Table 7-5 SUMMARY OF INSTRUMENTATION WORK (2/2)

Major Category	Sub-category	Remarks
	(2) Temperature control for benzol rich oil at outlet of heating furnace	
	(3) Flow rate control for wash oil	
	(4) Temperature control at top of light oil distilling tower	
	(5) Liquid level control for oil and water separation tank	
6 Waste water treatment plant	(1) pH control for neutralization tank	
	(2) ORP control for aeration tank	
7 Water supply system	(1) Liquid level control	
8 Weighing equipments	(1) Coal truck weigher	
	(2) Coal receiving belt conveyor weigher	
	(3) Coal preparation belt conveyor weigher	
	(4) Blending bin feeder and control	
	(5) Coal charge weigher	
	(6) Coke handling belt conveyor weigher	
	(7) Coke shipment belt conveyor weigher	
	(8) Ammonium sulfate belt conveyor weigher	
9 CPU systems	(1) Process computers for coal preparation facility	
	(2) Process computers for coke oven	
	(3) Process computers for gas purifying plant	

7.6.4 Civil Engineering and Construction

(1) General

Site preparation for the La Cañada plant site has been mostly completed. Civil engineering and construction works required for the proposed plant are foundations, buildings, roads, fences, and outlying structures.

Construction of buildings and structures for the coke making plant is very difficult because it involves robust foundations to support heavy loads, foundations and footings of complex shape, and complicated interface between facilities and equipment. Thus, qualified contractors with sufficient expertise and experience must be hired for the plant construction.

According to information obtained during the field survey, there are various companies in Venezuela, who have capability and experience in construction of process plants, including power plants and petrochemical plants. Thus, this feasibility study assumes that civil engineering and construction of the plant will be constructed by local contractors, in accordance with construction methods, and building and material standards generally accepted in the country.

(2) Major civil engineering and construction work

Civil engineering and construction work required for the plant is summarized in Table 7-6.

Table 7-6 SUMMARY OF CIVIL ENGINEERING AND CONSTRUCTION WORK (1/5)

Major Category	Sub-category	Remarks
1 Foundations for coke oven facility	(1) Foundation for coke oven (2) Foundation for coal charge bin	Including control rooms, switchboard rooms, and resting rooms related to coke oven
	(3) Foundation for end deck (4) Gas pipe pit (5) Foundation for chimney (6) Foundation for dust collecting duct (7) Foundation for quenching tower (8) Foundations for pump and sedimentation pond (9) Foundation for gas pipe support	
2 Foundations for moving machines related to coke oven	(1) Rail track for pusher machine	
	(2) Rail track for quenching car	
	(3) Rail track for coke guide car	Laying work only
	(4) Rail track for charging car	Laying work only
3 Foundation for dust collection facilities around coke oven	(1) Foundation for dust collector for coke guide car (2) Foundation for dust collector for charging car	
4 Foundations for coal receiving facilities	(1) Rail tracks for unloaders and shiploaders (2) Foundations for underground pit and receiving bin for domestic coal (3) Foundations for belt conveyors (4) Rail track for stackers (5) Foundation for coal yard (6) Foundation for berth switchboard room	
5 Foundations for coal preparation facility	(1) Rail track for reclaimers (2) Foundations for belt conveyors (3) Foundations for crushers and dust collectors (4) Foundations or intermediate towers	

Table 7-6 SUMMARY OF CIVIL ENGINEERING AND CONSTRUCTION WORK (2/5)

Major Category	Sub-category	Remarks
	(5) Foundations for blending bin and dust collectors	
	(6) Foundation for coal mixer	
	(7) Foundation for sludge adding equipment	
	(8) Foundation for dust collector for coal charge bin	
	(9) Foundation for coal preparation control room	Including switchboard room
6 Foundations for coke handling and shipping facilities	(1) Foundations for coke wharves	
	(2) Foundations for coke cutter room and dust collectors	
	(3) Foundations for belt conveyors	
	(4) Rail track for stackers	
	(5) Foundation for coke yard	
	(6) Rail track for reclaimer	
	(7) Foundation for screening room and dust collector	
7 Foundations for pollution control facilities for yards	(1) Foundation for water collection pit	
	(2) Reservoir and foundation	
	(3) Foundations for thickener and dehydrator	
	(4) Foundation for pit to water sprinkled over coal and coke yards	
	(5) Foundation for yard sprinkling pump	
8 Foundations for gas exhausting plant	(1) Foundation for indirect cooler	
	(2) Foundation for direct cooler	
	(3) Gas exhausting room, building foundation	Including control rooms, switchboard rooms, and resting rooms
	(4) Foundation for electric precipitator	
	(5) Foundation for ammonia liquor stripper	
	(6) Foundation for decanter	For ammonia liquor and tar
	(7) Foundations for side ditches and pits for ammonia liquor and tar	
	(8) Foundations for pumps and auxiliary facilities	

Table 7-6 SUMMARY OF CIVIL ENGINEERING AND CONSTRUCTION WORK (3/5)

Major Category	Sub-category	Remarks
	(9) Foundation for pipings, heat exchangers, and auxiliary facilities	
	(10) Foundations for tanks and auxiliary facilities	Including oil retaining wall
9 Foundations for desulfurization and sulfuric acid plants	(1) Foundation for wet desulfurization plants	
	(2) Foundation for sulfuric acid plant	
	(3) Foundations for pumps and auxiliary facilities	
	(4) Foundations for piping, heat exchangers, and auxiliary facilities	
	(5) Foundation for tanks auxiliary facilities	Including liquid retaining wall
10 Foundations for ammonium sulfate plant	(1) Foundation for ammonia recovery plant	
	(2) Foundations for ammonium sulfate separator and dryer, and buildings	Including switchboard room
	(3) Foundations for ammonium sulfate storage and feeder facility buildings	
	(4) Foundations for final coolers	
	(5) Foundations for pumps, and auxiliary facilities	
	(6) Foundations for piping, heat exchangers, and auxiliary facilities	
11 Foundations for light oil recovery plant	(1) Foundation for naphthalene scrubber	
	(2) Foundation for light oil scrubber	
	(3) Foundation for light oil stripper	
	(4) Foundations for pumps and auxiliary facilities	
	(5) Foundations for pipings, heat exchangers, and auxiliary facilities	
	(6) Foundations for tanks and auxiliary facilities	Including oil retaining wall

Table 7-6 SUMMARY OF CIVIL ENGINEERING AND CONSTRUCTION WORK (4/5)

Major Category	Sub-category	Remarks
12 Foundations for waste water treatment plant	(1) Foundation for activated sludge treatment plant	Including aerations and adjustment tanks
	(2) Foundations for activated carbon adsorptions tower and regenerator	
	(3) Foundations for pumps, blowers, and auxiliary facilities	Including switchboard room
	(4) Foundations for piping, heat exchangers, and auxiliary facilities	
	(5) Foundations for tanks and auxiliary facilities	
13 Foundation for COG holder	(1) Foundation for COG holder	
	(2) Foundations for pumps and auxiliary facilities	
	(3) Foundations for piping and auxiliary facilities	
14 Foundation for gas blowers	(1) Foundations for gas blowers and buildings	
	(2) Foundations for piping and auxiliary facilities	
15 Foundations for tank yard	(1) Foundation for crude tar tank	Including oil retaining wall
	(2) Foundation for crude light oil tank	Ditto
	(3) Foundation for received wash oil tank	
	(4) Foundations for pumps and auxiliary facilities	
	(5) Foundations for pipings and auxiliary facilities	
16 Foundations for cooling water system	(1) Foundation for cooling water system	Including pits
	(2) Foundations for pumps and auxiliary facilities	
	(3) Foundations for piping and auxiliary facilities	
17 Foundations for air compressor facility	(1) Foundation for air compressor building	Including switchboard room
	(2) Foundations for piping and auxiliary facilities	
18 Foundations for nitrogen generator	(1) Foundation for PSA device	

Table 7-6 SUMMARY OF CIVIL ENGINEERING AND CONSTRUCTION WORK (5/5)

Major Category	Sub-category	Remarks
	(2) Foundations for piping and auxiliary facilities	
19 Foundations for boiler plant	(1) Foundations for boiler	Including switchboard room for boiler plant
	(2) Foundations for auxiliary facilities	Including tanks and water supply system
	(3) Foundations for pumps and auxiliary facilities	
	(4) Foundations for piping and auxiliary facilities	
20 Foundations for water supply system	(1) Foundation for industrial water receiving pit	Including switchboard room
	(2) Foundation for portable water receiving tank	
	(3) Foundations for pumps and auxiliary facilities	
	(4) Foundations for piping and auxiliary facilities	
21 Other foundations	(1) Foundation for substation building	
	(2) Foundations for office buildings	Including locker rooms and shower rooms
	(3) Foundation for testing laboratory building	
	(4) Foundation for maintenance shop	
	(5) Foundations for material warehouses	
	(6) Road, side ditches, and parking facilities	Width of main roads – 10m/20m
	(7) Green belts	

7.6.5 Testing and Analysis Facility

(1) General

In connection with operation of the coke making plant, many tests need to be conducted for a variety of purposes, including quality control of coke and by-products and pollution control.

(2) Quality of coke and by-products

It is important to maintain qualities of coke and by-products shipped to markets within design specifications, with minimum variation. For this purpose, properties of coals delivered must be checked carefully and are furnished to plant operating divisions as feedback information. Also, periodical analysis of waste gas and waste water needs to be performed for effective environmental monitoring and pollution control. Table 7-7 lists major equipment and apparatuses required for various tests and analyses.

Table 7-7 LIST OF MAJOR TESTING EQUIPMENT

	Testing Items	Equipment
Coal	Carbonization test	Simulated coke oven
	Proximate analysis	Sample preparation equipment, electric furnace
	Coking properties	Fluidity/dilatation meter, FSI meter
	Calorific value	Measuring instruments
	Ultimate analysis	Measuring instruments, total sulfur meter
	Ash fusibility	Electric furnace, molder
	Maceral analysis	Molder, grinder, microscope
	Ash composition	Atomic absorption spectro photometer, absorption spectro photometer
Coke	Sample preparation	Crusher, sample reduction equipment, automatic screening equipment
	Strength tests	Drum strength, tumbler strength, Micum strength, Shatter strength, MSI, CSR/CRI
	Porosity	Measuring instruments
By-products Pollution	Component analysis	Gas chromatography, ion chromatography Distillation tester, absorption spectro photometer, atomic absorption spectro photometer Dust counter, sampler (whole set), ozone generator Noise meter, extractor, gas meter, gas sampler

7.7 Major Equipment List

7.7.1 Coal Unloading and Preparation Facilities

No.	Name of Equipment	Major Specification		Remarks
1	**Coal Unloading Facilities**			
	1) Unloader for Imported Coal	Type	Grab Trolley	
		Number	2	
		Capacity	1,500 t/h/unit	
	2) Unloading Facilities for Domestic Coal	Type	Underground Pit	
		Number	1	
		Receiving Capacity	200 t/h	
		Capacity of Hopper	300 t x 5	
		Discharging	1,500 t/h	
	3) Coal Stacker	Type	Stacker for Coal	
		Number	2	
		Capacity	1,500 t/h/unit	
	4) Coal Stock Yard	Area	25,000 m^2 x 4 fields	
		Capacity of Stock	240,000 t	
	5) Water Sprinkling Equipment for Coal Yard	Type	Sprinkler	Environmental Protection
		Pump Pressure	7 kg/cm^2	
	6) Facilities of Taking Measures Water of Coal Yard	Capacity of	2,000 m^3	Environmental Protection
		Capacity	10 m^3/h	
	7) Belt Conveyor Line	A Complete Set		
2	**Coal Preparation Facilities**			
	1) Coal Reclaimer	Type	Rotary Bucket	
		Number	3	
		Capacity	200 t/h/unit	
	2) Coal Crusher	Type	Hammer Crusher	
		Number	3	1 – spare
		Capacity	200 t/h/unit	

No.	Name of Equipment	Major Specification		Remarks
	3) Coal Blending Bin	Type	Construction of Iron Frame and Plates (With	
		Number	10 bin	
		Capacity	300 t/bin	
	4) Constant Feeder	Type	Constant Feed Weigher	
		Number	10	
		Capacity	6-50 t/h/feeder	
	5) Coal Mixer	Type	Double Roll Type	
		Number	2	1 – spare
		Capacity	300 t/h/mixer	
	6) Charging Coal Bin	Type	Reinforced Concrete	
		Number	3 bins	
		Capacity	1,000 t/bin	
	7) Equipment Adding Tar-sludge and Surplus Activated	A Complete Set		
	8) Magnet Separator			
	a) Magnet Separator	Number	3	
	b) Magnet Detector	Number	3 sets	
	9) Coal Sampler	Type	Swing Arm Type	
		Unloading Routes	2	
		Discharging Routes	2	
		Blending and Mixing Routes	1	
	10) Conveyor Weigher	Unloading Routes	2	
		Discharging Routes	3	
		Blending and Mixing Routes	1	
	11) Belt Conveyor	A Complete Set		
		(Hood are installed in BC after crusher)		Enviornmental Protection

No.	Name of Equipment	Major Specification		Remarks
3	**Dust Collector**			
	1) Hopper for Domestic Coal	Type Number Rate of flow	Bag filter 1 600 m^3/min	Enviornmental Protection
	2) Crushing Room	Type Number Rate of flow	Bag filter 1 800 m^3/min	Enviornmental Protection
	3) Blending Bin	Type Number Rate of flow	Bag filter 1 1,000 m^3/min	Enviornmental Protection
	4) Charging Coal Bin	Type Number Rate of flow	Bag filter 1 800 m^3/min	Enviornmental Protection

7.7.2 Coke Oven Facilities

No.	Name of Equipment	Major Specification		Remarks
1	**Coke Oven Facilities**			
	1) Coke Oven Battery	Number of chambers	100	
		Dimension of chamber (mm)	6,500 x 16,500 x 450 (6.050)(15.600)	( ):Effective length
		Efective volume of chamber	42.5 m^3/chamber	
		Taper of chamber	70 mm	
		Distance of oven	1,350 mm	
		Depth of oven top deck	1,300 mm	
		Diameter of charging hole, number	410 mmd x 5	
		Method of gas supply	COG: Underjet	Single stage
			AIR: Gun Type	
		Number of Flue	30 Flue/row	
		Flue Arrangement	Hairpin and zigzag flue	
	2) Metal Hardware Attaching to Coke Oven			
	a) Ascesion pipe	Outer x nner diameter	640 mmd x 500 mmd	Lining is coated with brick
		Number	100	
		Material	SS41	
		Top cover	Water seal	Enviornmental Protection
	b) Bend	Inner diameter	500 mmd	
		Number	100	
		Material	FCD	
		Slide part	Water seal	Enviornmental Protection
	c) Collecting Main	Inner diameter	2,000 mmd	
		Material	SS41	

No.	Name of Equipment	Major Specification		Remarks
	d) Flare pipe	Type	Auto Ignition	Enviornmental Protection
		Outer diameter x height	800 mmd x 15mH	
		Number	4 pipes x 2	
		Quantity of discharging gas	Max. 60,000 Nm³/h	
	e) Buckstay	Dimension of section	H–shape 422 mm x 315 mm Thickness 25 mm/32 mm	
	f) Platform	Width CS	4,000 mm	
		Width PS	4,000 mm	
		Structure of floor	Concrete + iron plate	
	g) Oven Door and Door Frame	Type	Air–cooled self–sealing type Side roller locking	
		Number	208 (= 104 x 2) (CS, PS)	Incl. 8 spares
		leveling door	Opening and Closing for 180℃ horizontally	
		Mmaterial - Main body	FCD	
		- Seal plate	YUS 304N	
		- Knife edge	Jucole Steel	
	h) Coal charge, discharge device	Type	Alligator mouth type	
		Opening and Closing power	Air cylinder	
		Number	5 gates x 3 rows	
3)	Heating Units			
	a) Gas Reversing Machine	Type	Oil hydraulic	
		Number	2 sets/coke oven battery	
		Cylinder	COG 4 COG purge 4 Waste valve 2	
	b) Reversing and Adjusting Cock	Reversing cock	COG 204	
		Adjusting cock	COG 204	

No.	Name of Equipment	Major Specification		Remarks
	c) Waste Valve	Number	208 (= 104 x 2)	
		Material	FCD	
	d) Ventilation Blower	Capacity	200 m³/min	
		Pressure	300 mmAq	
		Electric motor	30 KWh	
	e) COG Purgig Fan	Capacity	300 m³/min	
		Pressure	350 mmAq	
		Electric motor	37 KWh	
	f) Chimney	Type	Concrete self-standing	
		Number	1 (A, B common)	
		Height	120 m	
		Outer diameter	Outlet: 5,730 mmd Basement: 8,320 mmd	
	g) Automatical Combustion Control System	cf. instrumentation equipment		
4)	Equipment Attaching to Coke Oven			
	a) Oven Door Repairing Device	Type	Turning upside down	
		Number	2 set x 2 (CS, PS)	
	b) Spare Door Holder	Number	2 set x 2 (CS, PS)	
	c) Dust Monitor	Number	2	Enivironmental Protection
	d) NOx Meter	Number	2	Enivironmental Protection
	e) SOx Meter	Number	2	Enivironmental Protection
5)	Coke Quenching Equipment			
	a) Quenching Tower	Structure	Concrete Height 45 m Area of discharge outlet 48m²	
	b) Structure of Dust Separatio	Type	Demister	Enivironmental Protection

No.	Name of Equipment	Major Specification		Remarks
	c) Sprinkling	Type	High level tank	
		Capacity	90 m^3	
		Nozzle	For quenching	
		Nozzle	For cleaning of dust	
	d) Storage Pump	Capacity	600 m^3/h	
		Pump head	40 m	
		Electric motor	90 KWh (3,300V)	
	e) Pump for Demister	Capacity	260 m^3/h	
		Pump head	40 m	
		Electric motor	45 KWh (440V)	
	f) Settling Pond	Type	Under flow	
		Number	200 m^3	
	g) Telpher	Type	Grab Bucket	
		Number	1	

No.	Name of Equipment	Major Specification		Remarks
2	**Coke Oven Machinery**			
	1) Charging Car	Type	Welded construction gate	
		Number	2	
	a) Traveling Device	Drive System	Twin drive system	
		Traveling Speed	90 m/min	
		Electric motor	37 KWh x 2	
	b) Coal Feeder	Type	Stationary position coal charging system equipped with a	
		Loading capacity	Max. 35 t	
		Number	5 sets	
		Charging time	Less than 100 sec.(20 rpm)	
		Charging hood	Double hood	Enivironmental Protection
	c) Charging Hole Lid Lifting Device	Type	Rotary electromagnet type S-character motion	
	d) Oven Top Cleaning Device	Type	Moving vacuum cleaner loaded with charging car	Enivironmental Protection
		Dust catcher	Bag filter	
	e) Oil Hydraulic Unit	Type	Vane pump	
		Capacity	82 l/min	
		Electric motor	18.5 KWh	
	f) Mortar Sealing Device	A complete Set		Enivironmental Protection
	g) Cooler	A complete Set		Enivironmental Protection
	2) Pusher Machine	Type	Welded construction gate	
		Number	2	
	a) Pushing Device	Pushing speed	25 m/min	
		Drive method	Upper Rack Method	
		Electric motor	160 KWh	

No.	Name of Equipment	Major Specification		Remarks
	b) Coal Leveling Device	Leveling speed	60 m/min	
		Drive method	Rope method	
		Inserting and extracting chute	Oil hydraulic straight advancing	
	c) Returned Coal Handling Device	Type	Chain conveyor	
		Capacity	30 t/h	
	d) Leveling Door Opening Device	Type	Oil hydraulic drive	
			(Opeing and closing for 180℃ horizontally)	
	e) Traveling Device	Drive method	Twin Drive system	
		Traveling speed	60 m/min	
	f) Oven Door Attaching and Removing Device	Drive method	Oil hydraulic	
		Straight advancing speed of lifter	10 m/min	
	g) Door Cleaning Device	Type	Water jet + screw cutter	
	(leveling door cleaning device contained)	Drive method	Oil hydraulic	
		Capacity of water jet pump	20 l/min	
		Pressure	700 kg/cm^2	
	h) Seat Cleaning Device	Type	Scraper cleaning for seat surface and frame inside	
		Drive method	Oil hydraulic	
	i) Returned Coke Handling Device	Type	Chain conveyor	
		Capacity	10 t/h	
		Capacity of returned coke	4 m^3	
	j) Cooler	A complete set		Eniivironmental Protection
3)	Coke Guide Car	Type	Welded Steel plate construction 1 point type	
		Number	2	
	a) Traveling device	Drive method	Twin Drive system	
		Traveling speed	50 m/min	

No.	Name of Equipment	Major Specification		Remarks
	b) Oven Door Attaching and Removing Device	Drive method	Oil hydraulic, mounted on side of lifter	
		Straight advancing speed of lifter	10 m/min (max)	
		Rotating Angle	90 degree (with respect to the oven surface)	
	c) Coke Guide Device	Type	Through-shaped bottom plate of cast steel lined a heat-insulating material	
		Drive method	Oil hydraulic	
		Straight advancing speed of guide	10 m/min (max)	
	d) Door Cleaning Device	Type	Water jet + screw cutter	
		Drive method	Oil hydraulic	
		Capacity of water jet pump	20 l/min	
		Pressure	700 kg/cm^2	
	e) Seat Cleaning Device	Type	Scraper cleaning for seat surface and frame inside	
		Drive method	Oil hydraulic	
	f) Returned Coke Handling Device	Type	Chain conveyor	
		Capacity	10 t/h	
		Capacity of returned coke	1 m^3	
	g) Cooler	A Complete Set		Enivironmental Protection
4)	Quenching Car Locomotive	Traction Capacity	250 t	
		Number	2	
		Track guage	1,435 mm	

No.	Name of Equipment	Major Specification		Remarks
	a) Traveling Device	Type	Thyristor control	
		Drive method	Twin drive system	
		Traveling speed	Max. speed 180 m/min	
			Medium speed 60 m/min	
			Low speed 5 m/min	
	b) Cooler	A complete set		Enivironmental Protection
	5) Quenching Car	Type	ate open-close	
		Loading capacity	25 t	
3	**Dust Collector of Coke Oven Facility**			
	1) Dust Collector of Coke Guide Car	Type	Bag filter	Enivironmental Protection
		Rate of flow of blower	6,000 m /min (at 30 ℃)	
		Static pressure of blower	600 mmAq	
		Dust bin	20 m^3	
		Number	1	
		Quantity of dust in outlet	50 mg/Nm^3	
	2) Dust Collector of Charging Car	Type	Bag filter	Enivironmental Protection
		Rate of flow of blower	1,000 m^3/min (at 50℃)	
		Static pressure of blower	3,400 mmAq	
		Quantity of dust in outlet	50 mg/Nm^3	
	3) Smokeless Charging Device at Ascesion Pipe	Type	High pressure ammonia water jet	Enivironmental Protection
		Valve	Three-way ball valve	
		Ammonia water pump	20 m^3/h x 30 kg/cm^2	
		Number	2	1 - spare

7.7.3 Coke Handling and Shipment Facilities

No.	Name of Equipment	Major Specification		Remarks
1	**Coke Handling Facilities**			
	1) Coke Wharf	Type	Slant (Tile lining)	
		Number	6 fields	
		Capacity	50 t/fields	
	2) Feeder	Type	Roll feeder	
		Number	6	
		Capacity	200 t/h/unit	
	3) Coke Cutter	Type	Double roll	
		Number	2	1 – spare
		Capacity	100 t/h/unit	
	4) Coke Screen	Type	Bar Screen	
	a) Before Coke Cutter	Number	1	
		Capacity	200 t/h	
	b) Screen (Production coke)	Type	Vibrating screen	
		Number	1	
		Capacity	200 t/h	
		Screen Mesh	25 mm lattice	
	5) Coke Stacker	Type	Stacker for coke	
		Number	2	
		Capacity	200 t/h/unit	
	6) Coke Stock Yard	Area	16,000 m x 4 fields	
		Stock Capacity	96,000 t	
	7) Belt Conveyor	A Complete Set (Including hood cover, water sprinkling device)		Environmental Protection
2	**Coke Shipment Facilities**			
	1) Coke Reclaimer	Type	Rotary Bucket Wheel	
		Number	2	
		Capacity	300 t/h/unit	

No.	Name of Equipment	Major Specification		Remarks
	2) Stack–Reclaimer	Type	Rotary Bucket Wheel	
		Number	1	
		Capacity	Stacker: 300 t/h Reclaimer:300 t/h	
	3) Screen (Shipping Coke)	Type	Vibrating Screen	
		Number	2	
		Capacity	300 t/h/unit	
		Screen Mesh	25 mm lattice	
	4) Ship Loader	Type	Vertical Conveyor	
		Number	1	
		Capacity	600 t/h	
	5) Magnet Detector	Number	1 set	
	6) Coke Sampler	Type	Cutter Bucket	
		Shipment Routes	2	
	7) Conveyor Weigher	Handling and Shipment Routes	2	
	8) Belt Conveyor	A Complete Set (Including Hood Cover, Water Sprinkling Device)		Environmental Protection
3	**Dust Collector**			
	1) Cutter & Screening Room	Type	Bag Filter	Environmental Protection
		Number	1	
		Rate of Flow	2,000 m^3/min	
	2) Shipment Screening Room	Type	Bag Filter	Environmental Protection
		Number	1	
		Rate of Flow	1,000 m^3/min	

7.7.4 Gas Purifying Facilities

No.	Name of Equipment	Major Specification		Remarks
1	**Gas Cooling and Exhausting Plant**			
	1) Gas Exhausting, Tar, Ammonia Liquor Separator			
	a) Primary Gas Cooler	Type	Indirec/Direct Combination (Indirect: Horizontal Tube) (Direct: Spray)	
		Number	Indirect 3 Direct 1	1 – spare
		Capacity	COG capacity Max.60,000 Nm³/h Outlet COG temperature Less than 35℃ Indirect 30,000 Nm³/h/Unit Direct 60,000 Nm³/h	
	b) Gas Exhauster	Type	Turbo Blower (Variable speed)	
		Number	3	
		Capacity	30,000Nm³/h/unit Suction Pressure –400 mmAq Pressure raised 2,100 mmAq	
	c) Electrical Precipitator	Type	Vertical, natural flow of Tar	
		Number	2	
		Capacity	30,000 Nm³/h/unit Outlet Tar Mist 50 mg/Nm³	
	d) Ammonia Liquor Decanter	Type	Vessel type, Scraper Conveyor	
		Number	2	
		Capacity	500 m³/unit	

No.	Name of Equipment	Major Specification		Remarks
	e) Tar Decanter	Type	Vessel type, Scraper Conveyor	
		Number	1	
		Capacity	250 m^3/unit Outlet moisture contents of tar Less than 5%	
	f) Super Decanter	Type	Centrifugal and sedimental	
		Number	2	1 – spare
		Capacity	5 t/h/unit Outlet moisture contents of tar Less than 3%	
	g) Ammonia Water Circulation Pump	Type	Centrifugal	
		Number	2	1 – spare
		Capacity	1,000 m^3/h x 60 m/unit	
		Diesel Engine Back-up (emergency)		
	2) Ammonia Still	Type	Cap Tray	Environmental Protection
		Number	2	1 – spare
		Capacity	Capacity 30 m^3/h/unit Buffer Tank 1,000 m^3 x 2 NaOH 0.5 m^3/h (25% NaOH) NaOH Tank 30 m^3 x 1	
2	**Desulfurization and Sulfuric Acid Plant**			Environmental Protection
	1) Desulfurization Plant	Type	Wet Purification	
		Number	A Complete Set	
		Capacity	60,000 Nm^3/h H2S Inlet 5 g/Nm^3 Outlet 0.2 g/Nm^3 HCN Inlet 1.5 g/Nm^3	

No.	Name of Equipment	Major Specification		Remarks
	2) Sulfuric Acid Plan	Type	Contact and Oxidation Process	
		Number	A Complete Set	
		Capacity	Sulfuric Acid 17 t/day (By-Product Sulfuric Acid 300 t) (By Purchased Sulfuric 300 t)	
3	**Ammonium Sulfate Plant**			
	1) Ammonia Scrubber	Type	Spray	Environmental Protection
		Number	1	
		Capacity	60,000 Nm^3/h NH3 Inlet 8 g/Nm^3 Outlet 0.1 g/Nm^3	
		Ammonium Sulfate Production Capacity	44 t/day	
	2) Ammonium Sulfate Refining and Drying Device	Type	Centrifugal Separation	
		Number	A Complete Set	
		Capacity	2 t/h	
	3) Ammmonium Sulfate Storage and Discharge Device	Type	Storage	
		Number	A Complete Set	
		Storage Capacity	700 t	
4	**Light Oil Recovery Plant**			
	1) Naphthalene Scrubber	Type	Spray Tower	
		Number	1	
		Capacity	60,000 Nm^3/h	
	2) Light Oil Scrubber	Type	Tellaret filling up Tower	
		Number	1	
		Capacity	60,000 Nm^3/h BTX Inlet 32 g/Nm^3 Outlet 5 g/Nm^3 Naphthalene Inlet 2.5 g/Nm^3 Outlet 0.3 g/Nm^3	Sum of debenzol and denaphthalene

No.	Name of Equipment	Major Specification		Remarks
	3) Light Oil Distillation Plant	Type	Steam Distillation	
		Number	A Complete Set	
		Capacity	120 m^3/h	
5	**Waste Water Treatment Plant**			Environmental Protection
	1) Activated Sludge Treatment Plant	Type	Channeling Flow Type	
		Number	2,000 m^3 x 3	
		Capacity	30 m^3/h (Ammonia Liquor)	
	2) Activated Carbon Adsorption Plant, Regeneration Plant Capacity	Type	Adsorption Tower: Vertical Cylinder Type Regeneration Furnace: Kiln Type	
		Number	A Complete Set 30 m^3/h (Ammonia Liquor Feed)	
6	**COG Holder**	Type	Wet Type	
		Number	1	
		Capacity	50,000 m^3	
7	**Gas Boost Blower**	Type	Turbo	
		Number	2	1 – spare
		Capacity	30,000 Nm^3/h/unit Suction Pressure 500 mmAq	
		Pressure Raised	1,000 mmAq	
8	**COG Piping**	A Complete Set Distance between COG Holder and Power Station	2 km	
9	**Tank Yard**	Type	Corn Roof	
	1) Crude Tar Tank	Number	3,000 m^3 x 2	
	2) Crude Light Oil Tank	Number	3,000 m^3 x 2	
	3) Creosote Oil Tank	Number	500 m^3 x 1	

No.	Name of Equipment	Major Specification		Remarks
10	**Fire Extinguisher**			
	1) Fire extinguisher	A Complete Set		Gas purifying area
	2) Stand pipe	A Complete Set		Entire plant
11	**Utility Facilities**			
	1) Chilling Unit	Type	Forced Draft	
		Number	3	1 – spare
		Capacity	1,800 m^3/h/unit Inlet Temperature 45℃ Outlet Temperature 30℃	
	2) Air Compressor	Type	Screw	
		Number	3	1 – spare
		Capacity	7 Nm^3/min/unit Pressure 7 Kg/cm^2	
	3) N2 Generator	Type	PSA (Pressure Swing Adsorption)	
		Number	1	
		Capacity	100 Nm^3/h Pressure 7 Kg/cm^2	
		Holder	1,000 Nm^3 (at 7 Kg/cm^2)	
	4) Boiler Unit	Type	COG Exclusion Burning	
		Number	2	1 – spare
		Capacity	15 t/h/unit Pressure 7 Kg/cm^2	
	5) Industrial Water Receiving/Supply Facility	Tank	5,000 m^3 x 2	
		Pump	400 m^3/h x 2 Pressure 7 Kg/cm^2	1 – spare
	6) Portable Water Receiving Supply Facility	Tank	200 m^3 x 1	
		Pump	50 m^3/h x 2 Pressure 7 Kg/cm^2	1 – spare
		Filtering equipment	A Complete Set	
	7) Fire Water Facility	Pump	320 m^3 h x 1 Pressure 11 Kg/cm^2	

7.7.5 Common Facilities

No.	Name of Equipment	Major Specification		Remarks
1	**Substation**	Type Number Area	One-Storied House 1 1,000 m^2	
2	**Office**	Type Number Area	Three-Storied House 1 800 m^2	1st: Rocker Room 2nd: Office Room 3rd: Conference Room
3	**Experiment Station**	Type Number Area	One-Storied House 1 800 m^2	Within Apparatus
4	**Maintenance Factory**	Type Number Area	One-Storied House 1 750 m^2	
5	**Warehouse for Materials**	Type Number Area	Warehouse 1 600 m^2	
6	**Road**	Area	84,800 m^2	Asphalt Pavement
7	**Parking Lot**	Area	38,400 m^2	Asphalt Pavement
8	**Waste Channel**	Length	2,200 m + 3,000 m	Concrete
9	**Green Belt**	Area	144,800 m^2	Tree, Lawn
10	**Utility Line**	A Complete Set (For Common Equipment)		

7.8 Plant Equipment and Materials, and Supply Sources

7.8.1 General

Equipment and materials required for construction of the proposed coke making plant should be procured locally as far as possible. It should be noted, however, that most of them are refractory bricks and plant equipment.

Refractory bricks are a major factor in determining service life of the coke oven which has been reportedly extended over 30 years. In fact, they are required to meet increasingly high standards in quality, shape and other aspects, suggesting that the use of imported firebricks is a logical choice. Similarly, machinery and equipment purchased for fixed capital investment made in Venezuela is dominated by imported products which account for around 80% of total (between 1987 and 1988). Also, 80% of equipment and materials used for construction of petrochemical plants, power plants, and steel plants are reportedly imported. In consideration to these factors, it is assumed that equipment and materials which must meet high performance requirements will be imported.

7.8.2 Classification of Equipment and Materials Sourcing

Table 7-8 classifies major equipment and materials used for the plant construction according to their supply sources, namely import or domestic.

Table 7-8 LIST OF PROCURED EQUIPMENT AND MATERIALS BY SOURCE

Item	Category		Remarks
	Import	Domestic	
1) Refractory bricks for coke oven	o		Coke oven constructed locally
2) Castings for coke oven	o		Partially procured locally
3) Purchased equipment	o		Installed locally
4) Construction materials			
a) Steel piles		o	
b) Concrete piles		o	
c) Steel pipes for gas pipeline		o	
d) General steel materials		o	
e) Reinforced bars		o	
f) Building finish materials, girder crane	o		
Roofing materials		o	
Wall materials		o	
g) Rails	o		
h) Concrete, cement		o	
i) Other materials		o	Asphalt, aggregates
j) Construction bricks		o	
k) Wires and cables		o	
l) Lighting equipment		o	
m) Steel pipes for waterworks		o	
n) Valves and accessories	o		
o) Hume pipes		o	

7.9 Manpower Requirements for Plant Construction

7.9.1 General

The quality of construction work governs subsequent reliability of plant operation as well as service life. In particular, the coke oven is a complex structure made of several types of firebricks, including silica and Chamotte, in a few hundred shapes. Machinery and equipment are mostly operated at high speeds and/or under high pressures, involving complex chemical reactions, and are expected to show high levels of controllability, accuracy and/or performance. Installing and assembling them are very difficult and require high levels of skills and workmanship.

In Venezuela, the field survey indicates that there are several companies which have experience and expertise in construction of petrochemical and steel plants. Thus, it is assumed that the plant will be constructed by local contractors.

7.9.2 Manpower Requirements for Plant Construction

Manpower requirements for construction of the 1 million–ton coke making plant are estimated on the basis of comparable projects in Japan, and are shown in Table 7–9.

Table 7-9 BREAKDOWN OF MANPOWER REQUIREMENTS FOR CONSTRUCTION OF THE PROPOSED COKE MAKING PLANT

		Bricklayer		Metal	Mechanical	Electrical	Civil	Navvy	Total			SV (ex-patriate)
		Skilled	Unskilled	Skilled	Skilled	Skilled	Skilled	Unskilled	Skilled	Unskilled	Total	
Coke oven	Bricklayer	36,000	69,600	14,500				5,800	50,500	75,400	125,900	1,200
	Metalwork			9,800	12,100	800		4,200	22,700	4,200	26,900	1,500
	Moving machinery			5,000	5,400	2,200		1,000	12,600	1,000	13,600	800
	Dust collector			1,400	5,300	1,000		900	7,700	900	8,600	
	Building/civil			14,500	1,700		9,000	9,300	25,200	9,300	34,500	
	Electrical/instrumentation			7,900	2,100	9,900		3,200	19,900	3,200	23,100	
	Sub-total1	36,000	69,600	53,100	26,600	13,900	9,000	24,400	138,600	94,000	232,600	3,500
Coal preparation facility	Coal preparation			34,200	31,000	4,700		7,800	69,900	7,800	77,700	1,200
	Coke handling			14,300	14,600	2,400		3,500	31,300	3,500	34,800	800
	Building/civil			25,200	3,000		15,600	16,200	43,800	16,200	60,000	
	Electrical/instrumentation			3,600	1,000	4,600		1,500	9,200	1,500	10,700	
	Sub-total	0	0	77,300	49,600	11,700	15,600	29,000	154,200	29,000	183,200	2,000
By-product facility	Gas exhausting			9,550	37,000	7,150		6,000	53,700	6,000	59,700	900
	Gas purifying			7,300	28,200	5,450		4,550	40,950	4,550	45,500	600
	Building/civil			18,650	2,200		11,550	12,000	32,400	12,000	44,400	
	Electrical/instrumentation			16,400	4,350	20,700		6,750	41,450	6,750	48,200	
	Sub-total	0	0	51,900	71,750	33,300	11,550	29,300	168,500	29,300	197,800	1,500
Common facility	Building/civil			22,000	2,600		13,600	14,100	38,200	14,100	52,300	
	Electrical/instrumentation			1,950	250	9,600		1,300	11,800	1,300	13,100	
	Sub-total	0	0	23,950	2,850	9,600	13,600	15,400	50,000	15,400	65,400	0
Grand total		36,000	69,600	206,250	150,800	68,500	49,750	98,100	511,300	167,700	679,000	7,000

7.10 Project Implementation Schedule

7.10.1 General

For the purpose of this report, the plant construction period is defined as the period between the start of preliminary design/planning and the commencement of commercial operation of the coke making plant. The construction period for each of major processes or facilities is primarily determined by its equipment configuration and complexity.

The project period is roughly divided into the following phases:

· Preliminary design/planning	4 months
· Basic design/planning	4 months
· Tendering	3 months
· Plant construction/installation	29 months
Total	40 months

Generally speaking, construction of the coke oven becomes a critical path for the entire construction schedule. Thus, construction of other facilities or processes is assumed to be completed within the coke oven construction period.
Major milestones are established as follows:

1) The heating-up of the coke oven is assumed to take 90 days.
2) Since the heating-up and commissioning of the oven involves very complicated procedures, the heating-up of battery No.1B will be started 1 month after battery No.1A starts commercial operation.
3) The receiving and storing of coking coal will be started 2 months before the start of commercial operation of the coke oven.
4) Coal preparation, coke treatment and shipping, and gas purifying facilities will start operation concurrently with the coke oven.

7.10.2 Construction Schedule

Figs. 7-33 and 7-34 show a construction schedule for the proposed coke making plant.

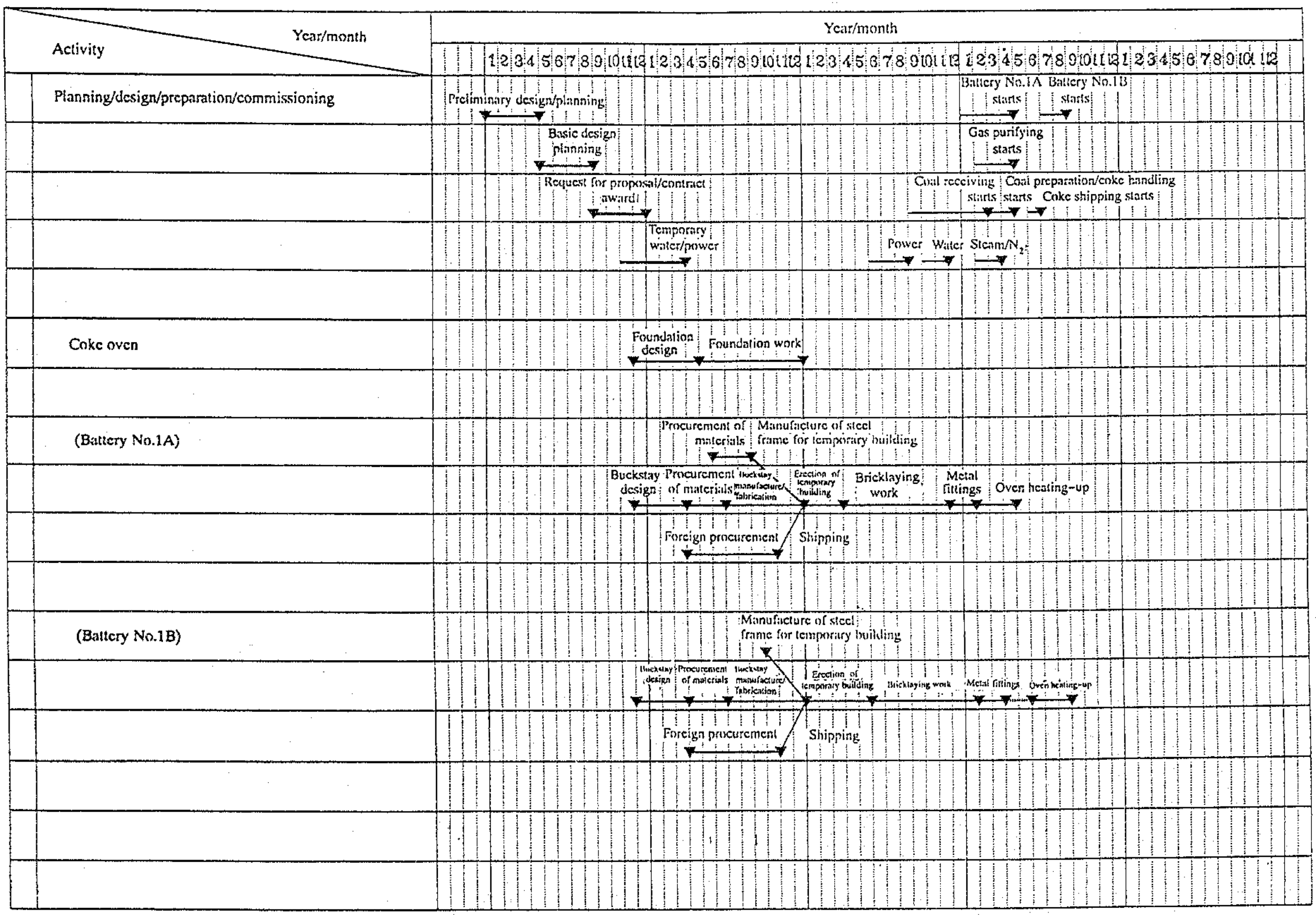


Fig.7-33 PRELIMINARY CONSTRUCTION SCHEDULE - COKE MAKING PLANT IN VENEZUELA(1/2)

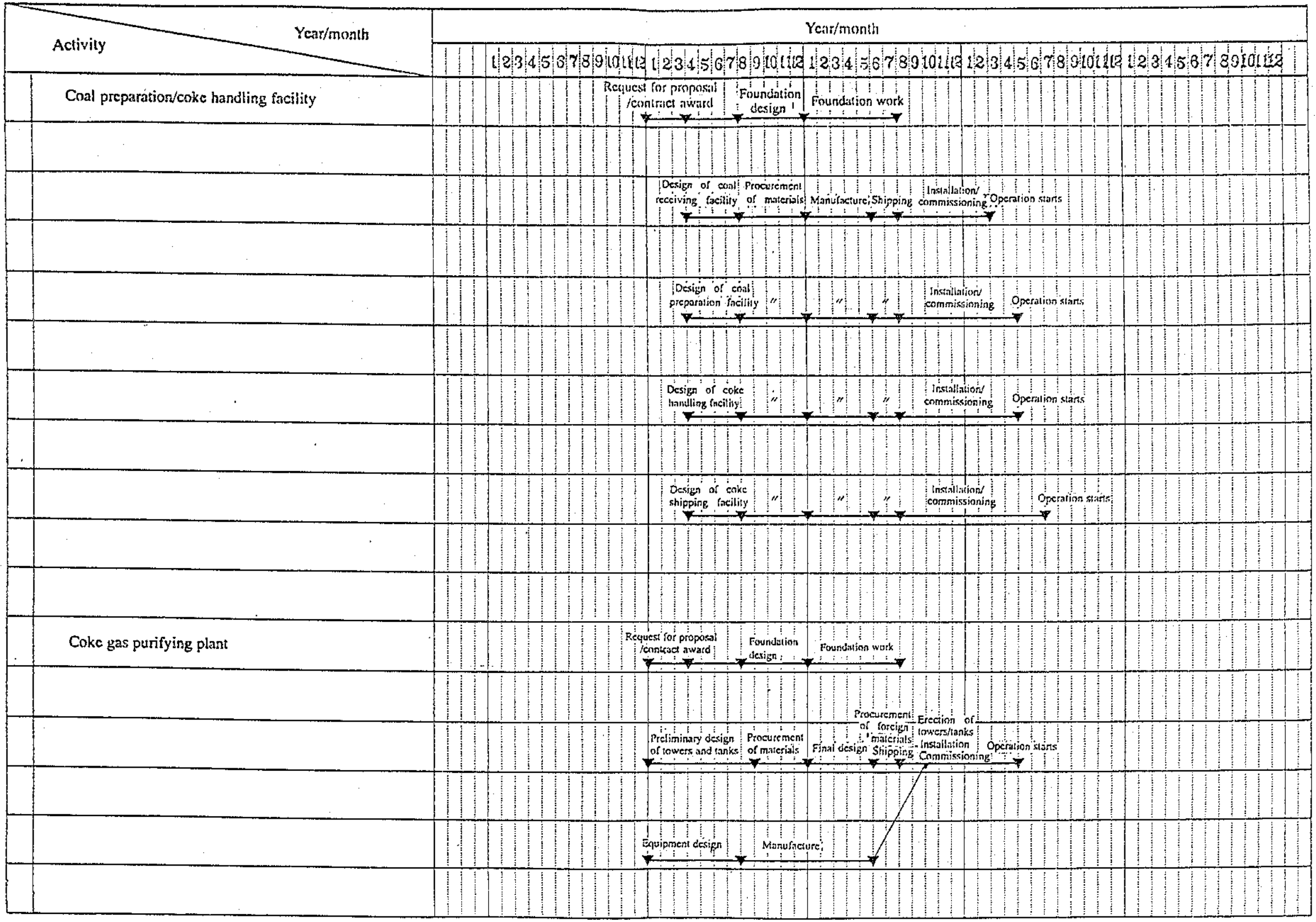


Fig.7-33 PRELIMINARY CONSTRUCTION SCHEDULE - COKE MAKING PLANT IN VENEZUELA(2/2)

7.11 Estimation of Construction Cost

7.11.1 General

The cost of building the coke making plant having annual production capacity of 1 million tons, with consideration to productivity, ease of operation, and pollution control, as described in Chapters 6 and 7, is estimated as follows.

7.11.2 Basis of Cost Estimation

(1) Classification of local and foreign currency portions

1) Equipment
Although equipment is locally procured as far as possible, classification has to wait until detail design. For the time being, international market or equivalent prices are estimated and converted to CIF Venezuela prices.

2) Manpower
Skilled and unskilled workers are assumed to be hired locally, while supervisors will be hired from abroad.

(2) Basic assumptions

1)	Estimation period	:average of 1993	
2)	Base currency	:Japanese yen	
3)	Foreign exchange rate	:115 yen/US$1	
4)	Local construction cost	:Skilled worker:	2,000 yen/person·day
		Unskilled worker:	1,000 yen/person·day
		Supervisor:	100,000 yen/person·day
5)	Escalation	:Not considered	
6)	Import tax	:Exempted	

7.11.3 Other Cost and Expense

In addition to the direct construction cost, the project incurs indirect cost and expense which are described as follows.

(1) Indirect cost

1) Spare parts and supplies

The cost of standby equipment, spare parts, and supplies, which are required for plant operation and should be provided prior to the start of commercial operation, is allowed for 2% of the direct construction cost.

2) Heating–up of coke oven

The gas consumed for heating–up the coke oven is included in the construction cost. Gas consumption is estimated as follows:

a) Coke oven gas basis = 3,060,000m^3 (4,500kcal/Nm^3) --- for battery No.1B
b) Natural gas basis = 1,252,000m^3 (11,000kcal/Nm^3) -- for battery No.1A

(2) Engineering service

1) Basic engineering cost

The basic engineering cost should cover the cost of hiring 5 foreign experts (supervision – 1; coke – 2; coal preparation – 1; gas purifying – 1) who will develop the final plant design and plan over 11 months from preliminary design to tendering:
2,000,000 yen/month·person x 11 months x 5 persons = 110,000,000 yen

2) Engineering fee

The amount of engineering fee depends upon what roles the plant owner in Venezuela and the engineering company will play. For the project, the engineering fee is assumed to be 3% of the direct construction cost.

(3) Project management cost

This includes costs and expenses related to preparatory education for operators and on–the–job training and guidance by foreign experts, including training in and outside of Venezuela and other activities required for and related to technology transfer.

1) Preparatory education in Venezuela

5 experts will be sent from Japan and will work for 4 months, 2 months for preparation including preparation of course materials, and 2 months for actual education at the site:

· Preparation:	2,000,000 yen/month·person x 2 months x 5 persons =	20,000,000 yen
· Education:	2,000,000 yen/month·person x 2 months x 5 persons =	20,000,000 yen
Total		40,000,000 yen

2) On-the-job training

10 experts will be sent from Japan and will provide on-the-job-training and guidance for 6 months, 2 months for preparation of training materials, and 4 months (1 months before the start of operation and 3 months thereafter) for training and guidance:

·Preparation:	2,000,000 yen/month·person x 2 months x 10 persons =	40,000,000 yen
·Training and guidance:	2,000,000 yen/month·person x 4months x 10 persons =	80,000,000 yen
Total		120,000,000 yen

7.11.4 Estimated Plant Construction Cost

The estimated construction cost for the proposed coke making plant is summarized in Table 7-10. Table 7-11 shows breakdown of direct construction costs as well as foreign and domestic currency portions.

Table 7-10 ESTIMATED PLANT CONSTRUCTION COST

	Construction Cost	
	Million yen	Million US$
Direct construction cost	60,990	530.35
Standby equipment/spare parts/supplies	1,220	10.61
Heating-up of coke oven	10	0.09
Basic engineering cost	110	0.96
Engineering fee	1,830	15.91
Project management cost	160	1.39
Total	64,320	559.31

Table 7-11 BREAKDOWN OF PLANT CONSTRUCTION COST

		Cost Breakdown		Currency Portions	
		Million yen	Million US$	Foreign	Domestic
Coke Oven	Oven	10,496	91.27	100	–
	Moving machinery	4,715	41.00	100	–
	Building/civil	2,816	24.49	20	80
	Electric/instrumentation	2,354	20.47	50	50
	Sub-total	20,381	177.23		
Coal Preparation Facility	Coal receiving/ preparation	9,066	78.84	70	30
	Coke handling/ shipping	4,091	35.57	70	30
	Building/civil	4,904	42.64	20	80
	Electric/instrumentation	868	7.55	50	50
	Sub-total	18,929	164.60		
By-product Treatment Plant	Gas exhausting	4,979	43.30	50	50
	Gas purifying	3,779	32.86	50	50
	Building/civil	3,629	31.56	20	80
	Electric/instrumentation	3,946	34.31	50	50
	Sub-total	16,333	142.03		
Common Facility	Building/civil	4,278	37.20	20	80
	Electric/instrumentation	1,069	9.30	50	50
	Sub-total	5,347	64.50		
	Grand Total	60,990	530.35		

Chapter 8 Plant Operation Plan

Chapter 8 Plant Operation Plan

8.1 General

The coke making plant is expected to produce high quality, low cost blast-furnace coke and supply it to users in the stable manner.

It is said that the beginning of the modern steel industry was the time when coke became available as the fuel to commercially produce pig iron at the blast furnace. Since then, high quality coke has been an essential factor in steel production and will increase its importance to blast furnace operation.

Essentially, coke is expected to fulfill the following four roles in the blast furnace operation:

1) A heat source by combustion
2) An agent to reduce iron ore to iron
3) A filler to maintain air permeability in the blast furnace
4) A heat exchange medium to give heat to pig iron and slag by forming a specific temperature range inside the furnace

To fully perform the above functions, the coke must be high quality, which is more precisely defined below:

1) Sufficiently high coke strength (crushing and wearing resistance)
2) Low ash and sulfur contents
3) Relatively large grain size with even distribution
4) Low reactivity and good heat property

The coke which can meet the above quality requirements can be produced at the well-designed plant which is operated by workers who recognize the importance of coke quality and have sufficient knowledge and experience in coke making long-stable operation.

8.2 Organization and Manpower Plan

8.2.1 Plant Organization

The organization of the proposed coke making plant is shown in Fig.8-1. As seen in the organizational chart, the plant is designed to have its own operation, maintenance, and administration organizations which can handle day-to-day management activity related to the plant, in addition to production activity.

8.2.2 Sections and Duties

(1)	General affairs section	: General affairs, personnel management, and education
(2)	Accounting section	: Bookkeeping and financial accounting
(3)	Safety and environment section	: Worker safety, health, and environment
(4)	Procurement section	: Purchase of raw materials, fuels, equipment and materials
(5)	Sales section	: Sales of coke and by-products
(6)	Production technology section	: Production management, quality control, and coordination of overall engineering matters
(7)	Testing and analysis section	: Quality tests related to raw materials, fuels, coke and by-products, and environmental measurement, exhaust gas analysis, and measurement of dust particulate
(8)	Coke section	: Coke production, coal receiving and preparation, and coke handling and shipping
(9)	By-product section	: Gas purifying , waste water treatment, and production of by-products
(10)	Plant engineering section	: Maintenance and design of plant facilities, and materials control and management
(11)	General maintenance section	: Maintenance and repair of civil engineering and construction facilities, machinery, and plant equipment
(12)	Electrical and instrumentation maintenance section	: Maintenance and repair of electrical installations, instrumentation, and electronic computers

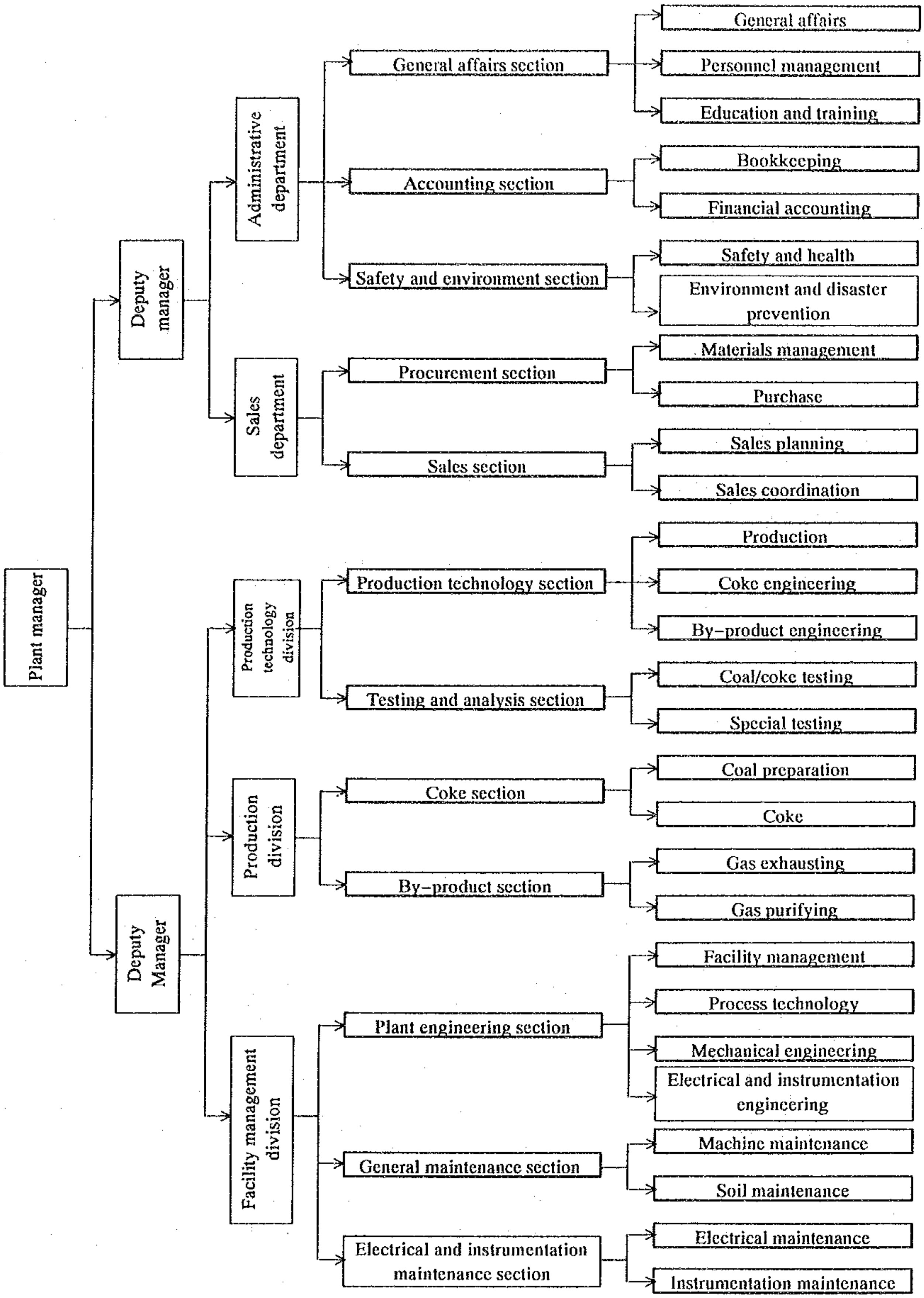


Fig.8-1 ORGANIZATIONAL CHART OF THE COKE MAKING PLANT

8.2.3 Manpower Allocation Plan

Manpower requirements for the plant are estimated on the basis of the organization in Fig.8-1 and the following assumptions:

(1) All plant facilities and equipment are directly operated and maintained by the plant's own employees.

(2) Plant facilities which require continuous operation are operated in three eight-hour shifts by 4 teams:

lst shift	- 7:00 a.m. - 3:00 p.m.
2nd shift	-- 3:00 p.m. - 11:00 p.m.
3rd shift	- 11:00 p.m. - 7:00 a.m.

Work schedule (4 teams, 3 shifts, 16 days/cycle)

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Team A	1	1	1	1	*	2	2	2	2	*	3	3	3	3	*	*
Team B	2	*	3	3	3	3	*	*	1	1	1	1	*	2	2	2
Team C	*	2	2	2	2	*	3	3	3	3	*	*	1	1	1	1
Team D	3	3	*	*	1	1	1	1	*	2	2	2	2	*	3	3

* holiday

(3) Division of responsibility between operation and maintenance sections is as follows:
- To maximize productivity in plant maintenance, a preventive maintenance system widely adopted in Japan is introduced. For this purpose, the maintenance department is established separately from the operation department, with the latter being responsible for daily inspection, lubrication and greasing, and minor repair by operators.

Manpower allocation at the plant as well as the plant operation and maintenance departments is summarized in Table 8-1, with details being shown in Table 8-2. This allocation plan has been developed on the basis of manpower allocation at various coke making plants in Japan, with some adjustment to reflect the differences in facility size, equipment configuration, and local conditions.

Table 8-1 OVERALL MANPOWER ALLOCATION BY JOB RANK

	Number	Remarks
Plant manager	1	
Deputy manager	2	
Manager	5	
Division chief	12	
Section chief	28	
Staff	84	47 in administrative sections and 37 in engineering sections
Foreman	33	
Sub-foreman	117	
Worker	418	
Grand total	700	

Notes: a) Staff or higher levels are assumed to be graduates from universities or colleges (technical high school)

b) Foreman and Sub-foremen are skilled workers with experience of 5 years or longer.

c) Workers are high school graduates.

Table 8-2 DETAILED MANPOWER ALLOCATION (1/8)

Section	Subsection	Responsibility	Field staff				Remarks
			Foreman	Sub-foreman	Worker	Total	
General affairs	General affairs				6	6	Staff
	Personal management				4	4	Ditto
	Education and training				2	2	Ditto
		Sub-total			12	12	
Accounting	Bookkeeping				5	5	Staff
	Financial				5	5	Ditto
		Sub-total			10	10	
Safety and Environment	Safety/health				4	4	Staff
	Environment/disaster prevention				3	3	Ditto
		Sub-total			7	7	
Procurement	Materials management				3	3	Staff
	Purchase				5	5	Ditto
		Sub-total			8	8	
Sales	Sales planning				5	5	Staff
	Sales coordination				5	5	Ditto
		Sub-total			10	10	
		Total			**47**	**47**	

Table 8-2 DETAILED MANPOWER ALLOCATION (2/8)

Section	Subsection	Responsibility	Field staff				Remarks
			Foreman	Sub-foreman	Worker	Total	
Production technology	Production	Blending design Blending plan Production control			5	5	Staff
	Coke engineering	Coke oven operation Design/planning Operation analysis			8	8	Ditto
	By-product engineering	By-product process operation Design/planning Operation analysis			7	7	Ditto
		Sub-total			20	20	
Testing	Coal/coke testing	Coal/coke testing	1	1 x 4	4 x 4	21	
		Coal/coke analysis	1	2	8	11	
		Sub-total	2	6	24	32	
	Special testing	By-product	1	2	6	9	
		Effluent		1	2	3	
		Pollution	1	1	4	6	
		Sub-total	2	4	12	18	
		Total	**4**	**10**	**36**	**50**	

Table 8-2 DETAILED MANPOWER ALLOCATION (3/8)

Section	Subsection	Responsibility	Field staff Foreman	Sub-foreman	Worker	Total	Remarks
Coke	Coal preparation and coke handling	Coal receiving	1			1	
				1 x 4		4	
		Unloader			2 x 4	8	
		BC operation			1 x 4	4	
		BC inspection			1 x 4	4	
		Receiving of domestic coal			1 x 4	4	
		Sub-total	1	4	20	25	
		Coal feeding and blending	1			1	
				1 x 4		4	
		Reclaimer			2 x 4	8	
		Crusher			1 x 4	4	
		BC operation			1 x 4	4	
		BC inspection			1 x 4	4	
		Residual tar treatment			1 x 4	4	
		Yard management			1 x 4	4	
		sub-total	1	4	28	33	
		Coke transportation	1			1	
				1 x 4		4	
		BC operation			1 x 4	4	
		BC inspection			2 x 4	8	
		Wharf			1 x 4	4	
		Reclaimer			2 x 4	8	
		Ship loader			1 x 4	4	
		Sub-total	1	4	28	33	
		Equipment	1			1	
		Equipment and materials		1		1	
					5	5	
		Cleaning		1		1	
					11	11	
		Sub-total	1	2	16	19	
		Total	4	14	92	110	

Table 8-2 DETAILED MANPOWER ALLOCATION (4/8)

Section	Subsection	Responsibility	Field staff: Foreman	Sub-foreman	Worker	Total	Remarks
Coke	Coke	3 shift operation	1 x 4			4	
		Oven top work		1 x 4		4	
		Charging			1 x 4	4	
		Charging car			1 x 4	4	
		Coke guide car			1 x 4	4	
		Quenching car			1 x 4	4	
		Oven side work		1 x 4		4	
		Pusher machine			1 x 4	4	
		sub - total	4	8	20	32	
		Combustion control	1			1	
		Oven temperature control		1		1	
					5	5	
		Gas reversing		1 ~ 4		4	
					2 ~ 4	8	
		Sub-total	1	5	13	19	
		Oven maintenance	1			1	
		Ascension pipe		1		1	
					5	5	
		Repair of oven		1		1	
					9	9	
		Sub-total	1	2	14	17	
		Equipment	1			1	
		Equipment and materials		1		1	
					2	2	
		Pollution		1		1	
					1	1	
		Cleaning around oven		1		1	
					5	5	
		sub-total	1	3	8	12	
		Total	**7**	**18**	**55**	**80**	

Table 8-2 DETAILED MANPOWER ALLOCATION (5/8)

Section	Subsection	Responsibility	Field staff				Remarks
			Foreman	Sub-foreman	Worker	Total	
By-product	Gas exhausting	Gas exhausting	1			1	
				1 x 4		4	
					1 x 4	4	
		Inspection			2 x 4	8	
		Sub-total	1	4	12	17	
		Ammonia liquor treatment	1			1	
				1 x 4		4	
					3 x 4	12	
		Utilities operation		1 x 4		4	
					2 x 4	8	
		Sub-total	1	8	20	29	
	Gas purifying	Gas purifying	1 x 4			4	
		Desulfurization		1 x 4		4	
					1 x 4	4	
		Sulfuric acid			2 x 4	8	
		Ammonium sulfate		1 x 4		4	
					3 x 4	12	
		Debenzolization			1 x 4	4	
		Sub-total	4	8	28	40	
		Shipment of ammonium sulfate	1			1	
				1		1	
		Operation of fork-lift			2	2	
		Shipment inspection		1		1	
					6	6	
		Equipment and materials control		1		1	
					2	2	
		Cleaning			10	10	
		Sub-total	1	3	20	24	
		Total	7	23	80	110	

Table 8-2 DETAILED MANPOWER ALLOCATION (6/8)

Section	Subsection	Responsibility	Field staff				Remarks
			Foreman	Sub-foreman	Worker	Total	
Plant Engineering Section	Facility management	Spare parts, equipment and materials, and firebricks	1			1	
				1		1	
					1	1	
		Sub-total	1	1	1	3	
	Process engineering	Measurement of heat flow, vibration, thickness	1			1	
				2		2	
					12	12	
		Sub-total	1	2	12	15	
	Mechanical engineering				10	10	Staff
	Electrical/instrumentation engineering				7	7	Ditto
		Sub-total	2	3	30	35	

Table 8-2 DETAILED MANPOWER ALLOCATION (7/8)

Section	Subsection	Responsibility	Field staff				Remarks
			Foreman	Sub-foreman	Worker	Total	
General Maintenance	Equipment Maintenance Section	On-spot maintenance team	1			1	
				1 x 4		4	
					5 x 4	20	
		Sub-total	1	4	20	25	
		Coal preparation	1			1	
		Coal receiving		2		2	
					8	8	
		Feeding/blending		2		2	
					8	8	
		Coke handling shipping		2		2	
					8	8	
		Sub-total	1	6	24	31	
		Coke oven	1			1	
				4		4	
					16	16	
		Sub-total	1	4	16	21	
		Gas purifying	1			1	
				5		5	
					20	20	
		Sub-total	1	5	20	26	
	Building maintenance	Coordination	1			1	
		Civil engineering		2		2	
					8	8	
		Building		1		1	
					5	5	
		Sub-total	1	3	13	17	
		Total	**5**	**22**	**93**	**120**	

Table 8-2 DETAILED MANPOWER ALLOCATION (8/8)

Section	Subsection	Responsibility	Field staff: Foreman	Sub-foreman	Worker	Total	Remarks
Electrical and Instrumentatin Maintenance	Electrical maintenance	On-spot maintenance team	1			1	
				1 x 4		4	
					2 x 4	8	
		Substation		1 x 4		4	
					1 x 4	4	
		Sub-total	1	8	12	21	
		Coordination	1			1	
		Coal-preparation		3		3	
					6	6	
		Coke oven		4		4	
					7	7	
		Gas purifying		3		3	
					6	6	
		Other		3		3	
					6	6	
		Sub-total	1	13	25	39	
	Instrumenta-ion maintenance	CPUs	1			1	
				3		3	
					4	4	
		Instrumentation	1			1	
				3		3	
					8	8	
		Sub-total	2	6	12	20	
		Total	**4**	**27**	**49**	**80**	
		Grand total	**33**	**117**	**502**	**652**	Not including subsection chief or higher
		Grand total	**33**	**117**	**418**	**568**	Not including subsection staff or higher

8.3 Employment Plan

The employment plan was developed in consideration to manpower requirements envisaged in preliminary design, construction schedule, training plan, heating–up and start–up of the coke oven, and trial operation.
The employment plan is shown in Table 8–3.

Table 8–3 EMPLOYMENT SCHEDULE

	Before the Start of Commercial Operation					
Year	–3.5	–3	–2	–1	–0.5	Total
Plant manager	1					1
Deputy manager	1				1	2
Manager	2		1		2	5
Division chief	4		1	4	3	12
Section chief	4	4	5	5	10	28
Staff	4	10	23	17	30	84
Foreman			7	26		33
Sub–foreman			18	99		117
Worker				200	218	418
Total	16	14	55	351	264	700

Notes : a) Manpower at year –3.5 is the same as that in the preliminary design/plan stage.
b) Manpower employed at years – 3 and –2 includes supervision, procurement, inspection and other jobs in connection with plant construction
c) Manpower employed at year –2 will be assigned to field sections and will receive overseas training.
d) Manpower employed at year –1 will become key personnel in field sections.
e) Manpower employed at year –0.5 will be half in administrative sections and another half in field sections.

8.4 Training Plan

Operation of the new plant and management of the coke making business requires sophisticated knowledge and experience, which needs to be learned through extensive education and training in a wide range of fields. In this connection, it is important to recruit workers who have willingness and ability to learn through education. Presence of managers and workers who are fully trained holds the key to the smooth start-up of plant operation, and the improvement of management and operating techniques forms a basis of reliable operation.

The educational program starts from orientation which instructs all the new employees about a general outline of the plant and its operation, including the purpose and organization of the company, duties and functions of different sections, and laws and regulations in Venezuela related to plant operation and management, and work rules and regulations at the plant.

Administrative staff will be trained at domestic companies who have facilities and equipment similar to those to be used at the proposed plant.

Engineers and field workers (including maintenance) will receive practical training at coke making plants in neighboring countries, such as Brazil and Colombia.

Table 8-4 TRAINING PLAN AND SCHEDULE

Item	Eligible Employees	Duration	Remarks
1. Orientation	All	1 month	
2. Domestic education	All	2 months	Special education by discipline
3. Overseas education	55	3 months	Practical training
4. Education on heating-up and start-up of coke oven	100	1 month	All employees related to operation of the coke oven, and engineering, equipment maintenance, and facility operation staff

8.5 Plant Operation

8.5.1 Coke Quality Control

Quality levels of coal and coke are primarily governed by operating conditions of the blast furnace and conditions of coking coal. Coke qualities required for blast furnace operation are roughly divided into those which must be satisfied for reliable operation of the blast furnace, and those which create economic disadvantages but are acceptable to a certain extent, such as ash and sulfur content. Thus, coke quality should be controlled according to priority of different quality items and supply and demand conditions of raw materials. Note that quality control should aim at minimizing variation of quality through strict control of field operation and work, so as to avoid uneven air permeability and/or temperature distribution in the blast furnace.
Coke making plants procure various types of coking coal for the purpose of maintaining a certain level of coke quality, and important points in quality control on the plant side are summarized as follows:

(1) To determine the optimum blending ratio of different types of coking coal by taking into account expected market conditions and properties of coking coals.
(2) To maintain the quality of the coal charge at required levels by blending and crushing coking coals in accordance with present operation standards.
(3) To minimize variation of carbonizing conditions in the coke oven and to secure sufficient soaking time.
(4) To monitor variation of coke quality all the time, inform it to appropriate sections, and take adequate and prompt action.
(5) To notify and consult with the procurement section of any acceptable conditions of the received coal.
(6) To standardize the sampling method as well as methods of various tests and analyses to allow accurate monitoring of coal and coke qualities.

Major test items adopted by many coke making plants are summarized in Tables 8-5 and 8-6.

Table 8-5 COAL SAMPLING METHOD AND TEST ITEMS (EXAMPLE)(1/2)

Item	Received Coal	Coal in Blending Bin	Coal Charge
Purpose of test	- Monitoring properties of received coal - Control of incoming coal volume	- Coke quality control - Control of consumption by brand	- Coke quality control - Control of volume of coal charge
Sampling method	Swing arm	Swing arm	Swing arm
Total Moisture	O	O	O
Size distribution	O	O	O
Proximate analysis	O	O	O
Ultimate analysis	O	O	O
Caking properties	O	O	O
Maceral analysis	O		
Ash composition analysis	O		
Reactivity	O		
Grindability	O		

Table 8-5 COKE SAMPLING METHOD AND TEST ITEMS (EXAMPLE)(2/2)

Item	Processed Coke	Shipped Coke
Purpose of test	- Coke quality control - Control of coke production volume	- Monitoring properties of shipped coke - Control of coke shipping volume
Sampling method	Cutter bucket	Cutter bucket
Total Moisture	O	O
Size distribution	O	O
Proximate analysis	O	O
Ultimate analysis	O	O
Drum Strength	O	O
Strength after reaction with CO_2	O	O
Ash composition analysis		O

8.5.2 Start-up of Coke Oven Operation

After drying and heating-up of the coke oven has been completed, the following activities need to be performed before starting the carbonization process by coal charge.

(1) Mortar grouting into expansion joints in the coke oven, and reinforced sealing

The coke oven is provided with expansion joints to absorb thermal expansion in the drying and heating-up process. Mortar is grouted into openings formed by unfilled expansion joints. Also, packings are inserted between firebricks and metals for sealing.

(2) Regular heating

Before starting combustion in flues by using distribution pipes and regenerators, instead of the lower part of the coking chamber in the heating-up process, various preparation works need to be performed, including supply of gas through distribution pipes, operation of flow regulating equipment, and operation of reversing arrangement.

(3) Removal of heating-up equipment

A temporary building for heating-up burners, fuel pipes, and burner bricks need to be removed after the heating-up process. The temporary building is to be removed in accordance with an installation schedule for moving machines and auxiliary equipment. heating-up burners will be removed immediately after regular heating.

(4) Repairing of the coke oven

The plugging of connection holes between the coking chamber and the combustion chamber, the repairing of vertical ducts in the underjet level, and the plugging of firebricks for oven doors, will be performed before the initial charging of coal.

(5) Test run of moving machines for the coke oven

In preparation for the initial charging and pushing, test run of moving machine and functional tests for other equipment will be performed. Also, break-in of auxiliary equipment, coke handling equipment, and gas purifying plant will be conducted.

(6) Initial charging and pushing

The initial charging will be performed after the coke oven is completely heated-up. An important and difficult part of the initial charging is, in addition to smooth start-up of each equipment as well as charging operation, to suction gas produced in the oven by the gas blower. In particular, gas pipes, towers, and holders between the Ascension pipe, the dry main, the suction main, the gas cooler, the gas purifying process, and the gas holder have to be filled with nitrogen before the initial charging, which will be replaced with coke oven gas as the charging progresses. Then the blower will be slowly operated to start suction. After all the ovens are charged, and the appropriate carbonizing time is passed, the initial pushing will be started.

8.5.3 Initial Operation Plan

Once the coke oven starts commercial operation, its working rate should be risen gradually for the purpose of adjusting temperatures within the oven and improving operating skills. It should be noted that battery Nos.1A and 1B will be started with a time lag of 4 months, it will take approximately 6 months before the working rate reaches 125%.
Fig.8-2 shows the initial operation plan for the coke oven. When the working rate of the coke oven reaches 125%, the plant operating rate reaches 100%. Thus, coke production in the initial year, based on the schedule in Fig.8-2, will be 800,000 tons/year (operating rate of 80%).

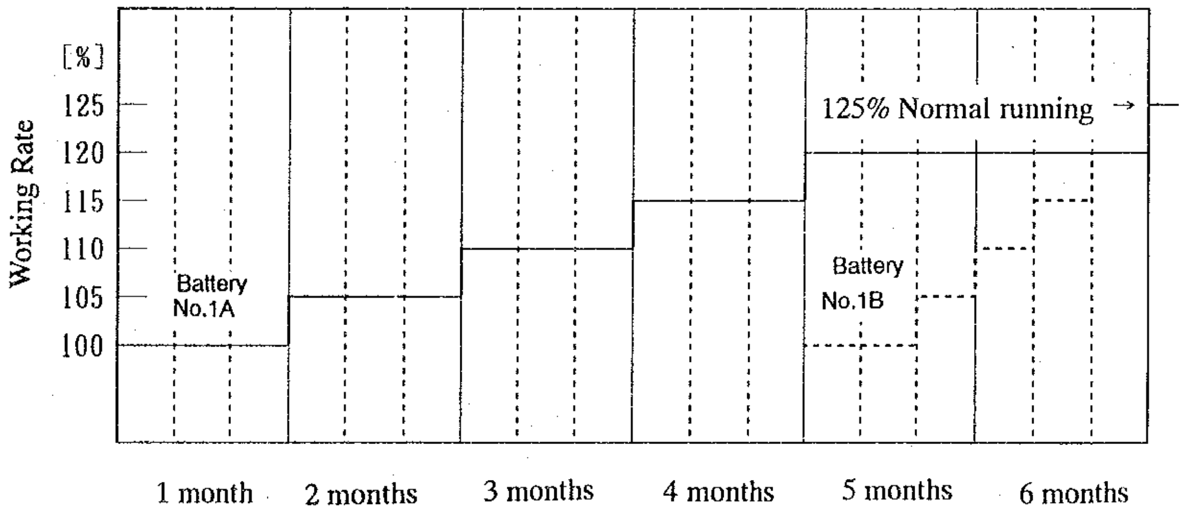


Fig.8-2 INITIAL OPERATION PLAN FOR COKE OVEN

8.6 Plant Maintenance

Since the coke making plant is operated day and night throughout the year, securing plant maintenance time is very difficult. While simple replacement of parts or minor repair work are generally done during resting time (1 hour/each), major work requiring long hours or suspension of equipment is performed during the special repair time reserved once or twice per month. The average repair time is 4 – 5 hours each, during which the coke pushing operation is suspended. Typical jobs performed are the replacement of rails for moving machine , belts for conveyors, and meshes for the vibration screening equipment.

Important equipment is maintained periodically by using spare equipment and an alternative route, so that they are always reserved for sudden equipment failure. The repair cost related to these plant maintenance activities is assumed to be 2% of the direct plant construction cost.

Chapter 9 Financial and Economic Analysis

Chapter 9 Financial and Economic Analysis

In this chapter, financial and economic analysis is performed to evaluate the project in terms of financial viability as well as benefits on a regional and national basis, by applying various assumptions established in the previous chapters.

The objectives of the project are to make use of coking coal to be exploited in Tachira State, and to construct coke plant of 1 million tons annually, and to export blast-furnace (BF) coke and by-products mainly to the U.S. market.
Therefore, the evaluation models used worldwide has been applied to financial and economic analysis of the project.
The main indicator to measure the project viability is Financial Internal Rate of Return (FIRR) and Economic Internal Rate of Return (EIRR) by Discounted Cash Flow (DCF) method as well as foreign currency earnings.

First of all, major assumptions established for financial and economic analysis are defined. Then, financial and economic analysis is performed for the preliminary project plan (base case) described in Chapter 6, as well as an alternative case which incorporates assumptions that could improve project viability.

Both the base case and the alternative case assume annual coke production capacity of 1 million tons. The differences in between two cases are:

Base case – To blend domestic coal (32%), U.S. coal (65%), and Colombian coal (3%) to secure the required level of coke quality, while considering the current availability on domestic coal and colombian coal.

Alternative case – To use domestic coal (80%) and Colombian coal (20%) with expectation that domestic coal production will increase to a sufficient level.

The investment cost for the implementation of the project is estimated in accordance with the assumption and procedure explained hereunder.

9.1 Estimation of Total Investment Cost and Financial Plan

9.1.1 Basic of Estimation

(1) Base currency and foreign exchange rates

The base currency used for estimation is the U.S. dollar, and Japanese yen and Bolivar which are converted to the U.S. dollar by applying the following exchange rates:

US$1 = 115 Yen (the average exchange rate in FY1993)
US$1 = 95 Bolivars (the prevailing rate at the first field survey conducted in August 1993)

The prices, which were estimated at dollar or converted by the above exchange rates may be adjusted when there is a substantial change over a year, however, there is no such a change for the prices on major items such as plant construction cost, coal and coke price employed in the project.

(2) Pricing level

All the costs and prices are estimated as of 1993, with no escalation in the future being considered. Such price projection is called "1993 fixed price base"

9.1.2 Total Investment Cost

The total investment cost consists of the plant construction cost described in Chapter 7, and other costs and expenses which are assumed as follows.

(1) Land cost

The proposed site selected as a result of the first field survey is located within an industrial park in the La Cañada district of Zulia State and required plant area is 863,200m^2 (86.32ha) as shown in Fig.6-4 of Chapter 6.

The land acquisition cost of the site is estimated at US$2.36 million (224 million Bs) as a appraisal value basis, however, site preparation cost is not included in this estimation.

(2) Physical contingency

Physical contingency needs to be allowed for any extraordinary cost and expense which may incur due to a cause not foreseen or included in the estimation. The physical contingency is assumed to be 5% of the direct construction cost.

(3) Price contingency

Price contingency is often considered to deal with possible inflation in the future. However, the project cost is estimated as the fixed price, and no price contingency is considered in this analysis.

(4) Import duty on machinery & equipment and technical service

The import duty on imported machinery & equipment and technical service is imposed with tariff rates of 5% and 50% respectively

– Machinery & Equipment	: 313.45US$,MM X 5% =	15.67US$,MM
– Foreign Engineering Service :	9.72US$,MM X50% =	4.86US$,MM
– Total		20.53US$,MM

(5) Pre–operating Expenses

Pre–operating expenses covers costs and expenses incurred by the project implementation body in preparation work required prior to commercial operation of the project, typically including the following:

a) Project promotion and planning cost
b) Recruitment cost
c) Administrative cost and expense including office supplies
d) Training cost including overseas training (expected to take place in neighboring countries such as Colombia and Brazil)
e) Commissioning cost
f) Others

The project envisages that a new organization is established for its implementation and the following pre-operating expenses are assumed.

BREAKDOWN OF PRE-OPERATING EXPENSES

(Unit:1,000 US$)

Item	Amount	Remarks
- Labor cost during the construction period	4,603	Based on tables 8-3 and 9-6
- Administrative cost, overseas training, and others	2,301	50% of the above labor cost
- Commissioning cost	15	
Total	6,919	

Employees are assumed to be hired for salaries and wages set forth in Table 9-6 and in accordance with the employment schedule in Table 8-3.

The commissioning cost of machinery unit is assumed to cover the amount of utilities consumption equivalent to 6 days. Note that the commissioning will require one month.

- Electricity	:	1,008,000 kwh X 0.013 \$/kwh	= US\$13 X 10^3
- Water	:	56,400 m^3 X 0.029 \$/m^3	= US\$ 2 X 10^3
- Total	:		US\$15 X 10^3

(6) Interest during construction

Since financial sources for the project have still to be determined, it is assumed that the project will be financed in the manner described in 9.1.3 and low-interest loans from foreign financial institutions will be available. Thus, 70% of the total project cost including domestic and foreign currency portions will be borrowed at an annual interest of 5%.
Interest during construction will be calculated on loan portions of disbursement made each year, for the period between the time of disbursement and the end of the year during which the disbursement is made.

$$IDC = (PC+IDC) \times L \times \{d_1(1+i)^{2.5} + d_2(1+i)^{1.5} + d_3(1+i)^{0.5} - 1\}$$

IDC : Interest during construction
PC : Construction cost and pre-operating expenses, not including interest during construction and the initial waking capital
L : Loan portion (70%), i: Interest rate (5.0% per annum)
dn : Disbursement schedule in nth year

$d_1 = 0.10$
$d_2 = 0.50$
$d_3 = 0.40$

(7) Initial working capital

The initial working capital will cover cost and expense incurred before start operation, namely the inventory of products, the inventory of raw coal in and outside the country, accounts receivable and payable. It is assumed to be financed immediately before commercial operation, thus no interest during construction is allowed for.

BREAKDOWN OF INITIAL WORKING CAPITAL

(Unit:1,000 US$)

Item	Amounts	Remarks
- Inventory of products	9,417	1.51 months of the production cost in the initial year, not including depreciation (Note)
- Inventory of imported coal	5,885	1.5 months of the imported coal cost in the initial year
- Inventory of domestic coal	375	0.5 months of the domestic coal cost in the initial year
- Account receivable	7,650	1 month of sales including By products except COG in the initial year
- Account payable	▲4,577	1 month of variable cost in the initial year
Total	18,750	

(Note) The inventories of products including BF coke and by-products except COG are taken into account as follows.
- BF coke : 1.5 months
- Coke Breeze : 1.0 month
- Crude Tar : 1.5 months
- Crude Benzene : 3.0 months
- Ammonium Sulfate : 1.0 month

Allocating the costs on the base of the above inventory period and sales revenue (deemed to correspond to cost) by each product, the average inventory period becomes 1.51 months.

(8) Total investment cost

Breakdown of the total investment cost required for construction of the proposed coke making plant is shown in Table 9-1.

9.1.3 Financing Plan

The total investment cost estimated in the preceding section is assumed to be financed as follows.

(1) Debt-Equity Ratio and disbursement schedule

It is assumed that 30% of the total investment cost will be financed from equity and the remaining 70% through long-term loans from foreign financial institutions.
Construction schedule including the commissioning period will be 29 months from the conclusion of the construction contract, which is assumed to occur in December 1995. Thus, commercial operation of the plant is assumed to start in May 1998.
The investment cost will be disbursed through the two financial sources according to the above proportions.

DISBURSEMENT SCHEDULE

Project year	Disbursement schedule (%)
1995	10 %
1996	50 %
1997	40 %
Total	100 %

(2) Long-term loan terms

For the purpose of this study, foreign loans are assumed to be provided under the following terms:

a) Interest rate : 5.0% annually
b) Grace period : 3 years during the construction period

c) Repayment term : Equal installments over 20 years after the grace period

(3) Other conditions

In case a cash shortage occurs during the plant operation, it is assumed that short-term loans which are provided at 5.0% per year and are to be repaid in the subsequent year.

9.2 Assumptions for Financial and Economic Analysis

9.2.1 Common Assumptions

As discussed in 9.1.1, the base currency is the U.S. dollar, all the cost and price are estimated as of 1993, with no escalation being assumed. Such price projection method is referred to as the 1993 fixed price base.

The plant will start commercial operation in May 1998. For the purpose of this analysis, the project year is difined to start in May and ends in next April, with the first year being 1998.

The project life is 23 years, 3 years for construction and 20 years for plant operation.

The salvage value covers the land cost, undepreciated assets, and working capital and will be credited in the final project year. For the project, land cost and working capital are credited.

9.2.2 Assumptions for Project Cash Flow

On the basis of various technical considerations related to plant operation, as done in Chapter 8, assumptions for financial and economic analysis are established as follows.

Fig.9-1 shows major items related to the base case for the coke production capacity of 1 million tons per year.
For the cost accounting purpose, BF coke is assumed to be the main product, while coke breeze, crude tar, crude benzene, ammonium sulfate, and COG are as by-products.
As for input, annual raw coal consumption is determined on the basis of coke yield (57.06%) and the following coal blending ratio.

BLENDING RATIO FOR BASE CASE

Raw Coal		Blending Ratio
Domestic coal(FNO/LAS)	:	32.0%
Colombian coal(Boyaca)	:	3.0%
U.S. coal (Pinnacle/Blue Creek)	:	65.0%
Total		100.0%

Total output of COG is assumed to be 441.5 million Nm^3, 198.85 million Nm^3 for captive consumption and 242.65 million Nm^3 for sales.

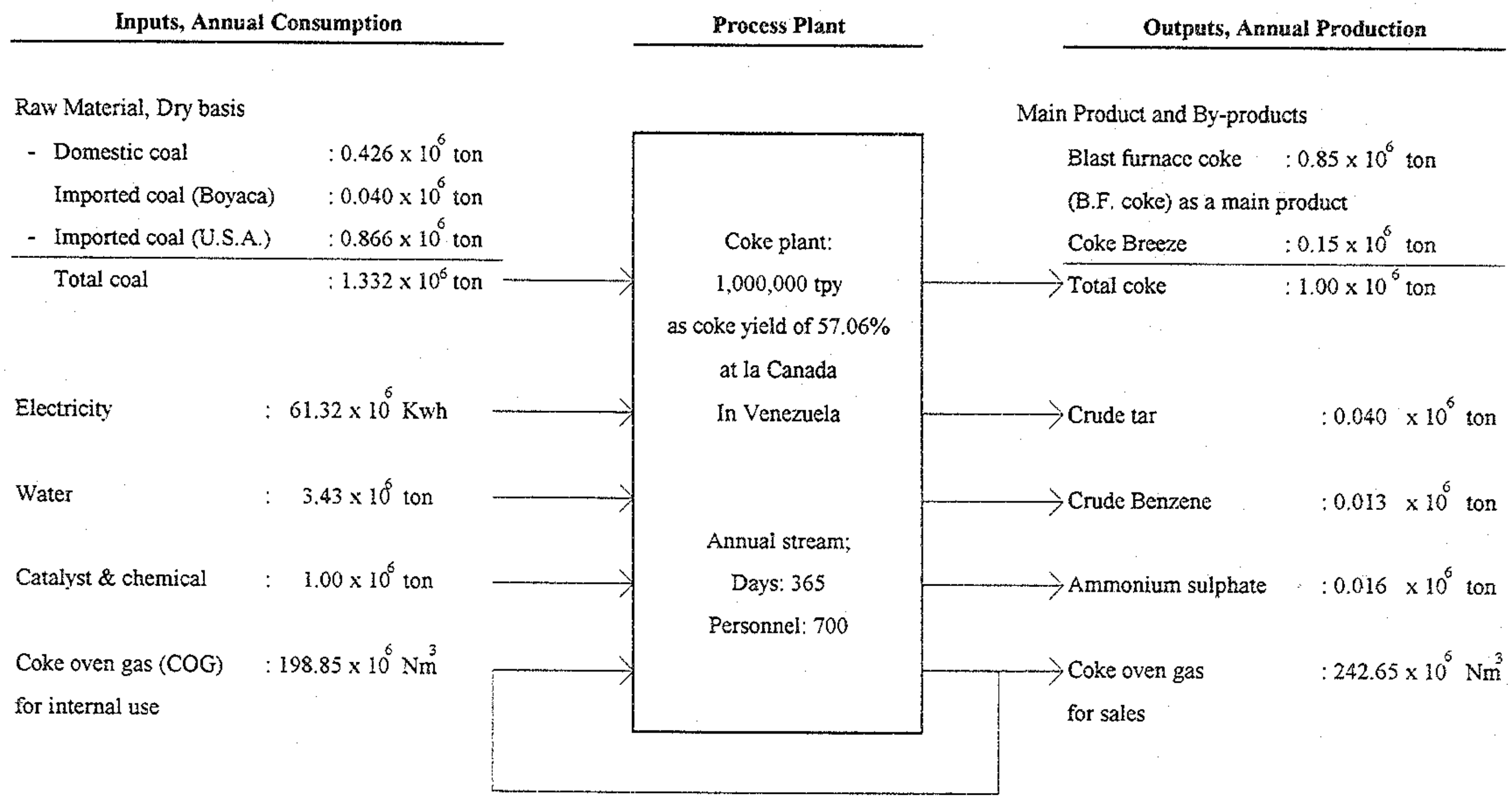


Fig.9-1 ANNUAL INPUTS AND OUTPUTS BALANCE

(1) Production and sales plan

As shown in Fig.9–1, annual production of BF coke – the main product – is 850,000 tons. The coke oven is assumed to be operated throughout the year. The plant operating rate in each year, as shown below, is based on technical consideration related to plant operation. The inventory of the BF coke product is 1.5 months, and BF coke will be all exported in accordance with the sales plan described in Chapter 3.

PRODUCTION AND SALES PLAN OF BF COKE

(Unit: %)

Project year	Plant operating rate	Inventory rate	Shipment rate
1998	80.0	10.0	70.0
1999	100.0	2.5	97.5
2000	100.0	–	100.0
|	|	|	|
2016	100.0	–	100.0
2017	100.0	(–)12.5	112.5
total	1980.0	–	1980.0

Similarly, by–products except COG will be exported taking the inventories into account as shown in 9.1.2.(7).

(2) Sales price

For the purpose of this analysis, the sales price of BF coke for export is estimated on the basis of coke prices in the U.S., as follows:

SALES PRICE OF BF COKE

(Unit: US$/ton)

Item	Estimated price
BF coke, CIF U.S.A.	135.0
Freight (Venezuela – the Gulf)	▲15.0
BF coke, FOB Venezuela	120.0

(3) Variable cost

The variable cost includes the costs of raw coals purchased from domestic and foreign sources, COG for internal consumption, utilities, catalysts, chemicals, and by-products. However, for the calculation of inventories for by-products except COG, COG is treated as a item deductible from the variable cost and other by-products is treated a revenue items.

Purchase (or sales) prices of variable cost items in 1993, and per unit consumption and unit cost per dry coal are summarized as follows.

PRICES AND PER UNIT CONSUMPTION RATES OF MAJOR VARIABLE COST ITEMS

Item	Unit	Purchase/sales price (US$/Unit)	Per dry coal	
			Unit consumption (per ton)	Unit cost (US$/ton)
Raw coal				
(excluding 9% moisture content)				
– Domestic coal	ton	26.370	0.320	8.44
– Colombian coal	ton	43.960	0.030	1.32
– U.S. coal	ton	65.930	0.650	42.85
COG	Nm^3	0.015	149.260	2.24
Utilities cost				
– Electricity	kwh	0.013	46.027	0.60
– Water	m^3	0.029	2.575	0.07
Catalyst/chemical	$	1.304	0.751	0.98
By-products				
– COG	Nm^3	0.015	331.39000	4.97
– Crude tar	ton	50.000	0.03000	1.50
– Crude benzene	ton	240.000	0.01000	2.40
– Ammonium sulfide	ton	100.000	0.01164	1.16
– Coke breeze (for export)	ton	40.000	0.11259	4.50

(4) Labor cost

The labor cost including bonus and welfare cost is established on the basis of wage data obtained from FIV. Annual wages by job rank in 1993 are assumed to be as follows.

WAGE SCHEDULE

(Unit: US$/person/year)

Rank	Category	Wage
Manager	Plant manager, deputy manager, division chief	20,520
Supervisor	Section chief, subsection chief	12,035
Staff (A)	Clerk, field supervisor, foreman	7,215
Staff (B)	Worker (unskilled labor)	4,169

Based on the organization and the employment plan discussed in Chapter 8, the manpower allocation table by section and rank is prepared in Table 9-5, and the wage schedule in Table 9-6. Accordingly, the total number of employees engaged in the project is 700, with the average wage of US$5,824/person/year. Thus, the total labor cost is estimated at US$4,077,000/year.

In addition, the overhead cost including administrative expenses, equivalent to 50% of the total labor cost, is allowed for.

(5) Maintenance and repair cost

As discussed in Chapter 8, the maintenance and repair cost covering ordinary repair service is assumed to be 2.0% of the direct construction cost.

(6) Taxes and insurance premiums

Taxes and insurance premiums are assumed to be 0.5% of fixed assets.

(7) Depreciation and amortization

The construction cost will be depreciated as follows:

Depreciation method	:	Straight line method
Salvage value	:	Zero
Service life	:	20 years

Similarly, the pre-operating expenses and interest during construction will be amortized by straight line method over 20 years with residual value of zero.

(8) Corporate tax and dividend

Corporate tax of 30% at present is imposed on the taxable income. However, dividend are not taken into account and profit after tax is retained .

(9) Working capital

Initial working capital is required for the preparation of the initial financial budget, however, additional working capital is required to maintain smooth plant operation after the start of commercial operation. In the accounting practices, the working capital is a balance of current assets after subtracting current liabilities, as shown in the balance sheet at the end of each fiscal year.

If the balance in a particular year exceeds that in the preceding year, it is called "change in working capital" and is treated as the outlay in the cash flow statement.

The analysis uses this amount for calculation of profitability in place of the initial working capital.

As discussed in 9.1.2, the working capital should cover the inventory of products, the inventory of domestic and imported coals, and accounts receivable and payable, which are valued by the first-in and first-out method.

Assumptions set for the base case are summarized in Table 9-2.

9.2.3 Assumptions for Calculation of Foreign Currency Earnings

In the calculation of foreign currency earnings as one of indicator in economic analysis, the project's contribution to improve foreign currency earnings in Venezuela is calculated as follows:

(1) Revenue from export sales of BF coke is added to foreign currency inflow.

(2) In addition, sales of the following by-products except for COG are considered to be foreign currency inflow:
- Crude tar
- Crude benzene
- Ammonium sulfate
- Coke breeze for export

(3) As for financial sources, long-term loans are considered to be the inflow of foreign currency, but they are offset by payment of the construction cost. On the other hand, reimbursement and interest after the start of commercial operation are considered to be the outflow of foreign currency.

(4) U.S. and Colombian coals, catalysts, chemicals, and 70% of maintenance cost are assumed to be the outflow of foreign currency.

(5) The net amount of foreign currency acquired from the project is calculated by subtracting the amount of foreign current outflow in items (3) and (4) from the amount of foreign currency inflow in items (1) and (2) above.

9.2.4 Assumptions for Calculation of Economic Internal Rate of Return

(1) Assumptions

Major assumptions applied to the calculation are as follows.

1) The same currency, exchange rate and pricing level shown in 9.1.1 are employed.
2) All taxes, duties and interests are excluded from economic values because they are considered as mere cash transfer items of the national economy.
3) Of the labor cost, it is judged that the wages of skilled labor will reflect opportunity cost and in the case of personal ranked above Staff A position a financial calculation of labor cost was made excluding tax elements based on the tax rates obtained at the first field survey.
   On the other hand, in view of the unemployment in Zulia, a shadow wage rate (50%) is applied to the wages of unskilled labor.
4) While key costs and prices such as plant construction cost, coke, imported coal, and

by-products are valued at international prices, it is judged that the costs of domestic coal as export goods reflect market price, therefore, they are evaluated at the same value as the financial analysis.

(2) Economic cost of investment

From the above assumptions, the same land cost and plant construction cost used in financial estimates are employed, while import duties and interest during construction are excluded from the investment cost. The pre-operating expenses and initial working capital are calculated for each element.
The breakdown of investment cost is summarized as follows.

BREAKDOWN OF INVESTMENT COST

(Unit: US$ Million)

Item	Amounts
Land Cost	2.36
Plant Construction Cost	585.83
Pre-operating Expenses	5.62
Interest During Construction	-
Initial Working Capital	18.53
Total	612.34

9.3 Financial and Economic Analysis of the Base Case

Based on the above assumptions, financial and economic analysis of the base case is conducted in terms of various financial indicators, operating ratio analysis, the FIRR and EIRR using the DCF method, and the amount of foreign currency to be earnings.
The following financial statements are attached in Appendix-1.

- Production and sales plan
- Production cost statement
- Working capital statement
- Profit and loss statement
- Funds flow statement
- Balance sheet
- Long-term loan repayment schedule

The result of financial analysis is summarized in Table 9-4.
The table summarizes the assumptions, FIRR, EIRR, debt service ratio (DSR), and the average production cost.

For the purpose of financial analysis, two evaluation criterion were adopted, the FIRR (in the case of a public project, it should be higher than the prevailing interest rate; and in the case of a private project, it should be higher than the opportunity cost obtained by adding 5% risk premium to the interest rate) and soundness of cash flow (DSR should be 1.15 or higher in each year).

The FIRR for the base case is -1.37%, well below the prevailing interest rate (5% for the project).

DSR for long-term loans is an important indicator to evaluate the soundness of cash flow and is expressed by the following formula:

$$DSR = \frac{\text{Profit after tax + Depreciation + Interest on L/T loan}}{\text{Repayment of L/T loan + Interest on L/T loan}}$$

The result shows that DSR is 1.0 or less throughout the project life, indicating cash shortage from the first year of operation.

The BF coke production cost in the tenth year of operation, or in the year of 2007, with and without depreciation and interest, is shown below. It is adopted as the average production cost for the project for comparison purposes.

BF COKE PRODUCTION COST

(Unit: US$/ton)

Item	Production cost
– Not including depreciation and interest	89.23
– Including depreciation and interest	153.63

Compared to the sales price of BF coke (US$120/ton), the production cost excluding depreciation expense and interest is lower, but that with depreciation and interest is higher by US$34.

Then, sensitivity analysis was conducted to measure the impacts of changes in factors governing the project's viability, coke sales price (including coke breeze), raw coal price, and investment cost. The FIRR for the following three cases which would contribute to the improvement of financial viability was obtained as follows:

- 20% increase in coke sale price 3.82%
- 20% decrease in raw coal price 2.20%
- 20% decrease in investment cost ▲1.24%

In any of the above cases, the FIRR obtained is below the interest rate.

In addition to the above analysis, the amount of foreign currency earned from the project is calculated.
The total amount of foreign currency to be acquired over the project life is US$212 million, which represent only 32% of the investment cost. Then, the EIRR for the base case is –0.58%.

Thus, the result of the analysis indicates that the base case shows no financial and economic viability nor earn enough foreign currency to cover the investment cost. Major reasons for this are summarized as follows:

- Relatively small amounts of Venezuelan and Colombian coals will be used, compared to a large amount of imported coal.
- All the coke produced will be exported, and its price will be restrained due to high transportation cost to the U.S.
- Prices of all the by-products are value at relatively low levels, because crude tar and benzene will have to be exported in unrefined form and COG prices are curtailed by natural gas prices, resulting in the high coke production cost.
- Environmental protection measures provided to clear strict standards have large cost impacts on investment.

9.4 Financial and Economic Analysis of the Alternative Case

To improve financial viability of the project, the alternative case is established, and financial and economic analysis is conducted.

9.4.1 Modified Assumptions

In future, a large amount of medium volatile content coal can be produced in Venezuela, such as the northern part of the LOB field, enough to replace imported coal with domestic and Colombian coals.
Based on coke yield of 74.30% estimated from the blend test in Chapter 5, the blending ratio of domestic and Colombian coals are determined as followed:

BLENDING RATIO FOR ALTERNATIVE CASE

Raw coal	Blending ratio
Domestic coal (FNO/LAS)	80.0%
Colombian coal (Boyaca)	20.0%
U.S. coal (Pinnacle/Blue Creek)	–
Total	100.0%

Under the above coke yield and blending ratio, production of crude tar, crude benzene. and ammonium sulfate will increased to change the production cost and working capital.
Assumptions for the alternative case are summarized in Table 9-3.

9.4.2 Financial and Economic Analysis

Based on the above assumptions, financial and economic analysis was performed for the alternative case. Financial statements are shown in Appendix 2, and the result of the analysis is summarized in Table 9-4.

The FIRR (before tax) for the alternative case has improved by more than 6 percentage points from that for the base case to 5.54%, barely over the interest rate.

The DSR is less than 1.0 in the first year of operation and grows above 1.15 in the 2th year. Thus, cash shortage continues for 2 years after the start of commercial operation.

The average BF coke production cost, with and without depreciation and interest, is calculated as follows:

BF COKE PRODUCTION COST

(Unit: US$/ton)

Item	Production cost
– Not including depreciation and interest	54.01
– Including depreciation and interest	106.56

The production cost with depreciation and interest is 13 dollars lower than the sales price of BF coke (US$120/ton).

Then, sensitivity analysis was conducted by varying the sales price of coke (including coke breeze), raw coal price, and investment cost. The result is summarized in Fig.9-2. The coke sales price has the largest impact on the FIRR, followed by investment cost and raw coal price.

The FIRR for the following cases which would contribute to the improvement of financial viability was obtained.

– 20% increase in coke sales price including coke breeze	9.29%
– 20% decrease in raw coal price	7.03%
– 20% decrease in investment cost	8.59%

Finally, the amount of foreign currency earned from the project was calculated. The total amount obtainable over the project life is US$1,149 million, equivalent to 1.75 times the investment cost.
Then, the EIRR for alternative case is 6.27%.

The above results indicate that the alternative case is better than the base case in terms of financial and economic viability, cash flow, and foreign currency earning. Nevertheless, the FIRR and EIRR are still too low to find the project justifiable investment.

Table 9-1 CAPITAL INVESTMENT COST FOR BASE CASE

Items	Capital Investment Cost, US$, MM		
	Foreign Currency	Local Currency	Total
1. Land & Site Preparation	-	2.36	2.36
2. Plant Direct Cost	313.45	216.90	530.35
- Coke Oven Facility	(147.41)	(29.82)	(177.23)
- Coal/Coke Storage Facility	(92.40)	(72.20)	(164.60)
- By-Products Facility	(61.55)	(80.47)	(142.02)
- Common Facility	(12.09)	(34.41)	(46.50)
3. Plant Indirect Cost	6.27	4.43	10.70
- Spare Parts	(6.27)	(4.34)	(10.61)
- Drying Expense in Coke Oven	(-)	(0.09)	(0.09)
4. Engineering Services	9.72	8.54	18.26
- Basic Engineering	(0.72)	(0.24)	(0.96)
- Engineering Services	(7.96)	(7.95)	(15.91)
- Project Management	(1.04)	(0.35)	(1.39)
Base Project Cost - 1993	329.44	232.23	561.67
5. Contingecy	15.67	10.85	26.52
- Physical Contingency	(15.67)	(10.85)	(26.52)
- Price Escalation	(Not considered in the analysis)		
6. Import Duty	-	20.53	20.53
Erected Plant Cost - 1993	345.11	263.61	608.72
7. Pre-Operation Expenses	-	6.92	6.92
8. Interest during Construction	27.37	-	27.37
9. Initial Working Capital	-	18.75	18.75
Capital Investment Cost - 1993	372.48	289.28	661.76

Table 9-2 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY FOR BASE CASE (1/3)

1. Project

Title	: Establishment of Coke Plant Project
Location	: La Canada, Venezuela
Project Case/Study Date	: Base Case/June 6, 1994
Selected Coal (Domestic)	: FNO/LAS
(Imported)	: Pinnacle/Blue Creek (USA) Boyaca(Colombia)
Maximum Operable Days	: 365 DPY
Coke Production @100%	: 2,740 TPD x 365 DPY = 1,000,000 TPY
Yield of Coke Product	: 75.06% of Feed Coal Input (dry base)
Feed Coal Input(Dry Coal Basis)	: 3,650 TPD x 365 DPY = 1,332,268 TPY (dry base)
Production Start Year	: 1998
Monetary Unit	: US dollars($) in terms of fixed price in 1993
Exchange Rate for Caluculation	: 1 US$ = 115 Yen as an average in 1993 : 1 US$ = 95 Bs during site survey in 1993

2. Schedule

Contract Award	: Dec. 01, 1995
Mechanical Completion	: Feb. 28, 1997
Production Start	: May. 01, 1998
Project Phase Out	: Dec. 31, 2017
Project Life	: 20 Years from Production Start
Project Year	: May to April
Construction and Commissioning	: 29 months from Contract Award

3. Financing Required and Financing Plan in 1993 Price Base

Financing Required	US$, MM	Financing Plan		US$, MM
Land/Site Development	2.36	Equity	: 30.0%	198.53
Erected Plant Cost	606.36	Foreign Soft Loan:	70.0%	463.23
- Coke Oven	(177.23)	- Interest	: 5.00%	
- Coal/Coke Storage	(164.60)	Short Term Loan	:	Balance
- By-Products	(142.02)	- Interest	: 5.00%	
- Common Facility	(46.50)			
- Engineering Service, etc	(76.01)	Financing Plan		661.76
Pre-Operational Expense	6.92			
Interest during Construction	27.37			
Fixed Capital Cost	643.01			
Initial Working Capital	18.75			
Financing Required	661.76			

Table 9-2 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY FOR BASE CASE (2/3)

4. Inputs and Pricing (CIF at the Plant in 1993 Price Base)

Inputs	Unit		Per Coal (Dry)		Per BF coke	Annual	
	Unit	Cost	Consumption	Cost	Cost	Consumption	Cost
		$/Unit	Unit/Unit	$/Unit	$/Unit	(MM, Unit)	$, MM
Raw Material dry excl. Moisture @9%							
- Domestic Coal	Ton	26.37	0.320	8.44	13.22	0.426	11.242
- Imported Coal(Boyaca)	Ton	43.96	0.030	1.32	2.07	0.040	1.757
- Imported Coal(U.S.A)	Ton	65.93	0.650	42.85	67.17	0.866	57.094
Coke Oven Gas	Nm^3	0.015	149.26	2.24	3.51	198.85	2.983
Utilities							
- Electricity	kwh	0.013	46.027	0.60	0.94	61.32	0.797
- Water	m^3	0.029	2.575	0.07	0.12	3.43	0.099
Cat/Chem	Ton	1.304	0.751	0.98	1.53	1.000	1.304
(1) Variable Cost	-	-	-	-	88.56	0.850	75.276
Operating Staff	M-Y	5,824			4.80	700	4.077
Overhead	Ope. Staff x 50%				2.40	-	2.038
Maintenance Cost	Plant Direct Cost x 2.0%				12.48	-	10.607
Tax & Insurance	Fixed Capital Cost x 0.5%				3.78	-	3.215
(2) Direct Fixed Cost	-	-	-	-	23.46	0.850	19.937
Credits							
- Coke Oven Gas	Nm^3	0.015	331.39	4.97	7.79	441.50	6.622
- Crude Tar	Ton	50.00	0.03	1.50	2.35	0.03997	1.999
- Crude Benzene	Ton	240.00	0.01	2.40	3.76	0.01332	3.197
- Ammonium Sulphate	Ton	100.00	0.01164	1.16	1.82	0.01551	1.551
- Coke Breeze (Export)	Ton	40.00	0.11259	4.50	7.06	0.15000	6.000
(Local)	Ton	66.32	-	-	-	-	-
(3) Total Credits	-	-	-	-	22.79	0.850	19.369
(4) Production Cost = (1)+(2)-(3)					89.23	0.850	75.844

Table 9-2 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY FOR BASE CASE (3/3)

5. Outputs and Pricing
(FOB at the Plant with Full Capacity Utilization in 1993)

Outputs	Unit	Unit Price ($/Unit)	Annual Production (MM, Unit)	Annual Sales ($, MM)
BF Coke*	Ton	120.0	0.850	102.000

(Note) *:FOB Venezuela Price = CIF USA (135 $/t) - Ocean Freight (15 $/t)

6. Operation Schedule

Project Year (Unit: %)

	(-)3 95	(-)2 96	(-)1 97	1 98	2 99	3 00	..20 2017	Total/ Avarage
- Financing Disbursement	10	50	40					
- BF Coke Production								
- Rated Capacity Utilization				80	100	100	100	1,980
- Inventory Increase				10	2	0	(-)12	0
- Inventory				10	12	12	0	0
- Sales				70	98	100	112	1,980

- Depreciation/Salvage Value 20 years straight line/Zero salvage value
- Amortization/Salvage Value 20 years straight line/Zero salvage value
- Corporate Income Tax 30%

- Debt Service

Loan Type	Maximum Grace + Maturity	Annual Interest Rate	Installments
- Long Term Loan/Foreign	3 + 20	5.00	20
- Short Term Loan/Local	0 + 1	5.00	1

- BF Coke Inventory 1.5 months
- Coke Breeze Inventory 1.0 month
- Crude Tar Inventory 1.5 months
- Crude Benzene Inventory 3.0 months
- Ammonium Sulfate Inventory 1.0 month
- Domestic Coal Inventory 0.5 months
- Imported Coal Inventory 1.5 months
- Account Receivable/payable 1.0 month/1.0 month

Table 9-3 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY FOR ALT. CASE (1/3)

1. Project

Title	: Establishment of Coke Plant Project
Location	: La Canada, Venezuela
Project Case/Study Date	: Alternative (ALT.) Case/June 6, 1994
Selected Coal (Domestic)	: FNO/LAS
(Imported)	: Boyaca (Colombia)
Maximum Operable Days	: 365 DPY
Coke Production @100%	: 2,740 TPD x 365 DPY = 1,000,000 TPY
Yield of Coke Product	: 74.30% of Feed Coal Input
Feed Coal Input(Dry Coal Basis)	: 3,687 TPD x 365 DPY = 1,345,895 TPY
Production Start Year	: 1998
Monetary Unit	: US dollars($) in terms of fixed price in 1993
Exchange Rate for Caluculation	: 1 US$ = 115 Yen as an average in 1993
	: 1 US$ = 95 Bs during site survey in 1993

2. Schedule

Contract Award	: Dec. 01, 1995
Mechanical Completion	: Feb. 28, 1997
Production Start	: May. 01, 1998
Project Phase Out	: Dec. 31, 2017
Project Life	: 20 Years from Production Start
Project Year	: May to April
Construction and Commissioning	: 29 months from Contract Award

3. Financing Required and Financing Plan in 1993 Price Base

Financing Required	US$, MM	Financing Plan	US$, MM
Land/Site Development	2.36	Equity : 30.0%	196.99
Erected Plant Cost	606.36	Foreign Soft Loan: 70.0%	459.63
- Coke Oven	(177.23)	- Interest : 5.00%	
- Coal/Coke Storage	(164.60)	Short Term Loan :	Balance
- By-Products	(142.02)	- Interest : 5.00%	
- Common Facility	(46.50)		
- Engineering Service, etc	(76.01)	Financing Plan	656.62
Pre-Operational Expense	6.92		
Interest during Construction	27.37		
Fixed Capital Cost	643.01		
Initial Working Capital	13.61		
Financing Required	656.62		

Table 9-3 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY FOR ALT. CASE (2/3)

4. Inputs and Pricing (CIF at the Plant in 1993 Price Base)

Inputs	Unit		Per Coal (Dry)		Per BF coke	Annual	
	Unit	Cost	Consumption	Cost	Cost	Consumption	Cost
		$/Unit	Unit/Unit	$/Unit	$/Unit	(MM, Unit)	$, MM
Raw Material exc. Moisture @9%							
- Domestic Coal	Ton	26.37	0.800	21.10	33.40	1.077	28.393
- Imported Coal(Boyaca)	Ton	43.96	0.200	8.79	13.92	0.269	11.833
- Imported Coal(U.S.A)	Ton	65.93	-	-	-	-	-
Coke Oven Gas	Nm^3	0.015	147.75	2.22	3.51	198.85	2.983
Utilities							
- Electricity	kwh	0.013	45.561	0.59	0.94	61.32	0.797
- Water	m^3	0.029	2.548	0.07	0.12	3.43	0.099
Cat/Chem	Ton	1.304	0.743	0.97	1.53	1.000	1.304
(1) Variable Cost	-	-	-	-	53.42	0.850	45.409
Operating Staff	M-Y	5,824			4.80	700	4.077
Overhead	Ope. Staff x 50%				2.40	-	2.038
Maintenance Cost	Plant Direct Cost x 2.0%				12.48	-	10.607
Tax & Insurance	Fixed Capital Cost x 0.5%				3.78	-	3.215
(2) Direct Fixed Cost	-	-	-	-	23.46	0.850	19.937
Credits							
- Coke Oven Gas	Nm^3	0.015	328.03	4.92	7.79	441.50	6.622
- Crude Tar	Ton	50.00	0.03	1.50	2.38	0.04038	2.019
- Crude Benzene	Ton	240.00	0.01	2.40	3.80	0.01346	3.230
- Ammonium Sulphate	Ton	100.00	0.01164	1.16	1.84	0.01567	1.567
- Coke Breeze (Export)	Ton	40.00	0.11145	4.46	7.06	0.15000	6.000
(Local)	Ton	66.32	-	-	-	-	-
(3) Total Credits	-	-	-	-	22.87	0.850	19.438
(4) Production Cost = (1)+(2)-(3)					54.01	0.850	45.908

Table 9-3 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY FOR ALT. CASE (3/3)

5. Outputs and Pricing
   (FOB at the Plant with Full Capacity Utilization in 1993)

Outputs	Unit	Unit Price ($/Unit)	Annual Production (MM, Unit)	Annual Sales ($, MM)
BF Coke*	Ton	120.0	0.850	102.000

(Note) *:FOB Venezuela Price = CIF USA (135 $/t) - Ocean Freight (15 $/t)

6. Operation Schedule

Project Year (Unit: %)

	(-)3 95	(-)2 96	(-)1 97	1 98	2 99	3 00	..20 2017	Total/ Avarage
- Financing Disbursement	10	50	40					
- BF Coke Production								
- Rated Capacity Utilization				80	100	100	100	1,980
- Inventory Increase				10	2	0	(-)12	0
- Inventory				10	12	12	0	0
- Sales				70	98	100	112	1,980

- Depreciation/Salvage Value   20 years straight line/Zero salvage value
- Amortization/Salvage Value   20 years straight line/Zero salvage value
- Corporate Income Tax   30%

- Debt Service

Loan Type	Maximum Grace + Maturity	Annual Interest Rate	Installments
- Long Term Loan/Foreign	3 + 20	5.00	20
- Short Term Loan/Local	0 + 1	5.00	1

- BF Coke Inventory	1.5 months
- Coke Breeze Inventory	1.0 month
- Crude Tar Inventory	1.5 months
- Crude Benzene Inventory	3.0 months
- Ammonium Sulfate Inventory	1.0 month
- Domestic Coal Inventory	0.5 months
- Imported Coal Inventory	1.5 months
- Account Receivable/payable	1.0 month/1.0 month

Table 9-4 PROJECT CASES COMPARISON SUMMARY ON COKE PLANT PROJECT

	Case		Base Case	Alt. Case
	Coke production	(tons/year)	1,000,000	1,000,000
	Coke yield	(%)	75.06	74.30
	Coal blending ratio			
	- Domestic coal	(%)	32.00	80.00
	- Imported coal (Boyaca)	(%)	3.00	20.00
	- Imported coal (U.S.A)	(%)	65.00	-
	B.F. coke sales volume for export	(tons/year)	850,000	850,000
1)	Capital Investment Cost	(million dollars)	661.76	656.62
2)	Financing Plan	(million dollars)		
	Equity	(30%)	198.53	196.99
	Long-term loans	(70%)	463.23	459.63
	Total		661.76	656.62
3)	Major Assumptions for Plant Operation			
	Sales prices for export	(FOB)		
	- B.F. cokes	($/ton)	120.0	120.0
	- Coke breeze	($/ton)	40.0	40.0
	Coal for coke making	(CIF, Dry base)		
	- Domestic coals	($/ton)	26.37	26.37
	- Imported coals (Boyaca)	($/ton)	43.96	43.96
	- Imported coals (U.S.A)	($/ton)	65.93	65.93
	Operating staff		700	700
	Service life on depreciation		20	20
	Interest rate on loan	(%)	5.0	5.0
	Repayment period		20	20
4)	Results of Financial/Economic Analysis			
	Financial internal rate of return(FIRR)	(before tax, %)	▲1.37	5.54
		(after tax, %)	▲1.37	4.95
	Debt service ratio	(DSR)		
	- 1st year of operation		0.42	0.87
	- 2nd year of operation		0.52	1.20
	- 3rd year of operation		0.53	1.26
	Average production cost	(per B.F. cokes, $/tons)		
	- Cost not including depreciation and interest		89.23	54.01
	- Cost including depreciation and interest		153.63	106.56
	Sensitivity analysis on FIRR	(before tax, %)		
	- Sales price including Breeze	(up 20%)	3.82	9.29
	- Coal prices	(down 20%)	2.20	7.03
	- Investment cost	(down 20%)	1.24	8.59
	Economic internal rate of return	(EIRR, %)	▲0.58	6.27
	Foreign currency earnings	(million, dollars)		
	- Whole project life		211.57	1,149.35

Note: Exchange rate: $1 = 115 yen = 95Bs
Pricing lebel: US$ in terms of fixed price in 1993
Project life: 23 years including 3 years of construction

Table 9-5 MANPOWER REQUIREMENT

	Number of Staff				
	Manager	Chief	Staff A	Staff B	Total
1. Administrative Division					
1.1 Director Room	3	0	0	0	3
1.2 General Division	1	10	29	0	40
1.3 Sales/Purchasing Division	1	6	18	0	25
Administrative Division Total	5	16	47	0	68
2. Production Division					
2.1 Production Control Section	1	4	20	0	25
2.2 Quality Control Section	0	3	14	36	53
2.3 Coke Production Section	1	3	43	147	194
2.4 By-Product Section	0	3	30	80	113
Production Division Total	2	13	107	263	385
3. Maintenance Division					
3.1 Engineering Section	1	5	22	13	41
3.2 Mechanical Section	0	3	27	93	123
3.3 Electric Instrument Section	0	3	31	49	83
Maintenance Division Total	1	11	80	155	247
Grand Total	8	40	234	418	700

Table 9-6 SALARIES AND WAGES CALCULATION

(Unit 1,000 US$)

	Salaries and Wages				Total
	Manager	Chief	Staff A	Staff B	
Man-Year	20.520	12.035	7.215	4.169	
1. Administrative Division					
1.1 Director Room	61.56	0.00	0.00	0.00	61.56
1.2 General Division	20.52	120.35	209.24	0.00	350.11
1.3 Sales/Purchasing Division	20.52	72.21	129.87	0.00	222.60
Administrative Division Total	102.60	192.56	339.11	0.00	634.27
2. Production Division				0.00	
2.1 Production Control Section	20.52	48.14	144.30	0.00	212.96
2.2 Quality Control Section	0.00	36.11	101.01	150.08	287.20
2.3 Coke Production Section	20.52	36.11	310.25	612.84	979.71
2.4 By-Product Section	0.00	36.11	216.45	333.52	586.08
Production Division Total	41.04	156.46	772.01	1,096.45	2,065.95
3. Maintenance Division				0.00	
3.1 Engineering Section	20.52	60.18	158.73	54.20	293.62
3.2 Mechanical Section	0.00	36.11	194.81	387.72	618.63
3.3 Electric Instrument Section	0.00	36.11	223.67	204.28	464.05
Maintenance Division Total	20.52	132.39	577.20	646.20	1,376.30
Grand Total	164.16	481.40	1,688.31	1,742.64	4,076.51

(ALTENATIVE)

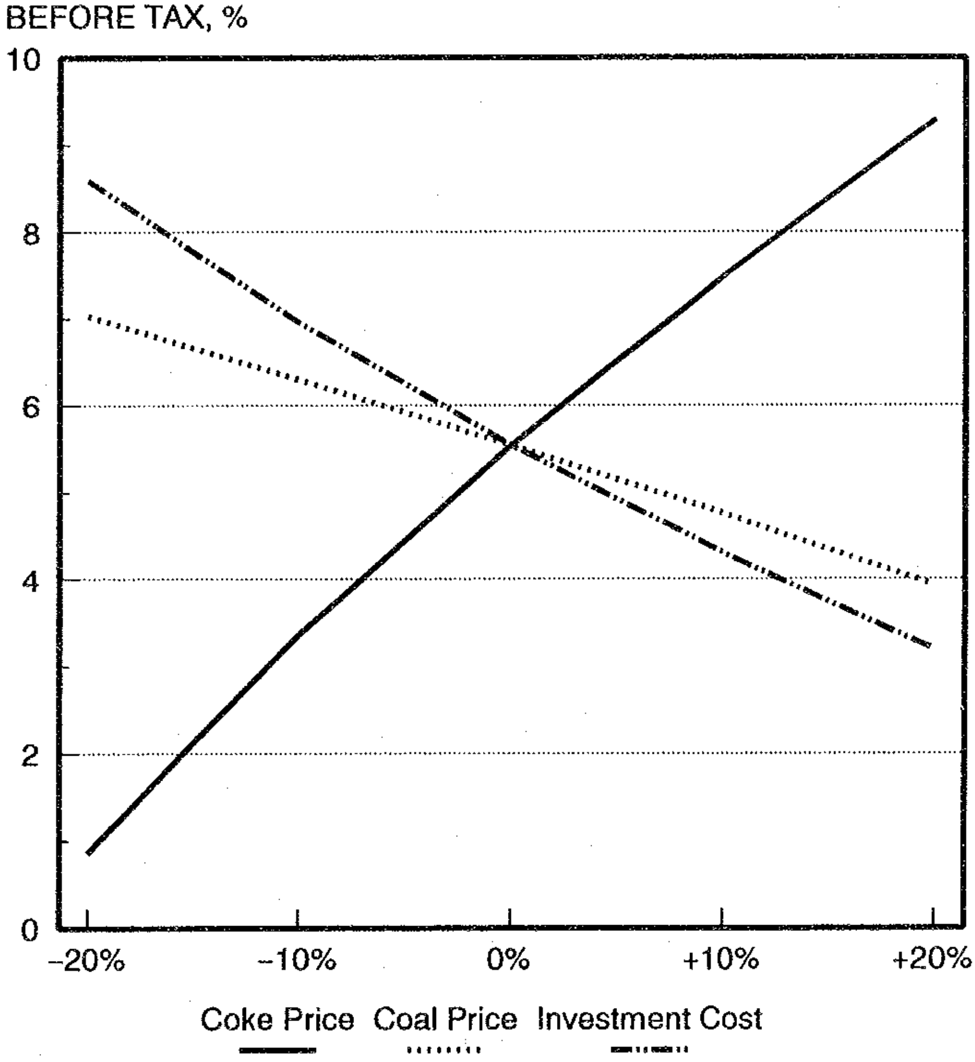


Fig.9-2 SENSITIVITY ANALYSIS OF FIRR ON INVESTMENT FOR COKE PLANT PROJECT, VENEZUELA

Chapter 10 Environmental Impact Assessment

Chapter 10 Environmental Impact Assessment

10.1 General

The candidate site for the proposed coke making plant is located in the La Cañada district in the suburbs of Maracaibo, Zulia State. In general, construction and operation of the coke plant would give the following impacts on the surrounding environment as follows. At the construction stage, dust, noise, vibration, and waste water and solid waste will be produced. Once the plant comes on stream, it will discharges exhaust gas and effluent water which will cause air pollution and water contamination. Also, it may produce noise, vibration, smell, and solid waste. These environmental impacts will affect natural environment in and around the plant, including wild animals, plants and soils, landscapes, and public safety (e.g., a risk of traffic accident) and other socioeconomic aspects of community life and activity. In the following sections, potential environmental impacts of the plant are identified and analyzed.

As discussed in Chapter 6 (Project Planning Framework), Chapter 7 (Construction Plan), and Chapter 8 (Plant Operation Plan) in detail, production of coke from coal involves a variety of physical and chemical processes, including coal receiving, coal storage, coal preparation, carbonization, and treatment and shipment of coke and by-products. The core of the coke making process is the carbonization process where coal is thermally decomposed and its carbon content is chemically converted to coke. At the same time, non-carbon contents are decomposed and many of them are separated and converted into a gaseous form. Table 10-1 summarizes distillates from the carbonization process and constituents contained in residual matters.

Table 10-1 CARBONIZATION DISTILLATES AND RESIDUAL MATTERS

	Carbonization Distillate	Residual Matter
Sulfur	H_2S, SOx, CS_2, CH_3SH, etc.	S combined with C Inorganic S
Nitrogen	NH_3, HCN, NOx, etc.	C combined with N
Oxygen	H_2O, CO, CO_2, SOx, NOx, etc.	C combined with O
Hydrocarbons	H_2, CnHm (lower grade hydrocarbon), CH_3SH, C_6H_5N, C_6H_5OH, etc.	C and trace of H
Other minerals	Hg, As, and compounds	Al, Fe, Si, Ca, and compounds

Carbonization products from dried coal charged to the oven are 75% coke, 300m^3/ton gas (coke oven gas (COG)), 10 – 13% gas condensate, 4 – 6% light oil and tar. This gas condensate mainly consists of water in which large amounts of ammonia and other impurities are dissolved, so that it is called ammonia liquor. Each product contains constituents of carbonization distillates listed in Table 10–1.

If these contents are discharged from the plant without treatment or are simply burned, they will cause serious environmental pollution. In the past, disposed tar and light oil, untreated ammonia liquor, and sulfur and nitrogen compounds contained in burned gas discharged without treatment have resulted in environmental damages.

At present, as the productive use of light oil and tar contents has been commercialized after separation and purification, they are not likely to present a serious environmental problem.

On the other hand, COG and ammonia liquor contain sulfur and nitrogen compounds, which are major environmental pollutants and must be removed before commercial use or disposal. Various techniques have been developed to produce sulfur or sulfuric acid from sulfur compounds in COG and ammonia liquor, and to separate ammonia from nitrogen compounds. The project plans to recover sulfur compounds and ammonia in the form of ammonium sulfate.

Thus, pollution control measures can be effectively incorporated into the coke oven, including commercial production of useful products. Major pollution control measures to be introduced to the plant are described in Table 10–2.

Table 10-2 SUMMARY OF POLLUTION CONTROL MEASURES

Section		Pollutants	Control measures
Coal Preparation	Coal unloading	Dust	Water sprinkler
	Coal yard	Dust	Water sprinkler
	Crusher	Dust/noise/vibration	Local ventilation/bag filter (dust) Use of hammer type crusher (noise) Installation in building (noise/vibration)
	Blending tank	Dust	Upper building/local ventilation/bag filter
	Upper coal tower	Dust	Upper building/local ventilation/bag filter
	Joints between belt conveyors	Dust	Enclosure
	Belt conveyors	Dust	Wind-shield cover (after crushing)
Coak Oven	Charging car	Dust Noise	Smokeless charging equipment/charging hood/fixed dust /ground dust collector Ground dust collector (bag filter) equipped with silencer
	Coke guide	Dust Noise	Duct and dust collector Ground dust collector (bag filter) equipped with silencer
	Quenching tower	Dust	Sprinkler demister
Coak Treatment	Screening room (screening equipment, crusher)	Dust/noise/vibration	Local ventilation/bag filter (dust) Inside building (noise/vibration)
	Coke yard	Dust	Water sprinkler
	Joints between belt conveyors	Dust	Enclosure
	Belt conveyors	Dust	Wind-shield cover (after crushing)
Combustion Facility	Coke oven Boiler Heating furnace	Nitrogen oxide Sulfur oxide Suspended particle	Deammonization plant (recovery of ammonia sulfide) Desulfurization plant (recovery of sulfuric acid) Use of low NOx burner, and low smoke operation (monitoring by dust concentration meter for coke oven, and control of dust and sludge generation)
Effluent Treatment	Ammonia liquor	Harmful substances	Ammonia distillation Activated sludge process equipment (including coagulation settlement) Activated charcoal absorption facility
	Waste water from yards	SS/pH	Settlement, pH adjustment facility
Others	Suction and exhaust blowers	Noise	Inside building
	Compressors/PSAs	Noise	Use of silencer
	Flare stack	Emission of unburned gas	Flare stack
Work Environment	Mobile equipment for coke oven	Entry of dust and tar	Enclosure of operator room, pressurizing, cooler
	Oven doors	Gas leakage	Use of air-cooled doors
	Top cover and bent of offtake	Gas leakage	Water-proof measures
	Charging holes	Gas leakage	Mortar seal
	Instrument room/resting room		Installation of coolers
Offensive Smell			
	Gas refining plant	Smell leak	Enclosure
	Recycling	Tar residue Activated sludge Bottoms	Returned to coke oven
Landscaping		Access road Green belts	Pavement Along battery limit

10.2 Air Pollution

(1) Current situation

The study team collected data and information showing the current state of air pollution in the La Cañada district by visiting CORPOZULIA, the site and its vicinities.

The relevant data on air pollution in the district obtained from CORPOZULIA are those on SO_2, NO_2, and H_2S which were measured near ENELVEN's thermal power plant (Planta Ramon Laguna) in the city center of Maracaibo for a specific period of time.
The measurement was taken at five locations in the city, 7 times over a period of consecutive 18 days (specific dates not known). Naturally, wind velocity and direction, and meteorological conditions varied during the period. The average wind velocity was 10.0m/second. Locations of the thermal power plant and the measurement points, variation of wind directions during the period, and the status of air pollution by detrimental gases are shown in Figures 10–1 through 10–5. Note that concentrations of major pollutants vary greatly among the measurement points.

In the area adjacent to the thermal power plant, such as measurement point No.3, the mean SO_2 concentration exceeds $80\mu g/Nm^3$. The maximum concentration level of SO_2 is $250\mu g/Nm^3$. Measurement point No.2 shows similar data as that of No.3. These data are higher than the limiting concentration (equivalent to environmental standards) in Venezuela and indicate a serious level of air pollution by SO_2. In contrast, air pollution by NO_2 and H_2S has not reached an alarming level.

On the other hand, at measurement point No.5 which is away from the thermal power plant and is less affected by air pollution in terms of wind direction, the average measurement data are SO_2 $15\mu g/m^3$, NO_2 $10\mu g/m^3$, and H_2S $0.4\mu g/m^3$. These data are considered to be concentrations of the air pollutants close to background concentrations in Maracaibo or the La Cañada district.

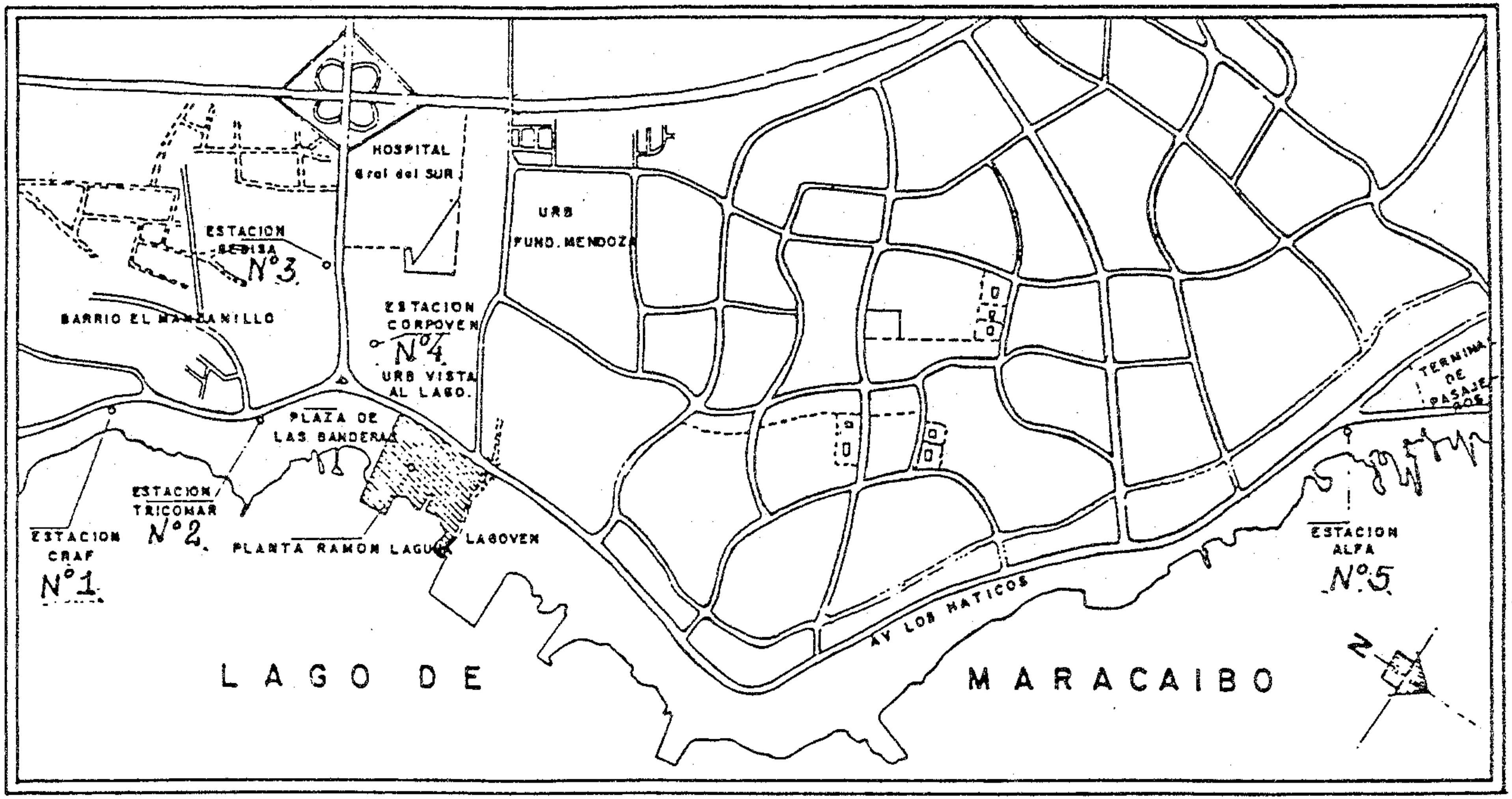


Fig.10-1 LOCATIONS OF THE THERMAL POWER PLANT AND MEASUREMENT POINTS

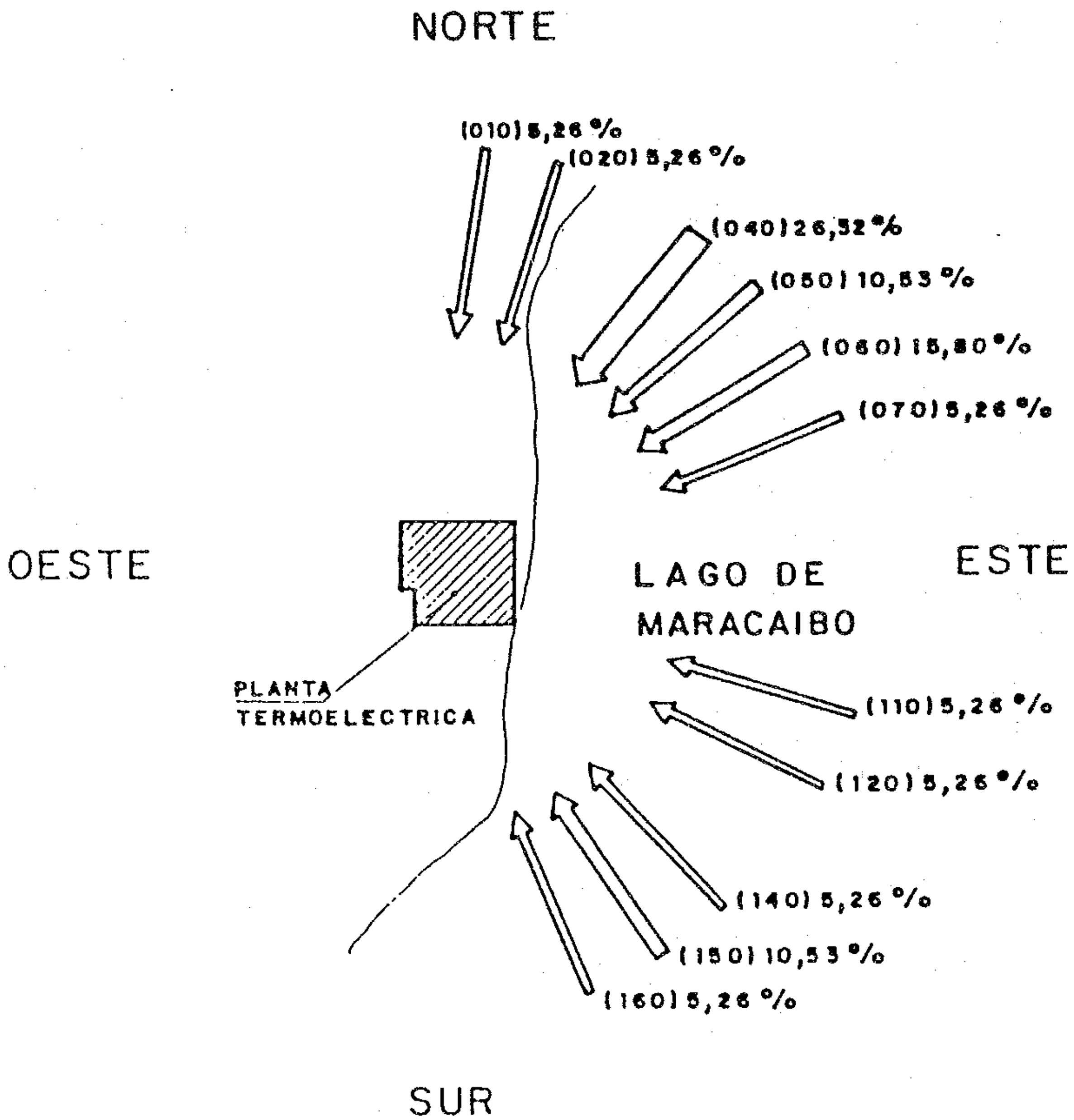


Fig.10-2 WIND DIRECTIONS DURING THE MEASUREMENT PERIOD

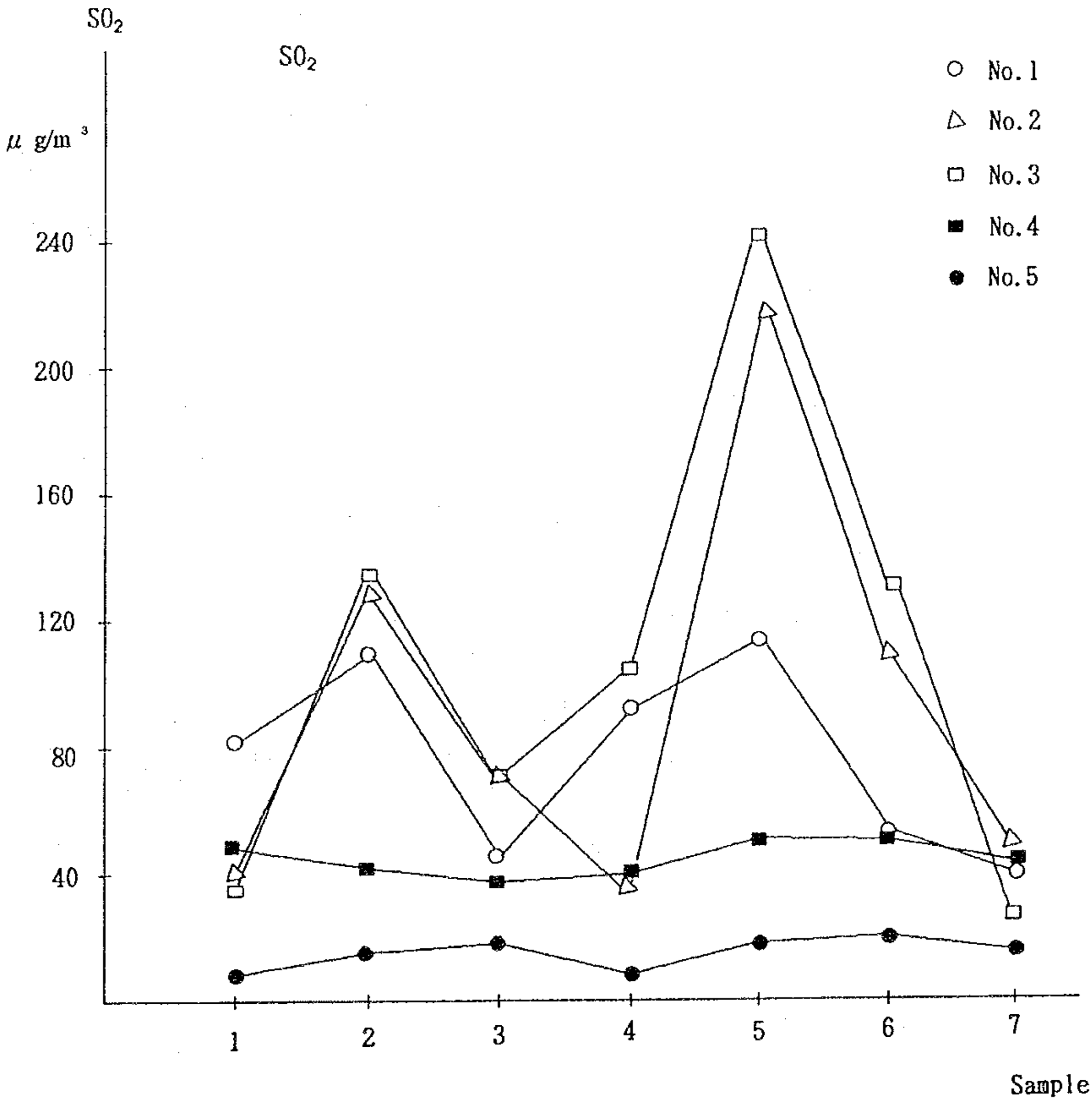


Fig. 10-3 LEVELS OF AIR POLLUTION BY SO_2

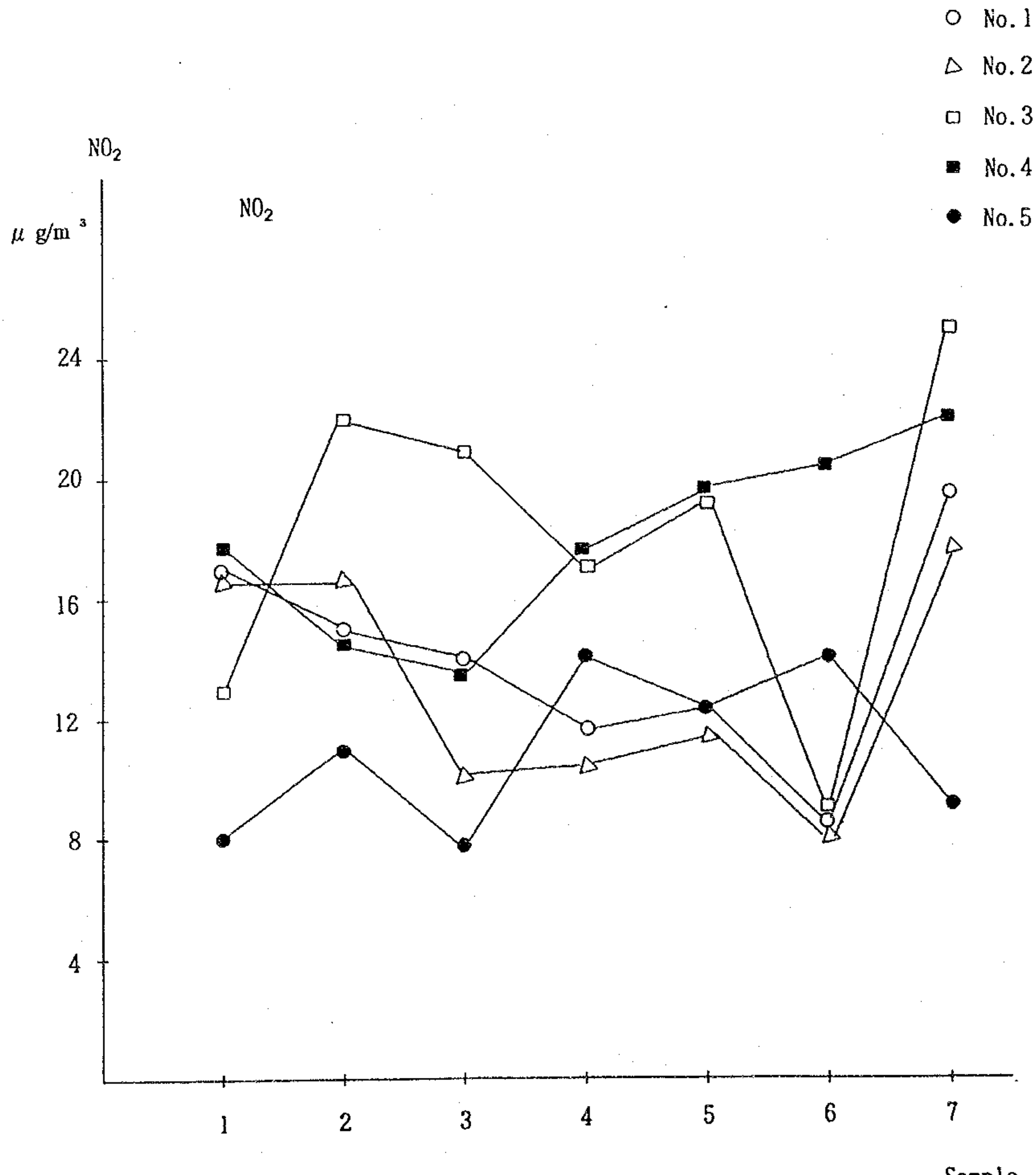


Fig. 10-4 LEVELS OF AIR POLLUTION BY NO_2

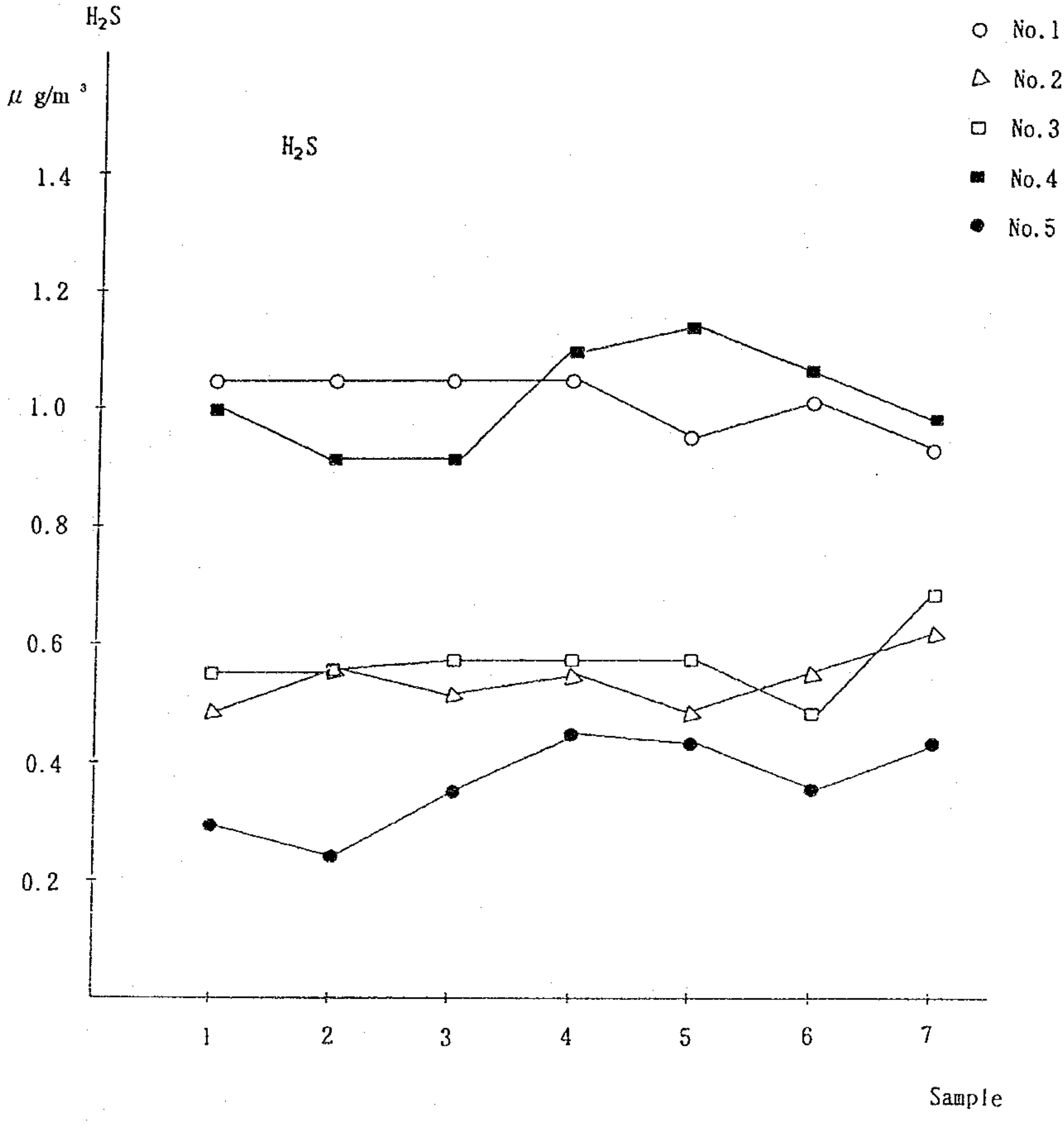


Fig. 10-5 LEVELS OF AIR POLLUTION BY H_2S

(2) Meteorological conditions

Meteorological data representing the city of Maracaibo and its surroundings are collected by the air force at the international airport located in the suburbs of the city. Note that the international airport was located in Grano de Oro up to 1970, and in La Chinita thereafter.

According to data obtained from CORPOZULIA, meteorological data collected at the Maracaibo airport between 1961 and 1974 are analyzed. The result of the analysis is summarized as follows.
In addition, on December 7, 1993, the study team obtained data on hourly atmospheric stability (calculable from intensity of solar radiation, cloud cover, and wind velocity data), wind velocity and direction. Analysis results of these data are compiled in (5) Environmental impacts of air pollutions and evaluation of control measures.

According to the past meteorological data, the daily mean temperature in Maracaibo ranges between 27°C and 29°C. The maximum mean temperature is 28.5°C between June and September. The average temperature drops thereafter to the lowest level of 27.2°C between December and February, and rises again thereafter. Note that the daily minimum temperature rarely drops below 20°C in Maracaibo.

The annual mean intensity of solar radiation is 440cal/cm^2/day. The monthly maximum value is 718cal/cm^2/day recorded in September 1961. The daily maximum value is 868cal/cm^2/day in July 1961, and the daily minimum value 101cal/cm^2/day in November 1972.

Predominant wind directions are north and northeast because the area is located in the trade wind zone. Wind velocity ranges between 5 - 15km/hour (1.4 - 4.2m/second). Less windy is between August through October, with infrequent gusts. Another important wind is southeast. Although not occurring frequently, it brings a gust which once recorded a velocity of 105km/hour. The gust generally blows in early afternoon. Distribution of wind velocities and directions is shown in Fig. 10-6.

Relative humidity ranges between 70% and 80%, with the average of 75%. There is little monthly fluctuation.
Precipitation is relatively small, less than 600mm annually. 570mm was recorded in a year. There are dry and rainy seasons. The former is between December and next July, and the latter is between August and November. While the rainy season comes in around May in

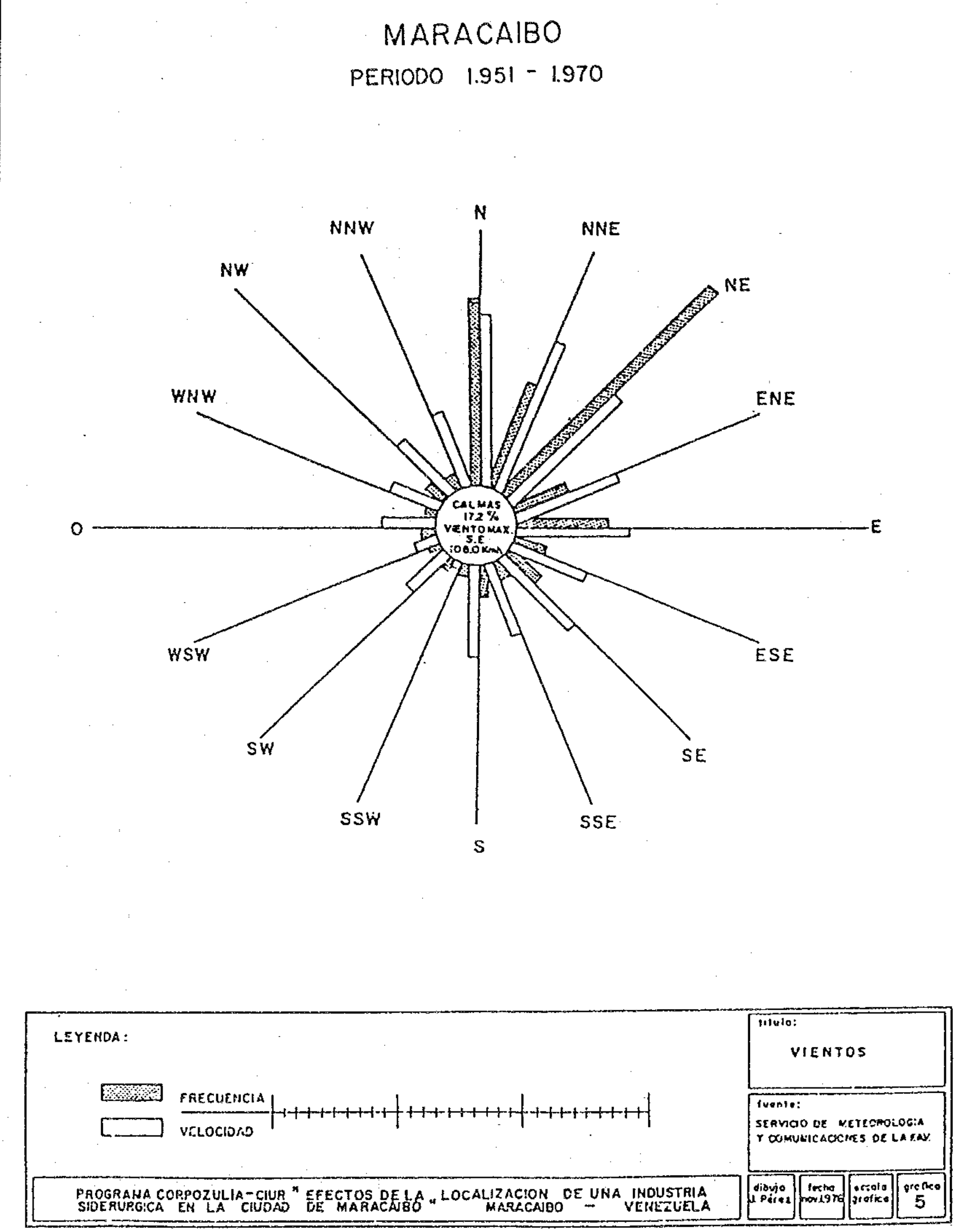


Fig.10-6 DISTRIBUTION OF WIND VELOCITIES AND DIRECTIONS IN MARACAIBO

other areas in Venezuela, it arrives late in Maracaibo and its surrounding areas with less rainfall. Although the area is classified as the savanna climate, actual data are closer to the desert climate.

Sunshine duration shows two-peak distribution throughout the year. The first peak level is 9 hours in February. Then, the duration decreases gradually to 5.86 hours in May and increases again to 8 hours in July. Then, it declines to 6.15 hours in October, followed by the rise toward February. The monthly maximum duration of sunshine is 11 - 12 hours throughout the year.

In contrast to relatively the small amounts of rainfall, cloud cover is relatively large. It amounts to 4/8 of all sky between December and February, and increases gradually to 6/8 - 7/8 between April and November.

Water evaporation is 4.0mm per day on average. The maximum level occurs in March, 7.5mm in 1965. The minimum level occurs in October and November, 1.6mm and 1.7mm on record respectively.

Atmospheric pressure averages 1,010mb.

(3) Target levels of air pollution control

The degree of air pollution is usually measured by SO_2, NO_2, and dust. For the project, SO_2 and NO_2 are used to set target levels of air pollution control.

In addition, locations and facilities which may generate dust are identified, and control measures are proposed.

The upper limits for concentrations of air pollutants, equivalent to environmental standards in other countries, are specified in Article 3 of Decree No.2225 dated April 23, 1992 "Standards for Control of Atmospheric Pollution (Normas sobre Control de la Contaminación Atmosférica)" which are summarized in Table 10-3.

Target levels of air pollution control are indicated in the upper limits for concentrations of air pollutants (environmental standards). While it is difficult to interpret this table, average limits for SO_2 and NO_2 concentrations appear to be $80\mu g/m^3$ (0.028ppm) and $100\mu g/m^3$(0.049ppm) respectively.

In addition, background concentrations in Maracaibo and its suburbs including the La Cañada district are assumed to be $15\mu g/m^3$ for (0.0053ppm) and $10\mu g/m^3$ (0.0049ppm) respectively.

Table 10-3 UPPER LIMITS FOR ATMOSPHERIC CONCENTRATIONS OF AIR POLLUTANTS IN VENEZUELA (ENVIRONMENTAL STANDARDS)

(25°C, latm)

Pollutant	Upper Limit ($\mu g/m^3$)	Samples Exceeding Limits (%)	Measurement time (hours)
1. SO_2	80	50	24
	200	5	24
	250	2	24
	365	0.5	24
2. Suspended Particle	75	50	24
	150	5	24
	200	2	24
	260	0.5	24
3. CO_2	10,000	50	24
	40,000	0.5	24
4. NO_2	100	50	24
	300	5	24
5. Hydrocarbons (expressed as CH_4)	160	0.6	3
6. Oxidants (expressed as O_3)	240	0.02	1
7. H_2S	20	0.5	24
8. Pb (Suspended Particle)	1.5	50	24
	2	5	24
9. HF	10	2	24
	20	0.5	24
10. F_2	10	2	24
	20	0.5	24
11. HCl	200	2	24
12. Cl_2	200	2	24

Soruce: Normas Sobre Control de la Contaminación Atomosféria, Articlo 3.

(4) Air pollutants discharged from the coke oven

Under the current design conditions, the coke oven and its auxiliary facilities are expected to discharge air pollutants as shown in the table below. Note that, since the plant will use COG as the principal fuel, which will produce a negligible amount of dust.

Table 10-4 AIR POLLUTANTS BY MAJOR SOURCE

	Coke Oven	Boiler	Heating Furnace
Height of smokestack (m)	120	50	25
Diameter of smokestack (m)	5.0	1.0	1.0
Exhaust gas temperature (°C)	200	180	250
Amount of exhaust gas (Dry, Nm^3)	107,000	12,000	2,300
(Wet, Nm^3)	130,000	14,000	2,700
SO_2 concentration (ppm)	50	50	50
NO_2 concentration (ppm)	170	130	150
Dust (g/Nm^3)	0.015	0.010	0.010
Oxygen in exhaust gas (%)	7	5	7

From the above table, amounts of SO_2, NO_2, and dust discharges per hour are estimated as follows:

Table 10-5 HOURLY DISCHARGE OF MAJOR AIR POLLUTANTS

	Coke Oven	Boiler	Heating Furnace
SO_2 (Nm^3/hour)	5.35	0.60	0.115
NO_2 (Nm^3/hour)	18.2	1.56	0.345
Dust (kg/hour)	16.05	1.20	0.23

In addition, the U.S. Clean Air Act regulates duration of smoke generation during the charging of coal, gas leakage through oven doors in the carbonization process, gas leakage through the offtake, and through coal charging lids. Gas leakage through oven doors will be dealt with by providing air-cooled doors with good sealing effects. The offtake will be water sealed and the charging lids will be mortar sealed. Smoke generation in the charging process will be minimized by using the smokeless charge device.

Within the plant, dust is expected to be produced at the following locations and facilities:

Coal receiving facility and coke ship loaders
Coal and coke yards
Belt conveyors for coal and coke transportation
Coke screening equipment
Coal blending tank and charged coal tank
Charging car (in charging) and coke guide car (in pushing)
Quenching tower

(5) Environmental impacts of air pollutants and evaluation of control measures

To predict the range and degree of atmospheric pollution caused by construction and operation of the coke oven plant in La Cañada, detailed meteorological data around the candidate site throughout 1992 were obtained under the assistance of FIV.

The stability index of air was determined from wind speed, solar radiation, and cloudage included in the data set, as shown in Table 10-6. Together with wind direction and speed data, the index was used as the basis of simulation of air pollution. Note that Table 10-6 shows classification standards for Pasquill stability index of air that are widely used in Japan.

Table 10-6 CLASSIFICATION OF AIR STABILITY

Wind speed on ground m/s	Daytime			Nighttime		
	Solar radiation Cal./Cm²/hour					
	Strong > 50	Fair 49 – 25	Weak <24	Full cloud (8 – 10)	Upper cloud (5 – 10) Medium/lower cloudage (5 – 7)	Cloudage (0 – 4)
< 2	A	A – B	B	D	–	–
2 – 3	A – B	B	C	D	E	F
3 – 4	B	B – C	C	D	D	E
4 – 6	C	C – D	D	D	D	D
> 6	C	D	D	D	D	D

Notes:
- A: Strong unstability
- B: Unstability
- C: Weak unstability
- D: Neutral
- E: Weak stability
- F: Stability
- G: Strong stability

Wind directions and speeds recorded in the 1992 meteorological data set were assorted and tabulated as shown in Table 10-7. Compared to general trends between 1961 and 1974 described earlier, north-north-west or north wind was dominate in 1992, with higher wind speeds.

Also, frequency distribution of instability period tends to fall under the neutral or weak unstable side, as shown in Table 10-8.

Table 10-7 SUMMARY OF WIND DIRECTION AND SPEED DATA IN 1992 – LA CAÑADA DISTRICT

Wind direction	Wind speed(m/sec.)						
	below 0.5	1–2	2–3	3–4	4–6	6up	Total
N			39	9	100	1,537	1685
NNE		1	60	5	74	569	709
NE		2	51	5	104	618	780
ENE		1	41	6	98	554	700
E			27	6	45	253	331
ESE			21	6	46	358	431
SE			13		25	217	255
SSE			11	3	20	140	174
S		1	10	2	17	98	128
SSW			8	1	15	52	76
SW			10	2	9	54	75
WSW			12		25	107	144
W		1	9	4	27	157	198
WNW			18		73	372	463
NW			17	1	52	517	587
NNW			30	3	101	1,632	1,766
Calm	247						247
Total	247	6	377	53	831	7,235	8,749

Note: (1) Wind slower than 0.5m/second in any direction is assumed to be no wind.

(2) Of 8,760 hours per year, daytime solar radiation data are missing on April 27, and meteorological data during the period are assumed to be missing.

Table 10-8 OCCURRENCE OF AIR STABILITY (1992)

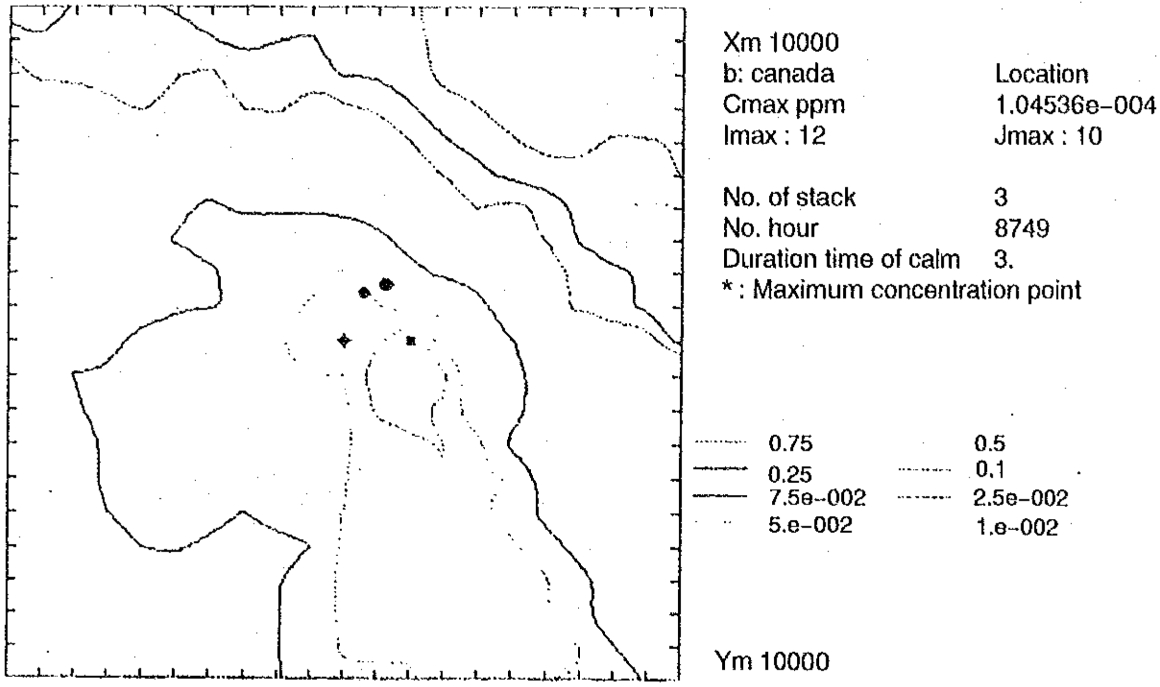
		No wind	Wind	Total
Unstable	Strong	12		12
		51	57	108
	Medium	50	138	188
			21	21
	Weak		769	769
Weak instability Neutral			218	218
Neutral			7,183	7,183
Stable	Weak		113	113
	Medium	131	3	134
	Strong	3		3
		247	8,502	8,749

Diffusion of smoke was simulated by applying Concawe's equation for ascending of smoke from smokestack, Puff's equation for smoke diffusion during no wind, and Plume's equation diffusion with wind. Also, the width of diffusion was calculated by the Pasquill–Gifford method.

By applying the above equations, diffusion of SO_2 and NO_2 contained in smoke released from 3 stacks at the coke oven plant was simulated as shown in Fig.10–7. The maximum ground level concentration was 0.0001ppm for SO_2 and 0.0004ppm for NO_2.

The location of the maximum ground level concentration is shown by 500m x 500m meshes on Fig.10–7. It is a mesh located 1km south–south–east of the mesh containing 2 small stacks, indicating that the small stacks contribute greatly to the occurrence of the maximum ground level concentration.

SO_2



NO_2

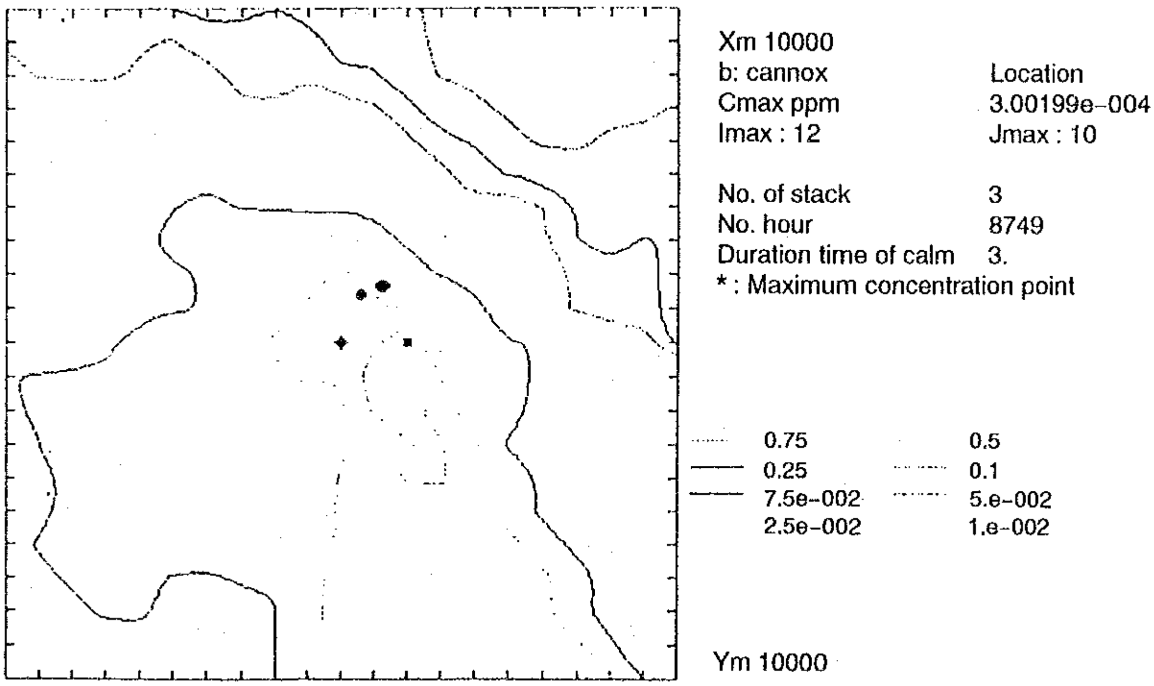
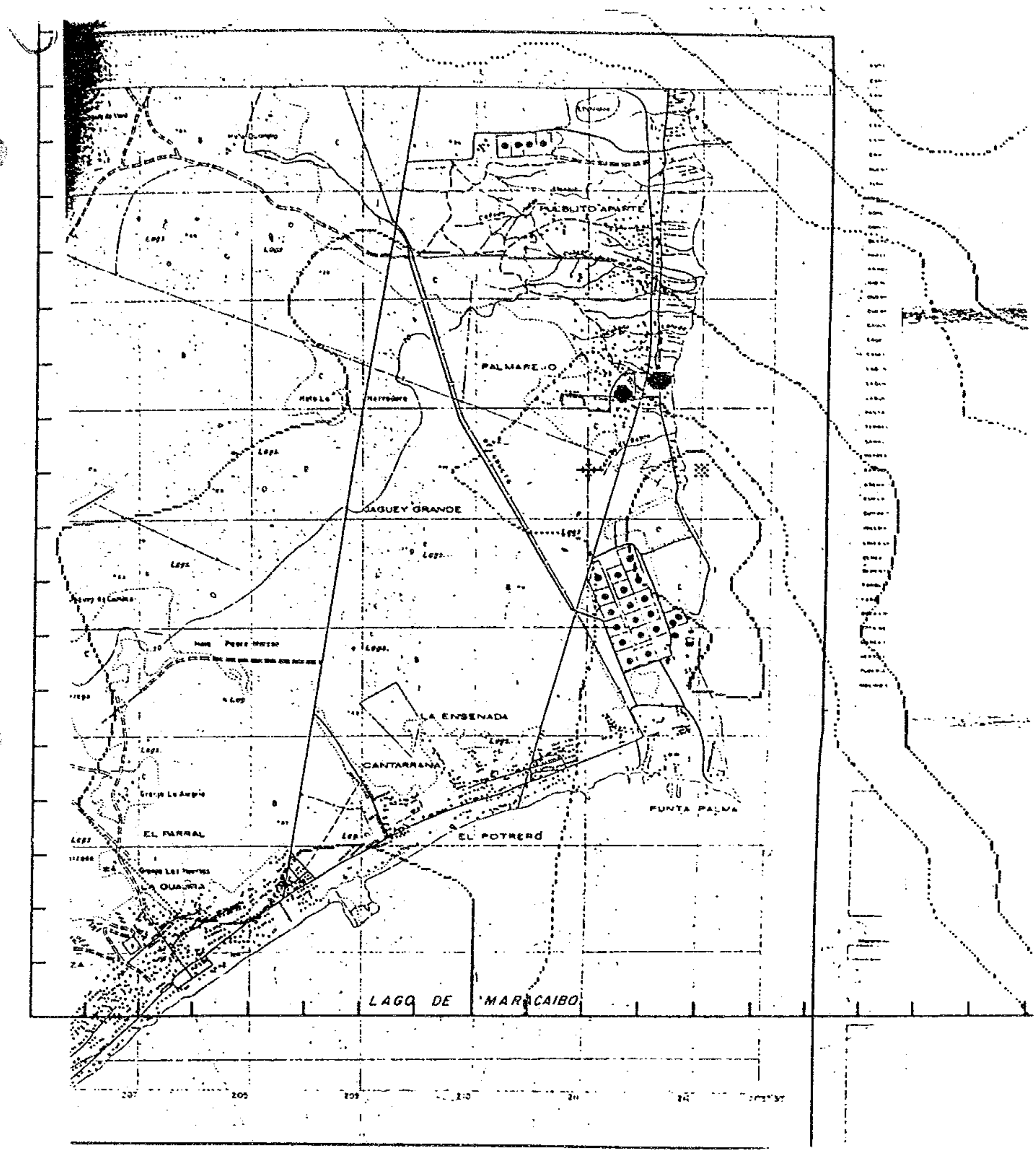


Fig.10-7 Simulation of SO_2 and NO_2 Diffusion

The simulation result indicates that the maximum ground level concentrations of SO_2 and NO_2 released from the plant will be less than 1/100 of 50% threshold concentrations in the country, namely 80μg/Nm^3(0.0187ppm) for SO_2 and 100μg/Nm^3(0.0487ppm) for NO_2. The result is also sufficiently smaller than background concentrations in Maracaibo and La Cañada, 15μg/Nm^3 (0.0053ppm) for SO_2 and 10μg/Nm^3(0.0049ppm) for NO_2.

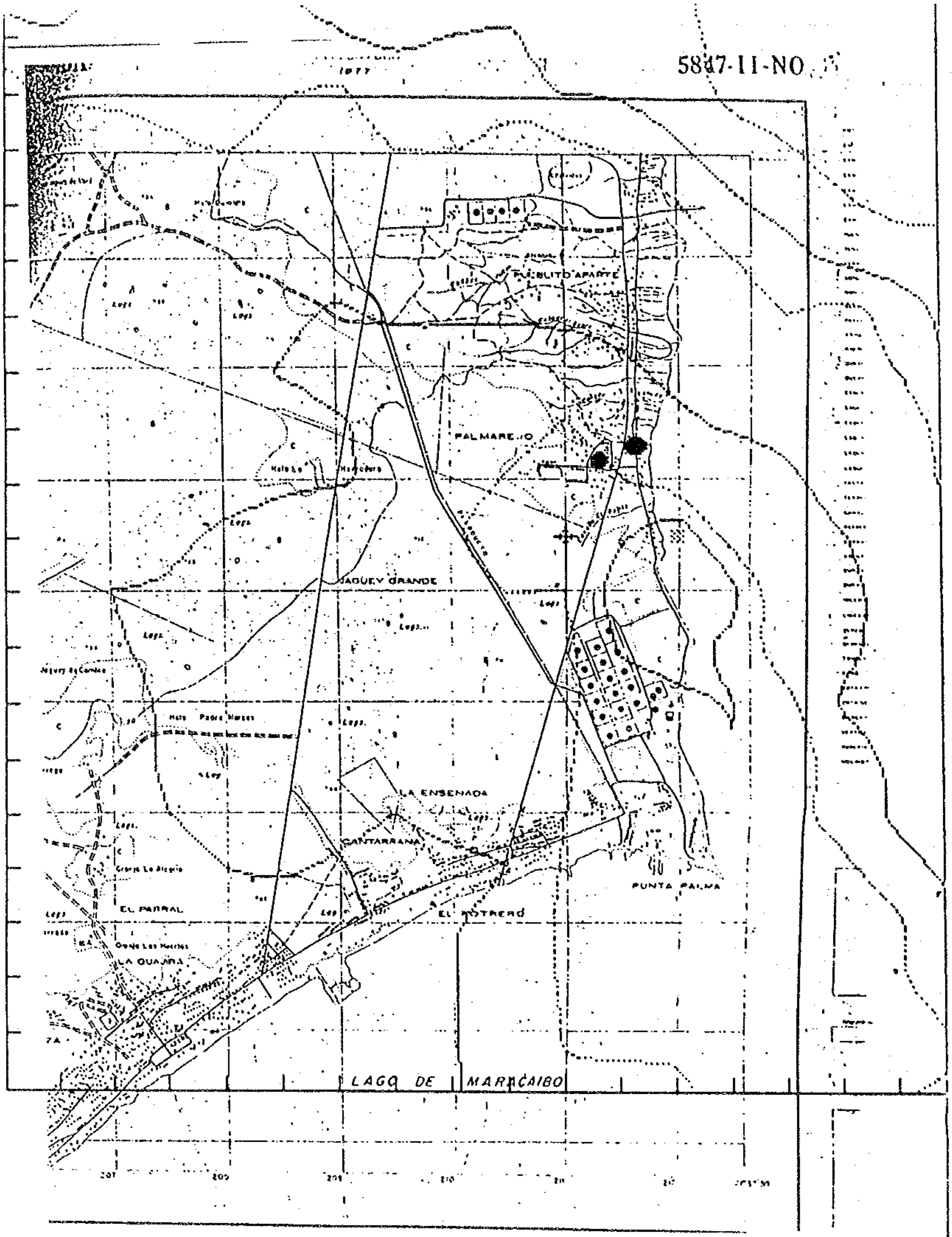
Thus, If the coke oven plant is constructed and operated in La Cañada, the impact of smoke released from the plant on the surrounding environment will be minimal, and SO_2 and NO_2 will cause little air pollution.

The simulation result is plotted on the site map to produce a pollution map as follows. (Figures 10–8 and 10–9)



Notes) Base point of the plant
Stack
Maximum concentration point

Fig.10-8 POLLUTION MAP OF SO_2



Notes) + Base point of the plant

● Stack

●

Maximum concentration point

Fig.10-9 POLLUTION MAP OF NO_2

On the other hand, dust is produced in the course of handling coal or coke. 85% of coal charge coal are 3mm or smaller in grain size. Coal preparation involves a variety of processes which tend to produce dust, particularly after the crushing process.
For instance, coal powder of 0.1mm in diameter floating 5m above the ground is carried by the 1.5m/second wind over a distance of 19.7m, and the 0.01mm dust 1,970m. At the 5m/second wind, the 0.1mm dust is carried 66m.

Measures to control dust generation at possible sources as follows. These measures are expected to minimize dispersion of dust and its environmental impacts.

1) Coal unloaders and coke ship loaders
To prevent dust generation in the handling and transportation process, water sprinkler systems will be provided for coal unloaders and coke ship loaders.

2) Coal and coke yards
Water sprinkler systems will be provided at the both yards to spray water over stacked piles. They will be automatically operated from the control room.

3) Belt conveyors for carrying coal and coke
Belt conveyors carrying coal before crushing are connected with seals. Those carrying coal after crushing are provided with wind-shield covers. Belt conveyors from the coke wharf to the screening machine also have wind-shield covers, with connections being enclosed.

4) Coal crushers
Coal crushers are of hammer type to minimize dust generation and are housed in a building. Bag filters are provided as part of a local ventilation system.

5) Coal blending facilities and charged coal tank
The coal blending facilities and the charged coal tank are setup in a building. Bag filters are also provided as part of a ventilation system.

6) Charging car
Dust produced by charging coal to the coke oven (through oven doors) is led through a connector and a fixed duct to bug filters on the ground.

7) Offtake

The smokeless charge devices are provided to suction dust coming out of the coke oven during coal charging by using high pressure ammonia liquor and to push it into the COG dry main.

8) Coke guide car

Dust and gas generated in the coke pushing process is led through a connector and a fixed duct to bug filters on the ground.

Cleaning equipment for the platform is also provided.

9) Quenching tower

The water demister is provided to remove dust and steam generated when red--hot coke is cooled down by water sprinkling.

10) Coke grader and screening equipment

The both equipments are housed in a building. Bag filters are provided as part of a local ventilation system.

Thus, adequate dust removal or prevention measures are provided for possible dust sources to minimize a risk of environmental pollution by dust generation.

10.3 Water Quality

(1) Current situation

Latest water quality data concerning Lake Maracaibo were obtained from CORPOZULIA and INZIT·CICASI.

The water quality data obtained are summarized in Table 10–9. Tidal level fluctuation in the lake is in the range between 1 – 2m. The lake water circulates counterclockwise as shown in Fig. 10–10.

Table 10–9 WATER QUALITY DATA OF LAKE MARACAIBO

Phytoplankton	Chlorophyta		888 cells/L	
	Cyanophyta		3,626 cells/L	
	Chrysophyta		148 cells/L	
	Total		5,254 cells/L	
Alkali			1.16 meq/L	
Nitrogen (as NH_4)			0.02 mg/L	
Phosphorous (as PO_4)			0.07 mg/L	
Chlorophyll			4.01 μg/L	
Feofitina			1.34 μg/L	
Clarity			3.25 m	
Current			<2 cm/sec	
Depth	Surface	5m	10m	12m
Water temperature (°C)	30.7	30.7	30.8	30.9
Electric conductivity (mmh/cm)	5.81	5.81	6.04	6.50
Dissolved oxygen (ppm)	7.20	7.81	6.73	6.15
pH	8.03	8.05	8.06	8.13
ORP(mV)	206	212	488	489
S(o/oo)	3.17	3.17	3.30	3.58

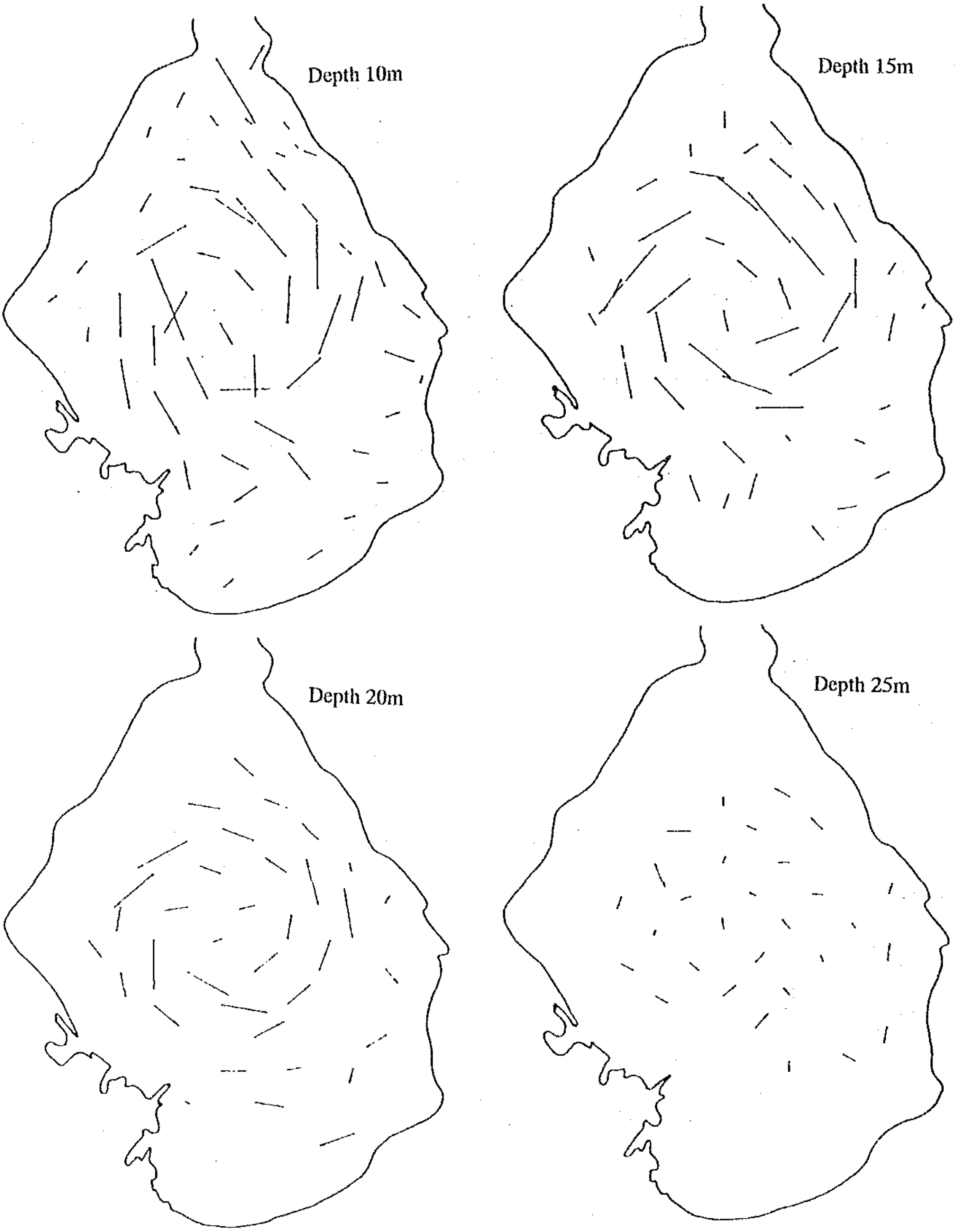


Fig.10-10 MAJOR CURRENTS ON LAKE MARACAIBO

Near La Cañada plant site, dissolved oxygen (DO) show 6.15 – 7.81ppm which represents Class A (cleanest) sea area (DO 7.5mg/L or more) or Class B (second cleanest) sea area (DO 5mg/L or more) under Japanese environmental standards.

In the water containing a significant level of dissolved oxygen, DO plus COD or BOD level is expected to be 10ppm. The COD or BOD level in Lake Maracaibo near La Cañada is estimated to be 2 – 4ppm. Thus, there is no risk or very small risk of water contamination by organic matters.

Lake water observed at the pier in La Cañada shows green color to suggest presence of many planktons. Growth of phytoplankton may supply dissolved oxygen at a supersaturation level.

However, it is difficult to estimate the current state of lake pollution near La Canada and other locations only from these data.

Electric conductivity data of lake water, which has been obtained with dissolved oxygen data, increase toward the center of the lake and deeper part, as shown in Fig.10–11.

Fig.10-11 GEOGRAPHICAL PATTERN OF ELECTRIC CONDUCTIVITY OF WATER – LAKE MARACAIBO

Water of Lake Maracaibo moves horizontally and is likely to be stratified without much vertical mixing actions.

Suppose water having high electric conductivity dissolves large amounts of substances, including inorganic matters, and becomes highly dense, it is not likely to ascend from the bottom to the surface. Also, as shown in Fig.10-12, the lower water tends to contain a very small amount of dissolved oxygen. Finally, pH indicates neutral to slight acidity, and dissolved phosphorus and ammonia nitrogen contribute greatly.
On the other hand, the upper water shows low electric conductivity and a high level of oxygen content, and pH shows some alkalinity, suggesting that low levels of dissolved phosphorus and ammonia nitrogen.

Field data show that the maximum concentrations of phosphorus and ammonia nitrogen occur slightly off the lake center in a southeast direction.

The study team also obtained data on heavy metals that were contained in the mud collected from the lake bottom near Cabimas and Lagunillas, which are oil tanker loading bases. Samples obtained from the two locations contain a few hundred ppm of vanadium and titanium. On the other hand, chrome is not found in samples collected in Cabimas, while presence in the order of a few hundred ppm is observed in Lagunillas. Also, copper, lead, zinc, nickel, and cobalt are detected at 10 – 20ppm from both samples.

It is difficult to determine whether these heavy metals are a result of water contamination or not, on the basis of these data. Nevertheless, they are present in some part of the lake bottom.

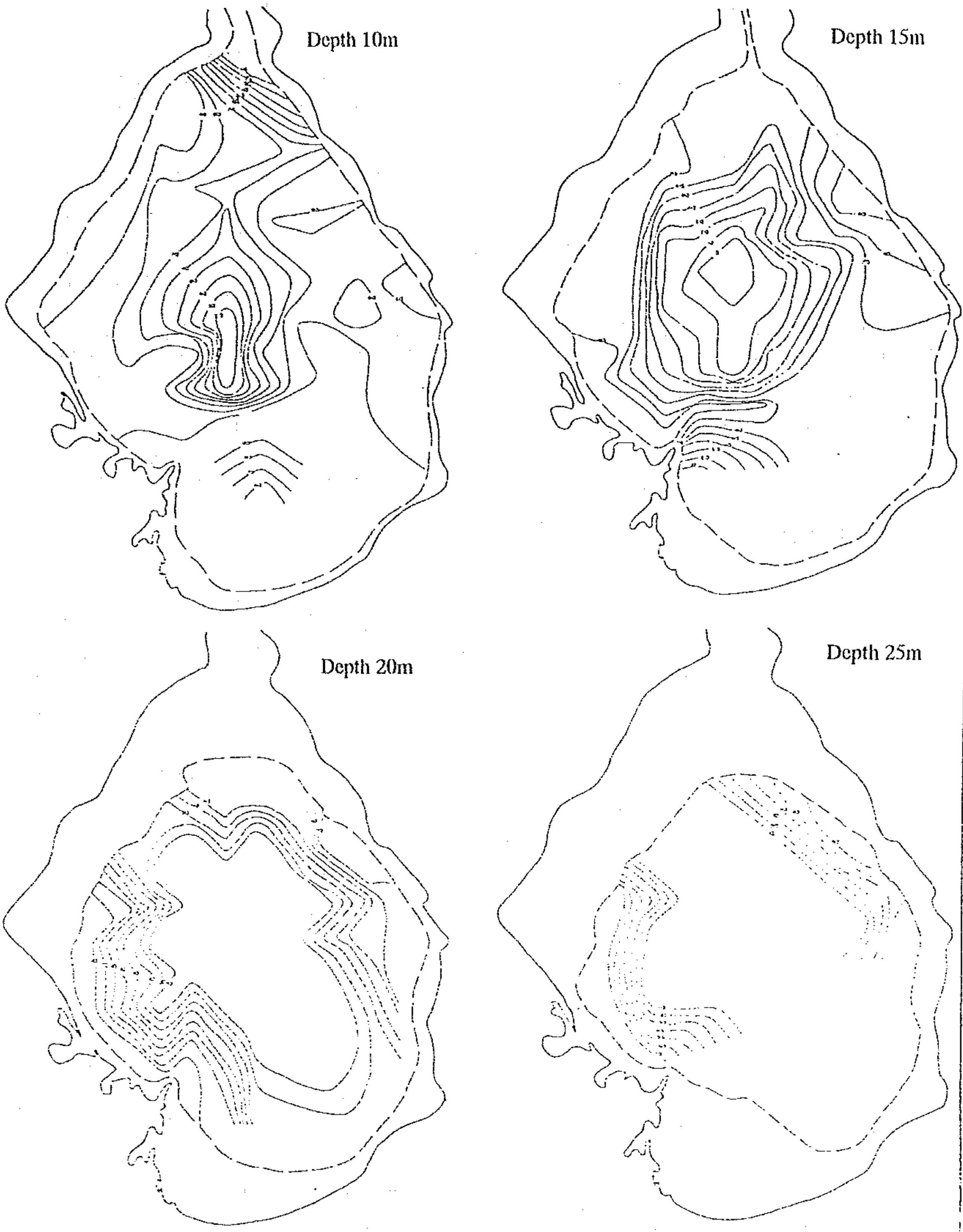


Fig. 10-12 DO CONTENT IN LAKE MARACAIBO

(2) Target levels of water pollution control

General indicators of water contamination are BOD, COD, and pH. Also, harmful substances which may be discharged from the coke plant include phenol, cyanide, and ammoniacal nitrogen.

In Venezuela, there are emission standards, but no environmental quality standards for water areas to which effluent is discharged. Thus, target levels of water pollution control should be set at a level conforming to effluent standards applied to Lake Maracaibo and related waters.
The emission standards (Normas sobre Classification de las Aguas y Medidas de Control de Calidad de los Vertidos Liquidos en la Cuenca del Lago de Maracaibo) are set forth in Decree No.2222 dated April 23, 1992, and have been summarized in Chapter 1.

Table 10–10 compares emission standards for Lake Maracaibo and those applied to Japanese waters. Clearly, the former is stricter than the latter.

Table 10-10 EMISSION STANDARDS APPLIED TO THE PROPOSED COKE MAKING PLANT AND COMPARABLE JAPANESE STANDARDS

(ppm)

	COD	BOD	SS	Phenol	T–N	T–P	Solubles	CN
Content	150	40	50	0.05	10	1.0	3,000	0.1
cf. Japanese standards	160	160	200	5	120	16	–	1.0

Note that the acceptable pH level of the effluent is 6 – 9 (6.5 – 8.6 in Japan).

(3) Quality of effluent

The gas refining facility at the proposed plant is designed to discharge the effluent having quality levels shown in Table 10–11. Of total, ammonia liquor shows the largest contamination load. However, the effluent from the coke plant has relatively low concentrations of COD, BOD, and SS which are associated with the organic matter load.

In addition, waste water mainly containing rainwater is discharged from the coal and coke yards.

TABLE 10-11 QUALITY OF EFFLUENT DISCHARGED FROM THE COKE MAKING PLANT

	Water Quality	Load
Water volume	–	5,700 (m3/day)
COD	40 (ppm)	210 (kg/day)
BOD	10 (ppm)	56 (kg/day)
SS	15 (ppm)	70 (kg/day)
Other	Below standards	–

At the plant, ammonia liquor and waste water from the yards will be treated in the following manner to minimize environmental impacts.

As shown in Fig. 6–6 "Gas Refining Process Flow," ammonia liquor combines an effluent from each process, water contained in the gas produced in the carbonization process, and cleaning water for dust gas coming out of the offtake. As a result, ammonia liquor contains many substances other than ammonia. It is processed in the distillation plant to remove ammonia and other matters and is sent to the waste water treatment plant.
Fig. 7–24 shows a conceptual diagram of the waste water treatment plant. Here, ammonia liquor is neutralized and is sent to the activated sludge method (ASM) process to remove organic matters, and detrimental phenol and cyanide. To remove phenol and cyanide, the ASM process installed as part of the coke oven facility is designed to keep the effluent in the aeration tank for around one week.

Although the ASM process is expected to remove most of phenol, the treated water is further sent to an activated charcoal bed to absorb residual phenol.

After the waste water treatment process with emphasis on ammonia liquor, the effluent combining those from all the processes (combined effluent) is expected to satisfy water quality and contamination load levels specified in Table 10–11. Note that these quality levels are designed to comply with emission standards applied to Lake Maracaibo, the strictest standards in Venezuela, as part of efforts to minimize environmental impacts of the new plant.