(3) Conditions for Equipment Plan

i. Hot rolled coil

Material	:	Low carbon mild steel
Strip thickness	:	1.6 to 6.0 mm
Strip width	:	600 to 1,300 mm
Coil weight	:	18 tonnes (max.)

ii. Products

Use	:	Cold rolled coil & sheet for general use
		Cold rolled coil for galvanized sheet
		Cold rolled coil for tinplate
Strip thickness	:	0.15 to 3.2 mm
Strip width	:	50 to 1,300 mm
Sheet length	:	1,000 to 4,000 mm
Coil weight	:	8 tonnes (max.)

iii. Production plan

Annual production in each stage is shown in Table 15.5.1.

iv. Typical sizes of products

Typical product size is shown in Table 15.5.2.

v. Operating conditions

The operating conditions of each equipment are shown in Table 15.5.3.

Table 15.5.1 Annual Production

Products	1st stage		2nd stage	
	t/y	%	t/y	%
Cold rolled sheet for general use	121,000	25.2	170,000	21.2
Cold rolled coil for general use	54,000	11.3	74,000	9.2
Cold rolled coil for galvanized sheet	224,000	46.8	305,000	37.9
Cold rolled coil for tinplate	80,000	16.7	255,000	31.7
Total	479,000	100	804,000	100

Table 15.5.2 Typical Size of Products

Products	Thick. x Width (mm x mm)	Hot coil weight (tonne)
Cold rolled sheet for general use	0.8 x 1,219	17.2
Cold rolled coil for general use	1.6 x 1,219	17.2
Cold rolled coil for galvanized sheet	0.2 x 762	10.9
Cold rolled coil for tinplate	0.23 x 810	11.6

Table 15.5.3 Operating Conditions

Equipment	Pickling line		Tandem mill	Reversing mill	Cleaning line	
Stage	1st	2nd	1st & 2nd	2nd	1st	2nd
1) Calender time h/y	8,760 (365 d/y x 24 h/d)					
2) Annual maintenance h/y	120 (5 d/y x 24 h/d)					
3) Periodical maintenance h/y	816 (51 time/y x 16 h/time)					
4) Lunch time h/y	0					
5) Non shift working h/y	2,472 (365-5-51)d/yx8h/d	0	0	0	2,472 (365-5-51)d/yx8h/d	0
6) Scheduled suspension 2)+3)+4)+5) h/y	3,408	936	936	936	3,408	936
7) Time to operate 1)-6) h/y	5,352	7,824	7,824	7,824	5,352	7,824
8) Rate of operation %	90	90	75	80	88	88
9) Operating time 7)x8) h/y	4,816	7,042	5,868	6,259	4,709	6,885
10) Number of shift shift/d	2	3	3	3	2	3

Table 15.5.3 (cont'd)

Equipment	Batch annealing furnace	Continuous annealing line	2 St'd skinpass mill	1 St'd skinpass mill	Shearing & slitting line	Coil preparation line
Stage	1st & 2nd	2nd	1st & 2nd	2nd	1st & 2nd	1st & 2nd
1) Calender time h/y	8,760 (365 d/y x 24 h/d)					
2) Annual maintenance h/y	72 (3d/y x 24h/d)	336 (14d/y x 24h/d)	120 (5d/y x 24h/d)	120 (5d/y x 24h/d)	72 (3d/y x 24h/d)	72 (3d/y x 24h/d)
3) Periodical maintenance h/y	48 (12time/y x 4h/time)	576 (12time/y x 48h/time)	816 (51time/y x 16h/time)	816 (51time/y x 16h/time)	816 (51time/y x 16h/time)	816 (51time/y x 16h/time)
4) Lunch time h/y	0	0	978 [3shift/d x (365-5)d/y - 2shift/d x 51d/y] x 1h/shift	978	984 [3shift/d x (365-3)d/y - 2shift/d x 51d/y] x 1h/shift	984
5) Non shift working h/y	0	0	0	0	0	0
6) Scheduled suspension 2)+3)+4)+5) h/y	120	912	1,914	1,914	1,872	1,872
7) Time to operate h/y	8,640	7,848	6,846	6,846	6,888	6,888
8) Rate of operation %	90	85	78	80	85	80
9) Operating time h/y 7) x 8)	7,776	6,670	5,340	5,476	5,855	5,510
10) Number of shift shift/d	3	3	3	3	3	3

(4) Description of Equipment

i. Equipment plan

a. Layout

The cold strip mill plant layout is designed to facilitate for highly efficient production of high quality products, with the following considerations;

- smooth material flow from hot coil reception to product delivery,
- additional installation of 2nd stage equipment without production confusion,
- rust prevention during production process and before delivery, and
- effective roll management and smooth roll handling to the roll shop.

b. Pickling line

A hydrochloric acid type pickling line is planned to effectuate pickling work and to produce high quality products. The maximum unit weight of coil to be handled at the exit is designed 20 tonnes max., because the products are mostly of thin gauge and light load overhead crane is desired. Based on the cost consideration of the total investment, pickling line planned for the 1st stage is to cover the entire production for the 2nd stage also. In addition, the acid recovery equipment is planned to reduce acid consumption.

c. Cold strip mill

At the 1st stage, the 5-stand tandem mill will be installed to enable the rolling from thin gauge to thick gauge. At the 2nd stage, the 5-stand tandem mill will increase its stand to 6-stand to be used as the mill for thin gauge. For thick gauges, the installation of the reversing mill is planned.

Each mill will be of Automatic Gauge Control (AGC) system utilizing hydraulic push-up system to enhance thickness accuracy. In order to increase the efficiency in roll change, the changing car with side shift device will be used for changing work rolls and the hydraulic operated sled will be used for changing backup rolls, respectively. An additional installation of rolling oil recovery equipment is planned to reduce oil consumption.

d. Cleaning line

The cleaning line is provided for the strip with thickness less than 0.8 mm, which is rolled by using palm or tallow base oil. However, one line will have a capacity to clean up to 1.6 mm thickness coil for unexpected occurrence. Electrolytic cleaning line is planned for highly efficient cleaning.

e. Batch annealing furnace

As batch annealing furnace, the tight coil, single stack furnace will be used because of their versatility for production. The cooling cover system will be used for cooling coils on the annealing base. Dissociated ammonia gas added with nitrogen (H_2-N_2 gas) will be used for atmospheric gas. The annealed coils are to be cooled by dry air blow in the coil cooling yard to avoid rust development, while being cooled or waiting for temper rolling.

f. Continuous annealing line

The plan in the continuous annealing line is to anneal the high temper grade coils for tinplate for required hardness, because this annealing is subject to rapid heating and cooling. Based on the amount of production, equipment capacity and operational cost, it has been decided to install the continuous annealing line in the 2nd stage. Therefore, the production of the high temper grade coils for tinplate will start at the

completion of the 2nd stage. As this line is arranged to contain the cleaning equipment, the rolled strip will be directly transferred to the continuous annealing line, without passing the cleaning line.

g. Skinpass mill

In the 1st stage, the 2-stand skinpass mill will be installed to enable handling of both thin and thick gauges. In the 2nd stage, the 2-stand skinpass mill will be used only for thin gauge, and for thick gauge the single-stand skinpass mill will be additionally installed. The highly responsive hydraulic push-up system will be used for the screw down system. In addition, the automatic elongation control system will be used. The plan further includes the off gauge handling device at the entry location, and at the exit location the dividing shear which enables to divide the mill edge coil within the skinpass mill.

h. Shearing and slitting line

In the 1st stage, the shearing-slitting combination line will be installed. In the 2nd stage the shearing exclusive line will be increased. As both lines are low speed and handle thick gauge, the use of the guillotine type flying shear is decided for shearing. For slitting, the drive cut type slitter will be used to obtain sharp cut edges. The tension leveller will be installed on the shearing and slitting combination line to meet the requirement for better product shape. The cut sheets will be packaged on the following sheet packaging line. The slitted coils are packaged on the off line packaging yard.

j. Coil preparation line

The coil preparation line handles the finishing of the cold coils for tinplate and the cold coils for galvanized sheet. The plan includes one line installation in the 1st stage and one line increase in the 2nd stage. The tension leveller will be installed on the No.2 coil preparation line to

meet the higher requirement for product shape. The finished coils are packaged on the following packaging line.

ii. Main equipment

Table 15.5.4 shows the number of main equipment.

Table 15.5.4 Number of Main Equipment

Equipment	1st stage	2nd stage
Pickling line	1	1
Tandem cold strip mill	1	1 (Expansion)
Reversing cold strip mill	–	1
Cleaning line	2	2
Batch annealing furnace	1	Expansion
Continuous annealing line	–	1
2 stand skinpass mill	1	1
Single stand skinpass mill	–	1
Shearing & slitting line	1	1
Shearing line	–	1
Coil preparation line	1	2

iii. Specifications of main equipment

Specifications of main equipment are shown in Table 15.5.5.

iv. Production capacity of cold strip mill

Production capacity of cold strip mill is shown in Table 15.5.6.

Table 15.5.5 Specifications of Main Equipment

Equipment	1st stage		2nd stage	
	Q'ty	Main specification	Q'ty	Main specification
1. Pickling line	1	Capacity 950,000t/y (input base) Type Hydrochloric acid type Max. speed Entry sec. 600 m/min Tank sec. 300 m/min Del. sec. 400 m/min Strip thickness 1.6 - 6.0 mm Strip width 600 - 1,300 mm Coil weight Entry 18t (max.) Delivery 20t (max.)	-	
2. Tandem cold strip mill	1	Capacity 710,000t/y (input base) Type 56" , 4Hi , 5 Stands , Hydraulic push-up sys. Max. speed 1,800 m/min Strip thickness: Entry 1.6 - 6.0 mm Delivery 0.15 - 3.2 mm Strip width 600 - 1,300 mm Coil weight 20t (max.) Roll changing system Work roll: Changing car with side shift type Back-up roll: Hyd. operated sled type Coolant system: Direct & recirculation system Work roll bending: Increasing & decreasing Roll size: WR: $584^{\phi} \times 1,422^{L}$ mm BUR: $1,422^{\phi} \times 1,372^{L}$ mm Mill motor Total: DC 20,000kW		704,000t/y (input base) 6 Stands (expansion) 2,300 m/min 1.8 - 4.5 mm 0.15 - 1.2 mm Total: DC 26,000kW

Table 15.5.5 (cont'd)

Equipment	1st stage		2nd stage	
	Q'ty	Main specification	Q'ty	Main specification
3. Reversing cold strip mill	-		1	Capacity 281,000t/y (input base) Type 56", 4Hi, Single stand, Hydraulic push-up sys. Max. speed 600 m/min Strip thickness: Entry 2.3 - 6.0 mm Delivery 0.5 - 3.2 mm Strip width 600 - 1,300 mm Coil weight 20t (max.) Roll changing system Work roll: Changing car with side shift Backup roll: Hyd. operated sled type Coolant system: Recirculation system Work roll bending: Increasing & decreasing Roll size: WR: $546^{\phi} \times 1,422^{L}$ mm BUR: $1,356^{\phi} \times 1,372^{L}$ mm Mill motor : DC 2,000kW
4. Cleaning line No.1	1	Capacity 274,000t/y (input base) Type Electrolytic cleaning Max. speed 600 m/min Strip thickness 0.15 - 0.8 mm Strip width 600 - 1,067 mm Coil weight 20t (max.)	-	
5. Cleaning line No.2	1	Capacity 274,000t/y (input base) Type Electrolytic cleaning Max. speed 600 m/min Strip thickness 0.2 - 1.6 mm Strip width 600 - 1,300 mm Coil weight 20t (max.)	-	

Table 15.5.5 (cont'd)

Equipment	1st stage		2nd stage	
	Q'ty	Main specification	Q'ty	Main specification
6. Batch annealing furnace	1	Capacity 343,000t/y (input base) Type Single stack, tight coil, direct fired furnace Number of Heating Cover: 22 Covers Number of Base: 54 Bases Charge Capacity: 80t/Base (max.) Piling Hight: 4,700 mm (max.) Atmospheric Gas: H_2 - N_2 Gas Cooling Sys: Cooling cover type	1	140,000t/y (input base) Same as left 9 Covers 24 Bases Same as left Same as left Same as left Same as left
7. Continuous annealing line	-		1	Capacity 170,000t/y (input base) Type CAL with electrolytic cleaning type Max. Speed Entry sec. 450 m/min F'ce sec. 350 m/min Del. sec. 450 m/min Strip thickness 0.15 - 0.6 mm Strip width 600 - 1,067 mm Coil weight 20t (max.) Atmospheric gas: H_2 - N_2 Gas
8. Skinpass mill	1	Capacity 346,000t/y (input base) Type 56", 4Hi, 2 Stands, Hydraulic push-up sys. Max. Speed 1,500 m/min Strip Thickness 0.15 - 3.2 mm Strip Width 600 - 1,300 mm Coil Weight 20t (max.) Roll Changing System Work Roll: Changing car with side shift type Backup Roll: Hyd. Operated sled type	1	329,000t/y (input base) 56", 4Hi, single stand, Hydraulic push-up system 600 m/min 0.2 - 3.2 mm 600 - 1,300 mm 20t (max.) Same as left Same as left

Table 15.5.5 (cont'd)

Equipment	1st stage		2nd stage	
	Q'ty	Main specification	Q'ty	Main specification
9. Shearing & slitting line	1	Capacity 138,000t/y (input base) Type Shearing & slitting combination type Shear Guillotine type flying shear Slitter Drive out type Max. speed Shearing 120 m/min Slitting 200 m/min Strip thickness: 0.4 - 3.2 mm Strip width Entry 600 - 1,300 mm Delivery 50 - 1,300 mm Sheet length 4,000 mm (max.) Coil weight Entry 20t (max.) Delivery 8t (max.)	-	
10. Shearing line	-		1	Capacity 108,000t/y (input base) Type Guillotine type flying shear Strip thickness 0.4 - 3.2 mm Strip width 600 - 1,300 mm Sheet length 4,000 mm (max.) Coil weight Entry 20t (max.)
11. Coil Preparation line	1	Capacity 348,000t/y (input base) Max. speed 1,220 m/min Strip thickness 0.15 - 1.0 mm Strip width 600 - 1,300 mm Coil weight Entry 20t (max.) Delivery 8t (max.)	1	Same as left Same as left Same as left 600 - 1,067 mm Same as left Same as left

Table 15.5.5 (cont't)

Equipment	1st stage		2nd stage	
	Q,ty	Main specification	Q,ty	Main specification
12. Auxiliary equipment				
1) Roll grinding machine	4		2	
2) Aux. roll grinding machine	1		-	
3) Surface grinding machine	1		-	
4) Shot blasting machine	1		-	
5) Work roll chock remover	1		-	
6) Crane	19		7	
7) Up-ender	1		-	
8) Down ender	1		-	
9) Coil cooling equipment	1	For coil cooling yard	1	For coil cooling yard
10) Buggy	5	For roll, coil & sheet	2	For coil & sheet
11) Coil packaging line	1		-	
12) Sheet packaging line	1		-	
13) Acid recovery equipment	1		-	
14) Waste water treatment eq't	1		-	
15) Rolling oil recovery eq't	1		-	
16) Atmospheric gas generator	1		-	
13. Main building		Approx. 84,900 m^2		Approx. 23,500 m^2

Table 15.5.6 Production Capacity of Cold Strip Mill

Item	Unit	1st stage	2nd stage	
		5 St'd Tandem mill	6 St'd Tandem mill	Reverisng mill
Time to operate	h/y	7,824	7,824	7,824
Rate of operation	%	75	75	80
Average t/h	Input t/h	121	120	44.9
Mill capacity *1)	Input t/y	710,000	704,000	281,000
Amount of required production	Input t/y	500,000	841,000	

Note: *1) Calculation of mill capacity

Tandem mill

1st stage: 121 t/h x 0.75 x 7,824 h/y = 710,000 t/y

2nd stage: 120 t/h x 0.75 x 7,824 h/y = 704,000 t/y

Reversing mill

2nd stage: 44.9 t/h x 0.8 x 7,824 h/y = 281,000 t/y

(5) Material Flow

The material flow in the 1st stage and 2nd stage is shown in Fig. 15.5.2.

(6) Plant Layout

The cold strip mill plant layout is shown in Fig. 15.5.3.

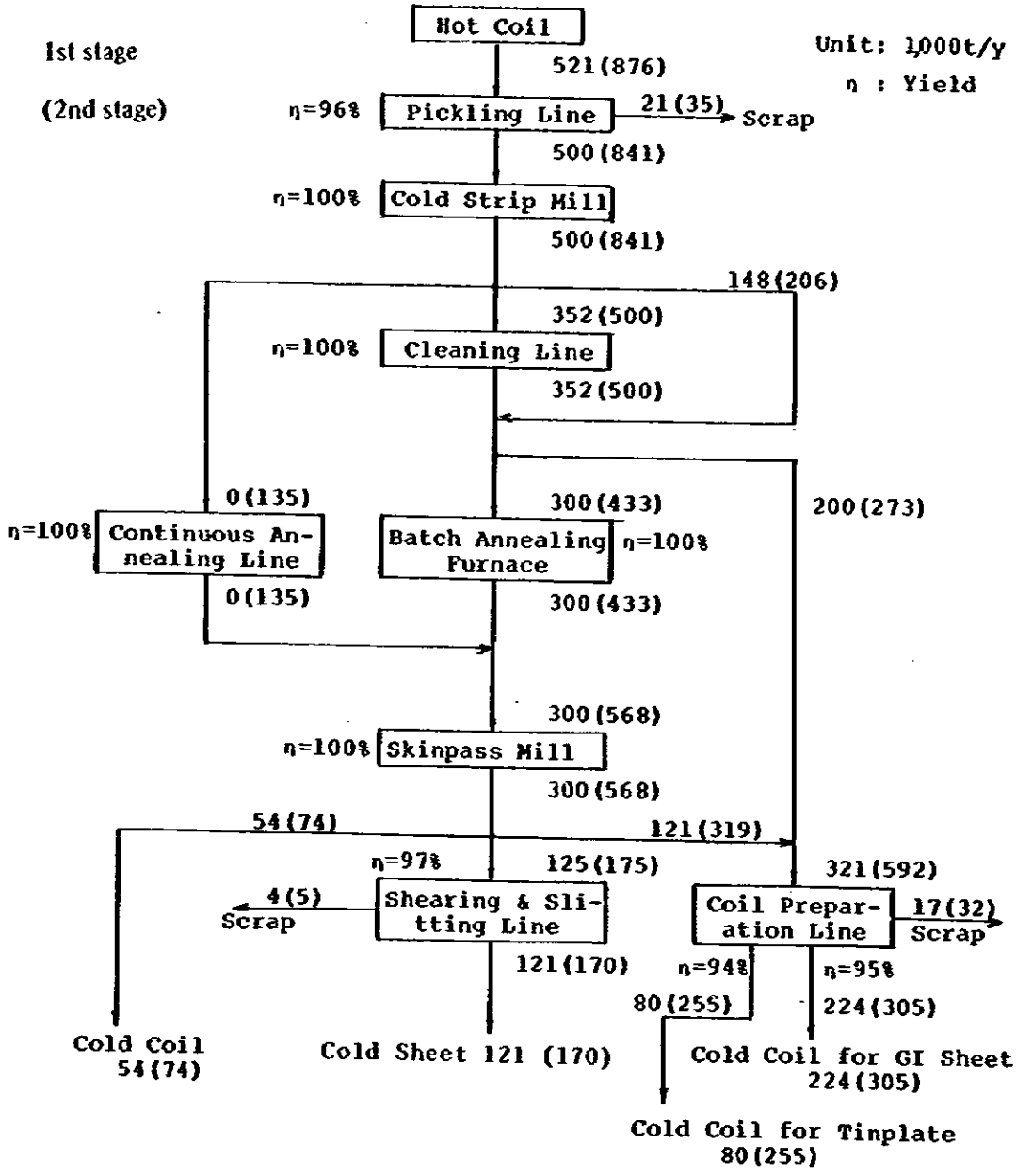
(7) Operation Data

i. Utility

The consumption of utilities is shown in Table 15.5.7.

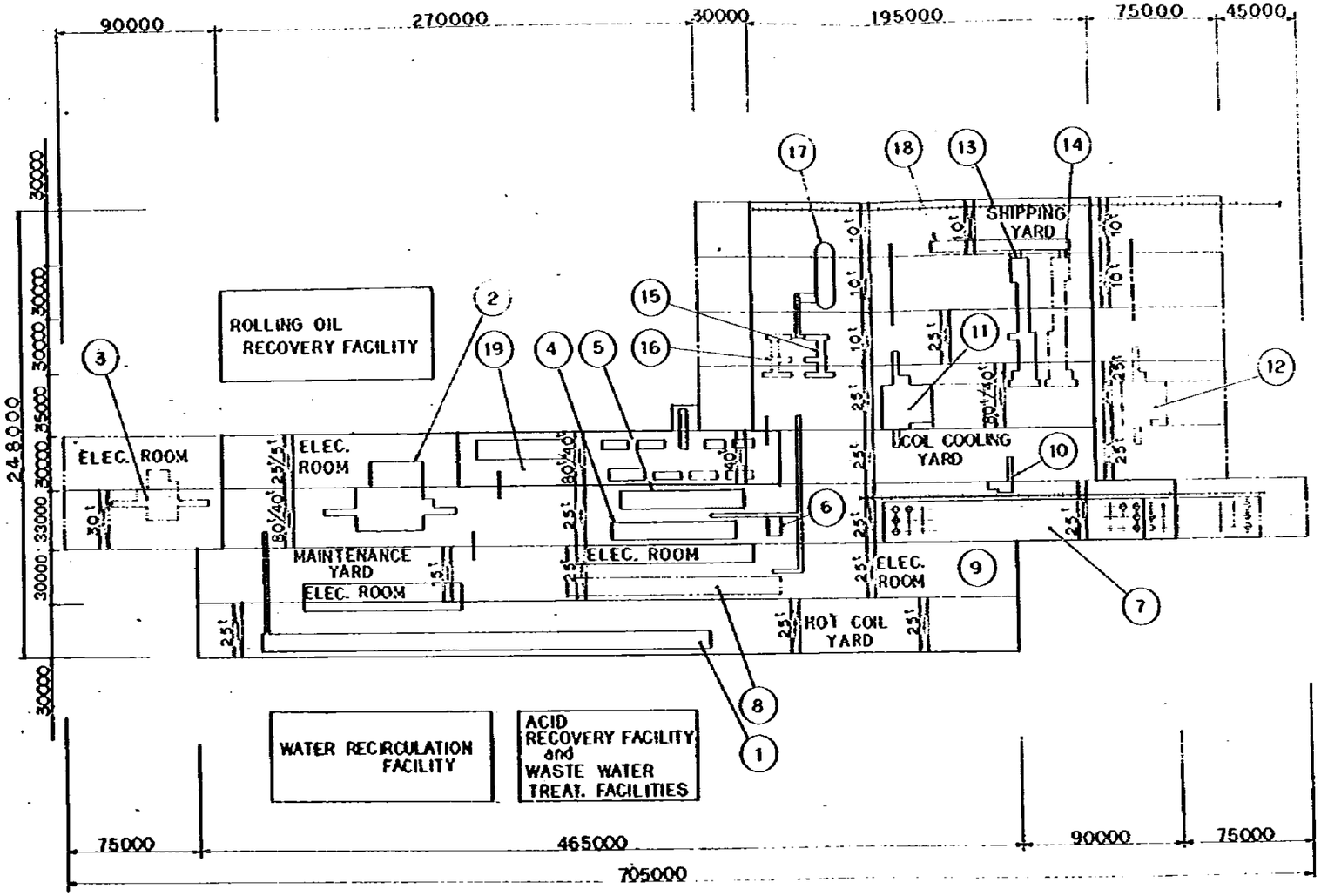
ii. By-products

The amount of by-products are shown in Table 15.5.8.



* Amount of Products: 479,000t/y (804,000t/y)

Fig. 15.5.2 Material Flow



NO	NAME
1	PICKLING LINE
2	5-STD. TANDEM COLD MILL
3	REVERSING COLD MILL (2nd Stage)
4	ELECTROLYTIC CLEANING LINE NO.1
5	ELECTROLYTIC CLEANING LINE NO.2
6	UP-ENDER
7	BATCH ANNEALING F'CE
8	CONTINUOUS ANNEALING LINE (2nd Stage)
9	ATMOSPHERIC GAS GENERATOR
10	DOWN-ENDER
11	2-STD. SKINPASS MILL
12	SINGLE STD. SKINPASS MILL (2nd Stage)
13	COMB. SHEAR AND SLITTING LINE
14	SHEAR LINE (2nd Stage)
15	COIL PREPARATION LINE NO.1
16	COIL PREPARATION LINE NO.2 (2nd Stage)
17	COIL PACKAGING LINE
18	SHEET PACKAGING LINE
19	ROLL SHOP

Legend

—— 1st Stage

—·— 2nd Stage

Fig. 15.5.3 Plant Layout

Table 15.5.7 Consumption of Utilities

Item	Stage	Unit consumption	Annual consumption
Natural gas	1st	27.8 Nm^3/t	13.3 x 10^5 Nm^3/y
	2nd	30.0 Nm^3/t	24.1 x 10^5 Nm^3/y
Electric power	1st	192 kWh/t	91.8 x 10^5 kWh/y
	2nd	194 kWh/t	155.6 x 10^5 kWh/y
Recirculation water	1st	35.9 m^3/t	17.2 x 10^5 m^3/y
	2nd	38.2 m^3/t	30.7 x 10^5 m^3/y
Make-up water	1st	1.63 m^3/t	0.78 x 10^5 m^3/y
	2nd	1.72 m^3/t	1.38 x 10^5 m^3/y
Once-through water	1st	2.80 m^3/t	1.34 x 10^6 m^3/y
	2nd	3.64 m^3/t	2.93 x 10^5 m^3/y
Steam	1st	289 kg/t	138.3 x 10^5 kg/y
	2nd	345 kg/t	277.1 x 10^5 kg/y
Compressed air	1st	93.7 Nm^3/t	44.9 x 10^5 Nm^3/y
	2nd	77.7 Nm^3/t	62.5 x 10^6 Nm^3/y
N_2 gas	1st	9.39 Nm^3/t	4.50 x 10^5 Nm^3/y
	2nd	21.1 Nm^3/t	17.0 x 10^5 Nm^3/y

Note: Production (finished products)
1st stage: 479,000 t/y
2nd stage: 804,000 t/y

Table 15.5.8 Amount of By-products

Equipment	By-products	1st stage	2nd stage
Pickling line	Scrap	21,000 t/y	35,000 t/y
	Sludge	3,200 t/y	5,400 t/y
Cold strip mill	Sludge	3,400 t/y	5,700 t/y
	Fatty acid	500 t/y	800 t/y
Cleaning line	Sludge	1,800 t/y	2,600 t/y
Shearing & slitting line	Scrap	4,000 t/y	5,000 t/y
Coil preparation line	Scrap	17,000 t/y	32,000 t/y

(8) Organization and Personnel

i. Organization

The organization in the cold strip mill plant is as follows.

- Cold strip mill plant
  - Office work group
  - Cold rolling group
  - 1st finishing group
  - 2nd finishing group
  - Crane group
  - Roll group

ii. Personnel

Personnel for the cold strip mill plant are shown in Table 15.5.9.

Table 15.5.9 Personnel for Cold Strip Mill Plant

Sup't.	Group	Ass't. sup't.	Engineer	Cleck	Foreman	Skilled worker	Semi-skilled	Un-skilled	Sub-total of group
1 (1)	General	1 (1)	– (–)	5 (7)	– (–)	– (–)	– (–)	– (–)	6 (8)
	Rolling	1 (1)	3 (3)	2 (3)	4 (5)	26 (43)	44 (63)	23 (34)	103 (152)
	1st finishing	1 (1)	2 (2)	2 (3)	4 (5)	24 (48)	27 (53)	26 (48)	86 (160)
	2nd finishing	1 (1)	1 (1)	8 (10)	3 (4)	13 (34)	33 (58)	72 (102)	131 (210)
	Crane	1 (1)	– (–)	1 (1)	3 (3)	21 (29)	21 (29)	20 (26)	67 (88)
	Roll	1 (1)	1 (1)	1 (1)	3 (3)	11 (15)	10 (14)	19 (25)	46 (60)
1 (1)		6 (6)	7 (7)	19 (25)	17 (20)	95 (169)	135 (217)	160 (235)	439 (679)
Total						440 (680)			

Note: 1) Figures in ( ) show the number of personnel required at the 2nd stage.
2) Rolling means pickling and rolling.
3) 1st finishing means cleaning, annealing and skinpass.
4) 2nd finishing means shearing, slitting and coil preparation.

CHAPTER 15-6

UTILITIES

15.6 Utilities

(1) General

i. Arrangement of utilities

Utilities are used throughout the whole process in a steelworks. To have a centralized and integral control/operation system is desirable from the viewpoints of standardization of technology, effective application of facilities, and simplification of control. From these, the utilities of the new steel plant are planned as follows:

Gas: Gas pressure is adjusted at the utility centre and delivered to each place of use.

Electric power: Power is transformed to an adequate voltage at the incoming substation and is then fed to each plant. Each plant is provided with an electric control room, from which power is distributed to the operating facilities in and around the plant.

Process steam: The utility center shall be provided with a boiler, from which the process steam is supplied to each place of use.

Compressed air: The utility center shall be provided with a compressor, which supplies compressed air to the whole steel plant.

Oxygen, Nitrogen: The utility centre shall be provided with an air separator and compressor unit. A gas holder for absorbing fluctuations in consumption will be installed near the respective plant.

Water facilities: Various cooling water treatment and circulation facilities are installed near the respective factories. This is because water treatment systems vary with each place of use so that centralizing the facilities results in no significant advantage and requires longer piping for water supply or return and also

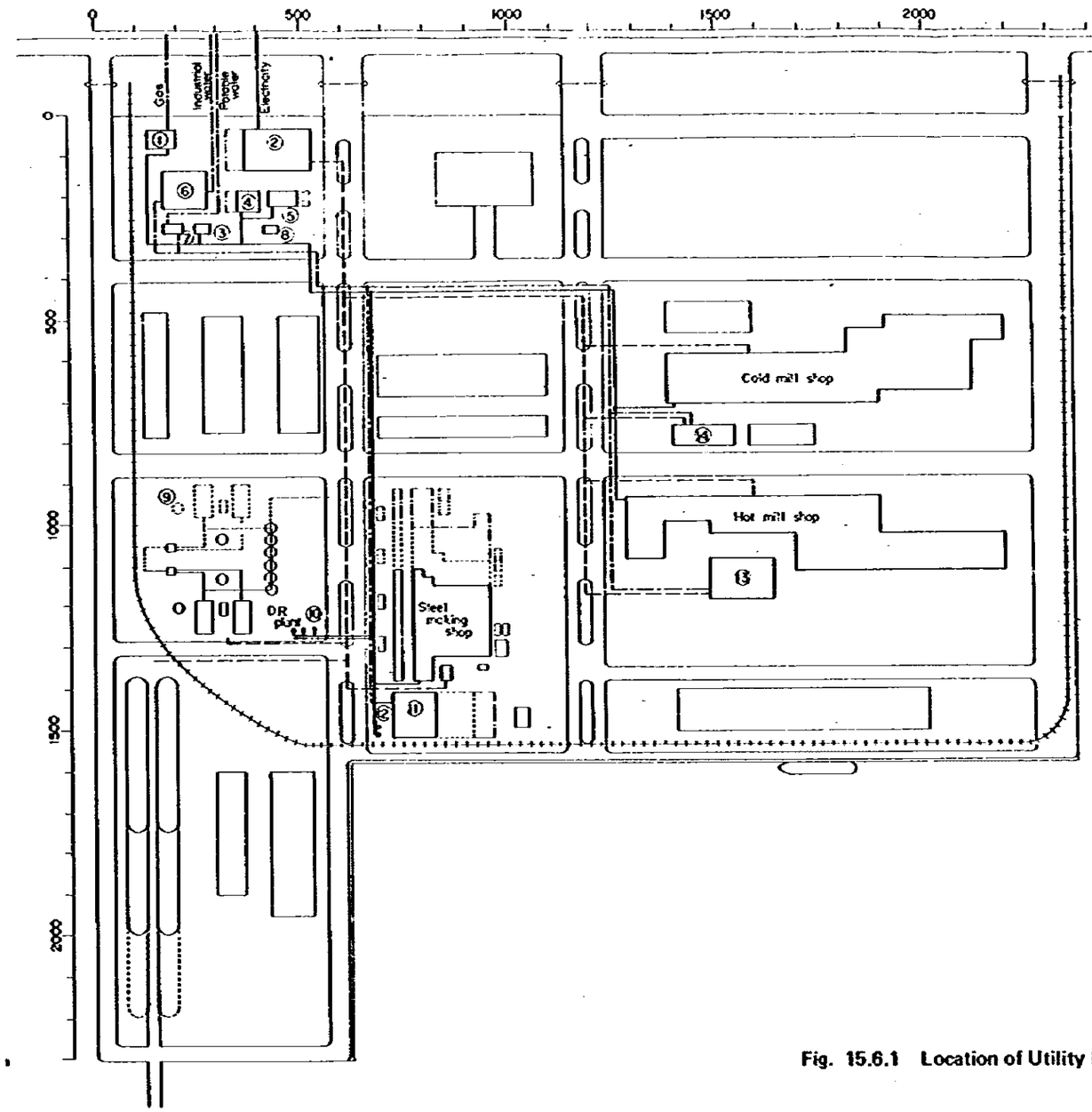
increases the pressure loss. The utility centre will be provided with an intake reservoir, from which industrial water is pressure-fed by pumping.

One operating station (monitoring room) is located for each facility. As the boiler, gas and compressed air facilities are positioned in close proximity, however, one station is to control them both.

Incorporating the above considerations, utilities are arranged as shown in Fig. 15.6.1, in which general piping routes and electric cabling are also illustrated. Water pipes are buried type as they are of large diametre and considerable weight. Gas, oxygen, air and steam piping uses the overhead piping system. The power cable runs through a culvert and part of it through a buried trough.

ii. Predicted utility consumption

Table 15.6.1 shows the annual consumption of utilities in the steel plant at the 1st stage and 2nd stage respectively. These figures are assumed, based on the facilities and operation of each division as projected and the operating results of modern steel works in Japan. The financial study of this report also used these figures.



① Gas receiving station
② Main sub-station
③ Boilers
④ Air compressor house
⑤ Oxygen plant
⑥ Industrial water reservoir
⑦ Potable water reservoir
⑧ Office for utilities section
⑨ Water treatment station for DR plant
⑩ Nitrogen spherical holders
⑪ Water treatment station for steel making shop
⑫ Oxygen spherical holders
⑬ Water treatment station for hot rolling mill
⑭ Water treatment station for cold rolling mill

——— : Overhead pipeline route for natural gas, steam, compressed air, oxygen and nitrogen
—·—·— : Underground pipeline route for water distribution
— — — — : Underground cable route for power distribution

Fig. 15.6.1 Location of Utility Facilities and Distribution Line Routes

Table 15.6.1 Annual Consumption of Utilities – 1st Stage

	Cost center	Production	Gas	Power	Steam	Plant air	Oxygen	Nitrogen Argon	Circulated water	Make up water	Once-through water	Fresh water	Potable water
		10^3 t	10^3 Nm³	10^3 kwh	t	10^3 Nm³	10^3 Nm³	10^3 Nm³	10^3 m³	10^3 m³	10^3 m³	10^3 m³	10^3 m³
Manufacturing section	D R plant	1211	411900	172000		10900		300	39700	1790		1790	
	Electric arc furnace	1296	15500	979000		10400	6500		88000	3960		3960	
	Continuous casting	1205	5600	17100		24100	22100	3400	58800	2650		2650	
	Hot rolling mill	1169	65900	114500	14500	37800			72300	3250		3250	
	Skinpass mill	279		1100		100							
	Shearing	199		1500		2700							
	Slitter	171		1200		2300							
	Sub total			3800		5100							
	Pickling	500	1600	7000	33900	12500			1300	60	310	370	
	Cold rolling	500		55000	20000	24000			7500	340	500	840	
	Sub total		1600	62000	53900	36500			8800	400	810	1210	
	Electrolytic cleaning	352		5300	63400	8400					530	530	
	Box annealing	300	11700	15000	21000			4500	8400	380		380	
	Skinpass mill	300		6600									
	Shearing, Slitter	121		1300									
	Coil processing	304		1600									
	Sub total		11700	29800	84400	8400		4500	8400	380	530	910	
	Total		92200	378200	152800	133200	28600	8200	276000	12430	1340	13770	
Auxiliary section	Raw material handling			1800									
	Industrial water			122900									
	Plant air			18600					3500	160		160	
	Natural gas												
	Oxygen plant			22900					2900	130		130	
	Electric power			27100									
	Steam boiler		15200	3100							180	180	
	Analyzing												
	Maintenance shop			700									
	Product handling			500									
	Stock house			100									
	General			700									660
	Head office			400									60
	Total		15200	198800					6400	290	180	470	720
	Grand total		527400	577000	152800	133200	28600	8200	282400	12720	1520	14240	720
	To be purchased		527400	577000								14240	720

Table 15.6.1 (cont'd) – 2nd Stage

	Cost center	Product	Gas	Power	Steam	Plant air	Oxygen	Nitrogen Argon	Circulated water	Make up water	Once-through water	Fresh water	Potable water
		10^3 t	10^3 Nm^3	10^3 kwh	t	10^3 Nm^3	10^3 Nm^3	10^3 Nm^3	10^3 m^3	10^3 m^3	10^3 m^3	10^3 m^3	10^3 m^3
Manufacturing section	O R plant	1912	650300	271500		16400		500	59500	2680		2680	
	Electric arc furnace	2044	24500	545300		16400	10200		132000	5940		5940	
	Continuous casting	1903	8900	27000		38100	34800	5400	83800	3770		3770	
	Hot rolling mill	1846	104000	180600	22800	46100			95200	4280		4280	
	Slabpass mill	446		1800		100							
	Shearing	274		2000		3100							
	Slitter	257		1800		2900							
	Sub total			5600		6100							
	Pickling	841	2700	11800	56900	17500			2200	100	530	630	
	Cold rolling	841		88300	33600	33600			12600	570	840	1410	
	Sub total		2700	100100	90500	51100			14800	670	1370	2040	
	Electrolytic cleaning	500		7500	90000	10000					750	750	
	Box annealing	433	16800	21700	30300			6500	12100	540		540	
	Slabpass mill	568		9100									
	Shearing, Slitter	170		1800									
	Coil processing	560		3000									
	Continuous annealing	135	4600	12400	66300	1400		10500	3800	170	810	980	
	Sub total		21400	55500	186600	11400		17000	15900		1560		
	Total		81800	285800	299900	185600	45000	22900	401200	18050	2930	20980	
Auxiliary section	Raw material handling			2900									
	Industrial water			178700									
	Plant air			23500					4400	200		200	
	Natural gas												
	Oxygen plant			36000					4500	200		200	
	Electric power			42800									
	Steam boiler		29800	6000							360	360	
	Analyzing												
	Maintenance shop			1100									
	Product handling			800									
	Stock house			200									
	General			1100									1000
	Head office			600									60
	Total		29800	293700					8900	400	360	760	1060
	Grand total		81600	2479600	299900	185600	45000	22900	410100	18450	3290	21690	1060
	To be purchased		81600	2479600								21690	1060

(2) Natural Gas

i. Gas balance

The natural gas balance for this plant is shown in Table 15.6.2.

Natural gas is consumed as a reductant in the DR plant, and as fuel for the gas cutter in the steelmaking shop, at the reheating furnace of the hot strip mill, at the annealing furnace of the cold strip mill and at the boiler.

Table 15.6.2 Natural Gas Balance

(Unit: 1,000 Nm^3/h)

	DR plant	Steelmaking	Hot mill	Cold mill	Boiler	Total
1st stage	54.9	8.0	8.4	1.7	2.5	75.5
2nd stage	86.7	12.0	13.3	2.9	3.8	118.7

ii. Supply system

Fig. 15.6.2 shows the supply system diagram of the natural gas. The natural gas which reaches the inlet of the steel plant at about 40 kg/cm^2g is reduced to the pressure required for each plant and is then distributed. Namely, gases are supplied at 8 kg/cm^2g to the direct reduction plant and steelmaking shop, and are also reduced to 1.5 kg/cm^2g for the hot strip mill and the cold strip mill. Furthermore, a 2,000 Nm^3/h flare stack is planned in order to serve as safety equipment against pressure change in the natural gas main line caused by an interruption of fuel shut-off in the furnaces, and for pipe line purging required for repairing the valves of the pipeline.

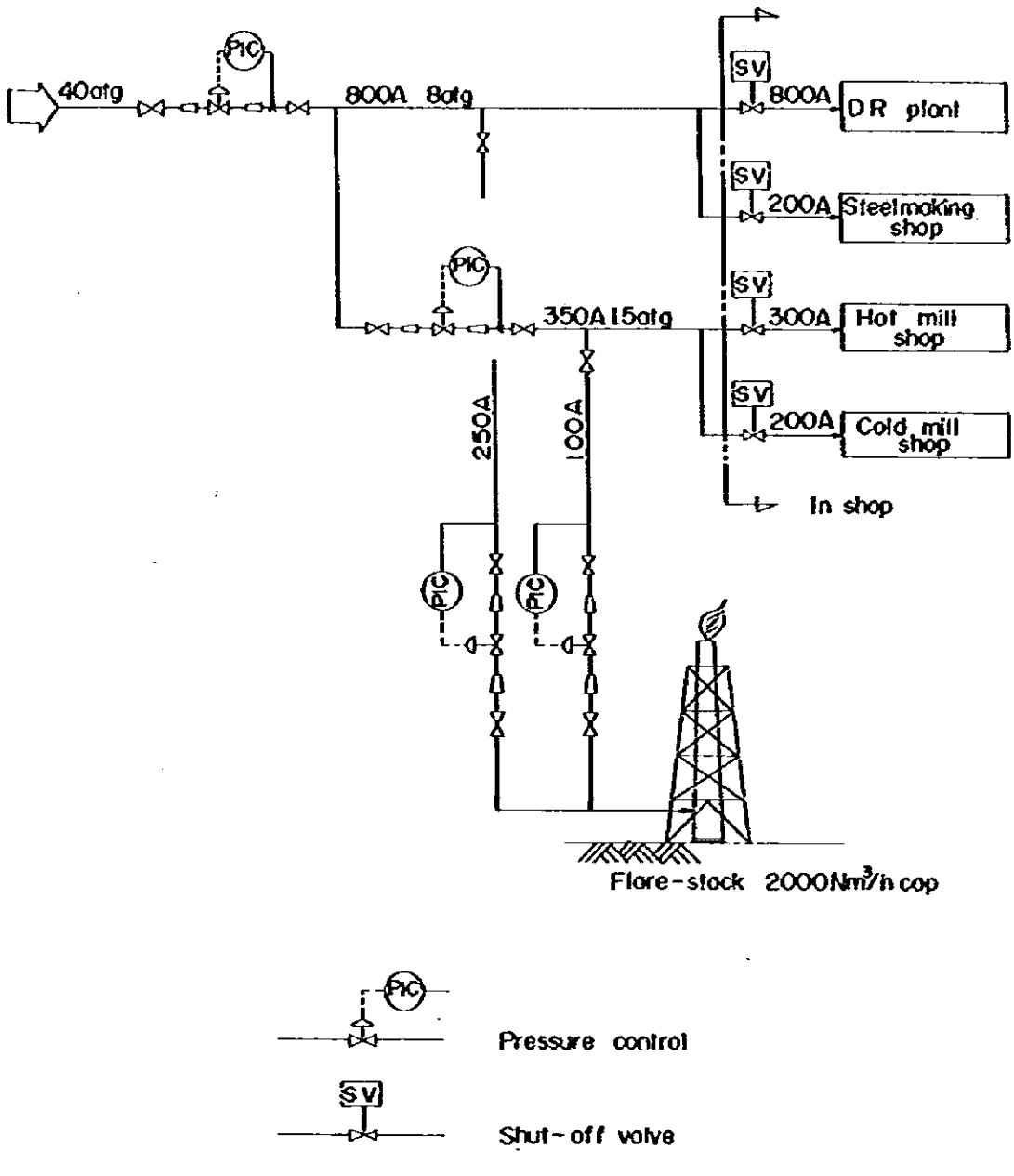


Fig. 15.6.2 Natural Gas Distribution Flow

(3) Power Facilities

i. Demand power

The demand power at each stage of the steel plant is shown in Table 15.6.3.

ii. Incoming and distributing system

See Fig. 15.6.3 and 15.6.4.

a. Incoming capacity

All the demand power is supplied by EGAT because no generators for private use are installed. The maximum demand power is 240 MW at the 1st stage and 360 MW at the 2nd stage. It is advised that the capacity of the lead-in wire be set for the final scale with some allowance (Approx. 15 percent), namely 450 MVA.

There may be 3 lines or more for the multiple incoming system, but two 230 kV lines are adopted for economic and operational reasons, and they have sufficient capacity to allow normal operation even if one line fails.

b. Incoming system

A MOF (Metering outfit, supply metre) shall be provided at the intake. A 230 kV double bus is provided through a 230 kV CB (Circuit breaker) to facilitate future expansion to make the facilities highly reliable. The breaking capacity of the circuit breakers shall be 40 kA to allow for future expansion.

The main transformer equipment shall be three 150 MVA units at the 1st stage and one additional unit at the 2nd stage. The transformer shall be provided with an on-load tap changer to obtain the desired range of private distribution voltages.

Table 15.6.3 Electric Power Demand

Application	Production (10^3 t/year)		kWh/t	Average (MW)		Load factor		Demand MW (max/h)	
	1st stage	2nd stage		1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
O R	1,211	1,912	142	20	31	0.87	0.88	23	35
E A F	1,295	2,044	756	111	175	0.78	0.79	142	221
C C	1,205	1,903	14	2	3	0.7	0.75	3	4
Hot	1,169	1,846	101	14	21	0.5	0.6	28	35
Cold	500	841	184	10	18	0.53	0.68	19	26
Utilities				22	33	0.74	0.78	30	42
Miscellaneous				1	2	0.6	0.6	2	3
Total				180	283			247	366
Div. factor								1.03	1.03
Max. power								240	355
10^6 kWh/year				1,577	2,480				

○ : Circuit breaker

× : Disconnecting switch

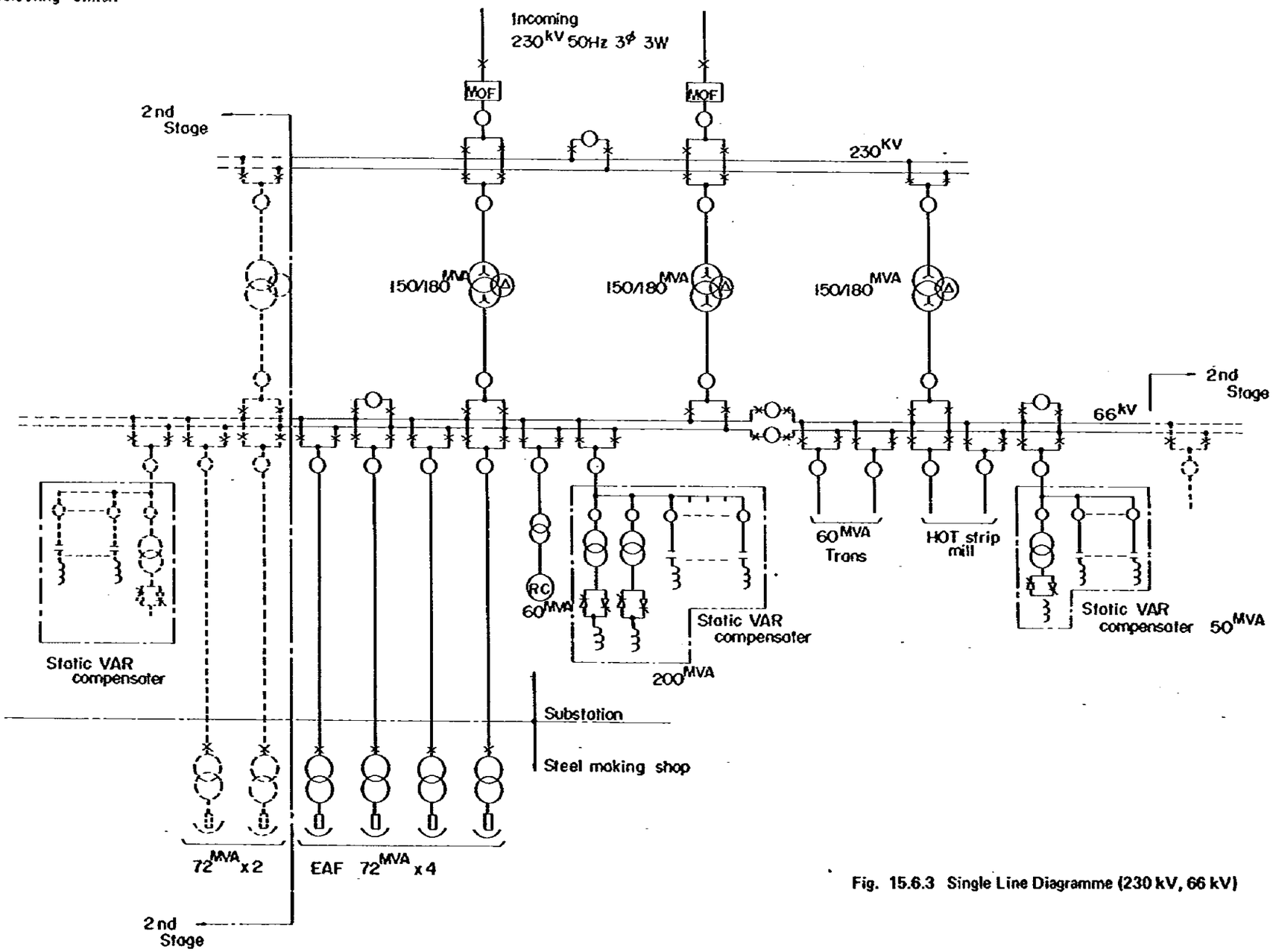


Fig. 15.6.3 Single Line Diagramme (230 kV, 66 kV)

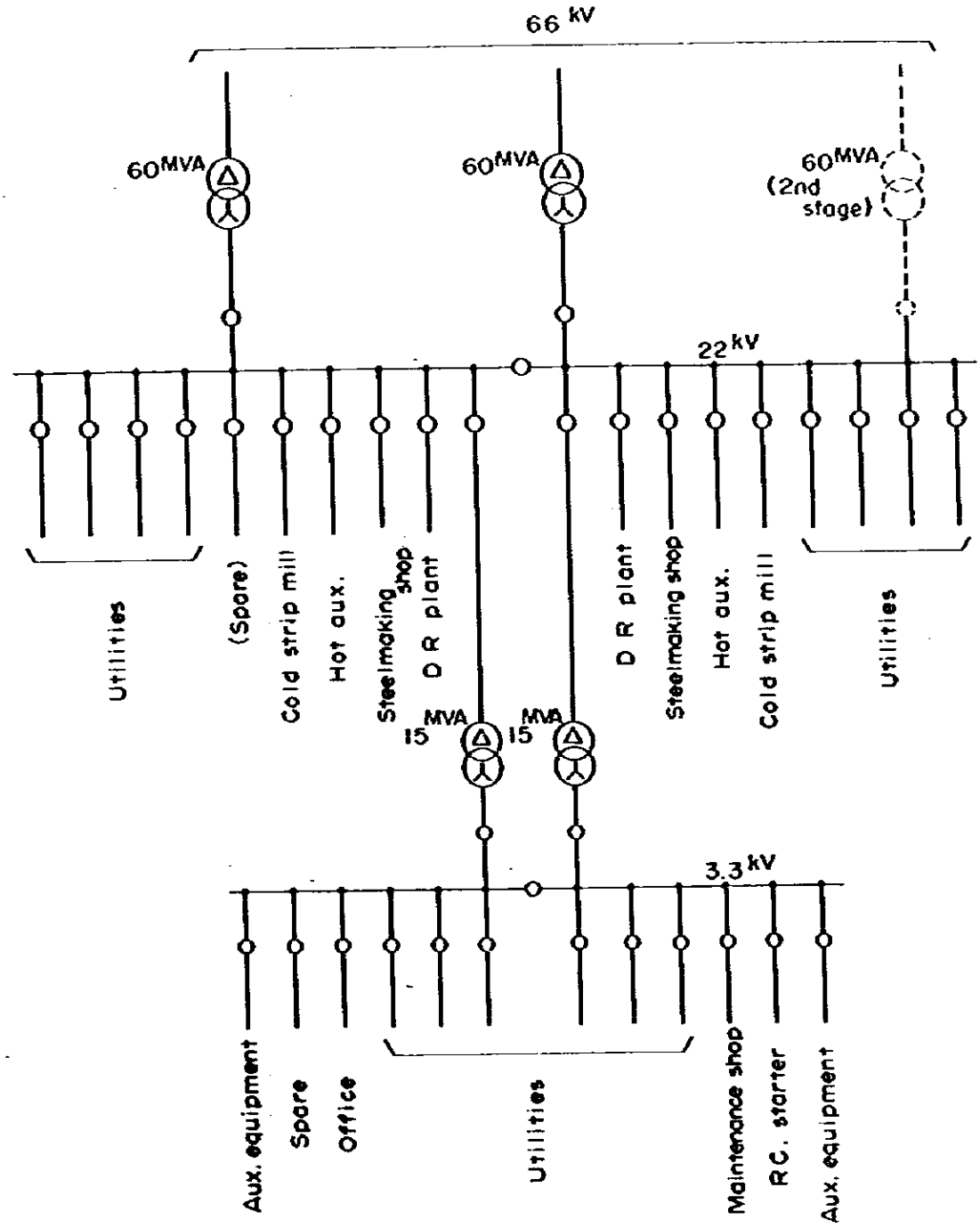


Fig. 15.6.4 Single Line Diagramme (22 kV, 3.3 kV)

A 230 kV lightening arrester is provided to prevent occurrence of abnormal external and internal voltages.

c. Wiring voltage

A 66 kV wiring voltage shall be used for the electric arc furnaces and the main machine of the hot strip mill which have large loads and sharp changes. The DR plant, CC plant, cold strip mill, oxygen plant, air compressor, water treatments for steelmaking and the hot strip mill and auxiliary facilities for hot strip mill shall have 22 kV wiring. Other utilities, maintenance shops, offices, etc., shall have 3.3 kV wiring.

d. Breaking capacities

These shall be 31.5 kA for 66 kV and 40 kA for 22 kV and 3.3 kV, respectively. The system short-circuit capacity shall be planned so as to keep below these values at present and in the future.

e. Grounding system

The grounding system shall resistance-ground at each transformer's neutral terminal so as to suppress abnormal voltage due to a ground fault under the various system operating conditions and also to provide a perfect protection to the system.

f. 66 kV bus form

The 66 kV bus form shall be of double-bus type with a bus-tying circuit breaker so that the electric furnace load may be fed apart from the other loads and operation may be separate even though one unit of the three main transformers (four units in the future) is out of order, and so that the future expansion is possible without shut-down.

g. 22 kV and 3.3 kV bus form

It shall be of single-bus type with a bus-tying circuit breaker.

iii. Distribution line

The private distribution line shall be of the underground-cable type. The main line with multiple wires shall be of the underground-culvert type and the branch line, of the trough-buried type, respectively.

iv. Protective relay system

a. Bus protector

The 230 kV bus shall be provided with well coordinated necessary bus protective relays, after arrangement with EGAT.

b. Transformer protector

Transformer protection shall be provided by a differential relay for short circuit faults and by a directional ground relay for ground faults.

c. Distribution line protector

Distribution line protection shall be provided by a circulating-current-type pilot-wire relay for two parallel distribution lines (22 kV or more), including that for short circuit and ground faults, and by over-current relay and directional ground relay for other lines.

v. Monitoring control system

This shall be a monitoring and operating system having a monitoring control panel installed in the control room.

vi. Flicker compensation

A static VAR (Reactive power) compensator and a rotary condenser shall be provided for controlling the voltage flicker resulting from the arc furnace so that it remains within tolerance. The tolerance value is set at within 2% in the short circuit voltage depression when the electrodes are shorted, and short cir-

cuit capacity of the system is assumed to be 2,000 MVA. In this case, a 200 MVA static VAR compensator and a 60 MVA rotary condenser are needed. Any trouble in this equipment may result in a shutdown or limitations in the production but spare units are not provided for economy reasons. In addition, a 50 MVA static VAR compensator shall be separately provided to prevent voltage change due to a change in rolling mill load. The configuration at the 1st stage is shown in Fig. 15.6.5.

At the 2nd stage, assuming that the system short circuit capacity increases to about 2,700 MVA a 60 MVA static VAR compensator may be equipped on the arc furnace load side.

vii. Higher harmonics measures

The arc furnace load generates higher harmonics with broad frequency spectrum and the rectifier for the DC motor produces higher harmonics specific to the commutating phase number. Also, higher harmonics are produced from the compensator for flicker prevention. These higher harmonics cause inductive faults in the channels and adversely affect capacitors and synchronous machines in the system.

The harmonics filter is necessary to prevent the above problems, but the capacitor of the VAR compensator is to be divided into the necessary higher harmonics orders to be used as a harmonics filter, too.

viii. Outline of incoming substation (See Table 15.6.4)

a. 230 kV switchgear

SF_6-gas-insulated switchgear shall be employed, which is the most effective in terms of salt-corrosion proof, dust proof and corrosive-gas proof. SF_6-gas-insulated switchgear is very economical and reliable, as

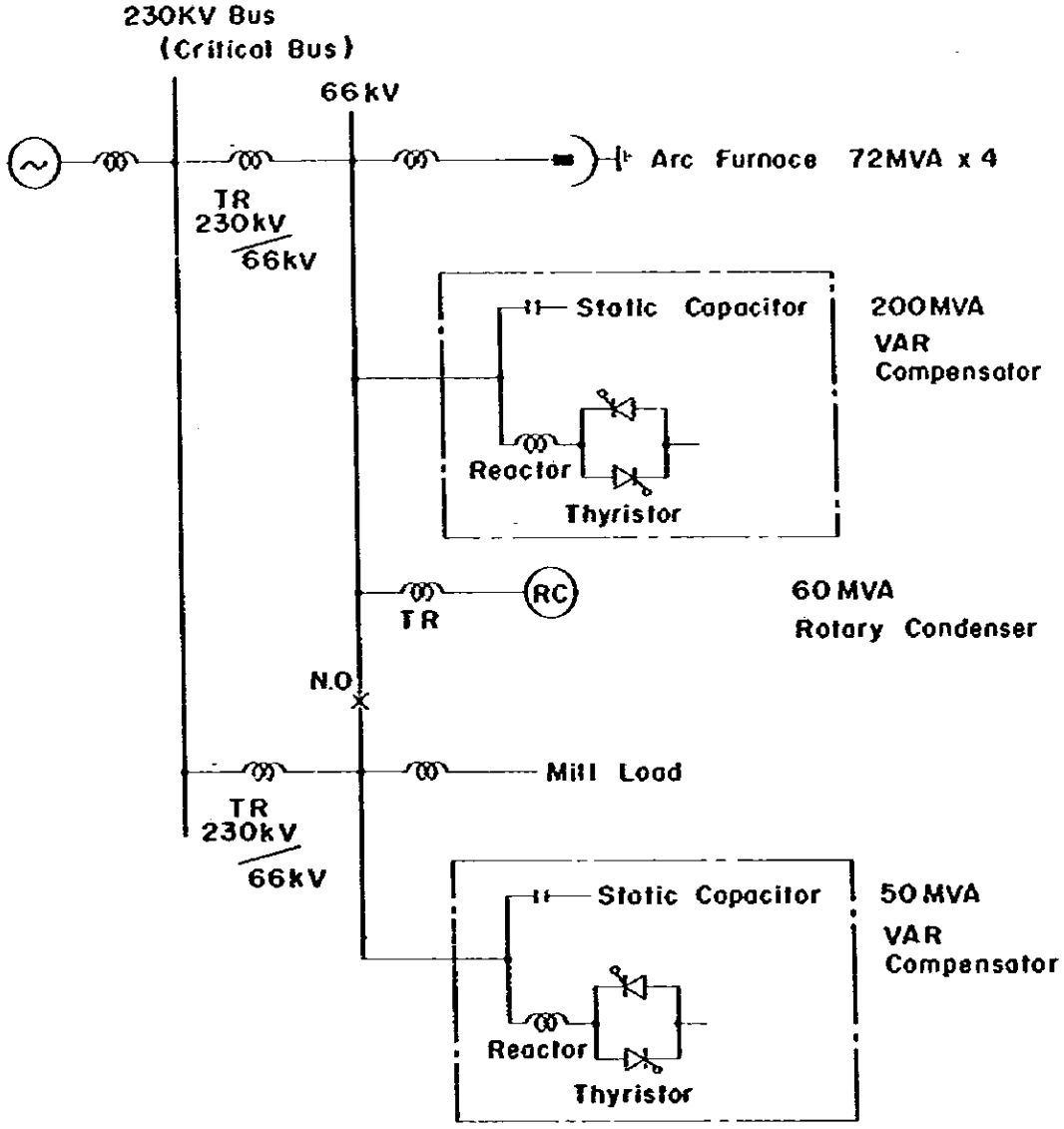


Fig. 15.6.5 Flicker Prevention Facilities

Table 15.6.4 Main Equipment of Substation

Equipment		Type · rating	Quantity	
			1st Stage	2nd Stage
230kV	SF6 Gas insulated switch gear	230kV,2000A,Double-Bus		
		Incoming	2	
		Feeder	3	1
		Bus tie	1	
	Circuit breaker	230kV,1200A,40 kA GCB.	6	1
	Metering outfit	230kV	2	
	Pt. Ct. Ds. Line arrestor			
	Transformer	230kV/66kV, 150/180 MVA Oil-forced, on-load top-changing	3	1
66kV	SF6 Gas insulated switch gear	66kV,3000A,Double-Bus		
		150MVA TR. secondary	3	1
		Feeder	11	4
		Bus tie	2	
		Bus section	2	
	Circuit breaker	66kV, 3000A/2000A /1200A 31.5kA, GCB	18	5
	Pt. Ct. Ds. LA			
	Transformer	66kV/22kV, 60MVA Oil-forced	2	1
22kV	Metal-clad switch gear	22kV,3000A,Single Bus		
		60MVA Secondary	2	1
		Feeder	18	
		Bus section	1	
	Circuit breaker	22kV,3000A/1200A 40kA	21	1

well as it requires much less space for a unit of the 200 kV class compared with an outdoor steel structure system. Thus, there is no exposed line part except for the lead-in busing from the aerial line.

b. 66 kV switchgear

As with a 230 kV equipment, SF_6-gas-insulated switchgear shall be employed. However, the three phase lumped type shall be employed for the 66 kV unit.

c. 22 kV and 3.3 kV metal clad switchgear

Both the 22 kV and the 3.3 kV switchboards shall be indoor-type enclosed switchboards and shall be accommodated indoors.

d. Transformers

Transformers of over 50 MVA (capacity) shall be of forced-oil air-cooled type and a 15 MVA one, oil-immersed self-cooled type, respectively. The 230 kV/66 kV, 150 MVA incoming transformer shall be equipped with an on-load tap changer, which maintains the private voltage within the fixed limits against gradual change in the system voltage of the power company.

e. Protection relay boards

A set of relay boards for 230 kV bus, transformer and private distribution protection shall be provided in the substation building. However, a 230 kV load-in wire protection device is not included, as this shall presumed to be furnished by the public power company.

f. Monitoring control panel

The system monitoring control panel with the mimic bus shall be equipped in the monitoring room of the substation to provide centralized monitoring of the distribution system.

g. Ancillary facilities

The following equipment for the private use in the substation shall be provided.

Private power equipment: Transformer cooler, air compressor, battery charger, lighting, etc.

Emergency generator: Generating unit for maintaining private power supply in case of a power failure.

DC power source device: DC 100V battery and charger as power source for monitoring and control.

Air compressor: Air source for operating the circuit breaker and disconnecting switch.

Air conditioning facilities: For relay chamber and monitor room.

Lighting facilities:

h. Power cable

The private distribution power cable shall be CV cable (cross-linked polyethylene insulated vinyl sheathed cable) throughout.

ix. Flicker preventing device

a. Static VAR compensator

This device consists of a capacitor (higher harmonics filter) and a thyristor-controlled reactor connected in parallel to each other.

The main items are as follows, which are installed outdoors.

For arc furnace

66 kV circuit breaker	: 1 set
Capacitor	: 66 kV, total 200 MVA
Transformer (For thyristor circuit)	: 66 kV/33 kV, 100 MVA x 2
Thyristor	: 33 kV, 100 MVA x 2
Reactor	: 33 kV x 2
Controller	: 1 set

For rolling mill load

66 kV circuit breaker	: 1 set
Capacitor	: 66 kV, total 50 MVA
Transformer	: 66 kV/33 kV, 50 MVA x 1
Thyristor	: 33 kV, 50 MVA x 1
Reactor	: 33 kV x 1
Controller	: 1 set

At the 2nd stage, a 60 MVA set for the arc furnace will be added.

b. Rotary condenser

This condenser for the arc furnace is connected to the 66 kV bus line. The equipment, including the starting motor, shall be installed outdoors, and the controller, the synchroscope, etc., shall be installed in the substation building. The main equipment is as follows:

60 MVA Synchronous Condenser 11 kV

Transformer 66 kV/11 kV 60MVA

Induction-Synchronous Motor (for starting)

Exciter

Control Panel, Synchroscope, etc.

(4) Process Steam Facilities

i. Process steam balance

The amount of steam consumed at the steel plant is shown in Table 15.6.5.

The process steam is used for heating the lubricating oil at the hot strip mill and chemical cleaning solution (such as for pickling, ECL, etc.) at the cold strip mill.

Table 15.6.5 Process Steam Balance

(Unit: t/h)

	Hot mill	Cold mill	Total
1st stage	1.9	23.1	25.0
2nd stage	2.9	35.0	37.9

ii. Boiler capacity and arrangement

The boiler equipment is shown in Table 15.6.6. One (1) spare boiler shall be maintained for the scheduled shut down during regular inspection (once a year) of the main unit.

Namely, three units at the 1st stage and one additional unit at the 2nd stage shall be provided. The process steam does not require high temperature or high pressure, so that steam of 10 kg/cm² at 270°C will suffice.

Fig. 15.6.6 shows the arrangements of the boiler. The boiler is gas-fired and therefore, a package type boiler shall be employed without any special pollution control device.

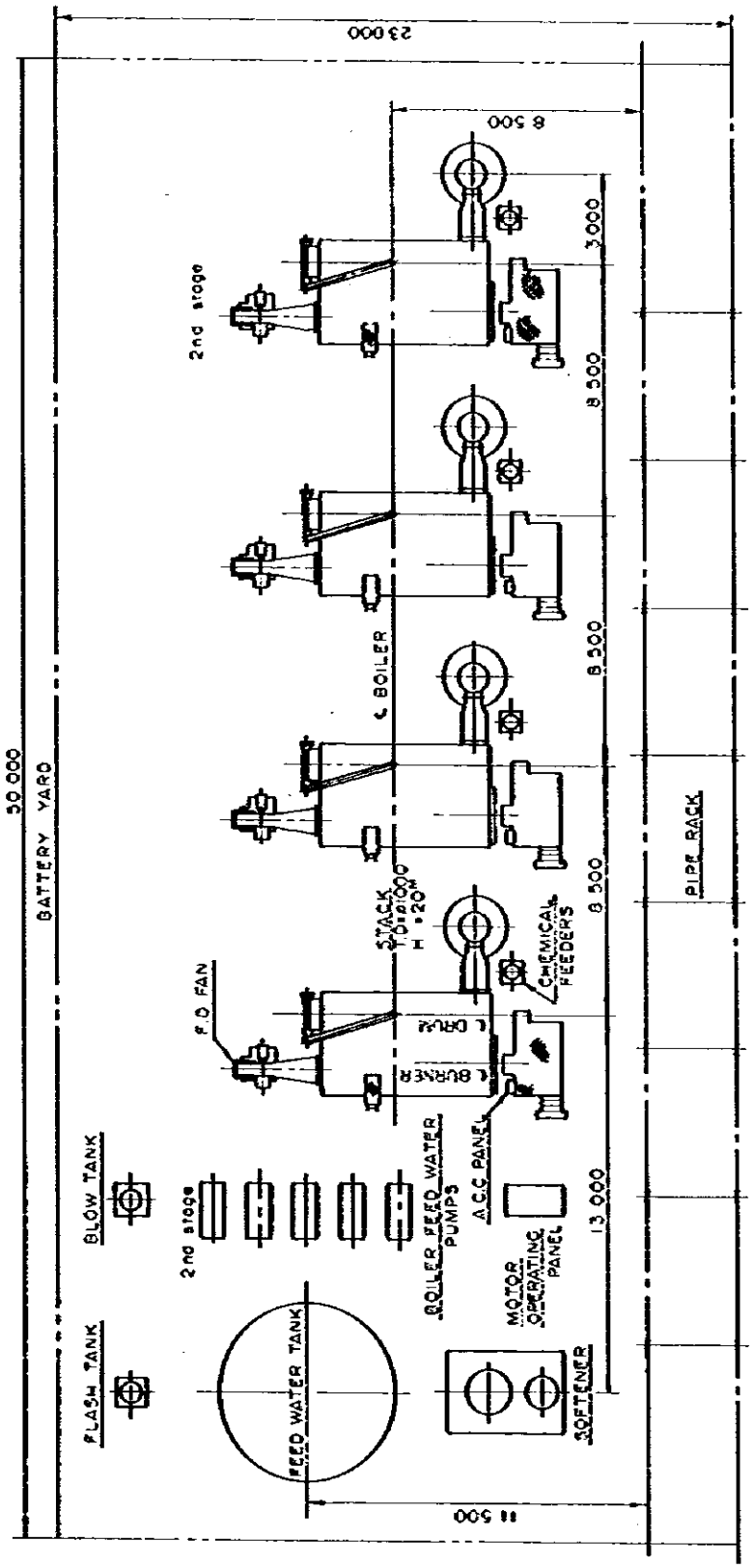


Fig. 15.6.6 Boiler Layout Plan

Table 15.6.6 Boiler Facility

		1st stage	2nd stage
Boiler	Capacity 15 t/h Steam pressure 10 kg/cm² Steam temperature 270°C Attached with automatic boiler control	3 sets	1 set
Feed water treatment	Softener	1 set	–

(5) Air Compressor

i. Air balance

The amount of compressed air used at the plant is shown in Table 15.6.7.

Air is used to operate each cylinder of the equipment and for operating each control equipment.

Table 15.6.7 Plant Air

(Unit: 1,000 N m³/h)

	DR plant	Steelmaking	Hot mill	Cold mill	Total
1st stage	1.8	4.7	6.0	7.0	19.5
2nd stage	2.4	7.6	6.7	8.0	24.7

ii. Outline of supply facilities

The outline of the air compressor is shown in Table 15.6.8. The centrifugal air compressor is to have a capacity of 13,000 Nm^3/h with 8.0 kg/cm^2g of discharge pressure.

At the 1st stage, three units shall be provided (one unit being a spare) and at the 2nd stage no units will be added. The total capacity has the reserve to prevent opening of the surge relief valve against the average balance as above, as it is designed to cope with the peak condition. The compressor is of suction vane control type, which minimizes lowering of efficiency under a partial load.

Fig. 15.6.7 shows the arrangement of the air compressor. Its control station is located in the adjacent electric room for centralized control of the air compressor, fresh water filtration plant, boiler, etc.

Table 15.6.8 Air Compressor Facility

		1st stage	2nd stage
Air compressor	Centrifugal type 13,000 Nm^3/h 8.0 kg/cm^2g Suction vane controlled	3 sets	–
Incidental water facility	Cooling tower 160 m^3/h	3 sets	–

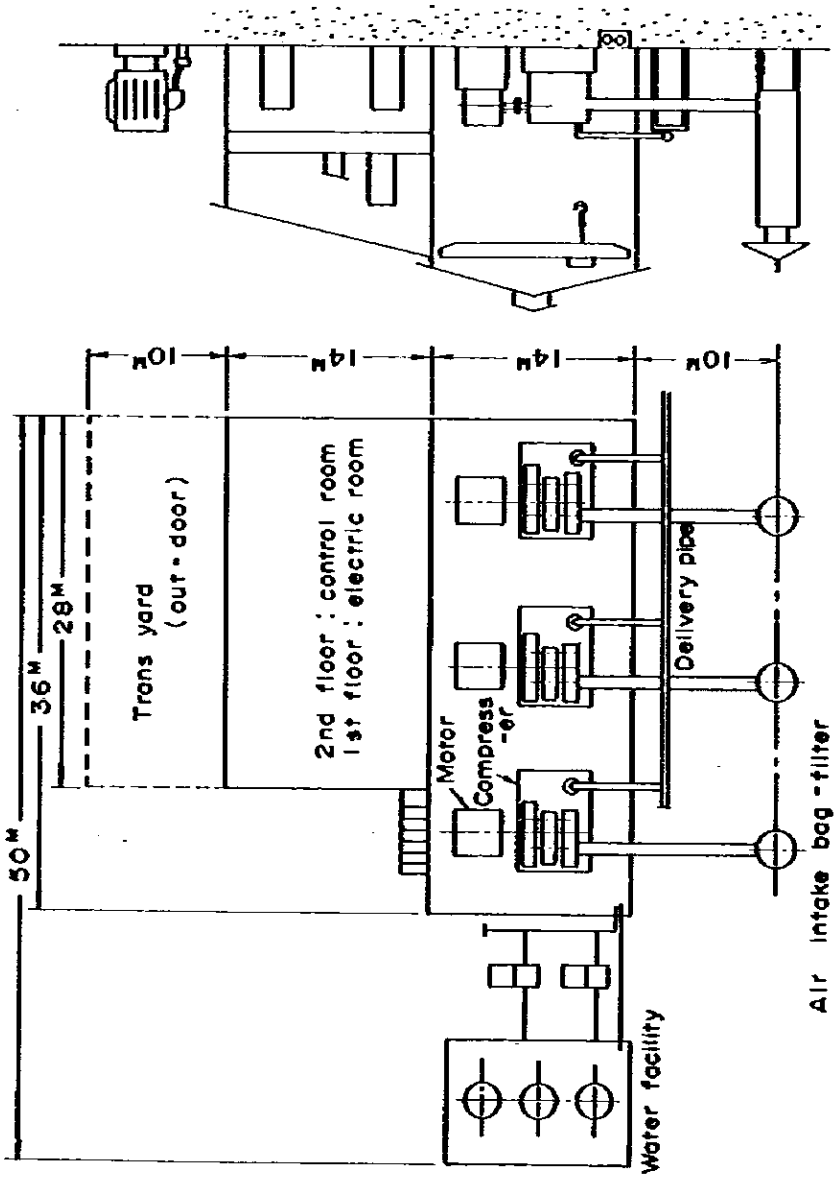


Fig. 15.6.7 Compressor Facility Layout Plan

(6) Oxygen, Nitrogen and Argon Equipment

i. Gas balance

The amount of oxygen, nitrogen and argon consumed in the steel plant are shown in Table 15.6.9.

Oxygen is used for blow-in to the electric arc furnace as well as the slab scarfer and the gas cutter at the continuous casting plant. Nitrogen is used at the annealing furnace of the cold strip mill and at the direct reduction plant as a purging gas. Argon is used as a stirring agent of molten steel at the ladles for continuous casting process.

ii. Oxygen generating plant

The components of the oxygen generator are shown in Table 15.6.10. The flow diagram and arrangement of the equipment are shown in Figs. 15.6.8 and 15.6.9, respectively. The design capacity of 1,600 Nm^3/h has been calculated based on the idea that during the regular maintenance period (approx. 30 days x 2 units = 60 d/y) of the oxygen plant, the O_2 supply to the electric arc furnace is interrupted and it is only supplied to the slab cutter at the continuous casting plant in order to achieve a higher annual operation ratio for the O_2 generator and reduction in capital expenditure.

Three units are installed in the 1st stage and one is added in the 2nd stage. The optimum capacity of the oxygen compressor shall be 3,000 Nm^3/h per unit on the basis of the balance shown in Table 15.6.9. One (1) unit shall be added as a stand-by. Namely, three units are installed and one unit is added at the 1st and 2nd stages, respectively.

Nitrogen is supplied to the whole plant by the oxygen generator at a purity of 99.999% – required at the annealing furnace inert-gas generator in the cold strip mill.

Table 15.6.9 Demand of Oxygen, Nitrogen & Argon

(Unit: Nm^3/h)

	Oxygen gas		Nitrogen gas		Argon gas	
	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
D R plant	4,000	6,200	1,000	1,000	300	500
Steelmaking			500	800		
Cold mill shop			500	2,100		
Total	4,000	6,200	2,000	3,900	300	500

Table 15.6.10 Equipment List of Oxygen Plant

Equipment	Capacity			No. of unit, installed	
				1st stage	2nd stage additional
Air separater unit	Oxygen	Flow rate	1,600 Nm^3/h	3	1
		Pressure	2,000 mm Aq		
		Purity	99.6 %		
	Nitrogen	Flow rate	1,000 Nm^3/h		
		Pressure	300 mm Aq		
		Purity	five-nine percent		
	Argon	Flow rate	30 Nm^3/h		
Oxygen gas compressor	2,000 Nm^3/h x 15 Kg/cm^2 , 300 Kw			3	1
Nitrogen gas compressor	1,000 Nm^3/h x 8 Kg/cm^2 , 135 Kw			2	1
High purity argon generator		Flow rate	120 Nm^3/r	1	—
		Pressure	8 Kg/cm^2		
		Purity	five-nine percent		
Miscellaneous	Cooling water recirculation facilities Electrical facility				

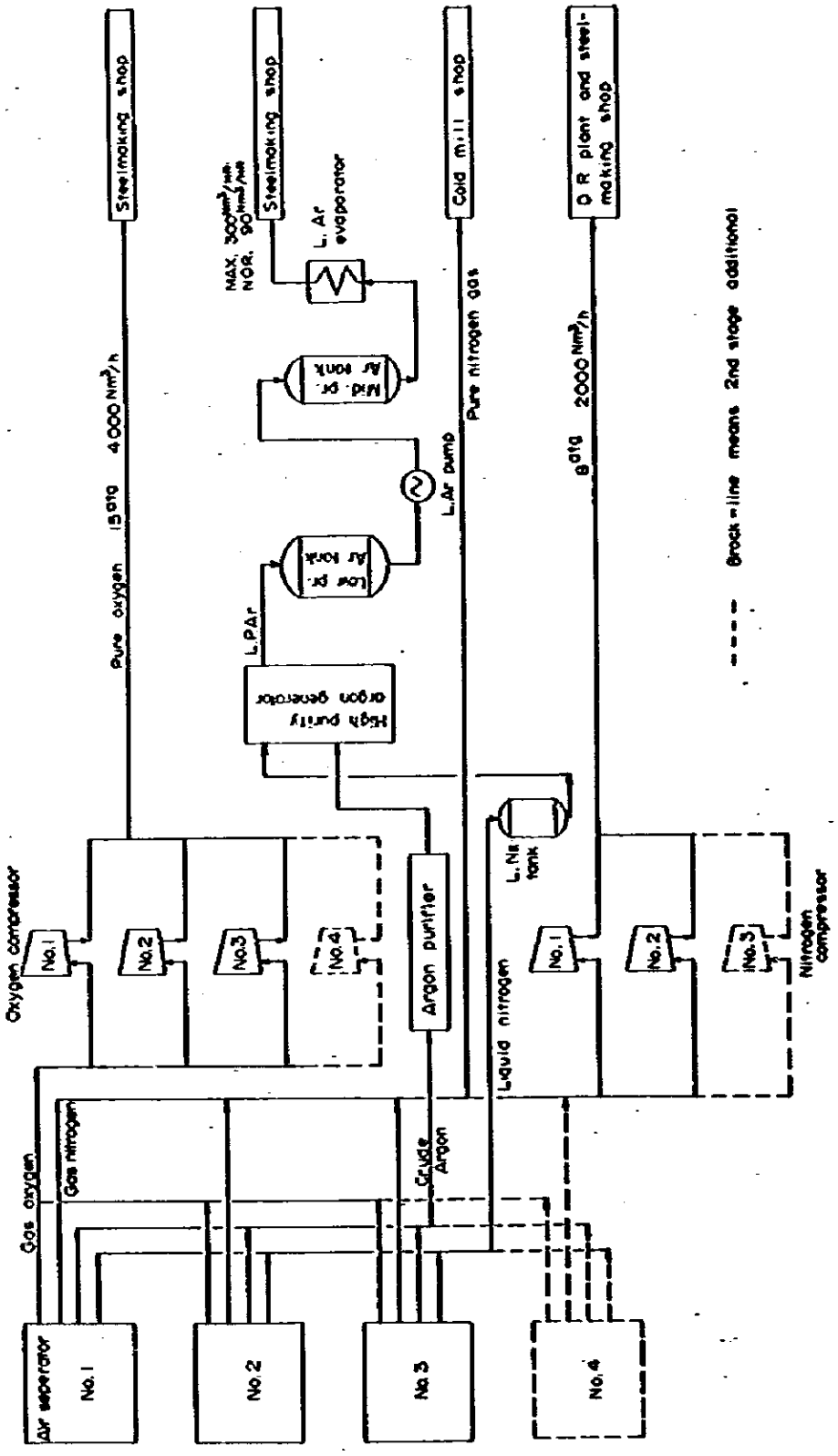
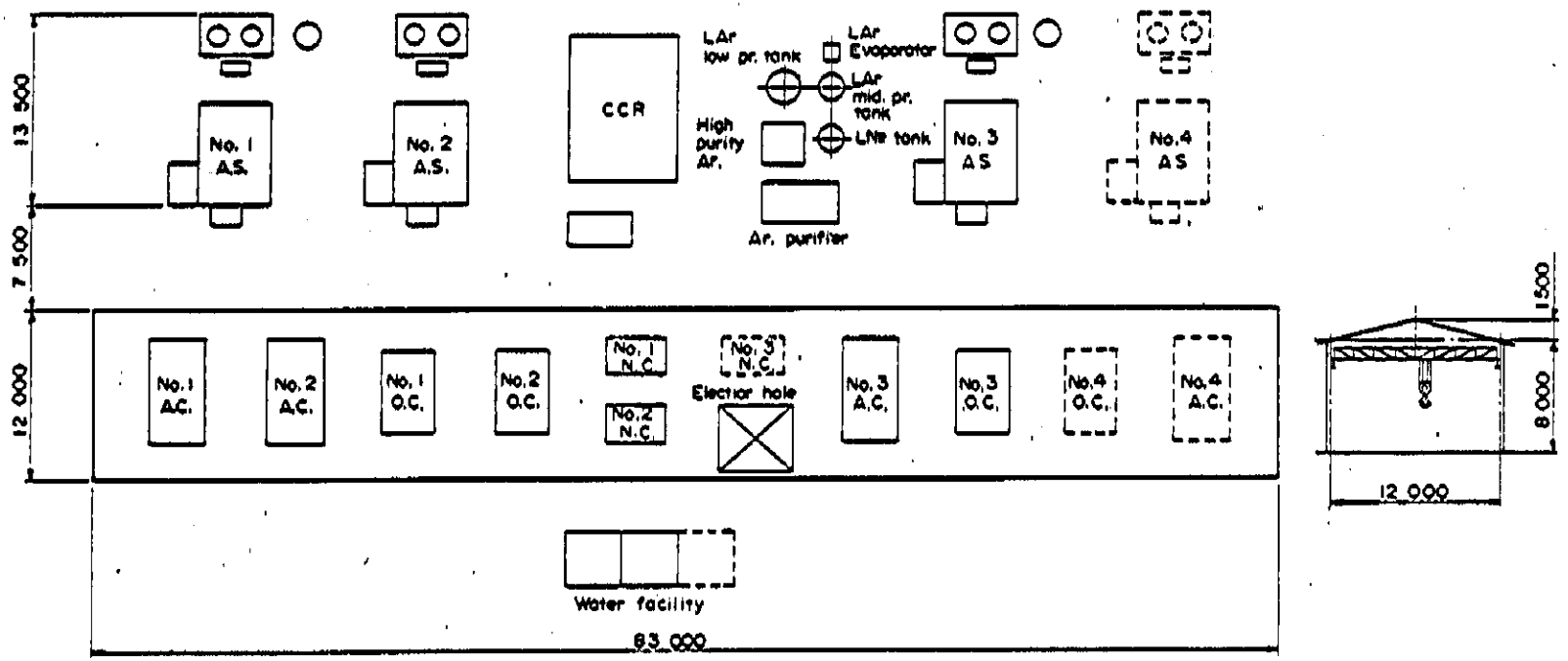


Fig. 15.6.8 Flow Diagramme of Oxygen Plant



A C : Air compressor
O C : Oxygen compressor
N C : Nitrogen compressor
C C R : Control room on 2nd floor , Electric equipments on 1st floor
A S : Air separator
[---] : 2nd stage additional

Fig. 15.6.9 Layout Plan of Oxygen Plant

The high purity nitrogen at the outlet of the oxygen generator is boosted to 1,500 mm Aq through the nitrogen blower (2,000 Nm^3/h unit) and supplied to the cold strip mill. Also, nitrogen is supplied to the direct reduction plant and the continuous casting plant after being boosted to 8 kg/cm^2g through the nitrogen compressor (1,000 Nm^3/h unit). Argon production shall be 30 Nm^3/h unit which is the maximum capable amount corresponding to 1,600 m^3/h per unit of generated oxygen. Also, to handle peak consumption, a complete set of argon refining, liquefying and evaporating units for four generators (30 Nm^3/h unit x 4 units = 120 Nm^3/h) shall be provided.

iii. Supply system

Fig. 15.6.10 shows the supply system diagramme of oxygen, nitrogen and argon.

The purpose of installing the oxygen holder is to adjust the supply to the oxygen requirement of the electric arc furnace of the steelmaking shop and the continuous casting slab cutter; i.e., to protect the continuous casting device from possible damage in an emergency shut-down of oxygen plant by continuing oxygen supply to enable slab cutting of at least 1 charge of casting.

Namely, for supply adjusting purpose, the capacity is designed to allow two electric arc furnaces charges to be operated simultaneously and at the same time to prevent continuous casting facilities from damage upon O_2 plant shut-down. In this case, the type shall be spherical holder and the required holder capacity is divided into two, i.e., 200 m^3 x 2 in consideration of their regular repair.

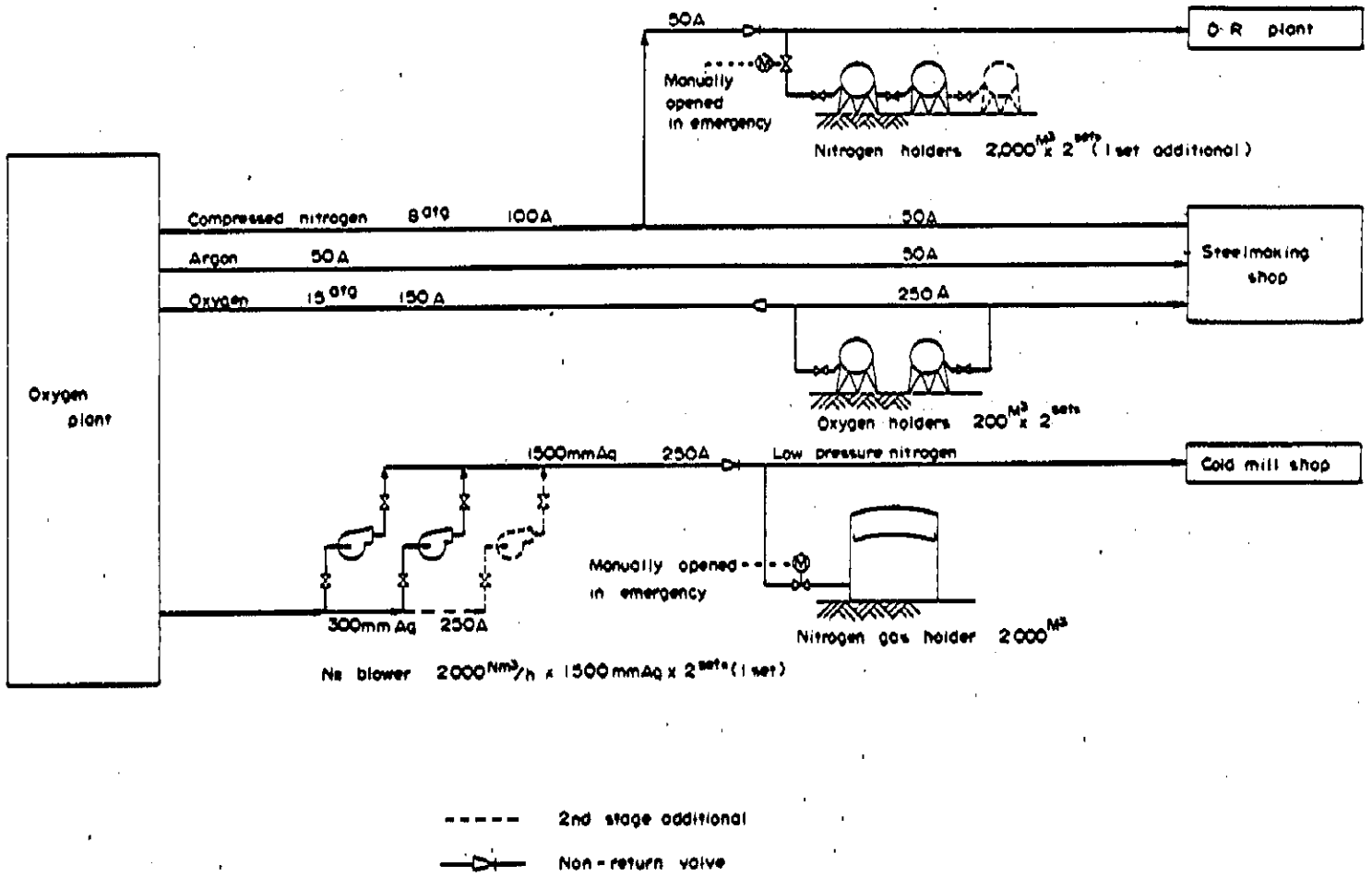


Fig. 15.6.10 Oxygen, Nitrogen and Argon Gas Flow Sheet

The nitrogen holders for the cold strip mill and direct reduction plant are intended for the maintenance of the respective plant. Namely, the nitrogen holder for the cold strip mill is for purging the annealing furnace at the shut-down of the whole works (emergency shutdown of annealing furnace or oxygen plant), and its effective capacity shall be 2,000 m^3 which corresponds to about an hour's consumption of nitrogen by the cold strip mill. The holder shall be of Wiggins type which has a good reputation as a high purity nitrogen holder.

The nitrogen holder for the direct reduction plant has a similar purpose. At the 1st stage, 2,000 m^3 x 2 units of spherical holders will be provided and one unit will then be added at the 2nd stage. Nitrogen will be supplied to both holders by operating the respective spare booster.

(7) Industrial Water Facilities

i. Usage of water in the steel plant

Steel plants use a lot of water for cooling the equipment and products, treating the products during cold processing and for operating the boilers. Of these, cooling water is primarily recycled and its replenishment requirement is assumed to be 4.5% of circulation volume. The water balance is shown in Table 15.6.11. The total consumption is 900,000 m^3/day of which replenishment accounts for 46,600 m^3/day, the total circulating rate being 95%. The industrial water (fresh water) is taken from the public utility to the reservoir from which it is distributed to each private treating facility.

Fig. 15.6.11 shows the flow. The capacity of the receiving pond is 30,000 m^3 or a 10-hour supply intended for the 2nd stage. It is intended to maintain supply in an emergency such as power failure of the industrial water supply system, etc.

ii. Water treatment station

The water recirculation system of the plant shall comprise indirect and direct cooling water systems.

The indirect cooling water cools various equipment through heat exchangers. The return water is at an elevated temperature and does not contain contaminants, so that it is cooled by a cooling tower for recirculation. As water partially evaporates to be lost and gradually condensed while being cooled through the cooling tower, the fresh water shall be replenished in order to make-up for the lost water and control the water composition. The overflow water from the reservoir is replenished into the direct water system or drained out of the plant, according to the water quality.

The reservoir of the indirect water system shall have a capacity corresponding to 30 min or more supply to the plant or 24 h or more equivalent of

Table 15.6.11 Water for The New Steel Plant (as 1st Stage)

(Unit: m^3/day)

Process	Recirculating water	Make-up for recirculation	Once-through water	Total, fresh water consumption
D R plant	125,000	5,500		5,500
Steelmaking shop	473,000	21,400		21,400
Hot rolling shop	223,000	10,100		10,100
Cold rolling shop				
Pickling	(5,000)	(200)	(1,400)	(1,600)
Cold rolling	(24,000)	(1,200)	(1,500)	(2,700)
Cleaning			(2,400)	(2,400)
Box Annealing	(24,000)	(1,200)		(1,200)
Sub total, cold shop	53,000	2,600	5,300	7,900
Utility plants	22,000	1,000		1,000
Steam boiler			700	700
Grand total	896,000	40,600	6,000	46,600

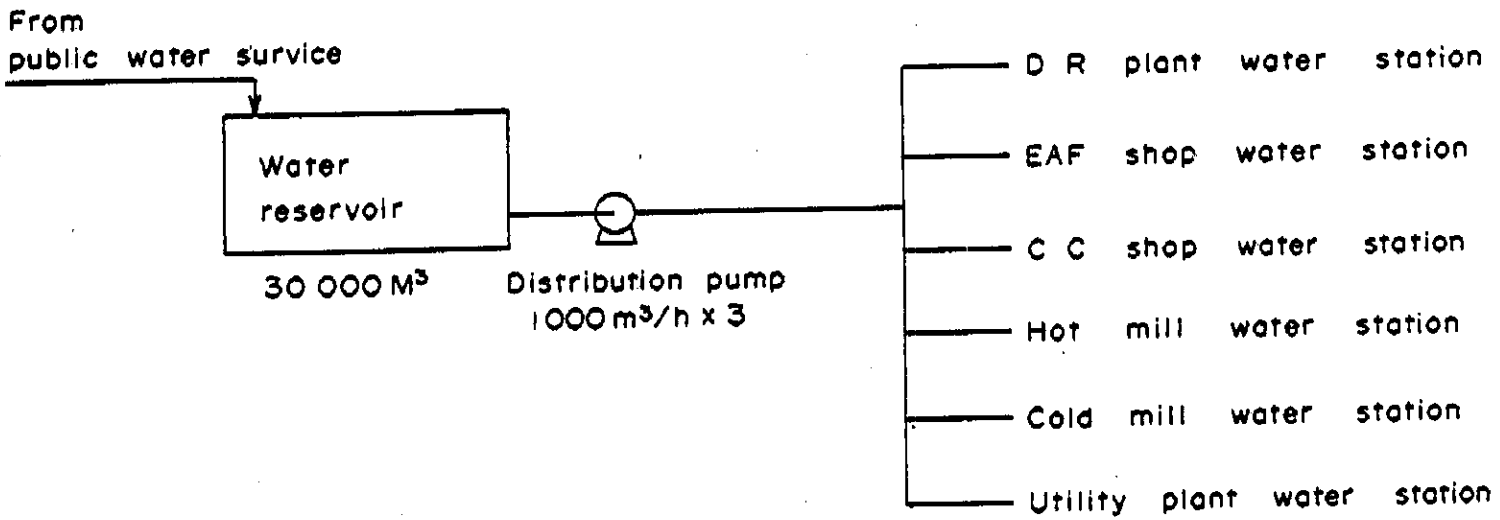


Fig. 15.6.11 Water Distribution Flow (1st Stage)

lost water so that supply to the plant may be maintained even in the event of failure or repair of the fresh water supply system.

The direct water in the cooling system provides direct cooling of the equipment, products and other cooling or spraying objects. The water used contains more contaminants and is at a high temperature. Thus, after sedimentation, and filtration or other water treatment to remove contaminants, the water is cooled in the cooling tower and fed from the reservoir to the plant for reuse.

In this case, the fresh water or the overflow of fresh or indirect water is replenished to make-up for lost water and to control the water quality.

The reservoir of the direct water system shall have a capacity corresponding to 30 min or more supply to the plant or 8 or more hours' equivalent of water loss.

In this manner, the required water quality can be maintained more economically by separately providing indirect and direct water systems and by adequately treating water based on the quality of used water.

Water used for special applications (such as boiler water, cleaning water for cold rolled coils, etc.) must be the best quality, so that part of the fresh water (replenishing water) or of the indirect system circulating water is filtered before being supplied to the plant. In case more stringent restrictions are imposed on the water quality, a higher level of treatment will be given at facilities using such water. The water quality control at each filtration plant is, as described earlier, carried out by controlling the circulating water condensation rate within a certain level. But, if required, such treatments as addition of chemicals, a higher degree of treatment of part of the circulating water, etc. will be additionally applied.

As examples of these systems, the flow diagram of a hot strip mill filtration plant is shown in Fig. 15.6.12; its layout, in Figs. 15.6.13 and 15.6.14, and the equipment list in Table 15.6.12, respectively.

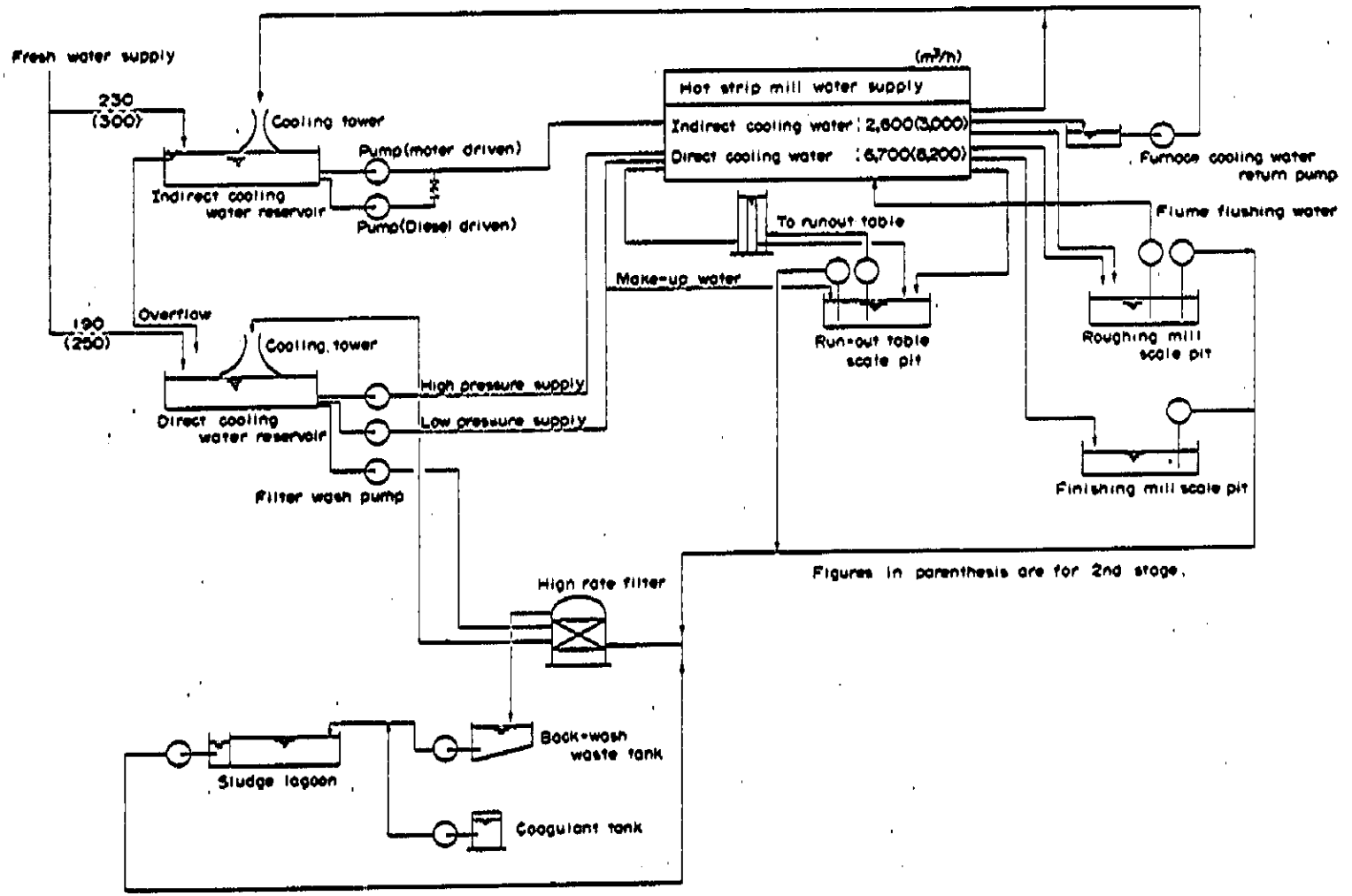


Fig. 15.6.12 Hot Strip Mill Water Treatment Flow Diagramme

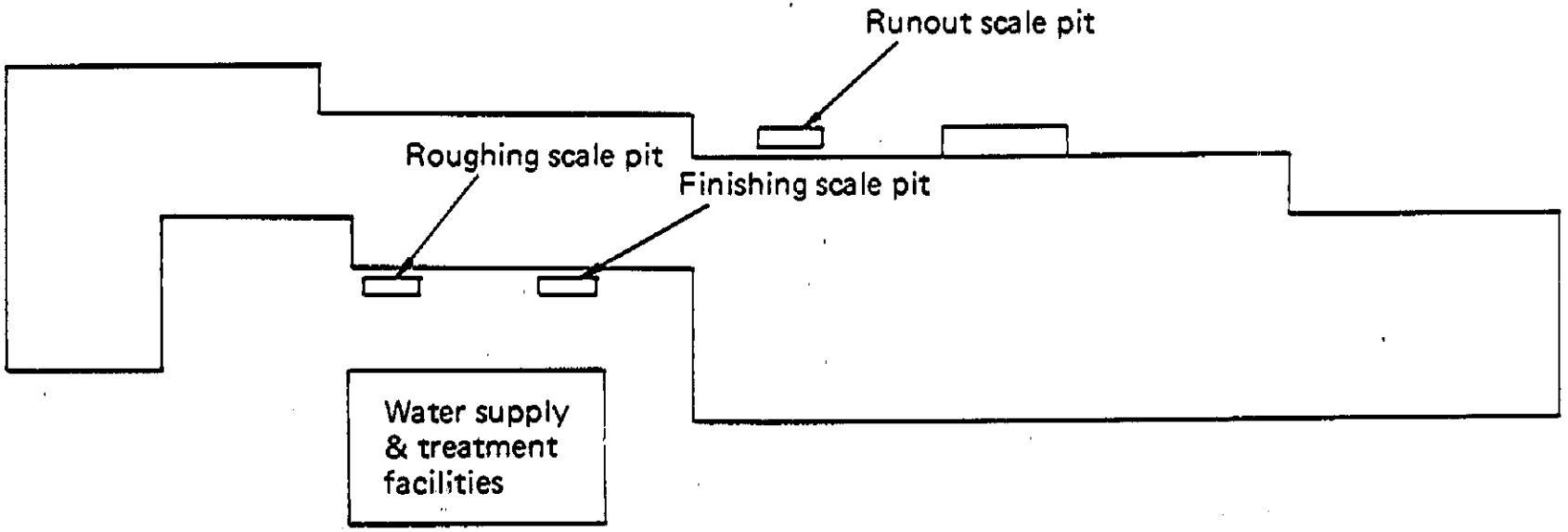


Fig. 15.6.13 Plot Plan of Water Treatment Facilities for Hot Rolling Mill

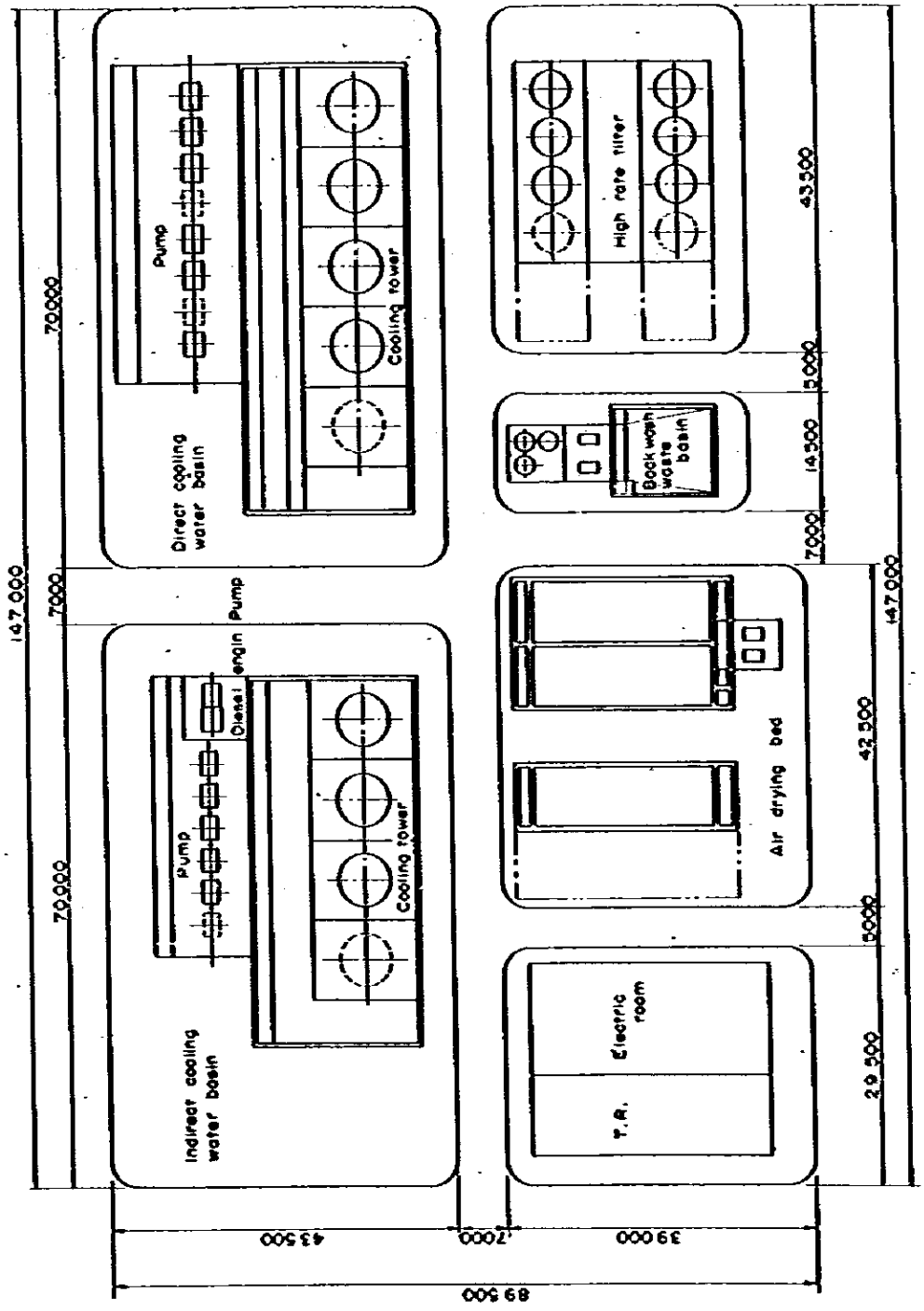


Fig. 15.6.14 Layout of Water Treatment Facilities for Hot Rolling Mill

Table 15.6.12 Details of Water Treatment Facility for Hot Rolling Mill

Water reservoir	For indirect cooling water 2,500 M^3 *		
	For direct cooling water 3,000 M^3		
Scale pit	Roughing mill 2,500 m^3/h		
	Finishing mill 2,500 m^3/h		
	Run-out table 4,500 m^3/h		
Pump	Indirect cooling water	1st stage 8 set	2nd stage additional 2 set
	Direct cooling water	22	1
Cooling tower	Indirect cooling water 1,000 m^3/h	3	1
	Direct cooling water 1,000 m^3/h	4	1
Water treatment	High-rate filter 750 m^3/h	6	1
	Back-wash waste basin 300 M^3	1	–
	Sludge lagoon 700 M^3	3	–
Diesel engine	200 PS	1	–
Head-tank		1	–

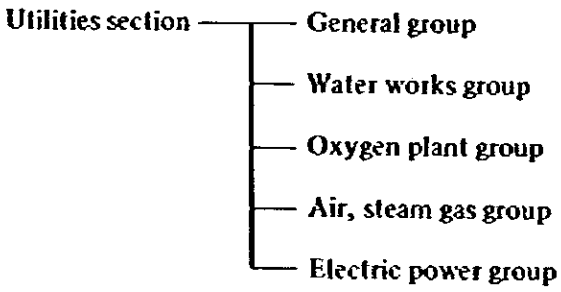
* "M^3" means volume of reservoir

At the 2nd stage, some facilities will be added, but an increase of operators will not be necessary as their skill will have improved. These operators' services include the operation, monitoring of the operating conditions with monitoring instruments and confirmation of the normal operating conditions by patrolling the equipment. The utility section needs continuous operation throughout 365 days, so that a special working system is required unlike the usual work-week system.

(8) Organization and Personnel

i. Organization

The organization of utilities section is planned as follows:



ii. Personnel

Personnel required for the utilities section is shown in Table 15.6.13.

Table 15.6.13. Personnel for Utilities Section (1st stage)

Super-intendent	Group	Ass't sup't	Engineer	Clerk	Formen	Skilled worker	Semi-skilled	Un-skilled	Total of group
1	General	1		4					5
	Water works	1	1	1	4	9	8	9	33
	Oxygen plant	1	1	1	4	10	11	10	38
	Air, Steam, Gas	1	1	1	4	10	8	10	35
	Electric power	1	2	2	4	7	7	7	30
	(Sub total)	5	5	9	16	36	34	36	141
Total					142				

CHAPTER 15-7

ANALYZING FACILITIES

15.7 Analyzing Facilities

(1) General

The analyzing facilities described here include the equipment and facilities which are needed for the general operation of the new steel plant, but do not involve the types of equipment for research and development.

The main job of the analysis centre is to analyze the samples received from the DR, EAF and CC plants through air tubes, and to feed back to these sections within minutes the required analytical values which are then used for controlling the production.

Further, check analysis for quality control and analyses of water quality and exhaust gas are carried out at this centre.

(2) Conditions for Equipment Plan

i. Basic condition

Equipment analysis, functionally capable of carrying out simultaneous poly-elementary analysis, is essential in performing the analytical processes rapidly, while the on-line analysis system through the data processor is necessary for rapid feedback of analytical data.

The accuracy and reliability of the analytical data are principal factors which determine the production procedures of DRI, molten steel, and quality of eventual products.

As for the main raw materials and sub-materials, based upon the assumption to adopt "consigner's analysis certificate final" as the terms of trade, this plan involves a provision of neither sampling nor sample preparation plant. Manual sampling and analysis will be conducted occasionally, as case may so require.

ii. Samples to be analyzed and the analyzer

Table 15.7.1 shows the samples to be analyzed and the analyzer.

a. There are two principal types of analyzers as follows:

Fluorescent X-ray analyzer (FX)

Photoelectric spectrochemical analyzer

Generally, elements lighter than $_{11}Na$ can not be analyzed by the FX analyzer, i.e., "C" analysis can not be effected, but samples in powder form such as slag can be analyzed.

On the other hand, although "C" and "B" analyses can be rapidly performed by the photoelectric spectro analyzer, the sample has to be in a solid form, and it therefore can not handle slag.

b. As the back-up equipment for the FX analyzer, photoelectric spectro analyzer and the data processor, a "C/S" determinator shall be provided.

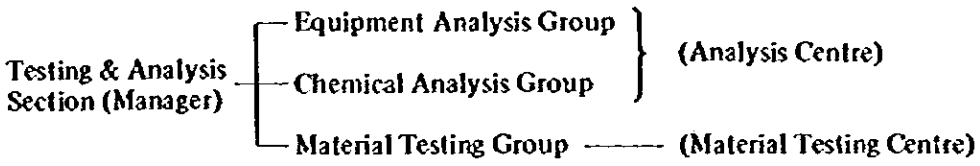
c. For the analysis of "Sol-Al" an atomic absorption analyzer is to be used. For the analysis of other substances which can not be effectively analyzed by the devices as above due to its size or form, a chemical analysis has to be carried out.

(3) Equipment List

Table 15.7.2 is the equipment list.

(4) Organization and Personnel

The organization covering the Analysis Centre and the Material Testing Centre which will be discussed in the next chapter shall be as follows:



Personnel for the Analysis Centre is as shown in Table 15.7.3.

Tabel 15.7.1 Samples and Analyzer in Analysis Center

	Samples	Purpose of analysis	Analysis items	Analyzer
Steel	DRI	Quality control	T.Fe, FeO, Met.Fe, T.C, FreeC, S	[All] : Photoelectric spectrochemical analyzer [C] : Carbon (and Sulphur) determinator [Other elements] : Fluorescent X-ray analyzer (FX)
	Scrap	Acceptance judgement according to the requirements in contract	C, Si, Mn, P, S, Cu, Ni, Cr, Mo, Sn	[All] : Photoelectric spectrochemical [C] : Carbon (and Sulphur) determinator [Other elements] : Fluorescent X-ray analyzer (FX)
	Scrap to be charged	Quality assurance		
	Sample in electric arc furnace	Analysis of elements in molten steel	C, Si, Mn, P, S, Cu, Ni, Cr, Mo, Sn	[All] : Photoelectric spectrochemical analyzer [C] : Carbon (and sulphur) determinator [N] : Nitrogen determinator [Sol.Al] : Atomic absorption analyzer [B] : Chemical analysis [Others] : FX, but samples, not applicable in size or shape, are analyzed chemically.
	Ladle sample	Representative chemical composition of the charge	ditto + Sol.Al, O, N, Ti, B, V, etc.	
	Products	(1) Quality assurance (Check analysis)	The same as the ladle analysis	
	Semi-finished products	(2) Examinations Quality control Claim Identification of steel	C and other element required	
Slag	EF slag	Slag composition in refining process	TFe, SiO_2, CaO (MnO, MgO, Al_2O_3, P, S, TiO_2,) CaO/SiO_2	[All Components] : FX
Other materials	Sewage, fuel, etc.			Chemical analysis

Table 15.7.2 Equipment List

NO.	Equipment	Q'ty	Specification	Remarks
1.	Fluorescent X-ray analyzer with analysis data processor	1	X-ray quantometer Simultaneous detection of 14 elements Scanner 2 with automatic sample feeding mechanism Data processor: Core 16 kWord Peripheries: Typewriter (1) CRT process operating console (1)	Fixed channel: Si, Mn, P, S, Cu, Ni, Cr, Mo, Al, Ti, Pb, Ca, Mg, Fe
2.	Photoelectric spectrochemical analyzer	1	Computer incorporated, MG, with tube cooler, Rh (3 kW) fixed 13 elements, 1 scanner	
3.	MG Installations for FX and data processor	1	220 V, 10 kVA	
4.	[C . S] Determinator	2	LECO CS-46 with ER-25 electronic balance and printer	
5.	[N] Determinator	1	LECO TN-15 with ER-25 electronic balance and printer	
6.	[O] Determinator	1	LECO RO-16 with ER-25 electronic balance and printer	
7.	AC Stabilizer 220V	2	30 kVA	For [C,S] and [N], [O] Determinators
8.	Balance desk	4	1,100 x 750 x 760 h for electronic balance	
9.	Atomic absorption & flame emission spectrophotometre	1		Analysis of [Sol.Al] and other metallic elements
10.	Manometre	1		Volume compensation of reference gas in determinator

Table 15.7.2 (cont'd)

NO.	Equipment	Q'ty	Specification	Remarks
11.	Sample preparation devices	1 Unit		
	(1) High-speed cutter (dry)		With dust collector	
	(2) Disk-vibration mill			
	(3) Briquette press		30t press	
	(4) Drilling machine			
	(5) Grinder			
	(6) Belter			
	(7) Balance cutter			
	(8) Rod cutter		Hydraulic	For cutting 2mmφ pin sample
	(9) VS cutter			For cutting 5 – 6mmφ pin sample
	(10) Rough balance		Scale 200g	For shaving chip
12.	Chemical analysis devices	1 Unit		
	(1) Draft chamber		Frontage: 1,800mm	Resolution with acid, vaporizing
	(2) Analyzing bench		2,000 x 750 x 900 h	determination in wet analyzing
	(3) Balance desk		1,100 x 750 x 760 h	for anlytical balance
	(4) Distillatory apparatus			
	(5) Centralized gas piping installations		Piping network of gas (Ar, He, N_2, C_2H_2, N_2O, air, etc.)	
13.	Physical and chemical appliances for chemical anlysis	1 Unit		
	(1) Digital		Wave length: 200 – 850mm	Extinction analysis (ex. Mn, P, e
	(2) pH metre		Range: pH 0 – 14, accuracy: 0.1 pH	etc.) pH measuremetn of waste
	(3) Digital balance		SAUTER, scale 200g, sentisivity: 0.9 mg	water, etc.
	(4) Rough balance		Scale 200g	
	(5) Magnetic stirrer		Max. 300°C	
	(6) Shaker of separated funnel			
	(7) Water bath			
	(8) Aspirator			
	(9) Oil concentration metre			
	(10) Electric muffle furnace		Heating temp.: Max. 1200°C; Timer: 48 hr.	

Table 15.7.2 (cont'd)

No.	Equipment	Q'ty	Specification	Remarks
13.	(cont'd) (11) Electric isothermal dryer (12) Refrigerator (13) Waste water treatment Installation		Heating temp.: Max. 300°C	Dryer for glass appliance and object to be analyzed
14.	Waste water treatment installations	1	Neutralizing/settling treatment	Removing heavy metal
15.	Exhaust gas treatment installations	1	Alkaline shower cleaning	Removing acid gas
16.	Standard samples for chemical and equipment analysis	1 set	National Bureau of Standards	

Table 15.7.3 Personnel for Analysis Centre

Manager	Assistant manager	Clerk	Foreman	Skilled worker	Semi-skilled worker	Un-skilled worker	Total
1	2	1	2	15	10	7	38

Note: 27 persons out of the above shall be under 3 shift basis.

CHAPTER 15-8

MATERIAL TESTING EQUIPMENT

15.8 Material Testing Equipment

(1) General

The material testing equipment for this plan refer to the followings required for general operation of a hot strip mill plant, a cold strip mill plant and a continuous casting plant installed in the steel plant. The equipment will be installed in the material testing centre.

a. The material testing equipment for the inspection of hot rolled plates and sheets and coils, and cold rolled sheets and coils

b. The material testing equipment required for the operation control of a hot strip mill plant, a cold strip mill plant and a continuous casting plant

(2) Conditions for Equipment Plan

i. Scope of plan

The scope of the projected tests shall include;

a. Mechanical tests

Tension test

Bending test

Impact test (Charpy test)

Hardness test (Vicker's, Rockwell and Rockwell superficial T scale tests)

Formability test (Erichsen cupping and conical cup tests)

b. Metallic structure tests

Microscopic test

Macrostructure test

Sulphur print test

ii. Capacity of testing equipment

The material testing equipment are designed to be capable of meeting the production for the 1st stage, with a consideration given to the easiness in acquiring additional testing capabilities upon the implementation of the 2nd stage expansion plan.

iii. Plant layout

The material testing centre shall be located in the premises of the steelmaking shop.

iv. Condition for selection of equipment

a. Automation of equipment

The operation of testing equipment has been mechanized as far as possible to provide uniform test performance regardless of a difference in the capabilities of individual workers.

b. Working conditions

Tests shall in principle be performed in a three-shift operation, except the tests which do not have direct bearing on the operation control; such tests are executed during the daytime.

c. Transportation of test pieces

Test pieces shall be transported by truck, etc.

(3) Equipment List

Table 15.8.1 gives an equipment list installed in the material testing centre.

Table 15.8.1 Equipment List

Item	Specifications	
	1st stage	2nd stage (Addition)
1. Building	Steel frame construction 40 m x 18 m = 720 m²	Steel frame construction 6 m x 18 m = 108 m²
2. Test piece preparing equipment	Shearing machines (for 13 mm and 3.2 mm) 2 units	Vertical milling machine 1 unit
	Surface grinding machine 1 unit	Others 1 set
	Vertical milling machine 1 unit	
	Band saw 1 unit	
	Punching machine 1 unit	
	Others 1 set	
3. Testing equipment	Tension tester (5 tonnes and 30 tonnes) 2 units	Tools and instruments, etc. 1 set
	Bending tester (30 tonnes) 1 unit	
	Formability tester (Erichsen cupping, conical cup) 1 unit	
	Vicker's hardness tester 1 unit	
	Rockwell hardness tester 1 unit	
	Rockwell superficial hardness T scale tester 1 unit	

Table 15.8.1 (cont'd)

Item	Specifications			
	1st stage		2nd stage (Addition)	
3. Testing equipment (cont'd)	Impact tester (Charpy test)	1 unit		
	Microscope	1 unit		
	Others	1 set		
4. Auxiliary equipment	Darkroom	1 set	Electrical equipment	1 set
	Electrical equipment	1 set	Water supply equipment	1 set
	Water supply and drainage system	1 set	Others	1 set
	Air conditioner	1 set		
	Hoist (2-tonnes)	1 set		
	Others	1 set		

(4) Organization and Personnel

The material testing centre shall, together with the analysis centre mentioned in 15.7 (3), belong to the testing and analysis section. Personnel shall be as specified in Table 15.8.2.

Table 15.8.2 Personnel for Material Testing Centre

Ass't. manager or engineer	Clerk	Foreman	Skilled worker	Semi-skilled worker	Unskilled worker	Total
2 (2)	1 (1)	1(1)	7(10)	3(6)	3(6)	17(26)

Note: Figures in ( ) show the number of personnel of the 2nd stage.

CHAPTER 15-9

MAINTENANCE FACILITIES

15.9 Maintenance Facilities

(1) General

The maintenance facilities will be constructed for the maintenance of the main plants and related facilities in the steel plant. The maintenance facilities consist of the central maintenance shop and the area maintenance shops, and are provided with the allocation of equipment and personnel in a way to assure optimum operating efficiency, flexibility and economy. The central maintenance shop is designed to be capable of manufacturing common parts required for ordinary maintenance work and of providing the repairing of machinery and equipment. It was also decided that the workshop would be capable of producing bearing metals only on assumption that local procurement of other casting will be available. A decision was passed to procure forgings and gears from overseas or local sources.

(2) Conditions for Equipment Plan

It was designed that the maintenance facilities would be capable of manufacturing and repairing parts required for ordinary maintenance work other than those equipment necessary for the manufacturing of special parts or large components. Most of the spare parts will be procured from outside sources, but the central maintenance shop will also be engaged in the manufacture of spare parts as available.

i. Spare parts to be produced

a. Small machined parts

b. Build-up welding and machining of spare parts for reuse

c. Steel fabricated products

d. Bearing metal castings

ii. Spare parts not to be produced

a. Large parts

b. Cast steel and iron

c. Forging

d. Gears

e. Components made up of rubber and high molecular materials

f. Electrical equipment and instrumentation

g. Other parts requiring special techniques for production or which cannot be manufactured economically.

(3) Maintenance System

The maintenance department is organized of the planning and design section, the central maintenance section, the area maintenance section and the utilities section.

The planning and design section is in charge of equipment planning, maintenance planning, budget control on equipment planning and maintenance cost, and design.

The maintenance department broadly consists of the central maintenance section and the area maintenance section, and area maintenance personnel are assigned to main plant such as DR plant, steelmaking shop, hot strip mill plant and cold strip mill plant. In the initial stage of operation at the steel plant, it is essential to introduce a system which gives precedence to the stable performance of each plant in the steel plant.

In the 1st stage, an emphasis will be given to area maintenance under the supervision of an engineer. The area maintenance section will privide oiling and lubrication, daily inspections, minor repair, and spare parts control with regard to mechanical, electrical and insrumentation equipment in the assigned areas. In the case of effecting major periodical works or major repair works, the area

maintenance section will be assisted by the central maintenance section. The section will also be responsible for entry and updating of maintenance records from the initial stage of operation of plants concerned, and for improving the maintenance and repair technique. Area maintenance will in principle be performed during the daytime, except that daily inspections and minor repair will be performed in three-shift operation. Also, a minimum number of engineers will be assigned to main plants in the three-shift operation in order to cope with emergencies and other unexpected accidents with the cooperation of the central maintenance section as required.

In the 2nd stage, a primary emphasis will be given to the centralized maintenance with preventive maintenance as a major object. The area maintenance section will be staffed with a bare minimum number of personnel required for inspections and minor repair and the bulk of manpower will be listed under the central maintenance section to provide central maintenance to the steel plant. Therefore, intended purpose can be achieved with nominal increments in maintenance personnel.

The central maintenance section shall be responsible for;

a. Manufacturing small machined parts,
b. Build-up welding and machining of spare parts for reuse,
c. Piping, steel-fabricating and sheet metalworking,
d. Casting of bearing metals,
e. Repair of mechanical, electrical and instrumentation equipment (a motor capacity not more than 1,000 kW),
f. Woodworking and painting,
g. Repair of utilities equipment,
h. Maintenance of vehicles,
j. Minor repair of civil works and buildings,
k. Control on procured spare parts and materials, and

m. Support for area maintenance shops.

The utilities section responsible for operation of utilities equipment belongs to the maintenance department.

(4) Equipment Plan

The central maintenance shop accommodates the following office, shops and warehouses. The area maintenance shop will be installed in the buildings of each main plant.

Central maintenance shop includes:

i. Centralized installation

a. Central maintenance office
b. Machining shop
c. Machine repair shop
d. Steel fabrication shop
e. Piping shop and foundry (inclusive of woodworking and painting shops)
f. Electrical equipment and instrumentation repair shop
g. Oil and grease warehouse

ii. Dispersed installation

a. Spare parts warehouse and materials warehouse
b. Refractories warehouse
c. Vehicle maintenance shop

Table 15.9.1 gives the equipment specifications and Fig. 15.9.1 the layout of the central maintenance shop (centralized installation).

Table 15.9.1 Equipment Specifications for the Central Maintenance Shop

No.	Item	Building area	Machinery & equipment	Q'ty
1	Central office	20 m x 50 m x 2F = 2,000 m²	Drafting machine	1 set
			Copying machine	1 set
			Mini-computer	1 set
			Microfilming instrument	1 set
			Measuring instrument, etc.	1 set
2	Machining shop	20 m x 100 m = 2,000 m²	Crane, 20 t	1 unit
			Crane, 10 t	1 unit
			Crane, 2 t	2 units
			Lathe	12 units
			Vertical lathe	1 unit
			Planer	1 unit
			Milling machine	2 units
			Drilling machine	4 units
			Grinding machine	3 units

Table 15.9.1 (cont'd)

No.	Item	Building area	Machinery & equipment	Q'ty
2	Machining shop (cont'd)		Other machine tools	8 units
			Tools and instruments	1 set
3	Machine repair shop	20 m x 100 m = 2,000 m²	Crane, 20 t	2 units
			Crane, 2 t	2 units
			Truck crane, 45 t and others	3 units
			Hydraulic press	1 unit
			Truck, 11 t and others	7 units
			Tools and instruments	1 set
4	Steel fabrication shop	30 m x 100 m = 3,000 m²	Crane, 10 t	1 unit
			Crane, 5 t	2 units
			Crane, 2 t	2 units
			Hydraulic press	1 unit
			Shearing machine	2 units
			Roll bender	1 unit

Table 15.9.1 (cont'd)

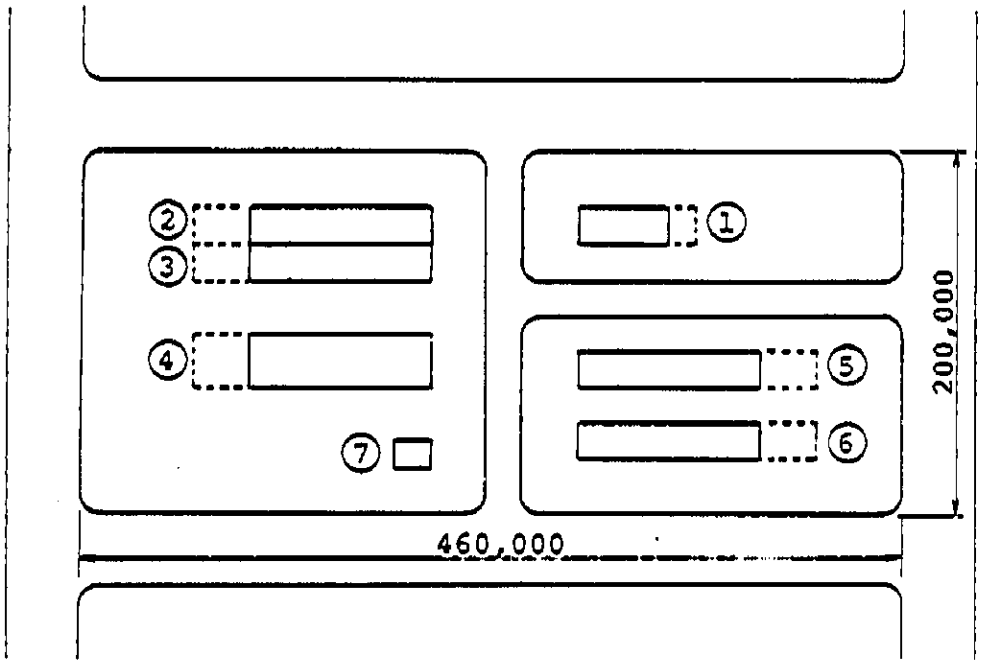
No.	Item	Building area	Machinery & equipment	Q'ty
4	Steel fabrication shop (cont'd)		Annealing furnace	1 set
			Build-up welding equipment	1 set
			Other tools and instruments	1 set
5	Piping shop and foundry	20 m x 100 m = 2,000 m²	Crane, 10 t	1 unit
			Crane, 5 t	1 unit
			Crane, 2 t	2 units
			Crucible furnace	1 set
			Equipment for casting	1 set
			Equipment for woodworking	1 set
			Tools and instruments	1 set
6	Electrical equipment and instrumentation repair shop	20 m x 100 m = 2,000 m²	Crane, 10 t	1 unit
			Crane, 2 t	2 units
			Lathe	1 unit
			Shearing machine	1 unit

Table 15.9.1 (cont'd)

No.	Item	Building area	Machinery equipment	Q'ty
6	Electrical equipment and instrumentation repair shop (cont'd)		Drying oven	1 set
			Testing equipment	1 set
			Tools, measuring instruments, etc.	1 set
7	Oil & grease warehouse	15 m x 20 m = 300 m²	Forklift, 2 t	1 unit
			Truck, 3 t	2 units
			Tools	1 set
8	Spare parts & materials warehouses	20 m x 100 m x 2 = 4,000 m²	Crane, 10 t	1 unit
			Crane, 5 t	1 unit
			Crane, 2 t	2 units
			Forklift, 2 t	2 sets
			Rack	1 set
			Truck, 3 t	2 units
			Measuring tools	1 set
9	Refractories warehouse	30 m x 50 m = 1,500 m²	Forklift, 2 t	3 units

Table 15.9.1 (cont'd)

No.	Item	Building area	Machinery & equipment	Q'ty
10	Vehicle maintenance shop	20 m x 100 m = 2,000 m²	Crane, 10 t	1 unit
			Crane, 2 t	1 unit
			Lifting jack	1 set
			Testing equipment	1 set
			Maintenance tools	1 set



① Central Maintenance Office
② Machining Shop
③ Machine Repair Shop
④ Steel fabrication Shop
⑤ Piping Shop and Foundry
⑥ Electrical Equipment and Instrumentation Repair Shop
⑦ Oil and Grease Warehouse

Fig. 15.9.1 Layout of Maintenance Shop

(5) Organization and Personnel

Table 15.9.2 shows the organization of the maintenance department and Table 15.9.3 shows personnel for the department.

Maintenance work will in principle be performed during the daytime, but a part of inspectors of the area maintenance section and personnel of the central maintenance section assigned to handling emergencies and accidents, and specific type of work will work in the three-shift operation.

Table 15.9.2 Organization for Maintenance Department

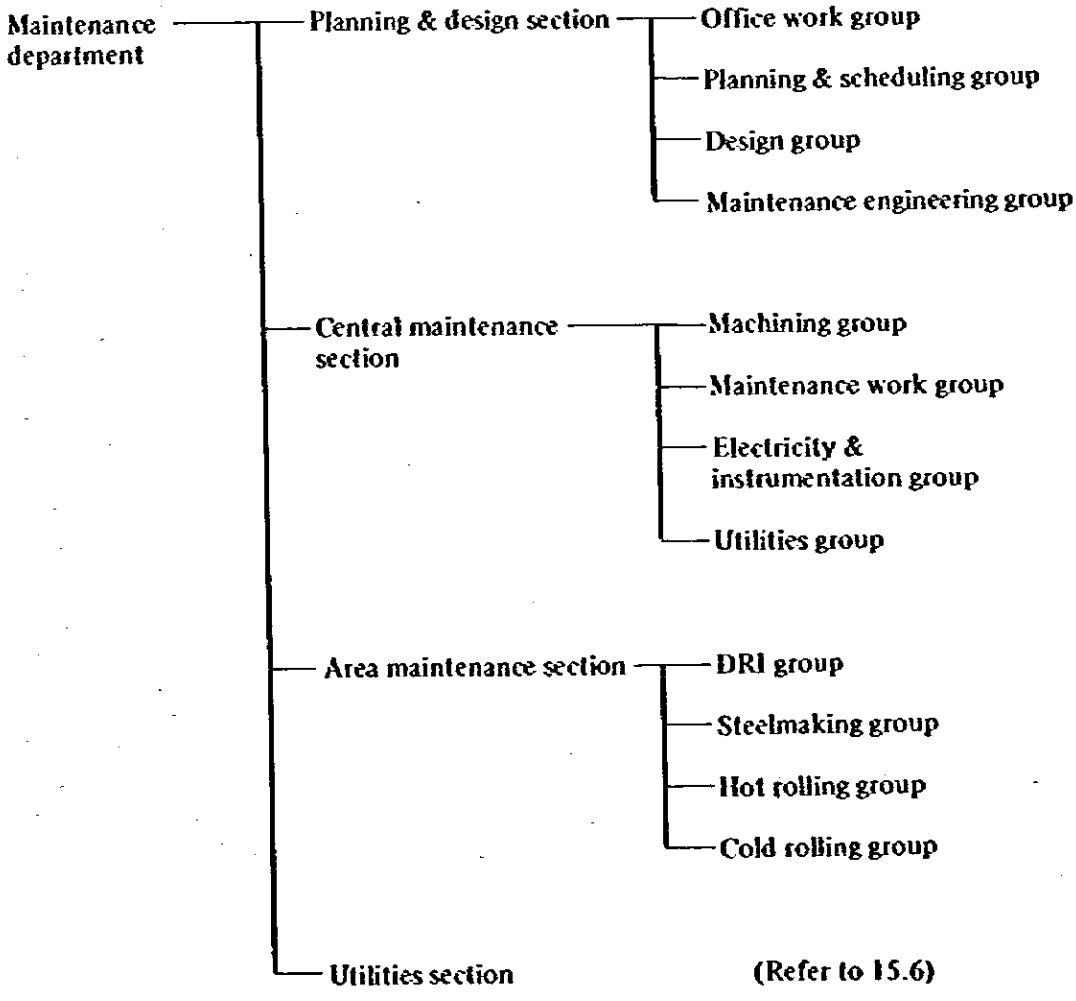


Table 15.9.3 Personnel for Maintenance Department

Section	Manager		Ass't Manager & engineer		Clerk		Foreman		Skilled worker		Semi-skilled worker		Un-skilled worker		Total	
Planning & design section	1	(1)	–	–	–	–	–	–	–	–	–	–	–	–	1	(1)
Office work G.	–	–	1	(1)	5	(8)	–	–	–	–	–	–	–	–	6	(9)
Planning & scheduling G.	–	–	7	(11)	2	(4)	–	–	–	–	–	–	–	–	9	(15)
Design G.	–	–	17	(28)	–	–	2	(3)	8	(12)	8	(12)	–	–	35	(55)
Maintenance engineering G.	–	–	12	(30)	–	–	2	(3)	8	(12)	8	(12)	–	–	30	(57)
Sub-total	1	(1)	37	(70)	7	(12)	4	(6)	16	(24)	16	(24)	–	–	81	(137)
Central maintenance section	1	(1)	–	–	–	–	–	–	–	–	–	–	–	–	1	(1)
Machining G.	–	–	20	(20)	1	(1)	10	(15)	40	(50)	43	(54)	63	(86)	177	(226)
Maintenance work G.	–	–	16	(16)	1	(2)	26	(32)	128	(150)	194	(227)	216	(267)	581	(694)
Electricity & instrumentation G.	–	–	6	(6)	1	(1)	6	(6)	14	(17)	18	(22)	16	(19)	61	(71)
Utilities G.	–	–	5	(5)	1	(1)	5	(5)	12	(12)	17	(17)	15	(15)	55	(55)
Sub-total	1	(1)	47	(47)	4	(5)	47	(58)	194	(229)	272	(320)	310	(387)	875	(1,047)
Area maintenance section	1	(1)	–	–	–	–	–	–	–	–	–	–	–	–	1	(1)
DRI G.	–	–	5	(3)	1	(1)	3	(2)	7	(7)	9	(8)	15	(8)	40	(30)
Steelmaking G.	–	–	10	(5)	1	(1)	9	(5)	29	(17)	40	(28)	47	(25)	136	(80)
Hot rolling G.	–	–	12	(6)	1	(1)	12	(8)	30	(20)	42	(30)	49	(26)	146	(91)
Cold rolling G.	–	–	12	(6)	1	(1)	12	(8)	33	(20)	47	(35)	53	(28)	158	(98)
Sub-total	1	(1)	39	(20)	4	(4)	36	(23)	99	(64)	138	(101)	164	(87)	481	(300)
Grand total	3	(3)	123	(137)	15	(21)	87	(87)	309	(317)	426	(445)	474	(474)	1,437	(1,484)

Notes: 1) Figures in ( ) show the number of personnel required at the 2nd stage.
2) The number of personnel for utilities section is not included in this table.

CHAPTER 15-10

INTRAWORKS TRANSPORTATION FACILITIES

15.10 Intraworks Transportation Facilities

(1) General

The intraworks transportation facilities are designed to deliver raw materials, semi-finished products, by-products and other materials within the premises of the steel plant, except those carried by the special transportation facilities, such as oxide pellets delivered to DR plant, and DRI and burnt lime delivered to steelmaking shop by belt conveyors, and slab delivered to hot strip mill plant by slab transfer cars. Materials shall be transported in the steel plant by trailers, dump trucks, flat-body trucks and dust lorries, etc.

(2) Conditions for Equipment Plan

i. Quantities of transportation

The quantities of transportation on which the equipment plan is based will be determined by production plan as given in Table 15.10.1.

ii. Working conditions

Operation shall in principle be performed in a three-shift basis, but the daytime operation shall be applied to those items not to be transported so frequently.

iii. Loading efficiency

The loading efficiency on the trailer of hot rolled coils consigned to a cold strip mill plant shall be 70%. The dump truck loading efficiency ranges 50 to 80% and that of the truck ranges 30 to 80% depending on the type of cargoes loaded.

(3) Equipment List

Table 15.10.2 gives list for transportation equipment.

(4) Organization and Personnel

Traffic personnel belong to the transportation section together with personnel engaged in product handling as mentioned in the next paragraph. See 15.11 (4).

Table 15.10.1 Quantities of Transportation (1st stage)

Classification	Items	Q'ty (t/y)	Type of vehicles
Raw materials	Imported scrap	138,500	18 t dump truck
	Return scrap	144,400	18 t dump truck
	Ferroalloys	8,150	18 t dump truck
	Carburizing material	4,700	18 t dump truck
	Aluminium	2,600	18 t dump truck
	Dolomite clinker	12,950	18 t dump truck
	Fluorite	3,200	18 t dump truck
DR plant	Oxide fine	89,000	18 t dump truck
	Sulphur cake	1,500	18 t dump truck
	Sludge	24,000	18 t dump truck
	Oxide dust	7,000	8 t dust lorry
Steelmaking shop	Refractories	34,900	8 t truck
	EAF slag	248,200	18 t dump truck
	Waste refractories	16,500	18 t dump truck
	Metallic Fe recovered from slag	8,000	18 t dump truck

Table 15.10.1 (cont'd)

Classification	Items	Q'ty (t/y)	Type of vehicles
Steelmaking shop (cont'd)	Scale	25,600	18 t dump truck
	Collected dust	12,800	8 t dust lorry
Hot strip mill plant	Coils to be cold rolled	521,000	25 t trailer
	Scale	16,000	18 t dump truck
Cold strip mill plant	Sludge	8,400	18 t dump truck
Circulating water treatment plant	Sludge	5,800	18 t dump truck
General	Miscellaneous	–	8t, 2t trucks

Table 15.10.2 Equipment List

Item	1st stage	2nd stage
Dump truck	Capacity 18 t 9 units	Capacity 18 t 5 units
Flat body truck	Capacity 8 t 3 units	Capacity 8 t 2 units
	Capacity 2 t 2 units	Capacity 2 t 1 unit
Trailer	Capacity 25 t 2 units	Capacity 25 t 1 unit
Dust lorry	Capacity 8 t 1 unit	Capacity 8 t 1 unit
Vacuum truck	Capacity 2 t 1 unit	
Front end loader	Capacity 2 m^3 2 units	Capacity 2 m^3 1 unit
Bulldozer	Dead weight 20 t 2 units	Dead weight 20 t 1 unit
Automatic weigher	Capacity 40 t 1 unit	

CHAPTER 15-11

PRODUCT HANDLING FACILITIES

15.11 Product Handling Facilities

(1) General

The product handling facilities are designed to ship plates, hot rolled sheets and coils, and cold rolled sheets and coils produced. This planning is based on the assumption that products will be delivered to clients by marine or overland transport (by goods wagon, trailer or truck). Products will be transported to product warehouse from each plant by trailers and shipped to customers after temporary storage at the warehouse. The plan envisages to install rail tracks in the hot strip mill plant and the cold strip mill plant and make provision for loading products directly aboard goods wagon or trailer as required. This product handling facility consists of a berth product loader, product trailer and warehousing equipment, and includes diesel locomotives for switching and shunting goods wagons, but does not include means of transportation to customers.

(2) Conditions for Equipment Plan

i. Product handling quantities

The product handling quantities on which equipment plan is based will be determined in accordance with the production plan as provided in Table 15.11.1.

Table 15.11.1 Product Handling Quantities

(Unit: 1,000 t/y)

Products	1ts stage	2nd stage
Hot coil	425	663
Hot sheet*	199	274
Cold coil	358	634
Cold sheet	121	170
Total	1,103	1,741

Note: * include plate

Assuming that the most of the products will be delivered to clients in the central area including the metropolitan area and that the metropolitan industrial complex are concentrated along the waterfront of rivers, this plan is primarily based on marine transport, including a small portion of overland transport (railway transport by goods wagon, and road transport by truck or trailer). The current plan envisages to transport products at a rate of 80% by vessel, 15% by vehicle and 5% by railway. Table 15.11.2 gives the product handling quantities by means of transportation.

Table 15.11.2 Product Handling Quantities by Transportation Methods

(Unit: 1,000 t/y)

Classification	Products	1st stage	2nd stage
Marine transport	Hot coil	340.0	530.4
Barge & small steel vessels	Hot sheet	159.2	219.2
	Cold coil	286.4	507.2
	Cold sheet	96.8	136.0
	Sub-total	882.4	1,392.8
Overland transport			
Vehicle (truck or trailer)	Hot coil	63.8	99.4
	Hot sheet	29.8	44.1
	Cold coil	53.7	95.1
	Cold sheet	18.2	25.5
	Sub-total	165.5	261.1
Railway (goods wagon)	Hot coil	21.2	33.2
	Hot sheet	10.0	13.7
	Cold coil	17.9	31.7
	Cold sheet	6.0	8.5
	Sub-total	55.1	87.1
	Grand total	1,103.0	1,741.0

ii. Product berth and type of vessels

Most of the products will be transported by water to domestic clients on coastal areas and the shores of rivers. As clients' berth are usually rather small and cargoes will be shipped in small consignments, the product berth plan is based on 200–1,000 DWT barges and small steel vessels, with an assumed average vessel size of 400 DWT. The plan envisages to allow a part of the berths to accommodate 2,000 DWT vessels in anticipation of the emergence of larger vessels in the future.

The berth plan is affected by the amount of cargoes loaded, vessel size and stevedoring efficiency. In this connection, this planning is based on the berth occupancy rate of not more than 70% in order to reduce the number of inward ships lying at anchor.

iii. Working conditions

Working will be performed in three-shift operation.

(3) Equipment Plan

i. Layout

Products to be shipped from rolling plants will be delivered to specific product warehouses depending on the kind of products and customers. The warehouses are located along the berth to permit both marine and overland transportations, providing access to goods wagons and off-track vehicles. Products by marine transport will be shipped out of the warehouse by overhead crane and loaded aboard vessel by level luffing loader capable of travelling along the berth.

ii. Loading berth and product loader

The product berth installation plan reviews the number of incoming vessels, stevedoring time and berth occupancy time on the basis of amount of cargoes handled, individual product weight, loader capacity and vessel size, and after reviewing the berth occupancy rate, will determine the number of loaders and berths to be used. Table 15.11.3 gives the results of study. The berth will be provided in the 1st stage with 4 berths (A, B, C and D). Berths C and D will be capable of accommodating 2,000 DWT ships. The loading berth will be extended in the 2nd stage to accommodate 6 berths, leaving some room for additional extension. For product loader, level luffing crane will be used because cargoes to be loaded will be coils or cut sheets, but not long materials. This crane will facilitate easy loading of products from warehouses by means of composite movements of turning and luffing. Designed capacity of the cranes are set at 10 tonnes to enable loading of a maximum 8 tonnes of products. Assuming that a product to be loaded weighs about 4 tonnes on the average, this plan is based on 50 t/h of total stevedoring capacity including shipments of products from warehouses. Five loaders are installed in the 1st stage, and in the 2nd stage three more loaders will be added bringing the total number to eight.

Table 15.11.3 Product Berth and Loader Plan

Items	1st stage	2nd stage
Products for shipment (1,000 t/y)	882.4	1,392.8
Average vessel size	400 DWT	400 DWT
Average number of inward vessels	2,206	3,482
Average weight of individual products (t)	4	4
Loader capacity (t/h)	50	50
Number of berths	4	6
Number of loaders	5	8
Berth occupancy rate (%)	64	63

iii. Product warehouse

Product warehouses, located in parallel behind the berth forming an interface between marine and overland transport, will be provided with product storage and sorting functions as a buffer for shipment of products. The product warehouses will be equipped with a floor space wide enough to store products for 2 weeks' production, and also with 10-tonne capacity overhead cranes.

iv. Trailer

On-rail and off-rail mode of transportation will be generally employed for the internal transportation of products. The on-rail type is suitable for the long-distance transport of a large quantity of products at one time, but carries a high initial cost. In this plan, a trailer system was adopted as a mobile and flexible means of an off-rail transportation. The trailer will have a rated loading capacity of 15 tonnes taking into account an individual product weight, transporting capacity and easiness of handling, etc. A total number of trailers required was calculated on the basis of average loading quantities at 70% efficiency.

v. Equipment specifications

Table 15.11.4 gives specifications for product handling equipment.

vi. Layout of product berth facilities

Figure 15.11.1 shows the layout of product berth facilities.

(4) Organization and Personnel

Product handling personnel will belong, together with intraworks transportation personnel as mentioned in the preceeding paragraph, to the transportation section with the following organization. Table 15.11.5 gives relevant personnel.

Table 15.11.4 Equipment Specifications

Item	1st stage	2nd stage (Addition)
1. Loading berth		
Total length	350 m	200 m
Description	A, B C, D	E, F
Max. ship size	1000 DWT, 2000 DWT	2000 DWT
Water depth	−5 m −6 m	−6 m
Length	75 m x 2 100 m x 2	100 m x 2
2. Product loader		
Number	5 units	3 units
Type	Level luffing gantry crane	Same as left
Lifting load	10 t	10 t
3. Trailer		
Number	10 units	6 units
Capacity	15 t	15 t
4. Diesel locomotives	2 units	
Capacity	25 t (1,435 mm gauge)	
5. Product warehouse		
Building area	Approx. 30,000 m²	Approx. 18,000 m²
	25 m x 120 m x 3, 2 units	25 m x 120 m x 3, 2 units
	25 m x 120 m x 4, 1 units	
Overhead crane	10 t x 20 units	10 t x 12 units

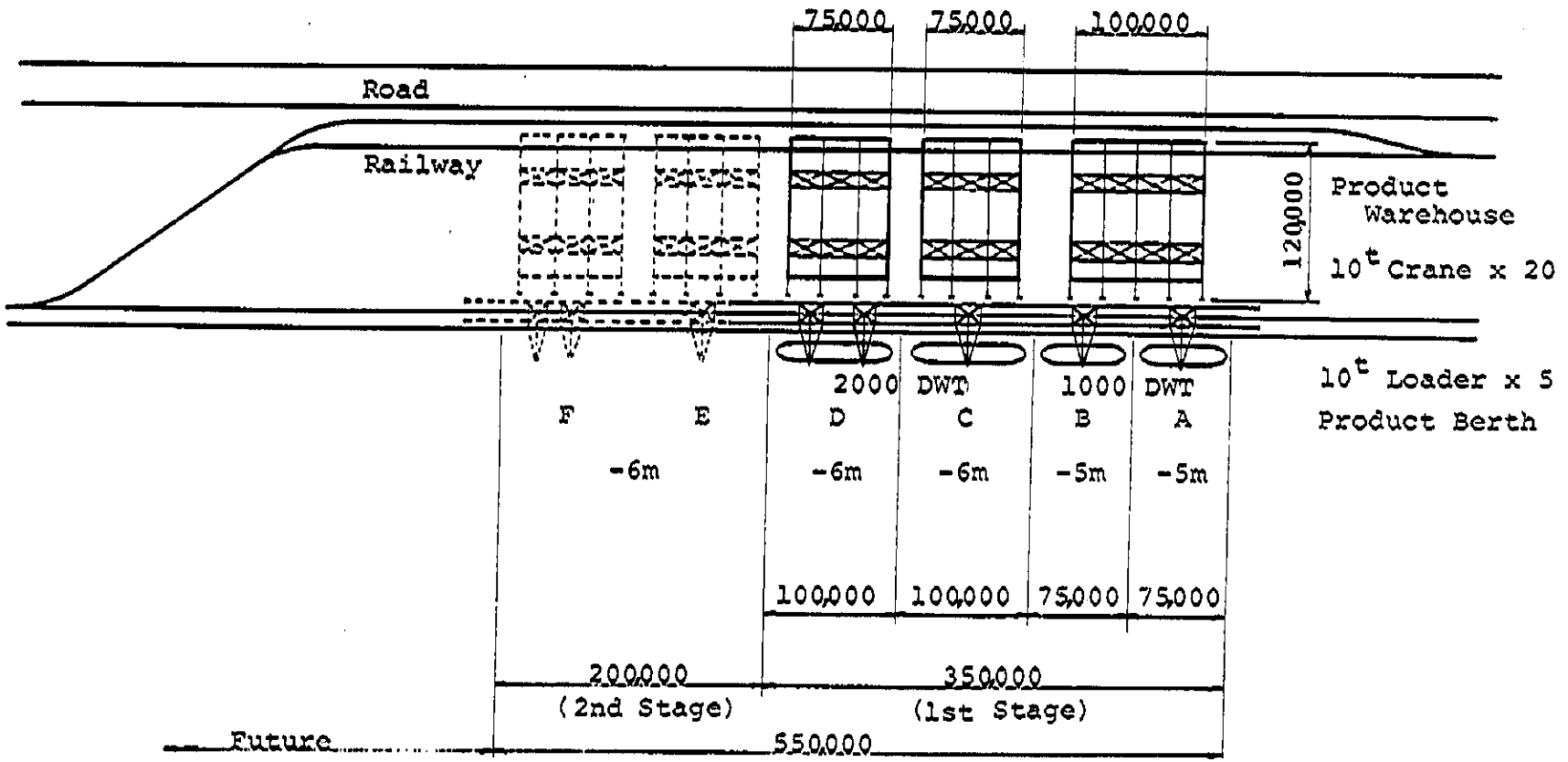


Fig. 15.11.1 Layout of Product Berth Facilities

Table 15.11.5 Personnel for Transportation Section

Manager	Group	Ass't manager or engineer	Clerk	Foreman	Skilled worker	Semi-skilled worker	Unskilled worker	Sub-total of group
1 (1)	Transportation	12 (12)	3 (3)	11 (11)	66 (102)	24 (30)	72 (113)	188 (271)
	Crane operation	5 (5)		4 (4)	21 (30)	9 (18)	60 (96)	99 (153)
1 (1)		17 (17)	3 (3)	15 (15)	87 (132)	33 (48)	132 (209)	287 (424)
Total					288 (425)			

Note: Figures in ( ) show personnel for the 2nd stage.

CHAPTER 15-12

PRODUCTION CONTROL SYSTEM

15.12 Production Control System

(1) General

For the steel plant project, the production control will be performed by using a computer. The system will be designed for order entry, production scheduling, work instruction, production record processing, shipping control and so on.

This system includes no process control computers for the production lines.

(2) Function of Each Sub-system

i. Order entry and production analysis system

a. All order information generated chiefly in the sales department will be collectively controlled and checked.

b. The specification, the inspection criteria and standard delivery date will be added to the above mentioned data.

c. Those data will be integrated and classified according to the type of product and delivery date.

The production standard master data previously established will be used to check the production capacity of each equipment line and delivery date, and resultantly the check list will be output.

ii. Production scheduling and work instruction system

a. The sold orders and field stock orders for which the order entry and produc-

tion analysis system has given a sign of "GO" will be grouped according to delivery time, type of steel, dimensions and inspection criteria.

b. Referring to the product inventory separately controlled by the shipping control system as described later, weekly and daily production schedule covering each line will be prepared and will be used for work instruction.

c. Further, based on the progress information at each line coming from the production record processing system, this system permits instruction to be reissued to assure the delivery date.

iii. Production record processing system

a. Gathering the production record from each line, the difference between scheduled and actual production will be comparatively examined and then request the production schedule and work instruction system to reissue an instruction.

b. By using the above mentioned data, many kind of reports will be output for production administration.

iv. Shipping control system

a. Based on production schedule and progress information, shipping schedule and instruction will be issued by this system.

b. With this system, the product flow will be finally controlled at shipment phase to issue the shipping list for customers and to function as a checkpoint

to assure the end quality of products.

c. This system will also grasp the product inventory and will convey those information to production scheduling and work instruction system and general administration system.

v. General administration system

In addition to the above, this computer will be used for the purpose of processing the general administration information including payroll, accounting, production cost, etc.

(3) General System Flow Chart

Fig. 15.12.1 shows the schematic diagramme of these systems.

(4) Equipment List

Computer hardware items are shown in Table 15.12.1.

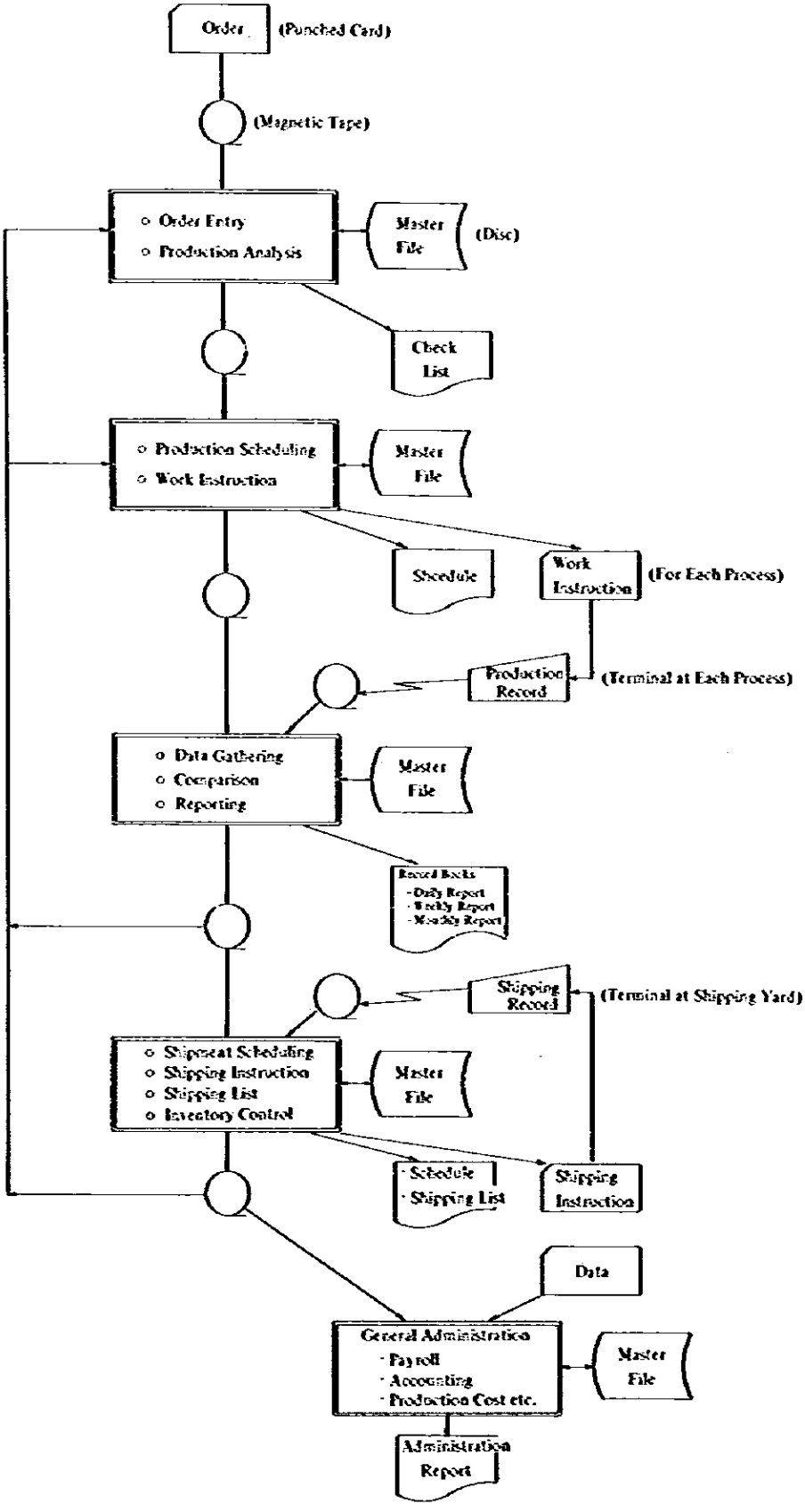


Fig. 15.12.1 General System Flow Chart

Table 15.12.1 Equipment List

Classification	Equipment	Quantity	Remarks
1.	Computer	1	o Core capacity: 512 K Byte Language used: Equal to COBOL System: Batch system (Equal to IBM 370/135)
2.	Auxiliary memory		
(1)	Disc.	5	o 100 M Byte/drive
(2)	Magnetic tape	3	
3.	Peripheral equipment		
(1)	Line printer	2	o 1,000 lines/min
(2)	Card reader	2	
(3)	On-line card punch	1	
4.	Power supply	As req'd	o Constant voltage and constant frequency 300 kVA
5.	Air conditioner (For computer room)	As req'd	
6.	Consumable supplies Card, printer form, ribbon, disc pack, and magnetic tape	As req'd	o For one year consumption
7.	Terminal Card reader Typewriter Setter		o Location: (EAF shop, CC shop, slab shop, hot mill skinpass · shear · recoil, pickling line hot yard, tandem cold mill, ECL, anneal, recoil, coil yard, warehouse, shipping yard)

APPENDIX

APPENDIX

I. Non Flat Steel Plant

This paper on an integrated non flat steel plant has been prepared at the request of Mr. Chira Panupong, deputy secretary of the Office of the Board of Investment of the Royal Thai Government.

With considerations given to the demand for non flat products in 1990 in the Kingdom of Thailand, to the improvement of the efficiencies of existing steel mills and to the new flat steel plant construction schedules, the proposed project here contemplates the construction of a 350,000 t/year (billet base) non flat steel plant including direct reduction plant, electric are furnace, continuous casting machine and bar and wire mill.

As the Study Report on the construction of the integrated flat steel plant in Thailand convers the details of direct reduction plant, electric arc furnace and continuous casting machine, this paper tries to describe only those requirements involved in changes in the production capacity, and detailed description of the rod and wire mill.

Although the production capacity of the rod and wire mill is assumed for annual 350,000 tonnes, it is required that a supply/demand balance, financial schedule, etc. be considered to determine a reasonable production capacity of the plant prior to commencement of its construction. As far as the land space is concerned, findings indicate that there is a sufficient room for the non flat steel plant in the site where the proposed integrate flat steel plant is to be constructed.

1. Direct Reduction Plant

(1) Concept

The direct reduction plant is planned to produce direct reduced iron (DRI) at a rate of 400,000 tonnes per year prior to supply the material to the steelmaking shop.

This plant is mainly composed of direct reduction facilities and desulphurizing

facilities.

(2) Production Plan

This direct reduction plant is to be constructed based on the basic design data as shown in Table (A) 1.

(3) Material Flow

The material flow in this plant is shown in Fig. (A)1.

(4) Equipment List

The main equipment for the direct reduction plant is shown in Table (A)2.

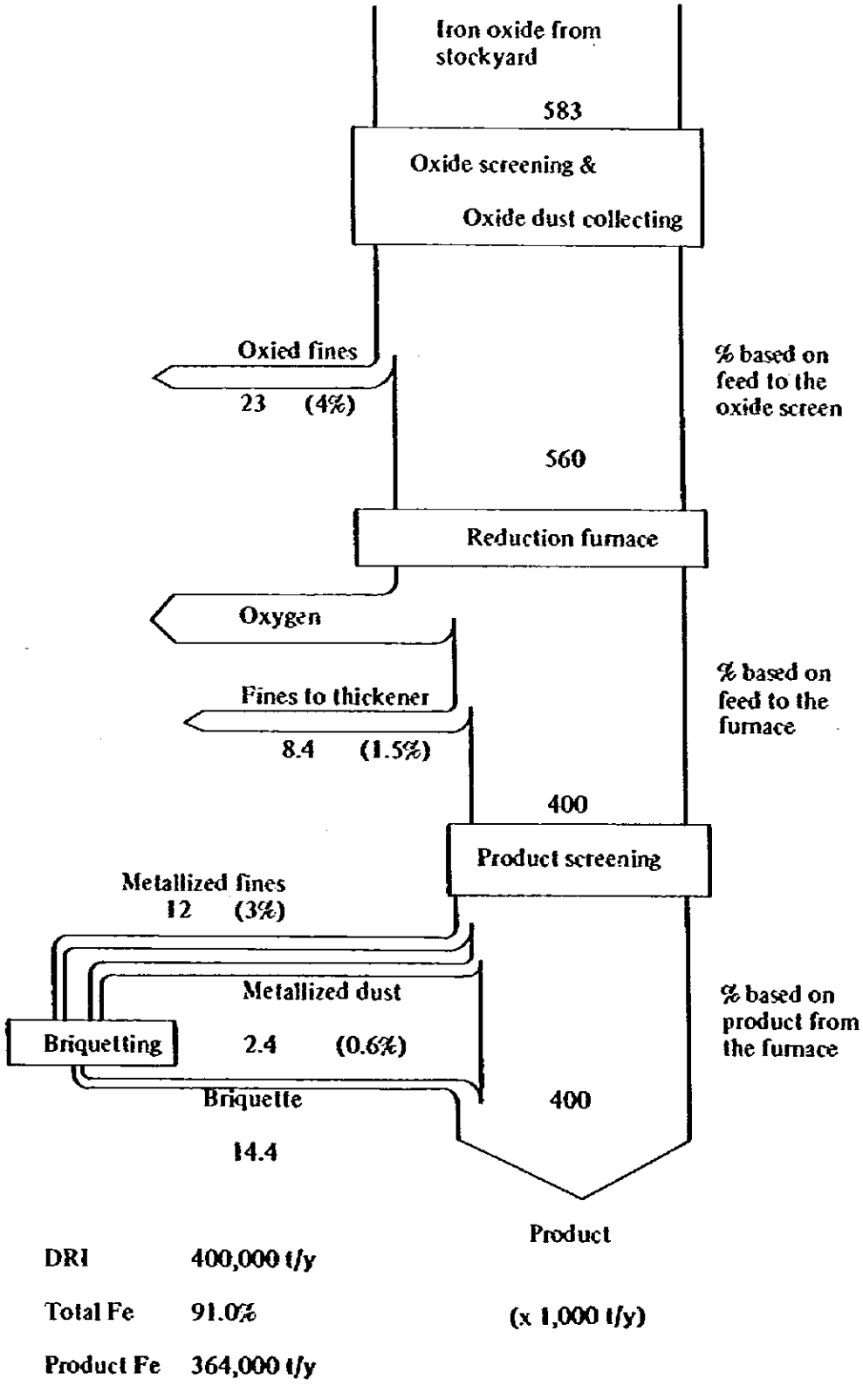


Fig. (A) 1 Material Flow of DR Plant

Table (A) 1 Basic Design Data of DR Plant

DRI production	400,000 t/y
Average production rate	1,280 t/d
Operation mode	24 hours, 3 shifts
Plant availability	7,500 h/y, 312.5 d/y
Total Fe of DRI	91.0 %
Metallization, nominal	93 %
Carbon content, nominal	1.5 %
Oxide feed from ore yard	583,000 t/y
	1,866 t/y
Oxide screen undersize (–3 mm)	12,000 t/y
Oxide dust collection fines	2,400 t/y
Furnace feed	560,000 t/y

Table (A) 2 Equipment List

Equipment	Q'ty	Description
1. Direct reduction furnace	1	Shift furnace (nominal capacity 400,000 t/y) equiped with charge hopper, slide, gates, burden feeders and wiper bar
2. Reformer	1	200 mm dia. tubes with catalyst
3. Top gas scrubber	1	Venturi and packed tower type
4. Cooling zone scrubber	1	– ditto –
5. Reformed gas cooler	1	Packed tower type
6. Seal gas cooler	1	– ditto –
7. Preheater	2	Sheel & tube type heat exchanger
8. Recuperator	2	Shell & tube type heat exchanger
9. Stack	1	Height: approx. 50 m
10. Process gas compressor	3	Positive displacement type rotary lobe compressors
11. Cooling zone compressor	1	Positive displacement type rotary lobe compressor
12. Main air blower	1	Centrifugal air blower
13. Auxiliary air blower	1	Centrifugal air blower
14. Dilution air blower	1	– ditto –
15. Seal gas compressor	2	Rotary lobe compressors
16. Mist eliminator	3	For process gas, cooling gas & seal gas
17. Piping system	1 set	Including valves and fittings
18. Dust collection system	1 set	Composed for cyclones, venturi scrubbers, fans and dust storage bin

Table (A) 2 (cont'd)

Equipment	Q'ty	Description
19. Water system	1 set	Composed of clarifier, cooling towers and pumps
20. Electrical and instrumentation system	1 set	
21. Oxide day bin	3	Capacity: 1,000 t x 3 Equiped with feeders
22. Material handling system	1 set	Composed of screens, belt scales and belt conveyors
23. H_2S removal facility	1 set	Stretford process

2. Steelmaking Shop

2.1 Outline of the Steelmaking Shop

(1) Concept

The steelmaking shop is planned to produce 369,000 tonnes of molten steel annually from DRI and scrap and to cast billet for the purpose of supplying it to the rolling mill.

Two electric arc furnaces and one continuous casting machine are planned to be installed in this shop.

(2) Production Plan and Main Facilities

The basic production plan and main facilities are shown in Table (A)3 and (A)4 respectively.

Water required for this steelmaking shop is planned to be treated at the facilities installed in the 1st and 2nd stage of the construction programme as described in the Study Report with some expansion in capacity.

Table (A) 3 Basic Production Plan

		Quantity (t/y)
Main material	DRI	328,000
	Scrap	82,000
Product	Molten steel	369,000
	Billet	350,000

Table (A) 4 Main Facilities

		Main specification
Melting/smelting	UHP electric arc furnace	75 t/heat x 2
Casting	Curved mould radial type billet continuous casting machine	6 strands x 1

(3) Layout

The layout of the steelmaking shop is shown in Fig. (A)2.

The design concept is similar to that of the steelmaking shop as described in the Study Report.

2.2 Electric Arc Furnace

(1) Concept

Two electric arc furnaces are planned to be installed to produce 369,000 tonnes of molten steel per year in accordance with the basic production plan (Table (A)3).

The transformer capacity will be 40,000 KVA for each electric arc furnace.

The material flow and the facilities such as slag disposal system and dust collection system etc., are basically similar to those described in the Study Report.

(2) Basic Design data of EAF

The electric arc furnace plant will be designed on the basis of the following conditions:

a. Tap-to-tap time : 175 min/heat

b. Number of taps : 8.2 heats/d.f'ce x 2 f'ces

c. Molten steel production : 75 t/heat x 8.2 heats/d.f'ce x 2 f'ces = 1,230 t/d

d. Tapping cycle time: 1,400 min/d ÷ 8.2 heats/d.f'ce ÷ 2 f'ce = 87.8 min/ch.

(3) Electric Arc Furnace Facilities

i. Ultra high power

The electric arc furnace will be of UHP type and its capacity will be 75 t/ch. each. The transformer capacity will be 40,000 KVA.

ii. Electrode

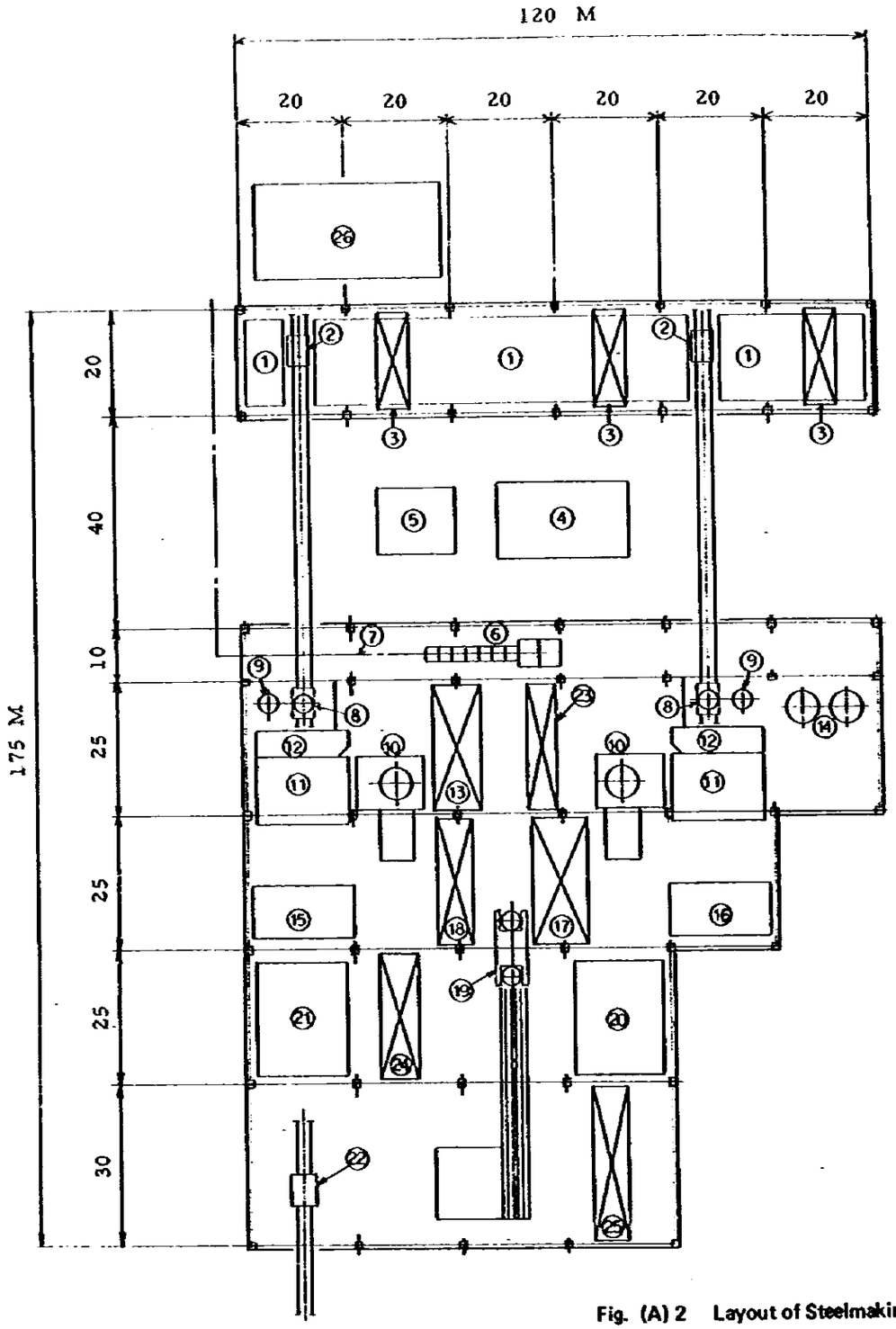
The diameter of the electrode will be 508 mm. and its hoisting device will be of electric wire rope winding type.

iii. Furnace

The inner diameter of the furnace will be designed to be 5,800 mm. Instead of conventional brick lining, water cooled panel will be widely adopted for the furnace wall and the furnace roof.

(4) Dust Collection System

In the electric arc furnace facilities, the following three dust collection systems will be provided to minimize the air pollution problems. The conception of these dust collection systems will be basically similar to that described in the Study Report.



1	SCRAP STORAGE AREA
2	SCRAP WEIGH SCALE
3	SCRAP CHARGING CRANE
4	DUST COLLECTOR
5	DUST COLLECTOR FOR HANDLING SYSTEM
6	D R I, LIME & OTHER MATERIAL HOPPER
7	CONVEYOR
8	SCRAP BUCKET TRANSFER CAR
9	SCRAP BUCKET
10	ELECTRIC ARC FURNACE
11	TRANSFORMER ROOM
12	CONTROL ROOM
13	FURNACE CHARGING CRANE
14	ROOF REPAIRING AREA
15	LADLE REPAIRING AREA
16	LADLE PREPAIRING AREA
17	HOT METAL LADLE CRANE
18	LADLE REPAIRING CRANE
19	C . C . MACHINE
20	TUNDISH REPAIRING AREA
21	MACHINE REPAIRING AREA
22	BILLET TRANSFER CAR
23	O. H. C.
24	O. H. C.
25	O. H. C.
26	SITE OFFICE & ELECTRIC ROOM

Fig. (A) 2 Layout of Steelmaking Shop (For Non-Flat Products)

a. For the treatment of the waste gases generated from the electric arc furnaces

– Bag filter type dust collectors

1,000 Nm^3/min. x 2 units

b. For the treatment of the waste gases generated at the time of scrap charging and tapping

– Electrostatic dust collector

15,000 Nm^3/min. x 1 unit

c. For the treatment of the dust generated while transferring the main and sub-materials from one conveyor to the other and at the storage hoppers

– Bag filter type dust collector

1,000 Nm^3/min. x 1 unit

(5) Equipment List of EAF

The main equipment for the electric arc furnace facilities is shown in Table (A)5.

Table (A) 5 Equipment List

Equipment	Q'ty	Description	
1. Raw material handling facilities	1 lot	Belt conveyor:	300 t/h x 1
		Hopper:	60 m^3 x 2
		Feeders:	100 t/h x 4
		Scrap bucket:	50 m^3 x 4
		Scrap bucket transfer car:	70 t x 2
		Scrap weigh scale:	Max. 70 t
2. Additives handling facilities	1 lot	Receiving hopper:	15 m^3 x 1
		Conveyor, tripper:	70 t/h
		Hopper:	30 m^3 x 2
		Hopper:	15 m^3 x 6
		Feeders, charger	

Table (A) 5 (cont'd)

Equipment	Q'ty	Description
3. Electric arc furnace facilities	1 lot	Electric arc furnace: 75 t (Max. 80 t) x 2 Inner diameter: 5,800 mm Electrode: 508 mmϕ Transformer: 40,000 KVA x 2 Slag pot: 11 m³ x 10 Slag pot carrier: 45 t x 2 Electrode connecting machine: x 2
4. Molten steel handling facilities	1 lot	Ladle: Max. 80 t x 6 Ladle stand, ladle preparation stand, ladle preheater, etc.
5. Dust collection system	1 lot	Bag filter: 1,000 m³/min. x 2 (at 220°C) Electric dust collector: 15,000 m³/min. x 1 (at 50°C) Bag filter: 1,000 m³/min. x 1 (at 20°C)
6. Crane system	1 lot	For scrap charging: 15 t x 3 For scrap handling: 70 t/20 t x 1 For service: 10 t/3 t x 1 For ladle handling: 120 t/35 t x 1 For ladle repairing: 40 t/15 t x 1
7. Interconnecting piping	1 lot	
8. Air conditioning system	1 lot	
9. Intercommunication system	1 lot	
10. Auxiliary equipment	1 lot	Refractories, lubricant, etc.
11. Steel structure	1 lot	
12. Electrical equipment	1 lot	
13. Instrumentation	1 lot	

2.3 Continuous Casting Machine

(1) Concept

The continuous casting machine will be designed to cast 350,000 tonnes of billet annually from the molten steel produced at the electric are furances. Fig. (A)3 is the continuous casting flow sheet.

(2) Outline

The conception of the continuous casting machine is basically the same as that described in the Study Report. Although the cast and sheared billets are designed to be cooled by water and scarfed at the scarfing line in the case of the shop in the Study Report, the cast and sheared billets in this case are planned to be transferred to the cooling bed by the billet transfer car to the billet yard. The billets will be piled up and then cooled to the ambient temperature before they are transferred to the rolling mill.

The layout of the main equipment is shown in Fig. (A)2.

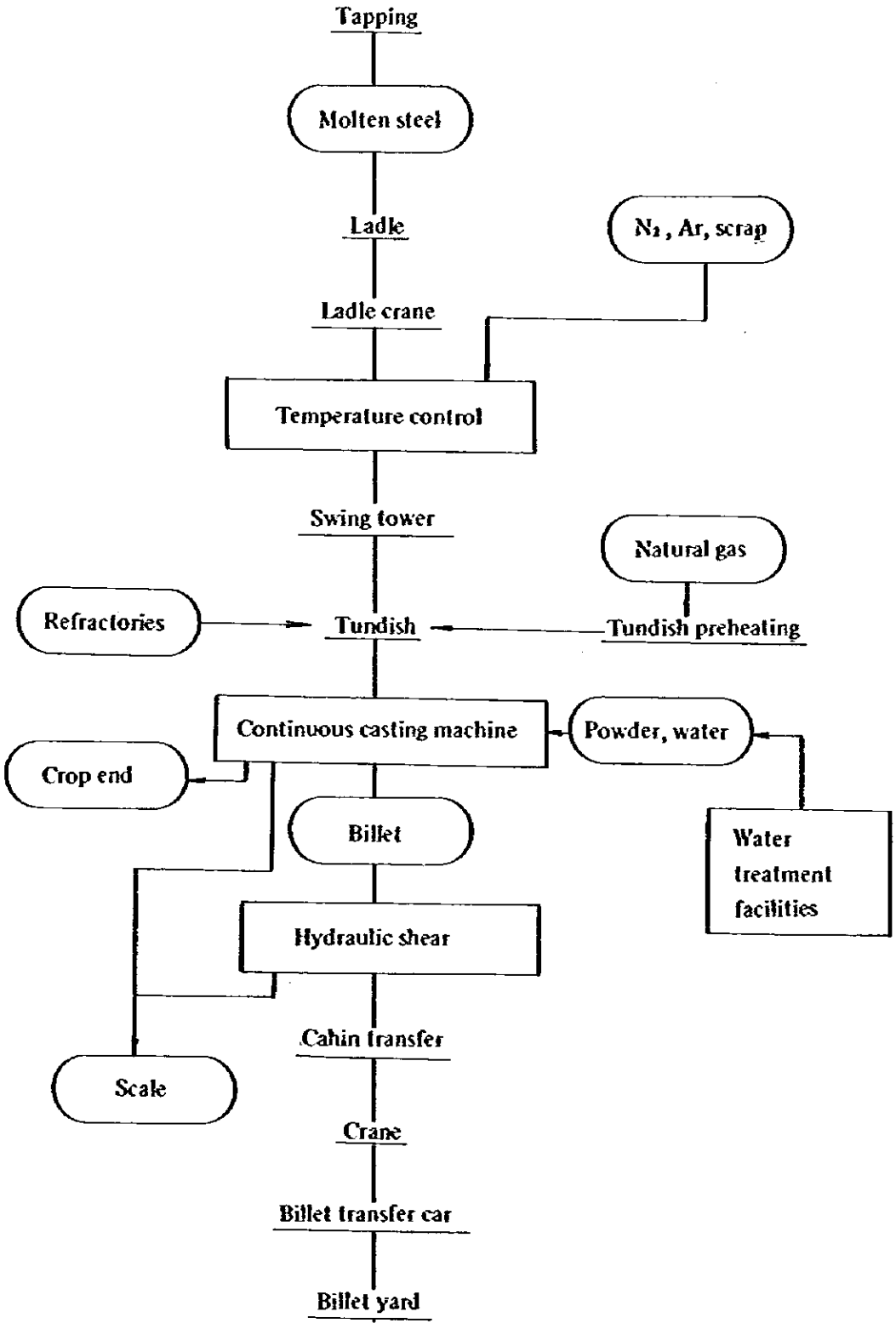


Fig. (A) 3 Continuous Casting Flow Sheet

(3) Basic Design Data

i. Production plan

The production plan is shown in Table (A)6.

Table (A) 6 Production Plan

	Annual production (tonne)
Molten steel	369,000
Cast billet	350,000

Note: Yeild: 95%

ii. Casting cycle

Premise:

Billet size	:	120 mmφ
Number of strands	:	6
Casting speed	:	2.4 m/min.
Heat size	:	75 t/heat

a. Casting time

75,000 kg ÷ (112.3 kg/m x 2.4 m/min. x 6 strs.) = 46.4 min./heat

Due to slower casting speed at the beginning and at the end, the casting time is designed to be 48 min.

b. Casting preparing time

Considering the time for discharging billets, setting dummy bars, mould packings and tundishes etc., the casting preparing time is designed to be 38 min.

c. Casting cycle time

Batch casting cycle time: 48 + 38 = 86 min.

d. Number of casting machines

Only one continuous casting machine will be needed, because the casting cycle (86 min./batch cast) is shorter than the tapping cycle (87.8 min./ch.).

Casting machine: 120 mmφ× 6 strs. x 1

Note: One continuous casting machine will be enough for the production plan in average. However, 2-heats continuous-continuous casting will be necessary, considering the fluctuation of the tapping cycle.

(4) Equipment Specification

i. Continuous casting machine and ancillary facilities

The major specifications of the continuous casting machine will be as follows.

Type	:	Curved mould
Number of strands	:	6
Intervals of each strand	:	1,300 mm
Billet size	:	120 mmφ
Billet weight	:	Max. 1,200 kg
Length of billet supporting	:	11 m
Casting speed	:	2.4 m/min.

The conception in designing the ancillary facilities such as slewing tower, tundishes, tundish cars and preheating devices, is basically the same as that shown in the Study Report.

ii. Billet discharging facilities

The sheared billets will be transferred to the cooling bed through the roller tables and be loaded onto the billet transfer car to transport them to the rolling mill.

(5) Equipment List

The main equipment of the continuous casting plant is shown in Table (A)7.

Table (A) 7 Equipment List

Equipment	Q'ty	Description	
1. Molten steel handling facilities	1 lot	Bubbling device:	1
		Immersion pyrometer:	1
		Ladle swing tower:	1
		Tundish with cover:	6
		Tundish car:	2
		Tundish preheater:	2
2. Continuous casting machine	1 lot	Mould:	12
		Mould oscillation mechanism:	6
		Secondary cooling equipment:	6
		Steam exhausting system:	1
		Withdrawal/straightening roller unit:	6
		Dummy bar:	6
3. Discharging facilities	1 lot	Hydraulic shear:	6
		Shear front table:	6
		Shear rear table:	6
		Run-out table:	6
		Dummy bar storage table:	6
		Intermediate stopper:	6
		End stopper:	6
		Cooling bed:	1
		Billet transfer car:	1
		Crop end collecting system:	1
4. Hydraulic system	1 lot		
5. Lubrication system	1 lot		
6. Interconnecting piping	1 lot		
7. Repair and assembly facilities	1 lot	Mould maintenance deck, roller apron aligning stand, etc.	

Table (A) 7 (cont'd)

Equipment	Q'ty	Description
8. Tundish preparation facilities	1 lot	Tundish cooling stand, tundish preparation stand, tundish drying device, etc.
9. Crane system	1 lot	For tundish handling: 10 t/10 t x 1 For billet handling: 10 t x 1
10. Auxiliary equipment	1 lot	Refractories, hydraulic oil, lubricant, etc.
11. Steel structure	1 lot	
12. Electrical equipment	1 lot	
13. Instrumentation	1 lot	

3. Rod and Wire Mill

(1) General

The rod and wire mill is intended to produce wire rod coils and straight bars from the billets supplied from the continuous casting machine, and consists of the following equipment:

Reheating furnace	1 set
Roughing mill train	1 set (6 stands)
Intermediate mill train	1 set (8 stands)
No.1 Finishing mill train	1 set (4 stands)
No.2 Finishing mill train (for bars)	1 set (2 stands)
Wire rod finishing block mill	1 set (8 stands)
Bar & rod cooling and finishing facilities	1 unit each

The rod and wire mill is so designed to meet the required production as shown in Table (A)8 so that the capital investment will be much efficiently rewarded.

Table (A) 8 Annual Production

Products	Size (mm)	Production (1,000 t/y)	(%)
Rod	5.5 ~ 6	60	17.2
	7 ~ 12	20	5.7
Bar	9 ~ 10	50	14.3
	11 ~ 12	40	11.4
	13 ~ 16	80	22.8
	17 ~ 32	100	28.6
Total		350	100

(2) Outline of the Mill Operations

i. Reheating furnance

The billets manufactured by continuous casting are received at the stock-yard in hot or cold state. According to the rolling schedule, they are carried in by a magnet crane and placed onto the charging conveyor located in front of the reheating furnace. The billets are charged into the reheating furnace of pusher type and then, heated up to about 1,250°C, before discharging by push rod bars through the furnace side.

ii. Rolling

The billets discharged from the reheating furnace are carried one by one to the roughing mill train and then rolled into rod and wire of predetermined sizes by the subsequent intermediate train and finishing train. Table (A)9 shows the pass schedule for each size of these products. The bars produced on this line include plain bars of diameters from 9mm to 32mm and deformed bars ranging from D10 to D32. For the purpose of improving the efficiency of rolling small diameter bars of 9mm to 12mm and D10 and D12, 2-strand rolling is performed starting with the intermediate finishing train. These rolled bars are then fed to the cooling bed of rake type having an overall length of 100m where they will be cooled off.

Rods, passing through the intermediate finishing train and No.1 finishing train, are rolled by the high-speed non-twist block mill having 8 stands and then cooled off on the controlled cooling conveyor and the hook conveyor.

iii. Finishing

After cooling, bars and rods are handled separately in their respective buildings as follows.

a. Bars discharged from the bar cooling bed is cut to the standard product length of 12m by No.1 cold shear. Fractional length at the last cut is treated by No.2 cold shear. Bars with the standard length are then counted automatically on the conveyor and a predetermined number of bars are bundled together.

b. Rod coils are hung from hook conveyor and cooled off. While being hung and cooled, they are inspected, bundled and weighed, and after being tagged for quality warranty, transferred to the coil stockyard by a crawler crane.

(3) Conditions for equipment plan

i. Billet

Type of steel: Low carbon mild steel

Billet sizes: (1) 120mm x 120mm x 4,650mm
(for 500 kg coil, and bars of 9mm ~ 12mm, and D10 ~ D12)

(2) 120mm x 120mm x 9,300mm
(for 1,000 kg coil, and bars other than above)

Weight: 515 kg and 1,030 kg

ii. Products

a. Wire rods

Size: 5.5, 6.0, 6.5, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0

Weight: 1.0 tonne and 500 kg coils

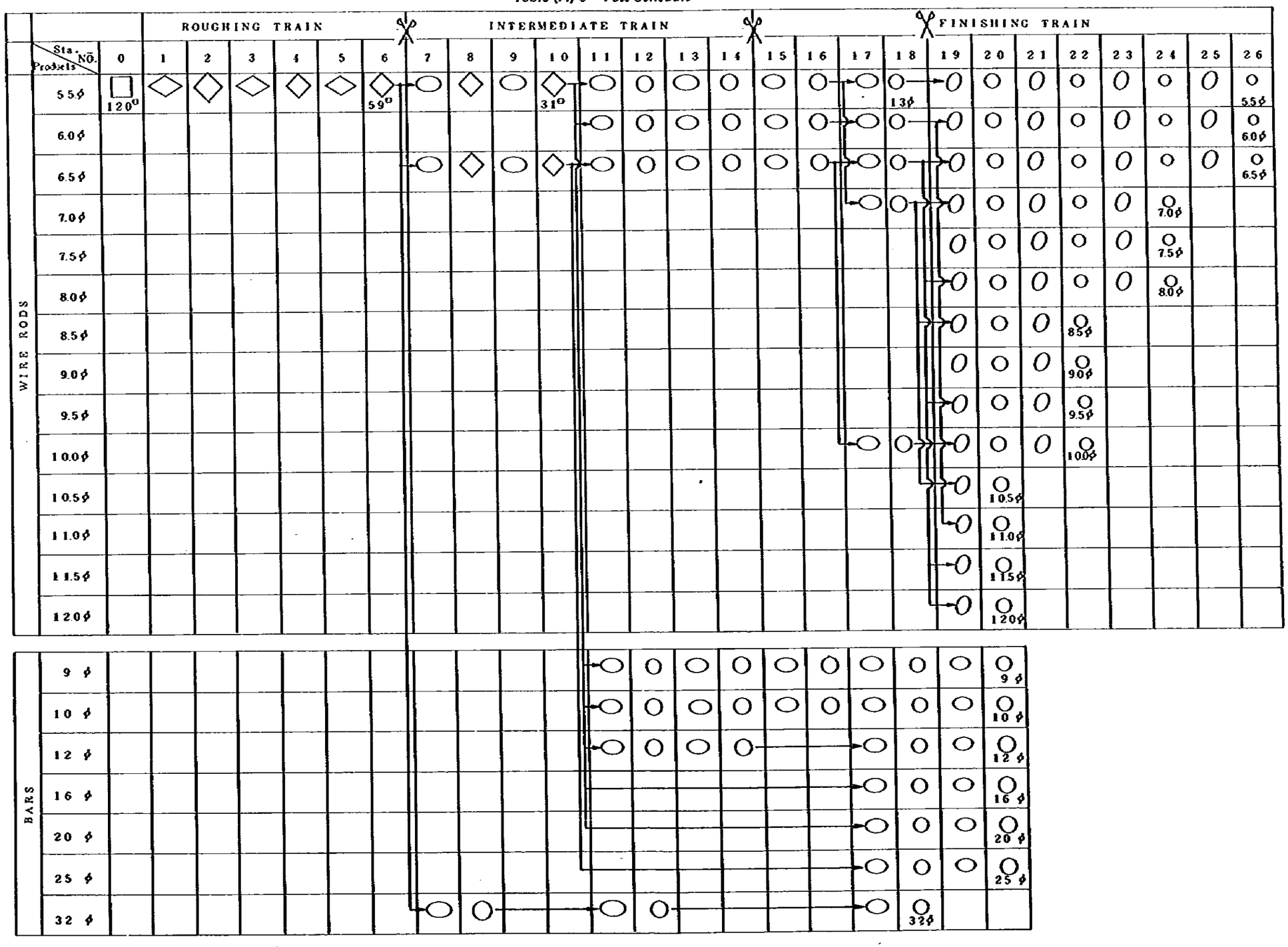
b. Bars (plain and deformed)

Size: (Deformed) D10, D12, D16, D19, D20, D22, D25, D28, D32

(Plain) 9, 10, 11, 12, 13, 16, 19, 22, 25, 28, 32

Length: Min. 6.0m, Max. 12.0m

Table (A) 9 Pass Schedule



iii. Production

Annual production is as shown in Table (A)8.

iv. Working conditions

Working conditions are as shown in Table (A) 10.

Table (A) 10 Working Conditions

(1)	Calendar time	(hr/y)	8,760 (365 d/y x 24 hr/d)
(2)	Annual maintenance time	(hr/y)	120 (5 d/y x 24 hr/d)
(3)	Weekly maintenance time	(hr/y)	816 (51 times/y x 16 hr/time)
(4)	Lunch time	(hr/y)	0
(5)	Non shift working time	(hr/y)	0
(6)	Total scheduled shutdown time (2) + (3) + (4) + (5)	(hr/y)	936
(7)	Time of operation (1) – (6)	(hr/y)	7,824
(8)	Operating ratio	(%)	75
(9)	Operating time (7) x (8)	(hr/y)	5,868
(10)	Number of shifts	(shift/d)	3

(4) Outline of Equipment Plan

i. Layout

The proposed plant is designed for a combination mill capable of producing both bars and rods, with latest equipment to expect high-quality and high-efficiency production. The bar line will be laid out straight from the section of rolling mills, and the rod line will be arranged parallel to the bar line. In order to permit future addition of another rod line, there will be the space provided accordingly. As the handling of bars differs from that of rods, they are designed to be handled in separate buildings. Roll shop, motor room, scale disposal equip-

ment, water treatment facility, etc. will be arranged on both sides of the main building.

ii. Reheating furnace

There will be no piling problem because of large billet size as 120mm square and it is being continuously cast, the reheating furnace is designed for pusher type.

By employing the through-side discharge method wherein billets are discharged through the side of reheating furnace by the push bar method, even when the tip of a bar is caught in a rolling mill, the rear end is still held inside the reheating furnace to prevent the loss of billet temperature. The reheating furnace will be natural gas fired. In order to minimize fuel consumption, it is so designed that hot billets can be cahrged in.

iii. Rolling mill

Roughing mill, intermediate mill and finishing mill will be arranged in tandem. All horizontal stands of the finishing mill will be of prestressed type. For rods, non-twist block mill will be used. With the use of these equipment, easy operation will be expected and dimensional accuracies will be improved. A flying crop shear will be installed between the mills in the rolling section to cut the top and bottom of material, including cobble cutting, so as to minimize erroneous rolling. Table (A)11 shows the type of rolling mills, the method of roll change, motor capacities, etc.

In order that speed between stands be controlled, the motors will be of independent driving type by D.C. and they will be designed on the basis of the maximum speed of 18 m/s for bars and the maximum speed of 75 m/s for rods.

iv. Bar cooling and finishing facilities

Rolled bars are cut by the disk type dividing shear to the predetermined length to expect high yield, and then transferred to the cooling bed. The cooling bed will have straightening grids arranged in a manner to permit bars to be cooled straight. At the centre of the cooling bed a device to make the end faces of bars aligned so that each bar taken out from the cooling bed will be cut from its end efficiently at high yield.

Bars cut to the sizes are transferred to the bundling conveyor. During transit on this conveyor, bars are automatically sorted into standard lengths and random lengths, the standard lengths being automatically counted by a weighing scale and bundled.

These equipment will minimize labour, but as random lengths will be small in quantity, they will be bundled by hand.

Table (A) 11 Description of Rolling Mills

	Stand number	Stand type	Method of roll change	Motor	
				kW x number	DC or AC
Roughing mill train	1	Closed top horizontal stand	Roll change	300 x 1	DC
	2			300 x 1	
	3			300 x 1	
	4			300 x 1	
	5			450 x 1	
	6			450 x 1	
Intermediate mill train	7	Closed top horizontal stand	Stand change	450 x 1	DC
	8			450 x 1	
	9			550 x 1	
	10			550 x 1	
	11			550 x 1	
	12			550 x 1	
	13			700 x 1	
	14			700 x 1	
No. 1 finishing mill train	15	Horizontal prestressed stand	Stand change	700 x 1	DC
	16			700 x 1	
	17			700 x 1	
	18			700 x 1	
No. 2 finishing mill train for bar	19	Horizontal prestressed stand	Stand change	700 x 1	DC
	20			700 x 1	
Wire rod finishing mill	19 to 26	8 stands non-twist block mill	Roll change	2000 x 2	DC

v. Coil controlled cooling and finishing facilities

Rolled rods are transferred across the water cooling zone to the laying head where the coil is overlapped in the spiral form and then cooled off while travelling on the coil cooling conveyor. This cooling process is adopted not only for an efficient coil treatment but also for obtaining required metallurgical and mechanical properties or for minimization of scale generation.

A horizontal method will be adopted for bundling the coils mainly because of the weight of a coil which is relatively light being a tonne at maximum. The coils are bundled while they are transferred by the hook conveyor. Generally a bundling machine frequently malfunctions due to minor troubles, but lest rolling operations should be stopped whenever minor trouble occurs, it is designed that hook conveyor is provided with about 30 minutes reserves.

(5) Specifications of Main Equipment

Specifications of main equipment are as shown in Table (A)12.

Table (A) 12 Specifications of Main Equipment

No.	Equipment	Q'ty	Main specification
1.	Reheating furnace	1 set	Capacity: 130 t/hr
	1) Combustion equipment		Type: pusher type
	2) Recuperator		Charge: hot & cold material
	3) Stack		Fuel: natural gas
	4) Refractories		
2.	Furnace charging & discharging equipment.	1 set	
	1) Chain conveyor		
	2) Billet charger		
	3) Push out machine		Hydraulic pusher type
			Pusher rod & pinch roll type

Table (A) 12 (cont'd)

No.	Equipment	Q'ty	Main specification
3.	Mills (roughing, intermediate train)	1 set	
3-1	Rough mills		2-Hi, closed top, 6-stands universal joint & antifriction bearing
	1) Toggle shear		
	2) No.1 ~No.6 roll stands		
	3) Drive equip. for stands		
3-2	Crop & cobble shear		Flying crank type
3-3	Intermediate mills		2-Hi, closed top, 8 stands, universal joint & antifriction bearing
	1) No.7 ~ No.14 roll stands		
	2) Driving equip. for stands		
3-4	Crank & cobble shear		Flying crank type
4.	No. 1 finishing mills	1 set	2-Hi, prestressed stand, 4 stands
	1) No.15 ~ No.18 roll stands		Universal joint & antifriction bearing
	2) Drive equip. for stands		
5.	No. 2 finishing mills, cooling bed, cold shear & finishing facilities	1 set	
5-1	No.2 finishing mills		2-Hi, prestressed-stand, 2 stands.
	1) No.19 ~ No.20 roll stands		Universal joint & antifriction bearing, disk shear type
	2) Driving equip. for stands		
	3) Dividing shears		
5-2	Cooling bed		Rake type
5-3	Cold shears		
	1) No.1 & No.2 cold shear		Cantilever down-cut shear
	2) Gauge stopper		
5-4	Finishing facilities		
	1) Bar transfer		Chain type with automatic counter
	2) Binding machine		
	3) Collecting bed		Chain type
6.	Wire rod block mill, cooling & finishing facilities	1 set	
6-1	Wire rod block mill with drive unit		Non-twist 8 stands, cantilever type

Table (A) 12 (cont'd)

No.	Equipment	Q'ty	Main specifications
6-2	Cooling equipment		
	1) Water cooling equipment		Cooling control system, horizontal overlapping spiral configuration
	2) Laying head		
	3) Air cooling equipment		
	4) Coil reforming tube		
6-3	Finishing facilities		
	1) Up-ender		
	2) Hook conveyor		Power & free type
	3) Binding machine		Hydraulic compactor
	4) Weighing scale		
	5) Coil capstan		
7.	Lubrication & hydraulic system	1 set	
	1) Oil circulation system		
	2) Central grease system		
	3) Hydraulic system		
8.	Utilities	1 set	
	1) Water piping		
	2) Compressed air piping		
	3) Natural gas piping		
	4) Steam piping		
9.	Roll shop	1 set	
	1) NC – roll lathes		2 sets
	2) WC – rod grinder		
	3) Bearing cleaning equipment		
	4) Shapper, boring machine		
	5) Electro-discharge machining of knobs		
10.	Miscellaenous equip.	1 set	
	1) Scrap removal equipment		
	2) Special tools		
	3) Water treatment		
	4) Others		
11.	Cranes and hoists	1 set	

Table (A) 12 (cont'd)

No.	Equipment	Q'ty	Main specification
12.	Electrical equipment	1 set	
	1) Power distribution		Including power factor compensation
	2) DC main drive motors and control		Individual thyrister control system
	3) Auxiliary motors & control		
	4) Control desks and posts		
	5) Detector		H.M.D. & H.M.P.D.
	6) Computor system		Operational guidance & data logging
	7) Lighting & small power system		
	8) Intercommunication system		Including I.T.V. system
13.	Spares	1 set	2 years
14.	Civil & building	1 set	

(6) Layout of Equipment

The general layout of equipment is shown in Fig. (A)4.

(7) Mill Capacity

Mill capacity is shown in Table (A)13.

Table (A) 13 Mill Capacity

Item	Unit	Rolling line
Time of operation	h/y	7,824
Rate of operation	%	75
Average t/h	product t/h	67.8
Line capacity *1	t/y	397,850
Required production	t/y	350,000

Note: *1 Line capacity calculation
67.8 x 7,824 hr x 0.75 = 397,850 t/y

(8) Operational Requirements

i. Utilities

Utility unit and annual consumptions are shown in Table (A)14.

Table (A) 14 Utility Consumption

Item	Unit	Unit consumption	Annual consumption
Fuel	Kcal/t	430×10^3	150.5×10^9
Electric power	kWh/t	135	47.25×10^6
Industrial water	m^3/t	5	1.75×10^6
Treated water	m^3/t	30	10.5×10^6
Compressed air	Nm^3/t	60	21×10^6
Steam	kg/t	15	5.25×10^6

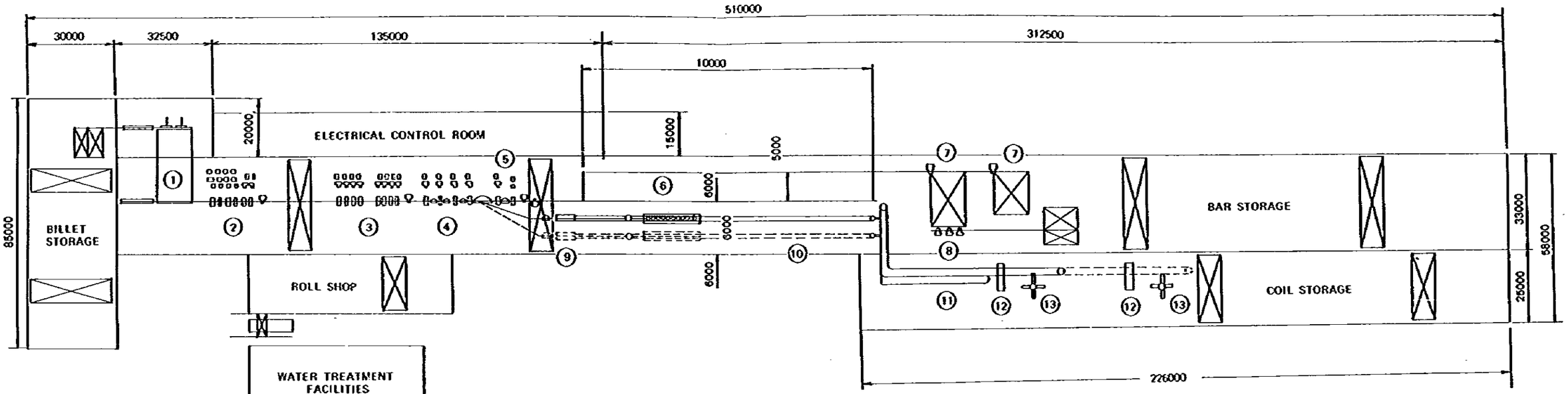
Note: Production 350,000 t/y

ii. Amount of by-products

Amount of by-products are shown in Table (A)15.

Table (A) 15 Amount of By-products

Equipment	By-products	Tonnes/y
Rod line	Scrap	20,680
Bar line	Scale	5,640



1 REHEATING FURNACE (130 T/H)
2 ROUGHING TRAIN
3 INTERMEDIATE TRAIN
4 NO.1 FINISHING TRAIN
5 NO.2 FINISHING TRAIN
6 COOLING BED
7 COLD SHEAR
8 TYING MACHINE
9 NO TWIST BLOCK
10 ROD COOLING ZONE
11 HOOK CONVEYORS
12 COMPACTOR AND BINDING
13 UNLOADER

Fig. (A) 4 Bar/Rod Mill General Layout

II. Estimated Cost of DRI Produced in the 400,000 t/y DR Plant

This paper on estimated cost of DRI in the 400,000 t/y DR plant has been prepared at the request of Mr. Chira Panupong, deputy secretary of the Office of the Board of Investment of the Royal Thai Government.

(1) Assumptions for cost calculation

a. This DR plant is to be installed within the complex of the proposed integrated flat steel plant.

b. Unit consumption required for the operations and the unit price are as same as those of DR plant in the Study Report.

c. Personnel requirement for this plant is also the same as the DR plant in the Study Report. However, labour cost per tonne of product is higher than that of in the Study Report due to smaller production capacity of this plant.

d. The passivation for DRI is required for this plant as the product is to be sold to outside customers. For this reason, variable cost and maintenance cost increase.

e. The direct construction cost for the proposed 400,000 t/y DR plant including the equipment for passivation is $7 million dollars.

(2) Cost of DRI

Breakdown of the production cost is shown in the Table (A)16. As is shown, the cost of DRI per tonne is about $104.26 resulting that the cost is $7.068 higher than that in the Study Report which is $97.192 per tonne.

Table (A) 16 Production Cost of DRI

Items	Q'ty unit	Unit price	Q'ty	Cost ($/t)
Variable cost:				
Pellet	tonne	39.52	1.156	45.69
Lump ore	tonne	24.21	0.301	7.30
Natural gas	Nm^3	0.062	340.13	21.04
Electric power	kWh	0.036	142.03	5.07
Nitrogen	Nm^3	0.078	6.4	0.02
Water	m^3	0.035	32.78	1.13
Chemicals				0.41
Transportation				0.17
Raw material preparation				4.94
Passivation				3.50
Others				3.50
By-products				−1.48
Fixed cost:				
Employee				0.15
Maintenance				2.08
Depreciation				10.68
Others				0.06
Total				104.26

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