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THE ISLAMIC REPUBLIC OF PAKISTAN

REPORT ON PAKISTAN RAILWAYS LOCOMOTIVES MANUFACTURING FACTORY PROJECT (PRELIMINARY DESIGN)

May, 1983

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

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PRELIMINARY DESIGN REPORT

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1. DETERMINATION OF THE REQUIRED CONDITIONS FOR A PRELIMINARY DESIGN

1-1 Geological and Meteorological Data for Intended Factory Site

Data concerning geological and meteorological conditions for the Bara Bandah district as given in the following table will be used as the fundamental conditions in designing.

Table 1-1 Geological and Meteorological Data for Site

Air temperature	Daily mean temperature in summer	maximum minimum	41°C 26°C
	Daily mean temperature in winter	maximum minimum	15°C 3°C
Relative humidity	Daily mean relative humidity in summer	minimum maximum	20 % 50 %
	Daily mean relative humidity in winter	minimum maximum	50 % 80 %
Precipitation	Mean monthly total in rainy season Mean monthly total in other season Heaviest fall in 24 hrs. recorded in 1958		200 mm 110 mm 100 mm
Wind speed	Average wind speed through the year Maximum wind speed		6 m/sec. 12 m/sec.
Seismic remark	The site is continuously being affected by Northern Pakistan Seismic Zones. And, it is advisable to adopt the factor on g/15		
Bearing capacity	The ultimate bearing capacity of the site at 1.2 m depth is 4.56 ton/sq.ft. = 50 ton/m^2		
Soil analysis	Location of test site	About 2 miles west of Nowshera-Mardan Road Railway Crossing	
	Depth drilled	113 m by reverse rotary	
	General report of the soil	The soil consist of silty clay with traces sand and gravels. This remaining throughout 1.2 m depth. The pocket penetrometer has shown unconfined compression strength between 3 to 4 tons/sq.ft.	

Water analysis (factors affecting for potability)	Colour	Normal
	Turbidity	Nil
	Odour	Nil
	Taste	Sweat
	Total dissolved solid (T.D.S)	209.1
	Manganese	Nil
	Iron	Nil
	Copper	Nil
	Zinc	Nil
	Calcium	7.0
	Magnesium	3.3
	Sulphates	51.4
	Chlorides	73.4
	Nitrates	Trace
	Fluoride	Nil
	Phenolic substance	Nil
	pH value	8.2

1-2 Locomotive Manufacturing and Production Schedule

The manufacturing flow of diesel electric locomotives is shown on the Fig. 1. The manufacturing schedule can be roughly arranged into two classifications as given below:

a) Manufacturing, assembling and furnishing of the body and underframe.

b) Manufacturing of the bogie frame, and fabrication of the bogie.

After assembling the wheel sets and traction motors on the bogie frame, traction motors are subjected to no load running tests. The body, after mounting on the bogies, is subjected to an overall inspection and tests. After these schedule, test running of locomotive is carried out and final inspection and adjustment is over, locomotive manufacturing schedule is completed.

The number of days required for each manufacturing process (staying days on each process) during the manufacturing of body and bogie is shown on Fig. 2. According to this figure, the number of net working days required for one locomotive from the beginning of the manufacturing to the final inspection of completed locomotive is 190, and if holidays are taken into account, it will be about 7.5 months. So 17

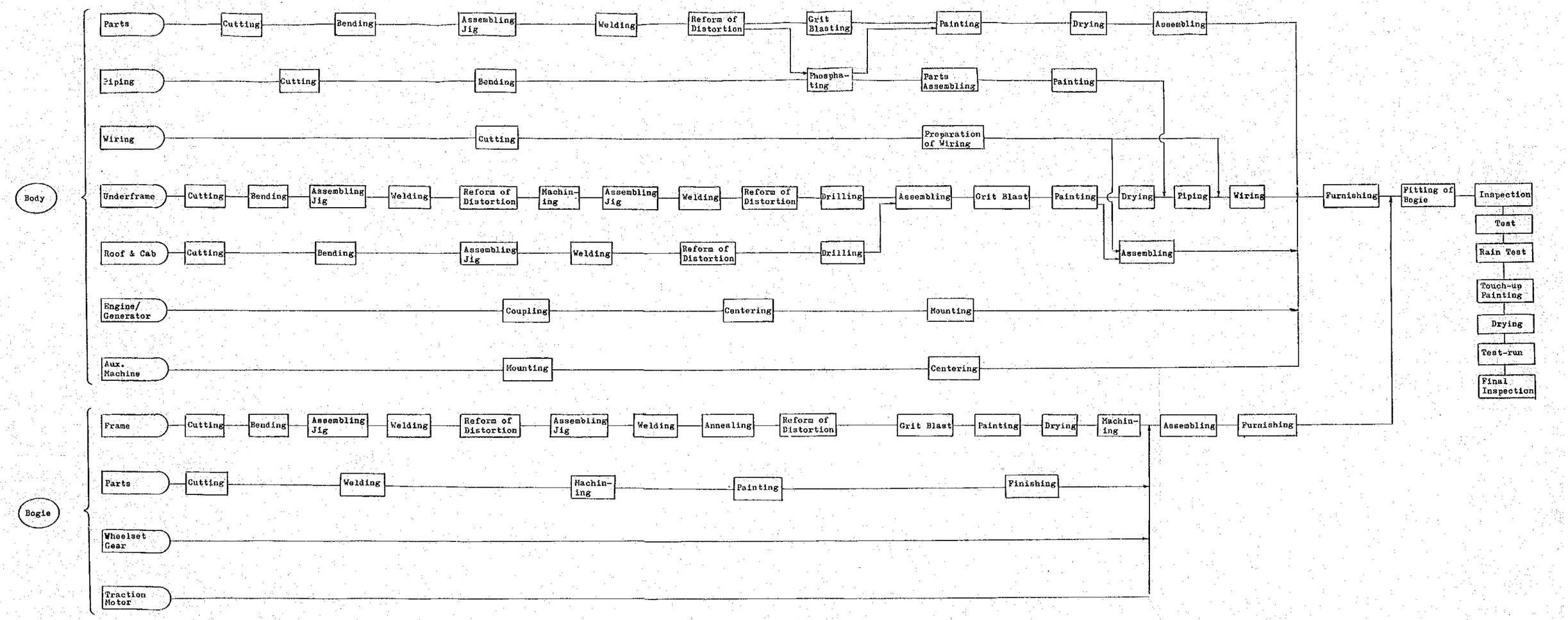
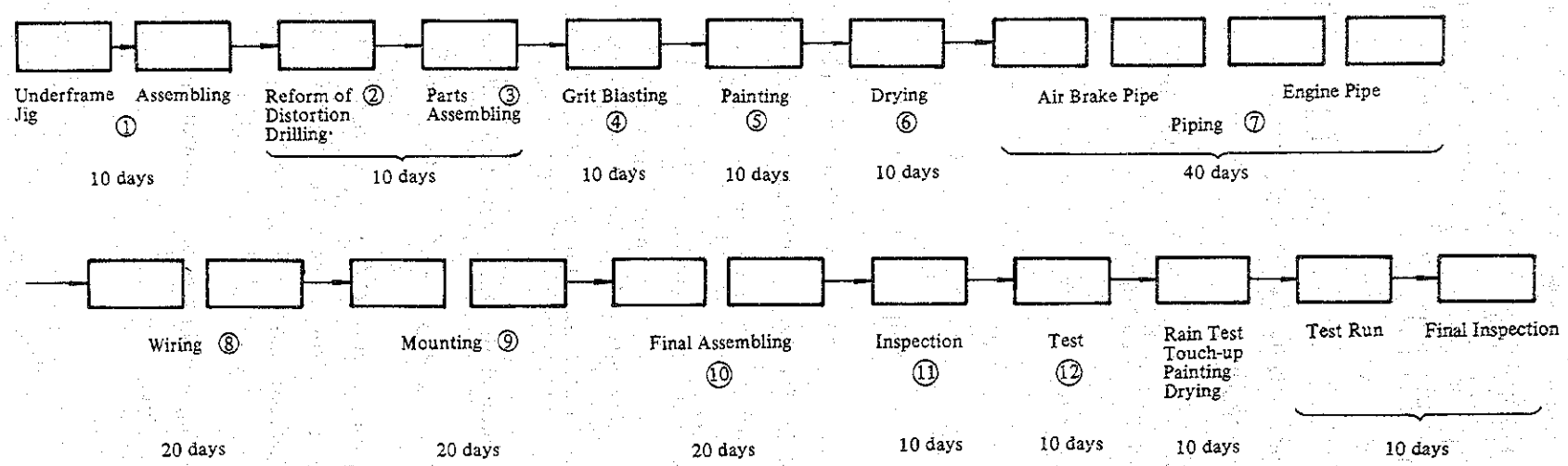


Fig. 1 Manufacturing Flow

1. Body and Underframe



2. Bogie Frame

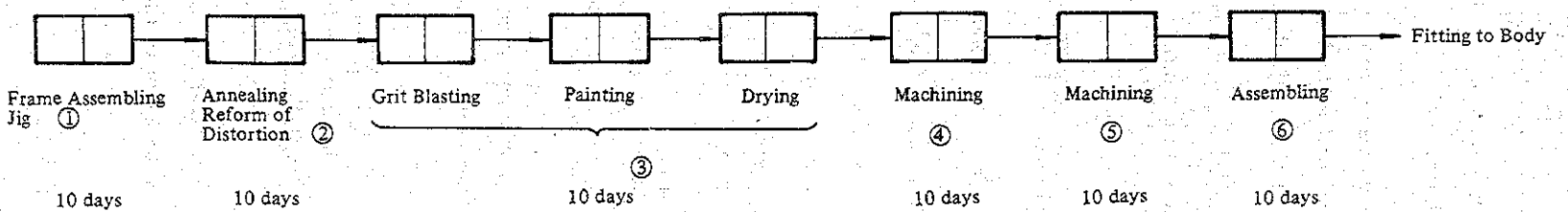


Fig. 2 Production Schedule

different stages of manufacturing of locomotives will be progressing simultaneously in this manufacturing schedule from fabrication of underframe and jig work to final inspection. In addition, work from ① to ⑫ in Fig. 2 will be carried out in the main workshop building, so that 19 locations will be needed to be occupied by body or its underframe.

The bogie is manufactured through 6 work stages, requiring a net work period of 60 days or about 3 months including holidays. In the main workshop building, 6 locations are required for manufacturing bogies.

Planning of the main workshop building will be made based upon the work procedures and the required number of locations for body and bogie frame.

1-3 General Layout Plan of the Factory

The general layout plan is shown on Fig 0-1.

1-3-1 Layout plan of the buildings

(1) The main workshop building, auxiliary workshop building and other facilities related to the work and facilities for the administration and welfare of the workers are positioned near each other in consideration of good working conditions and workers' convenience.

(2) Administrative office will be located adjacent to the center of main workshop building, most suitable location to keep communication with shops and office.

(3) A circular road is construted around the main workshop building to attain smoothness of operation.

(4) Entrance and exit gate to be used exclusively by the workers of the factory is located on the east side of the factory, where the Security Office, Time Office and Labour Bureau are arranged.

(5) The west side of the site is being held in reserve to provide space for future expansions of the workshop buildings.

1-3-2 Track arrangement plan

(1) Incoming track to the factory will be branched off from the main line, which will run parallel to the main line for about 100 m. This location will be used arrival and departure line of the commuter train for workmen, although platform will not be constructed.

(2) Special track for shunting locomotive has been adopted for shunting operation of wagons.

(3) Taking the future plan into consideration, the track layout to the steel materials storage yard is arranged in such a manner to permit the laying of track in the area allocated on the west side for future expansion of the main workshop building and in the western area outside the factory premises.

1-4 Determination of the Shop Layout Plan and Measurements/Details of Workshop Buildings

1-4-1 Shop layout plan

The arrangement of the each shop within the main workshop building and detail of the related facility around this building are shown on Fig. 0-2.

The arrangement of the each shop within the main workshop building have been planned to conform to the manufacturing procedures shown on Fig. 1 and Fig. 2.

In the main workshop building the heavy item warehouse and the warehouse of machinery, equipment for body, piping, wires and thin plate will be located. In addition, the plan also includes the location of the working area for the maintenance of machinery and the tool shop in the workshop.

1-4-2 Determination of measurements/details of the workshop buildings

In determining the design condition of the buildings, the following condition and dimension are planned for the manufacturing of locomotives.

(1) Main workshop building

A plan of the main workshop building is shown on the Fig. 0-3. The building consists of 3 houses with the entire length of 324 m (9 m span), and the width of the various houses being 30 m for the underframe and body house, and 22 m for the other 2 houses.

The height of runway of the overhead travelling crane from the floor surface is to be 8.5 m for all 3 houses in consideration of changes in the work procedure which may be made in the future and in order to standardize the design of the building. However, in the part of the final body assembling shop with a length of 126 m, as shown on the drawing, the body lifted by the overhead travelling crane must pass over the other bodies, so the height of the runway from the floor surface is planned to be 13.5 m. Moreover, in this final body assembling shop, overhead travelling cranes operating on runway at 2 different heights will be used.

The bogie manufacturing shop and the machining workshop will be provided with wall cranes (1 ton capacity) for handling light objects.

(2) Final adjustment and inspection shed for the locomotive

The plan for this inspection shed is shown on the Fig. 0-4.

The entire length of the building is 30 m, with the width of 8m. An inspection pit with side pit of 25 m length will be constructed within the building. A service deck will be provided along this pit in consideration of testing, adjustment and inspection.

The height of the ceiling in this building is planned to be 6 m considering the installation of the electric contact wire which will be required when electric locomotives production will be started in the future. Details of the inspection pit is shown on the Fig. 1-3.

(3) Shunting locomotive shed

The plan of this shed is shown on the Fig. 0-5. Entire length of the building will be 20 m with the width of 8 m. An inspection pit with side pit of 15 m length will be constructed within the building, and a service deck will be provided along this pit in consideration of testing, adjustment and inspection. Details of it is shown on the Fig. 1-3.

(4) Phosphating treatment shop building

The plan for this shop building is shown on the Fig. 0-6.
The building will be 27 m in length and 9 m in width. The height of the ceiling of this building will be 5 m as a Goliath Crane, travelling throughout the length of the building, will be installed in this building.

2. PLANNING

2-1 Civil Engineering

2-1-1 Earth work outside the yard

A roadbed branched from the main track extending to the yard will be constructed by cutting.

2-1-2 Grading within the yard

A roadbed will be constructed by cutting and filling.
This grading plan is shown in Fig. 1-1.

2-2 Tracks

2-2-1 Tracks

The incoming track branches off near the 12.k300m point on the main railway line, travels in parallel with the main line for about 100 m, and reaches the yard by 180 m length left curved track with a radius of 300 m.

A safety siding interlocked with the turnout of the main track will be provided to ensure safe operation for outgoing locomotives.
Ballast and concrete sleeper will be used for track fundamentally whether within or outside the yard.
The total length of these tracks will be about 2,170m.
For the interior of the buildings, short sleeper will be fixed into by concrete roadbeds, while the inside and outside of the rails will be paved with concrete strengthed with angle steel to a height level of the rail top.
The total length of these tracks will be 770m.

The layout of the track is shown in Fig. 2-1.

Rail used	37 kg/m	
Turnout	1 in 12	1 set (branch from main track)
	1 in 8 1/2	9 sets (others)
Safety siding (sanded)	1 line	
Stopper (of rail)	2 units	
Railway crossing	11 crossings	

2-2-2 Branching system for the factory siding

To branch off the incoming track to the factory, a manual operation and dual switching type turnout will be installed on the railway main line.

A switch man hut will be located at the branch point and switch men will be assigned to operate the turnouts. The switch man will also issue and receive the line clear token tickets, to block the railway section, after communication with train operation dispatchers of the both neighbouring RISALPUR and RASHKAI stations by the train operation telephone system. The switch man should show a train operation sign to an engine driver, and should be responsible for the operations of all trains passing through this junction.

(1) Turnout switching equipment

The turnout switching lever will be provided with a safety locking device, and the switching equipment will be manually operated and be dual switching type to enable simultaneous switching at both turnout points on the main line and on the siding. The turnout points will be provided with switch indicator to show a direction of the route setting for the train driver.

(2) Signs

The following two kinds of signs will be installed to indicate stop points at the junction for train driver, and to waren train driver approaching to stop point on the main line. These signs will be of reflective type to enable visual identification in the night.

(a) Car stop signs

Three car stop signs will be installed at the stop points for a train operated on the main line to the RISALPUR or the RASHKAI, or on the siding into the main line.

(b) Approach warning signs

Approach warning signs will be installed before the car stop signs which are only provided on the main line, and installed at three points before each car stop sign with interval of minimum 100 metres.

2-3 Buildings

An outline of the main buildings is as follows:

2-3-1 Main workshop building

(1) Plan and section

(a) For the floor plan, the various processes in the manufacture of locomotives were taken as the basis to determine column spacing, beam spacing for the building and the locations for working space, storage space and pathways.

(b) For the sectional measurements, the various conditions for the operation of the overhead travelling crane as given in Fig. 3-3-3 formed the basis for determining the spacing between the floor surface to the upper edge of the crane rail and that between the floor surface and the bottom edge of the beams.

(2) Construction plan

(a) As the building for a factory necessitates long beam spacing, the principal construction will be of steel frame.

(b) Assuming external forces such as wind pressure, seismic disturbances, load of the crane, an estimation was made of the measurements of the structural member through rough calculations and it was decided to use large H shaped steel for columns and steel framed truss construction for beams and levers.

(c) The design for the foundation was determined from data obtained through investigations on the bearing force of ground, load tests, sampling, etc.

(d) Expansion joints will be installed at strategic points to compensate for heat expansion of the steel material in the longitudinal direction of the building.

(3) Finishing plan

(a) As it would be preferable to use highly heat insulating material for the outer wall, brick walls, for which local procurement is comparatively easy, will be adopted.

(b) As the building is constructed with considerable spacing between beams, a material combining light weight with high heat insulating qualities was considered for the roof, and corrugated slate tile with an underlining plate of cemented excelsior board will be used. A highly pressure resistant material and one which will be suitable for each works will be used for the floor. Rainwater and drainage will be received by the eaves gutter, and will be discharged to the outside of the building through a vertical gutter.

(4) Lighting plan

Side window lighting and uniform natural lighting from the north side monitor roof at the upper part of the roof will be adopted. The west side windows will also be provided with shading facilities as protection against the extremely severe westering sunlight.

(5) Ventilation plan

Natural ventilation will be effected through the grille installed on the monitor roof.

2-3-2 Final adjustment and inspection shed

(1) This Shed will be constructed of reinforced concrete with brick walls which possesses high sound insulating properties to shut-off the noise generated by the testing the completed locomotives. The surface of the ceiling will also be lined with sound absorbing material to reduce the echo effect of the noise.

(2) The measurements for the entrance and exit will be such as to be able to accommodate electric locomotives in the future.

(3) The inspection pit and service deck are shown in Fig. 3-8.

2-3-3 Inflammable material store

(1) To prevent unexpected accidents from explosions, this building will be constructed in a corner of the yard, the walls being made of brick and the roof made of steel-frame with slate tiles to provide against explosions.

2-3-4 Administrative building

(1) Plan and section

(a) The plan will be of the centre corridor type with large and small rooms located according to the jobs in which they are to be engaged, and the area for the main room is calculated as shown in Table 2-1.

(b) The heights of the storey and ceiling will be such as to provide the necessary duct space below the beams for air conditioning. That is, the floor height will be 3.8m as against the ceiling height of 2.8m. Moreover, the ground floor level will be that of the yard passage-say level + 500mm.

(2) Construction plan

Construction will be of reinforced concrete 3rd storey and, with 6 m for girder direction and 7.5m for in-between beam direction.

(3) Finishing plan

(a) The windows exposed to direct sunlight will be provided with the louvres.

(b) A water-proof coating will be applied to the roofing slabs, while a ventilating layer specially effective for heat insulation will be provided.

(c) The ceiling and inside of the rooms will be lined with sound absorbing board, while the standard finish for the wall surface will be paint finished over an under-coat of mortar. Special rooms will be lined with decorative plywood. The standard finish for the floors will be a Terazo-block, but for special rooms, the floors will be formed of tiles, or covered with carpets. The partition walls will be constructed of concrete blocks.

(4) Illumination plan

The standard intensity of illumination for the interior of the rooms will be around 300 Lux.

2-3-5 Foreman's office

(1) This will be a 2-storied reinforced concrete construction building with a storey height of 3.5m and ceiling height of 2.8m, the ground floor level being GL + 500mm.

(2) The outer walls will be formed of brick, the ceiling will be lined with sound absorbing board, the walls will be finished with paint over an undercoating of mortar and the floors will be covered with Terazo-blocks and others.

(3) The windows on the western side will be provided with precast concrete louvres.

2-3-6 Time office, etc.

(1) The Time Office consists of the room for administration of duty of workers, labour bureau, guard room, and clinic.

(2) Construction will be of reinforced concrete including a 2-storied section, while the partitions will be formed of concrete blocks.
Storey height will be 3.5m, ceiling height 2.8m and the ground floor level will be GL + 500mm.

(3) The ceiling will be lined with sound absorbing board, the inside walls will have an under-coating of mortar and finished with paint, the floors will be covered with Terazo-blocks and the exterior will have tiled floors.

2-3-7 Substation building

(1) Constructions will be of reinforced concrete, with brick walls, and the constructional material used will be of a type to shut-off the outside temperature.

(2) Storey height will be 4.2m, while the ground floor level will be GL + 500mm.

2-3-8 Vehicle shed

(1) The vehicle shed will house the following. Firefighting cars, Trucks, Water supply cars, Staff cars, Ambulance, Mini bus and Forklifts for factory use. In addition to the vehicle shed, driver's room, toilet and storage will also be constructed together.

(2) Construction will be of reinforced concrete 3.5m between under beam to floor level, 7.0m between columns.

(3) Structure will be finished by concrete, inside wall will have an under-coating of mortar and finished with paint, and the floor with control joint finish.

2-3-9 Canteen and rest shelter

(1) This has been designed to accommodate about 50% of the workers of the factory. Exterior terrace part can be used for taking meals, and as a resting place and coffee counter in canteen is also prepared.

(2) Construction will be of reinforced concrete. Story height will be 4.0m, ceiling height 3.5m and ground floor level will be that of ground level + 500m.

2-3-10 Toilet

(1) The number of worker to make use of the toilets beside the main work shop is estimated to be 500 persons. Each toilet for 100 persons to be constructed at 5 locations within the yard, is provided with 7 stools and 5 urinals. These stools and urinals will be arranged to conform to custom in Pakistan.

(2) The toilet above mentioned will be constructed of reinforced concrete, the ceiling and walls will have an under-coating of mortar and finished with plaster, while the floor will be finished with mortar.

2-3-11 Boundary wall, lookout

(1) The walls will be constructed of brick, with reinforced concrete beam supports and lined with steel netting.

(2) A lookout cabin will be constructed of reinforced concrete at the boundary corner. Floor level will be GL + 2.2m.

Table 2-1 Number of Staff Accommodated in the Administrative Office

Dept.	Section \ Nos. of Persons / M^2/Person	Staff and Establishment						Total number	Total proposal area (M^2)
		G. manager	Principal officers		Others without individual room				
		S	A	B	C	D	E		
		55.7	26.9	20.4	7.4	5.1	4.6		
Administrative department	1. General manager	1						1	55.7
	2. Administrative dept.		1					1	26.9
	・Administration sec.		1					1	26.9
	General affairs			1	2	4	13	20	115.4
	・Finance sec.		1					1	26.9
	Account			1	3	7	9	20	119.7
	Finance			1	2	4	3	10	69.4
	・Purchase/storage sec.		1					1	26.9
	Storehouse			1	2	2		5	45.4
	Purchase			1	2	5	2	10	69.9
	3. Designing dept.		1					1	26.9
	・Design control sec.			1				1	20.4
	Control bureau				1	2	2	5	26.8
	Drawing & B/M				1	2	3	6	31.4
	Planning			1	1	1	2	5	42.1
	・Mechanical sec.		1					1	26.9
	Piping furnishing				1	2	2	5	26.8
	Bogie			1	1	2	2	6	47.2
	Body			1	1	2	2	6	47.2
	・Electric sec.		1					1	26.9
	Control equip.			1	1	2	2	6	47.2
	Rotating machine				1	2	2	5	26.8
	Sub-Total	1	7	10	19	37	44	118	979.7
Manufacturing department	1. Manufacturing dept.	1						1	55.7
	Control Bureau			1	1	3	5	10	66.1
	・Furnishing sec.		1					1	26.0
	Production control			1	4	4	3	12	84.2
	・Plate working sec.		1					1	26.9
	Production control			1	4	4	4	13	88.8
	・Production engineering sec.		1					1	26.6
	Scheduling			1	3	3	3	10	71.7
	Production eng.			1	6	6	3	16	109.2
	2. Test/inspection,sec.		1					1	26.9
	Control bureau				2	2	2	6	34.2
	Inspection			1	4	6	8	19	78.0
	Test			1	4	6	8	19	78.0
						2 m^2/man			
	Sub-Total	1	4	7	28	34	36	110	773.2
Total		2	11	17	47	71	80	228	1752.9

2-3-12 Air conditioning equipment

(1) Buildings to be air-conditioned and ventilated

(a) Administrative office

Area to be air-conditioned	1,853 m²
Area to be ventilated	176 m²

(b) Substation building

Area to be air-conditioned	71 m²
Area to be ventilated	5 m²

(2) Air conditioning and ventilation systems

(a) Administrative office

i) Air conditioning

This building is long from side to side, and considering condition of sunshine to the building, space for air conditioning on each floor is devided into two parts and consequently the building has 6 air conditioning zones. Package type air conditioner with air source heat pump is sdopted for the heat source equipment by reason of easiness of operation. Air conditioners are installed in the air conditioning machine rooms on both side of each floor and single duct system is sdopted in the air conditioning systems.

ii) Ventilation

Ventilation systems for toilet, kitchen and printing room have been established to conform to be application of the rooms. For the toilet system, in order to discharge the odorous air to the outside, the toilets on all floors are connected through 2 series of duct to collet the air, which is then collectively discharged outside of the building by means of exhaust fans installed in the ventilation machine room on the first floor and in the air conditioning machine room on the second floor.

For the kitchen system, in order to supply fresh air for cooking furnace and to discharge combustion gas outside through ducts, an air supply fan and exhaust fan will be installed in the ventilation machine room on the first floor.

For the printing room system, odorous air caused by printing chemicals is discharged by the exhaust fan on the wall.

iii) Electric power

Electric power will be supplied to the air conditioners and exhaust fans via power control panels installed in the air conditioning machine room and ventilation machine room.

Electrical control system will be adopted to control temperature and humidity of air conditioned room. Temperature and humidity of circulated room air is controlled automatically in the air conditioner according to the signals from the thermostat and humidistat located in the typical room of each air conditioning zoze.

Condition of the operation and fault of the air conditioner and exhaust fan will be watched by the central monitoring control panel installed in the control room on the second floor.

Fig. 3 shows the control system of the air conditioning.

(b) Substation building

i) Air conditioning

Package type air conditioner with air source heat pump will be installed in the office room and control room to do air conditioning of these rooms individually.

ii) Ventilation

Odorous air of the toilet will be discharged outside by the exhaust fan on the wall.

iii) Electric power

Electric power will be supplied to the air conditioners and exhaust fans via power control panel installed in the office room and control room. Temperature and humidity of the room air is controlled automatically in the air conditioner according to the signals from the thermostat and humidistat installed in the air conditioner.

(3) Design conditions

(a) Air conditioning

i) Condition of the outdoor air

Summer	42.5°C DB	20 % RH
Winter	2.1°C DB	90 % RH

ii) Condition of room air

Summer	26°C DB	50 % RH
Winter	22°C DB	50 % RH

iii) Number of persons in the room

Administrative office	260 persons
Substation building	7 persons

iv) Volumn of fresh intake air 30 m^3 /h/person

v) Lighting 20 W/m^2

vi) Draught

Room air changes per hour 0.5/h

(b) Ventilation

Room air changes per hour		0.5/h
Toilet	(air exhaust)	10/h
Kitchen	(air supply)	30/h
	(air exhaust)	20/h
Printing room	(air exhaust)	7/h

(4) Capacity of equipment

Capacity of equipment have been calculated based on the design condition mention mentioned before in (3), and in sclection of the equipment, unification of the capacity is taken into consideration so that the action for the failure and the maintenance work can be made easily. Further, another machine is installed for back up.

Capacity of equipment is shown in Table 2-2, 2-3.

Table 2-2 Capacity of Airconditioning Equipment

	Administrative office	Substation building	
Airconditioning system	H.P Airconditioners for NO. 1 – NO. 6 zones	H.P.A.C. for office	H.P.A.C. for control room
Cooling (kcal/h)	50,000	6,300	
Heating (kcal/h)	47,000	7,400	

Table 2-3 Capacity of Ventilating Equipment

	Administrative office					Substation building
Ventilating system	Supply fan for kitchen	NO. 1 exhaust fan for toilet	NO. 2 exhaust fan for toilet	Exhaust fan for kitchen	Ventilator for printing room	Ventilator for toilet
Air flow (m^3/h)	1,700	1,500	2,100	2,500	400	150
Ventilator type	Single suction multiblade fan outer dia. : 225 mm		Single suction multiblade fan outer dia. : 300 mm		Through-the-wall ventilator 20 cm	Through-the-wall ventilator 15 cm

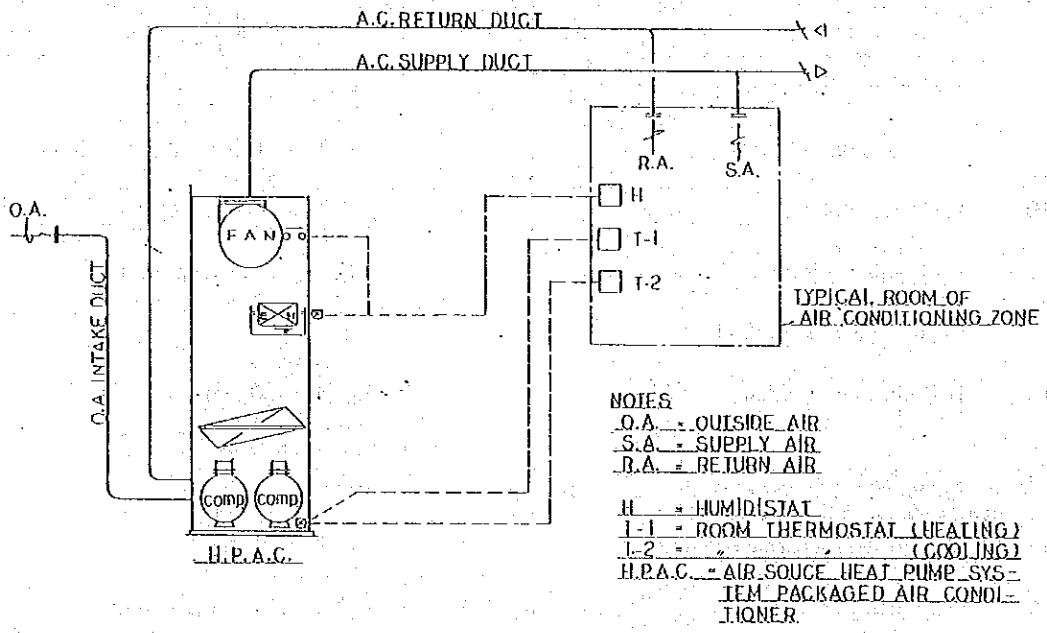


Fig. 3 H.P.A.C. Control Diagram

2-4 Machinery

The layout of the machines listed in Table 2-4, and 2-5, as based on the layout plan for the each work process to be performed within the main workshop building as shown Fig. 0-2, are given in Fig. 4-1-1, Fig. 4-1-2 and Fig. 4-1-3. The yard crane plan for the steel materials stock yard is shown in Fig. 4-2.

2-4-1 Production machinery

The names of the machines, the number required and main data for all machinery directly necessary for the manufacturing of locomotives are given in Table 2-4.

Table 2-4 Machine List of Production Machinery

(1) Machinery for plate work

NO.	NAME	QTY.	MAJOR PERFORMANCE
P1	Shearing machine	1	4.5 t, 3,050 mm
P2	Shearing machine	1	9 t, 3,050 mm
P3	Nibbling machine	1	3.2 t
P4	Mechanical press	1	55 Ton, stroke 150 mm
P5	Mechanical press	1	100 Ton, stroke 170 mm
P6	Hydraulic press	1	20 Ton
P7	Hydraulic press	1	50 Ton, stroke 550 mm
P8	Hydraulic pancher	1	ϕ30
P9	Hydraulic press brake	1	150 Ton, Table length 3,000 mm
P10	Hydraulic press	1	500 Ton, stroke 1,000 mm
P11	Hydraulic press brake	1	80 Ton, Table length 2,400 mm
P12	Corner shearing machine	1	3.2 t
P13	Grit blasting machine	1	2,000 x 320 mm (W) (H)
P14	Band saw	1	400 mm
P15	Shaped steel shearing machine	1	9 t, 90 x 90 mm
P16	Gas cutting machine	1	100 t, 1,500 x 6,000 mm
P17	Gas cutting machine	1	32 t, 1,500 x 6,000 mm
P18	Turn blast machine	1	ϕ1,000 x 800 mm
P19	Lathe	1	1,800 mm
P20	Milling machine	2	NO. 3
P21	Vertical milling machine	1	NO. 3
P22	Lifting magnet	2	1 Ton
P23	Upright drilling machine	1	ϕ25
P24	Radial drilling machine	1	ϕ50, 2.4 m

NO.	NAME	QTY.	MAJOR PERFORMANCE
P25	Bench grinder	3	ϕ305
P26	Groove processor	1	1,000 x 6,000 mm (W) (L)
P27	Annealing furnace	1	5 x 7.5 m for bogie frame
P28	Bogie frame welding positioner	1	
P29	Surface plate	16	7 x 3m x 1, 2 x 3m x 15
P30	Underframe welding positioner	2	
P31	Goliath drilling machine	1	ϕ50
P32	Spot welder	2	75 kVA
P33	D.C. Arc welder	10	300 A
P34	Semi-automatic Arc welder	30	300A x 25, 500A x 5
P35	Welding positioner	8	1 Ton x 3, 2 Ton x 2, 0.5 Ton x 3
P36	Phosphating treatment facility	8	1.5 x 1.5 x 6 m x 7 bathes, 1.0 x 1.0 x 6 m x 1 bath
P37	Gas supply equipment for CO_2 semi-automatic Arc welder	1	

(2) Machinery for machining

NO.	NAME	QTY.	MAJOR PERFORMANCE
M1	Lathe	1	2,800 mm
M2	Lathe	1	2,000 mm Ordinary type
M3	Lathe	1	2,000 mm N.C. type
M4	Lathe	1	1,500 mm
M5	Vertical lathe	1	1,600 mm
M6	Upright drilling machine	1	ϕ 50
M7	Radial drilling machine	1	Arm length 3 m
M8	Milling machine	1	NO. 3
M9	Vertical milling machine	1	NO. 3
M10	Horizontal boring machine	1	ϕ 110

NO.	NAME	QTY.	MAJOR PERFORMANCE
M11	Cylindrical grinder	1	ϕ 500 x 2,500 mm
M12	Surface plate	3	2 x 3 m
M13	Planomatic machine	1	10 x 21 m
M14	Layout machine	1	5 x 8 m
M15	Universal cutter grinder	1	
M16	Bench grinder	2	ϕ 305
M17	Universal drill grinder	2	ϕ 3 ~ ϕ 13 x 1 ϕ 13 ~ ϕ 16 x 1
M18	Radial drilling machine	1	ϕ 25, 2,000 mm
M19	Slotting machine	1	Stroke 300 mm

(3) Machinery for assembling

NO.	NAME	QTY.	MAJOR PERFORMANCE
A1	Band saw	1	5"
A2	Pipe cutting/threading machine (semi-automatic)	1	2"
A3	Chamfering machine	2	ϕ 60
A4	Chamfering machine	1	ϕ 120
A5	Pipe threading machine	3	3"
A6	Pipe bender	1	Right bending 2"
A7	Pipe bender	1	Left bending 2"
A8	Pipe bender	1	ϕ 100
A9	Welding positioner	1	ϕ 400, 100 kg
A10	Wire cutting machine	1	250 mm^2
A11	Wiring machine (semi-automatic)	1	
A12	Wire stripper	1	250 mm^2
A13	Semi-automatic Arc welder	1	300 A
A14	Electric furnace	1	200°C

NO.	NAME	QTY.	MAJOR PERFORMANCE
A15	Painting booth	1	6.5 x 25 m
A16	Grit blast booth	1	6.5 x 25 m for body
A17	Painting booth	1	6.5 x 9 m for bogie frame
A18	Grit blast booth	1	6.5 x 9 m for bogie frame
A19	Painting booth	2	4 x 6 m for parts
A20	Drying oven	1	L = 15 m for parts
A21	Surface plate	2	1.5 x 15 m
A22	Surface plate	1	3 x 5 m
A23	Pipe stocker	1	
A24	Pipe vise with table	6	
A25	Oil press for fitting and bending	1	20 Ton
A26	Surface plate	1	2 x 3 m
A27	Film thickness gauge	1	
A28	Colour meter	1	
A29	Film contraction tester	1	
A30	Cross hatch cutter	1	
A31	Impact tester	1	
A32	Conical mandrel bend tester	1	
A33	Paint film cutter	1	

(4) Material handling equipment

NO.	NAME	QTY.	MAJOR PERFORMANCE
H1	Goliath crane	1	1 Ton, span 6.5 m
H2	Overhead travelling crane	5	3 Ton, span 20 m
H3	Overhead travelling crane	2	40 Ton, span 28 m
H4	Overhead travelling crane	1	3 Ton, span 28 m
H5	Overhead travelling crane	1	20 Ton, span 28 m

NO.	NAME	QTY.	MAJOR PERFORMANCE
H6	Overhead travelling crane	1	30 Ton, span 28 m
H7	Overhead travelling crane	1	30 Ton, span 20 m
H8	Overhead travelling crane	1	5 Ton, span 20 m
H9	Trolly for parts	10	
H10	Trolly for body	26	
H11	Forklift	3	1 Ton
H12	Trailer	8	1 Ton
H13	Material stocker	1 set	
H14	Roller carpet	1 set	Total length approx. 300 m
H15	Pallet	1 set	(400)
H16	Pallet (steel mesh)	1 set	(200)
H17	Wall crane	10 sets	1 Ton
H18	Transfer machine for heavy parts	1	
H19	Load meter for crane	1	
H20	Trolly for heavy parts	1	20 Ton

(5) Testing equipment

NO.	NAME	QTY.	MAJOR PERFORMANCE
T1	Test stand for bogie	1 set	
T2	MG set	1 set	100 kW, 0 ~ 750 V variable
T3	Axle weight meter for locomotive	12	15 Ton
T4	Axle bearing puller	1 set	ϕ 10 ~ ϕ 60
T5	Maintenance tool kit for storage battery	1 set	
T6	Portable standard D.C. ammeter with carrying case and with external shunt	2 sets	2,000 A
T7	Synchroscope	2 sets	
T8	Oscillographs with resistor box (Portable photo corder)	2 sets	

NO.	NAME	QTY.	MAJOR PERFORMANCE
T9	Automatic voltage regulator	2 sets	0 ~ 160 V DC, 0 ~ 10 A
T10	Exhaust gas temperature meter	2 sets	0 ~ 800°C
T11	Function generator	1 set	0.01 Hz ~ 1 MHz
T12	Low frequency counter	2 sets	
T13	Digital tachometer	2 sets	
T14	Digital multimeter	2 sets	
T15	Ultrasonic flaw detector (for welded parts)	2 sets	
T16	Strain gauge tester	2 sets	
T17	Load box (water resistor type)	1 set	1,600 V, 2,500 A
T18	Magnaflux flaw detector	2 sets	Handy type
T19	Revolution speed meter	1 set	Digital type
T20	Electric thermometer	1 set	-20 ~ 500°C
T21	Dielectric strength tester	1 set	10 kV
T22	Vibration meter	1 set	
T23	Noise meter	1 set	
T24	Anemomaster	1 set	
T25	Magnet stand	1 set	for dial indicator
T26	Electric gap gauge	1 set	Non-contact type
T27	Loading gauge	1 set	for loading test
T28	Water tightness test device	1 set	
T29	Battery charger	1 set	
T30	Air compressor	1 set	0 ~ 10 kg/cm^2, 3,000 ℓ/min
T31	Water treatment tank	1 set	for mixture of anti-corrosion
T32	F.M. telemeter	1 set	for measurement
T33	Multirecorder	1 set	for long time recording
T34	Test bench with vise	1 set	

2-4-2 Auxiliary machinery

The names of the machines, the number required and main data for all machinery indirectly necessary for the manufacturing of locomotives are given in Table 2-5.

Table 2-5 Machine List of Auxiliary Machinery

(1) Testing equipment for laboratory

NO.	NAME	QTY.	MAJOR PERFORMANCE
L1	Amsler's universal material testing machine	1	50 Ton Oil pressure type
L2	Vibration testing machine	1	1,000 kg ± 3 g Oil pressure type
L3	Vibration testing machine	1	50 kg ± 100 g Electric type
L4	Impact testing machine	1	Charpy
L5	Hardness tester	1	Brinell type
L6	Hardness tester	1	Shore type
L7	Fatigue testing machine	1	20 Ton – max. load Oil pressure type Random vibration
L8	Microscope	1	x 2,000, Optical type
L9	Microscope	1	x 120, Stereo Microscope
L10	Salt-spray testing equipment	1	
L11	Universal measuring microscope	1	Length = 1,016 mm Min. scale = 0.001 mm
L12	Three-dimensional precision measuring machine	1	700 x 500 x 250 mm (X) (Y) (Z)
L13	Profile projector	1	Screen dia. ϕ 315
L14	Surface plate of marble	2	800 x 1,000 mm
L15	Surface roughness meter	1	x 1,000 - 50,000
L16	Optical index table	1	Min. scale = 10 sec.
L17	Hardness tester	1	Rockwel type
L18	Digital voltage, current meter for calibration	1	

(2) Machinery for maintenance shop

NO.	NAME	QTY.	MAJOR PERFORMANCE
R1	Jig boring machine	1	1,100 x 840 mm, Table stroke 950 mm
R2	Universal grinder	1	Max. external dia. ϕ 150
R3	Internal grinder	1	Internal dia. = ϕ 1.5 - ϕ 50
R4	Surface grinder	1	Table size 1,250 x 500 mm
R5	Optical forming grinder	1	Table size 380 x 150 mm
R6	Cylindrical grinder	1	ϕ 0.8 - ϕ 35
R7	Jig grinding machine	1	Table size 520 x 760 mm
R8	N.C. electric discharge cutting machine	1	Min. scale = 0.002 mm Table stroke 150 x 150 mm
R9	Electric discharge machine	1	Table size 600 x 400 mm
R10	High frequency induction hardening equipment	1	50 kW, 160 kHz
R11	Gas furnace (N_2 gas)	1	200 V, 12 kW, 1,050°C
R12	Electric furnace	1	80 kW, 1,200°C 500 x 700 x 1,000 mm
R13	Hydraulic honing machine	1	Air pressure 2 – 7 kg/cm^2
R14	Test piece grinding machine	1	Grinding for mirror surface, 240 rpm
R15	Micro-grinder	1	12,000 rpm
R16	Electric discharge	1	Coating thickness Max. 30 – 40 μ
R17	Bite grinder	1	
R18	Air hammer	1	1/8 Ton
R19	Gas furnace	1	1,200°C
R20	Overhead travelling crane	1	3 Ton, span 20 m
R21	Airconditioning equipment	1	Package type Room area 270 m^2

(3) Shunting locomotive and vehicles

NO.	NAME	QTY.	MAJOR PERFORMANCE
V1	Shunting locomotive	1	500 HP
V2	Forklift	3	3 Ton
V3	Battery truck	5	2 Ton platform type
V4	Cargo truck	2	Diesel 10 Ton
V5	Pick-up car	2	
V6	Staff car	1	
V7	Station wagon	1	
V8	Firefighting car	1	
V9	Mini bus	2	20 – 25 persons
V10	Tank lorry	2	

(4) Gantry crane and others

NO.	NAME	QTY.	MAJOR PERFORMANCE
X1	Yard crane	1	15 Ton, span 25 m include 110 m runway
X2	Incinerator	1	3 Ton/8 hr/day
X3	Weighbridge	1	90 Ton x 10 m
X4	Gasoline stand	1	2,000 lit. portable type

(5) Machinery for training

NO.	NAME	QTY.	MAJOR PERFORMANCE
Y1	Machinery for exercise	1 Ls.	

(6) Tools

NO.	NAME	QTY.	MAJOR PERFORMANCE
Z1	Measuring instrument, tool cabinet cutlery	1 Ls.	

2-5 Electrical Facilities

2-5-1 Site electrical system

In order to supply electricity to the facilities of the factory; substation equipment, high and low voltage power distribution lines, load centers, and standby generating equipment will be installed in the factory. Site lighting systems consisting of pole-mounted luminaires will also be installed to ensure safe traffics of vehicles and workers, outdoor works and security of the factory site.

(1) Substation

Substation will be provided to recieve electricity of dual 3 phase, 50 Hz, 132 kV; and to step-down the received electricity to 11 kV for power distribution in the factory. Substation equipment will be installed in dual bank system.

(a) 132 kV equipment

Main equipment on the 132 kV feeder circuits will be installed outdoor in the substation yard, and protection relays and associated devices will be installed on relay panel(s) in the control room of the substation building. On the 132 kV circuit, SF6 gas circuit breakers will be provided to protect the circuit from under voltage, over current, short circuit, grounding or power transformer fault.

The locations of the metering outfits and the scope of the construction for power receiving should be interfaced and coordinated with the electric utility authority of the WAPDA including the share of the expenses concerning the construction of the 132 kV transmission lines and charged to this project.

(b) 11 kV equipment

Switchgears, relays and other associated devices on the 11 kV circuits will be provided with enclosures, and installed in the switchgear room of the substation building. On the 11 kV feeder circuits, vacuum type circuit breakers will be provided to protect the circuits from electrical shut-down, short circuit, and grounding faults. Secondary feeders of the breakers will be connected through a tie-switch for which load break type switch is used.

The circuit breakers on the 11 kV feeders will be closed under normal condition, and the tie-switch will generally be opened. These three switchgears will be interlocked, i.e., if one circuit breaker on a 11 kV feeder is tripped by shut-down, the tie-switch will be automatically closed to supply power from another

circuit to power distribution lines in the factory; however, if the tripping is due to a fault in the power distribution systems, automatic closing of the tie switch should not be carried out for protection of the sound circuit.

(c) Low voltage power service equipment

The service equipment consisting of distribution panel(s) and transformers will be provided to supply low voltage power to the control/operation equipment for the switchgears and to utilization equipment of the substation building, site lighting systems, and equipment/buildings in the vicinity of the substation.

The power to this service equipment will be supplied and branched from each secondary feeder of the 11 kV switchgears. And low voltage power to the utilization equipment of the substation including control equipment will be supplied through power source transfer system.

(d) Standby generating equipment

The generator will be provided for power services in case of shut-down of commercial power supplied from WAPDA or fault on the power distribution systems in the factory.

The generating equipment will be installed in the switchgear room. The alternator will be driven by diesel engine, and its electric system is 3 phase 4 wires, 50 Hz, 230-Y/400 volts.

The generating equipment will be provided with automatic starting and stopping system when commercial power fault and returning, and will meet the rating of continuous 10 hours operation.

The generated power will be automatically switched from/to commercial power by the power transfer device installed in the substation, then, the power will be supplied to the following utilization equipment in the case of shut-down of the commercial power:

i) Emergency and security lights in the administration building

ii) Fire alarm and fire fighting equipment

iii) Public address equipment

iv) Master clock equipment

v) Security lights for the factory site

(e) Subsidiary equipment

Subsidiary equipment will be provided to support and assist the switchgears and will include relay and operation panels and battery equipment.

Relay panel and operation panel will be installed in the control room and provided to control and operate all circuit breakers and switches on the 132 kV and 11 kV feeders. Operators for these panels will be assigned. In addition to operation of the switchgears, they supervise the position-of all switchgears and electrical conditions such as voltage, amperage and wattage on each feeder.

Battery equipment will also be installed in the control room and provided to supply DC power for operation and control of the swichgears, and will consist of batteries, charger and breakers. The capacity of the batteries should be enough to make, at least, one feeding system after 10 hours shut-down of the commercial power system.

(2) High voltage power distribution lines

High voltage power distribution lines will be provided to supply electricity to load centers from the substation, and will be installed in underground duct banks. The system characteristics of this line will be three phase, three wires, 50 Hz, 11 kV and ring circuit.

On this ring distribution line, a sectioning switch will be installed to isolate the distribution line in case of fault such as grounding or short circuit. This sectioning switch will be opened under normal condition.

(3) Load centers and service system for utilization

Load centers will be provided to step-down 11 kV distributed power to 230-Y/400 V and to utilize electricity; and will consist of distribution panel(s), transformers and other accessories. These load centers will be of indoor type and installed in the main workshop building and electric rooms of the administration and air station buildings. The electric rooms will be installed with ventilators to control temperature rise due to heat generation by the transformers.

The main workshop will be electrically sectionalized into eight blocks, and low voltage power will be supplied from the transformers which are intended for each individual block. Bus wires will be installed at each block. The utilization power will be feeded out from these bus wires to every manufacturing machine groups

through protection switches. This power feeding system will provide flexible electricity service conforming to increase or change of the locations of the manufacturing machines which may be required, in the future, by alternation of works in the main workshop building.

The electricity for utilization within the switchman's hut located at the branch point of the factory siding will be locally supplied from the WAPDA in low voltage system; and will not be supplied from the distribution system of the factory.

The capacities of the facilities of each building/shed and shop of the main workshop building are shown in the following table 2-6.

Table 2-6 Electrical Loads

Description of Bldgs/Equipment	Capacity (kVA)
Administrative Bldg.	400
Water pumps	150
Substation	50
Exterior lighting	50
Fuel pump	5
Inspection, shunting loco., touch-up painting and weighbridge sheds	20
Vehicle shed	20
Time office & labour bureau	30
Canteen	30
Air and acetylene station	320
Effluent treatment equipment	220
Local offices	50
Main shop	
Parts store areas, maintenance & body furnishing shops	(700)
Paintings, machinings, wiring, piping & body furnishing shops	(800)
Bogie frame shop, roof, cab and underframe fabrication shops	(600)
Steel cutting & bending shops. Steel material stock yard crane	(700)
Subtotal of main shop	2,800
Total	4,145

(4) Site lighting system

Site lighting systems consisting of pole-mounted light will be installed for security of the factory site and outdoor works, and for traffic safety of vehicles and workers, in the night. The light will be provided with a high pressure sodium lamp due to its high efficiency. Mounting height of the luminaire head is generally eight metres above the finished road surface.

Exterior lights including for circular roads out of the boundary walls of the factory will be switched off after daily works in the midnight except heavy duty lights for security of the site. These heavy duty lights remaining whole night will be connected with a circuit to which generated power is transferred in case of fault on the commercial power system.

2-5-2 Communication system

Communication systems will be provided for effective administration of the factory and for announciations in emergency such as fire or security. This system will consist of telephone system, public address system, master clock system and fire alarm system.

(1) EPABX telephone system

EPABX (Electronic Private Automatic Branch Exchange) telephone system will be installed for communications among offices of the factory or with an outside subscriber. The telephone systems will consist of extension telephone sets installed at each office and master equipment installed in the telephone room of the administrative building. The telephone master equipment will include EPABX switchboard, attendant consol, batteries and charger.

Extension telephones will also be installed at key points for security in the factory site, and provided to communicate between the guard station and a patrolling guard.

Capacities of the EPABX telephone systems will be of 120 circuits for extension lines and 20 circuits for trunk lines.

The trunk line cable leading-in to the factory will be furnished and installed by the public telephone utility. Then, scope of the construction and share of the expenses to receive the telephone services, which are charged to this project, should be interfaced and coordinated with the telephone utility.

(2) Train operation telephone

As the incoming track to the factory is branched off from the railway main line between the RISALPUR and RASHKAI stations, train operation telephones will be installed at both stations, switchman hut and administrative office to ensure safety of train operation and blocking of this section and the siding.

For this telephone systems, magneto telephones will be employed, and exsisting telephone transmission lines will be used between both stations.

(3) Public address system

Public address system will be provided to announce from administrative office in ordinary or emergency occurence of fire, and to dispatch to patrolling guards from the guard station in emergency; and will consist of amplifiers, operation panels and speakers. The amplifiers will be installed at the telephone room and main workshop building, and the operation panels will be installed at the administrative office and guard station. And the speakers will be provided at each office, workshop and several points outside buildings to receive announciations at any where in the factory.

Principal performance of the components is shown as follows:

(a) Amplifiers

- Number of output circuits: min. 3 circuits
- Output power: min. 100 watts
- Number of input circuits: min. 2 circuits

(b) Operation panels

- Number of operation circuits: min. 3 circuits

(c) Speakers

- Input of trumpet types: min. 15 watts
- Imput of dynamic types: min. 3 watts

(4) Master clock system

Master clock system will be provided to keep work time schedules and thus to increase efficiency of works. Comparing with the case that clocks are installed independently, this system can eliminate variance of time indicating on the individual clocks.

The master clock system will comprise a master equipment installed at the telephone room and slave clocks. The slave clocks will be installed at each office and workshop, and they are driven by a 30-second pulse synchronizing signal.

(5) Fire alarm system

Fire alarm system linking to fire fighting system will be provided to enable fire fighting at early period through early detection of fire, and to ensure safty and minimization of damage due to fire.

This system will cover the administrative building, main workshop building and other office rooms or buildings in which employees are working; and will consist of centralized alarm panels, combination boxes and detectors. Centralized alarm panels will be installed at the fire station and guard station to indicate a burning-up building/section with bell alarming. Combination boxes will be locally installed in each building and workshop, and provided with an alarm bell, location lamp and pushbutton switch to send burning-up signal to the central alarm panel.

2-6 Utility Service Facilities

2-6-1 Water supply system

Fire hydrants inside the factory will be arranged in such a manner that a horizontal distance from each location of building to the fire fighting hose connection is less than about 50 m. It is also planned that the delivery pressure is more than 2.5 kg/cm^2 at a nozzle tip and the delivery rate is more than 350 l/min when two fire hydrants are used simultaneously. Besides the water supply piping network to each water consumption point is planned in each building. Two deep wells are also planned. These are shown in Fig. 6-1-1. The elevated water tank has a capacity of 50 m^3, with a height at 27 m. The principal water supply pipes will have ϕ150, ϕ100, and ϕ80.

The elevated water tank is shown in Fig. 6-1-2.

2-6-2 Drainage system

(1) Drainage of rainwater

The rainwater flow volume is calculated as follows:

$$Q = \frac{1}{3.6 \times 10^6} \cdot I \cdot C \cdot A$$

Q : Rainwater flow volume (m^3/sec)
I : Rainfall intensity (mm/h)
C : Flow rate
A : Water catchmen area (m^2)

Yard area A = 154,000 m^2

	Area A	Flow rate
Roof	32,000 m^2	0.9
Pavement surface	34,000 m^2	0.7
Soil (including green)	88,000 m^2	0.4

Rainfall intensity (assumed as I = 100 mm/h)

The yard was divided into 18 parts (six longitudinally and three transversely) to calculate the flow volume.

The drainage capacity was calculated according to the Manning's formula:

$$Q = \alpha \cdot Q_2$$

$$Q_2 = A \cdot V$$

Q	:	Drainage capacity	m^3/sec.
Q_2	:	Allowable water passage rate	m^3/sec.
α	:	Allowance	
A	:	Drainage sectional area	m^2
V	:	Mean flow speed	m/sec.

On the basis of above calculated result, the pipe with ϕ450 to ϕ1,300 (partially U-shaped gutter) will be used. The track and passage way will be provided a gutter on one side and the gutter will be connected to the drainage pipe.

The drainage pipe plan is shown in Fig. 6-2.

(2) Sewage from toilet, etc.

Sewage will be discharged into the drainage gutter after treatment in the respective sewage disposal tank.

2-6-3 Water treatment facility

Quality of underground water utilized in the factory is as shown on the Table 1-1, and it is not suitable for drinking, so it is necessary to provide water treatment facility to make it suitable for drinking.

(1) Load on water treatment facility

Load on this facility will be as follows;

Colony	600 m^3/day
(5 houses x 5 persons x 0.2 m^3/day/person x 1.2)	
Factory	140 m^3/day
(Refer to the Fig. 4 and Sec. 2-6-4)	
Flushing water of this facility	80 m^3/day
Total	820 m^3/day

(2) Performance of deep-well pump and water feed pump

(a) Deep-well pump

This pump will be operated for 10~11 hours in a day to draw up well water of 820 m^3/day.

820 m^3/11 hours = 80 m^3/h

So it is required to have a capacity of 80 m^3/h.

(b) Water feed pump for colony

This pump is used for lifting water to the elevated tank for the colony. It will be operated 10 hours in a day to feed 600 m^3/day of water.

600 m^3/10 hours = 60 m^3/h

So it is required to have a capacity of 60 m^3/h.

(c) Water feed pump for factory

This pump is used for lifting water to the elevated tank for the factory. It will be operated 5 hours in a day to feed 140 m^3/day of water.

140 m^3/5 hours $\fallingdotseq$ 30 m^3/h

So it is required to have a capacity of 30 m^3/h.

The treating capacity of this facility is 820 m^3/day, as mentioned above, and coagulation and high speed filtration system will be adopted in this facility. Under-

ground water which will be treated through this treatment facility will have the quality to satisfy such water quality standard as shown below.

pH	5.8 ~ 8.6
Turbidity	not more than 2°
Colour	not more than 5°

Flow sheet of this facility is shown on the Fig. 6-3-1. Underground water will be drawn up to the water reservoir by the pump and after that water will be treated through the process of coagulation and filtration, and flow into the filtered water basin. This treated water will be fed to the colony and factory via each elevated tank.

Overall dimension of this treatment facility is as follows;

(a) Amount of treated feed water 820 m^3/day

(b) Treating capacity 80 m^3/h

(c) Volume of water reservoir 1,200 m^3
(amount of feed water x 1.5)
Water in this reservoir will also be used for fire fighting in an emergency.

(d) Filtered water basin 500 m^3

Plan of this facility is shown on Fig. 6-3-2 and the underground water tank is shown on Fig. 1-4.

2-6-4 Effluent treatment and recycling facility

This facility is for treating and recycling water drained from factory. Mass balance of water utilization is shown on Fig. 4, and flow sheet of effluent treatment and recycling is shown on Fig. 6-4-1.

Water treated through this facility will have the quality to satisfy following water standard.

pH	6.5 ~ 8.0
Turbidity	not more than 20°
Total hardness	not more than 120 mg/l
Residue after vaporization	not more than 250 mg/l
Chlorine	not more than 80 mg/l

However, water which is drained from steel surface treatment will be treated independently and discharged to the river through a gutter. In this case this discharged

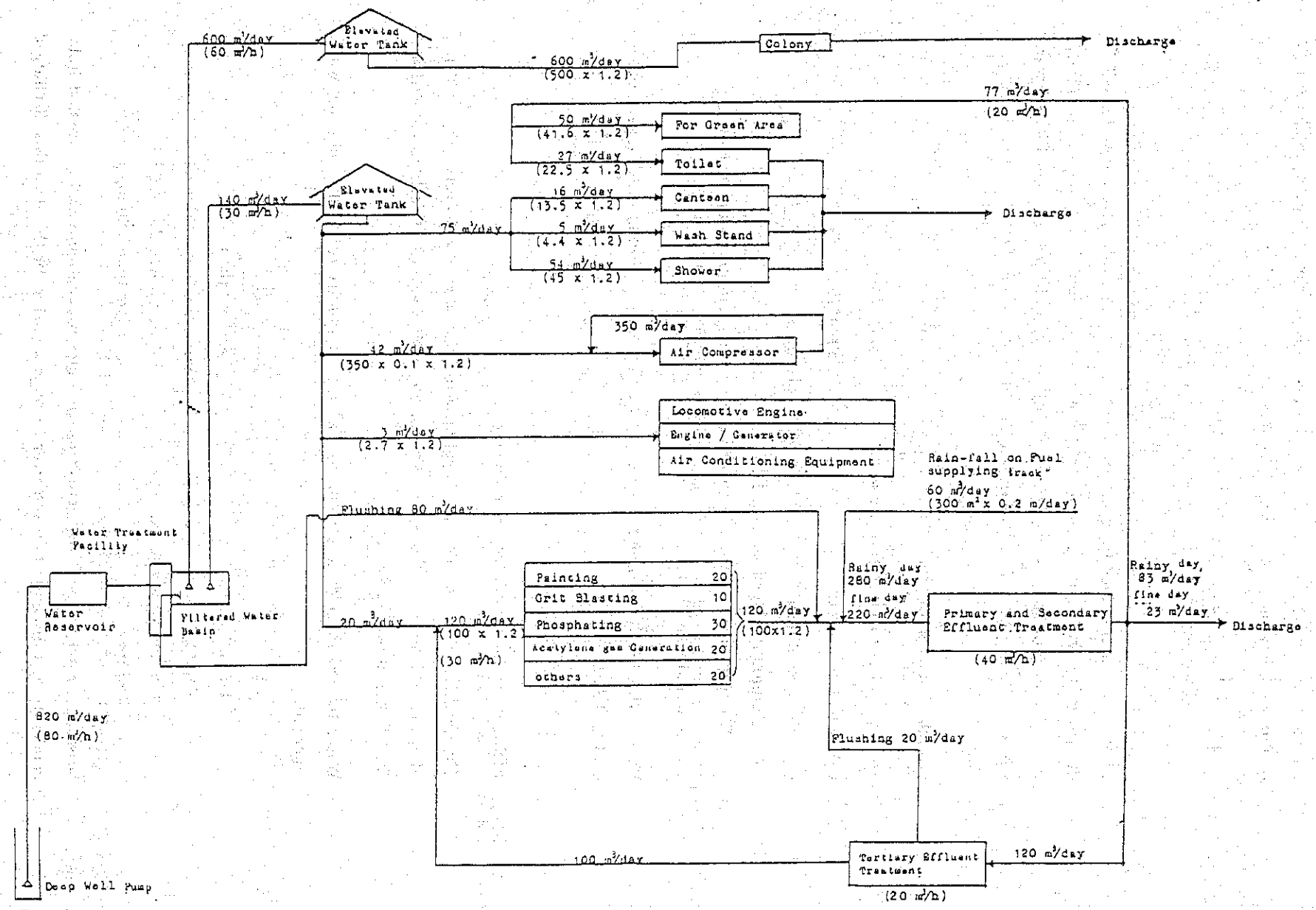


Fig. 4 Mass Balance of Water Utilization

water will have the quality satisfying such water quality standard as shown below.

pH	5.8 ~ 8.6
Soluble Fe	not more than 10 mg/l
Zn	not more than 5 mg/l
SS	not more than 200 mg/l

(1) Amount of water utilized in the factory

Water utilized in the factory is devided into two categories: water to be used for living and for industrial use. The amount of water utilized in the factory is estimated as below in accordance with these categories.

(a) Water for living

i) Amount of clean water

For dining room (2 places: administrative building and canteen) 16 m^3/day
(889 persons x 0.03 m^3/person/day x 8 hours/16 hours x 1.2 = 16 m^3/day)

For hand washing (12 places) 5 m^3/day
(889 persons x 0.01 m^3/person/day x 8 hours/16 hours x 1.2 = 5 m^3/day)

For shower bath (5 places) 54 m^3/day
(889 persons x 0.05 m^3/person/day x 1.2 = 54 m^3/day)

Total 75 m^3/day

ii) Amount of recycling water (Regenerated water through primary and secondary treatment process)

A part of water treated through primary and secondary treatment process is used the following purpose.

Toilet (12 places) 27 m^3/day
(889 persons x 0.05 m^3/person/day x 8 hours/16 hours x 1.2 = 27 m^3/day)

Watering to the plants 50 m^3/day
(104,000 m^2 x 1/10 x 4 mm/day x 1.2 = 50 m^3/day)

(b) Water for industrial use

i) Amount of clean water

Water supply to meet a deficit of cooling water of the air compressor (Ten percent of the cooling water will be vaporized in a day)		42 m^3/day
Cooling water of the engine on the locomotive	0.9 m^3/day	2.4 m^3/day x 1.2 ≒ 3 m^3/day
Cooling water of the engine coupled with generator for emergency	0.5 m^3/day	
Humidifier for air conditioning	1 m^3/day	
A supply to meet a deficit of water for industrial use in the factory		20 m^3/day
Total		65 m^3/day

The maximum rate of recycling of regenerated water will be 50~60%, and so 110~90 m^3/day of clean water will be supplied complementally in the case of treating 220 m^3/day of effluent in a fine day.

To supply this amount of water, 100 m^3/day of clean water, explained below, will be used to prevent deterioration of the quality of water such as gradual increase of salts.

(flushing water for water treatment facility 80 m^3/day)
+ (clean water 20 m^3/day) = 100 m^3/day

ii) Utilization of regenerated water (tertiary treatment)

Water treated through the tertiary treatment apparatus will be used for the following purpose.

Water shower in the painting booth	20 m^3/day
Grit blasting	10 m^3/day
Cleaning after phosphating	30 m^3/day
Generation of acetylene gas	20 m^3/day
Water proof test and others	20 m^3/ day
Total	100 m^3/day

(2) Outline of the facility

Flow sheet of this facility is shown on Fig. 6-4-1. Effluent is collected in the pipe buried underground and flow into the effluent water holding tank for a while and then forced to flow into the receiver tank. In the receiver tank primary treatment that is adjustment of amount and quality of effluent and floatation and sedimentation of suspended solid are carried out. After that water is delivered to the secondary treatment apparatus to trap coagulated suspended solid by flocculation process.

A part of treated water, on this stage, will be used for toilet and for watering to the plants. Remaining water will be delivered to the tertiary treatment apparatus to be treated through sand filter and absorption tank of activated carbon and reused for industrial use.

Plan of this facility is shown on Fig. 6-4-2, detail of the concrete tank is shown on Fig. 1-5-1, 1-5-2, 1-5-3.

Outline of the facility is as follows.

(a) Effluent treatment facility

i) Primary and secondary treatment facility

Effluent to be treated through this facility is as follows;

Drainage after industrial use	120 m^3/day
Flushing water of water treatment facility	80 m^3/day
Flushing water of tertiary treatment facility	20 m^3/day
Rain fall on fuel supplying track	60 m^3/day
Total (on rainy day)	280 m^3/day

This facility will treat this amount of effluent in 7 hours in a day, so the capacity of it will be 40 m^3/h.

Secondary treatment facility will adopt flocculation method which is suitable for treating oily water.

ii) Tertiary treatment facility

The amount of water to be treated through this facility is as follows;

Recycling water for industrial use	100 m^3/day
Flushing water for this facility	20 m^3/day
Total	120 m^3/day

This facility will treat this amount of water in 6 hours in a day and so it is required to have a capacity of 20 m^3/h. Treating system of this facility contains "filtration" and "absorption by activated carbon" process.

iii) Sludge treatment facility

Amount of sludge generated in a day is assumed to be 17.2 m^3/day and it has 99.4 % of water in it. After condensed in a state of 1.42 m^3 of volume and 92% of water content, it is burnt up in incinerator.

The incinerator will operate 7 hours in a day so it is required to have a capacity to incinerate 200 kg of sludge in an hour. Type of incinerator will be a rotary kiln which is suitable for treating water contained sludge.

(b) Recycling water pump

i) Pump for the water from the secondary treatment facility

Amount of water to be dealt with this pump is as follows;

Watering to the plants	50 m^3/day
Toilet	27 m^3/day
Total	77 m^3/day
	≒ 80 m^3/day

The pump will deliver this amount of water in four hours and so it is required to have a capacity to deliver 20 m^3 of water in an hour.

ii) Pump for the water from the tertiary treatment facility

Amount of water to be dealt with this pump is as follows;

Recycling water (for industrial use)	100 m^3/day
Flushing water	20 m^3/day
Total	120 m^3/day

The pump will deliver this amount of water in four hours and so it is required to have a capacity to deliver 20 m^3 of water in an hour.

2-6-5 Compressed air piping

Compressed air is used in the following work.

(a) Grit blasting and painting for body
(b) Grit blasting and painting for bogie frame
(c) Painting for component parts
(d) Pneumatic tools

Fig. 6-5 shows the arrangement of the air piping and its apparatus to supply compressed air to the air consumption points.

(1) In order to calculate total amount of air consumption, air consumption rate of an air blasting nozzle and pneumatic tool are estimated as below

(a) Air blasting nozzle

3 mmϕ	0.5 m³/min
5 mmϕ	1.3 m³/min

(b) Pneumatic tool (Impact wrench)

6 mmϕ	0.3 m³/min
9.5 mmϕ	0.75 m³/min
16 mmϕ	1.15 m³/min
19 mmϕ	1.36 m³/min
22 mmϕ	1.45 m³/min

(2) Air consumption of each work is calculated below.

(a) Air cosumption for the work related to body

Grit blasting booth	6 m X 25 m
3 mmϕ X 6 nozzles	0.5 m³/min X 6 = 3 m³/min
5 mmϕ X 3 nozzles	1.3 m³/min X 3 = 3.9 m³/min

(b) Air consumption for the work related to bogie frame

Grit balsting booth	6 m X 8 m
3 mmϕ / 2 nozzles	0.5 m³/min X 2 = 1 m³/min
5 mmϕ / 2 nozzles	1.3 m³/min X 2 = 2.6 m³/min

(c) Air consumption for the work related to component parts painting

Painting booth	4 m X 6 m X 2 booths
3 mmϕ X 4 nozzles X 2 booths	0.5 m³/min X 4 X 2 = 4 m³/min

(d) Pneumatic tools (Impact wrench)

Number of branched down pipe for air outlet valve to connect with pneumatic tool 98

6 mmϕ	0.3 m³/min X 32 = 9.6 m³/min
9.5 mmϕ	0.75 m³/min X 24 = 18 m³/min
16 mmϕ	1.15 m³/min X 14 = 16.1 m³/min
19 mmϕ	1.36 m³/min X 14 = 19 m³/min
22 mmϕ	1.45 m³/min X 14 = 20.3 m³/min

If these are used simultaneously, 14.5 m³/min for air blasting, 83 m³/min for pneumatic tools and totally 97.5 m³/min of air is necessary. But these are usually not used simultaneously, so the real air consumption at one time is assumed to be about 30 % (average 15~18 sec.) and 20 % (average 10~12 sec.) of above value for air blasting and pneumatic tools respectively. That is, total air volume needed will be as follows; (14.5 m³/min X 0.3) + (83 m³/min X 0.2) = 20.9 m³/min

Therefore, it is sufficient to install two air compressors having each capacity of 10 m³/min for supplying compressed air to the factory, because on the peak load two of these are operated together while one of them can be stopped when the air consumption it not more than 10 m³/min.

But considering for trouble and repair which may occur on the air compressor, installation of another one is desirable and finally three air compressors will be installed on the factory.

The performance of the air compressor will be as follows;

Delivery pressure	7 kg/cm²
Delivery air volume	more than 10 m³/min
Installed number	3 (one out of them is spare)

2-6-6 Acetylene gas generator and piping for delivery

It is hard to get soluble acetylene at Nowshera district, so the acetylene gas generator with carbide is adopted to obtain acetylene gas.

Acetylene gas is used for the tasks shown on the following.

(a) Gas copy cutting of steel plate

(b) Other gas cutting and gas welding

(1) Acetylene gas consumption for each task is assumed as the following;

(a) Gas welding

on an average per 1 meter	560 l/m

(b) Gas cutting

plate thickness	100 mm	1,000 l/h
plate thickness	32 mm	600 l/h

(2) From the above data, acetylene gas consumption per hour is as follows;

(a) Acetylene gas consumption per hour for gas welding

560 l/m X 10 m/day = 5,600 l/day ≒ 1,000 l/h

(b) Acetylene gas consumption per hour for copy cutting

(1,000 l/h/nozzle + 600 l/h/hozzle) X 6 nozzles = 9,600 l/h

≒ 10,000 l/h

Therefore, total acetylene gas consumption is 11,000 l/h.

1,000 l/h + 10,000 l/h = 11,000 l/h

(3) Capacity of gas generator

The maximum consumption of acetylene gas is assumed to be 120% of above value, then the capacity of gas generator is required to be 13,000 l/h.

11,000 l/h X 1.2 ≒ 13,000 l/h

The gas reservoir will have a capacity to hold the amount of gas generated minus those of consumed, so it will be as the following.

13,000 l/h - 11,000 l/h = 2,000 l/h

From these data mentioned above, acetylene gas generator and piping will be decided as follows.

(a) Acetylene gas generator

Stationary type, medium pressure gas generator

Capacity	13 m^3/h
Number of set	2
(one of these is for relief)	

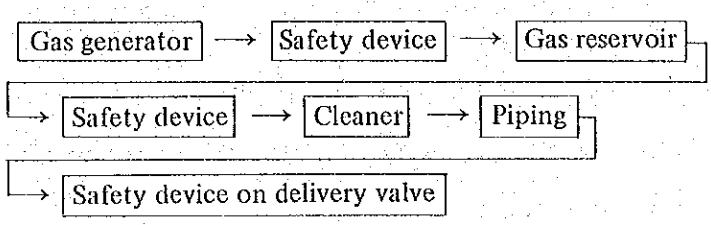
(b) Reservoir

Capacity	2.0 m^3

(c) Piping

Fig. 6-6 shows the piping.

Schematic diagram from gas generator to the safety device on the delivery value at the end of the piping is shown on the following.



(4) Necessary amount of carbide

Amount of acetylene gas generated from 1 kg of carbide is as follows.

200 l/kg

Maximum amount of acetylene gas used in the main shop is 13 m^3/h as mentioned above. It is assumed that acetylene gas is used in 75 % of 7 hours in a day and the average consumption of gas is assumed to be 60 % of max. consumption. Therefore, the average gas consumption in a day is,

13,000 l/day x 7 x 0.75 x 0.6 ≒ 41,000 l/day

Necessary amount of carbide used in a day is,

41,000 l/day ÷ 200 l/kg ≒ 210 kg/day

Usually, carbide is delivered in a drum (220 kg) or in a small can (20 kg). That is, in an average one drum of carbide will be used in a day.

(5) Carbide residue

Amount of carbide residue after generating acetylene gas is about 1 m^3/drum of carbide. As the amount of carbide used in a month is 5,500 kg, so the volume of carbide residue containing water will be 25 m^3 for a month.

The carbide residue from the generator is settled in the water of the pit to be discharged.

Carbide residue pit has three tanks and in the upper most tank carbide residue is settled naturally, and surface water which contains no suspended solid is flown down to the next tank by turns. Carbide residue settled on the bottom of the tanks is removed out at intervals of 1 or 1.5 months.

Two series of pit will be constructed to be able to do removal of carbide residue in every other month.

Outline of the pit is shown on Fig. 1-6.

2-6-7 Natural gas piping and its fixtures

SUI NORTHERN GAS PIPELINE CORPORATION will construct low pressure natural gas pipeline (2 kg/cm^2) to the factory from SUI Gas Station in Risalpur. So the distribution of the gas piping in the factory will be branched from the pipeline.

Natural gas will be used at such places as shwon on the following;

(a) Annealing furnace for bogie frame and forging furnace in maintenance shop

(b) Gas ranges in administrative office, foreman's office and canteen

(c) Fuel of the boiler for phosphating treatment

(d) Heater in winter season at foreman's office, clinic and time office

(e) Incinerater for sludge discharged from effluent treatment facility

(1) Characteristics of natural gas

Calorific value	10,000 ~ 10,500 Kcal/m^3
Pressure	≒ 80 ~ 120 mmAq
Specific gravity	0.58

(2) Gas consumption

(a) Annealing furnace for bogie frame

Inside dimension	4 m x 7 m x 3 m
No. of nozzle	8
(four nozzles arranged zig zag on each side)	
Maximum gas consumption for a nozzle	40 m^3/h
Total gas consumption in a day	320 m^3/h
(40 m^3/h x 8 = 320 m^3/h)	

(b) Forging furnace in maintenance shop

No. of nozzle	1
Gas consumption in an hour	40 m^3/h

(c) Gas consumption of the boiler for phosphating treatment

Volume of the phosphating treatment bath

1.5 m x 1.5 m x 6 m x 5 baths = 67.5 m^3

In order to raise the temperature 20°C of this volume of phosphate, the necessary gas amount is estimated about 64 m^3/h

(d) Gas range

Large type	2
(Dining room in administrative office and canteen)	
Small type	
(Clinic, foreman's office (6 places), coffee shop, time office and garage)	
Large type	4.85 m^3/h x 2 = 9.7 m^3/h
Small type	0.84 m^3/h x 10 = 8.4 m^3/h
Total	19.1 m^3/h

(e) Office heating

Total floor area for heating	950 m^2
Heating load	175,800 Kcal/h
Gas consumption in an hour	17.5 ≒ 18 m^3/h

From these, overall gas consumption is about 461.1 m^3/h.

(3) Gas piping

Gas pressure in the branched pipe is 80~120 mm Aq and diameter of the main pipe is 6 inches. Arrangement of the piping is shown on Fig. 6-7. Following formula is used in calculation of the diameter of the piping.

$$Q = K\sqrt{\frac{H \times D^5}{S \times L}} \quad (m^3/h)$$

where,

Q:	Gas consumption	m^3/h
K:	A factor	0.7055
H:	Pressure drop	mm Aq
L:	Length of pipe	m
D:	Inside dia. of pipe	cm
S:	Specific gravity of gas	0.58

2.6.8 Fuel supplying equipment and piping

This equipment will be installed to store and supply fuel oil used for test running of diesel electric locomotive and for operation of shunting locomotive.

(1) Underground fuel oil storage tank

The oil storage tank will be laid underground and it will have the capacity to be able to hold sufficient amount of fuel oil to be supplied to the diesel locomotives for a month.

(a) Assumption of fuel oil consumption for a month

i) Fuel oil consumption for test running

It is assumed that,

Number of locomotive performing test run for a month	2
Number of days required for test run for a locomotive	5 days

The operation time of engine is also assumed to be as follows;

Operation time in rated output	2 hours
Operation time in idling	2 hours

Therefore, total operation time for a month is as follows;

Operation time in rated output	20 hours
(2 hours x 5 days x 2 locomotives = 20 hours)	
Operation time in idling	20 hours
(2 hours x 5 days x 2 locomotives = 20 hours)	

Fuel oil consumption of engine is assumed to be as follows;

Operation in rated output	
2,000 PS	0.24 l/PS/h
Operation in idling	
700 PS	0.24 l/PS/h

Therefore, the fuel oil consumption for test running for a month is about 13,000 l.

(0.24 l/PS/h x 2,000 PS x 20 hours + 0.24 l/PS/H x 700 PS
20 hours = 12,960 l ≒ 13,000 l)

ii) Fuel oil consumption for shunting

Operation time of engine is assumed to be as follows;

Operation time in rated output	0.5 hours
Operation time in idling	0.5 hours

Fuel oil consumption of engine is assumed to be as follows;

Operation in rated output	
500 PS	0.24 l/PS/h
Operation in idling	
175 PS	0.24 l/PS/h

So, the fuel oil consumption for shunting for a month (24 days) will be 12,000 l.

(0.24 l/PS/h x 500 PS x 0.5 h x 24 days + 0.24 l/PS/h
x 175 PS x 0.5 h x 24 days = 1,944 ≒ 2,000 l)

iii) The amount of fuel oil to be replenished to the locomotives when they are leaving the factory

When diesel electric locomotives are leaving the factory fuel tanks of the locomotives are fully supplied with fuel oil and it is assumed that the total amount of fuel oil replenished for a month will be

7,000 l x 2 = 14,000 l

Where, a capacity of fuel oil tank of diesel electric locomotive is 7,000 l.

From the data mentioned above, total consumption of fuel oil is as follow;

13,000 l + 2,000 l + 14,000 l = 29,000 l

(b) Outline of fuel oil storage tank

The capacity of underground fuel oil storage tank is required to be 40,000 l from the above-mentioned data, and two oil tanks of 20,000 l will be laid in a pit.

(2) Equipment for fuel oil delivery piping

The performance of oil filter and oil supplying pump will be such as they can supply oil to the fuel oil tank of diesel electric locomotive having a capacity of 7,000 l.

Measuring instrument to measure the amount of fuel oil supplied to the fuel oil tank of diesel electric locomotive will be installed on the fuel supplying track. The plan of fuel supplying equipment and piping is shown on the Fig. 6-8.

3. DETAILS OF CONSTRUCTION SCHEDULE

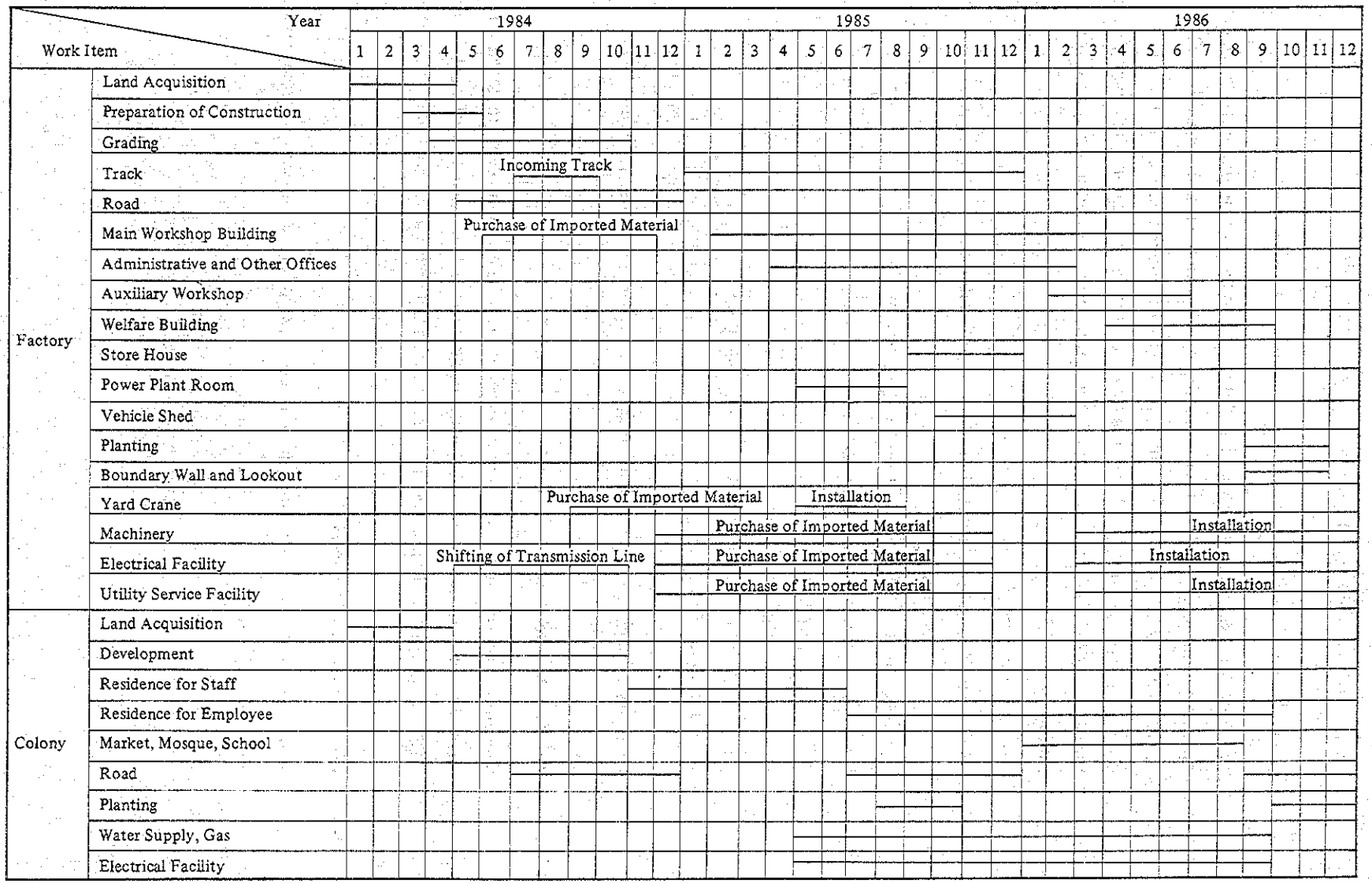
To commence the operation of locomotive manufacturing factory from the beginning of 1987, the construction will proceed through the following phases:

(a) Procurement of land and grading
(b) Laying to track for carrying in construction materials
(c) Temporary provision of access way, water supply, etc.
(d) Procurement of imported materials
(e) Construction of yard crane for unloading and storing of materials and machines from wagon
(f) Construction of building
(g) Construction of utility service facilities
(h) Construction of site electrical system
(i) Installation of machines
(j) Installation of lighting and telecommunication system

Details of construction schedule are shown in Table 3-1.

Of all buildings of the factory, the main workshop building should be completed as early as possible because the machine installation, electric work, utility service facilities of this building require considerable work period.

Table 3-1 Detailed Construction Schedule



4. DETAILS OF CONSTRUCTION COST

4-1 General

The unit price of each work was calculated on the basis of fundamental price elements such as labour cost, material, equipment, management cost, profit, etc. These unit prices were based on the distribution economy conditions as of July 1982. The local price was applied to those items procurable in the region. The composition of foreign currency and local currency in each unit price was determined according to the following classification.

Price composition in foreign currency:

- Purchasing cost of imported machinery and materials
- Wage of specialists
- Management cost and profit of foreign companies

Price composition in local currency:

- Local materials
- Wage of local employees
- Management cost and profit of local companies
- Commodity tax

Quantity of each work was calculated on the basis of preliminary design.

4-2 Analysis of Unit Cost

The unit cost of each work was calculated from the labour cost, material cost, etc. with due consideration on the local conditions. The conversion of cost in foreign currency portion to that in local currency was made with a rate at 1 Rs = ¥21.585.

4-3 Construction Cost Estimate

Table 4-1 shows the net construction cost excluding contingency, cost escalation, and import charges.

Table 4-1 Net Construction Cost

Unit: Million Rs

Item	FC	DC
Land acquisition		5.90
Civil		19.15
Track	1.18	4.78
Colony		93.35
Building	27.08	145.63
Production machinery	131.16	6.40
Auxiliary machinery	50.96	2.20
Site electrical system	21.53	20.34
Communication system	2.47	1.79
Utility service facilities	23.26	13.04
Sub-total	257.64	312.53
Share in expense for WAPDA, etc.		13.00
Fittings and appliances		0.93
Total	257.64	326.51

Table 4-2 Detailed Breakdown of Construction Cost

(1) Land acquisition

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Land acquisition	38	Acre		5.90				5.90
Total				5.90				5.90

(2) Civil

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Grading	204,900	M^3				6.65		6.65
Road works	34,100	M^2		3.87		1.66		5.53
Civil structure	1	Ls.		4.56		1.95		6.51
Planting	20,000	M^2		0.22		0.24		0.46
Total				8.65		10.50		19.15

(3) Track

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Track works	2,940	M	1.18	3.24		1.38	1.18	4.62
Turnout switching equipment	1	Ls.		0.10		0.06		0.16
Total			1.18	3.34		1.44	1.18	4.78

(4) Colony

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Land acquisition	214	Acre						5.10
Development	1	Ls.						17.00
Electric work	1	Ls.						4.00
Residence for staff	1	Ls.						11.80
Residence for employee	1	Ls.						38.35
Public utilities	1	Ls.						4.60
Road within colony	1	Ls.						7.00
Gas work	1	Ls.						3.50
Planting	1	Ls.						2.00
Total								93.35

(5) Building

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Preparation for construction	1	Ls.		2.59		2.96		5.55
Main shop building	23,382	M^2	23.80	60.69		40.51	23.80	101.20
Auxiliary shop building	1,275	M^2		2.30		1.54		3.84
Power plant building	716	M^2		1.19		0.80		1.99
Store house building	570	M^2		0.79		0.53		1.32
Office building	4,726	M^2		13.55		7.25		20.80
Welfare building	1,527	M^2		2.97		1.98		4.95
Vehicle shed & miscellaneous buildings	844	M^2		1.41		0.94		2.35
Boundary wall	1,800	M		0.60		0.90		1.50
Air conditioning equipment	3	Ls.	3.28	0.73		1.40	3.28	2.13
Total			27.08	86.82		58.81	27.08	145.63

(6) Production machinery

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Machinery for plate work	110	ea.	32.36				32.36	
Machinery for machining	23	ea.	26.93				26.93	
Machinery for assembling	41	ea.	28.93				28.93	
Material handling equipment	77	ea.	30.80				30.80	
Testing equipment	56	ea.	8.94				8.94	
Sending of engineers					3.20		3.20	
Installation works				3.84		2.56		6.40
Total			127.96	3.84	3.20	2.56	131.16	6.40

(7) Auxiliary machinery

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Testing equipment for laboratory	19	ea.	6.61				6.61	
Machinery for maintenance shop	21	ea.	14.78				14.78	
Shunting locomotive and vehicles	20	ea.	12.41				12.41	
Gantory crane and others	4	ea.	10.16				10.16	
Machinery for training	1	Ls.	3.15				3.15	
Tools	1	Ls.	2.75				2.75	
Sending of engineers					1.10		1.10	
Installation works				1.32		0.88		2.20
Total			49.86	1.32	1.10	0.88	50.96	2.20

(8) Site electrical system

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Sub-station equipment	1	Ls.	17.83	3.15		1.33	17.83	4.48
Load center	6	set		3.97		0.70		4.67
Power distribution line	8	km		3.53		1.44		4.97
Site lighting system	1	Ls.	0.88	0.64		0.48	0.88	1.12
Power service system for machinery in main shop	1	Ls.	1.16	2.32		2.78	1.16	5.10
Manufacturer's attendant	1	Ls.			1.66		1.66	
Total			19.87	13.61	1.66	6.73	21.53	20.34

(9) Communication system

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Telephone system	1	Ls.	0.93	0.09		0.17	0.93	0.26
Public address system	1	Ls.	0.23	0.05		0.07	0.23	0.12
Master clock system	1	Ls.	0.19			0.07	0.19	0.07
Fire alarm system	1	Ls.	0.23			0.09	0.23	0.09
Communication cabling	6	km		0.83		0.42		1.25
Manufacturer's attendant	1	Ls.			0.89		0.89	
Total			1.58	0.97	0.89	0.82	2.47	1.79

(10) Utility service facilities

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Water supply and drainage system	1	Ls.		3.90		1.67		5.57
Ground water treatment facilities	1	Ls.	3.87	0.64		0.27	3.87	0.91
Effluent treatment facility	1	Ls.	12.72	1.70		1.27	12.72	2.97
Compressed air piping system	1	Ls.	3.67	0.21		0.27	3.67	0.48
Acetylene gas piping system	1	Ls.	2.50	0.08		0.09	2.50	0.17
Natural gas piping system	1	Ls.		0.18		0.18		0.36
Fuel oil plant	1	Ls.	0.50	0.02		0.06	0.50	0.08
Share in expense for SUI gas line				1.25		1.25		2.50
Total			23.26	7.98		5.06	23.26	13.04

(11) Share in expense for WAPDA, etc.

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Cost for 132 kv power receiving						12.15		12.15
Cost for subscriber telephone service						0.80		0.80
Cost for elimination of 11 kv distribution line						0.05		0.05
Total						13.00		13.00

(12) Fittings and Applyances

UNIT: MILL. Rs

WORK ITEM	QUANTITY		MATERIAL COST		LABOUR COST		CONSTRUCTION COST	
			FC	DC	FC	DC	FC	DC
Fittings and Applyances				0.93				0.93
Total				0.93				0.93

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