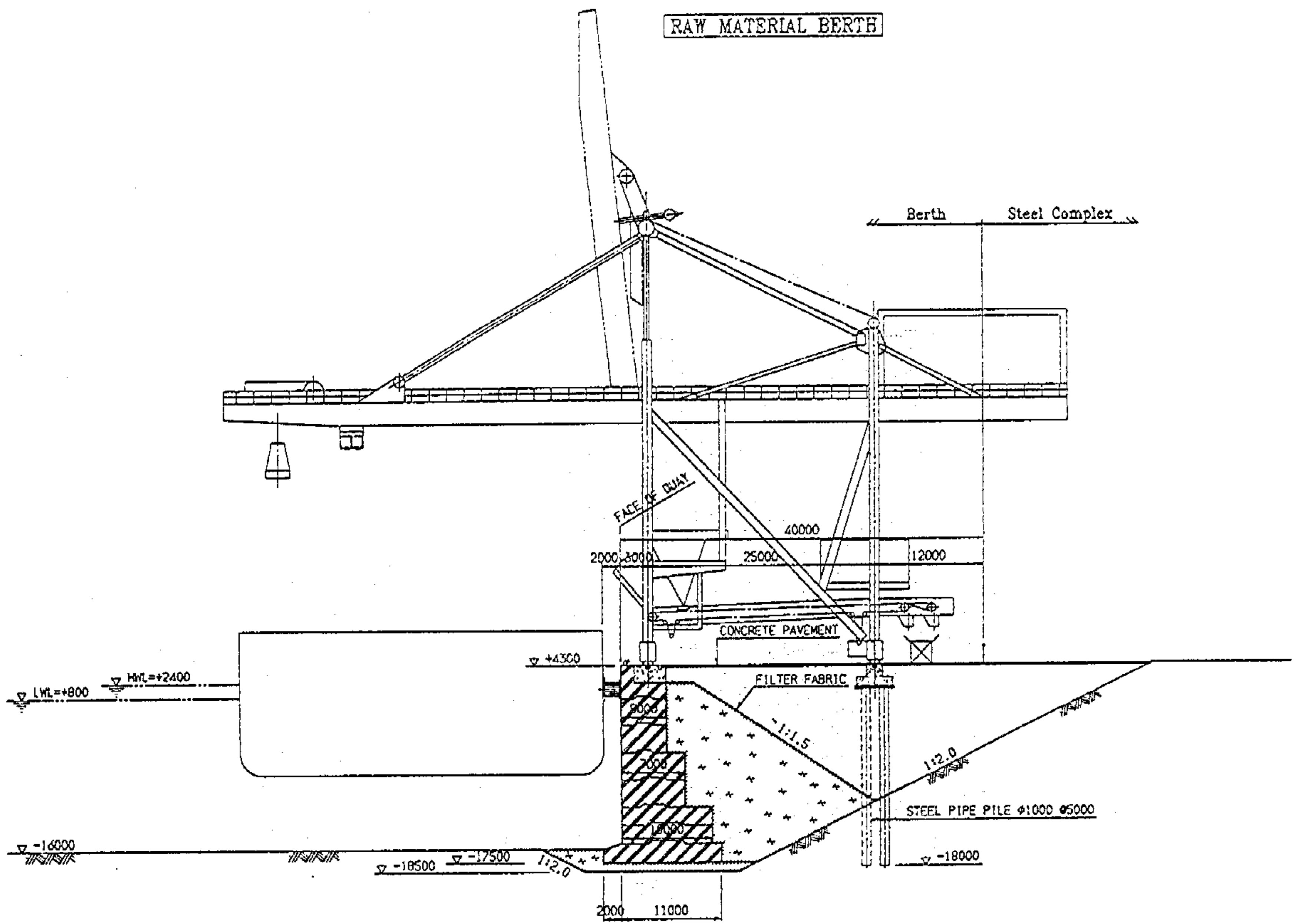


Figure 8-1-2 Typical Section of Raw Materials Berth

PRODUCT BERTH

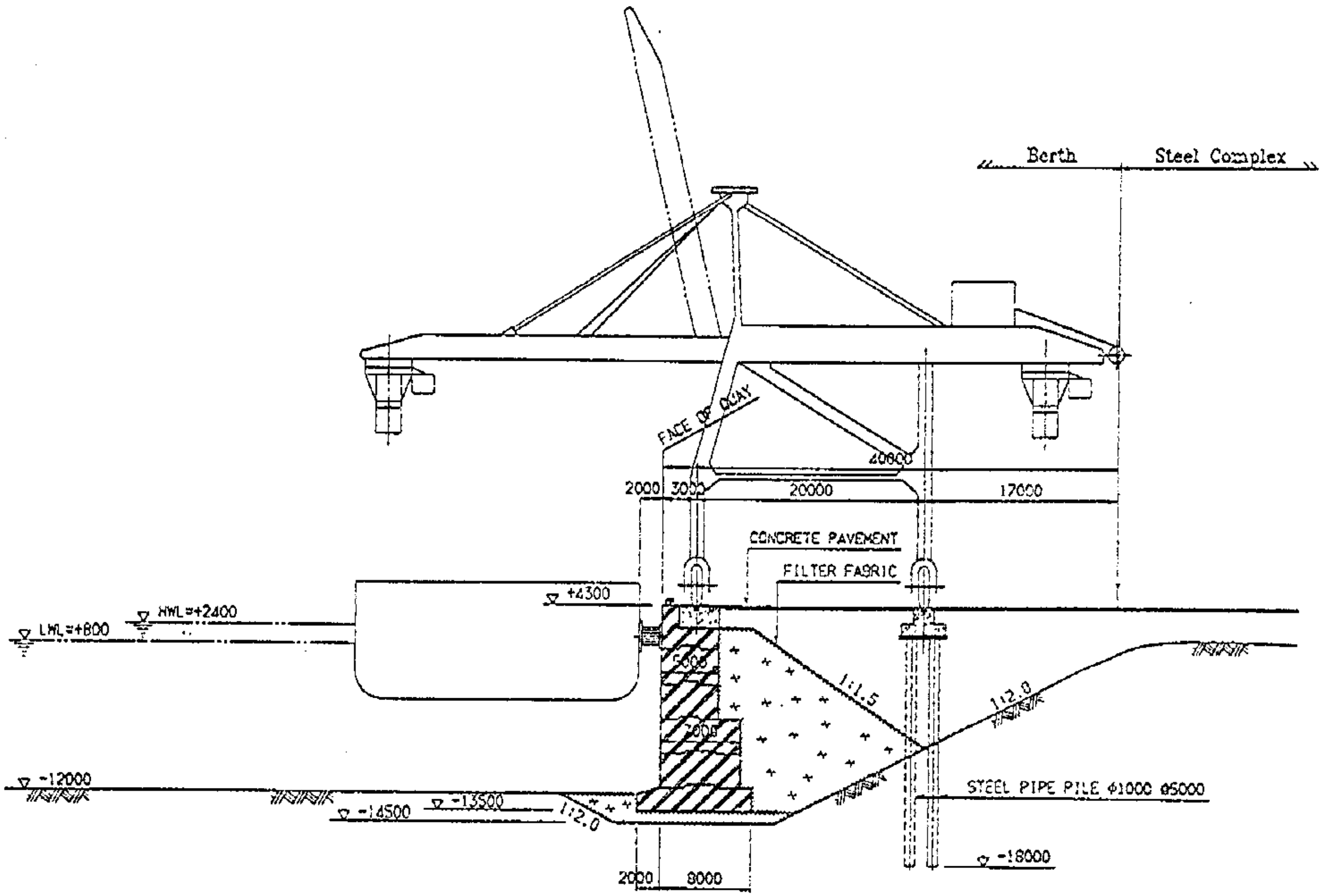


Figure 8-1-3 Typical Section of Product Berth

8.2 Road

The government is proceeding with a plan to construct access road from the existing trunk road (Route 1) to the port area. In addition, it is expected that main roads in the port area would also be constructed by the government. Therefore, construction of access roads from the Steel Complex site to these main roads will be the only concern of the Steel Complex construction project. Although the details of the construction plan of the main roads within the port area is not yet available or still unknown at present, it is assumed that total linear length of the roads, which should be constructed as a part of the Steel Complex construction project, is relatively short.

8.3 Electrical Power Supply

8.3.1 Power requirement

Approximate power requirement for the Steel Complex will be as follows;

- Maximum demand	: 200 MW
- Average load	: 164 MW
- Supply voltage	: 132 kV
- Number of line	: 2-lines
- Short circuit capacity of incoming power	: at least 1500 MVA at 132 kV

8.3.2 Conceptual design of power plant

The conceptual design of a power plant capacity 200MW for the Steel Complex covers basic matters, including the power generation system, equipment configuration and equipment specifications.

(1) Design conditions and fuel

1) Design conditions

The conceptual design of the mechanical and electrical facilities of the power plant will be based on the following design conditions, standards and criteria.

(a) Design conditions

Atmospheric temperature	: 50°C maximum, 5°C minimum, 30°C average, 50°C design
Sea water temperature	: 35°C maximum, 30°C design
Relative humidity	: 100% maximum, 40% annual average, 100% design
Rainfall	: 100mm annual average, 80mm maximum in 24 hour period
Maximum wind velocity	: 40 m/s
Number of thunderstorm days (IKL)	: 20 days/year
Elevation	: Maximum of 1,000m

(b) Voltage classifications and wiring method

Voltage	: 132kV, 33kV, 11kV, 6.6kV, 415V, 240V

Frequency	:	50 Hz
Wiring	:	3-phase 3-wire system, but 3-phase 4-wire system for 415V and 240V
Earthing	:	Direct earthing system on the primary side of the power transmission transformer and resistance earthing system on the secondary side

(c) Applicable standards and criteria

International Electrotechnical Commission (IEC)

Japanese Electrotechnical Committee (JEC) Standards

Japan Electrical Manufacturers' Association (JEM) Standards

Japan Electrical Association Code (JEAC)

Japanese Cable Makers' Association Standards (JCS)

Japan's Electrical Standards (issued by MITI)

2) Fuel and fuel supply

(a) Fuel

Fuel for the gas turbines in the combined cycle plant shall be as follows.

* Main fuel : Natural gas (lower heating value 35,800 kJ/kg)
* Emergency fuel : Distillate oil (lower heating value 42,915 kJ/kg)

Table 8-3-1 show the composition and basic data for distillate oil.

(b) Fuel supply

The Ministry of Oil and Gas shall install a natural gas pressure reducing station and connecting pipelines at the project site. All facilities up to the pressure reducing valve (and filter) will come under the jurisdiction of the Ministry of Oil and Gas. The power plant will need gas pipes leading from the pressure reducing valve. The natural gas supply must meet the plant's required pressure and volume conditions, namely :

* Service pressure : 20 kg/cm^2
* Service quantity : 42,000 kg/h (per GT unit)

Main fuel (natural gas) data shows in Table 8-5-2of chapter 8.5.

A distillate oil tank will also be installed to supply emergency fuel to the plant.

Table 8-3-1 Emergency Fuel (Distillate Oil) Data

Description	Figures
Density	0.8377
Kinetic Viscosity at 40°C (cS)	3.9
Cloud Point (°C)	-6
Pour Point (°C)	-15
Sulphur (% weight)	0.44
Ash (% weight)	0.005
Flash Point (°C)	114
Water Content	Nil
Sediment	Nil
HHV (kJ/kg)	45,700 (10,918 kcal/kg)
LHV (kJ/kg)	42,915 (10,252 kcal/kg)

Source : JICA 1994

(2) Selection of independent system power plant

1) Criteria and system selection

The system must support significant load follow up and frequent start up and shut down functions. It must also maintain high thermal efficiency during partial load, to reduce the consumption of natural gas fuel, while generating electricity in response to load fluctuations. A combined cycle power generation system which maintains high thermal efficiency is important because the electricity load becomes the base load for the plant. We therefore recommend the combined cycle for the power plant.

2) Combined cycle power plant outline and characteristics

A combined cycle power generation system uses a gas turbine based on the Brayton cycle, in which the fuel's combustion heat is used as the heat source of the high temperature cycle. The combined cycle system also uses a Rankine cycle, which uses the exhaust gas of the gas turbine as the heat source of the low temperature cycle. The combined cycle system uses these combined cycles as a heat engine to control the operating temperature, thus improving the total thermal efficiency.

Figure 8-3-1 shows the basic configuration of combined cycle power plant.

The characteristics of combined cycle power generation system are as follows.

(a) High thermal efficiency

The heat balance chart in Figure 8-3-2 indicates that while the gas turbine's thermal efficiency is 31% and thermal power generation is 40%, combined cycle power generation achieves a total thermal efficiency of more than 48% at the generator end (at the LHV base: 50°C). The short start up and shut down time minimizes heat loss, saving more than 10% in fuel costs, when compared with conventional thermal power plant.

(b) Short start up and shut down time

The combined cycle power plant comprises small capacity units. This ensures a large tolerance to load changes, and enables a short start up time of about one hour, compared to a two or three hour start up time for conventional thermal power plants. The combined cycle power plant also enables independent gas turbine operation, further reducing start up time to 15-30 minutes.

(c) Maximum output changes with atmospheric temperature

A combined cycle power plant primarily comprises gas turbines. The maximum output changes with the atmospheric temperature; the lower the atmospheric temperature, the greater the generator output (a single gas turbine unit with a rated output of 100 at 50°C, operating at a temperature of 15°C will produce almost 130 - an output increase of 30%). In contrast, a steam turbine following a drop in atmospheric temperature will increase the quantity of steam generated by the heat recovery steam turbine generator (HRSG), increasing the maximum output from that component (a rated output of 100 at a temperature of 50°C will produce a maximum output of about 110 at a temperature of 15°C).

A multi-shaft, combined cycle plant comprising one gas turbine and one steam turbine, with a 100% shaft output at an atmospheric temperature of 50°C, will increase output to about 120% when the temperature drops to 15°C.

(d) Low hot water discharge

The quantity of hot water discharge is 60-80% that of a steam power plant of the same capacity.

3) Plant dynamic characteristics during load fluctuations

Another strong characteristics of the combined cycle power plant is its excellent load follow-up capability. Making full use of this feature requires an understanding of the dynamic characteristics of the plant in connection with changes in the fuel ratio of the gas turbine. These dynamic characteristics are as follows:

(a) The gas turbine load will immediately follow-up in accordance with changes in the fuel ratio.
(b) The HRSG steam generation quantity will include a delay in transmission caused by ducts and pipes as well as a delay caused by the heat capacity possessed by HRSG. The delay will be for a few minutes.
(c) The steam control valve is kept open. Therefore, the generator output will be proportionate to steam quantity.

To compensate for the delay in the response of the steam turbine, the gas turbine must have quick response characteristics within the range of the allowable change rate. The gas turbine's maximum output changes with atmospheric temperature: the greater the temperature, the smaller the maximum output. These points must also be reflected in plant operations.

(3) The Combined Cycle Power Plant System and Basic Plant Structure

1) Combined cycle system

Combined cycle power generating systems are classified depending on the combination of gas and steam turbines. The exhaust heat recovery cycle and exhaust supplementary firing cycle mainly utilize gas turbines, while steam turbines are employed in the exhaust recombustion cycle, super charged boiler cycle and feed water heating cycle.

These cycles have particular characteristics. The system will be selected with consideration to plant output, types of fuel, and operating and site environmental conditions. As exhaust gas temperature increases with rising gas turbine temperatures, an exhaust heat recovery cycle is the most efficient system.

Figure 8-3-1 shows the operation of the exhaust heat recovery cycle, in which gas turbine exhaust gas is led to the heat recovery steam generator (heat exchanger HRSG), where HRSG generates steam to operate the steam turbine. This is the simplest of all combined cycle systems and is used at many plants around the world. The system's features include;

(a) A high proportion of gas turbine output than steam turbine output.
(b) Increasing thermal efficiency as the gas turbine inlet temperature rises.
(c) Short start-up time.

(d) Low level of hot water discharge per plant.

(e) Low level of CO_2 discharge per plant.

The combined cycle system enables installation of gas turbines in the first phase, with HRSG and steam turbines added in the second phase as electricity demand increases.
As exhaust heat recovery systems promise increased power output and improved thermal efficiency, this plant structure will be used for the Steel Complex.

2) Single shaft and multi-shaft systems
As Figure 8-3-3 shows, the combination of equipment under the combined cycle plant can be classified into either single shaft or multi-shaft. The single shaft system directly links one gas turbine with one steam turbine by a common shaft to create one unit, and combining several of these units creates a large capacity plant. The multi-shaft system combines one steam turbine with more than one gas turbine. The characteristics of the multi-shaft arrangement are;

(a) Power generation can continue where HRSG or steam turbine generator stops by independently operating the gas turbine (GT) (closing the HRSG inlet damper and operating the GT outlet bypass damper). Independent gas turbine operation is not possible in single shaft arrangements.

(b) As one gas turbine unit and one steam turbine meet minimum load operations, other gas turbines can be stopped.

(c) Each gas turbine unit can be started and loaded sequentially. Steam is allowed into the steam header when the HRSG-generated steam conditions match those during operations.

Due to the above mentioned reasons, a multi-shaft arrangement will be adopted.

3) Single and complex (dual) pressure types
The single pressure system has one pressure level (high pressure) for HRSG and steam turbine. The complex pressure type adds a low pressure steam system to the HRSG to effectively recover exhaust heat energy and lead low pressure steam to the steam turbine's low pressure section. The complex pressure type has a higher energy utilization rate and offers better efficiency and energy use economy. A complex pressure type will be used on this power plant.

4) Basic structure of the power plant

The operation of each unit in an organically combined plant can be controlled, enabling swift response to load changes through rapid start up and shut down, and ensuring high partial load efficiency. The plant utilization rate will increase because there are few areas for equipment failures.

5) Gas turbine

Gas turbines are the most important element in the exhaust heat recovery system of the combined cycle plant, accounting for about two thirds of plant output and having a significant impact on thermal efficiency.

Gas turbines employ high-temperature and high-pressure gas to make the blades revolve through an expansion process. As gas is not subject to phase changes, heating alone cannot provide heat energy. The gas must first be compressed, so the turbines incorporate a compressor and a combustion unit. The special features of the gas turbine are;

(a) There are few rows of blades as the expansion pressure drop is small.
(b) High temperature gas is used because of the major impact of working media temperature on thermal efficiency.
(c) As the working media temperature is extremely high, about 1,100°C, an ultra heat-resistant alloy is used, in association with measures such as air cooling of the blade.

The special features of the gas turbine power generation system are;

(a) Short start up time of 15-30 minutes for quick response to load changes.
(b) Low construction costs.
(c) Compact, standardized and lightweight plant requires short construction period, and small building, foundation and installation areas.
(d) Simple operation requires only a small number of operators.
(e) Simple structure and few components ensure high reliability and short open inspection period.
(f) Requires a small amount of cooling water (no treated water is required).

This Steel Complex's gas turbine design specifications are as follows. As the gas turbine output will be significantly affected by atmospheric temperature, the design temperature is set at 50°C and the rated output at 130 MW.

Type : Axial-flow

Quantity : 1 unit

Rated output : 130 MW (at 50°C atmospheric temp.) 163 MW (at 15°C)

Compressor : Axial-flow

Fuel shift : Automatic shift between main fuel (natural gas) and emergency fuel (distillate oil)

6) Heat recovery steam generator (HRSG)

The HRSG basic design guidelines are;

* Excellent thermal efficiency
* Ability to perform continuous and long-term operations
* Safety

Strength and anti-corrosion characteristics will also be considered. Thermal stress must be examined to ensure the HRSG can withstand the frequent, rapid start-up and shut down characteristics of gas turbines. Design considerations and factors which affect the HRSG's functions are;

(a) Exhaust gas components
(b) Exhaust gas temperature and flow rate
(c) Steam temperature
(d) Pinch point temperature difference and approach point temperature difference
(e) Exhaust gas pressure loss

HRSG performance is assessed through boiler efficiency by examining the ratio of heat output to heat input. Heat output is the amount of heat absorbed through HRSG working media, while heat input is the amount of heat supplied by the gas turbine exhaust gas.

HRSG efficiency increases as the HRSG exhaust gas temperature drops. This requires
a large thermal conductive area. However, large-scale facilities and problems of low temperature corrosion mean that exhaust gas temperature will be restricted.

Figure 8-3-4 shows the complex pressure natural circulation-type HRSG's main system to be used for the Steel Complex power plant. The design specifications are as follows;

Type : Fin tube system natural circulation model (module structure)

Quantity	:	1 unit
Pressure level	:	Complex pressure
Rated steam flow rate	:	220/20 t/h
Outlet steam pressure	:	80/9 ata
Outlet steam temperature	:	510/230°C
Economizer inlet feed water temperature	:	164°C
Exhaust gas temperature	:	170°C
Exhaust gas pressure loss	:	250mmH_2O (atmospheric temperature 50°C)
Efficiency	:	82%

Note : The complex pressure system's high-pressure and low-pressure values are on the left and right of the slash respectively.

7) Steam turbine and condenser

The high-pressure and low-pressure steam generated by the complex pressure system HRSG is sent to the steam turbine to generate power. Exhaust steam from the steam turbine flows into the condenser and is converted into water by vacuum deaerating.

The feed water pump increases the water pressure before supplying water to the HRSG's economizer. The steam turbine is designed to mitigate heat stress, and is adapted to frequent, rapid start up to improve the plant's thermal efficiency under a complex pressure system. The design specifications of the steam turbine and condenser are as follows.

(a) Steam turbine

Type	:	Water condensing, single flow exhaust system, axial-flow model
Quantity	:	1 unit
Rated output	:	70 MW (50°C atmospheric temperature), 83 MW (15°C atmospheric temperature)
Number of revolutions	:	3,000 rpm
Steam pressure in the first stage	:	80 ata
Steam temperature in the first stage	:	510°C
Exhaust steam pressure	:	90 mm Hg
Efficiency	:	31 %

(b) Condenser

Type	:	Surface type
Quantity	:	1 unit
Cooling water flow rate	:	$25000m^3/h$
Condenser load	:	130 Gcal/h
Inlet temperature	:	30°C
Condenser outlet temperature	:	49°C
Degree of vacuum	:	670 mm Hg

8) Generator

The generator will employ air cooling, and is structured to convert the steam turbine's revolution energy into high-efficiency electrical energy. A quick-response static excitation system will be used to ensure system stability.

The generator's design specification are ;

Type	:	Indoor type, horizontal, axial, cylindrical, rotary, field winding type, totally enclosed air cooling type
Quantity	:	1 unit
Rated capacity	:	88 MVA (for ST), 163 MVA (for GT)
Power factor	:	0.8
Voltage	:	11,000-15,000 V
Frequency	:	50 Hz
Number of phases	:	3
Number of poles	:	2
Number of revolutions	:	3,000 rpm
Insulation	:	F class (B class temperature raise used)
Cooling system	:	Air cooling (stator and rotor)
Short circuit ratio	:	0.5
Reactance	:	Xd-200 %, Xd'-20 %, Xd"-15 %
Excitation system	:	Static type
Peak voltage	:	1.5 pu
Response time	:	Less than 100ms (at 95% of peak voltage)

9) Electrical and control system

(a) Electrical system

Electricity generated at the Steel Complex power plant is increased to 132 kV transmission voltage from the terminals the gas turbine generator and the steam generator to the unit transformer. The electricity is then transmitted to the Steel Complex. Figure 8-3-5 shows the single line diagram.

(b) Control system

Rapid automation of operations has been promoted in the combined cycle power plant control system in response to such requirements as man-machine communications to reduce the burden on operators and the need to diversify and advance operations based on the power supply and demand situation. Consequently, the control system shall be built according to the following concept. Figure 8-3-6 shows an example structure. The figure shows a control system for one system comprising one gas turbine, one HRSG and one steam turbine.

a) Standardized and distributed control system structure
b) Central operation panel with a compact structure for single operator control
c) Load control and unit operation systems to suit the large number of plant units
d) Rational application of digital technologies

(4) Sea water and waste water.

Sea water is required for the power station and the required facility will be planned as sea water intake system-II.

Capacity of sea water intake system-II is 25,000 m^3/h and is same capacity of sea water intake system-I for Steel Complex.

The conceptual design of sea water intake system-II is almost same as in chapter 6.7.5 except the length of the sea water supply pipeline and waste water line. For conceptual design please refer to chapter 6.7.3.

Waste water is also the same as hot sea water of the Steel Complex, so please refer to chapter 6.7.6 .

Outfall of hot water is also same place of that of the Steel Complex.

(5) Drawing list

Figure 8-3-1	Basic Configuration of Combined Cycle Power Plant
Figure 8-3-2	Heat Balance Chart Comparing Combined Cycle Power Plant with Conventional Thermal Power Plant (LHV base, 50°C)
Figure 8-3-3	Comparison of Combined Cycle Power Plant

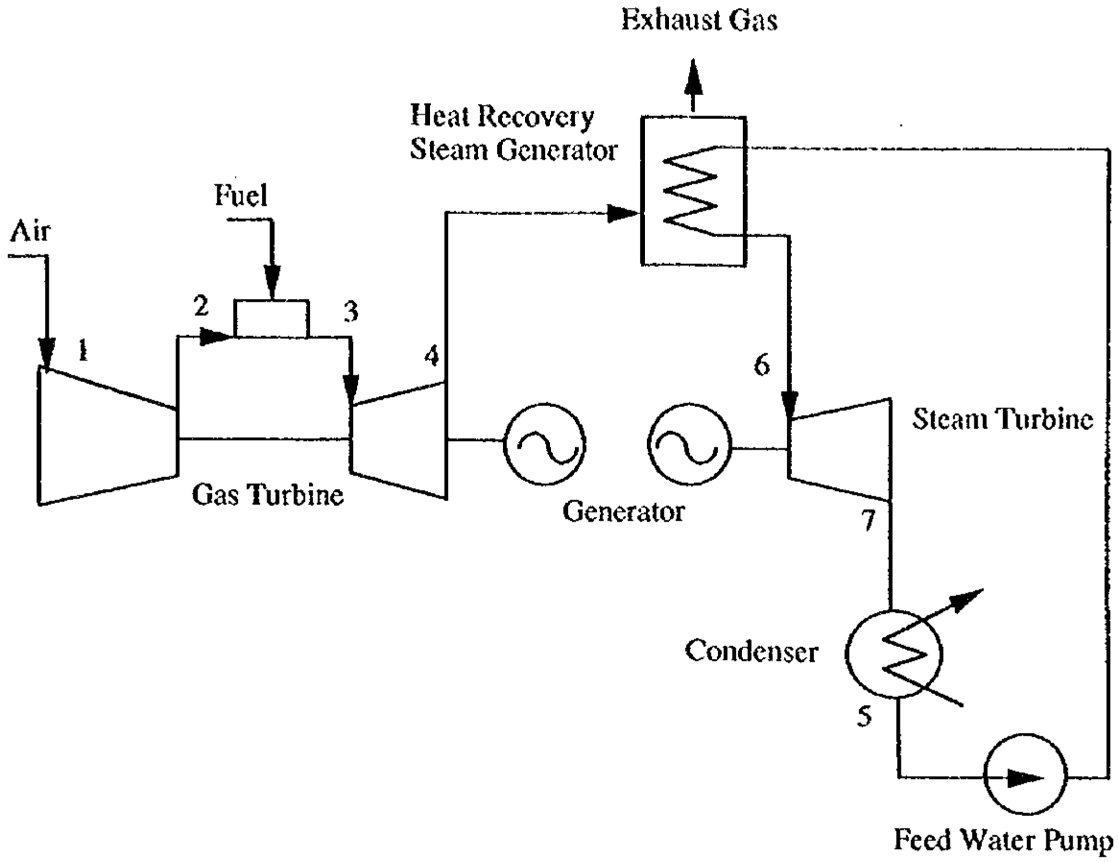
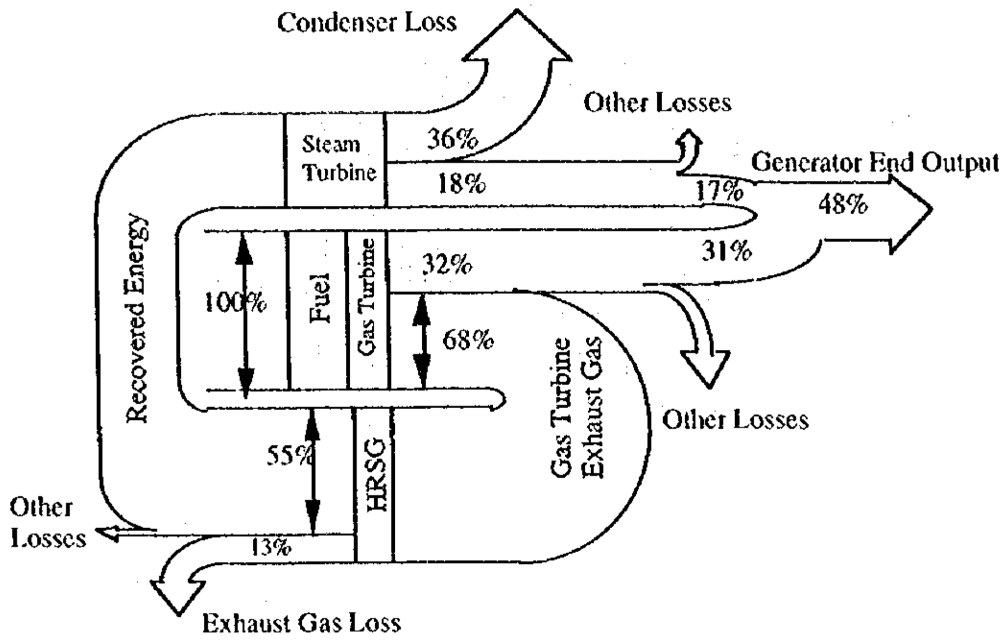
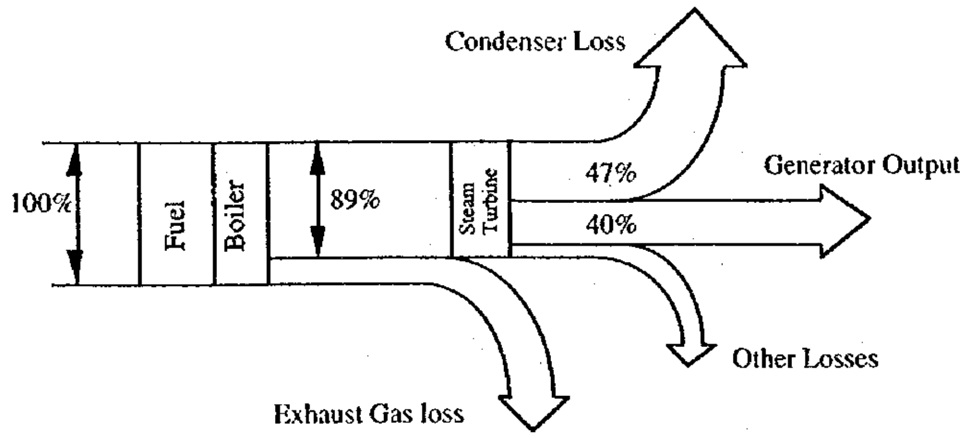


Figure 8-3-1 Basic Configuration of Combined Cycle Power Plant

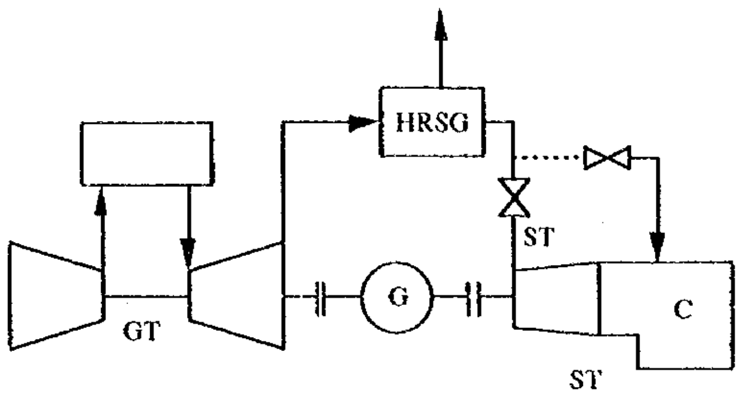


(a) Combined Cycle Power Plant (Example)

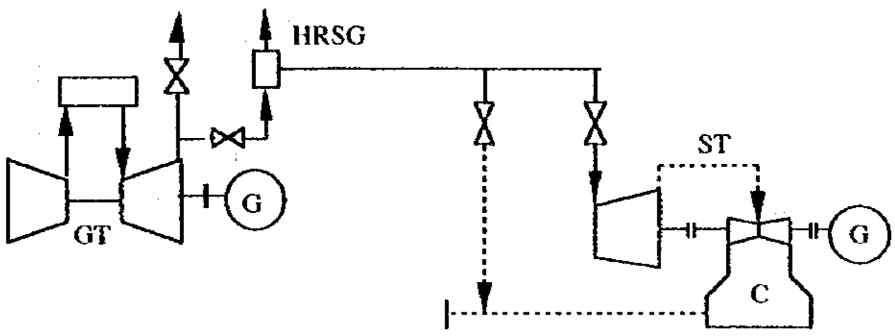


(b) Large Capacity Thermal Power Plant (Example)

Figure 8-3-2 Heat Balance Chart Comparing Combined Cycle Power Plant with Conventional Thermal Power Plant (LHV base, 50°C)



(a) Single Shaft Type



(b) Multi Shaft Type

GT : Gas Turbine
HRSG : Heat Recovery Steam Generator
ST : Steam Generator
C : Condenser
G : Generator

Figure 8-3-3 Comparison of Combined Cycle Power Plant

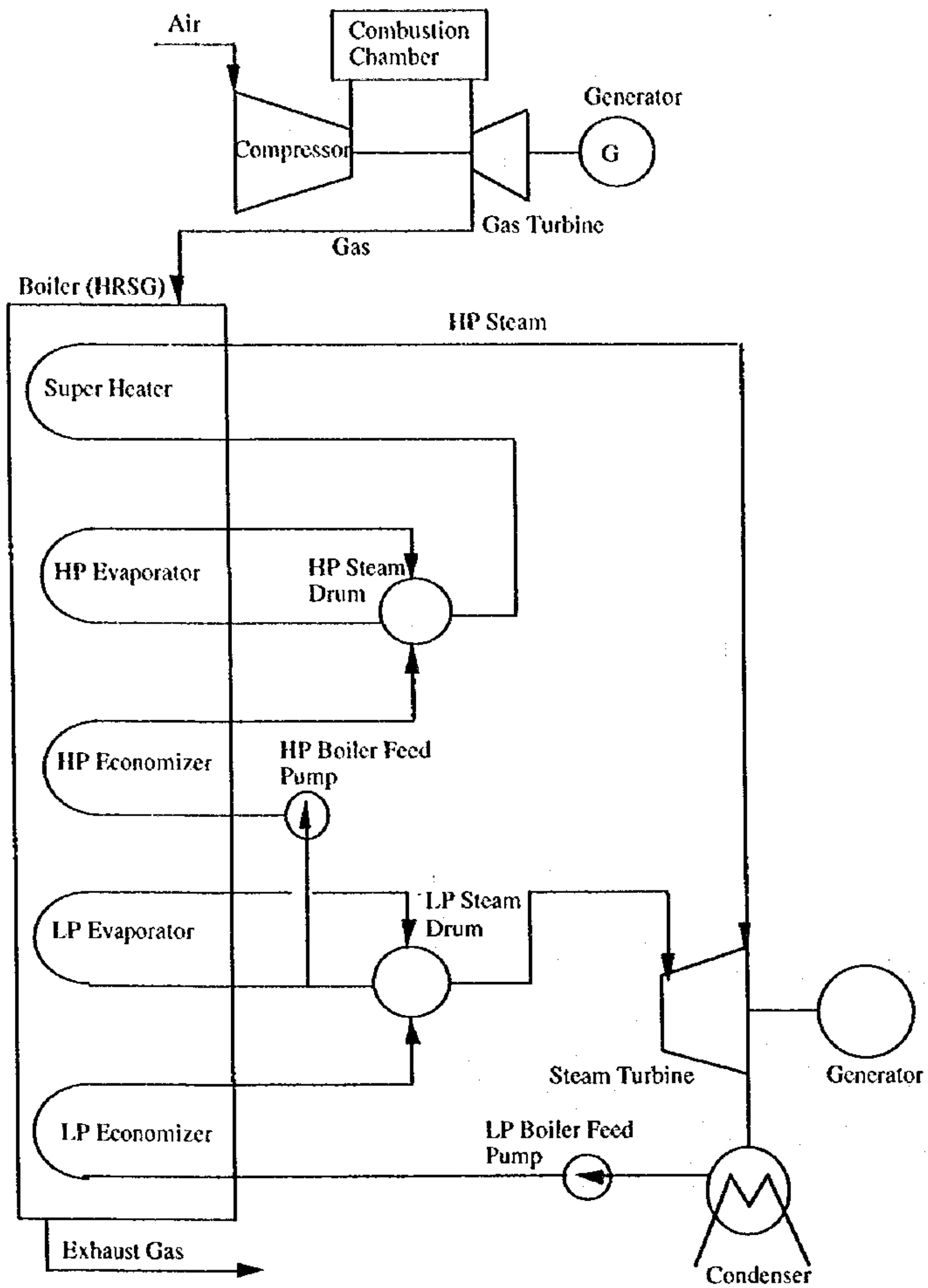


Figure 8-3-4 System Diagram of Power Plant with Dual Pressure Natural Circulation Boiler

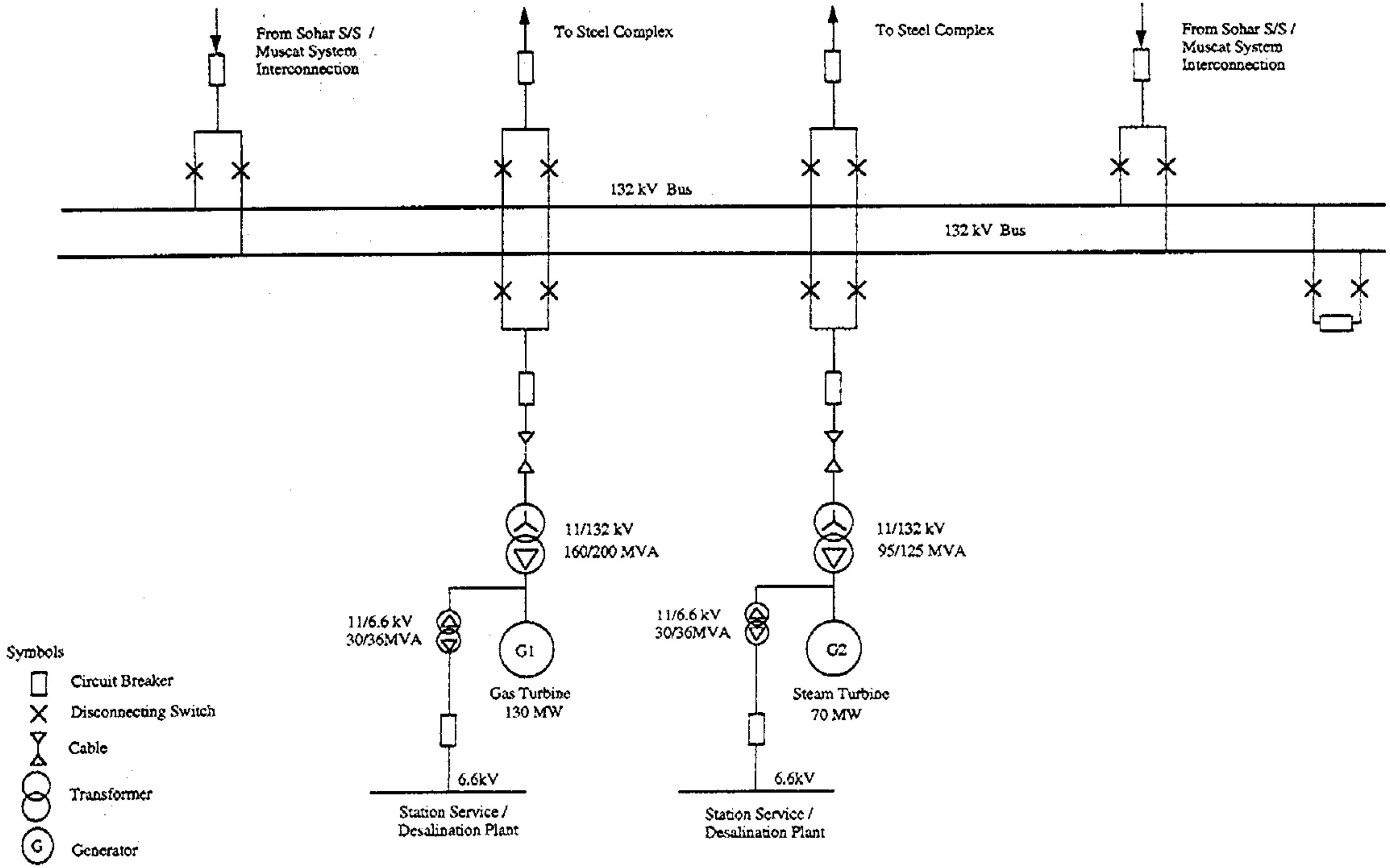


Figure 8-3-5 Single Line Diagram for Combined Cycle Power Plant

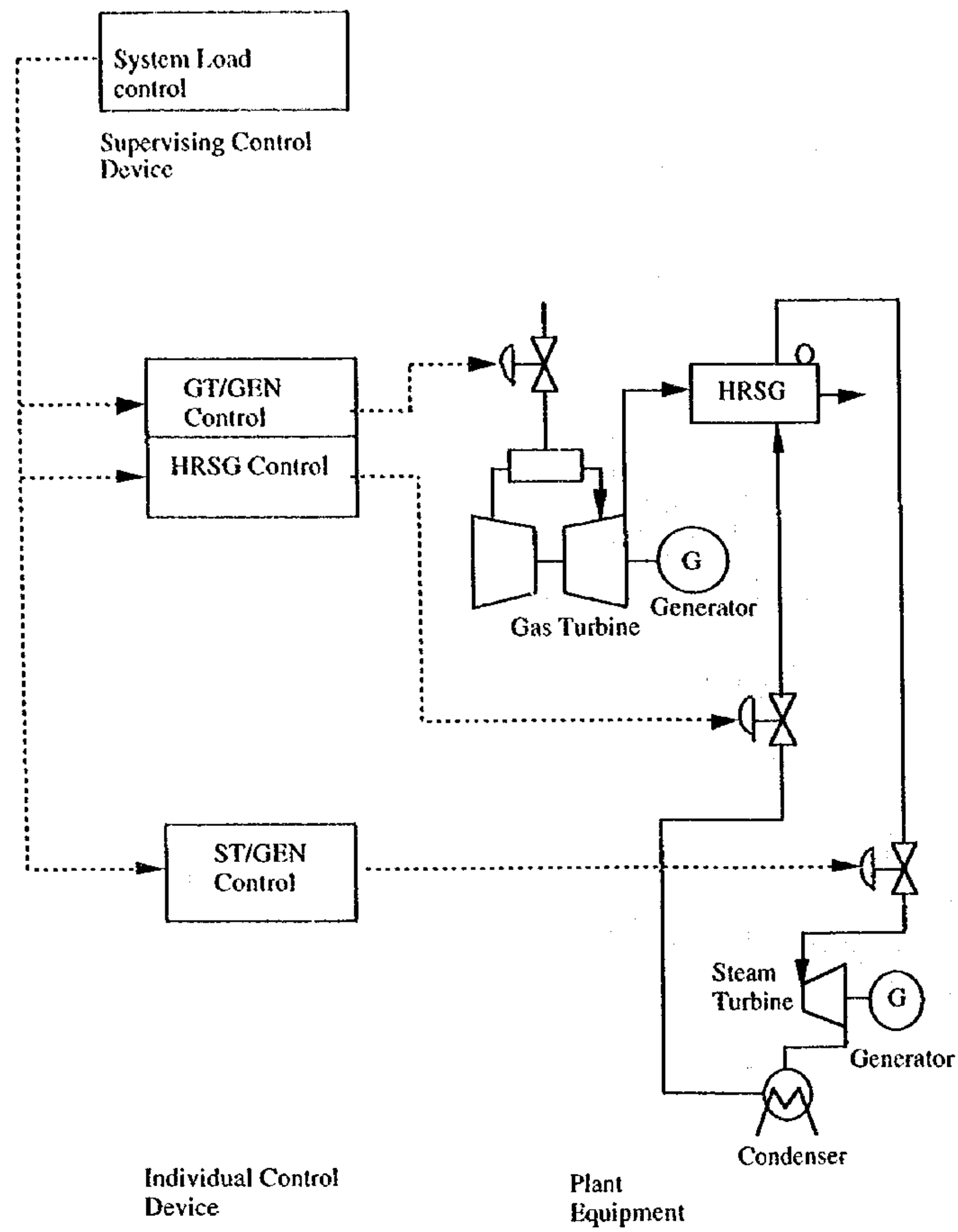
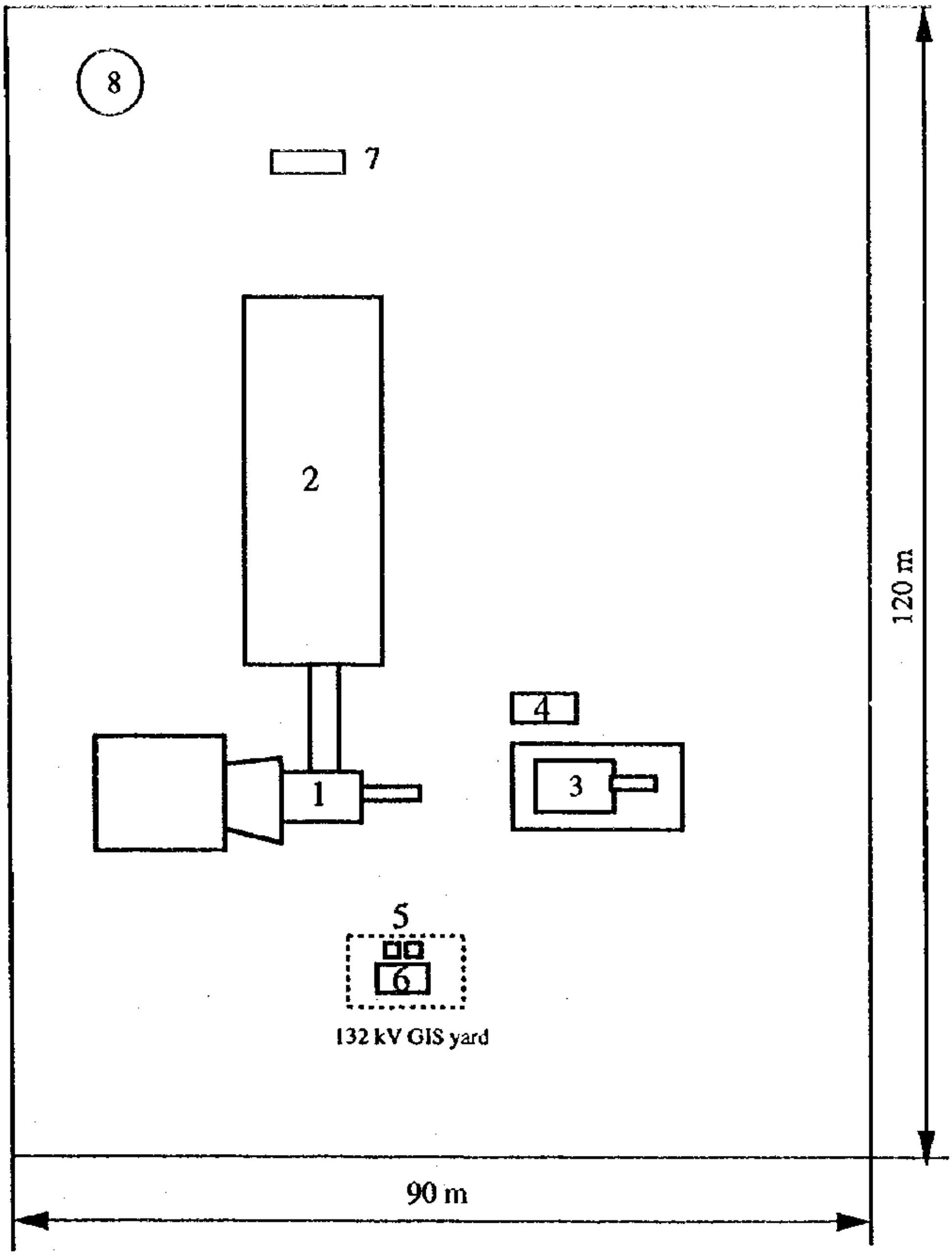


Figure 8-3-6 Configuration of Control System (Example)



1 : Gas Turbine Generator Package
2 : HRSG
3 : Steam Turbine Generator
4 : Electric and Control House
5 : Main Transformer
6 : 132 kV GIS
7 : Water Treatment System
8 : Fuel tank

Figure 8-3-7 General Arrangement of Combined Cycle Power Plant

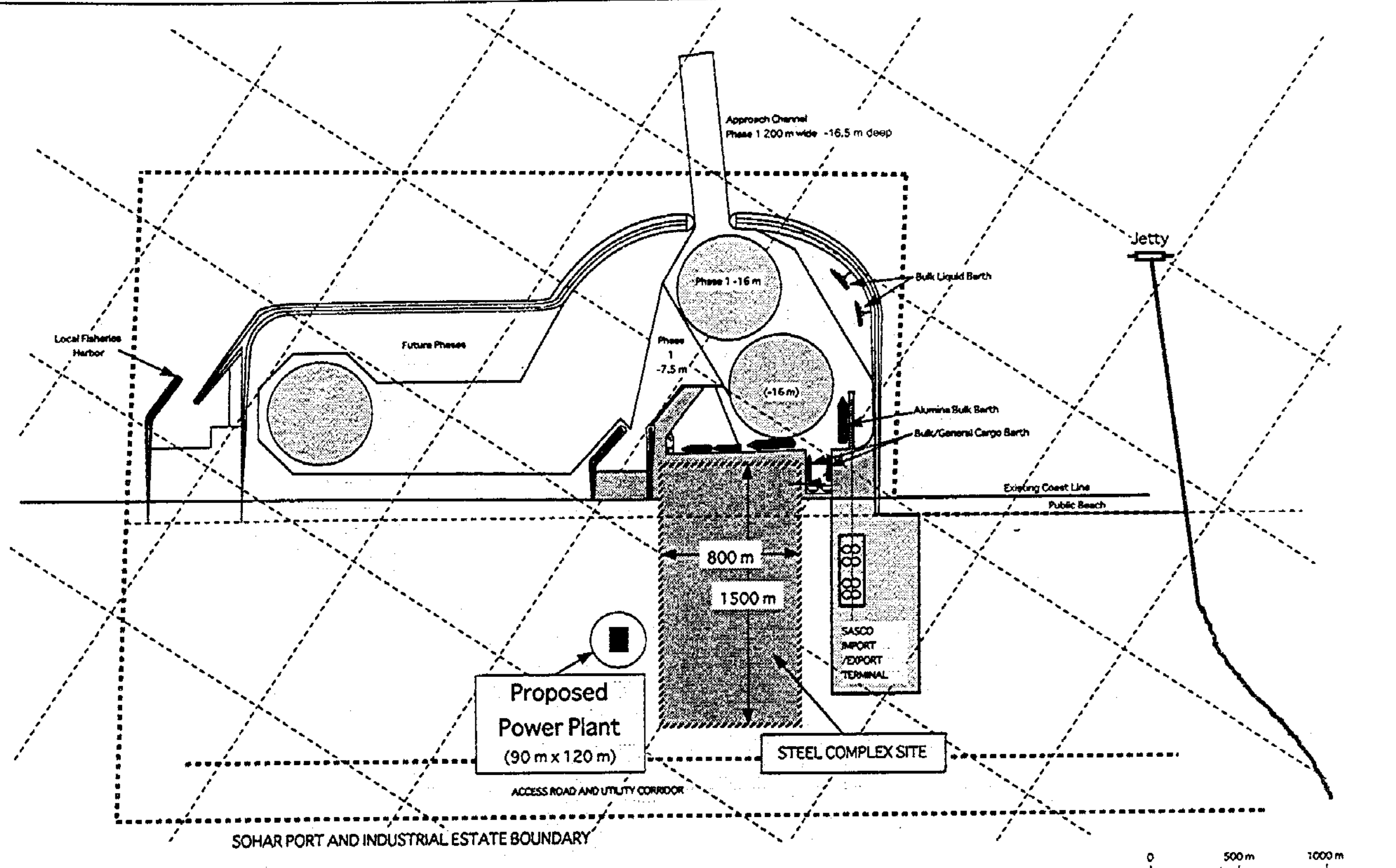


Figure 8-3-8 Proposed Location of Power Plant for the Steel Complex

8.4 Raw Water Supply

8.4.1 Potable water

(1) Steel Complex requirements

1) Volume of potable water

200 m3/day (200 liters/person x 1,000 persons)

2) Water quality

Water quality will be as per the Omanian standard or WHO Guideline for drinking water quality 1984.

(2) Potable water at the plant site (Sohar)

1) Volume

Sufficient potable water required by the steel complex is available in Sohar.

2) Water quality

Data on the quality of potable water was collected and is indicated in Table 8-4-1.

Table 8-4-1 Analysis of Potable Water in Sohar

Item		Unit
Origin of water sample	Sohar potable water	
Color	Clear-colorless	
Temperature	28	°C
Electrical conductivity	461.5	μS/cm
pH	8.2	
Total hardness	147.8	mg/l(as $CaCO_3$)
Total alkalinity	128	mg/l(as $CaCO_3$)
Iron	0.066	mg/l(as Fe)

Source: Sohar Development Office.

3) Supply facilities

Potable water is supplied from the 8-wells (1,000m³/day in each well) and supply capacity is 250 m³/h . The distance from the existing distribution net work to the proposed site is approximately 5 km for the 4" and 7 km for the 12" pipeline.

8.4.2 Industrial water

(1) Fresh water requirements

1) The volume of fresh water required by the Steel Complex and the power station is estimated as follows:

200m³/h, 4,800 m³/day, and 1,200,000 m³/year respectively.

Unit consumption: 1.0m³/t-steel product x 1,200,000 t/y

2) Water quality

Water quality as make-up water for cooling purposes as recommended by the Japan Iron and Steel Federation is indicated in Table 8-4-2.

Table 8-4-2 Water Quality as Make-up Water for Cooling Purpose

Item	Recommended value for cooling water unit (mg/l)
pH	< 7.5
BOD	< 1.0
COD	< 2.0
Turbidity	< 10.0 (NTU)
Total hardness	< 50.0 deg.C
Electric conductivity	< 150.0μS/cm
M alkalinity	< 50.0
Chloride ion	< 15.0
Ammonium ion	< 1.0
Fe	< 0.5
Free chlorine	< 0.5
Temperature	< 40 deg.C

Source: Japan Iron and Steel Federation

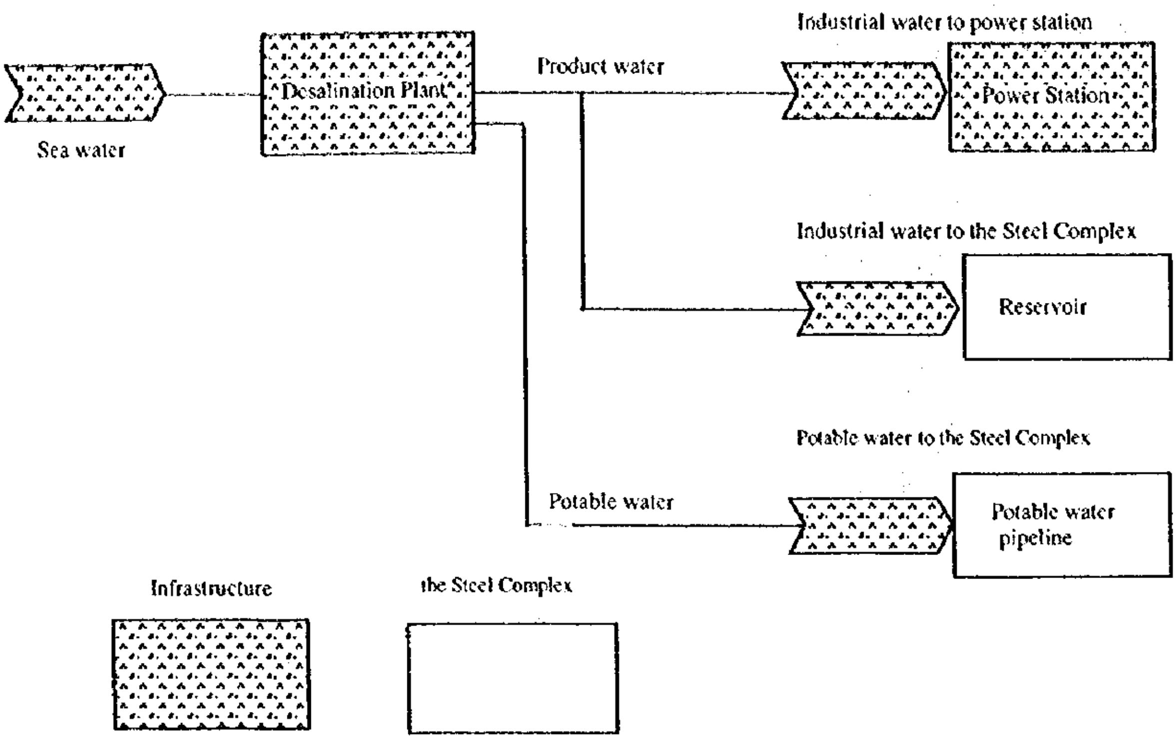
(2) Fresh water at Sohar

Fresh water for industrial use is not available in Sohar .
The maximum requirement of fresh water for the steel complex will be approximately 5,000 m^3/day and quantity of TSW is 3,000 m^3/day in Sohar, therefore the needs of the Steel Complex will not be met.
Installation of a desalination plant for the Steel Complex will be considered for Sohar.
There is a possibility that one of the big projects will have surplus electricity and water to give to other industries.

(3) Required facilities and scope of work

1) Facilities
- One desalination plant
- A connection pipeline for potable water
(For installation of a desalination plant, potable water can be supplied from the desalination plant, therefore, a connection pipeline is not required.)

2) Scope of work clarification
Some facilities will be prepared as infrastructure and other facilities will be prepared for the Steel Complex.
If big projects have surplus water, then a desalination plant would be not required for the Steel Complex. Facilities which will affected by preparation of the infrastructure are included as the infrastructure and summarized as follows:



8.4.3 Conceptual design of the desalination plant

Specifications for the desalination plant to be installed in Sohar are as follows:

1) Desalination plants

(a) Criteria

- Raw sea water :

Design condition : 30 deg.C

Maximum allowable temperature : 35 deg.C

Others : As per Table 8-4-3 Sea water analysis in Sohar

Table 8-4-3 Sea Water Analysis in Sohar

Item	Unit	Value
Turbidity	NTU	<1.0
Conductivity of sea water	μS/cm	54,100
Total dissolved solid (TDS)	mg/l	40,500
pH		8.1
Chloride ion	mg/l	20,500
Calcium ion	mg/l	400
Magnesium ion	mg/l	1,430

Source : Water sample was collected from seashore of Sohar proposed port and was analyzed in Japan on July 15 1998.

- Product water quality :

  Product water quality shall conform to the standard quality of drinking water in the Sultanate of Oman (OS 8/1978).

  Further more, the quality mentioned below shall be cleared.

  TDS : < 110 mg/litter

  Total hardness : < 20 ppm as $CaCO_3$

  Chloride iron : < 50 mg/l as $CaCO_3$

- Production capacity : 5,000 m^3/d

(b) Type of desalination plant

R-O (Reverse Osmosis) and MSF (Multi Stage Flush) type of desalination plant are mainly operating in the world, as shown in Table 8-4-4 which is excerpted from "Desalting Plants Inventory Report No. 14" 1996 by International Desalination Association (IDA).

R-O type desalination plant is selected in this Study as per Table 8-4-5.

Table 8-4-4 Desalting Plants Inventory Report

No.	Country	Location	Capacity m3/d	Unit	Process	Equip.	Feature	Customer	Water	User	Cn Year	Op Year	Manufacturer	Membrane
1	Arab Emirat. UAE	Dalma	4,500	1	VC	HTE	TVC	WED	SEA	MUNI	94	96	SIDEM F	
2	Arab Emirat. UAE	Jebel Dhanna	18,180	2	VC	HTE	TVC	WED	SEA	MUNI	94	96	SIDEM F	
3	Arab Emirat. UAE	Sharjar-Layyah	22,700	1	MSF	PROJ		WED	SEA	MUNI	94	95	ANSALDO I	
4	Austria A	Vienna	10,560	2	RO	SWM		OMV	BLACK	INDU	95	96	AE&E A	
5	Chile RCH		5,040	1	RO	SWM			BLACK	INDU	94	94	HYDROPRO USA	HYDRANAUTICS USA
6	Great Britain GB	Livingston	7,300	1	RO	SWM			WASTE	INDU	95	96	KURITA J	KURITA J
7	India IND		5,760	1	RO	SWM		Gujarat Electric	SEA	POWER	94	96	IONEXCHANGE IND	HYDRANAUTICS USA
8	India IND	Gujarat	5,500	1	ME	HTE	HST	SANGHI	SEA	INDU	95	96	IDE IL	
9	India IND	Viskhapatnam	4,800	1	RO	SWM		BIRLA PERICLASE	RIVER	INDU	95	95	NUCHEM WEIR IND	FILMTEC USA
10	Indonesia RI	Java	6,300	1	MSF	FLASH	FC	AMOCA	SEA	INDU	95	96	AQUA CHEM USA	
11	Iran IR	Tabriz	24,000	4	RO	SWM		TPC	RIVER	INDU	94	96	DEGRAMONT F	
12	Israel IL	Eilat-Sabha	8,000	1	RO	SWM	ER	MEKOROTH	SEA	MUNI	95	97	PREUSSAGNOELL D	HYDRANAUTICS USA
13	Israel IL	Eilat-Sabha-B	10,000	1	RO	SWM		MEKOROTH	BLACK	MUNI	95	95	MEKOROTH IL	HYDRANAUTICS USA
14	Italy I	Milan	11,734	2	RO	SWM		Milan Water	BLACK	MUNI	95	97	IONICS USA	
15	Japan J	Mie	4,080	1	RO	SWM			PURE	INDU	95	95	KURITA J	KURITA J
16	Japan J	Okinawa	15,000	3	RO	SWM		Ken Kigyokyoku	SEA	MUNI	95	96	KURITA J	NITTO/TORAY J
17	Japan J	Okinawa	10,000	2	RO	SWM		Ken Kigyokyoku	SEA	MUNI	94	95	KURITA J	TORAY J
18	Japan J	Shiga	4,800	1	RO	SWM			WASTE	INDU	94	94	KURITA J	KURITA J
19	Korea SKO	Daesan	15,600	1	RO	SWM		Hyundai Oil	BLACK	INDU	95	95	TORAY ENG J	TORAY J
20	Korea SKO	Songtan	5,000	1	ED	FM	EDR		BLACK	INDU	95	95	IONICS USA	
21	Kuwait KT	AZ Zour South	109,104	4	MSF	FLASH		MEW	SEA	MUNI	94	96	MHI/SASAKURA J	
22	Libya LAR	Derna	4,700	1	VC	HTE	TVC		SEA	INDU	94	96	SIDEM F	
23	Neth. Antil. NA	Curacao	12,000	1	VC	HTE	TVC		SEA	INDU	94	96	SIDEM F	
24	Oman OMA	Ghubrah 5	27,240	1	MSF	FLASH	HST	MED	SEA	MUNI	94	96	HITACHI ZOSEN J	
25	Saudi Arabia SA		7,500	1	RO	HFM			SEA	MIL	94	95	METITO SA	DUPONT USA
26	Saudi Arabia SA	Hail	105,980	10	RO	SWM		MOAW	BLACK	MUNI	95	96	EMCO USA	SIDMAS SA
27	Saudi Arabia SA	Hareeg	5,000	1	RO	HFM			BLACK	TOUR	94	95	METITO SA	DUPONT USA
28	Singapore SGP	Singapore	4,080	1	ED	FM			WASTE	INDU	94	95	IONICS USA	
29	Singapore SGP	Singapore	7,000	1	RO	SWM			WASTE	INDU	95	96	KURITA J	KURITA J
30	Spain E	Adeje	10,000	2	RO	SWM	ER	MOPTMA	SEA	MUNI	94	96	SPA E	FILMTEC USA
31	Spain E	Almanzora	20,000	2	RO	HFM	ER	Municipality	SEA	MUNI	94	95	CADAGUA E	DUPONT USA
32	Spain E	Almeria	9,500	2	RO	SWM	ER	ROQUETAS	WASTE	IRR	95	97	PRIDESA/PASA E	
33	Spain E	BI Mallorca	30,000	6	RO	SWM		EMAYA	BLACK	MUNI	94	95	DEGREMONT E	FILMTEC USA
34	Spain E	CI Gran Canaria	4,000	1	RO	SWM			SEA	MUNI	95	96	IONICS USA	
35	Taiwan RC	Kaohsiung	4,196	1	ED	FM	EDR		WASTE	INDU	95	95	IONICS USA	
36	USA	AZ	4,550	1	ED	FM	EDR		RIVER	MUNI	94	95	IONICS USA	
37	USA	CA Tustin	7,570	1	RO	MTU		Municipality	BLACK	MUNI	95	96	EMOCO USA	
38	USA	FL Jupiter	22,710	4	RO	SWM		City	BLACK	MUNI	95	96	HYDROPRO USA	

Table 8-4-4 Desalting Plants Inventory Report

No.	Country	Location	Capacity m3/d	Unit	Process	Equip.	Feature	Customer	Water	User	Cn Year	Op Year	Manufacturer	Membrane
39	USA	FL Martin Count	5,678	1	MS	PROJ		County	BLACK	MUNI	95	96	WET USA	TRISEP USA
40	USA	FL Palm Beach	30,280	4	RO	MTU		County	BLACK	MUNI	95	97	EMOCO USA	
41	USA	FL Wellington	6,813	1	RO	SWM		ACME District	BLACK	MUNI	95	96	HYDROPRO USA	FLUIDSYSTEMS USA
42	USA	ID	5,450	1	RO	OTHER			PURE	INDU	95	95	IONICS USA	
43	USA	TX	5,680	1	ED	FM	EDR		RIVER	MUNI	95	96	IONICS USA	
44	USA	TX Dallas	4,500	1	RO	SWM			WASTE	INDU	95	96	KURITA J	KURITA J
45	USA	TX Eugine	14,800	1	RO	SWM			WASTE	INDU	95	96	KURITA J	KURITA J
46	USA	TX Ft. Stockton	11,355	2	RO	SWM		Pecos County	BLACK	MUNI	95	96	HYDROPRO USA	HYDRANAUTICS USA
47	USA	UT	34,880	6	RO	OTHER			PURE	INDU	95	96	IONICS USA	

EXPLANATION OF ABBREVIATIONS

-Process :
ED: Electrodialysis, FREEZ: Freezing, HYBRI: Hybrid process, ME: Multieffect evaporation, MS: Membrane softening, MSF: Multistage flash, OTHER: All other processes, RO: Reverse osmosis,
VP: Vapor compression (mechanical and thermal)

-Equip. : The main equipment applied.
FLASH: Flash evaporator, FM: Flat membrane, HFM: Hollow fiber membrane, HTE: Horizontal tube falling film evaporator, MTU: Membrane type unknown, OTHER: All other equipment,
ST: Submerged tube evaporator, SW/FM: Dual membrane plant, SWM: Spiral wound membrane, TM: Tubular membrane, VPE: Vertical plate falling film evaporator, VTE: Vertical tube falling film evaporator.

-Features: The most important features of a desalination plant.
COOL: Cooling, EDR: Reversal polarization in ED plants, ER: Energy recovery in RO plants, FB: Fluidized bed, FC: Forced circulation, HST: Horizontal stack, TVC: Thermal vapor compression.

-Customer
MEW: Ministry of Electricity & Water, MOD: Ministry of Defense, MOAW: Ministry of Agriculture & Water, MOH: Ministry of Housing.

-Water: The quality of the untreated water
BLACK: Brackish water or inland water (TDS=3,000~20,000 mg/l), PURE: Pure water (TDS<500mg/l), RIVER: River water or other saline water of low concentration (TDS=500~3,000 mg/l),
SEA: Sea water or concentrated sea water (TDS=20,000~50,000 mg/l), WASTE: Other raw water, i.e., Waste water.

-User
INDU: Fresh water used as industrial or process water (TDS<10 mg/l), IRR: Fresh water used for irrigation (TDS<1,000 mg/l), MIL: Fresh water used as drinking water for military facilities(TDS=10~1,000 mg/l),
MUNI: Fresh water used as municipal drinking water (TDS: 10~1,000mg/l), POWER: Fresh water used as process water in power stations (TDS< 10 mg/l),
TOUR: Fresh water used as drinking water for tourist facilities (TDS: 10~1,000 mg/l)

-Cn Year: The year in which the contract was signed.
-Op Year: The year in which the plant was commissioned.

Table 8-4-5 MSF vs R-O Compasion

Item	MSF Process	R-O Process
1. Reliability of operation and maintenance	High reliability is confirmed through the operation records	Few past experiences, some failures occurred; but reliability is significantly improving.
2. Economics	Ghubrah No.5 unit (with power generation plant)	Same capacity plant as MSF (with power generation)
a) Construction cost	49 M.R.O (127 M$)	36.1 M.R.O (93.7M$)
b) Water production cost	2.91 baiza/gallon	1.96 baiza/gallon
3. Delivery time	MSF only : 2.5 years Power plant : 3 years	R-O: about 2 years (independently)
4. World operation record	68.4 % of large scale plants by capacity.	22.4 % of large scale of plants by capacity.
5. Operation	Constrained to power generation	Free operation due to the independence of power generation and the desalination plant
6. Environment	With same capacity as R-O, for product water and power output, fuel consumption is about 1.5 times R-O process and much CO_2 effluents.	Advantage of fuel consumption saving to about 2/3 of MSF process, including CO_2 effluence reduction.

Source: JICA Report 1994 (Barka Power and Desalination Plant Project) and Item-4. World operation record was updated by "Desalting Plants Inventory Report No. 14. 1996".

(c) Plant specifications

The main specifications of the desalination plant (5,000m^3/d) are indicated in Table 8-4-6.

Table 8-4-6 Main Specification of Desalination Plant

No.	Equipment	Q'ty	Specification
IW-001	Pressure filter Including: backwashing system	5	Filter media: sand Capa: 240 m^3/h,
IW-002	Back Wash Pump	2	Type: Centrifugal Capa: 300 m^3/h
IW-003	Filtrate Water Basin	1	Type: Rectangular/RC Capa: 360 m^3
IW-004	RO Supply Pump	4	Type: Centrifugal Capa: 240 m^3/h
IW-005	Cartridge Filter	5	Type: FRP
IW-006	1st Stage RO Unit	3	Type: Spiral Wound RO Membrane
IW-007	High Pressure Pump with Pressure Recovery Turbine	3	Type: Turbine Capa: 70 m^3/h, 600 m head
IW-008	1st Stage Treated Water Tank	1	Type: Rectangular/RC Capa: 360 m^3
IW-009	2nd Stage RO Unit	3	Type: Spiral Wound RO Membrane
IW-010	RO Supply Pump	4	Type: Centrifugal Capa: 85 m^3/h, 30 m head
IW-011	2nd Stage Treated Water Tank	1	Type: Rectangular /RC Capa: 360 m^3
IW-012	Chemical Dosing System Including: 1-pH Control Unit 1-Chemical Cleaning Unit 1-Chlorination Unit	1	
IW-013	Potable Water Tank	1	Type: Rectangular/RC Capa: 500 m^3
IW-014	Potable Water Supply Pump	2	Type: Centrifugal Capa: 30 m^3/h, 35 m head

(d) Process outline

The process flow is shown in Figure 8-4-1.

A R-O desalination plant consists of three sections pre-treatment, reverse osmosis, and post treatment.

- Pre-treatment

The sea water passes through the pressure filter and suspended matter in the sea water is removed. The filter consists of dual layers of anthracite and a lower layer of fine sand, and is regenerated periodically by backwashing.

The filtered sea water runs next through an adjusted safety filter where remaining minute particles in the sea water are removed to prevent the membrane from clogging.

- Reverse-osmosis

The sea water is pumped by the high pressure pump at a pressure of 60 kg/cm^2 and passes through the 1st. reverse-osmosis module where 35 % of the water is permeated through the membrane. The remaining 65% of the brine is discharged as waste through an energy recovery turbine to reduce energy consumption.

The quality of the permeated water will be 600 ~ 1,000 mg/l of TDS which is within the limit of potable water of Oman.

Further more, the permeated water is pumped by pressure pump and passes through the 2nd reverse-osmosis module in order to meet the requirements for the Steel Complex.

The quality of the product water will be 110 mg/l of TDS.

- Post treatment

The product water will be transferred by the pumps to the Steel Complex and the power station

The product water also stored in the potable water storage basin is dosed, sterilized, then the transferred as potable water to the Steel Complex and power station.

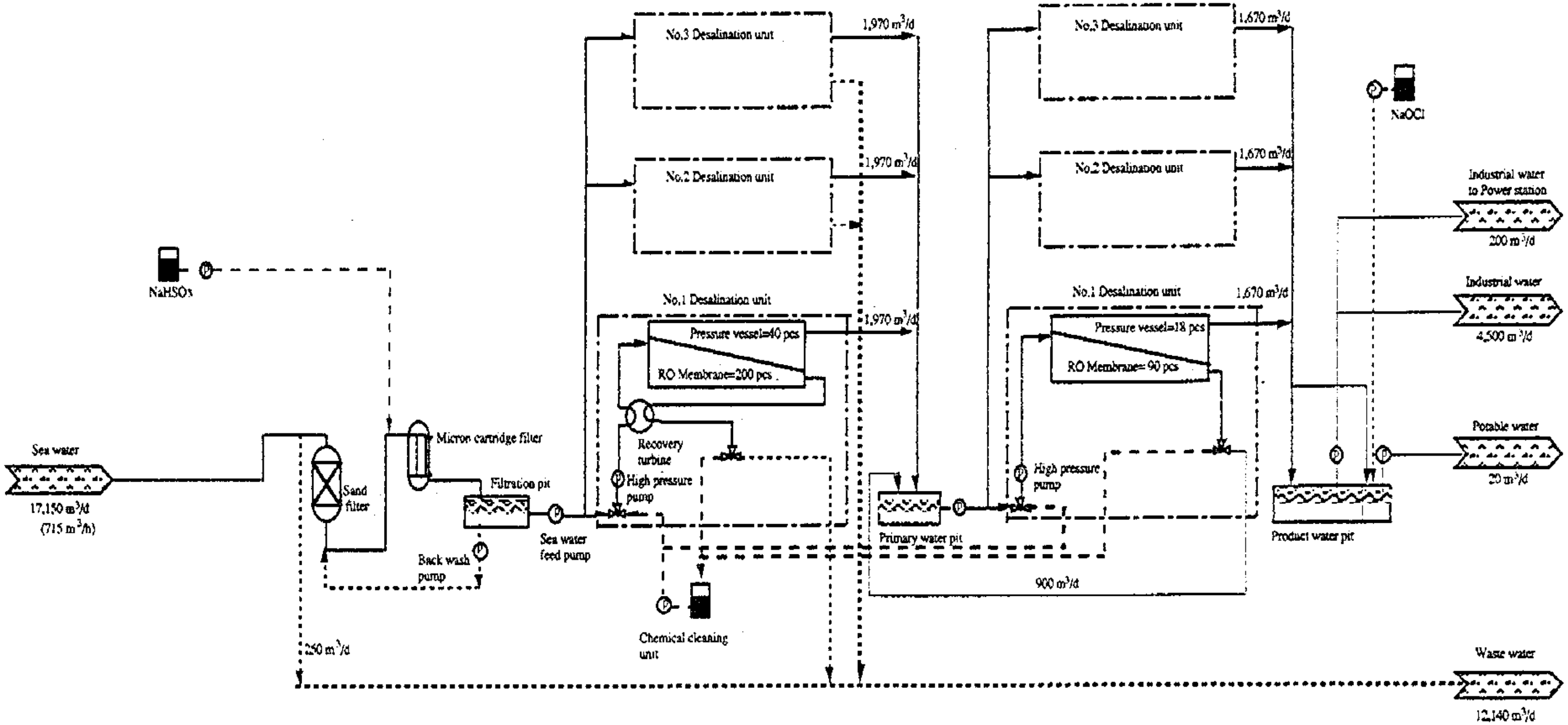


Figure 8-4-1 Flow Sheet of Desalination Plant