Table 13.5.1 Coal blending plan

Coal type	Blending ratio	Quantity of coal used
Low-volatile U.S. coal	8%	64,000 t/y
Medium-volatile U.S. coal	15	120,000
Australian hard coking coal	25	199,000
Australian medium coking coal	40	319,000
Australian soft coking coal	12	96,000
Total	100%	798,000 t/y

(2) Utility condition

The quantity of utility required at the coke and chemical by-product plant to secure production is shown in Table 13.5.2. Utility values shown there cover normal operation levels.

Table 13.5.2 Utility requirements

Utility	Unit of consumption	Utility quantity
Electric power	28.5 KWH/coal.t	22.74 x 10^6 KWH/y
Coke oven gas	20.0 Nm^3/coal.t	16.0 x 10^6 Nm^3/y
Mixed gas	650 Nm^3/coal.t	518.6 x 10^6 Nm^3/y
Steam	49.4 kg/coal.t	39.4 x 10^6 kg/y
Nitrogen	0.5 Nm^3/coal.t	0.4 x 10^6 Nm^3/y
Seawater	16.5 m^3/coal.t	13.14 x 10^6 m^3/y
Fresh water	1.74 m^3/coal.t	1.39 x 10^6 m^3/y
Purified water	0.07 m^3/coal.t	58 x 10^3 m^3/y
Absorption oil	0.88 kg/coal.t	0.7 x 10^6 kg/y
Phosphor	0.015 kg/coal.t	12.0 x 10^3 kg/y

(3) Production plan

A flow of raw materials and products at the coke and by-product plant together with a balance of quantities is shown in Fig. 13.5.1

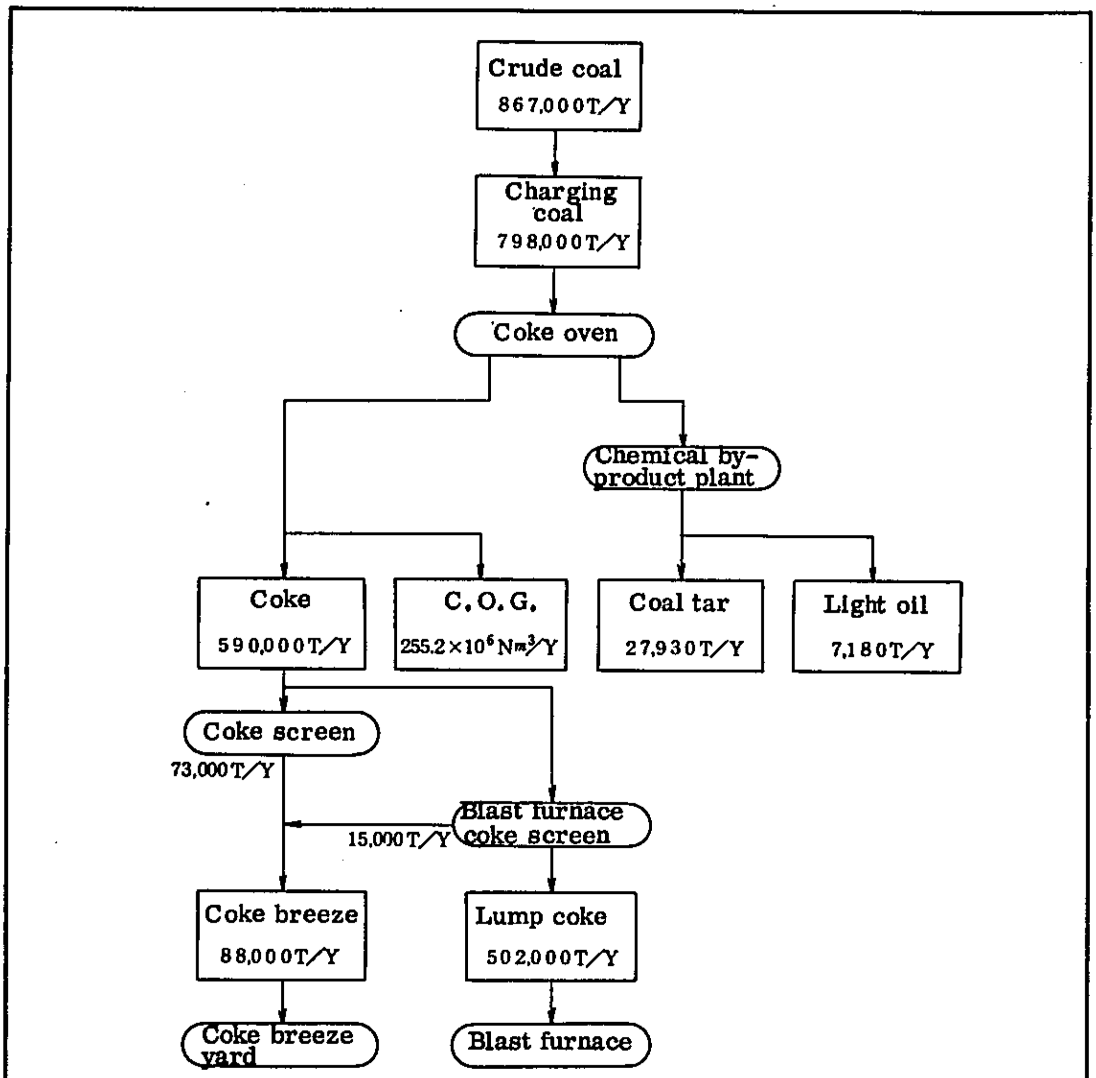


Fig 13.5.1 Coke and by-product plant production balance

(4) Operating condition

Since coke ovens, which form the main equipment of the coke and by-product plant, require continuous heating operations, the 3-shift continuous operation mode will be taken. Operating hours by equipment of the coke and by-product plant are shown in Table 13.5.3. Table 13.5.4 lists the rate of operation of major equipment.

Table 13.5.3 Operating hours of the equipment

Equipment	Operating hours
Coal preparation equipment	18 hours/day
Coke oven	"
Coke transport equipment	"
By-product plant	Continuous for 24 hours

Table 13.5.4 Major equipment operating rate

Equipment	Rate of operation
Coke oven	Average 140% Max. 155%
Belt conveyor	85%

(5) Equipment flowchart

The coke and by-product plan flowchart is shown in Fig. 13.5.2.

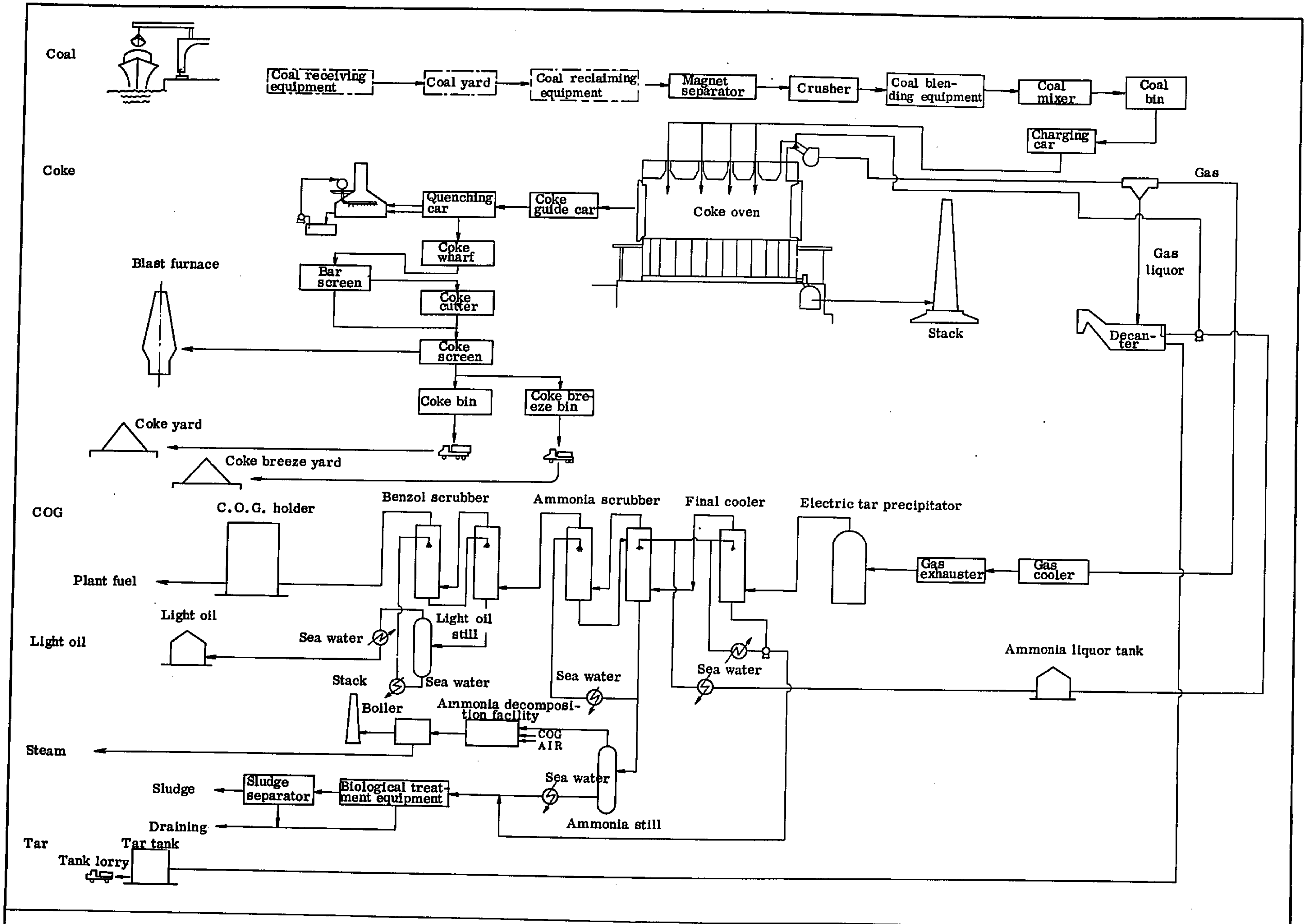


Fig. 13.5.2 Flow-sheet equipment and facilities

13.5.3 Equipment plan

The coke and by-product plant can be roughly divided into the following 7 equipment.

1) Coal preparation equipment, which crush, blend and carry coal released from the coal yard

2) Coke oven facility, which treats coal for carbonization

3) Coke transport equipment

4) Gas exhauster equipment, which handles gas and gas liquor generated from the coke oven

5) Ammonia decomposition facility, which collects ammonia gas contained in gases and cools the gas

6) Light oil recovery equipment, which collects and recovers light oil contained in gases

7) Biological treatment facility, which treats ammonia water and drainage from the chemical by-product plant

Main specifications of each equipment are listed in Table 13.5.5 - 13.5.11.

1. Table 13.5.5 Coal preparation equipment

Equipment	Number of units	Equipment specifications	
Coal receiving	1 system	Transport qt.	300 t/h
		Belt width	900mm
		Belt speed	120 m/min
Coal crusher	2 units	Handling cap.	300 t/h
		Type	Impact type
		Motor	650 KW
Magnet separator	2 units		4 KW
Coal blending bin	16 bins	Capacity	200 t/bin (385 m^3/bin)
Coal mixer	1 unit	Capacity	200 t/h
Constant feed weigher	16 units	Capacity 10 t/h·unit	40 t/h·unit (Remote variable type)
Charging coal conveyor	1 system	Transport qt.	200 t/h
		Belt width	900mm
		Belt speed	100 m/min
Charging coal bin	1	Capacity	1200t
Dust collector for crusher	1	Capacity	600 m^3/min
Coal preparation electric control center	1 building	1st floor	60 m^2
		2nd floor	60 m^2

2. Table 13.5.6 Coke oven facility

Equipment	Number of units	Equipment specifications
Coke oven	76 ovens	Coking chamber dimensions: 5000mm x 430mm x 15,800mm (oven ht.) (oven width) (oven length) Effective inner volume: 79.6 m^3/oven
Stack	2 units	Stack ht. 100m
Charging car	2 cars	Type: Fixed, coal-feeding type Equipped with oven-top cleaner and dust collector Coal-feeding: table feeder type
Pusher	2 units	
Coke guide car	2 cars	
Quenching car	2 cars	Coke load tonnage: 15.5t
Electric locomotive	2 units	Travelling speed: 200 m/min
Quenching equipment	1 system	Sprinkling pump cap.: 720 m^3/h
Gas reversing equipment	1 system	Type: Hudraulic type
Air blower for combustion	3 units	Blast volume: 36000 Nm^3/h
Quenching tower	1 unit	Tower ht.: 40 m
Butane gas generator for coke oven heat-ing up	1 system	Gas generating cap.: Max. 500 m^3/h
Coke sub-center	1 bldg.	1st floor: 345 m^2 2nd floor: 345 m^2

3. Table 13.5.7 Coke transport equipment

Equipment	No. of units	Equipment specifications
Coke wharf	1	Main dimensions: 50m x 9m Coke holding amount: For 6 ovens Angle of slant: 28^{o}
Coke cutter	1	Capacity: 100 t/h
Coke transport conveyor	1 system	Transport qt.: 180 t/h Belt width: 1050mm Speed: 90 m/min
Electric vibrating screen	1	Capacity: 180 t/h Screen mesh: 30 ~ 35 mm
Coke bunker	4	Capacity: 100 t/bunker
Coke breeze bin	1	Capacity: 150 t/bunker
Dust collector for coke cutter	1	Air volume: 700 m^3/min
Dust collector for coke screen	1	"

4. Table 13.5.8 Gas exhauster equipment

Equipment	No. of units	Equipment specifications
Coke oven gas exhauster	2	Capacity: 35000 Nm^3/h Boosting pressure: 2000 mmAq Motor: 350 KW
Gas cooler	4	Gas treating volume: 11500 Nm^3/h.unit Cooler conductive face: 3000 m^2/unit Type: Indirect type vertical water pipe
Electric dust precipitator	2	Gas treating volume: 17500 Nm^3/h.unit Dust precipitating cap.: over 90%
Ammonia liquor sprinkling pump	3	Volume: 500 m^3/h.unit Head: 45 m (water column)
Decanter	2	Volume: 150 m^3/unit
Ammonia liquor tank	1	Volume: 500 m^3
Tar tank	1	Volume: 800 m^3
Underground pit	1	Volume: 250 m^3
Gas exhauster room	1 bldg.	510 m^2

5. Table 13.5.9 Ammonia decomposition facility

Equipment	No. of units	Equipment specification
Ammonia scrubber	2	Capacity: 35000 Nm^3/h.unit Type: Packing type Ammonia removal rate: over 95%
Ammonia still	1	Treating cap.: 20 m^3/h
Final gas cooler	1	Capacity: 35000 Nm^3/h Type: Spray type
Ammonia decomposition equipment	1	
Waste heat recovery boiler	1	
Ammonia water cooler	1	

6. Table 13.5.10 Light oil recovery equipment

Equipment	No. of units	Equipment specifications
Benzole scrubber	2	Gas treating capacity: 35000 Nm^3/h.unit Type: Spray type
Light oil still	1 system	Absorption oil treating volume: 80 m^3/h
Dehydrating tower		Type: Sieve tray column type
Stripping still		Type: Bubble cup tray type
Depitching still		Type: Perforated type tray
Heat exchanger	1	
Light oil tank	1	Volume: 650 m^3
Wash oil tank	1	Volume: 50 m^3
Chemical by-product equipment electric control center	1 bldg.	1st floor: 160 m^2 2nd floor: 160 m^2

7. Table 13.5.11 Activated sludge treating equipment

Equipment	No. of units	Equipment specifications
Aeration tank	1	Ammonia liquor treating cap.: 480 m^3/d Volume: 800 m^3
Setting tank	1	Volume: 250 m^3
Sludge tank	1	Volume: 30 m^3
Dehydrator	1	Treating capacity: 3 m^3/h
Dehydrator room	1 bldg.	40 m^2

13.5.4 Lay-out

The coke and by-product plant layout is shown in Fig. 13.5.3.

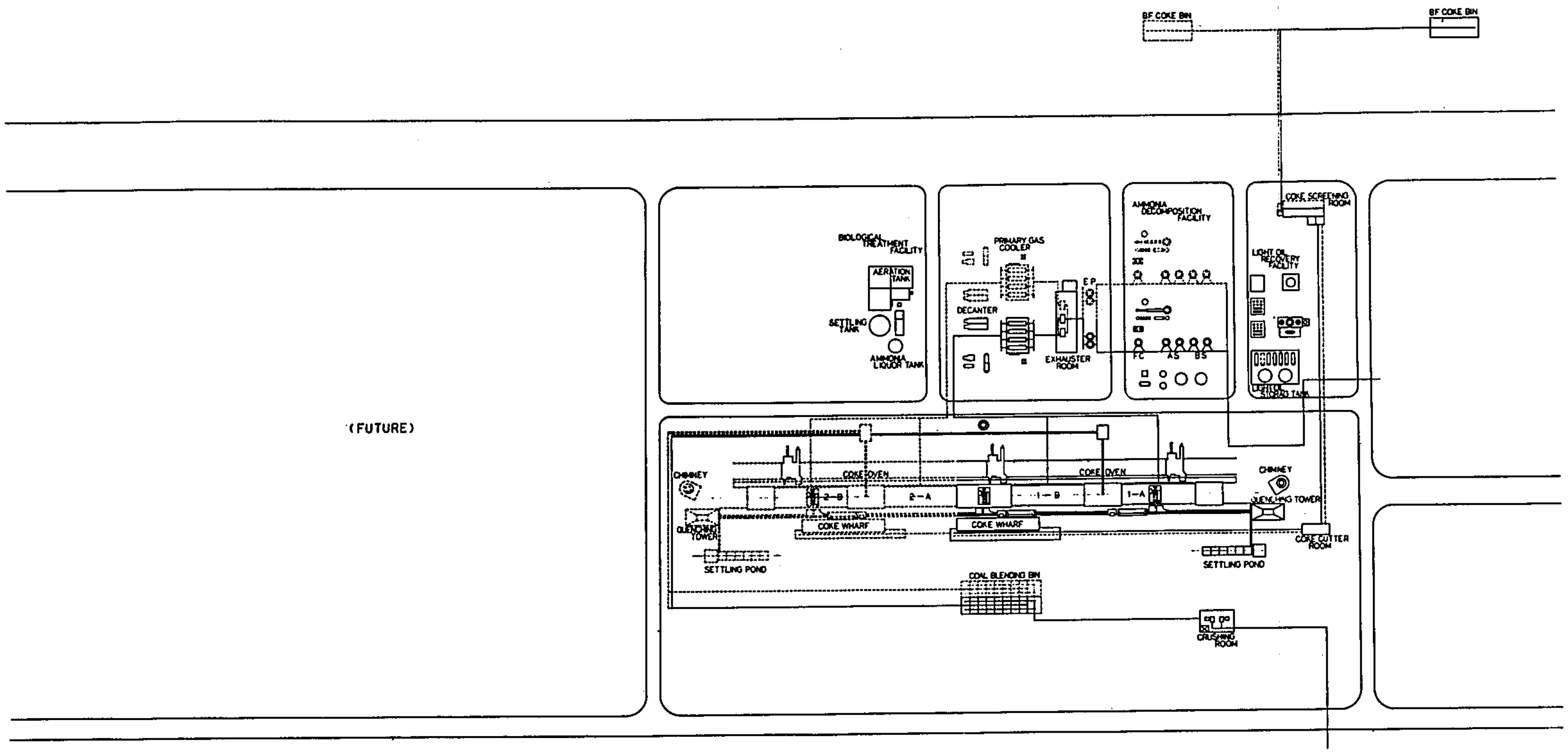


Fig. 13.5.3 Coke and by-product plant layout

13.5.5 Technical explanation

(1) Equipment operation outline at the coke and by-product plant

From the raw materials handling facility, coal is transported to the coke plant in terms of the type of coal. Coal is crushed according to the coal type, and blended and controlled by the bin-blending method to get the required coke quality. Since coal characteristics fluctuate even in the case of the same coal type, it is necessary to have an accurate and quick understanding of the coal characteristics at the time of coal blending and to perform proper blending at all times.

The coke oven is a complicated brick structure with silica bricks in the main, and is normally heated to 1280 - 1300°C.

In regard to oven temperature, control of the average oven temperature is as important as maintaining the end flue temperature and temperature deviation between flue at prescribed levels.
These are critically related to the coke oven operation efficiency. Note that bricks are subject to the maximum permissible temperature. Any abnormally high temperature with respect to flue temperature control should be made with utmost care.

Coke whose carbonization is completed, is quenched at the quenching tower, and it undergoes sizing and screening at the coke transport equipment to be carried to the blast furnace coke stock house.

In this process, good coke mesh control is a determining factor of the coke yield fluctuation and blast furnace operation results. It is a very critical control element.

Coke oven gas, tar and other by-products generated during carbonization are brought to the chemical by-product plant, where they are treated for COG cooling and recovery and elimination of various components. And C.O.G. becomes a purified gas that can be used for fuel at the steel works. In this plan, for removal of ammonia in gases is employed the ammonia decomposition facility, whose advantages include inexpensive equipment cost, and ease of operation and of equipment control.

(2) Bases for determining major equipment

Reasons for determining the coke oven facilities are as follows.

Required coke quantity:	1616 t/d (590000 t/y)
Coke oven effective volume:	29.6 m^3/oven (optimum size determined by various conditions)
Coke oven coal charging density:	0.7
Coke oven average rate of operation:	140%
Total coke yield:	0.745
No. of ovens installed in the battery:	$\frac{1616}{29.6 \times 0.7 \times 1.4 \times 0.745} \fallingdotseq 76$ ovens

The peak rate is considered to determine the capacity of the by-chemical product equipment, and reasons for determining that equipment capacity are as follows.

Coke oven coal charging quantity	2186 t/d (798000 t/y)
Gas generation unit:	320 Nm^3/coal.t
Generated gas peak rate:	1.1
Coke oven max. rate of operation:	155%

By-chemical product equipment capacity: =

$$\frac{2186 \times 320}{24} \times \frac{155}{140} \times 1.1 \fallingdotseq 35000\ Nm^3/h$$

(3) Coke oven heating up plan

All 1 month in advance of the blast furnace heating up, the coke oven operation begins. After the operation starts, there is a host of work for the coke oven: wall joints repair due to heating up process, adjustment of coke oven temperature distribution, taking appropriate measures for the initial malfunction of each piece of machinery and training of operators. While taking a balance with the blast furnace heating up, plans are to increase the rate of operation steadily as in Fig. 13.5.4.

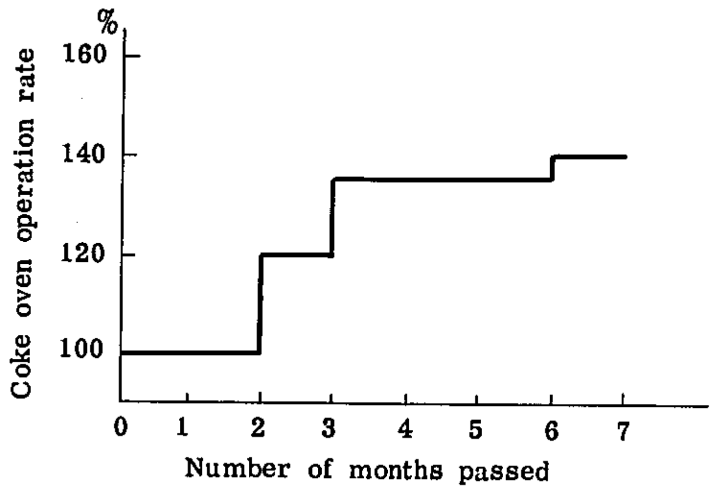
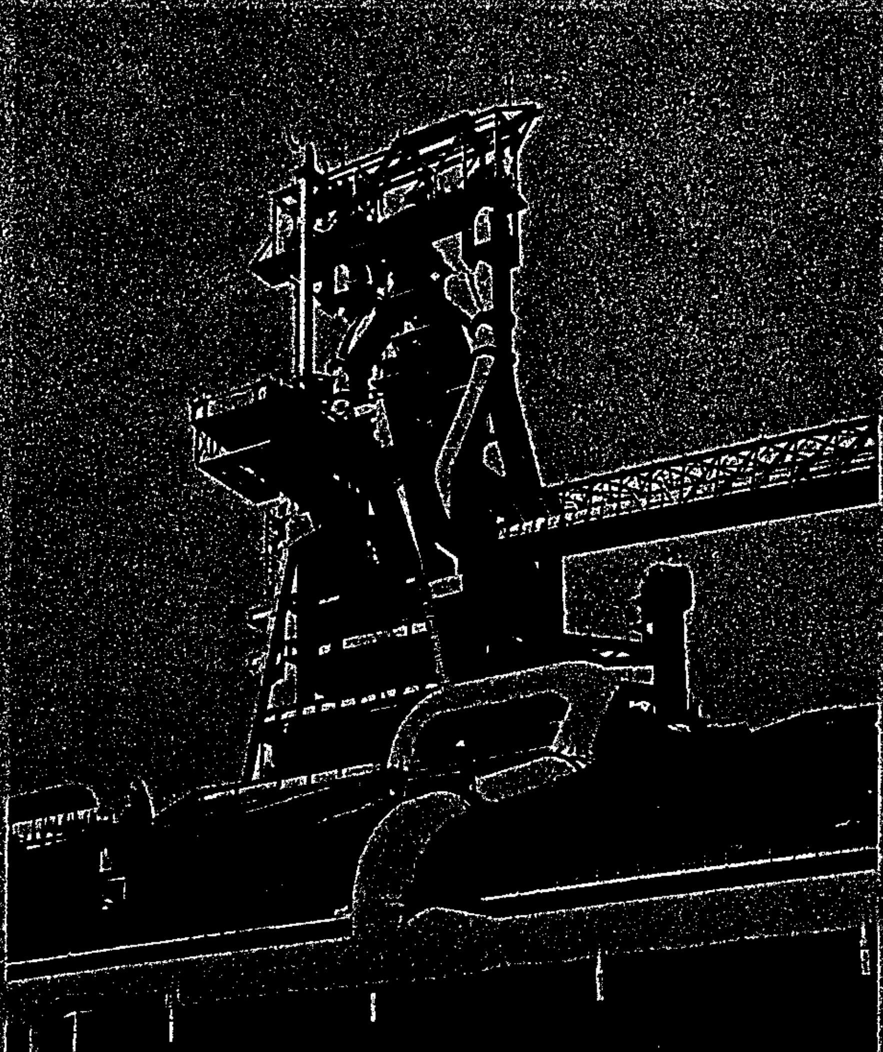


Fig 13.5.4 Coke oven heating up plan

CHAPTER 13-6

BLAST FURNACE PLANT



13.6 Blast furnace plant

13.6.1 Outline

The blast furnace has an inner volume of 1,800 m^3 and produces 965,000 t/y of pig iron. Blast furnace's stable production on a continuing basis is extremely important in keeping the production of the steel works as a whole stable. This calls for preparation of well-trained personnel in operation and work and the equipment of high reliability. Consequently, in working out the plans for the new steel works, the basic policy is to select the latest equipment and facilities currently employed in Japan, which, at the same time, possess ease of handling and superb durability -- the equipment of an exceptional degree of completion.

In selecting the planned values, such as the pig production ratio and other operating conditions have been consulted for reference to the values of Japan and other countries, so that the planned production can be accomplished with certainty. The equipment specifications will be such as to minimize the equipment cost in keeping with these operating conditions.

13.6.2 Preconditions

(1) Conditions of raw materials and fuels

The units of consumption of the raw materials and fuels are as shown Table 13.6.1. In order to secure the stability of operation, ratio of sinter and pellet will be 80%. Because of PSC's supply condition, sinter ratio will be about 60%, and so the pellet ratio will be set as about 20%.

Table 13.6.1 Condition of raw materials and fuels

Raw materials and fuels	Unit of Consumption	Remarks
Sinter	953 kg/t-p	58.9%
Pellet	342 kg/t-p	21.1%
Sized ore	325 kg/t-p	20.0%
Manganese ore	9 kg/t-p	
Limestone	40 kg/t-p	
Coke	520 kg/t-p	
Heavy oil	40 kg/t-p	

2) Operating condition

According to the foregoing way of thinking, the operating condition is determined as follows, and it will serve as a pre-requisite of the equipment plan.

Table 13.6.2 Operating condition

Item	Planned value
Pig iron production	
Normal day average	2,644 t/d
Normal day maximum	2,785 t/d
Operation mode	24 hours 3 shifts
Operating rate	95%
Productivity	1.5 t/d/m^3
Fuel ratio	560 kg/t-p
Coke ratio	520 kg/t-p
Oil ratio	40 kg/t-p

Item	Planned value
Sinter and pellet ratio	80%
Slag volume	300 kg/t-p
Coke ash	11%
Blast temperature	1050°C
Top pressure	1.5 kg/cm^2G
Blast volume	2,700 Nm^3/min
Blast pressure	2.5 kg/cm^2G
Gas generation	230,000 Nm^3/H
Flue dust (dry)	20 kg/t-p
Flue dust (wet)	10 kg/t-p
Charging sequence	O-O-C-C
Charging frequency	107 times/d
Charging quantity	
Coke	13.5 t/ch
Ore	43.3 t/ch
Tapping frequency	8 - 10 times/d

(3) Utility condition

The utility quantity required for securing the planned production output is as below.

Table 13.6.3 Utility condition

Item	Unit of consumption	Remarks
Blast volume	1,360 Nm^3/t-p	
Blast furnace gas	660 Nm^3/t-p	
Electric power	20 KWH/t-p	
Industrial water (fresh)	30 m^3/t-p	
Seawater	15 m^3/t-p	
Pure water	0.5 ℓ/t-p	Makeup water
Coke oven gas	2 m^3/t-p	
Steam	15 kg/t-p	

(4) Blast furnace plant system chart

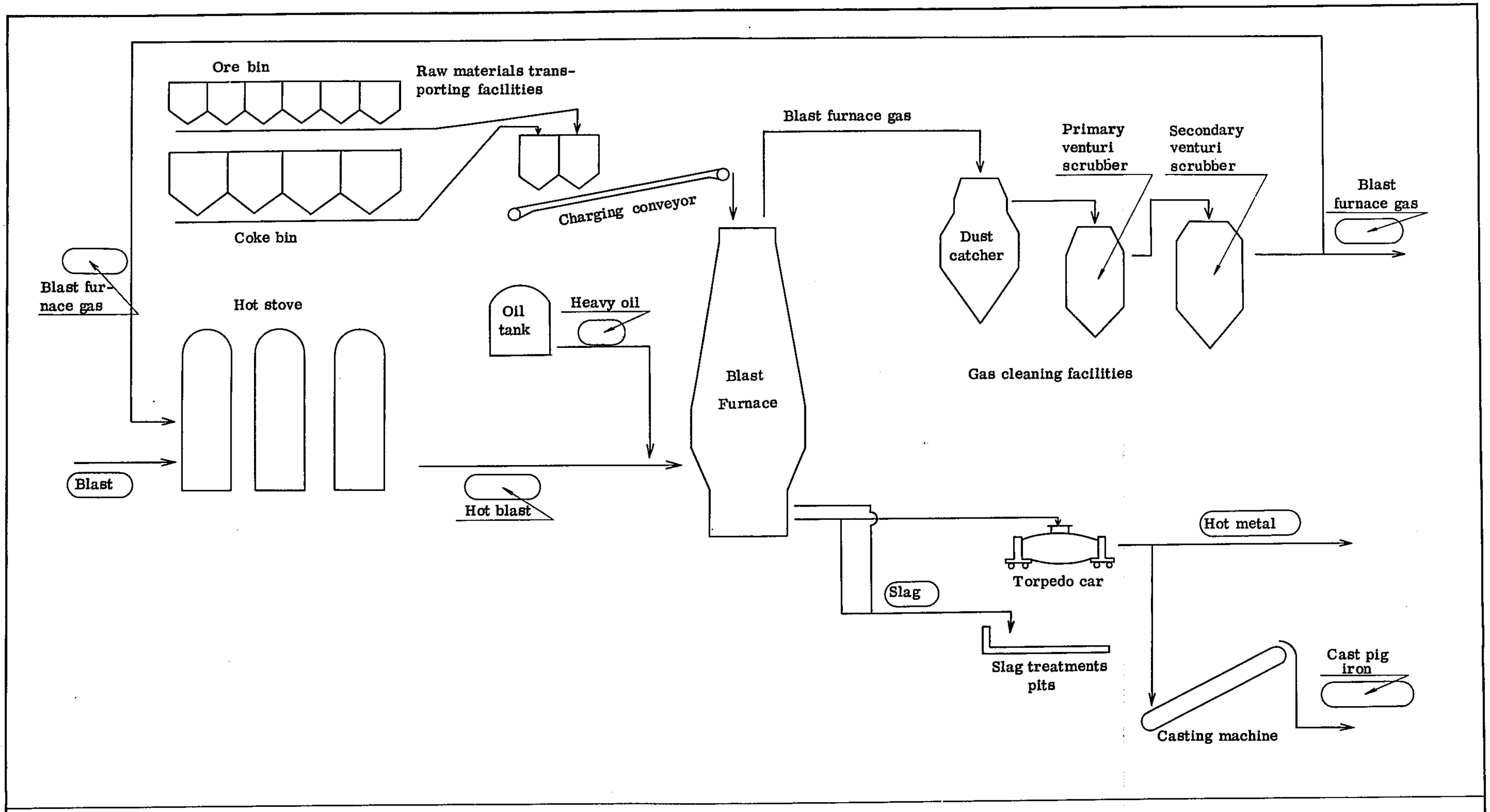


Fig. 13.6.1 System chart

13.6.3 Equipment plan

The blast furnace plant can be roughly divided into the following 6 equipments.

1) Raw materials transporting facilities, which blend the raw materials and transport them

2) Blast furnace equipment, which produces pig iron, slag and blast furnace gas through reaction of iron ore, fuels and hot blast

3) Cast house equipment, which handles pig iron and slag

4) Hot stove equipment, which heats the blast

5) Gas cleaning equipment, which removes dust from the blast furnace gas

6) Pig casting machine, which manufactures cast pig iron from hot metal when the B.O.F. is shut down.

Main equipment specifications of these equipment are as below.

Table 13.6.4 Equipment specifications

Item	Specifications
1) Raw materials transporting facilities	
a) Raw materials bins	Sinter bin: 270 m^3 x 4 bins
	Pellet bin: 270 m^3 x 1 bin
	Reserve bin: 270 m^3 x 1 bin
	Ore bin: 90 m^3 x 4 bins
	Submaterial bin: 90 m^3 x 2 bins
	Coke bin: 400 m^3 x 2 bins
b) Screen	Sinter: 110 t/h x 4 screens
	Coke: 60 t/h x 4 screens
c) Feeder	100 t/h x 6 feeders

Item	Specifications
d) Conveyor	For ore: 500 t/h x 2 lines For coke: 120 t/h x 2 lines For fine sinter: 50 t/h x 2 lines For coke breeze: 20 t/h x 2 lines
e) Charging conveyor	Belt width: 1,200 mm Belt speed: 120 m/min Capacity: Ore 1,400 t/h Coke 390 t/h
2) Blast furnace equipment	
a) Top charging gear	
Raw materials transport method	Belt conveyor transport
Top charging method	2-bell, valve seal
Large bell diameter	5,300 mmø
Small bell diameter	2,000 mmø
Pressure equalizing gas	Blast furnace gas
Other devices	1) Movable armour 2) Hydraulic equipment 3) Centralized lubricating equipment 4) Sounding device 5) Top gas sampler 6) Top igniter 7) High top pressure equipment
b) Blast furnace proper	
Inner volume	1,800 m^3
Hearth diameter	9,400 mm
Blast furnace main dimensions	See Fig. 13.6.2. BF cross-section

Item	Specifications
No. of tap holes	2
No. of cinder notches	2
No. of tuyeres	24
Furnace supporting system	Free standing type
Furnace body cooling system	Under hearth: water-cooling Hearth, Bosh, Belly, Shaft } Stave-cooling (Forced, chilled pure water-cooling)
c) Accessory equipment	
Fuel injector	Quantity of heavy oil injected: 40 kg/t-pig Number of tuyers for injection: all tuyeres (24)
3) Cast house equipment	
a) Cast floor dimension	About 70 m x 40 m
b) Main iron trough	Replaceable type
c) Iron runner	Fixed runner and tilting runner
d) Mud gun	Type: Full-hydraulic type Volume: 0.2 m^3/stroke (effective) x 2 guns
e) Tap hole opener	Type: Pneumatic, remote control type No. of units: 2
f) Cinder notch stopper	Type: Pneumatic, remote control type No. of units: 2
g) Cast house crane	50 t x 2 units

Item	Specifications
h) Cast house dust collecting equipment	Type: Dry type Air volume: 10,000 m^3/min x 1 system
i) Slag treatment pits	21 m(W) x 40 m(L) x 3 pits
j) Flet mill	Mill capacity: 2 t/h
4) Hot stove equipment	
a) Hot stove type	Cowper type
b) No. of hot stoves	3 stoves
c) Dome temperature	Max. 1,250°C
d) Exhaust gas temperature	Max. 350°C
e) Stove operating method	Blast: 45 min. Combustion: 80 min. Changeover: 10 min.
f) Fuel	Blast furnace gas
g) Heating surface	38,300 m^2/stove
h) Stove diameter	8,500 mmø
i) Stove height	41,400 mm
j) Volume of blast furnace gas for combustion	43,100 Nm^3/h
k) Volume of air for combustion	45,300 Nm^3/h
l) Burner fan	3 fans
5) Gas cleaning equipment	
a) Gas cleaning method	Dust catcher --► Primary venturi scrubber --► Secondary venturi scrubber
b) Degree of gas cleaning	Less than 10 mg/Nm^3
6) Casting machine	Max. 35,000 t/m Stationary fixed roller type

Item	Specifications
7) Building	
a) Cast house building	About 2,800 m^2
b) Integrated control room	350 m^2 x 3 fl
c) Blast furnace subcenter	910 m^2 x 2 fl

The blast furnace cross sectional drawing is shown below.

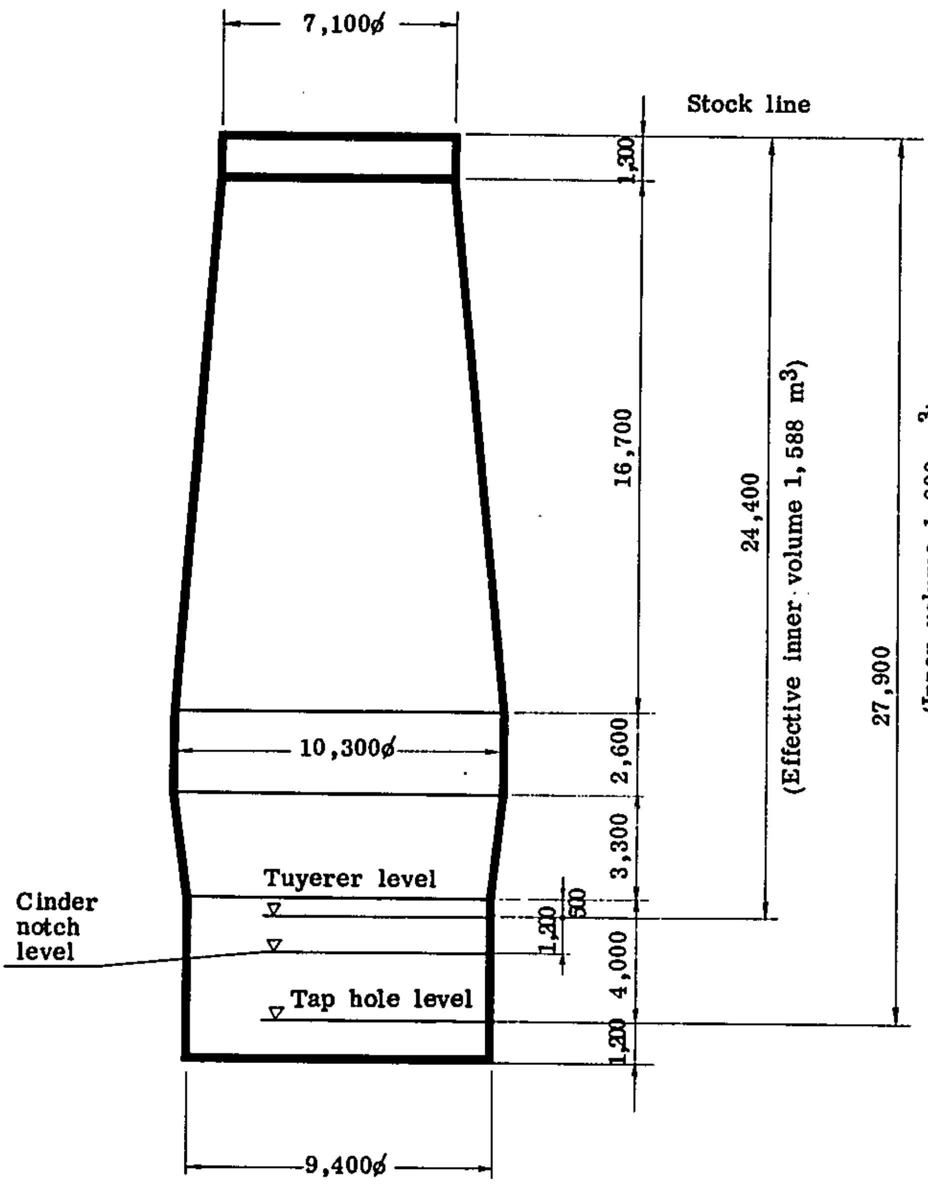


Fig. 13.6.2 Blast furnace cross section

5.6.4 Equipment arrangement

The raw materials facilities will be set up about 300 m from the blast furnace proper in the direction of the raw material yard and the coke plant in order to secure a sufficiently low gradient for the charging conveyor.

The casting machine will be set up about 600 m away from the blast furnace proper in order to secure a space for constructing another blast furnace in the future.

While other equipment will also be set up near the blast furnace proper, layout arrangement selected is the one that will insure ease of construction at the time of construction and relining. Equal attention is paid to minimizing the construction cost as well as insuring ease of working on a day-to-day basis. The layout is shown in Fig. 13.6.3.

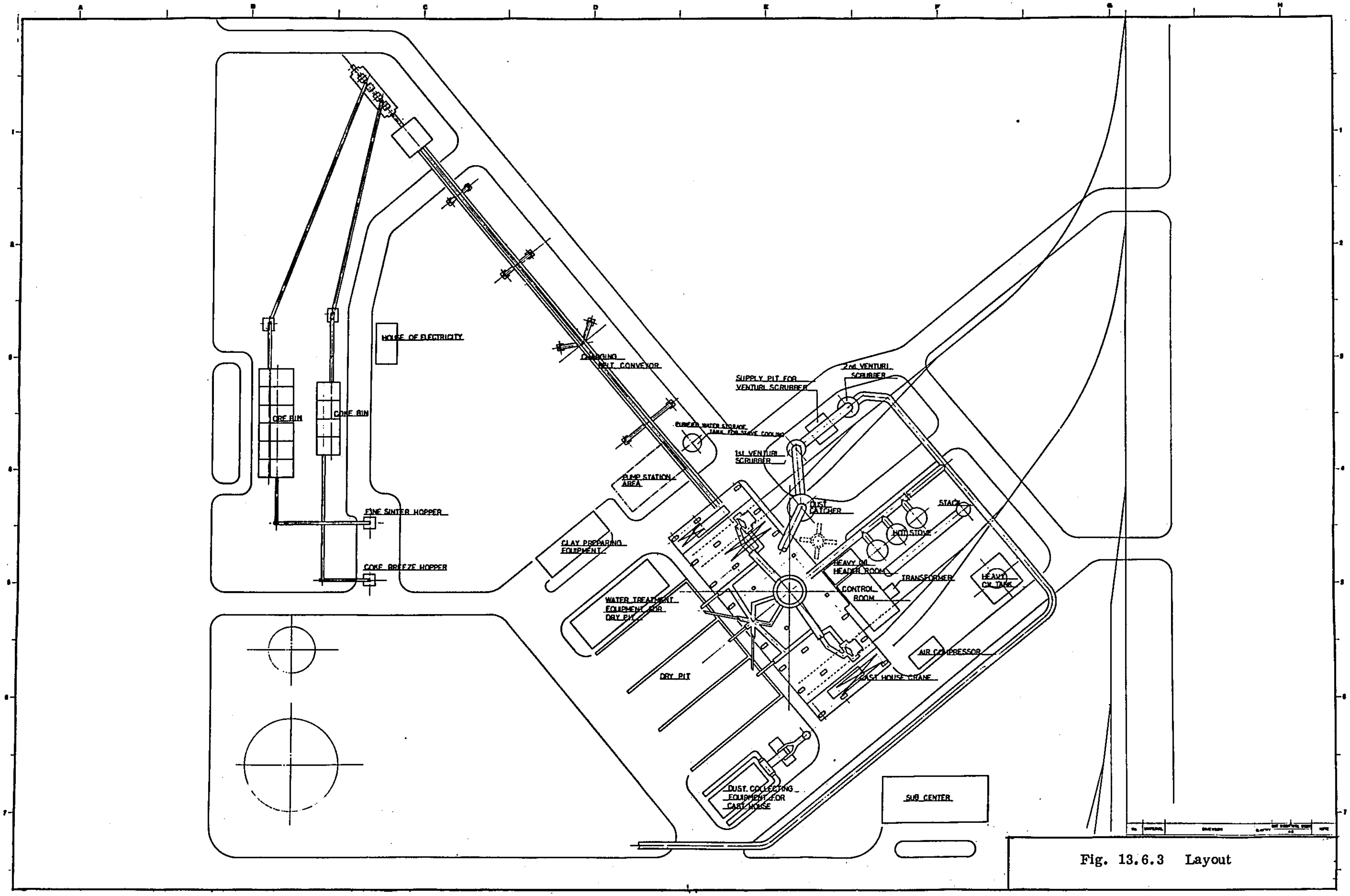


Fig. 13.6.3 Layout

13.6.5 Technical explanation

(1) Outline of the blast furnace plant equipment operation

Inasmuch as it is necessary to operate the blast furnace by keeping the temperature and gas distributions inside the furnace proper and maintaining a smooth descent of charging materials, meticulous care must be exercised in controlling the operating conditions that greatly affect the condition inside the furnace, e.g., coke blending ratio of raw materials, heavy oil volume, and blast temperature.

Much as the blast furnace proper is protected by the cooling system such as staves, damage to the cooling system will be directly connected to damage of the furnace proper, and a rapid cooling inside the furnace will occur if water leaks into the furnace. Therefore, checking and maintenance of the cooling equipment should be performed with an extra care.

Attention must be paid to controlling the work for tapping and putting slag out for two reasons: to supply a fixed amount of hot metal to the converter or casting machine in fixed time; and to insure no excess hot metal and slag remaining inside the furnace.

Stable function without disturbing the blast furnace operation is required for the raw materials transport facilities, hot stoves, and gas cleaning equipment, while ease of working is particularly required for the cast house equipment. The gas cleaning equipment serves a role of supplying clean fuel to the hot stove.

Information on the status of each equipment, cast floor work schedule, raw material quality and quality of blast furnace products should be all processed at the integrated control room so that all major operating conditions can be inputted there and that instructions to appropriate sections can also be outputted there.

2) Blowing in and relining

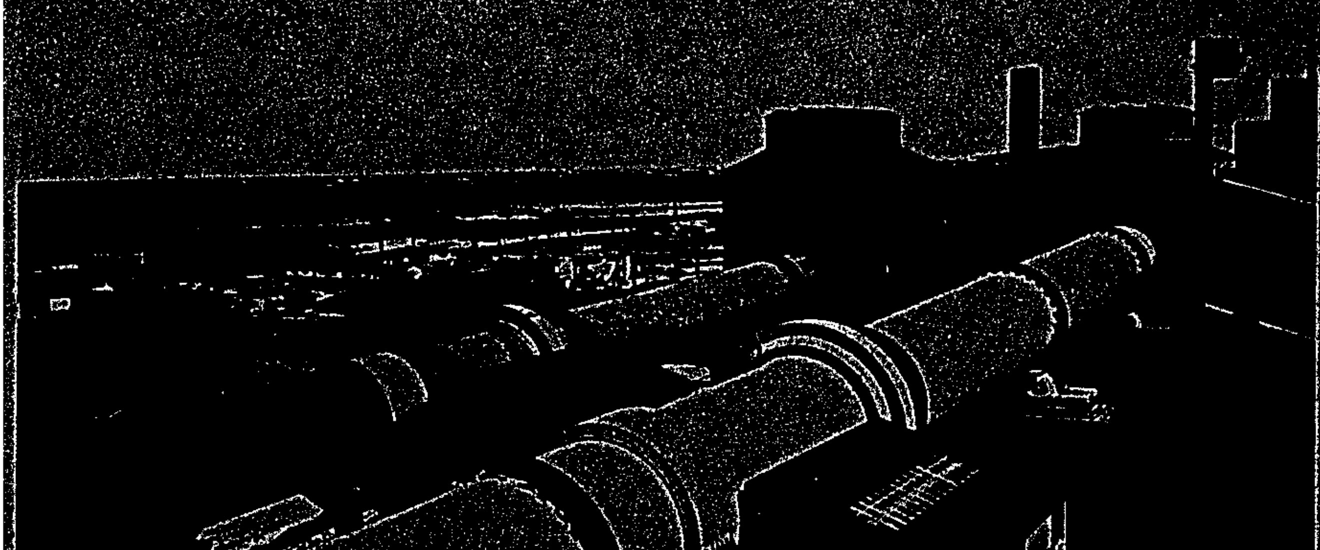
After operating for one campaign (about 6 years), the blast furnace undergoes relining of its refractories. This opportunity is also used to repair various equipment, which may take long time. A major repair is required for hot stoves and cast house after 3-campaign operations. As for the blast furnace blown in, it will normally take about 6 months before normal productivity is reached, and the fuel ratio is high during that period.

Month	1st	2nd	3rd	4th	5th	6th	7th
Normal day maximum production (t/d)	1,510	1,909	2,290	2,520	2,675	2,750	2,785
Fuel ratio (kg/t)	700	655	615	585	570	565	560

Since the quantity of hot metal to be received by the B.O.F will not reach this magnitude in the first year or so, cast pig iron is produced by the casting machine during that time.

CHAPTER 13-7

LIME CALCINING PLANT



13.7 Lime calcining plant

13.7.1 Outline

One lime calcining kiln will be installed with a nominal capacity of of 250 t/d so that 63,000 t/y of quick lime necessary for production of 1,050,000 t/y of molten steel at the B.O.F. plant can be obtained. In order to get high-grade and soft calcined quick lime necessary for the B.O.F. plant, the calcining kiln will be a rotary kiln. For auxiliary equipment, a preheater and a cooler will be installed. The grate travelling type will be used for these. In order that the lime calcining capacity can be increased to keep up with any future expansion of the B.O.F. plant capacity, it is planned that another kiln can be installed next to this kiln.

Before being charged into the kiln, limestone, which is a raw material, is water-washed, crushed and screened. After the limestone obtains proper raw material conditions, it is transported to the calcining kiln. As for quick lime, which is a product, its transport system is such that it is carried from a storage bunker with a capacity of some 1,800 t of quick lime directly to the submaterial transport equipment of the B.O.F. plant. Fuel for calcining is C.O.G., and arrangements will be made for LDG to be also used in the future. Waste gas is heat-exchanged by the preheater and dispersed in the atmosphere via dust catcher. Lime dust at the calcining and transport processes will be so planned that it will be collected at these places.

13.7.2 Preconditions of the equipment plan

(1) Production plan

In accordance with the production plan of the B.O.F. plant, the lime calcining plant's production plan will be as below.

Table 13.7.1 Lime calcining kiln production output

	Production output or unit of consumption
B.O.F. plant production output (molten steel basis)	1,050,000 t/y
(Good ingots and slabs)	1,006,700 t/y
Unit of consumption of quick lime used	63 kg/t, good ingots, slabs and billets
Amount of quick lime required	63,000 t/y
Lime calcining plant production	63,000 t/y

(2) Process yield

Table 13.7.2 Lime yield by process

	Yield
1) Raw limestone crushing yield $\left(\frac{\text{Limestone for washing after crushing}}{\text{Limestone accepted}} \times 100\right)$	90.0%
2) Raw limestone washing yield $\left(\frac{\text{Limestone charged into burning kiln}}{\text{Limestone washed}} \times 100\right)$	97.7%
3) Burning yield $\left(\frac{\text{Quick lime from the kiln}}{\text{Limestone charged}} \times 100\right)$	50.0%
4) Quick lime screening yield $\left(\frac{\text{Quick lime product}}{\text{Quick lime from the kiln}} \times 100\right)$	97.5%

(3) Operating condition

Basic items of the operating condition are listed in Table 13.7.3.

Table 13.7.3 Operating condition of the calcining plant

		Planned values
1) Operating time	1.1) Operating	329 days
	1.2) Operating days per month	Ave. 27 days
2) Kiln shutdown*1	(Scheduled kiln shutdown days)	36 days
		(Average: once per 2 months x 6 days per shutdown Maximum: once per 2 months x 8 days per shutdown)
3) Availability	$(\frac{\text{Days of operation}}{\text{Calendar days}} \times 100)$	90.0%
4) Production output	4.1) Annual production	63,000 t
	4.2) Average monthly production	5,300 t
	4.3) Daily production	
	Average production	5,300 t/27 days =200t/d
	Kiln shutdown month production	5,300 t/(30 - 8) days = 245 t/d
5) Kiln capacity	5.1) Average calcining cap.	250 t/d
	5.1) Max. calcining cap.	280 t/d
	5.2) Min. calcining cap.	150 t/d

*) Scheduled kiln shutdown

The lining bricks of rotary kiln must be relined in company with their wear and tear. The relining work is performed with a schedule of approximately once per two months for the length of 7-8 m each in the longitudinal direction one after the other. Overall and simultaneous maintenance works also are carried out for mechanical and electrical equipment as well with this Kiln shutdown.

13-7-3 Manufacturing process flow

The manufacturing process flow at the Calcining Plant is shown in Fig. 13.7.1.

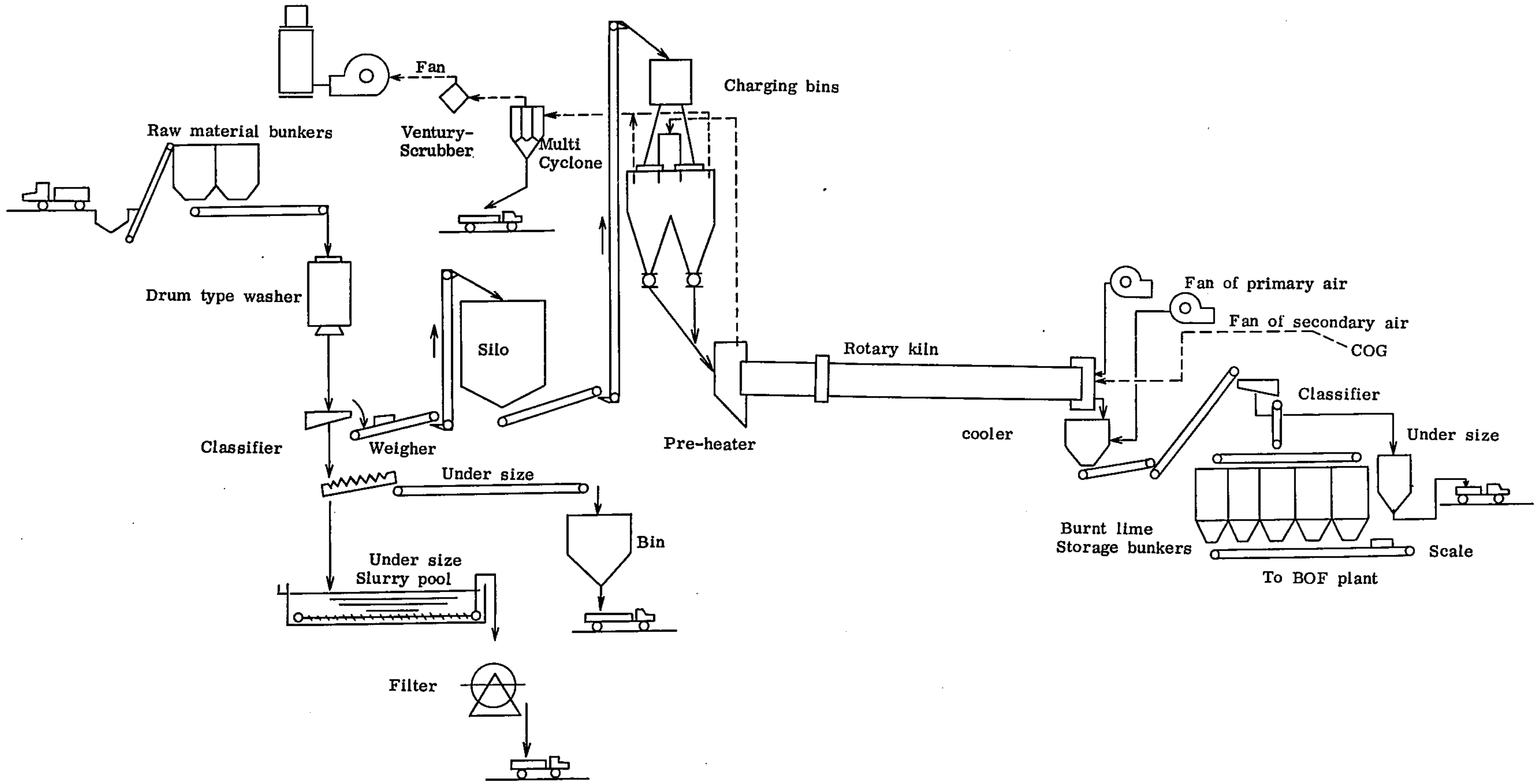


Fig. 13.7.1 Manufacturing process flow at the calcining plant

13.7.4 Equipment specifications

(1) Layout

The calcining plant's overall arrangement is considered in relation to the submaterial transport line of the B.O.F. plant by locating the calcining plant southeast of the B.O.F. plant. The plant layout is shown in Fig. 13.8.2

(2) Raw limestone receiving/storage facility

In normal operation, raw limestone is received by the truck and directly dumped into the hopper (cap. 35 m^3). Capacity of the crushing, washing and screening machine is set at 150 - 200 t/h. The storage bin's capacity is 660 t enough for one day storage of raw limestone. Hence, the raw limestone receiving work is carried out regularly in the daytime.

(3) Charging equipment

Raw limestone discharged from the storage bin is carried by the belt conveyor, hoisted to the charging bin by the bucket elevator and charged into the preheater. At the time of charging into the preheater, charging equipment by size is installed to select raw limestone by size. This equipment is for the purpose of improving the thermal efficiency of the preheater. A series of charging equipment is planned to have a capacity of about 40 t/h.

(4) Preheater

Charged raw limestone is heated up to about 800°C in the preheater. The preheater's type is that of grate travelling. Raw limestone falling during grate travelling is caught by the chain conveyor and picked up by the bucket elevator. Capacity to pick up falling limestone is planned to be about 10 t/h. Preheater's capacity is planned to be 550 t/d to match the calcining capacity (max. 280 t/d).

(5) Kiln

For an average capacity of the kiln, 250 t/d are planned. How much quick lime to keep depends largely on the operating condition of the B.O.F. plant. In consideration of that factor, what is planned is a kiln that can calcine while maintaining good product quality levels even in cases of low or overload operation in the range of 150 to 280 t/d. The kiln type will be the rotary kiln, which enables notch selection of the kiln rotary speed in between 0.5 to 2.0 rpm. Moreover, to cope with any kind of trouble at the time of power outage, a gasoline engine and an emergency rotating system will be used.

At the beginning, COG will be used for fuel. When the B.O.F. plant reaches such a stage as to recover LDG, it is planned to change over from COG to LDG.

(6) Cooler

A cooler will be set up to cool quick lime, whose temperature immediately after calcining is approximately 1,150°C, down to 50°C or so. As for cooler's type, the same grate travelling type as the preheater will be used. Fan for the cooler will have a capacity of some 500 m^3/min. Air used for cooling is to be used as the secondary air for the kiln. Cooler's capacity is planned to be max. 280 t/d (average 250 t/d).

(7) Waste gas treating equipment

Waste gas generated in the kiln is heat exchanged in the preheater and dispersed in the atmosphere via dust catcher. Its temperature when it enters the dust catcher is estimated to be approx. 350°C. Blower's capacity is planned to be about 1,800 Nm^3/min.

The dust catcher will be of the 2-stage dust catching type. The first stage is the cyclone dust separator, while the second stage is the venturi scrubber. Each dust catcher's capacity will be 1,800 Nm^3/min.

(8) Product transport and storage equipment

Transport of quick lime, which is a product, is carried out by the belt conveyor, whose capacity is 50 t/h. Through the screen, quick lime is separated into lump quick lime and fine quick lime, which are stored in respective bunkers. Storage capacity of the lump quick lime bunker (this quick lime to be sent to the B.O.F. plant) is set at 1,800 t (about 9 days' supply), and the fine quick lime bunker is planned to be capable of 50 t. Uses of fine quick lime are for sintering plant, hot metal desulphurizer at the B.O.F. plant and fertilizer for outside sale.

Main equipment specifications are as follows. (Table 13.7.4)

Table 13.7.4 Equipment specifications

Division	Equipment	No. of units required	Main specifications
1	Raw limestone receiving equipment		
01	Truck charging hopper	1	Capacity: 35 m^3
02	Shovel bulldozer	1	Capacity: 2 t
03	Crusher	1	Capacity: 200 t/h
04	Water-washer	1	Capacity: 200 t/h
05	Screen	1	Capacity: 200 t/h
06	Belt conveyor	1	Capacity: 200 t/h
07	Bucket elevator	1	Capacity: 150 t/h
08	Accessory equipment	1	Classifier: 50 t/h x 1
09	Limestone storage bin	1	Storage capacity: 470 m^3 (660t)
2	Limestone charging equipment		
01	Belt conveyor	2	Capacity: 40 t/h
02	Bucket elevator	1	Capacity: 40 t/h
03	Screen	1	Capacity: 40 t/h
04	Material charging equipment	1	Capacity: 40 t/h
3	Preheater		
01	Preheater proper	1	Capacity: 550 t/d Type: grate travelling type
02	Chain conveyor	1	Capacity: 10 t/h
03	Bucket elevator	1	Capacity: 10 t/h
04	Accessory equipment	1	Beam cooling fan x 2 sets

Division	Equipment	No. of units required	Main specifications
4	Kiln		
01	Kiln proper	1	Capacity: 150 t ~ 280 t/d Type: Rotary kiln Kiln shape: About 3.0 mø x 47 m
02	Tilting device	1	Tilting speed: 0.5 - 2.0 rpm
03	Accessory equipment	1	1) Emergency kiln rotating device x 1 set Gasoline engine 2) Kiln hood equipment x 1 set 3) Air seal equipment x 1 set 4) Kiln head cooling fan
04	Combustion equipment	1	Fuel COG Burner equipment 1 set Primary air fan 1 set
5	Cooler		
01	Cooler proper	1	Cooling capacity: Max. 280 t/d Type: Grate travelling type
02	Cooling fan	2	Capacity: about 500 m^3/min
03	Dust catcher	1	Type: Bag filter
6	Waste gas treating equipment		
01	Dust catcher	1	Capacity: Abt. 1,800 Nm^3/min Type: Multi-cyclon type
02	Blower	1	Capacity: Abt. 1,800 Nm^3/min at 550 mmH_2O
03	Wet dust catcher	1	Capacity: Abt. 1,800 Nm^3/min Type: Venturi scrubber

Division	Equipment	No. of units required	Main specification
7	Product transport and storage equipment		
01	Belt conveyor	1	Capacity: 50 t/h x 1 system 25 t/h x 1 system
02	Screen	1	Capacity: 50 t/h
03	Dust catcher	1	Dust catching capacity: Abt. 650 m^3/min Bag filter type
04	Lump product bunker	1	Storage capacity: 1,800 t (450 t/hold x 4)
05	Fine quick lime bunker	1	Storage capacity: 50t
8	Auxiliary Equipment		
01	Air compressor and piping	1	Compressor 2 units
02	Miscellaneous piping	1	COG Miscellaneous water
03	Emergency limestone yard	--	Area required about 3,000 m^2
9	Electrical equipment		
01	Power supply equipment	1	
02	Lighting equipment	1	
03	Communications equipment	1	Interphone (4 stations)
04	Power supply cable equipment	1	
10	Instrumentation	1	1) Raw materials transport and charging control equipment 2) Preheater, calcining kiln and cooler control equipment 3) Quick lime product transport control equipment

Division	Equipment	No. of units required	Main specification
11	Civil and foundations	1	Equipment and building foundation Concrete: Abt. 3,400 m^3 Piling, steel tube piles: Abt. 1,000 pcs Concrete piles Abt. 300 pcs Steel materials Abt. 45 t Road in the vicinity Abt. 4,300 m^2
12	Buildings	1	Main control room and product bunker Steel materials Abt. 350 t
13	Water works	1	Equipment drainage and piping equipment

13.7.5 Technical explanation

The items stipulated below will be required as the characteristics of the quality of quick lime to be used at the B.O.F. plant.

(1) Chemical analysis

CaO	$> 88\%$
CO_2	$< 3\%$
MgO	$< 5\%$
SiO_2	$< 2\%$
Al_2O_3, Fe_2O_3	$< 2\%$
S	$< 0.04\%$
P	$< 0.03\%$
Others	$< 1\%$

(2) Reactivity test values

Reactivity in 30 seconds -- 40°C and over (High reactive lime as defined in ASTM Specification C-11-71 Section 9.)

(3) Quick lime size

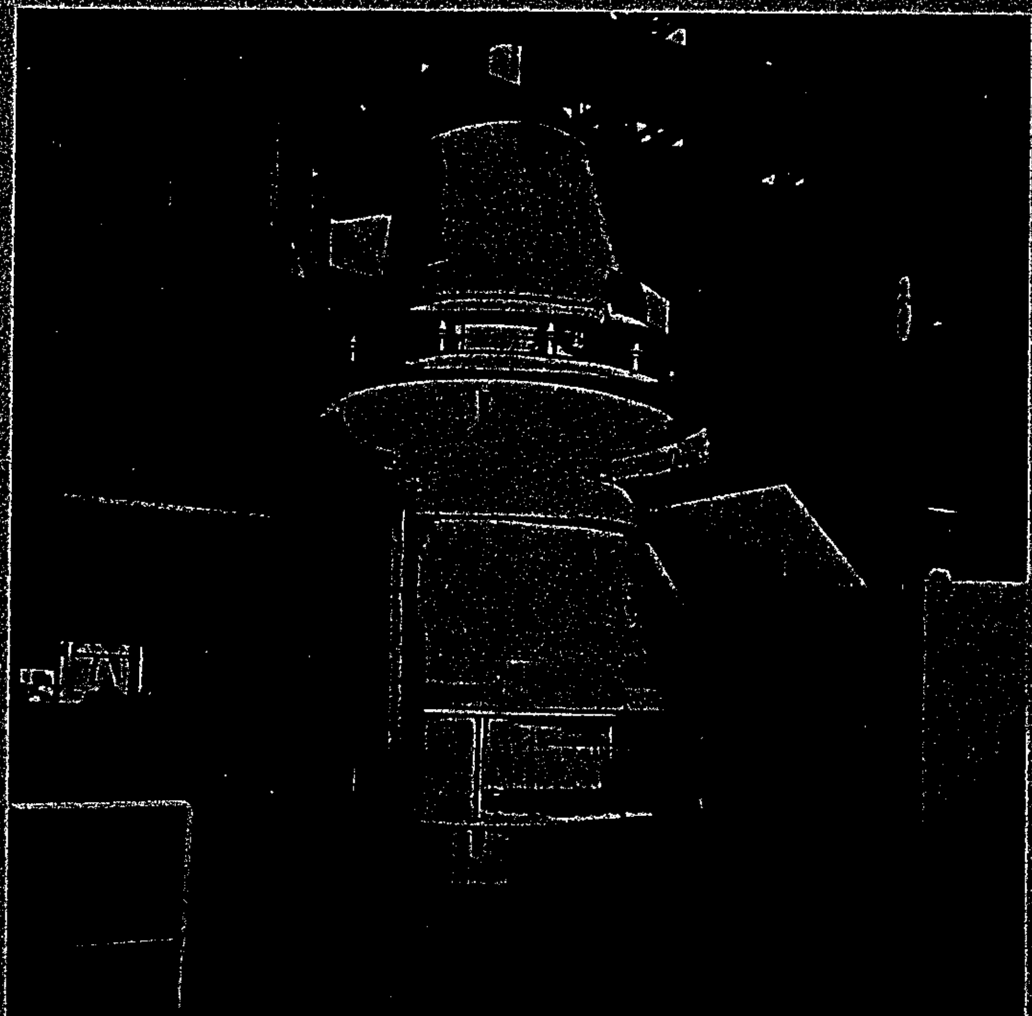
5 - 30 mm   Upper limit of the fines mixing rate: 5%

(4) N.B.

Quick lime to be used at the B.O.F. plant must not be "slaked."

CHAPTER 13-8

BASIC OXYGEN FURNACE PLANT



13.8 Basic oxygen furnace plant

13.8.1 Outline

Two basic oxygen furnaces, each with a nominal capacity of 110 t/heat (average 105 t/heat), will be installed at the B.O.F. plant in order to achieve production of 1,050,000 t/y on the molten steel basis.

The mode of operation will be 2 furnaces maintained with one of the furnaces in operation regularly. The arrangement will be such that an addition of one more B.O.F. is possible in the future, and that eventually the mode of operation will be 3 furnaces maintained with 2 of the furnaces in operation regularly.

Although the non-combustion type is adopted for the converter waste gas treating system, the waste gas will not be recovered in view of the equipment cost reduction and gas balance and consequently waste gas is to be burnt and dispersed through the flare stacks. The oxygen flow rate at the B.O.F. is planned to be an average of 25,000 Nm^3/h

Hot metal is conveyed by the torpedo car to the B.O.F. plant and transferred to the charging ladle in the plant. It is so designed that some measure of desulphurization can be done by adding a desulphurizer at this time. This operation is performed in the pit of a separate building partitioned off from the main building.

Scrap produced at each mill or plant is first stored at the scrap yard. Selected and prepared there, it is carried to the B.O.F. plant by dump trucks and loaded by the lifting magnet to the charging chute.

The underground bunker is set up outside the plant for submaterials, which are carried up by the belt conveyor above the furnace. Ferro-alloy is hoisted by the telpher to the hoppers behind the furnace and stored there. It is so designed that hoisting submaterials to the high level bunkers, charging them to the furnace, and ferro-alloy addition to the teeming ladle can be performed by remote control. The ingot pouring bay and mold handling bay will be arranged adjacent to the countinuous casting plant. Pouring is into moulds on the teeming car. After teeming and solidification, the teeming car is moved, and ingot handling is performed.

13.8.2 Preconditions of the equipment plan

Production plan, main raw materials blending and yield as preconditions are listed in Tables 13.8.1 and 13.8.2.

(1) Production plan (molten steel basis)

Table 13.8.1 Production plan (t/y)

	Continuous casting	Ingot
1) For continuous casting of blooms		
Merchant bar	220,000	
2) Ingots for slabs		
Electrolytic tin plate material		155,000
Hot roll finishing material		
3) For continuous casting of slabs		
Plate material	169,200	
Pipe material	505,800	
Hot roll finishing material		
Galvanizing material		
Cold roll material		
Subtotal	895,000	155,000
Total	1,050,000	

(2) Main raw materials blending ratio and yield

Table 13.9.2 Raw materials blending and yield

		%
1) Main raw materials blending ratio	Hot metal + cast pig iron blending ratio	85.7
	Scrap blending ratio	14.3
2) Yield	Yield of steel produced (to main raw materials)	93.0
Ingot	Yield of good ingots (to steel produced)	98.0
Slab	Yield of good slabs (to molten steel)	96.0
"	Conditioning yield (to good slabs)	98.5
Bloom	Yield of good blooms (to molten steel)	94.0

13.8.3 Operating condition

(1) Converter furnace capacity

The furnace capacity necessary for molten steel production of 1,050,000 t/y is set at a maximum of 110 t and an average of 105 t. This thinking is based on consideration of the following conditions.

1) The average tap to tap time of 36 min. is adopted, which is a standard value of the modern B.O.F. plant.

2) For days of operation per year, regular shutdown maintenance days (2 days/month = 24 days/year) are deducted from the calendar days, and they are 336 days. Consequently, the number of hours available for operation per year is 8,184 hours. From this, time for hot metal waiting as the non-steelmaking time, crane trouble, other unexpected stoppage and idle time for matching the converter and continuous casting machine are deducted. Then, the actual

steelmaking time becomes 6,048 h/y. In terms of availability, the actual steelmaking time is 74% to the time available for operation and 70% to calendar hours.

3) As a result, the furnace capacity is automatically obtained in relation to the tap-to-tap time, actual steelmaking time and production required:

a) $\text{Heat/year} = \dfrac{6{,}048 \text{ h/y} \times 60 \text{ min/h}}{36 \text{ min/heat}} = 10{,}080$

b) $\text{Average heat capacity} = \dfrac{1{,}050{,}000 \text{ t/y}}{10{,}080 \text{ heat/y}} = 104.2 \text{ t} \fallingdotseq 105 \text{ t}$

The maximum furnace capacity is set at 110 t in consideration of fluctuations in product lot size and in tapping yield. Table 13.8.3 shows the operating condition.

Table 13.8.3 Converter plant operating condition

		Scheduled values
1) Operating time	1.1) Annual calendar days of operation	336 days
	1.2) Monthly number of days in operation	28 days
	1.3) Regular shutdown maintenance	2 days/month (12 hours x 4 times/mon.)
2) Availability	(Total steelmaking time/calendar time)	70%
3) Per heat	Tapping tonnage	Average 105.0 t Max. 110.0 t
4) Production in tons	Annual	1,050,000 t
	Monthly	87,500 t
	Daily	3,125 t
5) No. of heats	Annual	10,080 heat
	Monthly	840 "
	Daily	30 "

6) Daily tapping in tons by destination and number of heats tapped	Continuous casting of slabs	2,008.9 t (19.1 heat)
	Continuous casting of blooms	654.8 t (6.3 heat)
	Ingot pouring	461.3 t (4.4 heat)
7) Steelmaking time	(tap to tap)	Average 36 m/heat
	Breakdown Charging time	4 min
	Blowing time	14 min
	Killing and temperature measurement	11 min
	Tapping time	5 min
	Slagging off time	2 min
	Note: Re-blow time is included in the time for killing and temperature measurement.	

(2) Production process

The production process from the B.O.F. plant to the Continuous Casting Plant is outlined in Fig. 13.8.1

(3) Raw materials-to-product balance

The raw materials-to-product balance at each of the B.O.F. Plant, Continuous Casting Plant, Ingot-making process and Billet Mill is shown in Fig. 13.8.2.

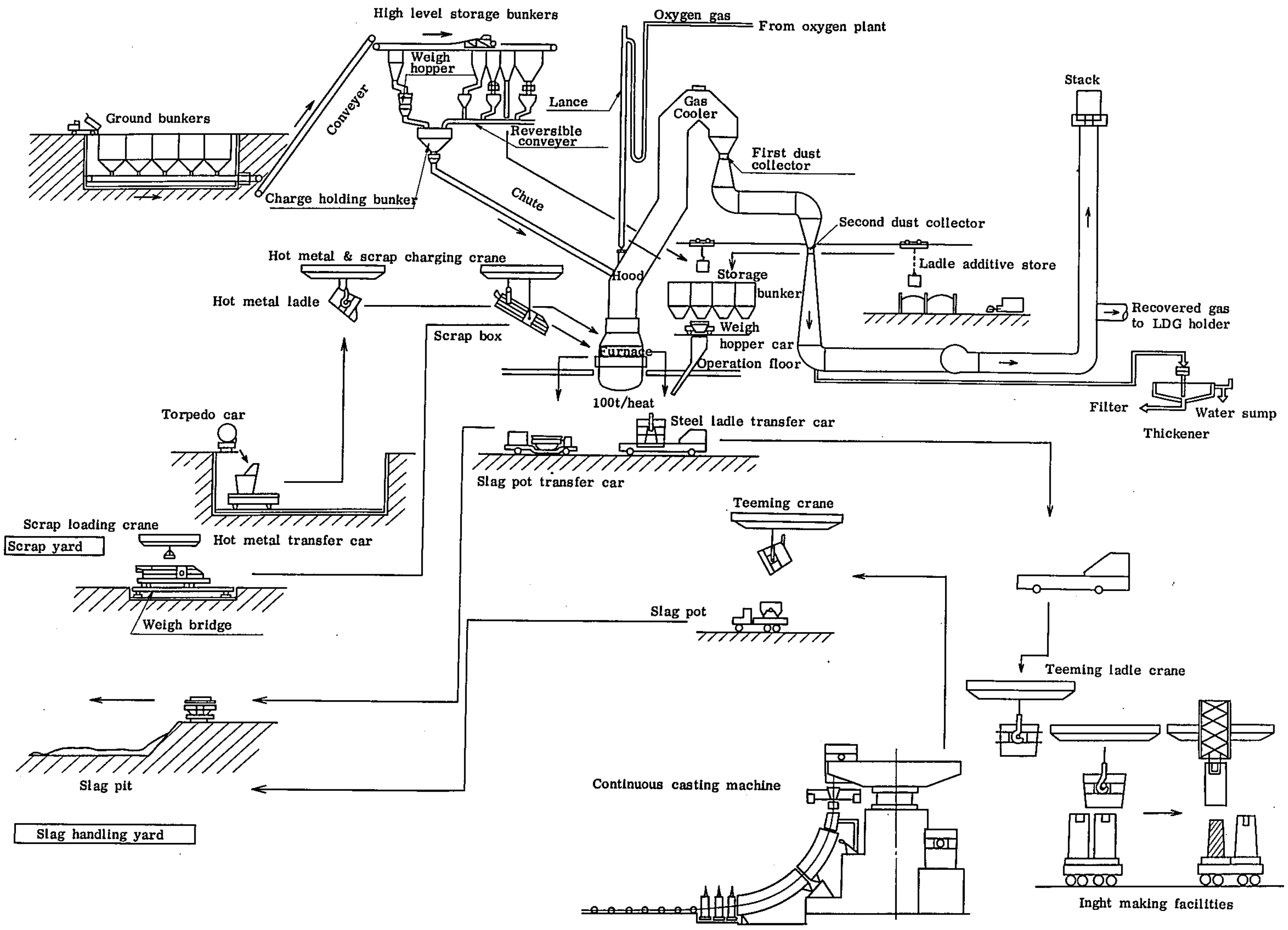


Fig. 13.8.1 Production process flow

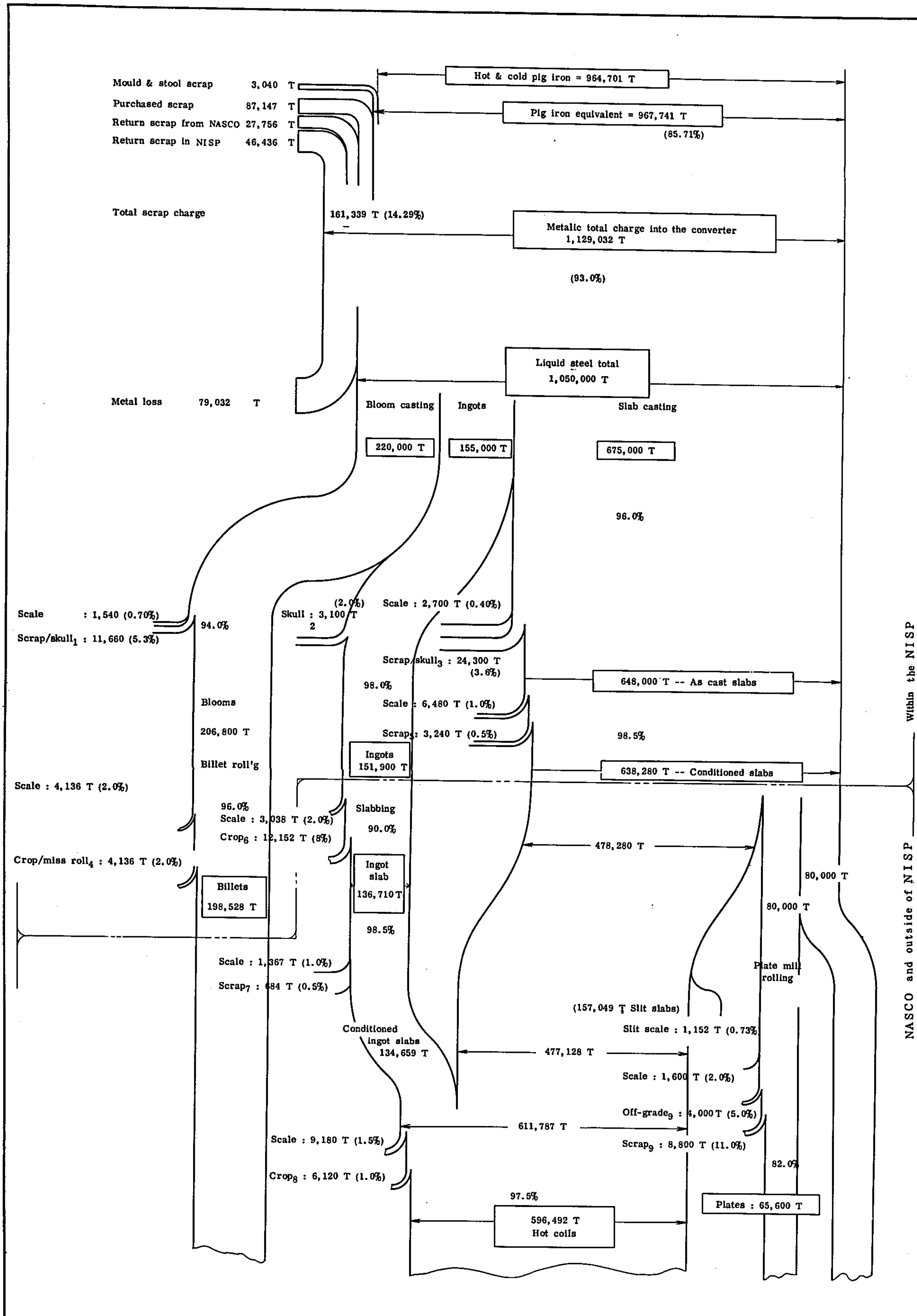


Fig. 13.8.2 Raw materials balance

13.8.4 Equipment specifications

(1) Layout

As shown in Fig. 13.8.3, the plant layout is so designed with B.O.F. in operation in the center that charging of the hot metal and scrap will not interfere with the molten steel and slag to be discharged. In order that various operations will not get entangled with others at the Continuous Casting Plant, a ladle preparation building is set up in between the B.O.F. Plant and Continuous Casting Plant. The scrap loading operation into the charging box is performed at the charging building, and 2-stage girders are installed for the scrap charging crane and loading crane to travel on. In addition to a compact layout of the plant, full consideration is given to ease of construction and operation when the B.O.F. plant operates with 2 furnaces in operation out of the 3 maintained in the future.

(2) Hot metal equipment

A 200 t-capacity torpedo car is to be adopted for transporting hot metal from the Blast Furnace Plant to the B.O.F. Plant. Since the torpedo car offers a little drop in hot metal temperature during transport and since it has a capacity of average 2 heats of converter tapping, no hot metal mixer will be installed. Therefore, the torpedo car is more economical from the standpoint of total investment. In the hot metal receiving pit, hot metal is transferred from the torpedo car to the hot metal charging ladle. Since the hot metal charging ladle is placed on the weighing car (180 t), the

Hot metal quantity, maximum:	120 t
Hot metal ladle tare:	55 t
Reserve:	5 t
Total	180 t

the charged volume is continuously displayed so that the required volume of hot metal can be accurately obtained. By continuously charging a desulphurizer into the hot metal ladle during hot metal weigh-in, [S] in the hot metal can be reduced. Dust generated at this time is collected by the hood and removed by the bag filter. (6,000 m^3/min)

(3) Scrap equipment

On the west end of the charging building, 3 scrap pits are set up for receiving scrap from the scrap yard. By assuming 75% as the minimum hot metal blending ratio, the scrap charging box capacity will be 30 t. Weigher (60 t) will be placed one each in between scrap pits. Loading on the scrap charging box is carried out by the 15 t lifting magnet crane.

(4) Converter equipment

The furnace capacity will be a maximum of 110 t/heat with an inner volume of 107 m^3 (ratio to volume 0.97). For ratio of the furnace height to diameter, namely, H/D, = 1.35 is adopted so that the basic dimensions of the furnace proper will be approximately H = 8,800 mm and D = 6,500 mm. The tilting device is driven by 4 DC motors, and the tilting speed can be freely controlled by notch in the range from 1 to 0.1 rpm.

(5) Oxygen blowing equipment

In order to secure the tap-to-tap time of 36 min., the blowing for an average of 14 min. is adopted, and the lance is designed for the oxygen-blowing rate of a maximum of 28,000 Nm^3/h. The oxygen supply piping capacity and pressure and flow rate control capacity will be a maximum of 30,000 Nm^3/h. Also, it is so designed that a lance exchange can be quickly performed by remote control.

(6) Waste gas treating equipment

The non-combustion type waste gas treating equipment will be set up for each of the 2 converters from a standpoint of providing waste gas recovery for energy conservation in the future. Gas generated is computed from the maximum volume of oxygen supplied and the charged quantity of iron ore; it is planned to be about 66,000 Nm^3/h. The dust quantity in the waste gas after dust collection is to be less than 0.1 gr/Nm^3. At the outset, the waste gas is burnt and dispersed from a 75 m-high stack (3-collected stacks.)

(7) Submaterial equipment

Submaterials other than quick lime are brought by trucks to the underground bunker, which is made up of a total of 8 bunkers for 5 brands. These submaterials are carried by the belt conveyor to the high level bunkers, and the quick lime conveyor also joins on the way there. The high level bunkers are located on top of each of the 2 converters, consisting of 8 bunkers for 6 brands. Charging equipment into the converter is planned in consideration of the need to produce high-grade steel so that charging can be done in the middle of converter blowing.

The equipment specifications are outlined below.

Table 13.8.4 List of equipment specifications

Division	Equipment	No. of units required	Main specifications
1	Hot metal handling equipment		
01	Hot metal charging ladle	3	Capacity 120 t
02	Hot metal weighing car	2	Capacity 180 t Electrically-driven, self-travelling type
03	Hot metal slag-off machine	1	Cylinder type

Division	Equipment	No. of units required	Main specifications
04	Desulphurizer adding device	1	
05	Hot metal ladle transfer car	1	Capacity 50 t
2	Scrap handling equipment		
01	Scrap charging chute	3	Capacity 30 t
02	Scrap weighing machine	2	Capacity 60 t
03	Scrap yard facilities		
	1) Scrap storage area	1	22,500 m^2 (150m x 150m)
	2) Scrap gas-cutting device	1	Oxygen, acetylene cutting method
	3) Crawler crane	2	Capacity 25 t
	4) Piling equipment	1	3 columns, winch type
	5) Converter cooling material cutter	1	Cutting cap. 3.0 t/h Accessory equipment: 2 t jib crane
	6) Cooling material box	10	Capacity 1.5 t
3	Converter equipment		
01	Converter proper	2	Nominal capacity: 110 t/heat Inner volume (after lining) Approx. 107 m^3 Furnace height: Abt. 8,800mm Furnace diameter: Abt. 6,500mm
02	Converter tilting device	2	Single side drive type, 4 motors, shaft mounted type Tilting speed: High speed 1.0 rpm Low speed 0.1 rpm

Division	Equipment	No. of units required	Main specifications
4	Oxygen blowing system		
01	Lance and its accessories	6	Oxygen blowing capacity: Max. 28,000 Nm^3/h Lance dia. Abt. 250 mmø Flexible hose for oxygen (copper-made) 1 unit Flexible hose for cooling water (natural rubber made) 1 unit
02	Lance lifting device	4	Type: quick change type
03	Oxygen blowing pressure control device	2	Piping capacity: max. 30,000 Nm^3/h Lance cooling water equipment 1 unit Required water volume: Abt. 200 t/h Cooling system: cooling tower
5	Waste gas treating equipment		
01	Converter waste gas treating equipment	2	Type: Non-combustion type (OG) equipment Cap.: Waste gas volume abt. 66,000 Nm^3/h Dust in waste gas 0.1 gr/Nm^3 Blower 66,000 Nm^3/h x 2
02	Stack	1	Tri-pod type Ht. 75,000 mm
03	Cooling water equipment	1	Hermetic sealing, circulating type
04	Furnace mouth and hot metal receiving pit dust collector	1	Type: bag filter Cap. Abt. 6,000 m^3/min

Division	Equipment	No. of units required	Main specifications
6	Submaterial transport and charging equipment		
01	Underground bunker equipment	1	Bunker capacity: 5 brands 8 bunkers
02	Transport equipment	1	Belt conveyor transport method
03	High level bunker equipment	2	Bunker capacity: 6 brands 8 bunkers
04	Equipment for releasing into the furnace	2	Belt conveyor/chute system
7	Ferro-alloy transport and charging equipment		
01	Ferro-alloy transport equipment	1	Monorail, hoist method
02	Ferro-alloy high level bunker	2	Bunker capacity: 5 brands 5 bunkers
03	Special alloy high level bunker	2	Bunker capacity: 2 brands 2 bunkers
04	Ferro-alloy charging equipment	2	Rotating chute type
8	Converter brick lining equipment		
01	Relining tower	1	Scale tower type
02	Lining breaker	1	Uni-shovel type
03	Brick receiving ladle	2	Capacity: 30 t
04	Brick cutter	1	Electric motor-type brick cutter

Division	Equipment	No. of units required	Main specifications
9	Auxiliary equipment		
01	Elevator	2	1) For goods 2) For passengers
02	Shovel bulldozer	2	Capacity: 2.0 t
03	Forklift	2	Capacity: 2.0 t
04	Miscellaneous piping	1	(1) O_2 piping (2) N_2 piping (3) COG piping (4) Compressed air piping (5) Ar piping (6) Miscellaneous water
05	Air conditioning equipment	1	
06	Sump pump and piping	1	
07	Temperature measuring equipment	4	(1) Measuring temperature in the hot metal ladle (2) Measuring temperature in front of the converter (3) Measuring temperature behind the converter (4) Measuring temperature of the teeming flow
08	Communications equipment inside the plant	3	(1) I.T.V. camera x 1, monitor x 8 (2) No. of interphone stations: 8 (3) No. of paging stations (2 systems) 10 stations each
09	Pneumatic pipe	1	Chemical analysis lab - Teeming platform - Continuous casting control center

Division	Equipment	No. of units required	Main specifications
10	Molten steel transport equipment		
01	Molten steel ladle	15	Steel receiving capacity: 110 t
02	Molten steel ladle car	2	Loading capacity: 180 t Motor-driven, self-travelling tyle
03	Molten steel ladle tilting device	2	Tilting capacity: 30 t Winch/wire tilting method
04	Ladle nozzle setting device	2	Removing/attaching power 70 kg/cm^2 Hydraulic control
05	Sliding nozzle operating deivce	3	Hydraulic control, 1 set
06	Ladle repair facility	1	Repairing platform: 5 stands
07	Ladle drying facility		Drying capacity: 8 h/800^oC Drying: COG burner method
11	Slag disposal equipment		Note: For transport equipment, see transport equipment.
01	Slag yard facilities	1	Slagyard area: Abt. 3,000 m^2 Shovel bulldozer: 2 t x 2 units Shovel car: 1.5 t x 1 unit Cold slag dumping equipment: 1 set Accessory equipment: 1 set
12	Crane equipment		
01	Hot metal charging crane	1	180 t/30t
02	Scrap charging crane	1	60 t/50t
03	Scrap loading crane	2	15 t Lifting magnet crane

Division	Equipment	No. of units required	Main specification
04	Converter service crane	1	30 t Radio-operated crane
05	Molten steel ladle service crane	1	60 t/20 t
06	Wall crane	1	2 t
07	Hoist for crane repair	3	7 t x 1, 5 t x 2
13	Electrical equipment	1	Power supply equipment and electrical work materials: 1 set Plant lighting and work materials: 1 set Trolley line and power work materials: 1 set
14	Instrumentation	1	Oxygen blowing, converter waste gas treating control equipment: 1 set Molten steel temperature measuring control equipment: 1 set Hot metal, scrap weighing control equipment: 1 set Submaterials, ferro-alloy charging control equipment: 1 set Hot metal desulphurization system control equipment: 1 set Others
15	Civil and foundations	1	Plant area: Abt. 13,700 m^2 Concrete: Abt. 2,600 m^3 Piling: Steel piling Abt. 4,400 t Concrete piles Abt. 1,500 pcs Steel structure: Abt. 450 t

Division	Equipment	No. of units required	Main specifications
16	Buildings equipment	1	Steel structure: Abt. 11,500 t Rails: Abt. 1,300 t Roof: Abt. 17,900 m^2 Wall: Abt. 25,700 m^2
17	Water works	1	Plant drainage and piping facilities

13.8.5 Plant layout

Layouts of the B.O.F. Plant, CC Plant and Calcining Plant are altogether shown in Fig. 13.8.3. Furthermore, enlarged views of the B.O.F. Plant and CC Plant are shown in Fig. 13.8.4.

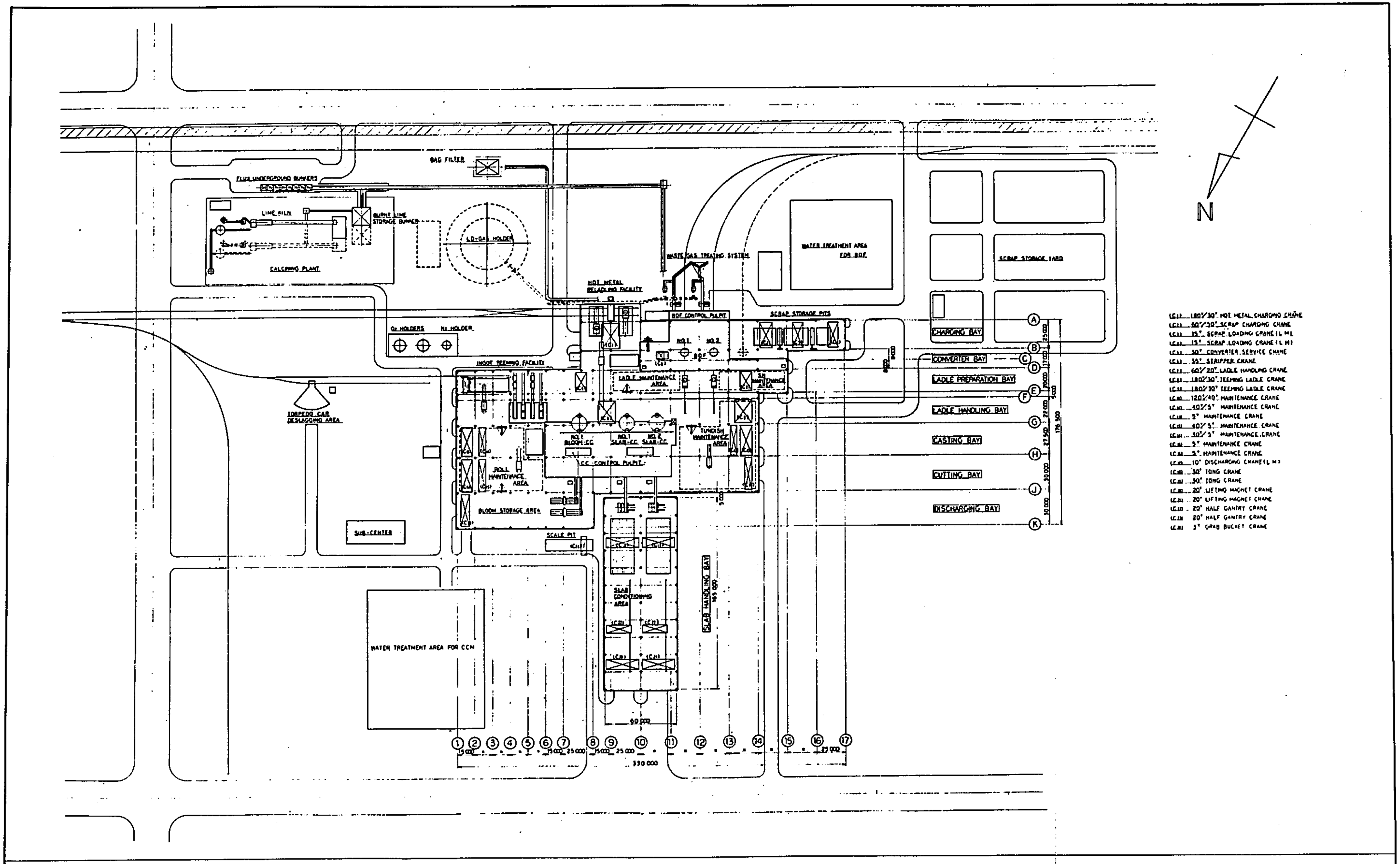


Fig. 13.8.3 Plant layout

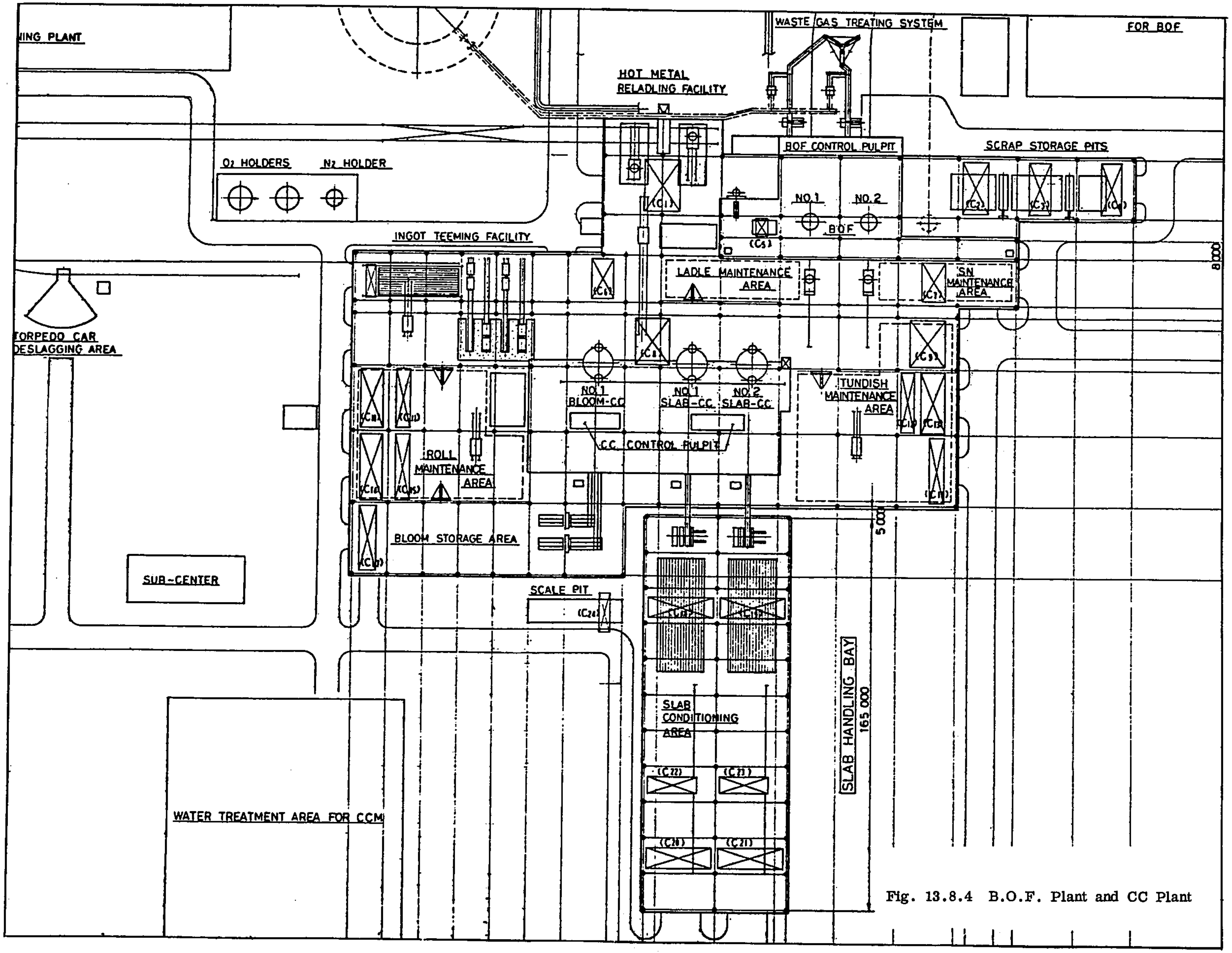
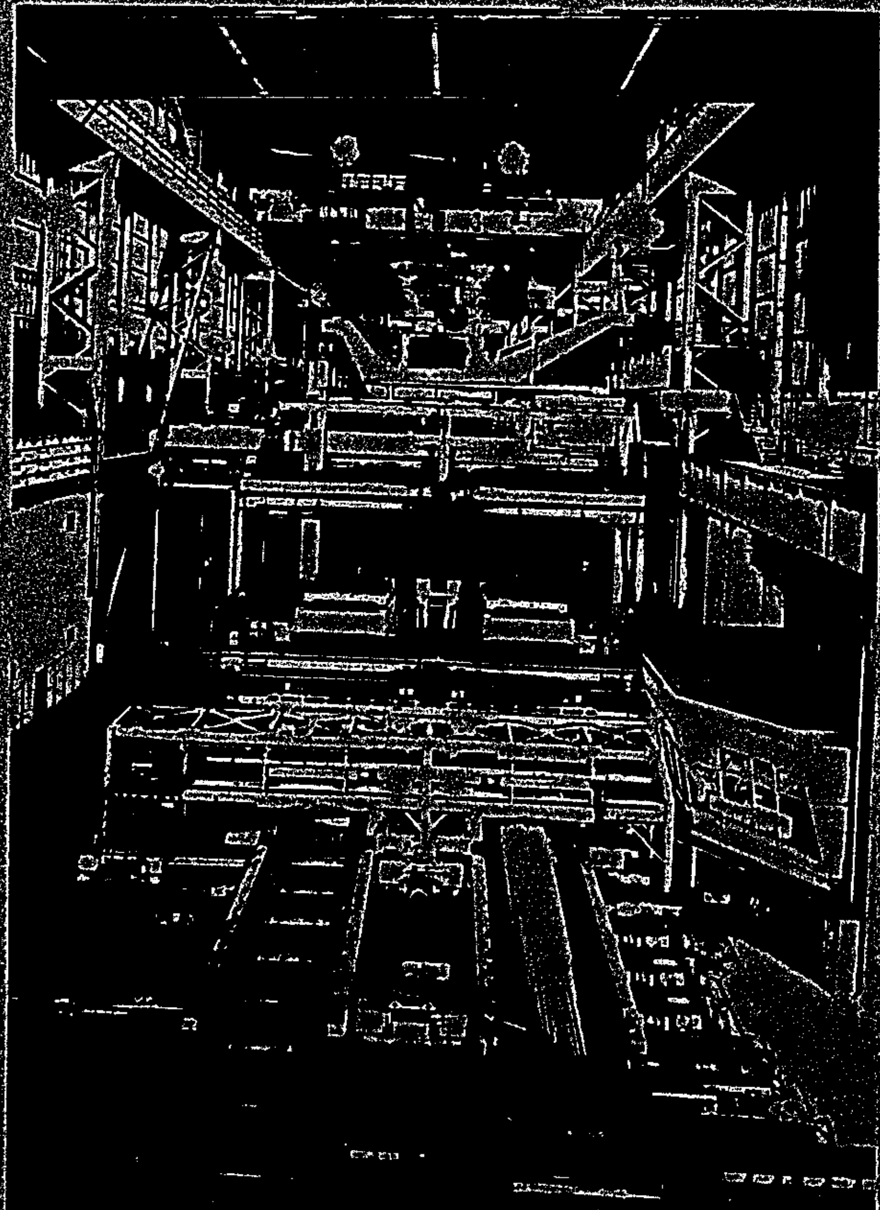


Fig. 13.8.4 B.O.F. Plant and CC Plant

CHAPTER 13-9

CONTINUOUS CASTING PLANT AND INGOT-MAKING FACILITIES



13.9 Continuous casting plant and ingot-making facilities

13.9.1 General

As for continuous casting facilities, 2 units of 1-strand machines for slabs and 1 unit of 4-strand machine for blooms will be installed, which will produce 648,000 ton/year of slabs for both hot rolling mill and plate mill, and 206,800 ton/year of blooms for billet mill, respectively.

The layout will be designed based on the assumption that continuous casting facilities will be expanded in the future to the west side of the works to meet the future expansion of B.O.F. plant.
On the other hand, ingot-making facilities will be installed with the primary object of manufacturing ingots as materials for tinplate. The secondary object of these facilities is to serve as a buffer in the transition period after start-up of B.O.F. plant and continuous casting plants, and the object is to function as emergency facilities for the continuous casting plants.

13.9.2 Prerequisites

(1) Production processes

Table 13.9.1 Production

Process	Production of liquid steel (t/year)	Production of castings (t/year)
Slab continuous casting	675,000	648,000
Bloom continuous casting	220,000	206,800
Ingot casting	155,000	151,900
Total	1,050,000	1,006,700

(2) Production plan

1) Production plan of slabs

Production volume by width of continuously cast slab is summarized in Table 13.9.2, and the detailed flow of slabs is shown in Table 13.9.3.

Table 13.9.2 Production of CC slabs by width

Slab width	Production of as-cast slabs (t/year)	Percentage distribution (%)
3 ft	77,006	12
4 ft	249,117	38
5 ft	81,218	13
6 ft	240,659	37
Total	648,000	100

2) Production plan of blooms

Continuously cast blooms will be all of a single size, intended for manufacture of merchant bars.

3) Production plan of ingots

Of 151,900 t of ingots, 136,521 t are ingots for 3-ft wide Al-killed slabs for electrolytic tinplate, and the remaining 15,379 t are for emergency ingot-making in which ingots for 3-ft slabs are cast using the same moulds. (See Table 13.9.3)

Table 13.9.3 Flow of slabs

	Nominal width	As-cast slab (t/year)	Conditioned slab (t/year)	Sheared slabs (t/year)	Slabs to be hot rolled (t/year)
1	3 ft	77,006	75,851		75,851
	(Slabs from ingots)	(136,710)	(134,659)		(13,633) (121,026)
2	4 ft	249,117	245,380		245,380
3	5 ft (for plate)	81,218	80,000		
4	6 ft (for hot strip)	159,441	157,049	(155,897) △1,152	155,897
	(for plate)	81,218	80,000		
	Total	240,659	237,049		
CC slabs		648,000	638,280	(155,897)	477,128
Slabs from ingots		(136,710)	(134,659)	-	(134,659)
Total		784,710	772,939	-	611,787

Table 13.9.4 Production plan of ingots

	Ingot production (t/y)	As-rolled slabs(t/y)	Slabs after conditioning (t/y)
Ingots for electrolytic tinplate	136,521	122,869	121,026
Emergency ingots	15,379	13,841	13,633
Total	151,900	136,710	134,659

(3) Specifications of slabs, blooms and ingots

1) Specifications of slabs

Table 13.9.5 Dimensions and unit weight of as-cast slabs

Nominal dimensions	Thickness (mm)	Width (mm)	Length (mm)	Unit weight (t)
3 ft	202	914	6,100	8.8
4 ft	202	1,219	6,100	11.7
5 ft	202	1,524	6,100	14.6
6 ft	202	1,842	6,100	17.7

Table 13.9.6 Dimensions and unit weight of conditioned slabs

Nominal dimensions	Thickness (mm)	Width (mm)	Length (mm)	Unit weight (t)
3 ft	200	910	6,100	8.7
4 ft	200	1,215	6,100	11.6
5 ft	200	1,520	6,100	14.5
6 ft	200	1,838	6,100	17.5

2) Specifications of blooms

Table 13.9.7 Dimensions and unit weight of blooms

Item	Specifications
Cross sectional dimensions, mm	220 x 260
Length, mm	5,000 max.
Unit weight, t/m	0.446
Weight of a bloom, t	2.23 max.

3) Specifications of ingots

Table 13.9.8 Dimensions and unit weight

Item	Specifications
Unit weight (t)	15
Type	Big end down with hot top
Mould ratio	1.1
Weight of a mould (t)	16.6

(4) Operating conditions

Table 13.9.9 Operating conditions

		Planned value
1) Operating days	1.1) Annual operating calendar days	336 days
	1.2) Monthly operating days	28 "
	1.3) Periodical repairs	2 days/m (12 hr. x 4 repairs/ month)
2) Average tapping tonnage per heat		105 t/ladle
3) No. of heats to be cast	3.1) Annual	10,080 heats
	3.2) Monthly	840 "
	3.3) Daily	30 "
4) No. of heats to be cast by casting machine	Monthly	Daily
No. 1 slab CCM	270 heats/m	9.6 heats/d
No. 2 slab CCM	260 "	9.5 "
Bloom CCM	175 "	6.3 "
Ingot-making	123 "	4.4 "
	(834)	30

(5) Yield rates by process

Table 13.9.10 Yield rates by process

		Yield rate %
1) Slab casting yield	Cast slabs to molten steel	96.0
2) Bloom casting yield	Cast blooms to molten steel	94.0
3) Ingot-making yield	Sound ingots to molten steel	98.0
4) Slab conditioning yield	Conditioned slabs to cast slabs	98.5
5) Blooming & slabbing yield	As-rolled slabs to ingots	90.0
6) Slab shearing yield		99.27

(6) Production processes

Production processes are shown in Fig. 13.8.1, and the flow of materials is shown in Fig. 13.8.2.

13.9.3 Equipment specifications

(1) Layout

A liquid steel ladle transfer building will be constructed adjacent to the B.O.F. plant. In the new building, two 180/30 T liquid steel ladle cranes will be installed for transporting liquid steel ladles to continuous casting machines and for teeming molten steel into ingot moulds. Discharging operation of residue in the liquid steel ladle into the slag ladle after teeming is also performed in this building.

To ensure smooth transportation of liquid steel ladles, maintenance works of tundishes and ladles are not carried out in this building, as a rule.

3 continuous casting machines will be installed almost in the middle of the continuous casting building, at a right angle to the buildings, with the east side of these machines being a roll maintenance shop and the west side being a tundish repair shop. With this layout, better atmosphere can be achieved in the roll maintenance shop by natural ventilation.

A slab cooling, conditioning and shipping building will be constructed at a right angle to the casting building to ensure smooth flow of slabs.

In view of the fact that production of billets for merchant bars is being planned, and that uniform surface quality can be expected through the manufacture of large-sized blooms, blooms will be subject only to a simple inspection after cooling and will be transported by trailers to the succeeding billet mill.

Consequently, a bloom cooling and shipping building, which can be reduced to a compact size, will be constructed in the northeast of the casting building from an economical point of view.

With such a multi-facted consideration, delivery of slabs, blooms and scales as well as transportation of machine parts and refractories can be smoothly and rationally in this works even in the second stage plan.

(2) Liquid steel handling facilities

Ladle turrets will be employed for positioning liquid steel ladles for continuous casting. This reduces mutual interference of cranes and ensures effective transportation of liquid steel ladles.

The ladle turrets will have a capacity of 180 T (molten steel + ladle weight) with its swivelling speed being max. 1 r.p.m. A backup device is provided in the ladle turret to allow its swivelling operation in power failure.

As a means for controlling liquid steel flow in the liquid steel ladles and tundishes, the latest type of hydraulic slide valve will be introduced to ensure stable teeming operations, at elevated temperatures and for hours.

(3) Continuous casting machines

1) Productivity

2 units of 1-strand slab continuous casting machines and 1 unit of 4-strand bloom continuous casting machine will be installed. Productivity of these machines exceeds well enough that of the B.O.F., as shown in the table below.

Table 13.9.11 Productivity of continuous casting machines

	Productivity* ton/hr.
Continuous casting machines.	
No.1 slab continuous casting machine	Average 89
No.2 slab continuous casting machine	Average 89
Bloom continuous casting machine	70
Total	248
B.O.F. plant	175**

* Productivity of continuous casting machines was calculated based on the 2-ladle continuous-continuous casting with set-up time of 50 minutes.

** Productivity of B.O.F. plant was calculated at the tapping cycle of 36 minutes. Both figures were based on 105 T/heat of liquid steel.

2) Slab continuous casting machine

Single radius curved mould low head casters, the most typical of continuous casters now available in the world have been designed in this study. This type of machine, though a little complicated in its construction as compared with the vertical type, is economical in terms of capital investment because of the reduced height of the machine. Withdrawal speed has been set to 0.95 - 1.10 m/min, taking into consideration slab size, the heat size of B.O.F. plant and slab quality. The casting rate and required teeming time at this speed range are shown in Table 13.9.16, and main specifications of the machine in Table 13.9.12 below.

Table 13.9.12 Main specifications of slab continuous casting machine

1	No. of strand		1
2	Radius of curvature		Approx. 10,500 mm
3	Dimensions of slab	Thickness	200 mm
		Width	900 - 1,900 mm
		Length	5,000 - 6,100 mm
4	Unit weight of slab		17.7 T. max.
5	Driving speed (during casting)		1.5 m/min max.
		(when setting dummy bar)	5.0 m/min max.

3) Bloom continuous casting machine

The same type as that for slabs has been designed for bloom continuous casting machine. Dimensions of bloom have been set at 220 x 260 mm in cross section, aiming at higher productivity per strand, the minimum possible number of strands and the stable internal and surface quality of blooms to be cast.

Main specifications of bloom continuous casting machine are given in the following table.

Table 13.9.13 Main specifications of bloom continuous casting machine

1	No. of strands		4
2	Radius of curvature		10,500 mm
3	Dimensions of bloom,	Cross section	220 x 260 mm
		Length	3,700 - 5,000 mm
4	Unit weight		2.23 T max.
5	Driving speed (during casting)		1.5 m/min max.
		(when setting dummy bar)	5.0 m/min max.

4) Slab delivery and conditioning facilities

After cut by the automatic sizing gas flame cutter, slabs are automatically transferred to the slab conditioning building by roller tables and pushed toward the piler (30 T) by the pusher (thrust: 30 T).

Slabs are then transported to the cooling bed (1,000 m^2 x 2) with the tong crane (30 T) for natural cooling. Slab conditioning is carried out by the hand scarf. To turn slabs, semi-gantry cranes for the conditioning yard are equipped with lifting magnets (20 T) having slab turning capability.

Conditioned slabs are loaded on the trailers with the lifting magnet cranes (20 T).

(4) Ingot-making facilities

Although the steady-state production of ingots is 4.4 heats/day, ingot-making facilities will have maximum 13 heats/day of top pouring ingot-making capacity with a total of 4 lines of teeming ladle cars consisting of 2 cars per heat in order to absorb the difference of the start-up characteristics between the blast furnace/B.O.F. plant and the continuous casting machines, to minimize the production of cast pig iron and to maintain the start-up balance of the entire works.

To avoid excessive capital investment on ingot-making facilities, however, teeming cars will be arranged in comb-shaped configuration and the mould cooling yard will be provided adjacent to the teeming platform to eliminate an independent mould yard.

Stripped hot ingots will be transported outdoors with transfer cars and unloaded on the ground for natural cooling.

(5) List of equipment specifications

Specifications of continuous casting plant and ingot-making facilities are shown in Tables 13.9.14 and 13.9.15.

Table 13.9.14 Continuous casting equipment

	Equipment	Slab continuous caster		Bloom continuous caster		Common equipment	
		Qty	Main specifications	Qty	Main specifications	Qty	Main specifications
1	Liquid steel handling equipment						
01	Ladle turret	2 units	Load capacity 180 t Swivelling speed 1 rpm	1 unit	Same as left	-	
02	Sliding nozzle device	1 set	Hydraulic type	1 set	Same as left	-	
03	Tundish	15 units	Capacity Approx. 18 t	8 units	Same as left	-	
04	Tundish car	4 units	Loading capacity: Approx. 35 t with lifting device	2 units	Same as left		
05	Tundish ancillary equipment	1 set	Preheater: 6 units, etc.	1 set	Preheater: 3 units, etc.	-	
06	Liquid steel temperature control device	-		-		1 unit	Stopper rod type argon top blow
2	Continuous caster	2 units		1 unit		-	
			Type: Low head curved mould type 1-strand slab caster		Type: Low head curved mould type 4-strand bloom caster		
			Slab size: 200x900x5,000 mm, min. 200x1,900x6,100 mm, max.		Bloom size: 220x260x5,000 mm		
			Driving speed:				
			For casting; 1.5 m/min.	max.	1.5 m/min, max.		
			For dummy bar; 5.0 m/min,	max.	5.0 m/min, max.		
			Machine length: Approx. 21.5 m		Approx. 18.5 m		
01	Equipment of the caster proper	8 units	Water cooled copper mould	8 units	Same as left.		
		2 units	Mould oscillator	4 units	Same as left.		
		2 units	Casting support and guide	4 units	Same as left.		
		2 units	Casting and straightening equipment	4 units	Same as left.		
		2 units	Casting cooling equipment	4 units	"		
		2 units	Cooling chamber	1	"		
		2 units	Steam discharge equipment	1	"		

	Equipment	Slab continuous caster		Bloom continuous caster		Common equipment	
		Qty	Main specifications	Qty	Main specifications	Qty	Main specifications
01	Equipment of the caster proper (cont.)	2 units	Dummy bar and its support	4 units	Same as left.		
		2 "	Gas cutter	4 "	"		
		2 "	Casting cropping & delivery equipment	2 "	"		
		2 "	Hydraulic equipment	4 "	"		
		2 "	Slab stamper	4 "	Bloom stamper		
						1 unit	A casting floor common to three continuous casters Height: Approx. 11,000 mm Area: Approx. 105x45 = 4,725 m^2
3	Castings transport equipment						
01	Roller table	12	Roll dia.: Approx. 400 mmø Roll pitch: 1,200 and 1,500mm Roll barrel length: 2,200 mm Table length: 7,500 mm	1 set	Approx. 300 mmø 1,000 mm 450 mm 6,000 mm		
02	Pusher	2	Capacity: 20 t Stroke: Approx. 4,000 mm	2	50 t 2,000 mm		
03	Piler	2	Capacity: 30 t	-			
04	Cross conveyor	-		2	Capacity: 3 t Speed: 20 m/min		
05	Cooling bed	2	20 m x 50 m = 1,000 m^2	2	5 m x 10 m = 500 m^2		
4	Electrical equipment						
01	Power supply equipment	1 set		1 set			
02	Continuous casting electrical equipment	1		1			
03	Castings transport electrical equipment	1		1			

	Equipment	Slab continuous caster		Bloom continuous caster		Common equipment	
		Qty	Main specifications	Qty	Main specifications	Qty	Main specifications
5	Instrumentation						
01	Continuous casting control instrumentation	2		4			
02	Castings cutting program control equipment	2		4			
03	Fluidic measuring equipment	-		-		1 set	
6	Gas piping system	-		-		1 set	Oxygen, LPG, argon, COG, air and other piping systems
7	Water piping system	-		-		1 set	Direct cooling, indirect cooling and emergency cooling water piping systems
8	Auxiliary equipment					6 units	CO_2 automatic fire extinguishing systems
						3 units	General service air compressors
						3 units	Instrumentation air compressors
						3 units	Transfer cars
						1 unit	LPG gasifier
						1 set	Slab scarfing tools
						1 set	Air conditioner
						1 set	Industrial TV system
						1 set	Intercommunication system
						1 set	Others
9	Crane equipment	2	Slab delivery tong cranes: 30 t	1	Bloom delivery lifting magnet crane: 10 t	2 units	Liquid steel ladle cranes: 180/30 t
		2	Slab delivery lifting magnet cranes: 20 t			1	Roll maintenance crane: 40/5 t
		2	Slab conditioning lifting magnet cranes: 20 t			1	" 30/5 t
						1	Tundish maintenance crane: 40/5 t
						3	Roll maintenance crane 5 t
						1	CCM service cranes: 120/40 t
						1	Scale delivery grab bucket: 3 t
						3	Wall cranes: 2 t
						10	Crane maintenance hoists: 2-7 t

	Equipment	Slab continuous caster		Bloom continuous caster		Common equipment	
		Qty	Main specifications	Qty	Main specifications	Qty	Main specifications
10	Buildings	-		-			Area: 33,000 m^2 Weight of steels: 8,210 t
11	Civil engineering works	-		-			Volume of concrete: 35,600 m^3 Pipe piles: 5,260 t Floor pavement: 19,500 m^2 Access roads: 16,200 m^2

Table 13.9.15 Ingot-making facilities

	Equipment	Qty	Main specifications
1	Teeming cars	8	Loading capacity: 100 t Self-propelled.
2	Stripper crane	1	35 t
3	Mould cooling bed	1	400 m^2
4	Auxiliary equipment	1 set	Transfer cars for ingot mould Mould cleaning equipment Mould repair tool Others

13.9.4 Layout

The layout is shown in Figs. 13.8.3 and 4.

13.9.5 Technical description

(1) Productivity

Casting rates of slabs and blooms are shown in Table 13.9.16.

Table 13.9.16 Casting rates and teeming time

Dimensions	Weight per meter, t/m	Average withdrawal speed, m/min.	Casting rates, t/min.	Teeming time, min
3 ft	1.44	1.1	1.6	66
4 ft	1.92	1.1	2.1	50
5 ft	2.40	1.1	2.6	40
6 ft	2.90	0.95	2.8	38
Blooms	0.446	0.90	1.61	65

Assuming that 3-ft and 4-ft slabs are cast in No. 1 slab continuous caster and 5-ft and 6-ft slabs in No. 2 slab continuous caster, the casting time ratio of each continuous caster will be as shown in Table 13.9.17.

Table 13.9.17 Casting time ratio of each continuous caster

CCM	Production of castings t/year		ch/year	ch/month	Casting time	Casting time ratio
No. 1 CCM	3-ft	77,006	764	64	70 hrs	
	4-ft	249,117	2,471	206	172	
	Total	326,123	3,235	270	242	34%
No. 2 CCM	5-ft	81,218	806	67	45	
	6-ft	240,659	2,387	199	126	
	Total	321,877	3,193	266	171	24%
Bloom CCM		206,800	2,095	175	190	26%

These casting time ratios are almost equal to the values obtained in all continuous casting plants in Japan.

(2) Determination of slab size

1) Determination of slab thickness

Judging from the latest level of continuous casting techniques in Japan, the desirable slab thickness should be within the range of 230 - 250 mm. However, in this project which envisages the supply of slabs to the hot strip mill as a converted NASCO steckel mill, the slab thickness has to be limited to 200 mm because of the limited mill power after conversion. In view of the fact that there are many continuous casting plants in Japan and other countries that produce slabs about 200 mm thick for hot strip and plate, products with sufficient quality competitiveness can be manufactured with 200 mm thick slabs.

2) Determination of slab width and slitting of slabs

Since the width of the NASCO mill is 5 ft, the slab width was set at 5 ft max. in the initial plan. At the request of the counterparts however, the maximum casting width has been set at 6 ft and a process for slitting 6-ft slabs lengthwise has been introduced for the manufacture of part of 3-ft slabs.

It should be kept in mind, however, that sophisticated operating techniques are indispensable for manufacturing hot rolled coil from slit slabs.

Since it is favorable in terms of slab handling to perform slab slitting operations not in the new works, but in NASCO, no slitting facilities will be installed in the new works.

3) Slab size for plate mill

Judging from the product mix for an ordinary plate mill, the product flow has been designed at the 50:50 ratio of 5-ft and 6-ft slabs.

Secondary cutting of slabs for plate mill will also be carried out by the manufacturer of plate mill and no slab cutting facilities will be installed in the new works.

The slab thickness has been set at 200 mm as that for hot rolled coil. With this thickness, products up to 25 - 33 mm in thickness can be manufactured.

CHAPTER 13-10

BILLET MILL PLANT

13.10 Billet mill plant

13.10.1 General

The billet mill produces 50-mm, 80-mm and 115-mm sq. billets from blooms with a cross-sectional area of 220 x 260 mm sent from the continuous casting plant.

The continuous cast blooms are transferred from the CC floor to the reheating furnace materials bay by trailer. Swivel type cranes shall be used at the materials bay for materials handling and charging blooms into the reheating furnace so that they can be stored at the bay in parallel crosses because they are short in length. Blooms to be charged into the reheating furnace are cold ones.

The reheating furnace shall be fuelled exclusively by coke oven gas (COG).

The billet mill consists of a reversing roughing mill and a two-stand continuous finishing mill. 80-mm and 115-mm sq. billets shall be rolled on the roughing mill while 50-mm sq. ones on the roughing and finishing mills. In the future production stage of 500,000 t-billets/year, the finishing mill capacity will be increased by two stands and billets with cross-sectional areas 80 mm sq. or less will be rolled all on the finisher. If, even in that stage, 50-mm sq. billets will account for 50% of the total billet production, the same percentage as in the presently-planned stage, addition of the roughing capacity would also be required.

Since this is still uncertain, however, no expansion of the roughing capacity is taken into account here.

Since billets to be produced are planned mainly for merchant bars, finished billets shall be sent to the subsequent process without conditioning except for those in which significant defects are found after cooling.

13.10.2 Pre-conditions

(1) Production plan

We assume that each billet will be 5 m long in view of the fact that the proposed minimum cross-sectional area is 50-mm sq. We also assume that the maximum rolling length of each billet will be 50 m for easier handling by the planned reversing type roughing mill.

The billet dimensions and production plan, which are indicated in the following table, are as proposed by counterparts.

Table 13.10.1 Production plan

Size of bloom		Size of billet		Bloom, quantity t/y	Produc-tion quantity t/y	Remarks
Cross-sectional x Length, mm size	Unit wt., tons	Cross-sectional x Length, mm size	No. of billets bloom			
220x260x4767	2.072	115x115x5000	4	51,700	49,632	
220x260x4616	2.004	80x80x5000	8	51,700	49,632	
220x260x3830	1.665	50x50x5000	17	103,400	99,264	To be divided in two at the delivery side of the roughing mill before entering the finishing mill.
Total				206,800	198,528	Yield: 96%

(2) By-products

From the billet mill operations such by-products as scale which collects in the scale pit and various steel scrap including crops cut off by the shears, miss-roll etc. are produced in amounts as follows:

Table 13.10.2 Output of by-products

By-product	Output, t/y
Scale	4,136
Scrap	4,136
Total	8,272

(3) Unit consumption and annual consumption

Table 13.10.3 Specific consumption in billet mill

Item	Unit consumption	Annual consumption	Remarks
COG for reheating furnace	100 Nm^3/t	20,680 x 10^3 Nm^3/y	4,500 $Kcal/Nm^3$ 1,000 - 1,300 mmAq
Electric power	30 KWH/t	6.204 x 10^3 KWH/y	
Roll	0.12 kg/t	24.8 t/y	

In the production stage where only one blast furnace is in service, the output of blast furnace gas varies with conditions under which the blast furnace is operated; use of mixed gas (COG + BFG) for the reheating furnace may result in an unstable operation of the reheating furnace. Since the proposed rolling mill plant of the new steelworks involves only the billet mill and the estimated gas balance seems to permit the use of COG, the reheating furnace is planned to be fuelled exclusiveiy by COG.

(4) Operating conditions

The planned operating conditions of the billet mill are summarized in Table 13.10.4. The downtime for roll change allows for the time required for rolls to be changed because of changes in the billet size and wear of rolls itself.

Table 13.10.4 Operating conditions

Item		Time	Remarks
Calendar time (A)		8,760 hrs.	24 hr. x 365 days
Scheduled downtime	Annual maintenance	336	24 hr. x 14 days
	Periodic maintenance	368	8 hr. x 4/month x 11.5 months
	Inspection and adjustment	240	
	Roll change	345	
	Sub-total (B)	1,289	
Workable time (C)		7,471	(A) - (B)
Rolling time (D)		5,249	
Working ratio		70.9 %	(D)/(C) x 100
Operating ratio		60.4 %	(D)/(A) x 100

The difference between the workable time and the rolling time includes the roll changing time due to some troubles, the waiting time due to failure of rolling mill or other equipment, the waiting time for cooling bed and waiting time for the bloom reheating time in the reheating furnace by 115 mm sq billet rolling, which is detailed later in this chapter. The last, assumably about 430 hours in total, will not pose any problem of particular importance.

13.10.3 Equipment specification

(1) Reheating furnace equipment

A continuous type reheating furnace shall be employed to reheat cold blooms. Among the continuous reheating furnaces are a pusher type reheating furnace and a walking beam type one. Here, the pusher type one, which is very simple in construction and requires less initial investment, shall be adopted because billets to be produced are mainly for merchant bars.

The reheating furnace shall have a capacity of 40 tons per hour to meet the requirements of the production plan as noted in Table 13.10.1. At this level of the reheating furnace capacity, however, the rolling capacity will surpass the reheating furnace capacity and, as the result, a waiting time should arise as a gap between the capacities if 115-mm sq. billets are to be produced.

(2) Rolling equipment

Billets are usually rolled by either reversing or continuous mills or a combination of both. Which type of the rolling mill to select is determined through consideration of various aspects: product-mix, production quantity, equipment cost, operational performance, etc.

Here, a combination of the reversing mill and continuous mills shall be employed since it has to handle billets and blooms with comparatively large cross-sectional areas: 50 to 115-mm square for billets and 220 x 260 mm for blooms. In this mill configuration, the rolling capacity to be shared by each type is optimized in consideration of the overall rolling capacity, size of billets, operational simplicity and initial capital cost. As for the projected billet mill, billets with final cross-sectional areas of 115-mm and 80-mm square will be rolled on the reversing mill (hereafter referred to as roughing mill) while those with cross-sectional area will be rolled first on the roughing mill down to 65-mm square and finished to 50-mm square by two continuous mills.

In the future stage of 500,000 t/y, two continuous finishing mills will be added to the capacity and 80-mm square billets will also be finished on the continuous mills. The pre-production investment for this purpose has already been made. If the relative importance of 50-mm sq. billets in the total production is to be increased to 50%, it becomes necessary to increase the roughing mill capacity, necessitating an added capital cost. Because of this, no consideration is given to the addition in our plan. In carrying out this project, therefore, a careful insight into the future product-mix will be essential.

For example, change in the cross-section of billets to be handled by the roughing mills is illustrated schematically below.

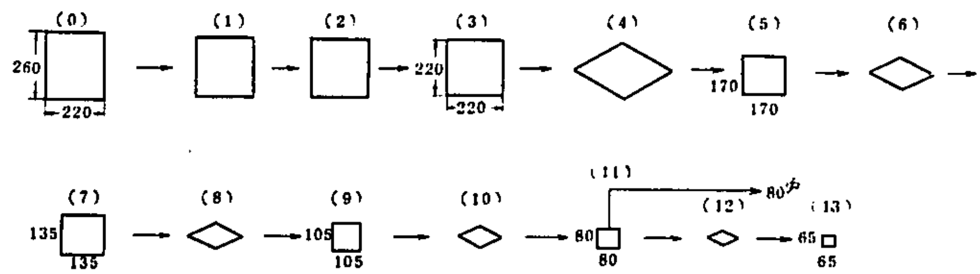


Fig. 13.10.1 Change in cross-sectional view of bloom

Table 13.10.5 provides the rolling capacity in tons/hr of roughing mills by size of billet. As seen in the table, the rolling mill capacity for 115-mm square billets exceeds the planned capacity of the reheating furnace, 40 t/h. The difference between the capacities represents the waiting time of the furnace. On an annual basis, however, the rolling capacity is sufficient.

Table 13.10.5 Rolling capacity (roughing mills)

Size of bloom	Size of billet	Unit wt.	No. of passes	t/h	Remarks
220 x 260 x 4767	115 x 115	2.072	9	68.7	
220 x 260 x 4616	80 x 80	2.004	11	45.8	
220 x 260 x 3830	65 x 65	1.665	13	30.3	To be reduced to 50-mm sq.

(3) Shears

Behind the roughing and finishing mills shears will be installed. The small shear to be installed behind the roughing mill stand (with shearing capacity up to 150-mm sq.) will be a stationary one which cuts billets as they are at a standstill while the shear behind the finishing stands (with shearing capacity up to 80-mm sq.) will be a flying shear.

(4) Cooling bed

The billet cooling bed is comprised of an on-line type and an off-line type, each consisting further of a pusher type and a walking-beam type.

The off-line cooling bed is designed to cool billets transferred and arranged in position on the bed by craw crane.

In the present plan, the on-line, pusher type is selected because billets are relatively short and constant in length, 5 m and it requires less capital cost. Further, an easy-to-operate type cooling bed without a forced-cooling device shall be used considering the relatively low cooling rate required. The flow sheet, layout and a list of equipment specifications of the billet mill are shown in Figs. 13.10.2 and 13.10.3 and Table 13.10.6, respectively.

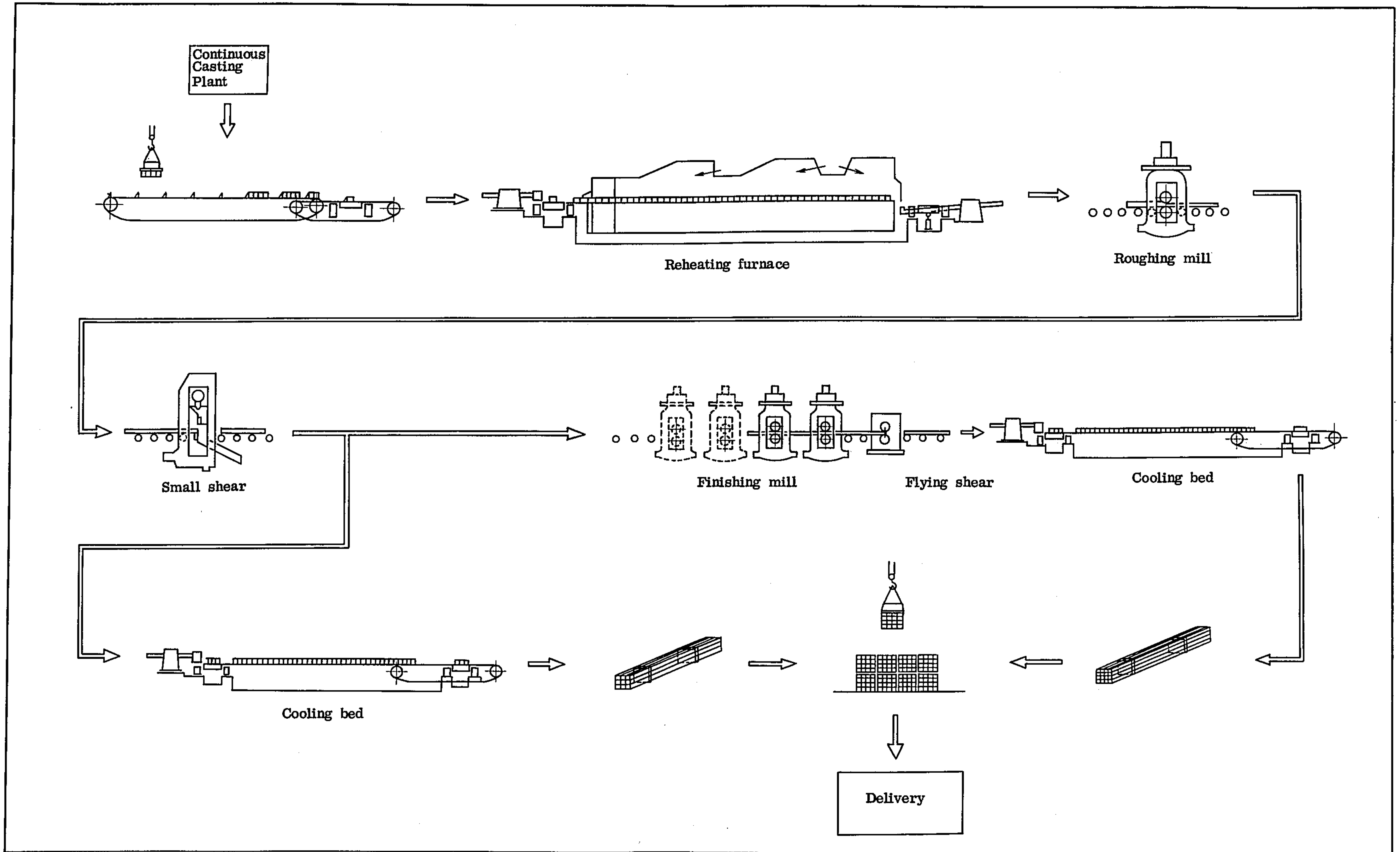


Fig. 13.10.2 Flow sheet of billet mill

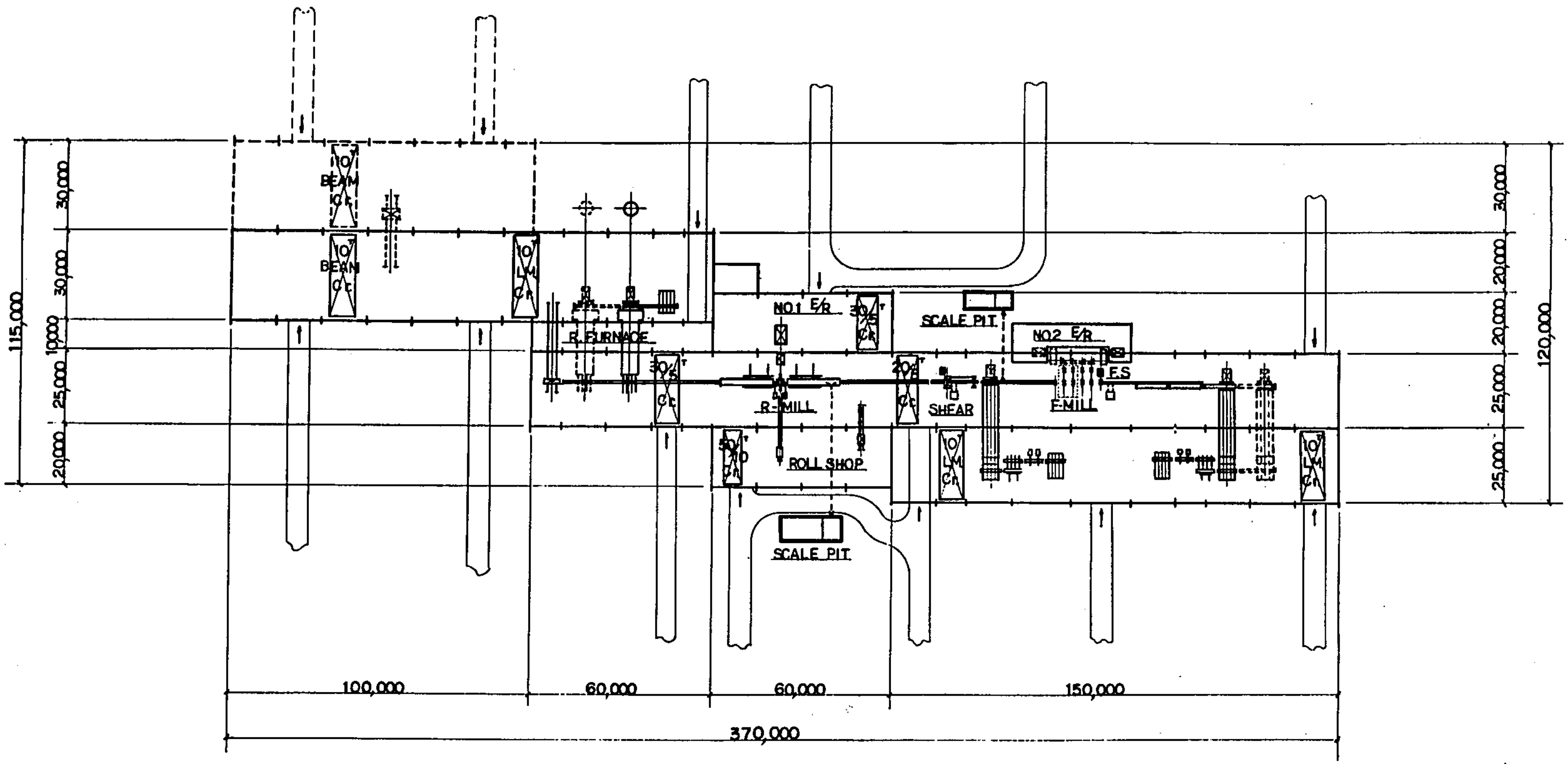


Fig. 13.10.3 Billet mill plant layout

Table 13.10.6 Equipment specifications

No.	Equipment	No. of units	Main specifications
1	Reheating furnace equipment		
(1)	Reheating furnace	1	Type: Pusher type Capacity: 40 t/h
(2)	Recuperator	1	Type: Stack type metallic recuperator
(3)	Pusher	1	Type: Electrical motor driven rack pinion type
(4)	Extractor	1	Type: Hydraulical (for the vertical movement); electrical motor driven (for the horizontal movement)
(5)	Bloom feed transfer	1	
(6)	Front and rear tables	1	
2	Rolling equipment		
(1)	Roughing mill	1	Type: Reversing 2-high mill Roll size: 1100ø x 3000(L) Roll rpm: 0/60/120 Motor output: 2,000 KW
(2)	Finishing mill	2	Type: Continuous 2-high mill Roll size: 700ø x 1200(L) Final rolling speed: 2.5 m/s (max.) Motor output: 500 KW
(3)	Small shear	1	Type: Electrical motor driven, down-cut, start-stop type Max. cross-sectional area to be sheared: 150 ф

No.	Equipment	No. of units	Main specifications
(4)	Flying shear	1	Type: Electrical motor driven, rotary, start-stop type Max. cross-sectional area to be sheared: 80ϕ
(5)	Bloom tilter	2	Type: Operated by a hydraulic clamp for front and rear tables of the roughing mill
(6)	Rolling mill table	1	
3	Cooling equipment		
(1)	Pusher	2	Type: Electrical motor driven rack pinion type
(2)	Cooling bed	2	Type: Pusher type, natural air-cooling
(3)	Cooling bed front and rear tables	1 set	
(4)	Billet piler	2	
(5)	Bundling machine	2	
4	Crane		
(1)	Bloom receiving crane	1	Type: Overhead travelling beam swivel type Capacity: 10 t
(2)	Bloom delivery crane	1	Type: Overhead travelling beam, lifting magnet swivel type Capacity: 10 t
(3)	Rolling bay crane	2	Type: Overhead travelling Capacity: 30 t/5 t, 20 t/5 t

No.	Equipment	No. of units	Main specifications
(4)	Electrical room crane	1	Type: Overhead travelling Capacity: 30 t/5 t
(5)	Roll shop crane	1	Type: Overhead travelling Capacity: 50 t/10 t
(6)	Billet delivery crane	2	Type: Overhead travelling beam, lifting magnet Capacity: 10 t

13.10.5 Technical explanation

In order to produce high quality billets in the billet mill, the following are necessary;

(1) Designing of good calibers and guides

(2) Good maintenance

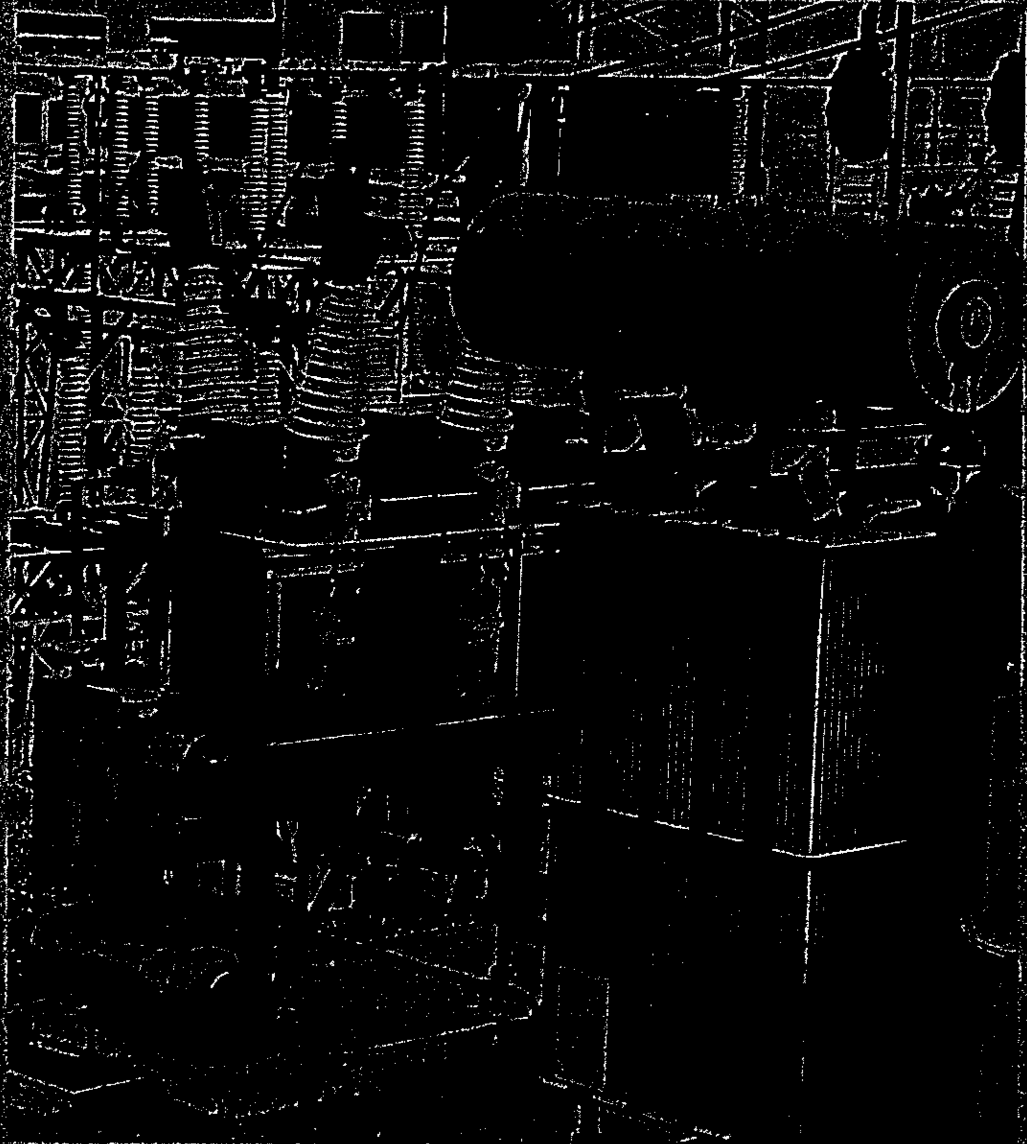
(3) Operators with high level rolling techniques.

For the overall capacity of a rolling line is determined by the capability of the roughing mill incorporated in it. In using a continuous type finishing mill, or a twisting type mill, operators must be very careful to provide shapes of billets with a high accuracy.

In addition to 2 shears, a small shear and a flying shear, 2 each of cooling beds and bundling machines are provided. Since these equipment will not be operated simultaneously in parallel, there is no need for providing 2 teams of operators for them.

CHAPTER 13-11

POWER RECEIVING AND DISTRIBUTION FACILITIES



13.11 Power receiving and distribution equipment

13.11.1 General

Power receiving and distribution equipment include those equipment for distributing purchased and generated power to each electrical room, telephone equipment within the premises, road illumination equipment and temporary power supply equipment required for construction.

13.11.2 Basic plan

(1) Power receiving equipment

1) Current capacities of power receiving circuit breakers and bus bars

Assuming that the maximum hourly power requirements after the second stage is 100 MW, current capacities of power receiving circuit breakers and bus bars has been designed at 1,000 A.

2) Short-circuit capacity at receiving point

Short-circuit capacity at the receiving point has been designed at 3,500 MVA, based on the expected power capacity of Mindanao Power System around 1984.

3) Specifications of power receiving transformers

The capacity of power receiving transformers has been designed at 30 MVA, taking into consideration the estimated power consumption in the case of total failure of home power plants, and 2 units of transformers will be installed for ease of maintenance and inspection.

On-load tap changers will be equipped to absorb voltage fluctuations, and the primary tap voltage will be temporarily set at 138 kV ±7.5% (17 TAPS) because the fluctuation range of the power supply voltage is unknown.

4) Insulation design

Insulating strength will be as follows.

138 kV circuit	BIL	650 kV
34.5 kV circuit	BIL	200 kV
Neutral point of receiving transformer	BIL	200 kV

5) Bus system

Bus system will be of dual bus system for ease of maintenance and inspection. The bus system for the 138-kV line will be of outdoor type from economical viewpoint, but that for the 34.5-kV line will be of indoor type because this bus is very important in the whole distribution system, in which the purchased power and the privately generated power system are separated to each other at an accident.

6) 34.5-kV grounding system

The 100-A resistance grounding system will be employed, taking into consideration abnormal voltage and induction troubles in grounding failures.

7) Protective system - Refer to Fig. 13.11.1.

a) Power receiving line

To prevent home power plants from failing together with a receiving line accident, high response speed and reliability pilot wire relays will be employed. (Wires will not be included.)

b) 138-kV bus, 34.5-kV bus

To minimize the effect of bus failures, high response speed and reliability grouped/divided type bus protection relays will be employed.

c) Transformer protection

Internal failure and overload protection will be provided for transformers.

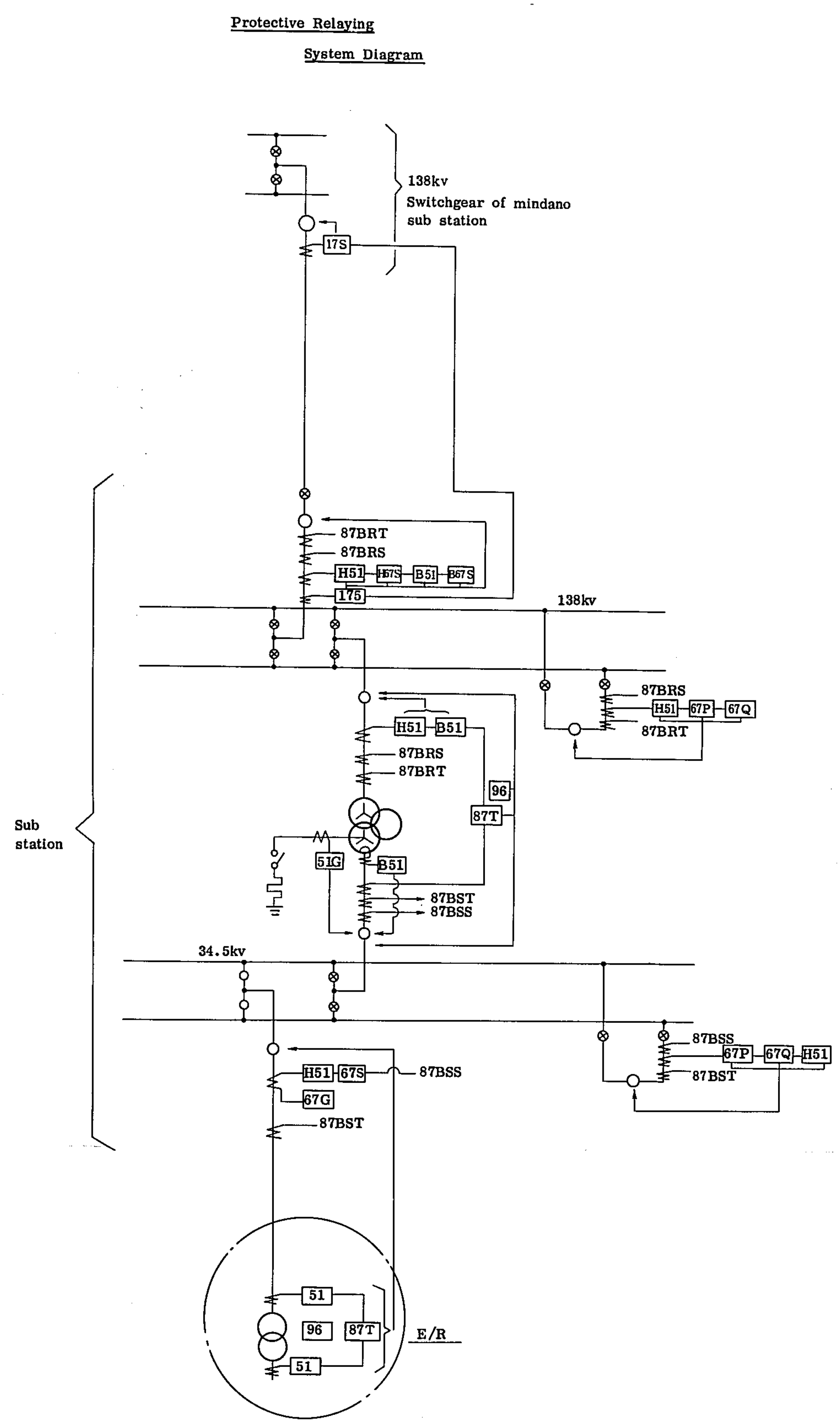


Fig. 13.11.1 Protective relaying system diagram

d) 34.5-kV line protection

Overload protection and ground fault protection will be provided.

e) Electrical room main transformers

Since elephant type transformers are employed in the interest of economy, substation circuit breakers will be tripped by transferring system for protection in the case of internal failure and overload of main transformers.

(2) Power distribution equipment

Cables will be used for all the 34.5-kV distribution lines, and the laying method will be the direct burying method. Refer to Fig. 13.11.2.

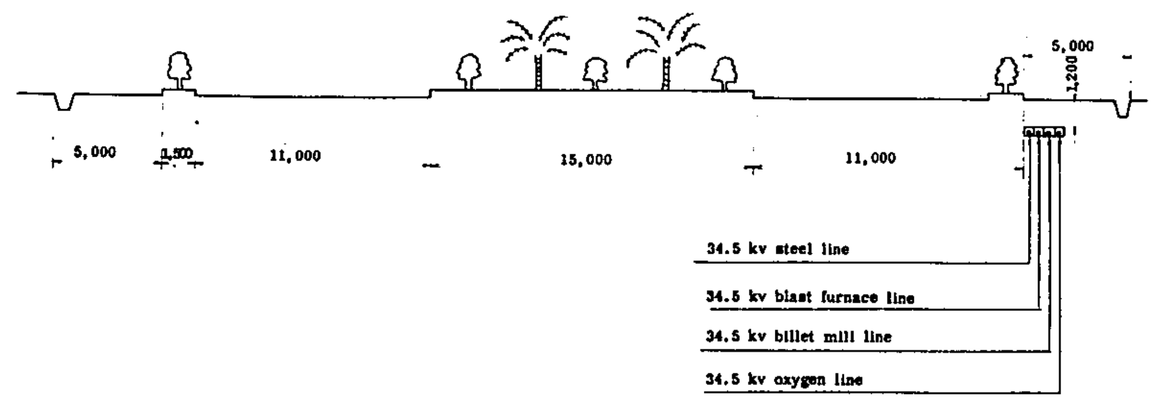


Fig. 13.11.2 Example of direct burying method

(3) Telephone equipment

Only works inside telephone system will be considered here. Crossbar type 500-channel automatic exchange will be installed. Telephone trunk lines will be laid in underground conduits.

(4) Road illumination equipment

Road illumination equipment will be designed with the minimum illumination of 1Lx for main roads. The designed road length will be 15,000 m.

(5) Temporary power supply equipment

Power to be received for the temporary power supply equipment will be 34.5 kV, and the 3.3-kV power will be distributed with overhead distribution lines. Three overhead lines having the distribution capacity of 2,000 kVA will be considered.

13.11.3 Equipment specifications

Table 13.11.3 Equipment specifications

Equipment	Qty	Specifications
1) Substation equipment	1 set	138-kV switchgear x 5 30-MVA, 138/34.5-kV transformer x 2 34.5-MVA switchgear x 18 (Refer to Figs. 13.11.2 and 13.11.3.)
2) Distribution equipment	1 set	34.5-kV CV 100 mm^2 x 3C 7,700 m 34.5-kV CV 250 mm^2 x 3C 400 m
3) Telephone equipment	1 set	Exchange 500 channels Telephone sets 500 units Underground conduit line 9,000 m
4) Road illumination equipment	1 set	Road length 15,000 m
5) Temporary power supply equipment	1 set	34.5-kV power receiving equipment x 1 6 MVA, 34.5/3.3 kV transformer x 1 3.3 kV switchgear x 3 Overhead lines OC 80 mm^2 11,500 m

Distribution system diagram and substation layout are shown in Figs. 13.11.3 and 13.11.4, respectively.

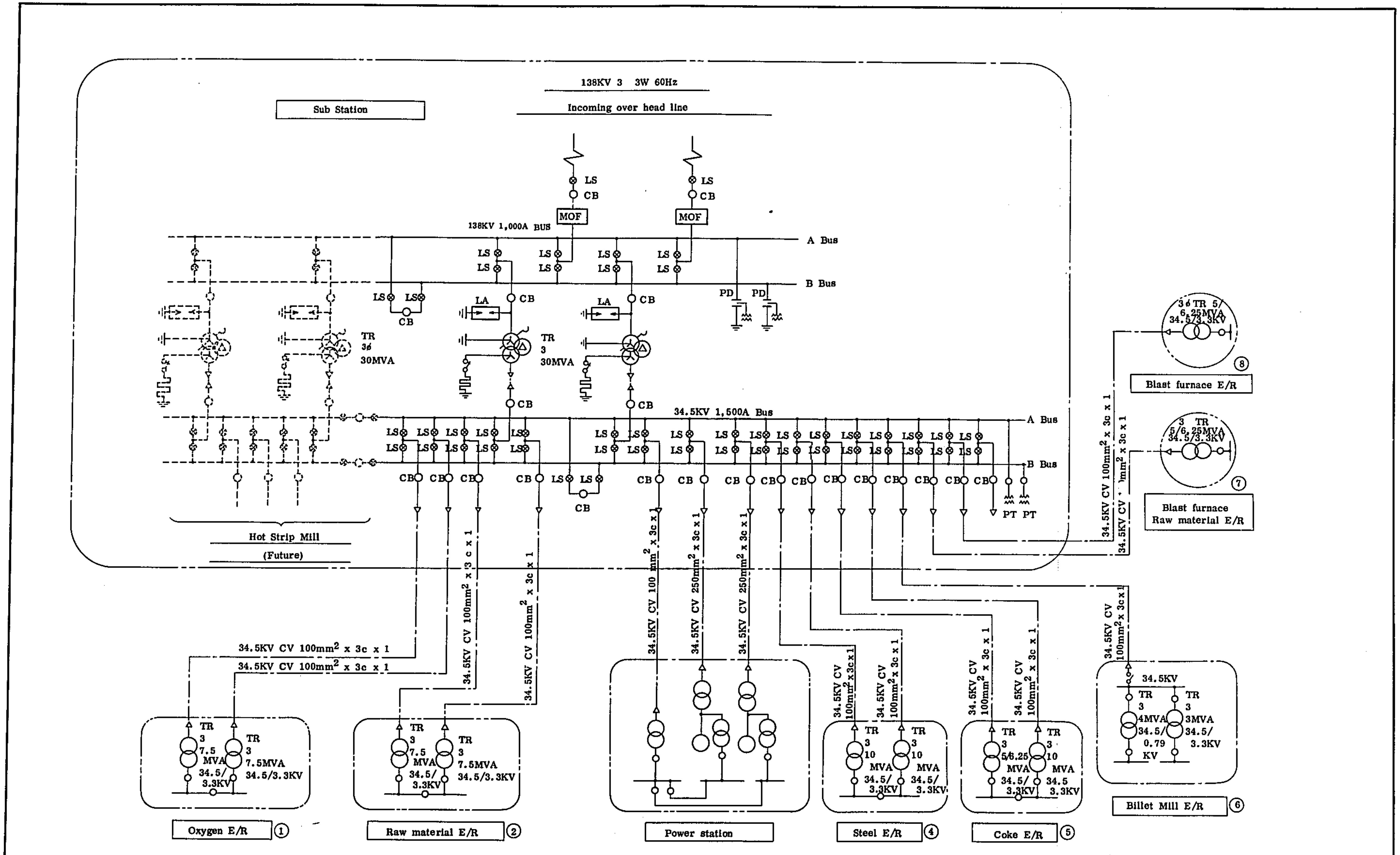


Fig. 13.11.3 Distribution system diagram

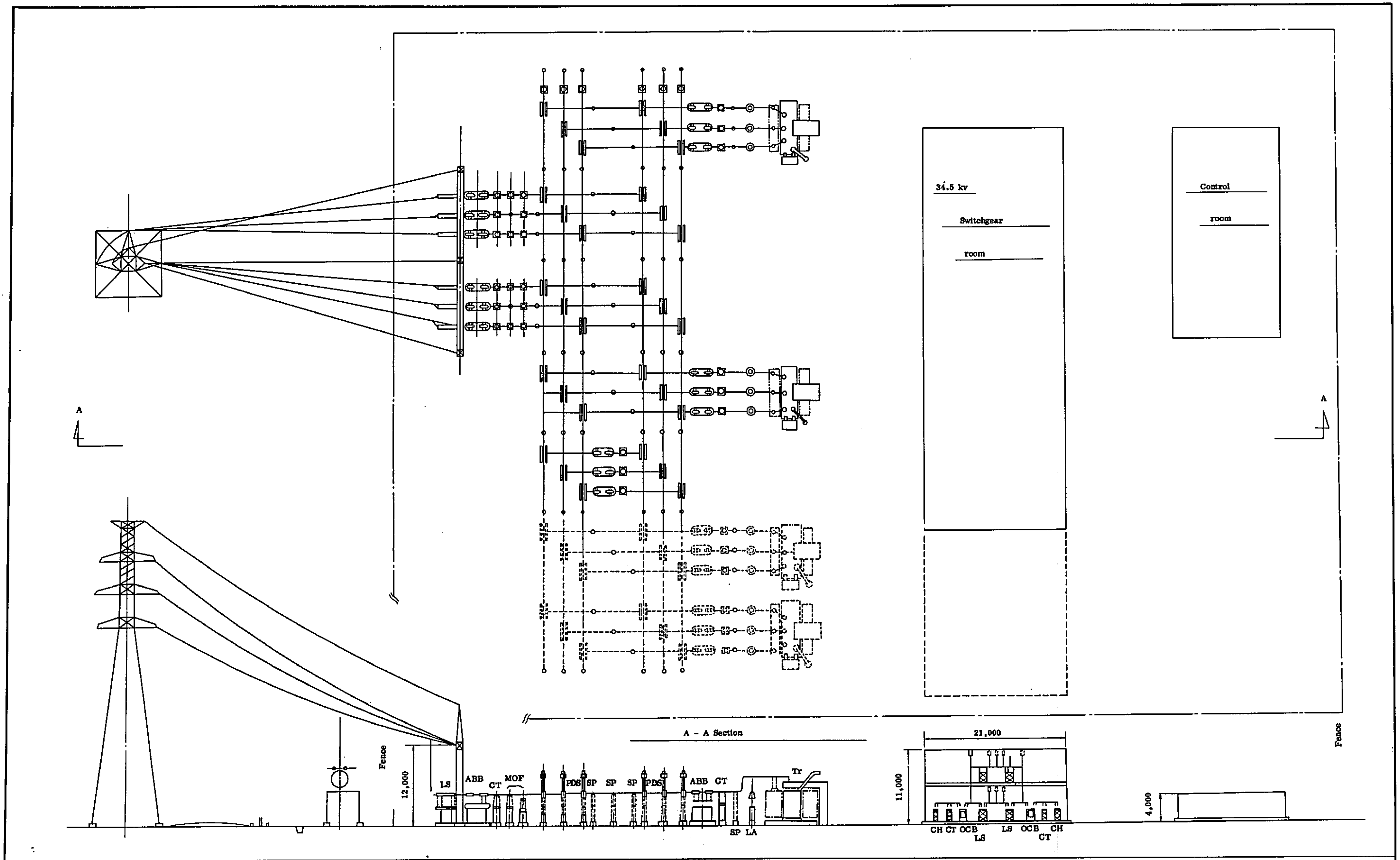


Fig. 13.11.4 Sub-station layout (1/500)

CHAPTER 13-12

POWER AND B.F. BLOWER PLANT

13.12 Blast blower and power plant

13.12.1 General

This plant is an equipment for driving blast blowers and generating power to be consumed within the works by making effective use of B- and C-gases generated in the works as by-products, and comprises two sets of boilers, turbines, power generators and blast blowers.

A generator and a blower are driven by the same steam turbine in a single set, and when a blast furnace is in operation, one set is used as a generator/blower and another set as a generator. An outline of one set of this equipment is shown in Fig. 13.12.1.

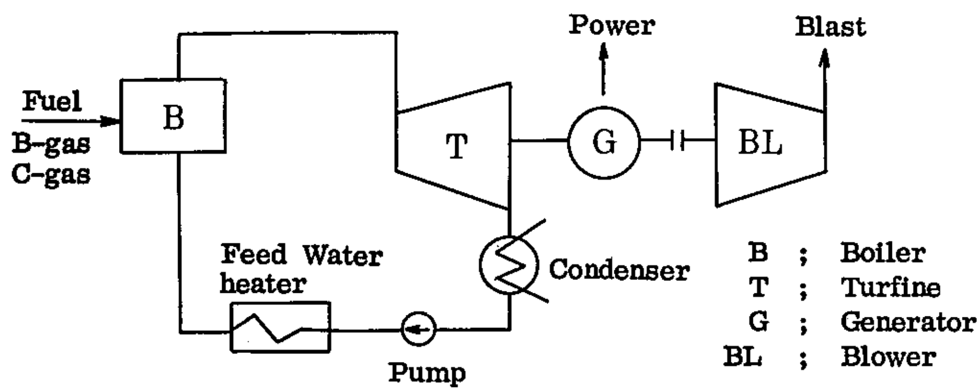


Fig. 13.12.1 Block diagram of the generator/blower system

13.12.2 Equipment specifications

(1) Production

Electric power and blast volume generated by two sets of the equipment in this plant in steady-state operation are as shown in Table 13.12.1.

Table 13.12.1 Power and blast volume generated by the blast blower power plant

	Turbine output	Blower shaft input	Output at sending end	
No. 1 unit	23,000 kW	*11,000 kW	12,000 kW	
No. 2 unit	23,000 kW	-	23,000 kW	
Total	46,000 kW		35,000 kW	

* (Note) Blower shaft input may fluctuate within the range of 10,000 kW - 14,000 kW with temperature changes (30°C - 35°C).

(2) Specifications of major equipment

Specifications of major equipment are shown in Table 13.12.2.

Table 13.12.2 Equipment specifications

Equipment	Qty	Specifications	
(1) Boiler	2	Quantity of evaporation Steam pressure Steam temperature	95 T/H 95 kg/cm^2 525°C
(2) Steam turbine	2	Output Revolution Degree of vacuum	23,000 kW 3,600 rpm 709 mmHg
(3) Generator	2	Output Voltage	23,000 kW 11,000 V
(4) Blast blower	2	Maximum blast volume Maximum pressure Normal blast volume Normal pressure Maximum shaft input	3,100 Nm^3/min 3.7 kg/cm^2 2,710 Nm^3/min 3.2 kg/cm^2 15,000 kW
(5) Temperature and pressure reducing device	2	Steam supply	30 T/H

(Note) The required shaft input of blower in normal blowing operation is 11,000 kW.

(3) Preconditions

1) Cooling water

- Kind	Seawater
- Temperature	Max. 30°C
- Quantity	15,400 m^3/H (for 2 units)

2) Fuel

- B-gas	Up to 90% of the required heat input of boiler can be supplied.
- C-gas	Up to 100% " "
- Heavy oil	Up to 65% " "

3) Air temperature

- Maximum	35°C
- Average	25°C

13.12.3 Rational

The power plant shall have such a capacity (equivalent to 46,000 kW) that can absorb B-gas and C-gas in steady state calculated from the gas balance at the annual crude steel production of 1.05 million ton. Preconditions of blast blowers shall be established based on the blast volume and pressure at the inlet of the hot blast stove calculated from the inner volume of blast furnace and top pressure with the assumed piping resistance of 0.2 kg/cm^2 between the blast blower/power plant and the hot blast stove.

Blast blowers will be designed in a 2-unit system because a stand-by unit is required for blast furnace operation.

In order to ensure stable operation for a long time, at least biennial periodical inspection works (work period: approx. 30 days) are required. Since construction of one more unit to absorb by-product gas released during such an inspection is uneconomical, the number of blast blowers will have to be limited to 2 units.

(1) Determination of installed capacity

1) Steam turbine output

In view of the precondition that the plant shall have such a capacity that can absorb B-gas and C-gas generated as a surplus from processes in the works in the gas balance, the output per unit of steam turbine has been set at 23,000 kW.

2) Blower capacity

Blast pressure has been set at 3.7 kg/cm^2, taking into consideration the required pressure at the inlet of the hot blast stove and piping resistance and other factors.

Blown air temperature	35°C
Relative humidity of blown air	75%
Delivery pressure	3.7 kg/cm^2
Delivery	3,110 Nm^3/min dry
Adiabatic efficiency of blower	85%

The required maximum shaft input of blower has been set at 15,000 kW by calculating from the data above and taking into account some allowances.

3) Introduction of T-G-BL

In view of the fact that a standby unit is required for blower, the T-G-BL system, which can increase the operating efficiency of the steam turbin of the standby unit and is most economical in effective use of energies available in the steel works, will be employed.

4) Steam conditions

In view of the fact that steam conditions greatly affect construction costs and thermal efficiency, high temperature and high pressure steam of 90 kg/cm^2, 520°C (at the turbine inlet), which is said to be most economical for 20,000 kW-class turbines, will be used.

13.12.4 Layout

The layout of the whole blast blower/power plant is shown in Fig. 13.12.2.

13.12.5 Technical explanation

Technical comments will be given as follows.

(1) Since this type of plant is almost completed technically, there will be no technical problems if only the plant is supplied by a specialized manufacturer.

(2) In general, blast blowers must be designed with full understanding of the blast furnace properties (blast pressure and blast volume). Blowers for this project will be designed so that they can be operated at their maximum efficiency under normal operating conditions and can be sufficiently operated in such conditions as a scaffolding removing and a blast pressure reducing operation with a sudden shock.

(3) Since blast blower operation is subject to considerable fluctuations depending on the operating conditions of the blast furnace, blowers will be equipped with high reliability protective equipment to prevent damages due to surging.

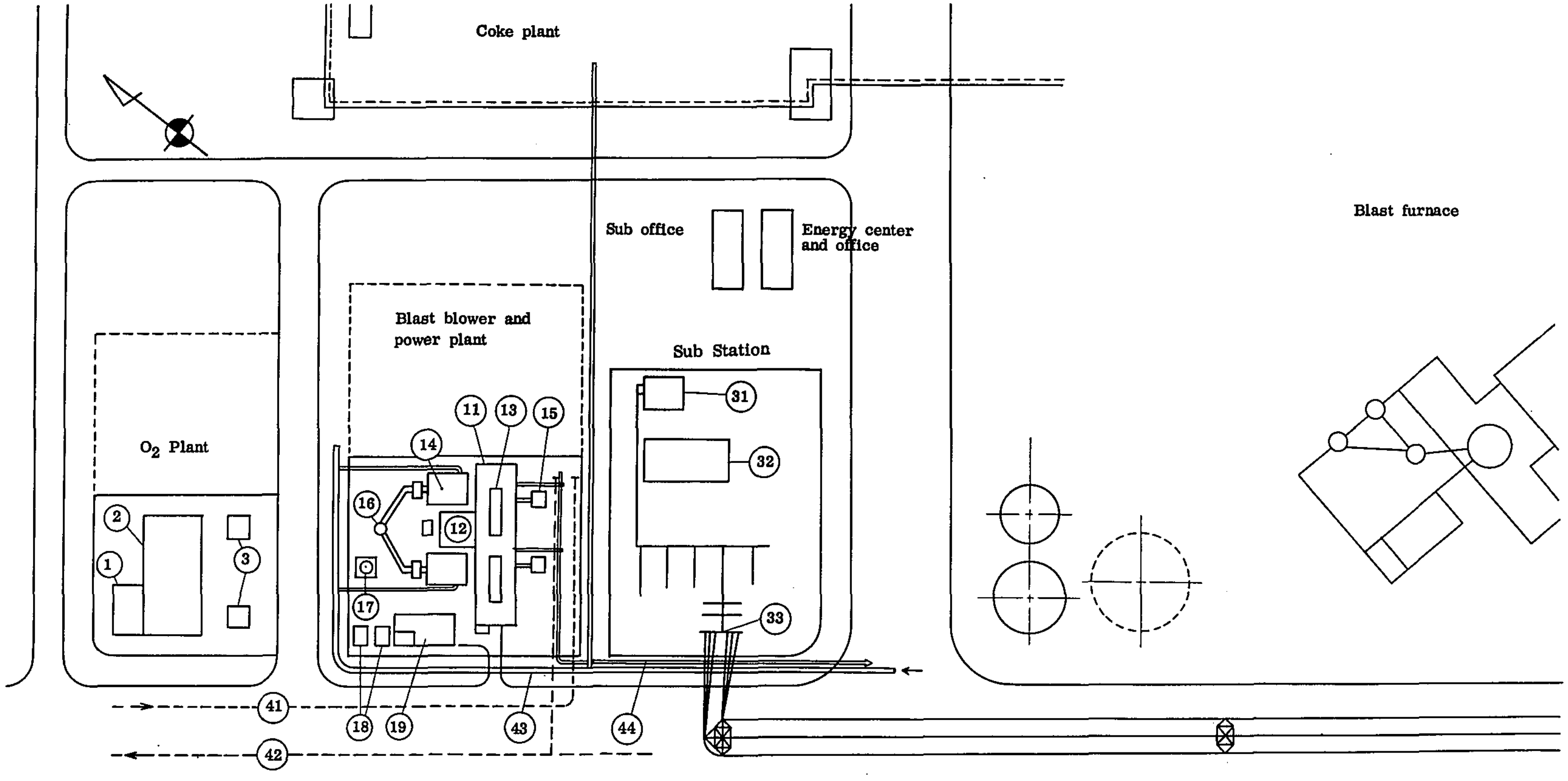
(4) Because the breakdown of blast blowers greatly affects the blast furnace, careful technical consideration will be given so as to ensure stable operation of blowers. Such measures include securing DC power supply and the use of interlock circuits.

(5) Blast blowers will be equipped with the constant blast flow control equipment to maintain constant flow of blast to the blast furnace in the normal operation.

(6) The power plant plays an important role in the effective use of gases in the steel works. In designing the power plant, therefore, due consideration will be given to enable frequent changeover of fuels, for example, through remote changeover of by-product gas and heavy

oil. (In this respect, a home power plant in a steel works differs from an ordinary thermal power plant.)

(7) The calorific value of by-product B-gas may suddenly change due to a slip in the blast furnace, causing the temporary extinguishing of the boiler and a subsequent explosion set off by fire in the boiler. To prevent this, a minimum quantity of C-gas will be fed to the boiler for safety.

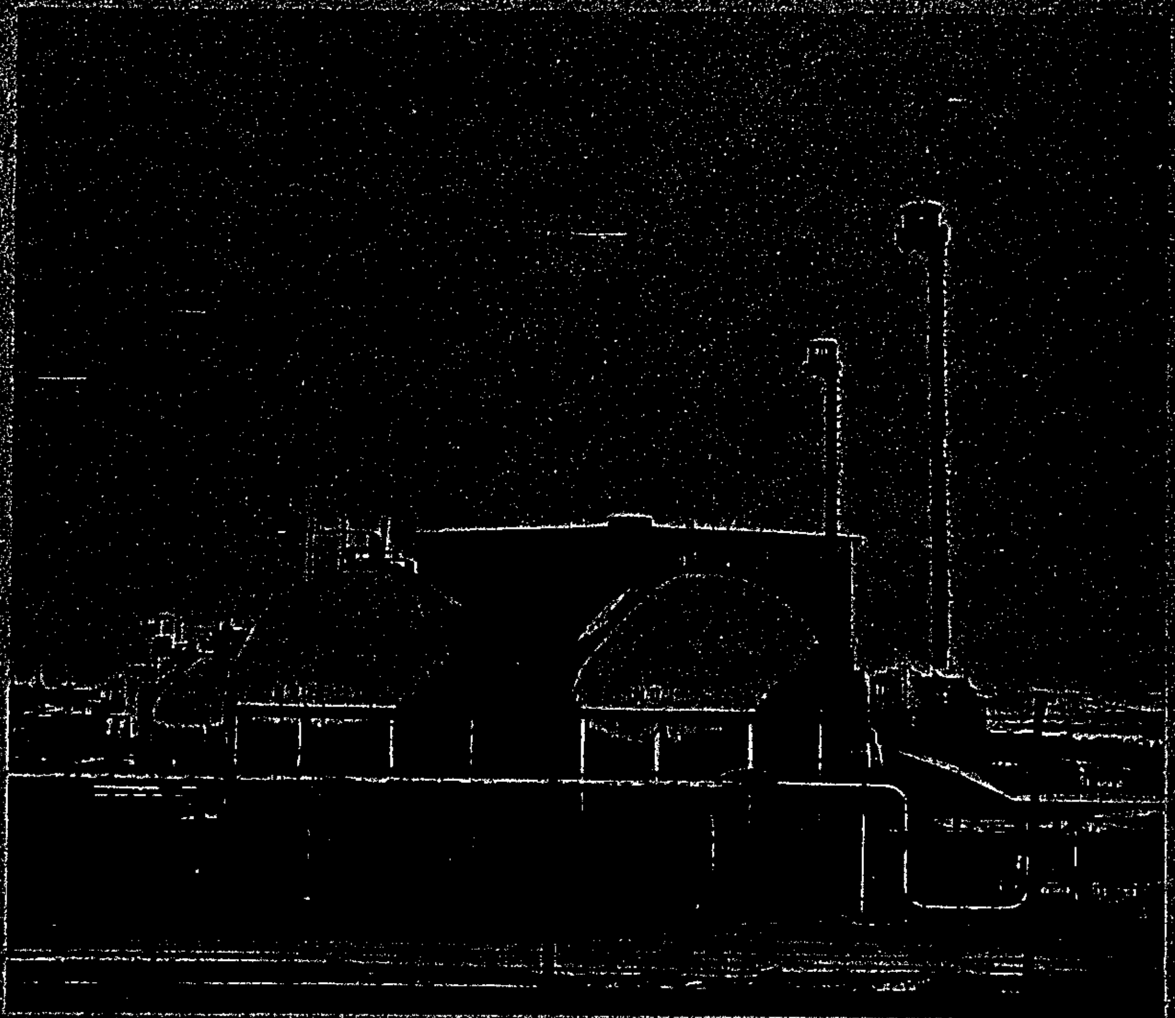


				44	Blast air pipe 1,400ϕ
13	Turbine, generator and blower	20		43	B-Gas pipe 2,600ϕ
12	Control Room	19	Water treatment	42	Effuent pipe
11	Turbine room	18	Low pressure boiler 7 T/hr	41	Supply pipe for sea water
		17	Fuel oil tank		
3	Air separator	16	Stack 70 m	33	Power receiving point
2	Compressor room	15	Bag filter	32	Electric room
1	Electric room and control room	14	Boiler 95 T/hr	31	Control room

Fig. 13.12.2 O_2 Plant and power station General layout

CHAPTER 13-13

OXYGEN PLANT



13.13 Oxygen plant

13.13.1 General description

This plant intended to manufacture and distribute oxygen, nitrogen and argon gases required in various steel-making processes, the oxygen plant consists of an air separator, oxygen compressor, nitrogen compressor, liquefied oxygen equipment and liquefied argon equipment.

13.13.2 Equipment specification

(1) Capacity, purity and pressure (See Table 13.13.1.)

Table 13.13.1 Capacity, purity and pressure of each gas

	Capacity	Purity	Pressure	Remarks
Oxygen gas	12,400 Nm^3/h	O_2 99.6 %	30.5 kg/cm^2	
Liquefied oxygen	600 Nm^3/h	O_2 99.6 %	-	Pressure after evaporation: 7 kg/cm^2
Nitrogen gas	2,500 Nm^3/h	N_2 99.9 %	6.0 kg/cm^2	O_2 = 0.1 %
Liquefied argon	60 Nm^3/h	Ar 98.0 %	-	Pressure after evaporation: 8 kg/cm^2

(2) Component equipment and their specifications (See Table 13.13.2.)

Table 13.13.2 Equipment specifications

Equipment	Qty	Specifications
1) Air separator		
Air absorption tower	1	Constructed of steel plate, 30 m high
Air filter	2	Capacity: 38,500 Nm^3/h; Type: Bag filter
Air compressor	2	38,500 Nm^3/h x 5.1 kg/cm^2; turbo-compressor
Trickling cooler	2 sets	Capacity: 38,500 Nm^3/h

Equipment	Qty	Specifications
Expansion turbine	2 sets (4)	8,900 Nm^3/h x 4.8 kg/cm^2; blower brake type
Reversing heat exchanger	2 sets	Capacity: 38,500 Nm^3/h
Rectifying colume	2 sets	6,200 Nm^3/h for O_2 and 2,500 Nm^3/h for N_2
Liquefied oxygen circulating pump	2 sets (4)	6,500 Nm^3/h x 20 m
Deicer	1 set	
Overhead crane	1 each	15 t x 14 m; 5 t x 14 m
2) Argon equipment		
Ar refining equipment	2 sets	30 Nm^3/h
Liq. argon storage tank	1	5 t
Liq. argon pump	1	30 Nm^3/h x 8 kg/cm^2
Liq. argon vaporizer	1	4,500 Kcal/h x 8 kg/cm^2
3) Oxygen gas compressor		
Medium-pressure oxygen		
Compressor	2	6,200 Nm^3/h x 5 kg/cm^2; turbo type
High-pressure oxygen compressor	3	6,200 Nm^3/h x 30.5 kg/cm^2; reciprocating type
4) Nitrogen gas compressor	2	2,500 Nm^3/h x 6.0 kg/cm^2; reciprocating type
5) Liquefied oxygen equipment		
Liq. oxygen storage tank	1	1,000 t
Liq. oxygen pump	1	2,500 Nm^3/h x 7 kg/cm^2
Liq. oxygen vaporizer	1	300,000 Kcal/h

Equipment	Qty	Specifications
6) Electrical equipment	1 set	12,800 kW
7) Building	1 set	Compressor room: 1,800 m^2 Electric room & control room: 375 m^2

13.13.3 Bases of planning

It seems logically possible that a single plant will be enough to meet the requirements for oxygen (12,400 Nm^3/h), nitrogen (2,500 Nm^3/h) and argon (20 Nm^3/h) of the new steel works with a production capacity of 1,050,000 t/Y of crude steel. Should any trouble occur or when the singly installed capacity is subjected to scheduled maintenance, however, the result will be a total paralysis of the integrated steelworks. This is especially true where no alternative to that source is available like the planned steelworks. This consideration has led us to plan a dual-plant configuration and, in addition, a liquefied oxygen plant so that about 70% of the total oxygen requirement can be satisfied by the remaining one even when either one is shut down.

(1) Capacity of oxygen gas

The production capacity of oxygen gas has been planned at a level that will satisfy all the oxygen requirements of BOF and CC Plant as well as those for construction work and other non-productive purposes.

(2) Capacity of nitrogen gas

It has been planned that each oxygen plant can produce 2,500 Nm^3/h of nitrogen gas so that it can meet the nitrogen gas requirements of the steelworks as a whole even when either one of the plants is shut down.

(3) Argon equipment

The argon equipment has been planned to be capable of meeting the argon requirement of the CC Plant. Argon shall be produced as liquefied argon and vaporized when required for distribution to each user. The planned liquefied argon storage tank has a capacity of 5-day supply.

(4) Liquefied oxygen plant

This plant is planned to have a capacity that can meet 70% of the total oxygen gas requirement of the entire steelworks when either one of the proposed oxygen plants is shut down. Usually, 5% or less of gaseous oxygen will be taken as liquefied oxygen and stored in the liquefied oxygen storage tank in amounts equal to a 2-week supply.

(5) Stand-by equipment

Since 2 air separation plants have been planned, as already stated, for safety considerations, only one each of reciprocating compressors has been planned as a stand-by necessary in ordinary maintenance.

(6) Gas flow

1) Oxygen gas flow (See Fig. 13.13.1.)

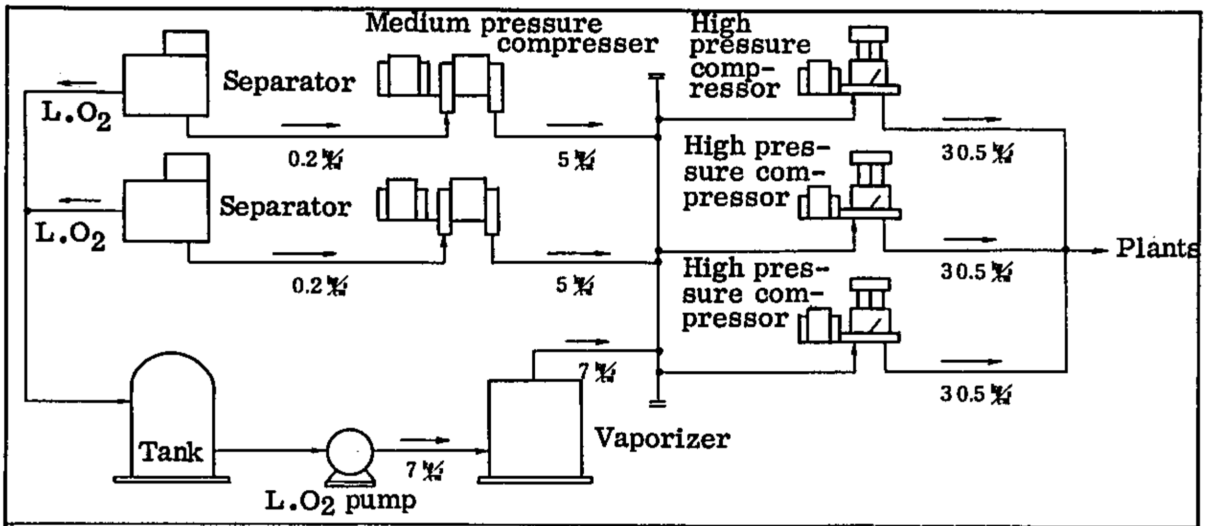


Fig. 13.13.1 Oxygen gas flow

2) Nitrogen/argon gas flow (See Fig. 13.13.2.)

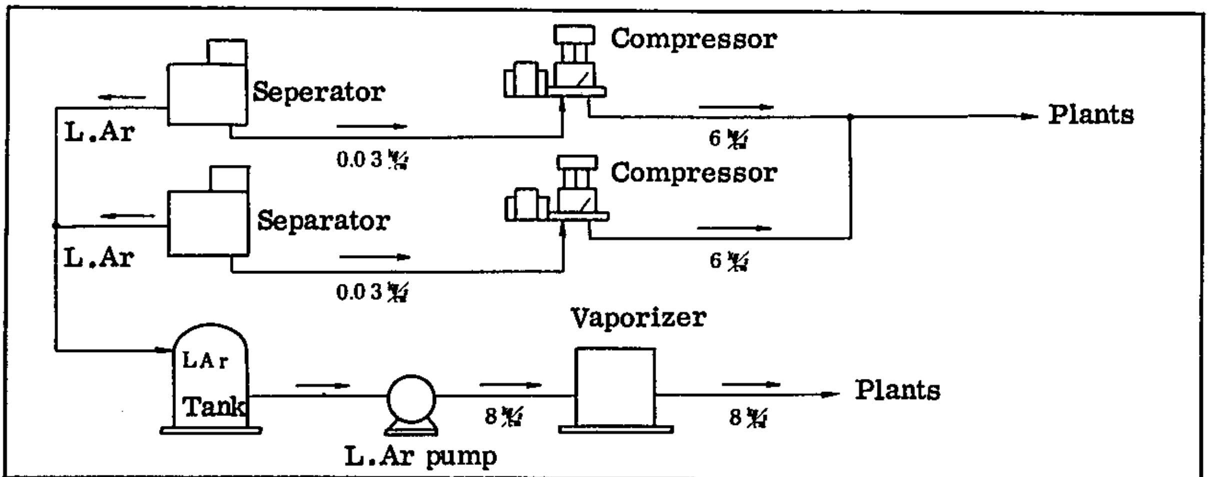


Fig. 13.13.2 Nitrogen/argon gas flow

13.13.4 General layout of oxygen plant

The general layout of the oxygen plant is provided in Fig. 13.13.3.

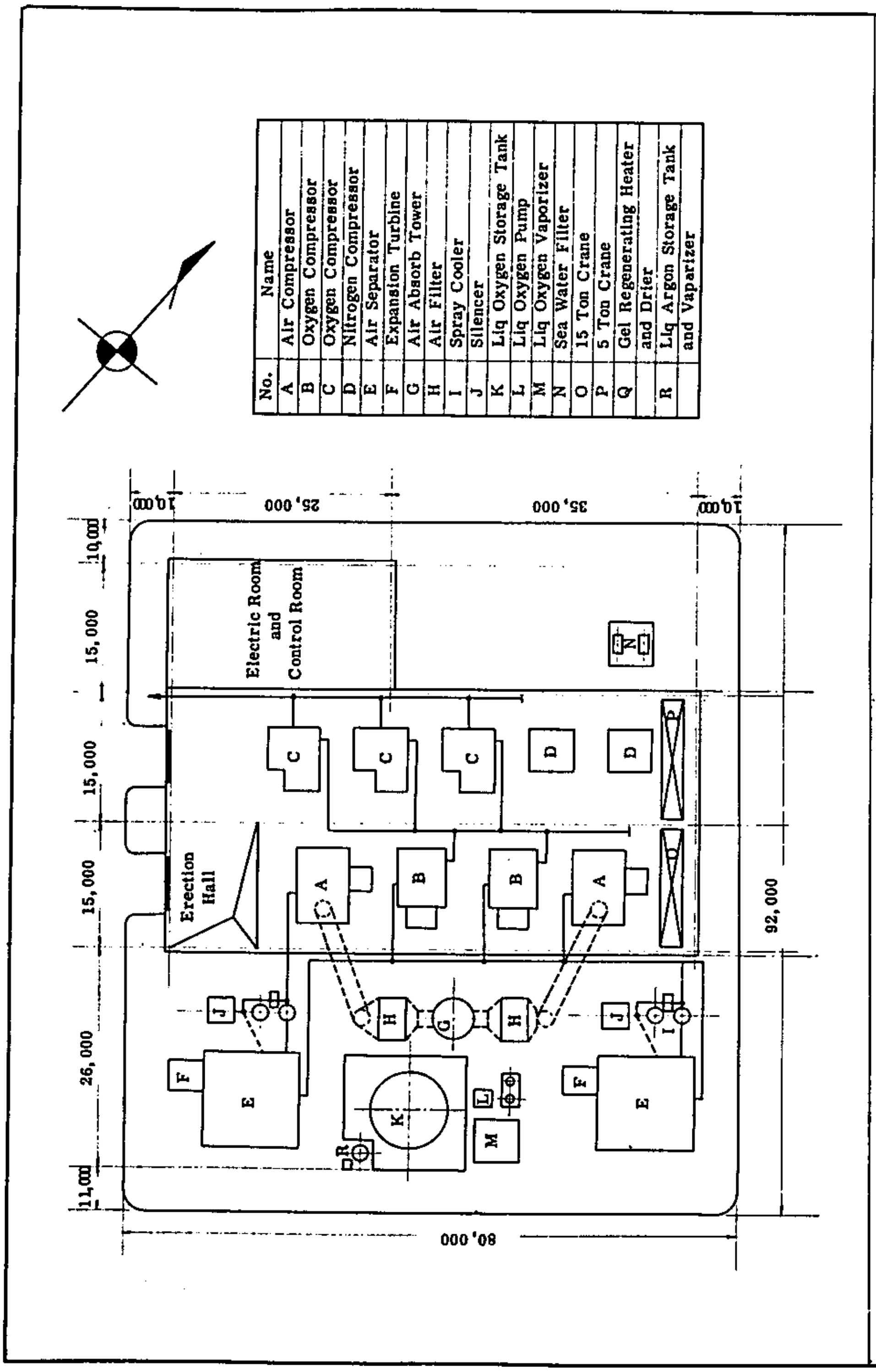


Fig. 13.13.3 Oxygen plant layout

13.13.5 Technical explanation

(1) Special notes

1) The air separation plant can operate for a year without interruption, though the maximum period for which reciprocating compressors can operate on an uninterrupted basis will be a month.

2) It is necessary to discharge at all times liquefied oxygen in amounts at least 1% of the toral output of oxygen gas in order to prevent explosion or fire.

3) For the same reason, the hydrocarbon content of liquefied oxygen shall be controlled to 40 mg or less per litre of liquefied oxygen.

4) The purities of nitrogen gas and argon provided in Table 13.13.1, 99.9% and 98%, respectively, mean that the nitrogen gas and liquefied argon produced contain 0.1% or less and 2% or less oxygen, respectively. In other words, each contain impurities other than oxygen.

5) Actual production of each gas should vary with atmospheric conditions. (The present plan assumes atmospheric temperature at 30°C, atmospheric pressure at 760 mm Hg and relative humidity at 80%.)

6) Up to 6,000 Nm^3/h of nitrogen gas and up to 90 Nm^3/h of argon may be taken from each plant if required.

7) The air separators can be operated at loads down to 70% of the rated capacity.

8) In operating the oxygen plant, particular care should be taken to keep it away from oil.

(2) Start-up conditions

1) Prerequisites: Required amounts of electricity, cooling water and steam shall be available.

2) Start-up time: It will be about 50 hours between initiation of cooling and the first yield of product gas. The plant can restart operation in 2 to 10 hours after temporary shut-down once it is started up. (Such a temporary shut-down shall not run for more than 5 days.)

3) The total time required to deice will be approx. 24 hours per plant.

CHAPTER 13-14

FUEL FACILITIES

13.14 Fuel facilities

13.14.1 General description

Fuel facilities comprises equipment for supplying blast furnace gas (B.F.G.) and coke oven gas (C.O.G.) generated in the works and heavy oil as a purchased fuel to each user plants. In addition, a fuel distribution center will be established for the effective use of these fuels. Package-type boilers for general service steam for use in plants will also be included.

13.14.2 Equipment specifications

Specifications of fuel facilities are shown in Table 13.14.1.

Table 13.14.1 Equipment specifications

Equipment	Qty	Specifications	
(1) B-gas holder	1	Capacity	40,000 m^3
		Pressure	550 mmH_2O
(2) C-gas holder	1	Capacity	30,000 m^3
		Pressure	600 mmH_2O
(3) B-gas flare stack	1	Discharging capacity	
			Max. 160,000 Nm^3/H
		Diameter	1,500 mmø
		Height	50 m
(4) C-gas flare stack	1	Discharging capacity	
			Max. 34,000 Nm^3/H
		Diameter	600 mmø
		Height	50 m
(5) Heavy oil tank equipment			
Heavy oil tank	1	Capacity	3,500 ton
		Inside diameter	18,000 mmø
		Height	16 m

Table 13.14.1 (contd.)

Equipment	Qty	Specifications
Oil feed pumps	2	Delivery capacity 15 ton/H Pressure 15 kg/cm^2G
(6) C-gas blowers	2	Capacity 6,000 Nm^3/H Delivery pressure 1,300 mmH_2O
(7) Boilers for general service steam	2	Capacity 7 ton Steam pressure 12 kg/cm^2G Fuel C-gas
(8) Fuel distribution center		Will be set up on the second floor of the Energy Department office.

13.14.3 Fuel system flow

(1) B-gas flow

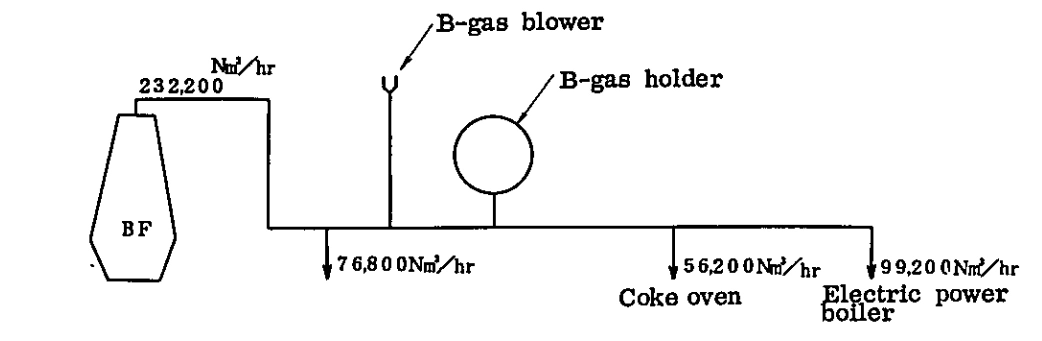


Fig. 13.14.1 B-gas flow

(2) C-gas flow

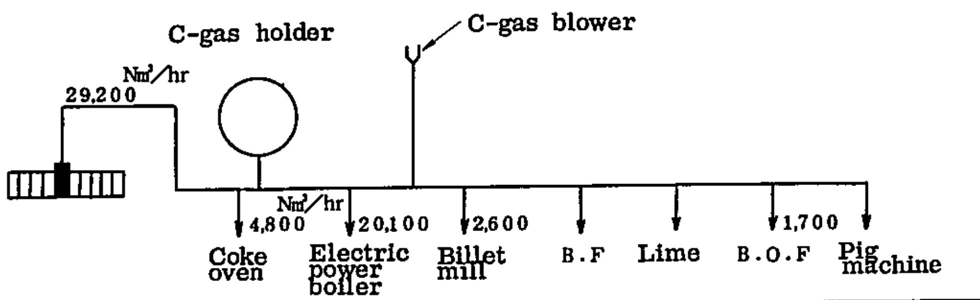


Fig. 13.14.2 C-gas flow

(3) Heavy oil flow

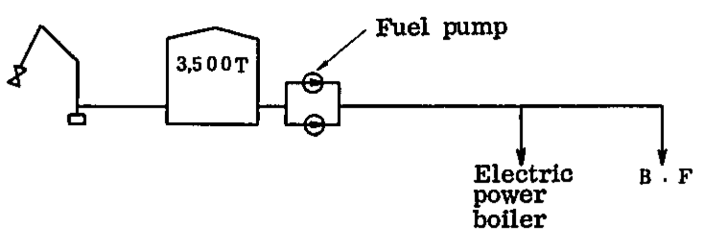


Fig. 13.14.3 Heavy oil flow

13.14.4 Bases of planning

In designing fuel facilities, due consideration has been given to ensure the effective use of fuels generated in the new steel works with the annual crude steel production of 1.05 million ton to cope with fluctuations in fuel consumption in each user plant.

(1) The capacity of the B-gas holder has been set at 40,000 m^3, taking into consideration the capacity required for users to switch over fuels in a sudden blowing-down of the blast furnace.

(2) The capacity of the C-gas holder has been set at 30,000 m^3 taking into consideration the capacity required for users to switch over fuels.

(3) The capacity of the B-gas flare stack has been set at 160,000 Nm^3/H, the quantity obtained by deducting consumption in the hot blast stove from B-gas production.

(4) The capacity of the C-gas flare stack has been set at 34,000 Nm^3/H, total C-gas production.

(5) The capacity of the heavy oil tank has been set at 3,500 ton, taking into consideration normal consumption and the size of ships. However, one more unit will have to be added before the periodical structural inspection.

(6) The capacity of the C-gas blower has been set at 6,000 Nm^3/H, to meet the maximum consumption at user plants.

(7) The capacity of boiler for general service steam has been set at 14 ton/H, taking into consideration average consumption and the load factor of boiler, and has been divided into two units of 7 ton/H each.

In a blowing-down of the blast furnace where a large quantity of steam is required, steam will be supplied by the power generating boiler after the temperature and pressure of steam are lowered (max. 30 ton/H).

(8) In the fuel distribution center, production of B- and C-gases and

receiving of heavy oil and their consumption will be monitored and the fuel facilities will be remotely controlled. The control of steam, however, will be made in the power plant because it has no direct connection with fuels.

13.14.5 Layout of gas holders

The layout of gas holders is shown in Fig. 13.14.4.

13.14.6 Technical notes

(1) Conditions at start-up

Among fuel facilities, heavy oil equipment has a special relation with the start-up of the power plant. It should be therefore completed about a month before the test run of the power plant.

(2) Gas holders

A B-gas holder with a capacity of 150,000 m^3 will be constructed in the future, and the 40,000-m^3 B-gas holder to be designed at this stage will be used as a C-gas holder. For this reason, the B-gas holder will be designed at the same design pressure as that of the C-gas holder.

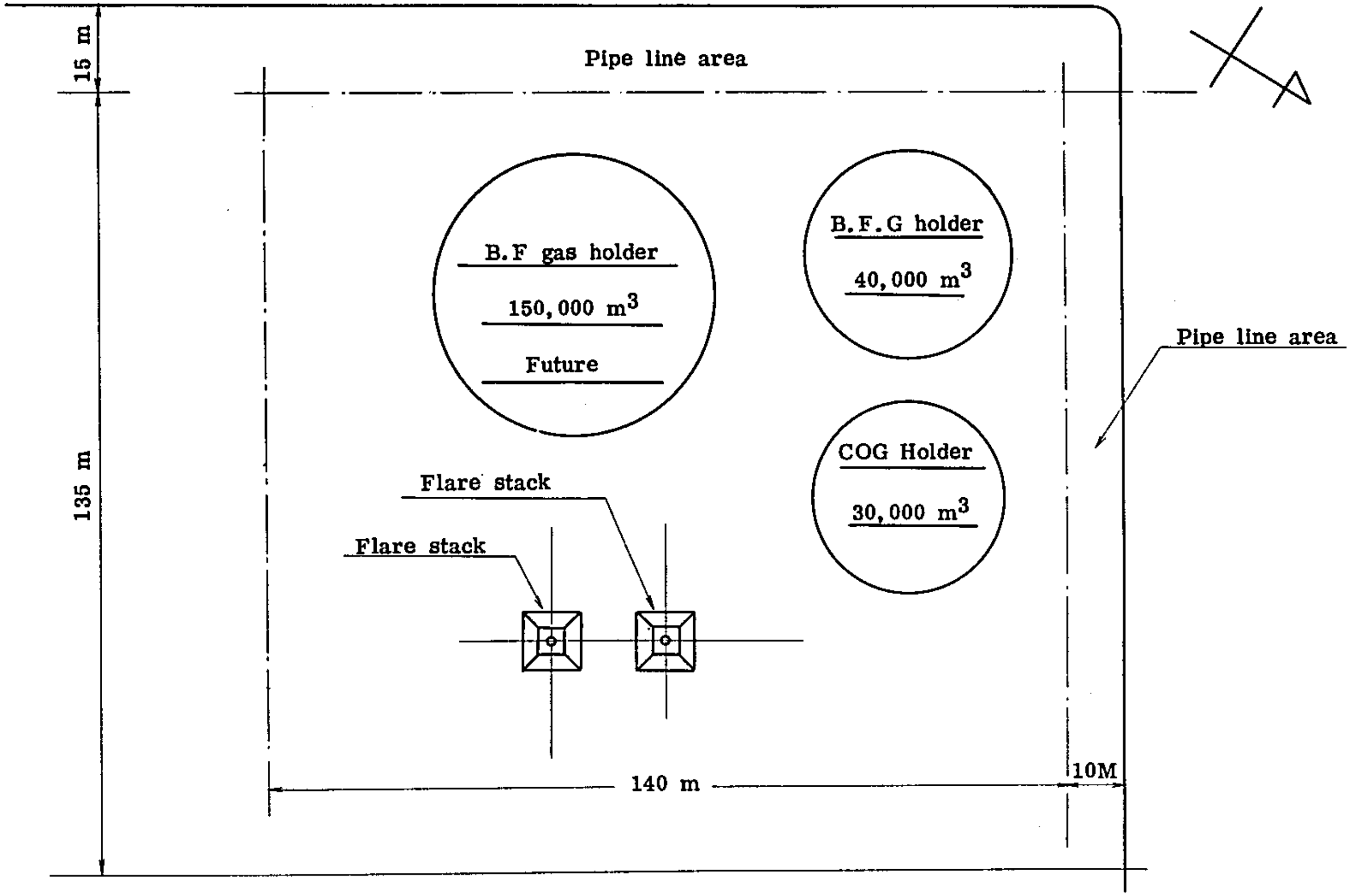


Fig. 13.14.4 Gas holder layout

CHAPTER 13-15

MAIN PIPING

13.15 Main pipings

13.15.1 General description

The overall yard piping has been so planned and designed that blast furnace gas, coke oven gas, oxygen and nitrogen gas produced at the oxygen plant, heavy oil and steam can be used effectively at each stage of users (process equipment).

The system consists mainly of large-diameter gas lines, upon which smaller pipe lines rest.

The system consists mainly of large-diameter gas lines, upon which smaller pipe lines rest.

The mains for BFG has been planned so that it can serve through the second stage of the project.

13.15.2 Equipment specification

The main specifications of yard piping are provided in Table 13.15.1.

Table 13.15.1 Equipment specifications of yard piping

Line	Pipe dia., mmø	Line length, m	Remarks
(1) BFG line			
Mains	3,200	800	Material: SS
To gas holder	2,200	100	"
To coke plant	1,500	300	"
To power generation plant	2,600	350	"
(2) COG line			
Mains (1)	1,800	550	"
Mains (2)	800	150	"
To power generation plant	1,200	300	"

Line	Pipe dia., mm	Line length, m	Remarks
To gas holder	1,000	100	Material: SS
To BF	250	150	SGP
To BOF	600	700	SS
To billet mill	350	100	SGP
To pig casting machine	200	1,000	"
(3) BF blast line	1,400	900	SS
(4) Steam line			
Mains	250	800	SGP
To BF	200	200	"
To BOF	125	300	"
To billet mill	50	100	"
To coke plant	150	300	"
To power generation plant	200	250	"
To oxygen plant	50	50	"
To heavy oil tank	100	1,700	"
To office	50	500	"
To pig casting machine	50	1,000	"
(5) Oxygen line			
To BOF	150	1,300	STPG
(6) Heavy oil line			
Mains	100	2,300	SGP
To BF	100	150	"

Line	Pipe dia., mm	Line length, m	Remarks
To power generation plant	100	150	Material: SGP
(7) Nitrogen line			
Mains	150	800	SGP
To BF	150	200	"
To BOF	150	400	"
To coke plant	25	300	"

13.15.3 Cross-section of pipe line

The cross-sectional view of the line pipe system is provided in Fig.

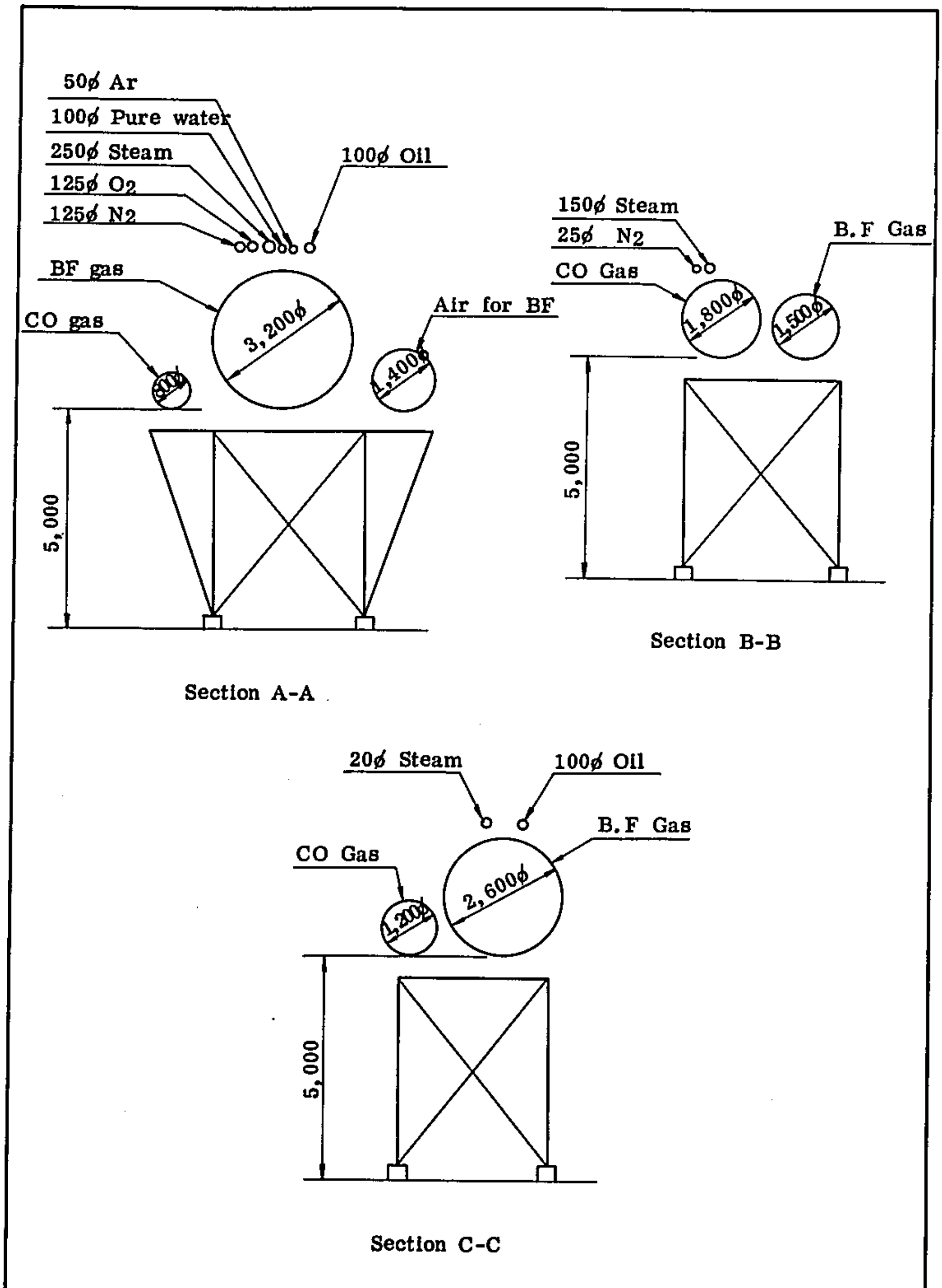


Fig. 13.15.1 Cross-section of pipe line

CHAPTER 13-16

WATER SUPPLY FACILITIES

13.16 Water supply facilities

13.16.1 General

The steel works relies on two sources for its water requirements: sea water and river water. Water taken from river first enters the reservoir. Water leaving the reservoir is sent to the central potable water/industrial water station, where it is treated in the coagulation basin and separated into the potable water system and industrial-water system.

The industrial water thus separated is distributed through an industrial-water line via head tank to each water recirculation system for use as make-up water.

Potable water, on the other hand, is filtered and sterilized in the filtration plant after being treated in the aforesaid coagulation basin, and is distributed through a potable water line via head tank as cooling and/or service water.

Sea water will be taken from the sea area near the end of the new steelworks and transported, after being filtered and sterilized by the travelling screen, to the blast furnace, oxygen, coke-oven and coke by product plants and the power station.

The installed capacity of the water supply facilities has been planned as follows in consideration of economy and future expansion:

The potable -water/industrial-water center, potable -water pipe line system and industrial-water pipe line system, part of sea water pumps and equipment related to sea water supply line shall have an installed capacity suitable for the operation stage with one blast furnace, while the water reservoir and the remaining part of the sea water pumps shall have a capacity enough to meet the water requirements expected to arise through the second stage.

13.16.2 Basic assumptions

Our planning for the water supply facilities is based on the assumptions as defined in Table 13.16.1 below.

Table 13.16.1 Basic assumptions for planning of water facilities

Water reservoir facilities	Water level: H.W.L.: E.L. + 7.00, L.W.L: E.L. + 1.0 (G.L. : E.L. + 6.40) Capacity: 60,000 m
Potable-water/industrial-water center facilities	For industrial water Throughput: 1,400 m^3/hr Raw water quality: SS - max. 1000 ppm; average - 30 ppm; PH - 5.8 to 8.6 Quality of treated water: SS $\leq$ 15 ppm; PH 5.8 to 8.6. For other variables, to be in accordance with Japanese standards for the quality of industrial water. Water temp.: 29°C ± 5°C For potable water Throughput: 600 m^3/hr Raw water quality: SS - 15 ppm, PH - 5.8 to 8.6 Quality of treated water: Turbidity - not more than 2°; PH - 5.8 to 8.6; For others, to be in compliance to the Japanese standards for the quality of potable water. Water temp.: 29°C ± 5°C Supply system: Potable water will be supplied through an head tank (with a capacity of 100 m^3 and 30 m head). Industrial water will be supplied through a head tank (with a 200-m^3 capacity and 30-m head). Even in power supply trouble, the necessary minimum amount of industrial water can be supplied using a Diesel Pump.

Potable water line facilities	Capacity: 400 m^3/hr for each plant; service water 200 m^3/hr; total population which the facilities can serve - 10,000
Industrial-water line facilities	Capacity: 800 m^3/hr for each plant
Sea water pump station facilities	Water intake: Destination / Water flow (m^3/hr) / Pressure (kg/cm^2) Power station: 15,400 / 1.5 Coke by-product: 1,920 / 3.0 Coke oven plant: 40 / 2.0 Oxygen plant: 1,650 / 3.0 BF plant: 2,000 / 2.0 Total: 21,000 Sea water temp.: Approx. 30°C Water level: Sea water level HWL + 1,280; LWL ± 0 Sea water pump station GL + 4,000; plant site level + 5,000 to 6,400
Sea water line facilities	Capacity: No. 1 line to Power Station: 15,400 m^3/hr No. 2 line to coke-BF product, coke oven, oxygen and BF plants: 5,600 m^3/hr

The flow chart of the water supply system is shown in Fig. 13.16.1.

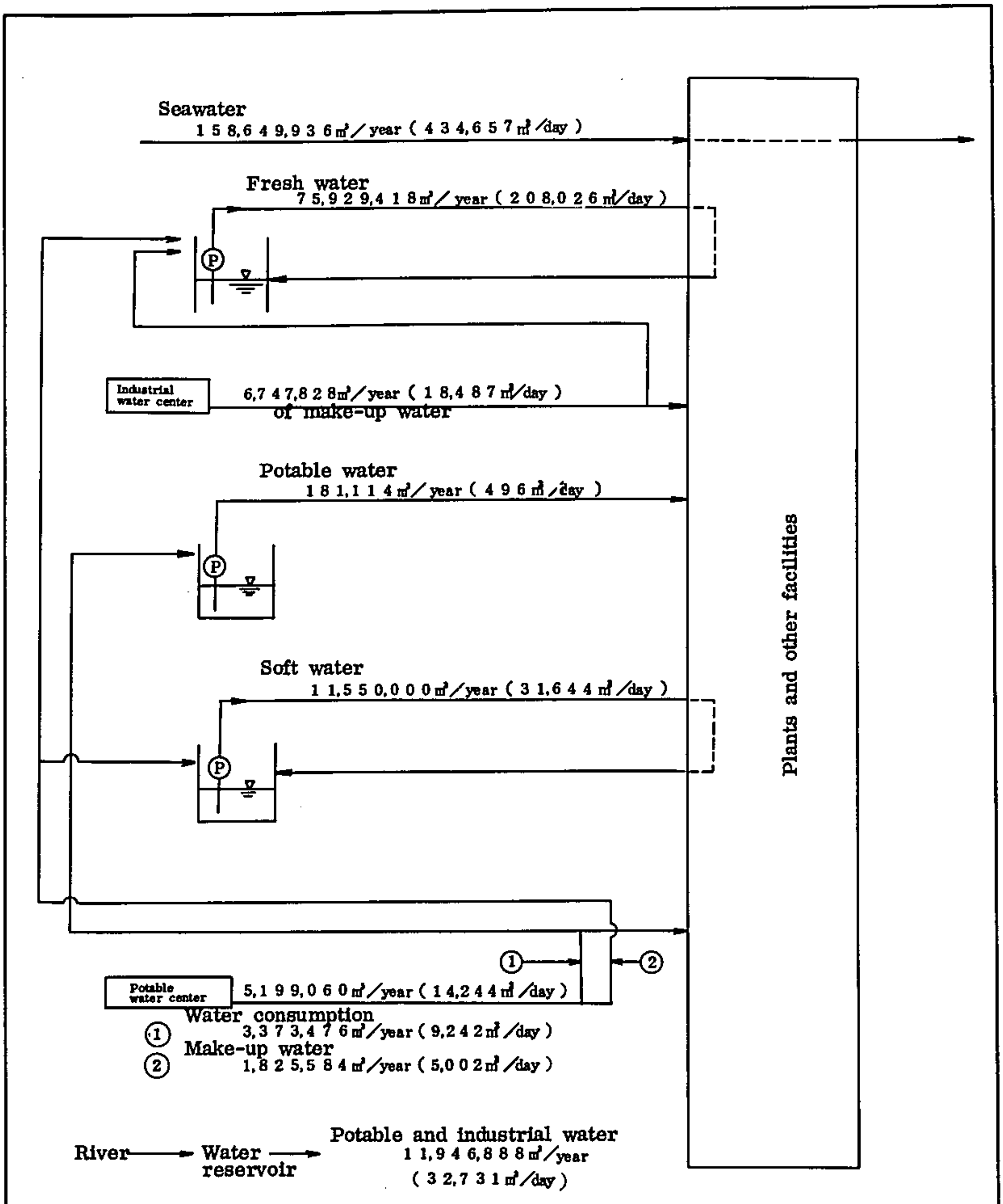


Fig. 13.16.1 Flow chart of water system

13.16.3 Equipment specifications

The main equipment specifications for the water supply facilities are provided in Table 13.16.2.

Table 13.16.2 Equipment specifications

Equipment	Specification/dimensions	
(1) Water reservoir facilities	Semi-underground; 100 m x 100 m x 6 mH 60,000 m^3/reservoir	
(2) Potable water/industrial water center facilities	Coagulation basin	1,575 m^3/basin
	Treated water tank	960 m^3/tank
	Filtration tank	10 m x 20 m x 5 mH (for drinking water)
	Potable water storage tank	4,000 m^3/tank (for potable water)
	Sterilizing equip't	1 set (for potable water)
	Head tank	200 m^3/unit (for industrial water)
	Head tank	100 m^3/unit (for potable water)
	Pumps and others	1 set
(3) Potable water line facilities	1 set of valves and piping downstream the head tank (2) above	
(4) Industrial water line facilities	1 set of valves and piping before and behind the head tank (2) above.	
(5) Sea water pump station facilities	Water intake tower	8 mø x 2.5 mH x 2 units
	Screening facilities	1 set
	Water supply tank	1,500 m^3/tank x 2 tanks
	Sodium hypochlorite generator	1 set

13.16.4 Layout plan and flow sheet

(1) Overall layout plan — Fig. 13.16.2

(2) Water reservoir facilities — Fig. 13.16.3

(3) Potable water line facilities — Fig. 13.16.4

(4) Industrial water line facilities — Fig. 13.16.5

(5) Sea water line facilities — Fig. 13.16.6

(6) Sea water line layout — Fig. 13.16.7

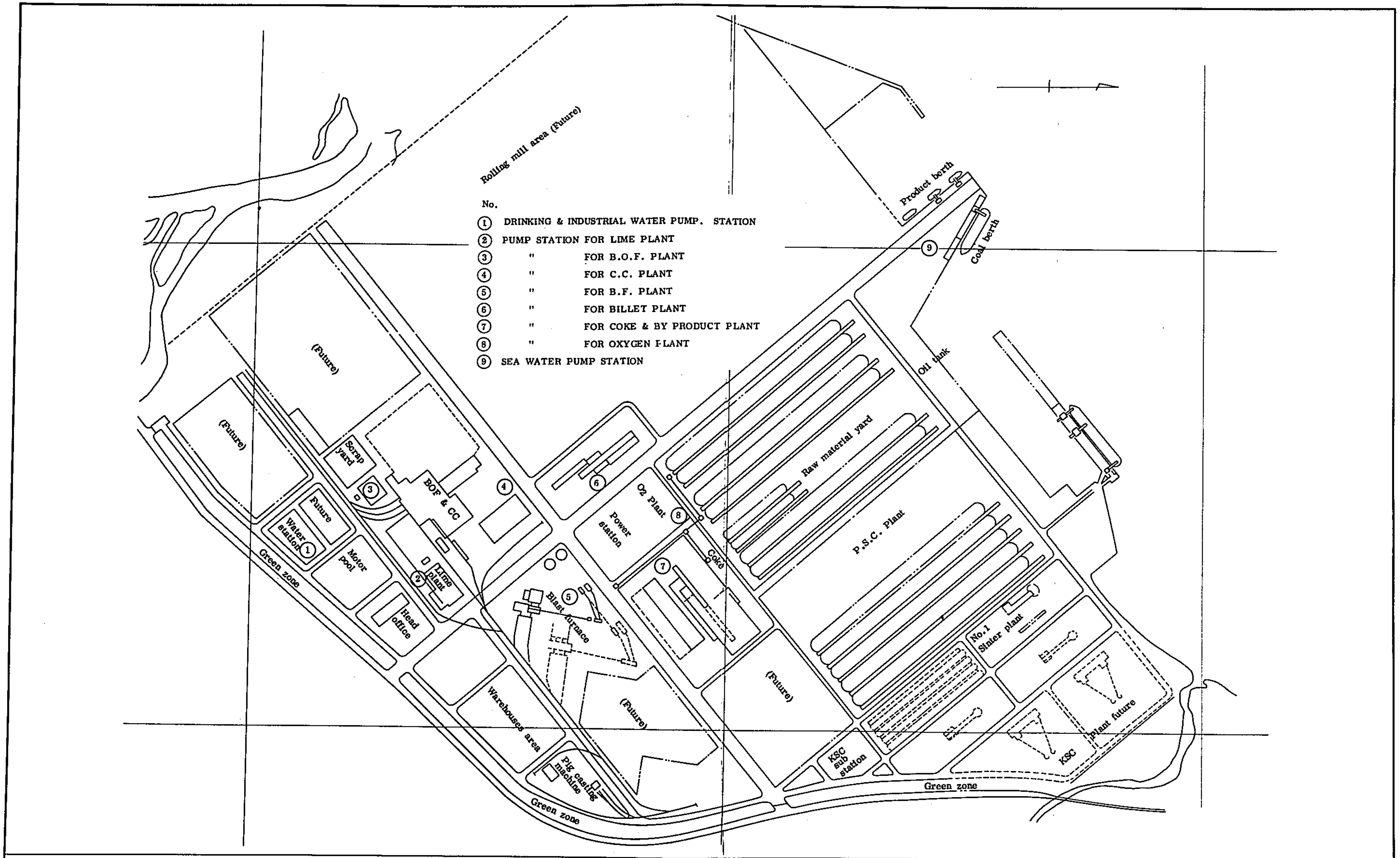


Fig. 13.16.2 Overall layout plan

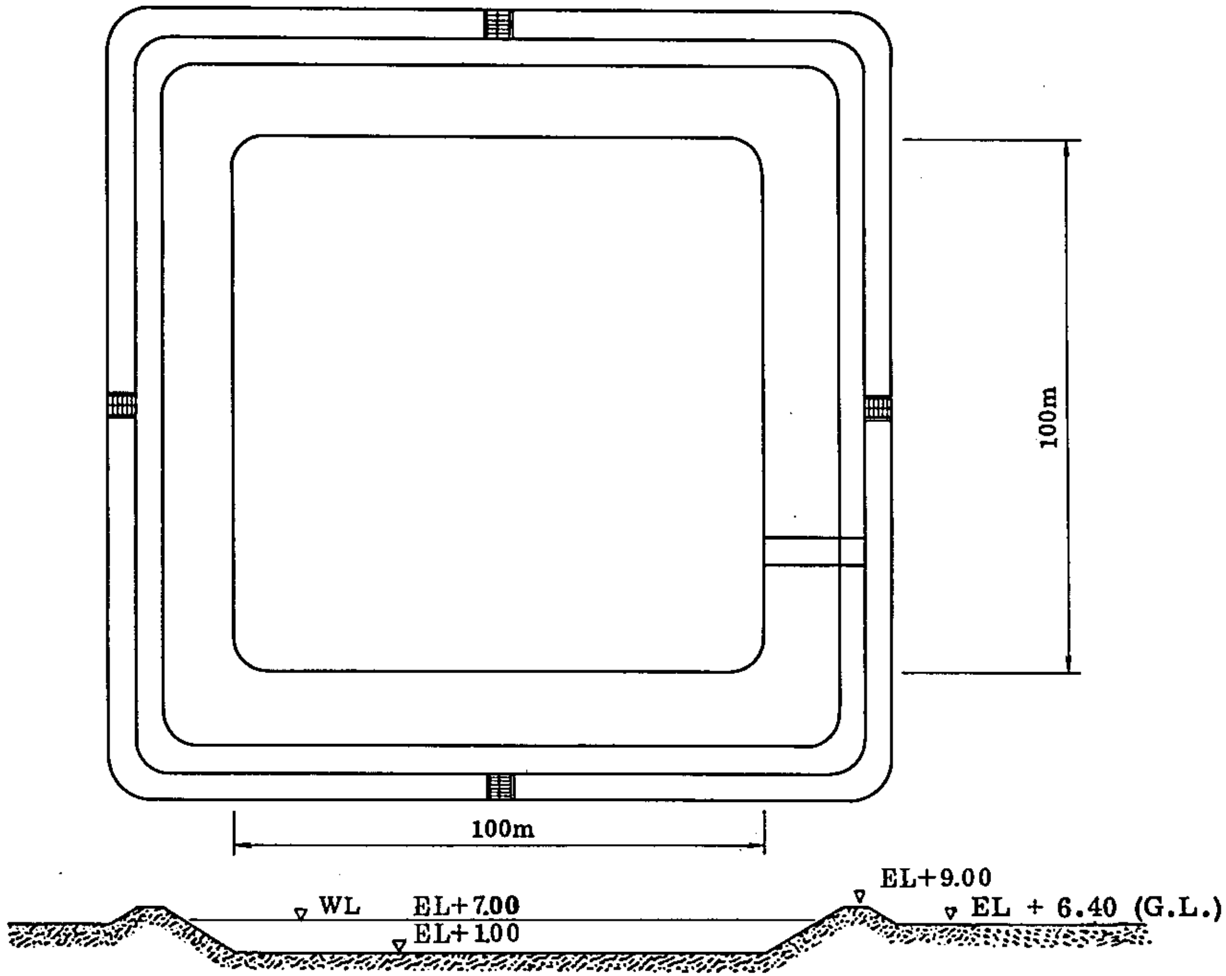


Fig. 13.16.3 Water reservoir facilities

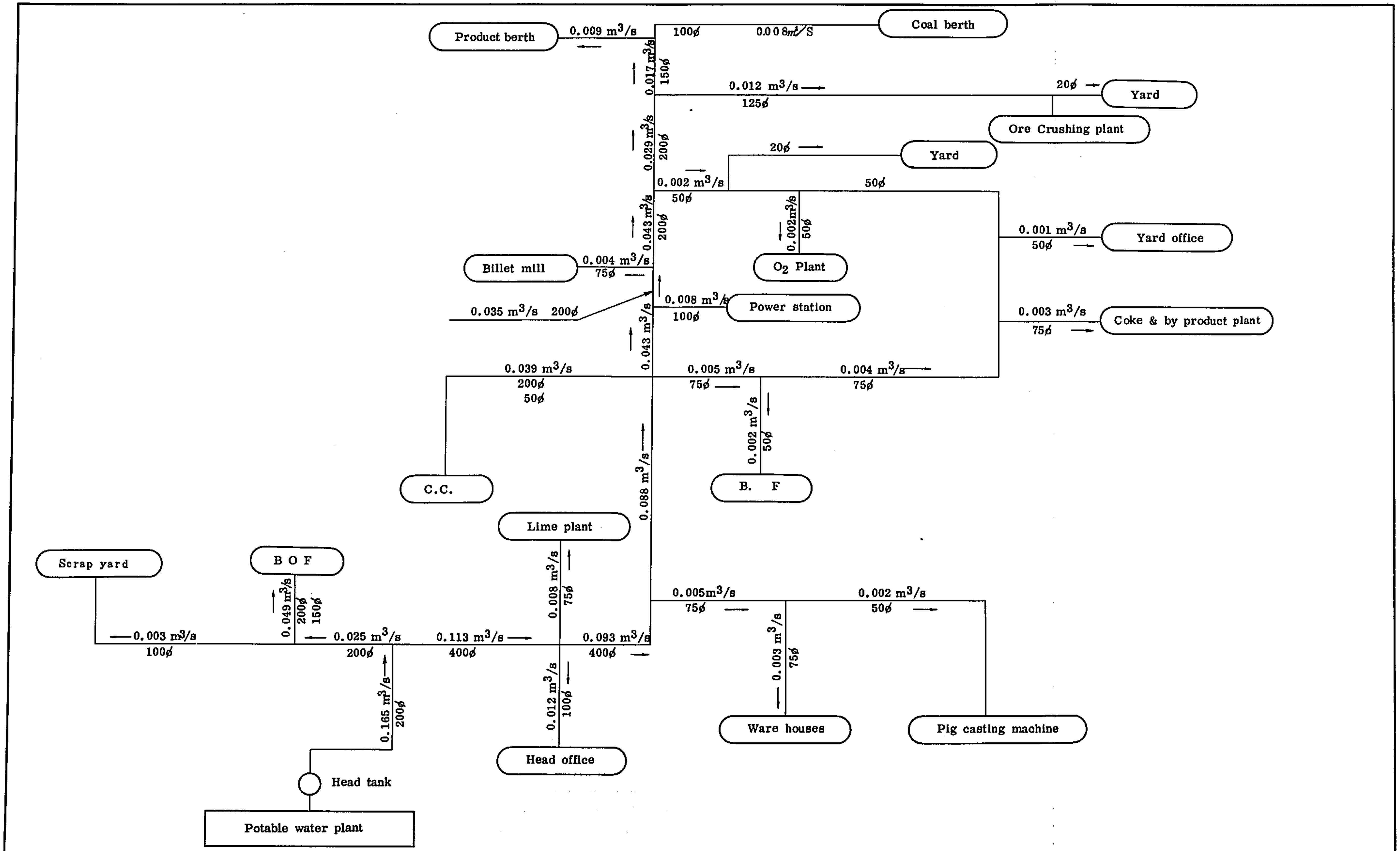


Fig. 13.16.4 Potable water line facilities

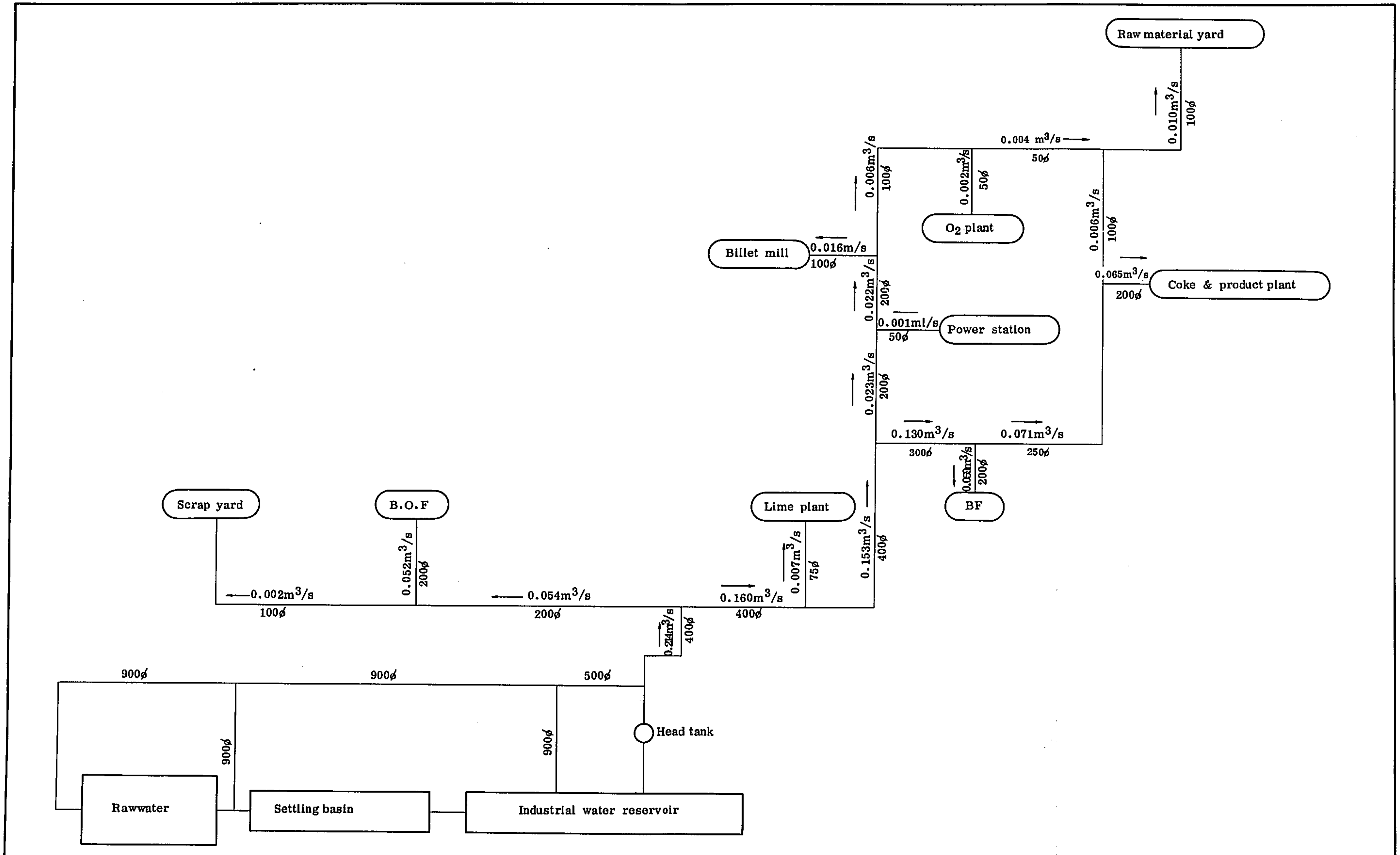


Fig. 13.16.5 Industrial water line facilities

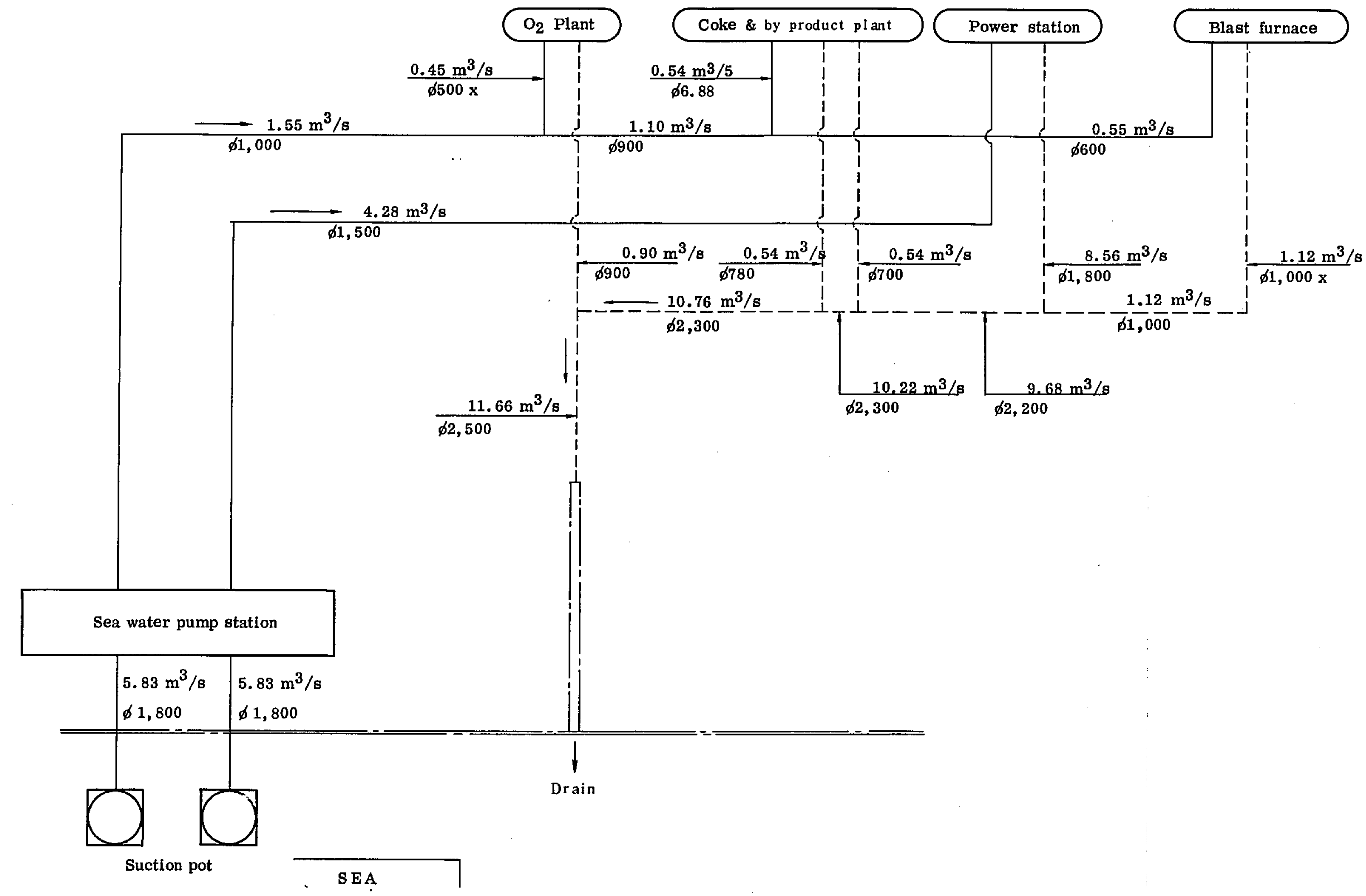


Fig. 13.16.6 Sea water line facilities

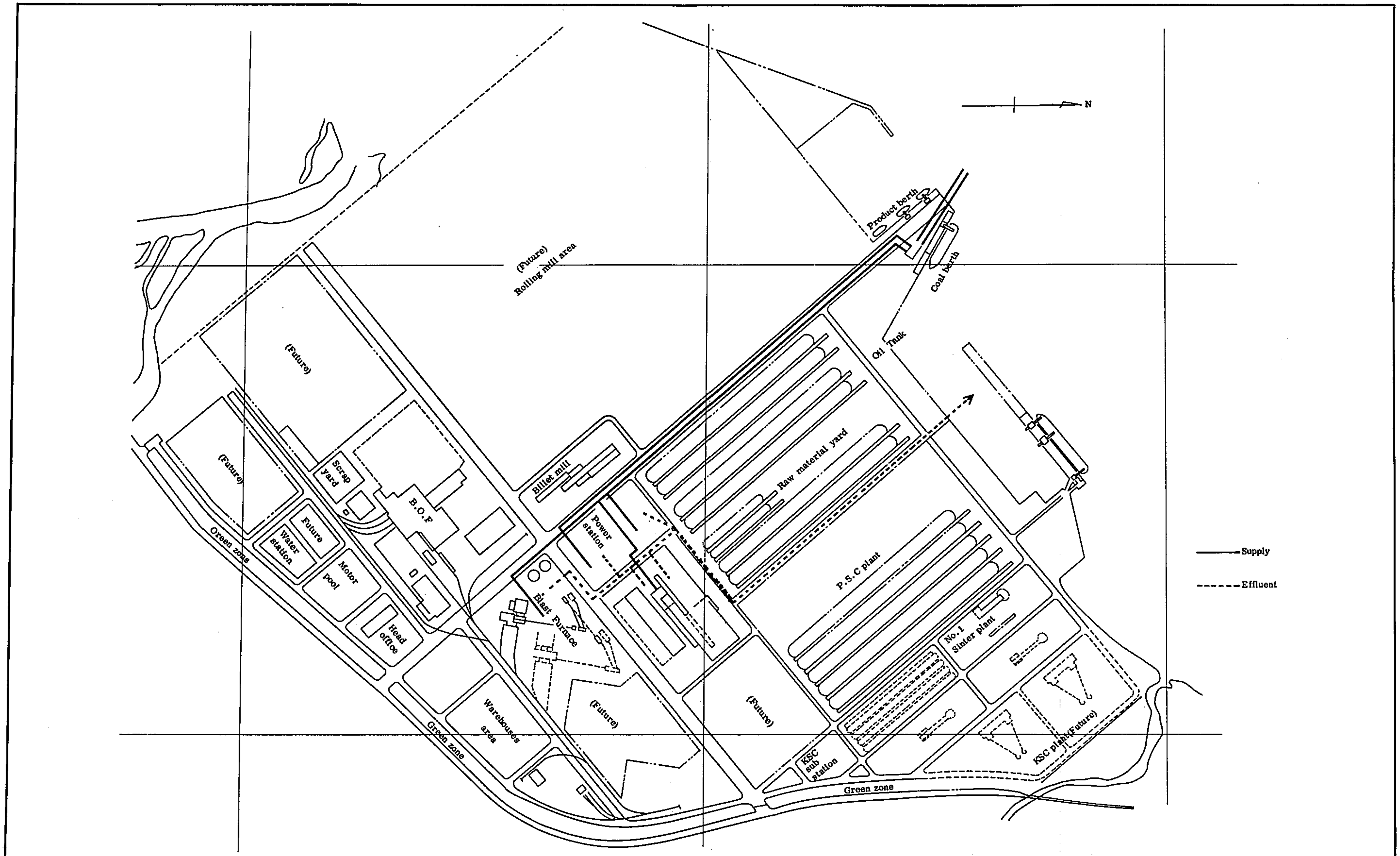
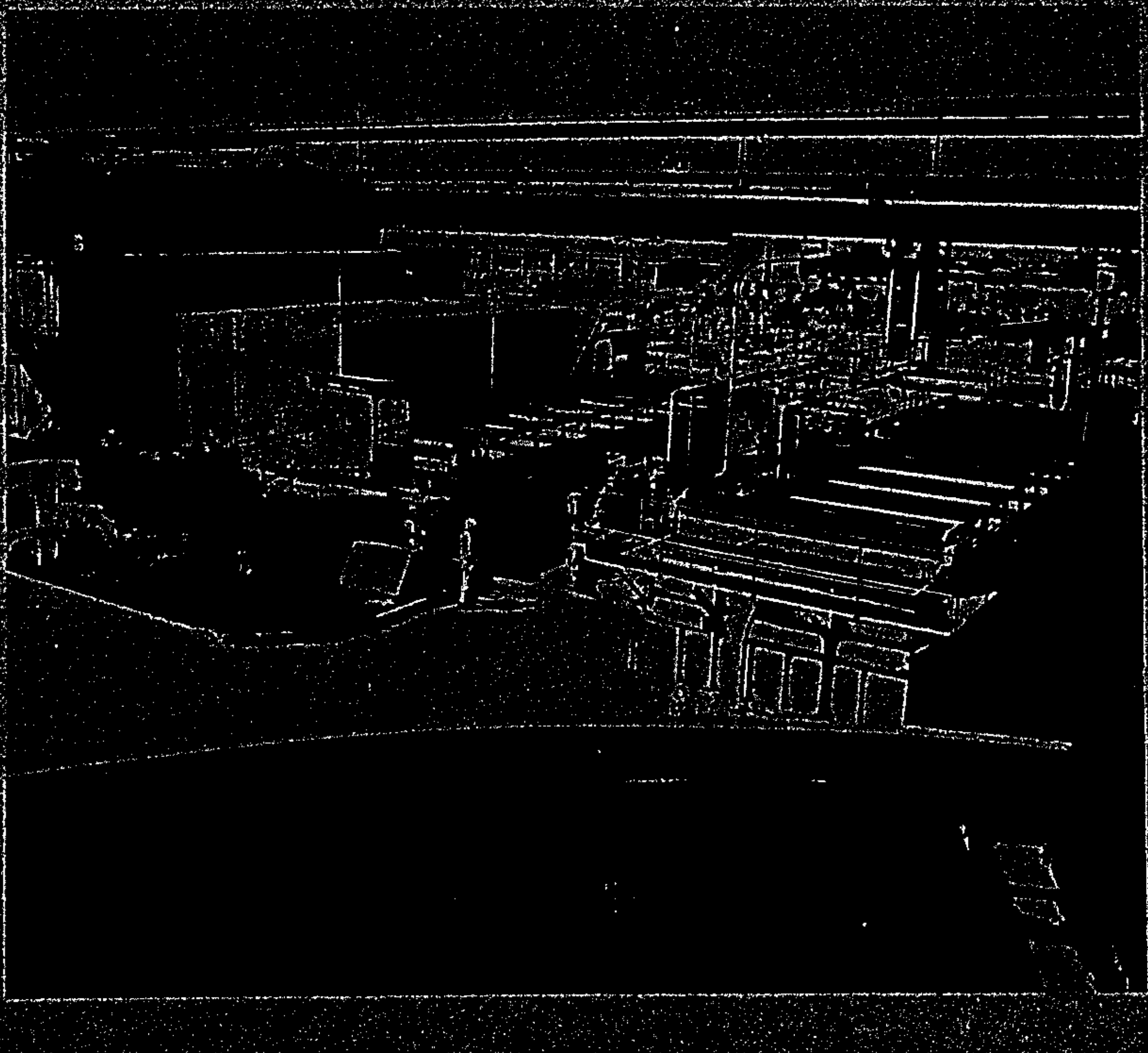


Fig. 13.16.7 Sea water line layout

CHAPTER 13-17

WATER RECIRCULATION FACILITIES



13.17 Water recirculation facilities

13.17.1 General

Fresh water to be used in each plant will be treated with independent return water equipment installed in each plant for recirculation.

Recirculating water is roughly divided into the direct cooling system and the indirect cooling system. In the direct cooling system, return water from plants is high in both suspended solid content and water temperature. To cope with this, therefore, return water in the direct cooling system will be treated as follows. It is first treated in the scale pit and the coagulating sedimentation basin to reduce the suspended solid content. Treated water is then collectéd in the return water tank and fed to the cooling tower to lower the water temperature. Cooled water is fed to the water supply tank where it is pumped to each plant. Sedimentation basins in plants requiring clear water are equipped with filters. Since repeated recirculation increases the salts concentration, some water is forcibly blown down.

In the indirect cooling system, return water is not with suspended solids, unlike the direct cooling system, the water temperature is raised.

Return water in the indirect cooling system is first collected in the return water tank and then fed to the cooling tower to lower the water temperature. Cooled water is fed to the water supply tank where it is pumped to each plant. In the indirect cooling system, too, repeated recirculation increases the salt concentration and the suspended solid content, so part of recirculating water is filtered or forcibly blown down.

There are seven return water pump stations, the operation and monitoring of which are concentrated to the BF pump station and the continuous casting plant pump station in the interest of economy. The operation and monitoring of pump stations for coke and by-product plant and

and oxygen plant are concentrated to the blast furnace pump station. The operation and monitoring of pump stations for BOF, lime plants and billet mill are concentrated to the CC station.

In plants where uninterrupted supply of water is required, diesel engine pumps and head tanks will be installed.

Taking into consideration economy and relative difficulty in future expansion, equipment capacity will be set as follows.

Those having capacities for operation of one unit of blast furnace include the facilities of pump station for blast furnace, BOF, continuous casting, billet mill, coke and by-product, and oxygen plants.

Those having capacities for the second stage include sea water discharge.

13.17.2 Preconditions

Table 13.17.1 shows preconditions for return water equipment.

Blast furnace pumping equipment	Cooling system for tuyeres, etc. Cooling of tuyeres, etc. Amount of recirculation water 2,000 m^3/hr Suspended solid content in recirculating water 20 ppm Feed water temperature 35°C, return water temp. 41°C Feed water pressure 5 kg/cm^2 Miscellaneous water Amount of recirculating water 900 m^3/hr Suspended solid content in recirculating water 20 ppm Feed water temperature 35°C, return water temp. 41°C Feed water pressure 5 kg/cm^2 Dust collection system Dust water Amount of recirculating water 1,000 m^3/hr

Blast furnace pumping equipment (contd.)	Suspended solid content in feed water 50 ppm Feed water temperature 35°C, return water temp. 45°C Feed water pressure 8 kg/cm² Water for pig machines and dry pits Amount of feed water 130 m³/hr Suspended solid content in feed water 50 ppm Feed water temperature 35°C Feed water pressure 1 kg/cm² Length of recirculating water piping (between pumping station and plant) will be 200 m.
Pumping equipment for BOF plant	OG cooling system OG cooling Amount of recirculating water Max. 2,100 m³/hr, ave. 1,000 m³/hr Suspended solid content in recirculating water 5 ppm Feed water temp. 40°C, return water temp. 65°C Feed water pressure 11 kg/cm² Cooling of lance and vessel Amount of recirculating water Max. 560 m³/hr, ave. 280 m³/hr Suspended solid content in reciruclating water 5 ppm Feed water temp. 40°C, return water temp. 65°C Feed water pressure 14 kg/cm² Dust collection system Dust collecting water : Amount of recirculating water Max. 600 m³/hr, ave. 300 m³/hr Suspended solid content in recirculating water 50 ppm Feed water temp. 50°C, return water temp. 60°C Feed water pressure 8.5 kg/cm²

Pumping equipment for BOF plant	High pressure miscellaneous water Amount of feed water Max. 170 m^3/hr Ave. 80 m^3/hr Feed water temp. 35°C Feed water pressure 7 kg/cm^2 Water for works Amount of feed water Max. 180 m^3/hr, ave. 90 m^3/hr Feed water temp. 35°C, feed water pressure 1.5 kg/cm^2 Soft water Amount of water to be treated 80 m^3/hr Quality of raw water M-alkalinity 50 - 62 ppm (as $CaCO_3$) SO_4 5 - 38 ppm (as SO_4^{--}) Cl^- 5 - 10 ppm (as Cl^-) SiO_2 23 - 95 (as SiO_2) Ca^+ 16 - 35 (as Ca^+) Mg^+ 10 - 32 (as Mg^+) (Na^+ + K^+) 10 ppm (as $CaCO_3$) SS 10 ppm Total hardness 129 - 166 (as $CaCO_3$) pH 7.5 - 8 Quality of treated water SS 3 ppm Ca^+ 1 ppm (as $CaCO_3$) pH Neutral Length of recirculating piping (between pumping station and plant) will be 200 m.

Pumping equipment for continuous casting plant	Mould machine system Mould (slabs) Amount of recirculating water 840 m^3/hr Suspended solid content in recirculating water 5 ppm Feed water temperature 35°C, return water temp. 45°C Feed water pressure 10 kg/cm^2 Mould (bloom) Amount of recirculating water 600 m^3/hr Suspended solid content in recirculating water 5 ppm Feed water temp. 35°C, return water temp. 45°C Feed water pressure 10 kg/cm^2 Machine (slab) Amount of recirculating water 1,800 m^3/hr Suspended solid content in recirculating water 5 ppm Feed water temp. 35°C, return water temp. 45°C Feed water pressure 5 kg/cm^2 Machine (bloom) & air conditioner Amount of recirculating water 600 m^3/hr Suspended solid content in recirculating water 5 ppm Feed water temp. 35°C, return water temp. 45°C Feed water pressure 5 kg/cm^2 Spray system Slab Amount of recirculating water 760 m^3/hr Suspended content in feed water 20 ppm Feed water temp. 35°C, return water temp. 45°C Feed water pressure 11 kg/cm^2 Bloom Amount of recirculating water 740 m^3/hr Suspended solid content in feed water 20 ppm Suspended content in return water 200 ppm

Pumping equipment for continuous casting plant (contd.)	Feed water temp. 35°C, return water temp. 45°C Feed water pressure 11 kg/cm² Length of recirculating piping (between pumping station and plant) will be 200 m.
Pumping equipment for billet mill	Heating furnace system Heating furnace cooling water Amount of recirculating water 240 m³/hr Suspended solid content in recirculating water 20 ppm Feed water temp. 35°C, return water temp. 45°C Feed water pressure 2.5 kg/cm² Indirect cooling water for equipment Amount of recirculating water 1,530 m³/hr Suspended solid content in recirculating water 20 ppm Feed water temp. 35°C, return water temp. 45°C Feed water pressure 2.5 kg/cm² Direct cooling system for equipment Direct cooling water of equipment Amount of recirculating water 370 m³/hr Suspended solid content in feed water 20 ppm Feed water temp. 35°C, return water temp. 45°C Feed water pressure 2.5 kg/cm² Length of recirculating water piping (between pumping station and plant) will be 200 m.
Pumping equipment for coke oven and coke by-product plant	Coke oven plant system Quenching tower Amount of feed water 60 - 90 m³/hr Mixed gas water seal valve Amount of feed water 99 - 180 m³/hr Equipment cooling Amount of recirculating water 70 m³/hr Make-up water for equipment Amount of feed water 25 m³/hr

Pumping equipment for coke oven and coke by-product plant (contd.)	Water quality Suspended content in feed water 20 ppm Feed water temp. 35°C, return water temp. 45°C Feed water pressure 2 kg/cm² Coke by-product plant system Equipment cooling Amount of recirculating water 60 m³/hr Make-up water Amount of feed water 20 m³/hr Water quality Same as above Feed water pressure Same as above Length of recirculating water piping (between pumping station and plant) will be 200 m.
Pumping equipment for lime plant	Limestone cleaning system Amount of limestone treatment 192,000 t/y = 21.9 t/hr Amount of treating water 130 m³/hr Water quality Item Feed water Suspended solids 100 ppm Temperature 50°C The rate of suspended solid generation is assumed to be 1% of raw limestone. Therefore, the amount of suspended solids will be 220 kg/hr. Feed water pressure 4 kg/cm² Remarks: The amount of suspended solids varies depending on the extent to which pretreatment of raw limestone (flushing, cleaning, etc.) has been made in the mine. This plan is based on the assumption that 1% of raw limestone to be treated will be generated as suspended solids. In addition, because of lack of information on the grain size distribution of suspended solids, a coarse grain separating tank will be installed to prevent coarse grain over 100 μ in size from entering the sedimentation basin and subsequent processes.

Pumping equipment for lime plant (contd.)	Dehydrator cleaning water, dust collector system Amount of treating water 140 m^3/hr Water quality Item Feed water Suspended solids 100 ppm Temperature 50°C Feed water pressure Dehydrator system 3 kg/cm^2 Dust collector system 6 kg/cm^2 Equipment cooling system Amount of feed water Equipment cooling 50 m^3/hr Plant miscellaneous water 3 - 6 m^3/hr Water quality Item Feed water Suspended solids 20 ppm Temperature 35°C Feed water pressure Equipment cooling 5 kg/cm^2 Plant miscellaneous water 2 kg/cm^2 Length of recirculating pipe (between pumping station and plant) will be 200 m.
Pumping equipment for oxygen plant	Amount of treating water 35 m^3/hr Water quality Item Feed water Suspended solids 20 ppm Temperature 35°C Feed water pressure 3 kg/cm^2 Return water pressure 1.5 kg/cm^2 at G1 of the cooling tower. Length of recirculating pipe (between pumping station and plant) will be 200 m.

Sea water discharge	Discharge amount	Coke oven plant: 66 m^3/hr, by-product plant: 3,800 m^3/hr, power plant: 30,000 m^3/hr, oxygen plant: 3,300 m^3/hr, blast furnace plant: 4,000 m^3/hr.

For the flow of water consumption, refer to Fig. 13.16.1.

13.17.3 Equipment specifications

Table 13.17.2 Equipment specifications

Item	Specifications and dimensions
(1) Blast furnace pumping equipment	
1) Cooling system	Return water tank 325 m^3/tank Cooling tower 1 unit 12.1 m x 17 m x 8.82 mH Water supply tank 975 m^3/tank Filtering tank 3 units 2.88 mø x 4.5 mH Pumps, etc. 1 set
2) Dust collector system	Dust separator 2 units 60 m^3/unit Surface aeration tank 4 units 87 m^3/unit Thickener 2 units 1,700 m^3/unit Return water tank 1 unit 227 m^3/tank Cooling tower 1 unit 9.3^m x 12.5^m x 4.57 mH Water supply tank 1 unit 390 m^3/tank Caustic soda dosing equipment 1 set Polymer dosing equipment 1 set Pumps, etc. 1 set
(2) Pumping equipment for BOF plant	
1) OG cooling system	Cooling tower 1 unit 11.9m x 11.0m x 6 mH Cooling water tank 1 unit 450 m^3/tank Filtering tank 6 units 4.7 mø x 5 mH Water supply tank 1 unit 450 m^3/tank Anti-corrosive dosing, soft water treatment equipment 1 set Pumps, etc. 1 set

2) Dust collection system	Dust separator 2 units 20 m^3/unit Thickener 2 units 200 m^3/unit Mixing tank 4 units 25 m^3/unit Sedimentation basin 2 basins 300 m^3/basin Return water tank 1 unit 75 m^3/unit Cooling tower 1 unit 6.25m x 5.2m x 4.57mH Cooling water tank 1 unit 300 m^3/unit Water supply tank 1 unit 147 m^3/unit Filtering tank 1 unit 2.8 mø x 4.5 mH Treated water tank 1 unit 210 m^3/unit Polymer dosing equipment 1 set Caustic soda dosing equipment 1 set Sulfuric acid dosing equipment 1 set Pumps, etc. 1 set
(3) Pumping equipment for continuous casting plant	
1) Mould, machine system	Cooling tower 1 unit 13.1m x 25m x 11.2 mH Feed water tank 1 unit 975 m^3/unit Filtering tank 3 units 2.88 mø x 4.5 mH Head tank 1 unit 200 m^3 (for slabs) Head tank 1 unit 100 m^3 (for blooms) Pumps, etc. 1 set
2) Spray system	Sedimentation basin 2 basins 430 m^3/basin Return water tank 1 unit 220 m^3/unit Filtering tank 4 units 3.6 mø x 4.5 mH Cooling tower 1 unit 11.9m x 11m x 6mH Feed water tank 1 unit 480 m^3/unit Pumps, etc. 1 set

(4) Pumping equipment for billet mill	
1) Heating furnace system	Return water tank 1 unit 210 m^3/unit Cooling tower 1 unit 11.9m x 11.6m x 6mH Water supply tank 1 unit 450 m^3/unit Head tank 1 unit 40 m^3/unit Pumps, etc. 1 set
2) Direct cooling system for equipment	Mixing tank 4 units 22 m^3/unit Sedimentation basin 2 basins 630 m^3/basin Return water tank 1 unit 75 m^3/unit Cooling tower 1 unit 9.3m x 5.2m x 4.57mH Water supply tank 1 unit 210 m^3/unit Caustic soda dosing equipment 1 set Alumina dosing equipment 1 set Polymer dosing equipment 1 set Pumps, etc. 1 set
(5) Pumping equipment for coke oven and by-product plant	Return water tank 1 unit 36 m^3/unit Cooling tower 1 unit 3.686m x 1.457m x 2.972mH Water supply tank 1 unit 108 m^3/unit Filtering tank 1 unit 1.68 mø x 3 mH Backwash effluent tank 1 unit 30 m^3/unit Pumps, etc. 1 set
(6) Pumping equipment for lime plant	
1) Limestone cleaning system	(Pre settling basin) Coarse grain sedimentation tank 2 units 44 m^3/unit Return water tank 1 unit 36 m^3/unit Thickener 1 unit 339 m^3/unit Water supply tank 1 unit 56 m^3/unit Pumps, etc. 1 set

2) Dehydrator cleaning water, dust collector system	Return water tank	1 unit	36 m^3/unit
	Thickener	1 unit	368 m^3/unit
	Water supply tank	1 unit	72 m^3/unit
	Pumps, etc.	1 set	
3) Equipment cooling system	Return water tank	1 unit	18 m^3/unit
	Cooling tower	1 unit	1.908m x 0.978m x 2.137mH
	Water supply tank	1 unit	27 m^3/unit
	Pumps, etc.	1 set	
(7) Pumping equipment for oxygen plant	Cooling tower	1 unit	1.829m x 0.914m x 2.5m
	Water supply tank	1 unit	45 m^3/unit
	Pumps, etc.	1 set	
(8) Sea water discharge piping system	Discharge piping	1 set	

13.17.4 Layout plan and flow sheet

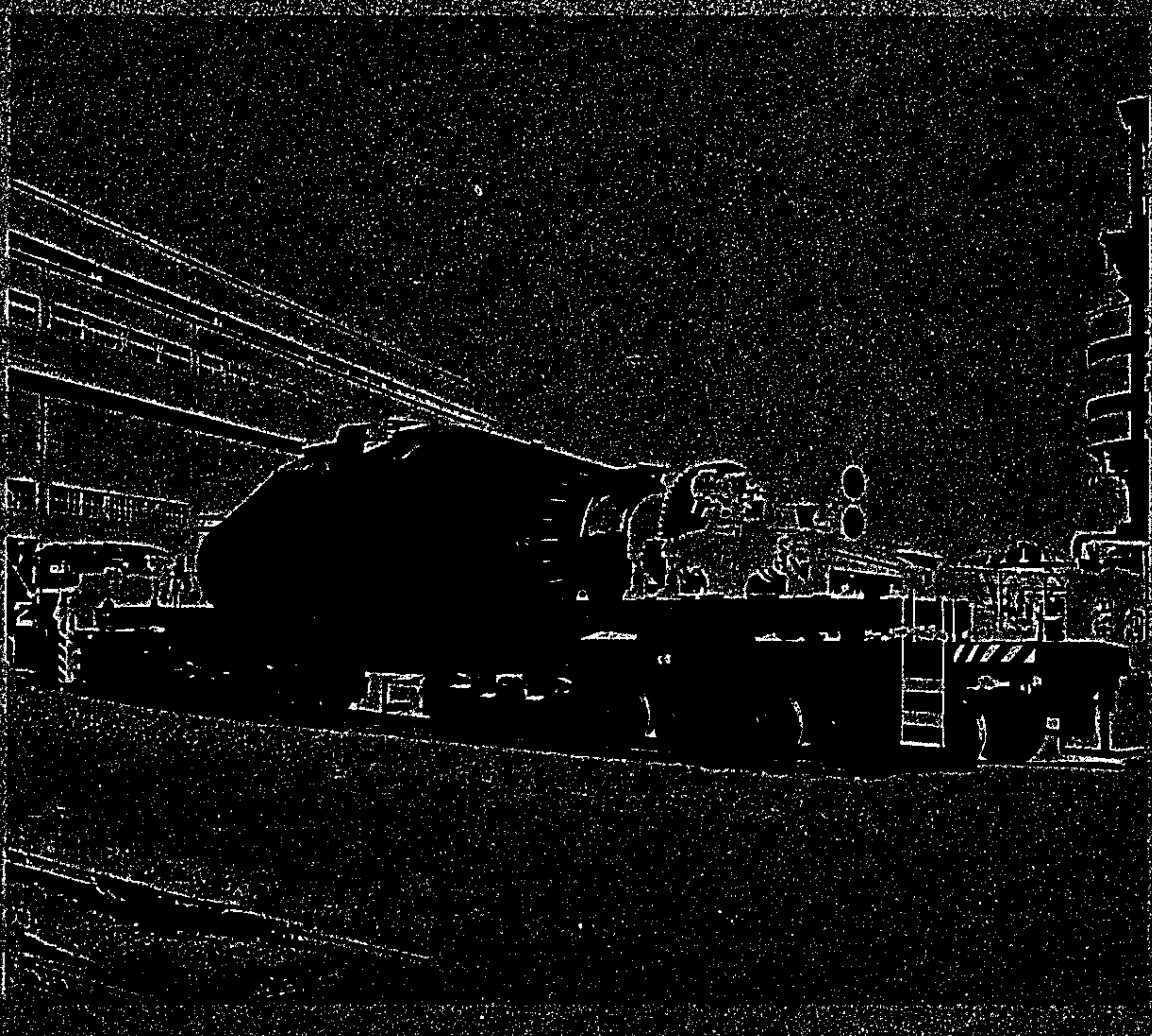
(1) Overall layout Refer to Fig. 13.16.2.

(2) Sea water discharge piping system
Refer to Fig. 13.16.6.

(3) Layout of sea water supply and discharge piping system
Refer to Fig. 13.16.7.

CHAPTER 13-18

TRANSPORTATION FACILITIES



13.18 Transportation facilities

13.18.1 Outline

This plan is formed for the purpose of studying the transportation equipment necessary for transportation of raw materials, by-products and semi-finished products for the iron production of 965,000 t/y at the one-blast-furnace stage.

Transportation of high-temperature heavy-weight materials like molten iron, BOF slag and ingots is planned as railway transportation. Transportation of other materials like raw materials and by-products is planned as road transportation.

(1) Railway transportation

For molten iron transportation, which is high-temperature, heavy-weight and large-volume transportation, torpedo cars will be used because they are already employed widely at many countries' steel-works and proved advantageous from the aspects of operation, transportation cost and product quality. The BOF slag to be generated in the BOF plant is planned to be transported by using high-efficiency slag ladle cars provided with tilting equipment.

Ingots will be transported by flat cars, and their loading and unloading at the ingot yard will be carried out by rail-traveling diesel crane. As the tractors for these railway wagons, diesel locomotives will be used.

As the equipment for the daily checking, lubrication and water supply of the diesel locomotives and rail-traveling diesel cranes, a locomotive shed will be installed. Also for the safety of railway transportation, high-way crossing signals and track illuminating devices will be installed. The railway track is planned by 1,435 mm gage in consideration of the large wagons.

(2) Road transportation

Raw materials and by-products will be transported by dump trucks and self-loading trucks, and their loading and unloading will be carried out by using bulldozers, shovel cars and crawler cranes. Semi-finished products and maintenance parts are planned to be transported by trailers.

In addition to the above, an automobile weigh bridge will be installed for the inventory control of purchased goods and by-products, and an automobile gasoline station will be built for the oil-filling of these road vehicles. The width and others of the roads will be laid out in consideration of the traveling frequency of each vehicle.

13.18.2 Preconditions

(1) The transportation volumes on the basis of which the transportation equipment is planned are as shown in Figure 13.18.1 "Material Balance Flow Sheet."

(2) The general operational conditions are that the number of operating days per month is 28 and that the operation is carried out continuously by the 3-shift system. Transportation of small-volume items, however, will be carried out by daytime operation.

(3) The loading efficiencies of the various vehicles are 100% for torpedo cars and slag ladle cars, 90% for flat cars, 60 - 80% for trucks and 80% for trailers.

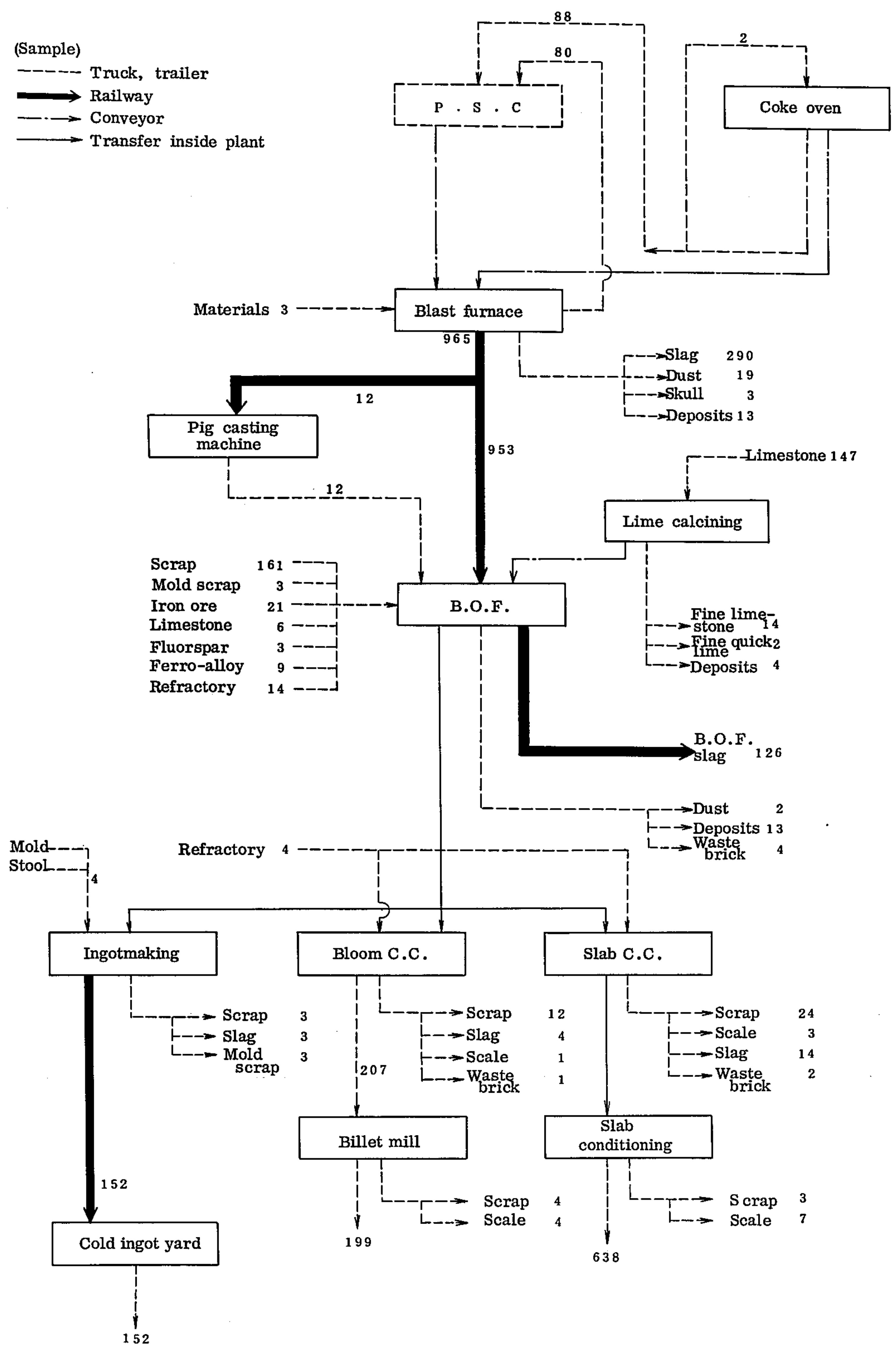


Fig. 13.18.1 Material balance flow sheet (Unit: 1,000 t/y)

13.18.3 Equipment specifications

Table 13.18.1 List of equipment specifications

Equipment	Quantity	Specifications
Railway equipment		
Torpedo car	8	Capacity 200 T
Slag ladle car	6	" 20 T
Slag ladle	6	" "
Flat car	6	" 100 T
Diesel locomotive	5	" 60 T (deadweight)
"	1	" 25 T (deadweight)
Rail-traveling diesel crane	1	" 35 T lift
Highway crossing signal	6	Electronic electric-bell type
Locomotive shed		18m x 18m, with gasoline station
Railway track	7,230 m	1,435mm gage, with a set of track illuminating devices
Road equipment		
Dump truck	21	Capacity 11 T
Trailer	1	" 60 T
"	3	" 35 T
Tractor	2	" 10 T
Self-loading truck	1	" 20 T
Ladle	4	" 20 T
Shovel car	3	" 14 T (deadweight)
Bulldozer	3	" 20 T (deadweight)
Crawler crane	2	" 20 T lift
Automobile gasoline station	1	Light oil filling station
Automobile weigh bridge	1	Capacity 60 T
Road	286,000m^2	Width 50 m, 30 m, 20 m, 15 m
Common use		
Transportation sub-center	2,000m^2	For 170 persons

13.18.4 Technical explanation

(1) Torpedo cars

1) Features

Transportation of molten iron at most works used to be carried out by hot metal ladle cars. This system consists of receiving molten iron into the hot metal ladle car from the blast furnace, transporting it to the steelmaking plant, storing it in the mixer and supplying it to the steelmaking furnace.

Nowadays, however, the system is usually replaced by a new system which does not use any mixer. The new system consists of receiving molten iron into the torpedo car from the blast furnace and transporting it to the steelmaking furnace directly by that torpedo car.

Since the furnace capacity of the torpedo car is large, the composition of hot metal is effectively uniformalized, achieving the purpose of the conventional mixer. One of the advantages of the torpedo car, therefore, is the elimination of the need for constructing mixers.

The torpedo car has a cylindrical furnace body with conical ends. The furnace has an opening at the center of its top, so that it has a higher heat-retaining capacity than the ladle car which is completely open at its top. Also, it is possible to design torpedo cars with large capacities because the center of gravity can be lowered.

It may therefore be said that the use of torpedo cars can simplify the hot metal transporting and handling processes.

2) Construction

The furnace for storing molten iron is of steel plate welded construction. The furnace is provided with cast steel trunnions at both ends and is lined with refractories on the inside. On one side of each trunnion is mounted tilting equipment. Fig. 13.18.2 shows the appearance of torpedo car.

The furnace is tilted by the controlling equipment installed on the ground.

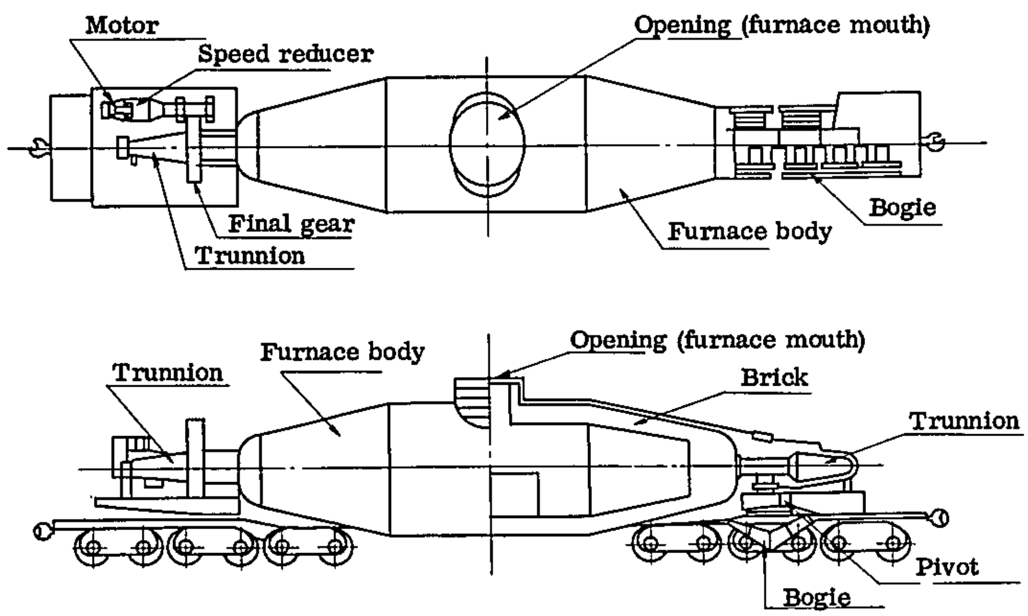


Fig. 13.18.2 Appearance of torpedo car

3) Torpedo car capacity

The iron production of the blast furnace is maximum 350-400 tons per tapping, and the steel production of the BOF is average 105 ton per heat. The torpedo car capacity is planned at 200 t/unit so that two torpedo cars can receive the iron produced by one tapping of the blast furnace and one torpedo car can store the iron required to supply two heats of the BOF.

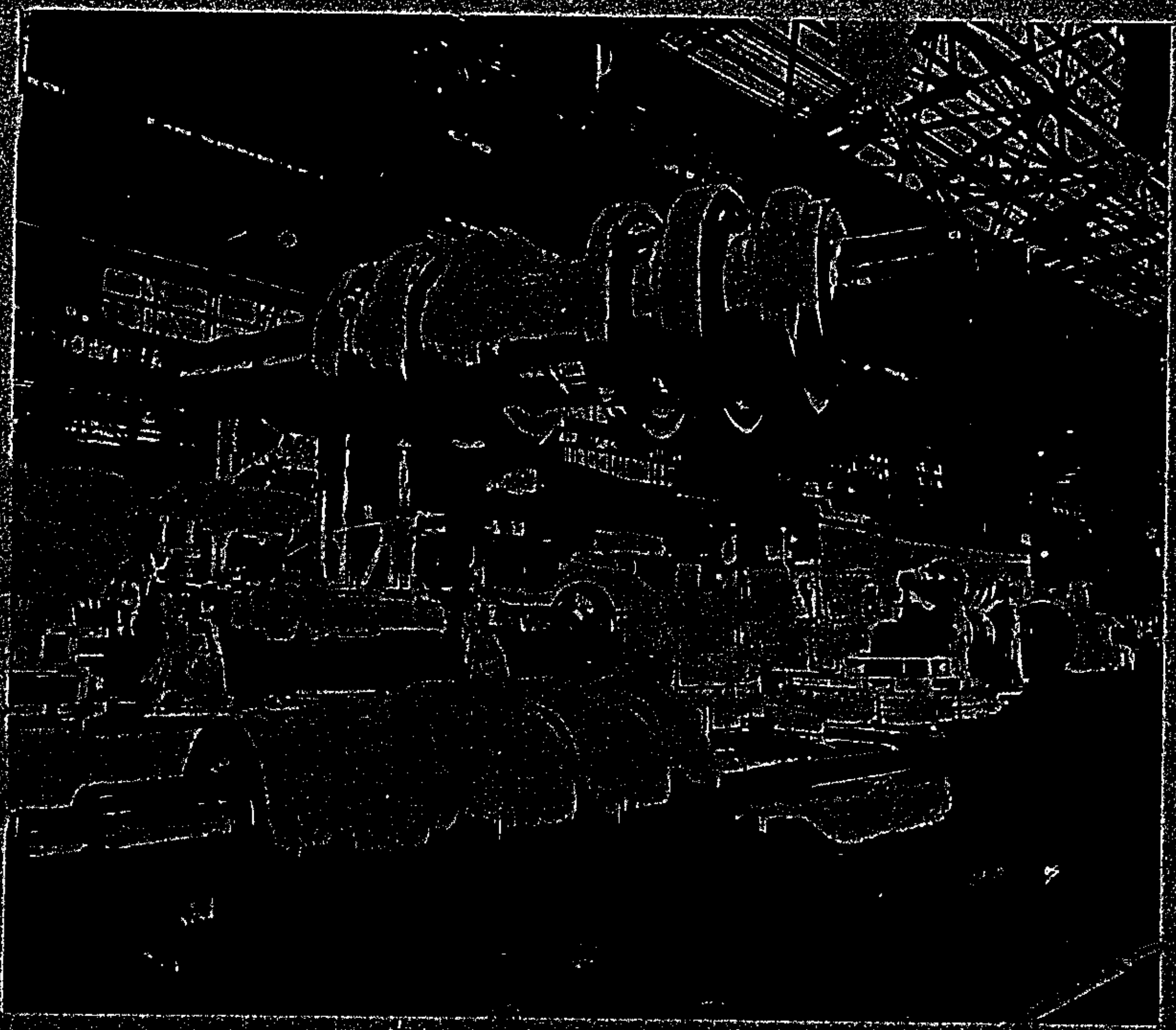
4) Maintenance

Maintenance of torpedo cars may be divided into maintenance of mechanical parts and relining and maintenance of furnace brick. The maintenance of mechanical parts is very little, and most maintenance of torpedo cars consists of bricklaying works.

The furnace brick is relined after every 600-700 times of hot metal transportation. Partial repair or relining of the brick is performed several times during the period between two total relining works. The maintenance rate of torpedo cars is 75-80%.

CHAPTER 13-19

MAINTENANCE SHOP AND WAREHOUSE



13.19 Maintenance Facilities

13.19.1 General

Maintenance facilities will be provided to maintain main plants and their auxiliary facilities in the new steelworks. The maintenance facilities will consist of a central maintenance station and local maintenance shops. Though the central maintenance station will be basically of a scale that will permit it to perform ordinary maintenance work, it will be so equipped that it can handle a complete range of jobs necessary for the manufacture of parts and repair of equipment including casting, forging, machining, steel-fabrication, etc., considering the fact that related industries surrounding the new steelworks are still in the infant stage of industrialization.

As for the location of the central maintenance station, the site will be selected somewhere outside the new steel complex through advice by counterparts taking into consideration the possible relationship which the new steelworks will have to maintain with related industries.

13.19.2 Basic conditions of the project

(1) Scale of production facilities to be maintained

1,050,000 tons/y on molten steel production basis

(2) Scale of maintenance facilities

The planned maintenance facilities will be so equipped that it can handle ordinary maintenance work and will not include such facilities as required when manufacturing or servicing special equipment (high-quality or heavy-duty production equipment) whose manufacture and repair require special techniques and expensive equipment. Though spare parts will basically be purchased from outside sources, surplus capacity, if any, of the central maintenance station will be assigned to the manufacture of these spare parts.

(3) Maintenance system

The planned maintenance system is an independent, centralized one incorporating all the maintenance-related organizations in a single body and consists of the central maintenance station and the local maintenance shops.

Maintenance work will be carried out in well-designed combination of maintenance equipment and personnel. Along with these maintenance work by the personnel specializing in maintenance, daily inspection will be done also by operational crew at main plants such as iron-making, steelmaking and rolling mill plants as part of everyday production activities.

(4) Main duties and location of central and local maintenance shops

1) Central maintenance station

The Central Maintenance Station serves the purpose of the manufacture of parts and repair of mechanical equipment, electric instrumentation and other facilities and also serves a centralized back-up facility for each local maintenance shop.

Ideally it should be located in the center of the new steelworks, but our plan assumes location somewhere outside the complex as aforesaid. It is obvious, however, the site selected should offer maximum convenience for the station to perform its duties.

2) Local maintenance shops

Each main plant will have a specific maintenance shop, or local maintenance shop, in its vicinity, which will perform maintenance work singly or jointly with operational crew at the plant.

13.19.3 Maintenance facilities plan

(1) Central maintenance station

1) Centralized facilities

a) Central maintenance office

b) Machine repair shop

c) Machining shop

d) Steel-fabrication shop

e) Foundry

f) Forging shop

g) Electrical equipment and instrumentation repair shop

h) Civil, construction and waterworks service shop

i) Spare parts warehouse

2) Other located facilities

a) Rolling stock repair shop

b) Motor vehicle repair shop

c) Oil/grease warehouse

d) Refractories warehouse

(2) Local maintenance shops

1) Maintenance shop at raw materials plant

2) Maintenance shop at coke oven plant

3) Maintenance shop at blast furnace plant

4) Maintenance shop at B.O.F. plant

5) Maintenance shop at continuous casting plant

6) Maintenance shop at billet mill

7) Maintenance shop at power plant

(3) Equipment specifications

1) Central maintenance

Shop name	Building area	Equipment	Q'ty
Central maintenance office	20(m)x75(m)x2F = 3000m^2	Drafting machine	1 set
		Duplicator	1 set
		Mini computer	1 set
		Typewriter	1 set
		Microfilming equipment	1 set
		Measuring instruments	1 set
Machine repair shop	30 x 120 = 3600	Crane 10 t	2 units
		30 t	1 unit
		Hydraulic press	2 units
		Balancing machine	1 unit
		Tools and instruments	1 set
Machining shop	30 x 120 = 3600	Crane 2 t	2 units
		10 t	1 unit
		30 t	1 unit
		Lathe	13 units
		Drilling machine	4 units
		Milling machine	4 units
		Other machine tools	24 units
		Tools	1 set
Steel-fabrication shop	30 x 120 = 3600	Crane 7.5 t	1 unit
		10 t	2 units
		40 t	1 unit
		Hydraulic press	3 units
		Shearing machine	1 unit

Shop name	Building area	Equipment	Q'ty
(contd.)	30 x 120 = 3600	Bending roller	2 units
		Heat treatment f'ce	2 units
		Tools and instruments	1 set
Foundry	55 x 120 = 6600	Crane 2 t	3 units
		5 t	1 unit
		40 t	2 units
		Electric furnace	3 units
		Crucible	1 unit
		Casting equipment	1 set
		Woodworking equipment	1 set
		Tools and instruments	1 set
Forging shop	20 x 50 = 1000	Crane 10 t	1 unit
		Air hammer	2 units
		Furnace	1 unit
		Tools and instruments	1 set
Electrical equipment and instrumentation repair shop	30 x 150 = 4500	Crane 3 t	1 unit
		5 t	1 unit
		15 t	1 unit
		Other equipment	30 units
		Tools and instruments	1 set
Civil, construction and waterworks service shop	Part of machine shop	Tools and instruments	1 set
Rolling stock repair shop	22 x 180 + 240 = 4200	Crane 3 t	1 unit
		10 t	1 unit
		40/10 t	1 unit
		Machine tools	15 units
		Tools and instruments	1 set

Shop name	Building area	Equipment	Q'ty
Motor vehicle repair shop	15 x 150 = 2250	Crane 3 t Testing equipment Maintenance tools	1 unit 1 set 1 set
Spare parts warehouse	40 x 150 = 6000	Crane 2 t 10/5 t Forklift Shelves Measuring instruments	2 units 1 unit 2 units 1 set 1 set
Oil/grease warehouse	10 x 50 = 500	Forklift Instruments	2 units 1 set
Refractories warehouse	75 x 100 = 7500	Forklift	4 units

2) Local maintenance shops

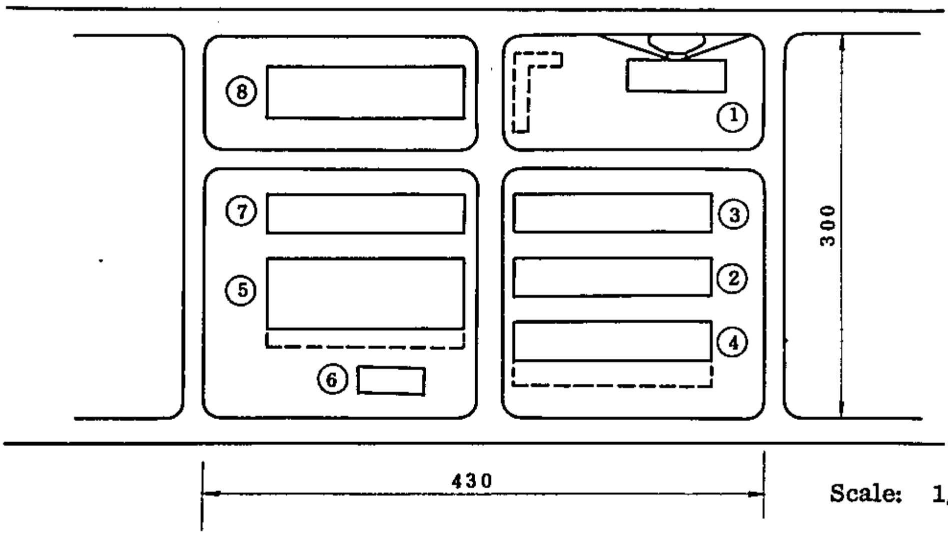
Shop name	Building area	Equipment	Q"ty
Local maintenance shops	20 x 50 x 7 shops = 7000	Crane 3 t 5 t Machine tools Tools	1 unit each/shop " 7 units each/shop

3) General materials and supplies warehouse

Shop name	Building area	Equipment	Q'ty
General materials and supplies warehouse	20 x 100 = 2000	Forklift Shelves	2 units 1 set

13.19.4 Layout plan

Central maintenance station (Centralized facilities)



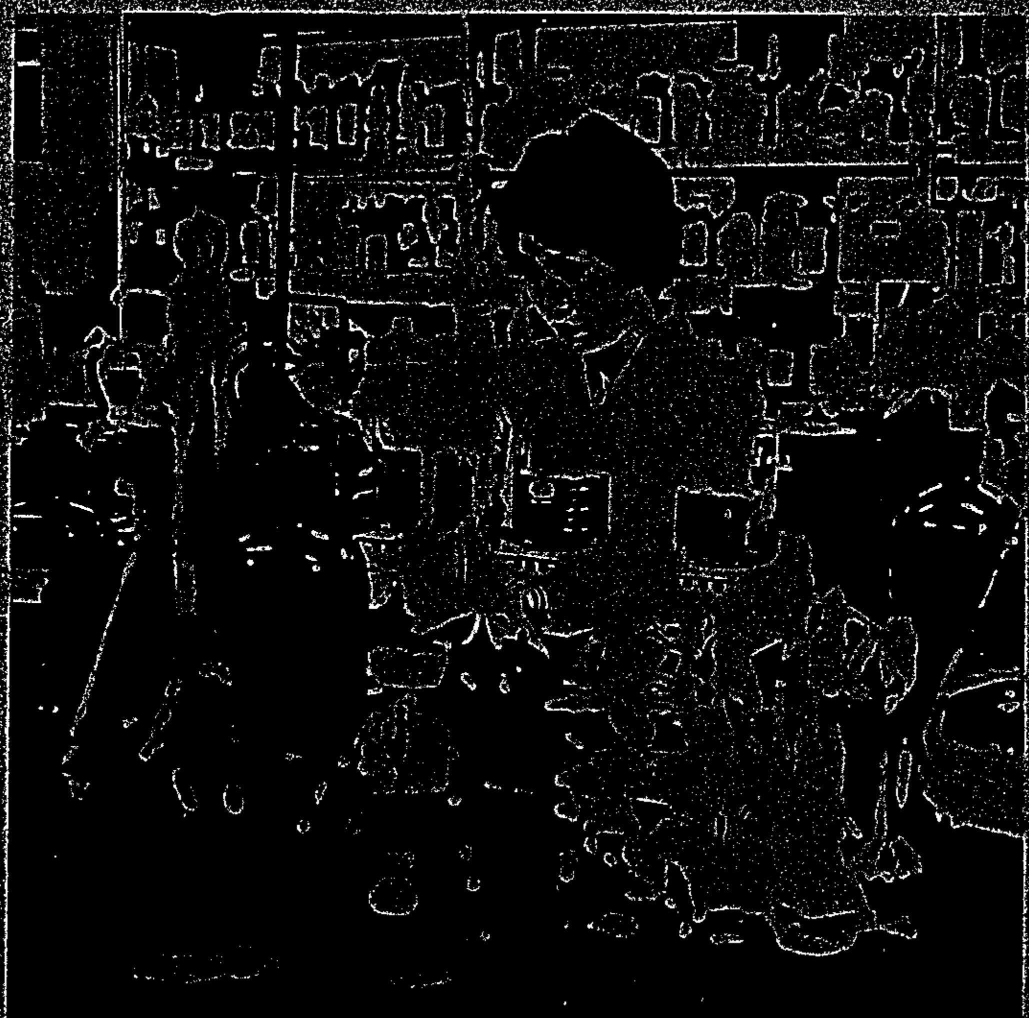
Scale: 1/500

① Central maintenance office
② Machine repair shop
③ Machining shop
④ Steel-fabrication shop
⑤ Foundry
⑥ Forging shop
⑦ Electrical equipment and instrumentation repair shop
⑧ Spare parts warehouse

Fig. 13-19-1. Layout

CHAPTER 13-20

TESTING AND ANALYSIS EQUIPMENT



13.20 Testing and analysis equipment

13.20.1 Outline

The testing and analysis equipment in this plan is only the equipment for testing and analysis closely related to the ordinary operation of the works and does not include the equipment for purposes of development and research such as the development of new products and the improvement of product quality.

(1) Raw materials testing equipment

1) Equipment necessary for the acceptance inspection of raw materials to be used in blast furnace and BOF, such as iron ore, sintered ore, limestone, fluorite and ferro alloy, and the control of raw material preparation operations, such as crushing and blending, for these materials.

2) Various testing equipment for coal acceptance inspection and the testing of coal and coke necessary for coke oven operation.

(2) Analysis equipment

1) Equipment for the analysis of the compositions of the above main and sub materials.

2) Equipment for the quick analysis of hot metal, molten steel and slag necessary for blast furnace and BOF operations.

3) Analysis equipment necessary for the operation control of the coke plant and by-product plant.

The above two items of equipment, which will have a capacity capable of meeting the iron production of 965,000 t/y of blast furnace and the steel production of 1,050,000 t/y of BOF, will be housed in the raw material testing center and analysis center.

13.20.2 Basic conditions of the plan

(1) Scope of the plan

The scope of the plan of testing and analysis equipment is the following.

1) Raw materials inspection equipment

a) Equipment for the acceptance inspection of main and sub materials to be imported and purchased.

b) Testing equipment necessary for the control of raw material preparation operations, such as crushing and blending, for the accepted raw materials.

c) Testing equipment for the acceptance inspection of coal and the operation control of coke ovens.

2) Analysis equipment

a) Analysis equipment necessary for the control of blast furnace and BOF operations.

b) Inspection equipment for by products.

c) Equipment for the checking and analysis of the compositions of ingots, slabs and billets.

3) Raw material testing center building
including
Equipment foundations, water supply and drainage and air-conditioning equipment.

4) Analysis center building
including
Equipment foundations, water supply and drainage and air-conditioning equipment.

5) Electrical equipment

Transformers, distribution boards, power wiring, room lighting, etc.

6) Gas piping

(2) Equipment capacity

The testing and analysis equipment is planned to have a capacity capable of adequately meeting the iron production of 965,000 t/y of blast furnace and the steel production of 1,050,000 t/y of BOF.

(3) Equipment layout

The equipment is laid out to permit future expansions without suspending the present testing and analysis operations.

(4) Locations of the raw material testing center and analysis center

These centers will be built at the following locations so that the testing and analysis operations can be carried out most rationally.

1) Raw material testing center

Location in the vicinity of the raw material yard and coke plant.

2) Analysis center

In the BOF plant.

(5) Equipment selection standards

The equipment will be selected according to the following standards.

1) Automation of equipment

- Automated machinery and equipment will be introduced as much as possible so that even inexperienced personnel can perform testing or sample preparation without individual differences.

2) Standby machines for the equipment

For such equipment items as will stop the testing operation completely if they fail, standby machines will be installed. For equipment items which can be substituted if they fail, standby machines will not be installed.

3) Transportation of samples

Transportation of samples from the inside of the BOF plant and blast furnace will be carried out unmannedly by pneumatic tube equipment. Transportation of other samples will be carried out mannedly by trucks and other vehicles.

4) Operational condition

The testing and analysis operations will be carried out by the 3-shift system as a general rule.

13.20.3 Equipment specifications

Table 13.20.1 List of equipment specifications

Division of equipment	Outlined specifications
Raw material testing center	
1. Buildings	
1) Main building	58m x 18m = 1,044 m^2
2) Auxiliary building	15m x 8m = 140 m^2 (outfit room and bath) 8m x 5m = 40 m^2 (oil storehouse)
2. Testing equipment	
1) Sample preparation equipment	Jaw crushers (2), roll jaw crushers (2), sample grinders (3), top grinders (5), rotary cone divider (1), vibration mills (3), etc.
2) Testing equipment	Fluorescence X-ray spectrometer (1), tumbler tester (1), drying furnaces (2), Vibration screens (2), low tap screens (3), coal expansion tester (1), drum tester (1), etc.

Division of equipment	Outlined specifications
Analysis center	
1. Building	20m x 10m = 200 m^2 An analytical laboratory having this area will be built inside the BOF plant.
2. Analysis equipment	
1) Sample preparation equipment	Automatic quick cutter (1), manual quick cutter (1), grinder (1), vibration mill (1), grinding machine with emery belt (1), briquette press (1), etc.
2) Analysis equipment	Vacuum-type emission spectrometer (2), fluorescence X-ray spectrometer (1), oxygen and nitrogen analyzer (1), microscopic carbon analyzer (1), sulfur analyzer (1), etc.

13.20.4 Layout

Fig. 13.20.1 shows the layout of the raw material testing center.

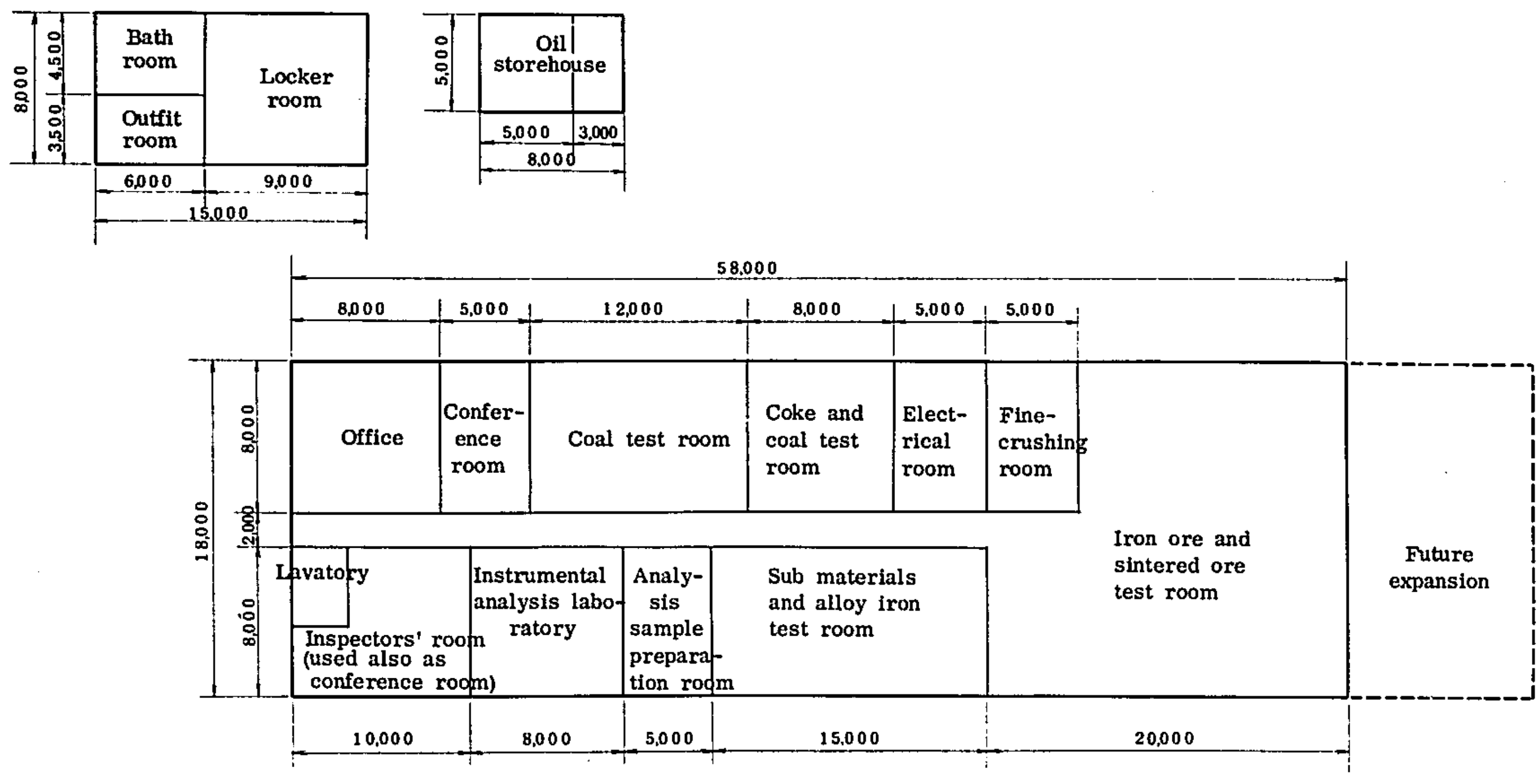
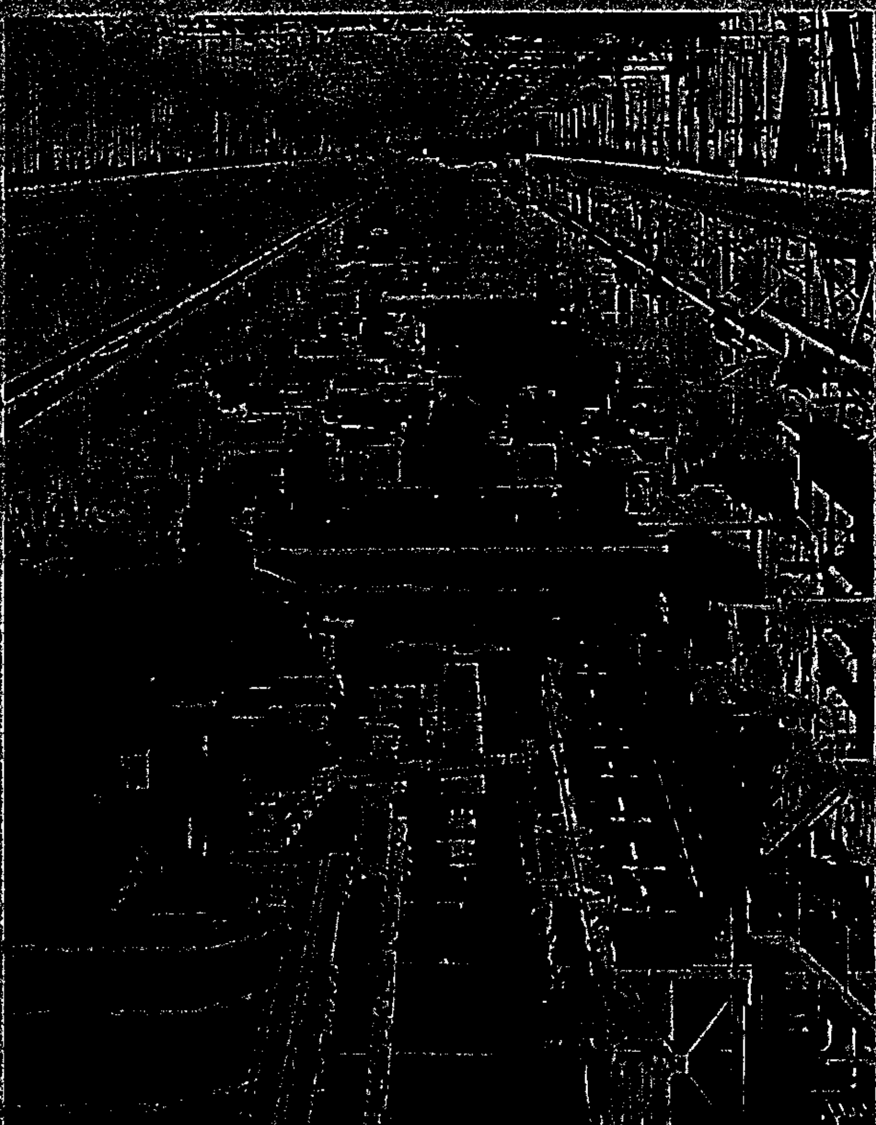


Fig. 13-20-1. Raw material testing center

CHAPTER 14

NASCO EXPANSION PLAN



CHAPTER 14 NASCO EXPANSION PLAN

14-1. Basic concepts

14-1-1. Assumptions for modification

The NASCO's hot steckel mill is a well-balanced mill which is designed to enable three types of rolling - slabbing, plate rolling and hot coil rolling - economically. When used for hot coil rolling only, its capacity is estimated to be approximately 350,000 tons/year. Study will be made as to whether it is possible to process slabs for hot coils produced at the 1st B.F. stage of the new steelworks by modifying this steckel mill and, if possible, as to what modification plan will be the most suitable.

This study is based on the following assumptions.

(1) Slabbing and plate rolling are possible even after modification.

(2) All ingots produced at the new steelworks are slabbed at NASCO.

(3) All slabs produced at the new steelworks are CC slabs, their thickness being 200 mm.

(4) Hot-rolled coils for tin plate are producible.

(5) Modification is minimized, placing emphasis on investment efficiency.

14-1-2. Outline of the study on modification

(1) Capacity of the existing equipment

The theoretically calculated capacity of the existing equipment is as follows.

1)	Reheating furnace	:	100 t/hr
2)	Rougher	:	250 t/hr
3)	Hot steckel mill	:	85 t/hr

The actual capacity of the whole equipment is estimated to be 65 t/hr in consideration of the mutual interference of the equipment and the effect of minor shutdowns which are not included in the calculation.

(2) Essential points of modification

To process all slabs for hot coils produced at the first stage of the new steelworks, the rolling capacity must be approximately 160 t/hr. To this effect, the capacities of the reheating furnace and hot finisher must be increased.

1) Increase in reheating capacity

The installation of additional reheating furnace is necessary for increasing the reheating capacity. In this case, it is recommended to adapt the reheating capacity and slab size to the specification of the existing furnace. It will be possible to meet the above-mentioned actual rolling capacity of 160 t/hr by installing one more reheating furnace of the same specification as the existing furnace.

2) Increase in the capacity of hot finisher

There are two methods of increasing the capacity of the hot finisher. One is to finish 5-pass rolling by the existing steckel mill in three passes and to finish rolling up to the required thickness by adding a 3-stand tandem mill behind the steckel mill. Another method is to replace the existing steckel mill by a tandem finisher. In the former case, however, the theoretically calculated capacity cannot exceed 135 t/hr. For this reason, the former method cannot be adopted for modification. Accordingly, the method of replacing the steckel mill with a tandem finisher will be adopted.

For the selection of the number of stands of a tandem finisher, Table 14-1 gives a comparison of merits and demerits of each number of stands.

Table 14-1. A comparison of merits and demerits of each number of stands

Item \ Number of stands	4 stands	5 stands	6 stands	7 stands
Bar thickness	approx. 14 mm	approx. 19 mm	approx. 24 mm	approx. 30 mm
Bar length (200mm x 6.1m slab)	approx. 87 m	approx. 64 m	approx. 51 m	approx. 41 m
Max. PIW	200 - 300 PIW	300 - 550 PIW	1,000-1,200 PIW	More than 1,400 PIW
Amount of investment	Small ——————→ Large			

A 4-stand finisher is not realistic, because the available PIW is too small. Since the maximum available PIW of the existing mill is 625 PIW, the adoption of 6 or more stands increases the capacity of the finisher too much, losing the balance with other equipment. Accordingly, it is the best way to adopt a 5 stand tandem mill. In this case, the bar thickness will be 19 mm which is equal to that of the bar being now produced, and therefore the existing crop shear can be used as it is.

(3) Other considerations on modification

1) Cooling water

In Japan, it is a usual practice to recirculate the cooling water by installing water treatment facilities. As we are informed that the recirculation of water is not necessary at NASCO because of the abundance of water, the water treatment facilities have been excluded from the modification plan. It is, therefore, necessary to increase the water intake capacity drastically so as to make possible the supply of water at a rate of 70 m^3 per minute to the hot strip mill.

2) Electric power

The total capacity of the generators supplying power to NASCO is as follows.

150 MW (At present)

380 MW (According to the 1979 plan)

The power fluctuation after the modification of the hot strip mill is estimated to be 46,000 kW. The voltage and frequency fluctuations due to this power fluctuation may be as given in Table 14-2.

Table 14-2. Voltage and frequency fluctuations

Total capacity of generator	150 MW (At present)	380 MW (in 1979)
Voltage fluctuation (at NSACO's receiving point)	More than 5%	Less than 5%
Frequency fluctuation	More than ±3 Hz	Less than ±2 Hz

As described above, the voltage and frequency fluctuations will be too great if the total capacity of generators remains unchanged. Accordingly, the modified mill must be put into operation after 1979 when the total capacity of generators will be increased to 380 MW.

3) Number of coilers

In view of the investment efficiency, the operation will be started with only one coiler for the time being. If the funds permit, however, it is desirable to install two coilers.

3) Coil yard

At present, the capacity increase of the coil yard is not under consideration. It is, however, possible to extend the building and there is no obstacle to this extension. It is recommended to install an additional coil yard, depending on the actual condition after the modified mill has been put into operation.

14-2. Equipment expansion plan

14-2-1. Steps of expansion

At first, the equipment should be expanded so as to be compatible with the 1st stage of the new steelworks, including the installation of an additional reheating furnace (2 furnaces in total), the adoption of a 5-stand tandem hot finisher and the accompanying modification. It is, however, possible to install one more reheating furnace (3 furnaces in total) at the last stage.

14-2-2. Production capacity after equipment expansion

The amount of hot coils rollable during the hours remaining after slabbing of all ingots produced at the new steelworks and rolling of 80,000 tons of plate in slab equivalent is calculated as follows.

1) Slabbing capacity : Rolling capacity : 200 t/hr
   Rate of operation : 70%

2) Plate rolling capacity : Rolling capacity : 100 t/hr
   Rate of operation : 80%

3) Hot coil rolling capacity :
   Rolling capacity : When two reheating furnaces are in operation : 160 t/hr
   When three reheating furnaces are in operation : 220 t/hr
   Rate of operation : 70%
   Rolling yield : 97.5%

4) Annual working hours

It is assumed that periodical repair is conducted four times a month (16 hrs x 3 times, 24 hrs x one time) and annual repair is conducted for five days once a year. Accordingly, the annual working hours will be 7,776 hrs/year.

5) Hot strip rolling capacity

a) Slabbing : 152,000 t/y   Slabbing hour : 1,086 hrs/y

b) Plate rolling: 80,000 t/y   Plate rolling hour: 1,000 hrs/y

c) Hot strip rolling hours

7,776 hrs/y - 1,086 hrs/y - 1,000 hrs/y = 5,690 hrs/y

d) Hot strip rolling capacity

When two reheating furnaces are in operation (1st stage):

5,690 hrs/y x (160 t/hr x 70%) x 0.975 = 620,000 t/y

When three reheating furnaces are in operation (final stage):

5,690 hrs/y x (220 t/hr x 70%) x 0.975 = 854,000 t/y

Namely, hot coils can be rolled in 620,000 t/year at the 1st stage and in 854,000 t/year at the final stage in addition to slabbing of 152,000 t/year and plate rolling of 80,000 t/year.

14-2-3. Mill shutdown due to the modification work

The foundations for the finisher and run-out table must be wholly reconstructed. For this construction work, the mill must be shut down for about 1.5 years. For the modification of the reheating furnace approach table and the transfer of the cooling bed, however, the mill need not be shut down for such a long time. Accordingly, plate rolling and slabbing can be continued during the modification of the finisher.

14-2-4. Costs for expansion

Table 14-3 shows the costs required for the expansion in the range as shown in Fig. 14-1, breaking them down by stages. Table 14-3 also shows the main specification to be changed by the modification and special remarks.

Table 14-3. Summary of expansion plan

Item	Present condition	After modification	
		1st stage	Final stage
PIW	625 PIW	625 PIW (Actual operating range: 536 PIW)	625 PIW (Actual operating range: 536 PIW)
Reheating furnace	1	2	3
Finisher	Hot steckel mill	5-stand continuous rolling mill	Same as left
Coiler	1	1	2
Production capacity	Hot coil: 350,000 t/y	Slabbing: 152,000 t/year Plate rolling: 80,000 t/year Hot coil: 620,000 t/year	Slabbing: 152,000 t/year Plate rolling: 80,000 t/year Hot coil: 854,000 t/year
Expansion costs	-	$ 46 million	+$ 7 million
Shutdown due to works	-	approx. 1.5 years	approx. 1 month
Special remarks			
1. Water-supply capacity	20 m^3/min	70 m^3/min should be secured.	Same as left
2. Coil yard		Additional installation as needed	Same as left
3. Electric power		Total capacity of generators should be higher than 380 MW.	Same as left

14-3. Specification for modified equipment

Table 14-4 shows the main specification of modified equipment in comparison with that of the existing equipment. Fig. 14-1 shows the layout after modification in comparison with the present layout. In Fig. 14-1, the coloured portions indicate the points of modification.

Table 14-4. Specification for NASCO's hot strip mill

Item	Present state	After modification	
		1st stage	Final stage
1. Slab size			
Thickness	104 - 234 mm	Same as left (Actual operating range is up to 200mm)	Same as left
Width	508 - 1,524mm	Same as left	Same as left
Length	4,980 - 6,100mm	Same as left	Same as left
2. Product size			
Thickness	1.78 - 7.95mm	Same as left	Same as left
Width	584 - 1,543mm	Same as left	Same as left
Inside diameter of coil	711mm	Same as left	Same as left
Outside diameter of coil	max. 1,524mm	Same as left	Same as left
3. Max. weight of slab	14,000 kg	Same as left	Same as left
4. Max. piw	625 piw	Same as left (Actual operating range is up to 536 piw)	Same as left
5. Slab yard			
Crane	30/15-ton crane x 2	2	3
Slab depiler	1	Slab depiler with depiler table x 1	Same as left
Slab pusher	1	2	3

Item	Present state	After modification	
		1st stage	Final stage
6. Discharging table	None	4	6
7. Reheating furnace			
Quantity	1	2	3
Furnace length	27,430mm	Same as left	Same as left
Furnace width	6,700mm	Same as left	Same as left
Reheating capacity	102mm thick slab: 107 t/hr 127 - 152mm thick slab: 114 t/hr 203mm thick slab: 103 t/hr	Same as left	Same as left
8. Reheating furnace delivery table	1	2	3
9. Edger entry table	Roll barrel length: 2,896mm	Same as left	Same as left
10. Edger			
Quantity	1	Same as left	Same as left
Roll diameter	1,067 ø	Same as left	Same as left
Motor output	300 HP x 2	Same as left	Same as left
11. Rougher approach and rear tables	Roll barrel length: 2,896mm	Same as left	Same as left

Item	Present state	After modification	
		1st stage	Final stage
12. Rougher			
Quantity	1	Same as left	Same as left
Roll size	965ø/1346ø x 2896mm (Four high at the time of plate rolling and hot rougher) 1168ø x 2896mm (Two high (at the time of slabbing))		
Motor output	3,500 Hp DC x 2, 40/80 rpm		
13. Slab shear	1	Same as left	Same as left
14. Slab pusher and slab transfer car	1	Same as left	Same as left
15. Delay table	1	Same as left	Same as left
16. Plate cooling bed	1	Same as left (To be moved)	Same as left
17. Flying crop shear	1 (Capacity: approx. 19mm)	Same as left (To be moved)	Same as left
18. Finisher	Hot steckel mill x 1	5-stand con-tinous mill	Same as left
Roll size	660ø/1245ø x 1676mm	Same as left	Same as left
Max. speed	467 m/min	695 m/min	Same as left

Item	Present state	After modification	
		1st stage	Final stage
Motor output	5000 Hp DC, 100/225 rpm	F1 - F3: 3750 kW DC	Same as left
		F4: 2,500	Same as left
		F5: 2,000 kW DC	Same as left
		(Steckel mill and motor are used at F1 stand after modification.)	
19. Runout table	Max. speed: 718 m/min	Same as left	Same as left
	Overall length: approx. 83m		
20. Strip cooler	Laminar flow type	Same as left (To be modified for capacity increase)	Same as left
21. Coiler			
Quantity	1	1	2
Mandrel diameter	711∅	Same as left	Same as left
Max. speed	810 m/min	Same as left	Same as left
Motor output	150 Hp x 2		
22. Coil converyor	1	Same as left	Same as left
23. Roll shop	Roll shop for cold strip mill will be used.	Construction of new building	Same as left
Roll grinder	Ditto	Installation of two new grinders	Same as left
Crane		Installation of new 60-t crane	Same as left
24. Mill yard crane	75/25 ton crane x 1	2	Same as left

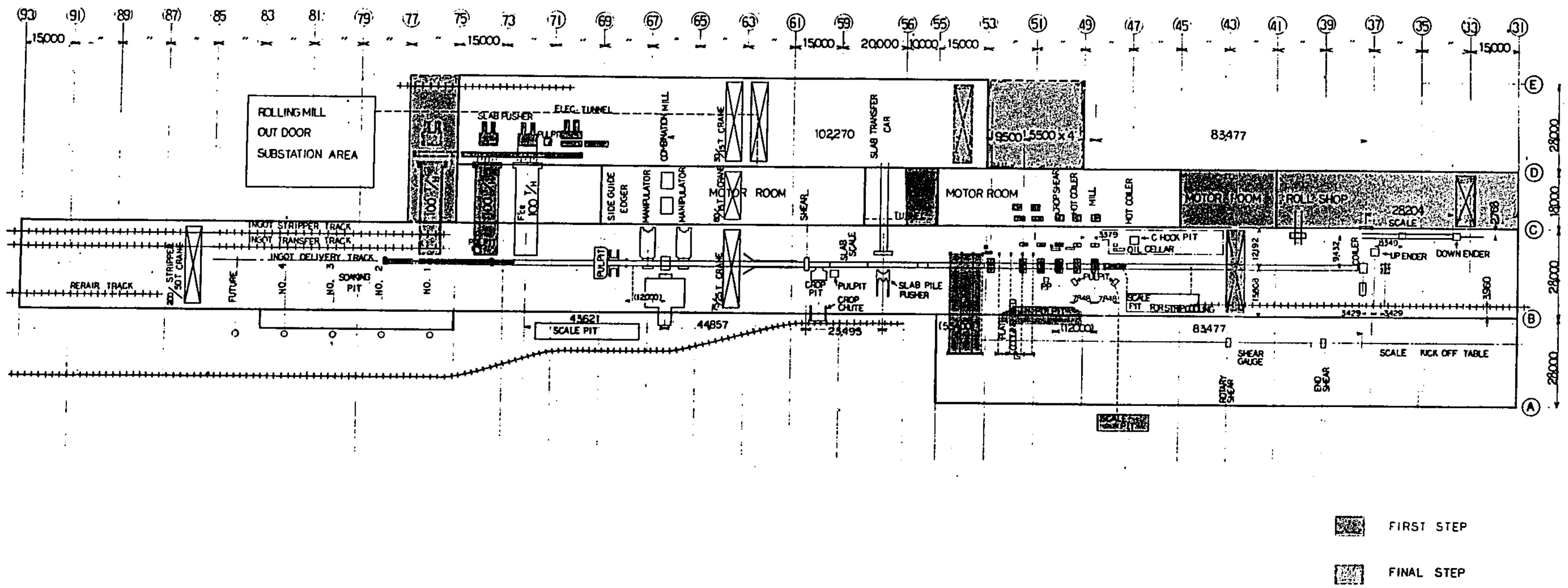


Fig. 14-1 Lay-out NASCO Hot Strip Mill after Modification

APPENDIX

(Appendix) New Hot Strip Mill Construction Plan

If a new hot strip mill with a capacity of approximately 2 million tons per year is to be constructed within a new steelworks in the most economical way, a mill with two roughers and seven finishers as shown in Table 14-5 may be cited as an example, although it may vary widely with the conditions given. In this example, the construction is divided into two stages. In the first stage, one rougher and six finishers are constrcuted. The construction costs required in each stage are also given in Table 14-5. Table 14-5 also shows the outline of the NASCO expansion plan. According to this plan, the following improvements will be achieved, because there are no limiting conditions on the new hot strip mill of the new steelworks.

(1) Enlargement of product thickness range

(2) Enlargement of PIW

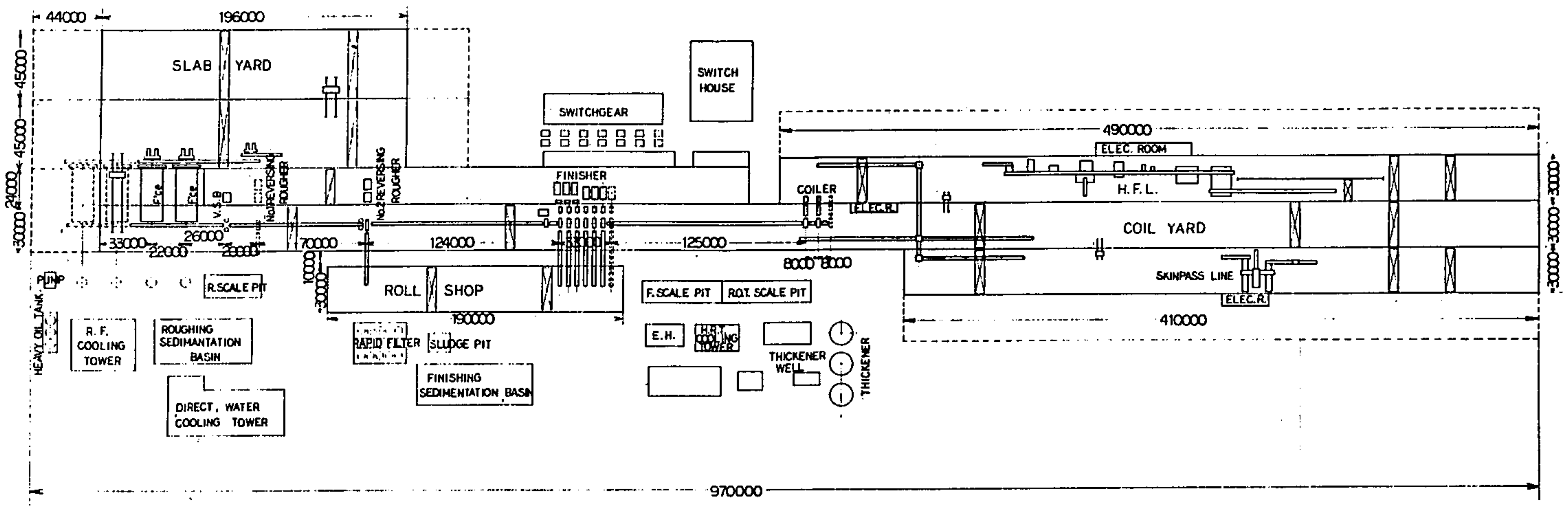
(3) Capacity increase

However, it should be understood that the amount of investment required for the construction of a new hot strip mill will be more than three times as high as those required for NASCO expansion.

The layout and main specification of a new hot strip mill are shown in Fig. 14-2.

Table 14-5. A comparison between the construction of a new hot strip mill in a new steelworks and the expansion of NASCO

	New construction		NASCO expansion	
	1st stage	Final stage	1st stage	Final stage
1. Capacity	1,800,000 t/y	3,000,000 t/y	Slabbing: 152,000 t/y Plate rolling: 80,000 t/y Hot coil: 620,000 t/y	Slabbing: 152,000 t/y Plate rolling: 80,000 t/y Hot coil: 854,000 t/y
2. Construction cost	$ 130 million	Total $ 160 million	$ 46 million	Total $ 53 million
3. Product size Thickness	1.6 - 12.7mm	1.2 - 12.7mm	1.78-7.95mm	Same as left
Width	600 - 1,600mm	Same as left	508 - 1,524mm	Same as left
4. Max. PIW	800 PIW	Same as left	625 PIW (Actual operating range: 536 PIW; 402 PIW for tin plate)	Same as left
5. Reheating furnace	180 t/hr x 2	180 t/hr x 4	100 t/hr x 2	100 t/hr x 3
6. Rougher VSB	1,500 kW x 1	Same as left	None	None
R1	None	6,000kW reverse x 1	5,250kW reverse x 1	Same as left
R2	8,000kW reverse x 1	Same as left	None	None
7. Finisher	6-stand (900 m/min)	7-stand (1,000 m/min)	5-stand (695 m/min)	Same as left
	F1-5 7,000kW F6 5,000kW	F1-6 7,000kW F7 5,000kW	F1-3 3,750kW F4 2,500kW F5 2,000kW	Same as left
8. Coiler	2	3	1	2
9. Overall mill length	approx. 480m	approx. 520m	approx. 330m	Same as left



MAIN SPECIFICATION

PRODUCT THICKNESS	1.2mm – 12.7mm
PRODUCT WIDTH	700mm – 1600mm
MAX. WEIGHT	23000Kg
MAX. PIW	800 PIW
SLAB THICKNESS	200mm
SLAB LENGTH	MAX. 9100mm
FURNACE CAPACITY	180 T/H/F'ce

	INITIAL STAGE	FINAL STAGE
FURNACE	2 FURNACES	4 FURNACES
ROUGHER	1 REV. ROUGHER	2 REV. ROUGHERS
FINISHER	6 S'TD FINISHER	7 S'TD FINISHER
COILER	2 COILERS	3 COILERS
CAPACITY	1800000 TONS PER YEAR	3000000 TONS PER YEAR

Fig. 14-2 Lay out and Main Specification of a Hot Strip Mill to be Newly Constructed.