THE FEASIBILITY STUDY REPORT
FOR
THE RENOVATION OF CAUSTIC SODA PLANT
OF
P.T. INDUSTRI SODA INDONESIA (PERSERO)
IN
THE REPUBLIC OF INDONESIA

NOVEMBER, 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of Indonesia, the Government of Japan decided to conduct a feasibility study on the Project for Renovation of the Waru Plant of the P.T. Industri Soda Indonesia and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Indonesia a survey team headed by Mr. Katuo Adachi from May 16 to June 5, 1984.

The team had discussions with the officials concerned of the Government of Indonesia and conducted a field survey in the Project-related areas, including Jakarta and Surabaya. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the team.

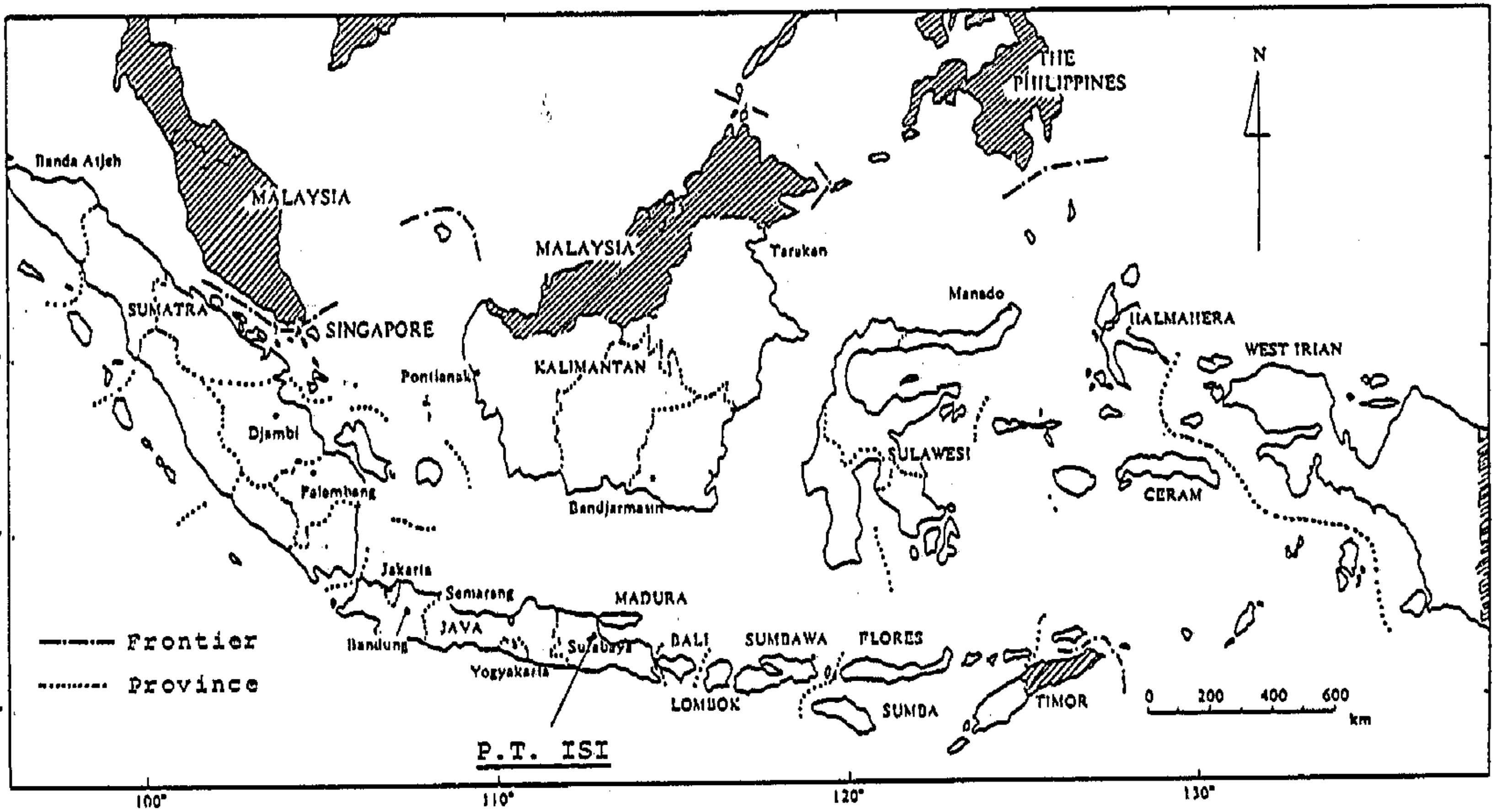
Tokyo, November, 1984.

Keisuke Arita

President

Japan International Cooperation Agency

INDONESIA



(Source) : Atlas Indonesia, Yayasan Dwidjendra, 1976, Denpasar

ABBREVIATIONS AND SYMBOLS

Unit and Conversion

mm	Millimeter
cm	Centimeter
m	Meter
km	Kilometer
in	Inch (1 in = 2.54 cm)
ft	Foot (pl. feet) (1 ft = 0.305 m)
cm^2	Square centimeter
m^2	Square meter
ha	Hectare (1 ha = 10,000 m^2 = 2.471 acres)
ft^2	Square foot (1 ft^2 = 0.0929 m^2)
Rai	(1 Rai = 1,600 m^2)
m^3	Cubic meter
Nm^3	Normal cubic meter
MMm^3	Million cubic meters
ft^3, cu ft	Cubic foot (1 ft^3 = 0.0283 m^3)
SCF	Standard cubic foot
MMSCF	Million standard cubic feet
l	Liter
gal	Gallon (1 British gallon = 4.546 liters, 1 U.S. gallon = 3.785 liters)
bbl	Barrel (1 barrel = 42 U.S. gallons)
g	Gram
kg	Kilogram
ton, t, T, Ton	Metric ton
lb(s)	Pound (1 lb = 0.454 kg)
sec	Second
min	Minute
hr, h, Hr	Hour
d, D	Day
m, M	Month

y, Y	Year
C	Degree centigrade
F	Degree fahrenheit
Cal	Calorie
Kcal, K cal	Kilo calorie
BTU, Btu	British thermal unit (1 BTU = 0.252 Kcal)
MMBTU, MMBtu	Million British thermal units
LHV	Low heating value
HHV	High heating value
A	Ampere
V	Volt
W	Watt
kW	Kilowatt
mW	Megawatt
kVA	Kilo-volt ampere
mVA	Mega-volt ampere
kWh, kWH	Kilowatt-hour
mWh, mWH	Megawatt-hour
HP	Horse power
%	Percent
ppm	Parts per million
ppb	Parts per billion
g/Nm^3	Gram per normal cubic meter
pH, PH	Hydrogen ion concentration
kg/cm^2	Kilogram per square centimeter
lb/in^2	Pounds per square inch
mmAq	mm aqua (= water)
t/d, ton/day, T/D, tpd	Metric tons per day
t/y, ton/year, MTA, MT/Y, T/Y, tpa, tpy	Metric tons per year

Technical Terms

BLC	Calcium hypochlorite
BLN	Sodium hypochlorite
CL	Chlorine
HCL	Hydrochloric acid
HTH	High test hypochlorite
MSG	Mono sodium glutaminate
VCM	Vinyl chloride monomer
EDC	Ethylene dichloride
NaOH	Caustic soda
PVC	Polyvinyl chloride
G-	Gaseous
L-	Liquefied
Aq-	Aqueous
S-	Solid
F-	Flake
D (process)	Diaphragm (process)
IM (process)	Ion exchange membrane (process)
M (process)	Mercury (process)
BOD	Biological oxygen demand
COD	Chemical oxygen demand
SCR	Silicon rectifier
MSL	Mean sea level
ISBL	Inside battery limit
OSBL	Outside battery limit

Financial and Economic Terms

DCF	Discounted cash flow
IRR	Internal rate of return
ERR	Economic internal rate of return
FRR	Financial internal rate of return
ROI	Return on investment

GDP	Gross domestic product
GNP	Gross national product
C & F	Cost and freight
CIF	Cost, insurance and freight
FOB	Free on board
NPV	Net present value

<u>Currency and Exchange Rate</u>

Rp	Indonesian Rupiah (1 U.S. dollar = Rp 1,000., 1984)
US$, $	U.S. dollar
yen	Japanese yen (1 U.S. dollar = 230 yen, 1984)

<u>Organization and Company</u>

BAPINDO	Bank Pembangunan Indonesia (Indonesian Development bank)
BI	Bank Indonesia
BKPM	Badan Koordinasi Penanaman Modal (Investment Coordinating Board)
BPS	Biro Pusat Statistik (Central Burean of Statistics)
DGBCI	Direcorate General of Basic Chemical Industry
GOI	The Government of the Republic of Indonesia
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
MOI	Ministry of Industry in Indonesia
PLN	Perusahaan Umum Listrik Negara
PT. ISI	P.T. Industri Soda Indonesia
PUG	Perusahaan Umum Garam

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PART I INTRODUCTION

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Chapter 1 Objectives and Scope of Study

1.1 Background of Study

A lot of plants have been constructed with priority given to Asean countries owing to the economic cooperation programs of the Government of Japan, and because of superannuation or insufficient maintenance, there are many plants which declined in the efficiency of plant operation and resulted in the increase of production cost.

Under those circumstances, the requests were made for the Government of Japan to undertake the coorporation for the repair and renovation of those plants, and in response to the request, Mr. Nakasone, the prime minister of Japan, announced his intention to accept the requests while he made a round of visits to Asean countries at the end of April, 1983.

In accordance with this announcement, the Government of Japan dispatched the pre-study team to Asean countries on November, 1983 and confirmed the selection of the candidate projects, and thereafter in response to the request of the Government of the Republic of Indonesia, the Government of Japan dispatched the pre-study team to Indonesia and agreed with the scope of work for the execution of the detailed study on the proposed project on February, 1984. Hence, this study shall be implemented on the basis of this agreement.

According to the request of the Government of Indonesia, the plant which is the objective of this renovation study is the works of PT. ISI located at Waru, 8 km away from the downtown of Surabaya.

The works was constructed in 1953-1956 by Asahi Glass Co., Ltd. in Japan as the first Chlor-alkali plant owned by the Government of Indonesia manufacturing such major products as 10 t/d of NaOH, 10 t/d of HCL and 10 t/d of BLC based on a mercury process.

Since the production of NaOH decreased to the level of 30% of the designed capacity due to the insufficient maintenance and operation management, the rehabilitation project was carried out during 1967-1969 by utilizing Asahi Glass Co., Ltd. once again on the basis of Yen credit.

In 1977-1978, the installation of No. 2 unit with the designed capacity of 20 t/d NaOH as 100% basis was carried out based on a mercury process by Wah Chang International Corporation, an engineering company in Taiwan.

In 1983, the conversion of the anodes from carbon to titanium in No. 2 unit was carried out and the production capacity of the unit was increased to 30 t/d.

On the other hand, No. 1 unit on which the rehabilitation was made in 1969, was again superannuated resulting in the lowering of the capacity up to 6 t/d, concurrently with the lowering of the efficiency as to the facilities of HCL and L-CL as well as the common facilities for No. 1 and No. 2 units.

In the meantime, the poisonous nature of the mercury process which was adopted by the works of PT. ISI has became a worldwide controversial problem and a technology for preventing mercury leakage from the plant was developed and in addition ion exchange membrane process which does not use any mercury and excellent in efficiency has been invented and developed into actual application.

It becomes necessary for PT. ISI not only to establish the renovation project for No. 1 unit of which the production efficiency became lowered but also to make a comprehensive review for all the facilities on the conversion to ion exchange membrane process as well as the prevension of environmental pollution.

This is the reason why the study in this report was planned for implementation.

1.2 Objectives of Study

The objectives of the study is to diagnose the works of PT. ISI at Waru and investigate the possibility of the renovation project from the comprehensive discussions in view of the product marketability, quality of raw salt, technical, financial and economic standpoints, and to formulate the renovation programs in order to contribute to increasing production capacity, production efficiency and improving product quality. Furthermore, the diagnosis will be made to suggest the improvement programs on the current aspects of the operation management, education and training, pollution and safety control, and maintenance activity.

1.3 Scope of Study

The study will cover the following items.

(1) The study on the caustic soda industry in Indonesia.

i) Present situation of and national policy on the caustic soda industry in Indonesia.

ii) The plant relocation plan and the future projects of PT. ISI.

(2) Diagnosis on the management of the following aspects.

i) Operation and quality control

ii) Maintenance of the machinery and equipment

iii) Cost control

iv) Administration system

v) Education and training

(3) Technical diagnosis on the machinery and equipment of the plant in the following aspects.

i) Production control

ii) Quality control

iii) Unit consumption

iv) Inspection for the superannuation of each machinery and equipment

v) Study for the improvement of power factor and the change of receiving voltage at the electrical substation

(4) Investigation of raw salt

(5) Survey for the domestic market

(6) Study on environmental aspects

(7) Formulation of the renovation program

The renovation program for PT. ISI will be formulated, taking into account the economical and environmental effects including the followings.

i) Planning for the renovation program

ii) Survey for the plant relocation and the future projects

iii) Estimation of the total capital requirement

iv) Planning for the education and training plan

v) Planning for the implementation program of the renovation project.

(8) Financial analysis and evaluation of the project

(9) Economic evaluation of the project

(10) Conclusion and recommendation

Chapter 2 Implementation Procedure and Outline of Study

2.1 Survey Procedure and Schedule

In the implementation stage of this study, the study team comprising 6 persons of specialists (Note 1) headed by Mr. K. Adachi visited Indonesia for an on-site survey for 21 days from May 16 to June 5 in 1984, and formulated the renovation program after returning to Japan on the basis of the information collected through an on-site survey.

On the occasion of an on-site survey in Indonesia, the counterpart team was organized which comprised the associated staffs who were nominated both from the Directorate General of Basic Chemical Industries, Ministry of Industry, in charge of the implementation of this project as a counterpart agency to the study team and PT. ISI (Note 2).

The study team has conducted the collection and analysis of the required information as well as pointed out the problems concerned and selected the machinery and equipment to be repaired by and through the co-works and discussions in detail with the counterpart team during an on-site survey period in Indonesia. In addition, the market survey team has visited the chlor-alkali plants and the customers for caustic soda and chlorine compounds located at Surabaya district as well as at the other part of Jawa Island, and grasped the problems to be solved and collected the necessary data (Note 4).

(Note 1) The members of the study team are as shown in Appendix I-1 attached at the end of the report.

(Note 2) The members of the counterpart team in Indonesia are as shown in Appendix I-2.

(Note 3) The list of the organizations visited during an on-site survey is attached in Appendix I-3, and the local survey schedule performed by the study team is as shown in Appendix I-4.

(Note 4) The list of the documents obtained by the study team is an shown in Appendix I-5.

2.2 Outline of Study

According to the scope of work for the project, the major part of the study can be summarized as follows:

(1) Market for the products
(2) Administration system of PT. ISI
(3) Technical problems of PT. ISI including the followings

  i) Current conditions of the existing plant
  ii) Raw salt
  iii) Economical utilization of electric power
  iv) Environmental protection

(4) Renovation project of PT. ISI
(5) Total capital requirement and financing plan
(6) Financial analysis and economic evaluation
(7) Comprehensive evaluation

2.2.1 Market survey

The market survey is limited to the domestic demand since in Indonesia 75% of total demand for caustic soda is currently imported and export of the chlorine products seeems difficult in transport point of views. As there is a petrochemical complex project in Indonesia which includes a vinyl chloride monomer (VCM), a large amount of demand for chlorine can be expected. But in this case, an electrolysis plant will be constructed in the location next to a VCM plant, so that such a demand for chlorine cannot be expected as the effective demand for PT. ISI. But for the purpose to make the future vision of the caustic soda industry in Indonesia, the study is also made in this aspect.

(1) The demand/supply forecast

The interviews were conducted for the large scale users in order to survey the capacity expansion projects of the user plants, the expansion and scrapping projects of the electrolysis plants and the possibility to use the domestic chlorine products in place of the imported ones.

The demand/supply forecast was made for the three cases such as (a) optimum forecast which is supposed to have the highest possibilities, (b) optimistic (maximum) forecast, and (c) pessimistic (minimum) forecast. Also, the forecast was made for the demand/supply balance of the nationwide scope as well as the scope of the market confined to PT. ISI.

(2) Survey for price of products

Since the caustic soda sales price of PT. ISI has varied in correlation with CIF Indonesia, the price forecast was made on the basis of survey for the correlation between CIF price and the domestic sales price, taking into account the particular feature of the domestic market in Indonesia. As for the price of the chlorine products, the future price was projected by examining the composition of price elements. In addition, as a part of price forecast, the study was made on the distribution system and transport expense of the products.

The result of the study is described in Part II of this report.

2.2.2 Administration system of PT. ISI

The study team made an on-site survey for the following items at the works of PT. ISI, and the result of the survey and the suggestions made by the study team are described in Part III, Chapter 1 of this report.

i) Operational condition, capacity utilization, and frequency and reason for plant shut-down

ii) Compilation of maintenance and operation mannuals and their observance

iii) Operation control and quality control

iv) Education and training

v) Maintenance system and spare part control system

2.2.3 Survey for technical problems of PT. ISI

(1) Conditions of existing plant

i) The study team examined the operation records and reviewed the problems of the plant operation through the hearing from the operators.

ii) The study team examined the progress of superannuation for each machine and equipment and projected their durable years from now on.
Based on the above examination, the machine and equipment were classified in the following groups as (a) needed for replacement, (b) needed for partial reparing and (c) not needed for reparing.

(2) Raw salt

The study team visited PUG (Perusahaan Umum Garam), and inspected the quality of raw salt as well as made a projection of raw salt quality to be purchased in the future on the basis of the quality of the raw salt which was purchased by PT. ISI in the past.
The discussion was made as to whether or not the raw salt washing facility is necessary by economical comparison between the loss of raw salt in the case that the raw salt washing is made by constructing the facility to improve the purity of raw salt, and the increment of chemicals for removing the inpurities in the case that the raw salt washing is not made.

(3) Economical utilization of electric power

The study team reviewed the tariff system of electric power in Indonesia and projected the tariff to be paid by PT. ISI in the event that the power factor of PT. ISI is improved by 0.1 as well as the receiving voltage changes from 20 KV to 70 KV.

Also, the discussion was made as to whether or not the investment for the change of receiving voltage and the improvement of power factor is necessary by estimating the construction cost of the facilities.

(4) Environmental protection

The study team inspected and clarified the current situation of the leakage of chlorine and mercury, and the waste water from the existing plant, and made a suggestion for the improvement of environmental protection. The result of the study is described in Part III, Chapter 2 of this report.

2.2.4 Discussion on renovation project

The following study is made on the basis of the above discussions.

(1) Regarding replacement of the electrolytic cells which is the major item for discussion in this project, the comparison is made for three cases which are membrane process, mercury process and ion exchange membrane process.

(2) Regarding the conceptual design for the renovation project, it was decided to make a projection for the following three alternatives.

i) The mercury process electrolytic cells of No. 1 unit will be replaced by ion exchange membrane process and the production capacity will comply with the rectifier capacity of No. 1 unit.

ii) The mercury process electrolytic cells of No. 2 unit will be replaced by ion exchange membrane process and the production capacity will comply with the rectifier capacity of No. 2 unit. Operation of No.1 unit is to be stopped.

iii) The mercury process electrolytic cells both of No. 1 and No. 2 unit will be replaced by ion exchange membrane process and the production capacity will comply with the rectifier capacity of each unit.

(3) The modification program for the facilities other than the electrolytic cells and the environmental protection were projected and the conceptual design was made.

(4) The scope of the renovation project including the facilities and services was worked out and the construction procedure and schedule were projected.

The outcome of the above study is described in Part III, Chapter 4.

2.2.5 Total financial requirement and financing plan of project

On the basis of the discussions made in section 2.2.4 above, the total financial requirement and financing plan were projected. The total financial requirement was summed up based on the current cost at the middle of 1984, and the physical contingency as well as the price contingency being determined by the escalation rate and the construction schedule were included therein.
The project cost was devided into the portions of foreign and local currency, and the detail are described in Part IV.

2.2.6 financial and economic evaluation

On the basis of the above project cost, the further study was made on the required figures for the projection of production cost and on the sales price of the products, thus the production cost and the financial tables were projected. Based on the above projection, the financial ratios and the internal rate of return (IRR) were calculated, and the financial evaluation was made.

For the purpose to estimate the investment effect of the renovation project, the benefit was calculated for two cases, that is, the case whereby the investment was made, and the case whereby the investment was not made and the plant was operated as it was. The balance of two benefits was deemed as the investment effect and the IRR was projected. The result of the projection is desribed in Part V. Also, by the projection of the economic rate of return, the saving effect of foreign currency, the economic NPV, and the other extended effects, the economic evaluation was made, and the result is described in Part VI.

PART II MARKET STUDY

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Chapter 1 Demand Forecast

1.1 Introductions

Caustic soda (NaOH) and chlorine (CL, Cl) are produced by electrolysis of salt, a process which also produces hydrogen (H_2) as co-product. The production ratios of those products are constant as shown below.

Caustic soda	:	1 ton (as 100% NaOH)
Chlorine	:	0.88 ton
Hydrogen	:	280 m^3

Hence when the demand for caustic soda and for chlorine (including chlorine compounds) in a country are not in the above ratio, the operation of the plants is generally scheduled to satisfy the domestic demand of chlorine which is difficult to transport over long distances, and adjustment of the domestic demand/supply balance of caustic soda is made by either import or export of caustic soda.

It is said in the developed countries that the chlor-alkali industry has developed on the strength of demand for chlorine notably for compounds, due to the vigorous demand for compounds such as chlorinated solvents and PVC, and the effective utilization of caustic soda as co-product becomes a key point for the development of the industry. On the other hand, in the developing countries such as Indonesia, since the demand for chlorine is relatively smaller than the demand for caustic soda which is a basic material for the chemical and other industries, the production is scheduled to meet with the demand for chlorine and caustic soda is imported to make up for the consequential shortage.

As is explained in detail later, the supply/demand balance in Indonesia in 1984 is estimated as shown below.

SUPPLY/DEMAND BALANCE FOR NaOH & CL IN INDONESIA IN 1984

(Unit: ton)

Item	NaOH (100%)	CL
Capacity	37,500 (32%)	33,000 (135%)
Production	27,700 (23%)	24,400 (100%)
Import	90,900 (77%)	nil
Demand	118,600 (100%)	24,400 (100%)

(Note) Production capacity of NaOH is 125 t/d in total, therefore, annual capacity is projected as
125 t/d x 300 d/y = 37,500 t/y

As shown in the above table, it is observed that in terms of production ratio the demand for chlorine is low compared to the demand for caustic soda. This has been a prime factor retarding the development of the industry in Indonesia.

In view of the above, it is planned that the market study done for this report is to be concentrated on the domestic market, and especially the domestic chlorine demand, due to the following reasons.

(a) The demand for caustic soda is in the range which can fully absorb the increased production of PT. ISI even after the renovation project is implemented.

(b) In the developed countries which have excess chlorine production capacity, the plants have been operated to meet the domestic chlorine demand and in principle have not produced excess chlorine for export.

(c) Even if excess chlorine is produced for export, a surplus of caustic soda also will be produced, which will increase the production cost of the products.

(d) When chlorine is imported, the transportation cost becomes very high since chlorine has to be transported in liquefied form and in high pressure vessel.

(e) In the large scale electrolysis plants located at petrochemical complexes, there are, in general, few chlorine liquefication and shipping facilities.

The major uses for chlorine in the developed countries, are for production of vinyl chloride monomer (VCM), chlorinated solvents and bleach for pulp and paper, etc. Since domestic production of VCM has not yet been started in Indonesia although the domestic demand for PVC in 1984 has reached approximately 100,000 tons (62,000 tons of chlorine requirement), a substantial increase of chlorine demand is certain if domestic production of VCM is begun. As chlorine consumption for VCM is so great that a large scale electrolysis plant will be constructed next to the VCM plant in the event that VCM is to be domestically produced. Therefore, it is not only unreasonable for the existing manufacturers of caustic soda (all are small in scale) to expect chlorine demand for VCM in the future, but also it is believed that construction of a large scale electrolysis plant will pose a threat to the marketing activities of smaller plants.

In this context, the demand forecast in this report is in principle limited to the existing demand fields of chlorine and does not include the demand for VCM, assuming that the entire chlorine requirement for VCM will be supplied by an electrolysis plant to be constructed next to the VCM plant in the event that the VCM plant is constructed in the future.

1.2 Historical Supply/Demand Trend

(1) Existing production capacity

The production capacities of electrolysis plants in Indonesia as of 1984 are as shown in Table II-1.1, from which it is evident that they are small in scale of production capacity compared with those of other countries. Key features of electrolysis plants on returns to scale in production are not as great as in other chemical industries, and many plants are integrated with the user industries such as pulp & paper and monosodium glutamate (MSG) due to the difficulty of transporting chlorine long distances. In Indonesia, there are only two non-integrated manufacturers which produce all their products exclusively for sale, that is, PT.ISI and PT. Soda Sumatra.

The outline of the production capacities on a 100% caustic soda basis is as shown below.

	Company	Capacity (t/d)
Non-integrated	2	56
Integrated with pulp & paer	7	51
Integrated with MSG	2	18
Total	11	125

(2) Historical demand

The projected production of major products which consume caustic soda or chlorine, in 1973 - 1983, are as shown in Table II-1.2, a portion of which is estimated. The projected demand for caustic soda and for chlorine are as shown in Table II-1.4, and have been calculated by multiplying unit consumptions of caustic soda or chlorine in Table II-1.3 by those production figures. The following table shows the projected demand for caustic soda and chlorine in 1983.

NaOH & CL DEMAND BY INDUSTRY (1983)
(Unit: 1,000 ton)

	NaOH	CL
Soap	43.6	-
Detergent	1.8	-
Pulp for paper	9.9	8.3
NSG	9.8	5.2
Textile	8.0	1.3
Rayon	21.6	-
Water treatment	6.5	2.2
Others	8.1	5.2
Total	109.3	22.2

The annual production of the above products are projected based on the figures reported in Industri Selay Pandang (1982 edition) and Pengembangan Kapacitas Nasional Sector Industri (1983 edition).

But the figures in these publications have been slightly modified on the basis of information supplied by PT.ISI or interviews with the manufacturers. For the production of pulp for paper, the figures are obtained from "Pulp & Paper International, World Review Number" which is published in Japan.

(3) Historical supply/demand balance

Table II-1.5 shows the historical total demand & domesitc production of caustic soda & chlorine in 1976-1983. If the daily production capacity of 125 t/d is multiplied by 300 d/y, the annual production capacity of caustic soda (100%) and chlorine are 37,500 t/y and 33,000 t/y respectively, which indicate about 67% of capacity utilization in 1983. This low utilization ratio is believed to prove that the plants were operated to meet the domestic chlorine demand. The shortage of caustic soda is supposed to have been at the scale of imports of 84,100 t/y.

Table II-1.1 PRODUCTION CAPACITY OF ELECTROLYSIS INDUSTRY IN INDONESIA (1984)

(Unit: t/d as 100% NaOH)

Company	Capacity	Process
A. Commercial Plant		
(1) PT. Industri Soda Indonesia	36	Mercury
(2) PT. Soda Sumatra	20	"
B. Integrated with Pulp & Paper Plant		
(3) Pt. Ciwi Kimia	9	Diaphram
(4) PT. Kertas Blabak	3	"
(5) Perum Kertas Gowa	5	Mercury
(6) Lembaga Penelitian Selulosa	5	"
(7) PN. Kertas Letjes	19	7t/d Diaphram 12t/d Mercury
(8) Perum Kertas Basuki Rachmat	8	Mercury
(9) PN. Kertas Padalarang	2	Diaphram
C. Integrated with MSG Plant		
(10) PT. Miwon	6	"
(11) PT. Sasa	12	Mercury
Total	125	

(Notes) 1. PT. Uci Jaya (8t/d) has stopped operation of the plant since 1979 due to the waste water pollution struggles with the farmers.

2. PT. Ciwi Kimia has additional capacity of 27t/d which is not formally approved by the government for operation.

3. PT. Miwon has sold its caustic soda produced by diaphram process and purchased its all requirement by PT. ISI.

Table II-1.2 HISTORICAL PRODUCTION BY INDUSTRY

No.	Item	Unit	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
	[Major Assumption]												
1	Population	MM	126.3	129.2	132.2	135.2	138.3	141.6	144.9	148.3	151.9	154.5	158.1
2	Real GDP Index		0.83	0.89	0.94	1.00	1.09	1.17	1.25	1.37	1.47	1.58	1.70
3	Real GDP per capita (1975)	US$	209	218	225	234	248	263	272	293	307	326	342
4	Index of Real GDP per capita		0.89	0.93	0.96	1.00	1.06	1.12	1.16	1.25	1.31	1.39	1.46
	[Industry]												
1	Soap												
	Production	10^3t	131.3	148.9	164.6	175.5	194.9	218.5	202.9	213.0	207.8	279.8	290.8
	Consumption per capita	kg	1.04	1.15	1.25	1.30	1.41	1.54	1.40	1.44	1.37	1.81	1.84
2	Detergent												
	Production	10^3t	6.6	7.0	34.9	33.4	38.5	44.2	46.5	54.4	63.9	66.8	70.1
	Production (Soap + Detergent)	"	137.9	155.9	199.5	208.7	233.4	262.7	247.4	267.4	217.7	346.6	360.9
	Consumption (Soap + Detergent) per capita	kg	1.09	1.21	1.51	1.55	1.68	1.86	1.72	1.81	1.79	2.24	2.28
	Consumption (Detergent) per capita	"	0.05	0.05	0.26	0.25	0.27	0.31	0.32	0.37	0.42	0.43	0.44
3	Pulp & Paper												
	Demand (Paper)	10^3t	267	230	300	321	359	392	464	513	546	603	661
	Local Production (Paper)	"	40	43	51	62	82	155	214	232	256	297	342
	Local Production Radio (Paper)	%	15.0	18.7	17.0	19.3	22.8	39.5	46.1	45.2	46.9	49.3	51.8
	Consumption (Paper) per capita	kg	2.11	1.78	2.27	2.37	2.60	2.77	3.20	3.46	3.59	3.90	4.18
	Demand (Pulp)	10^3t	40	60	63	64	94	148	167	188	205	238	274
	Local Production (Pulp)	"	37	44	41	44	50	48	71	81	115	139	165
	Local Production Radio (Pulp)	%	92.5	73.3	65.1	68.8	53.2	32.4	42.5	43.1	56.1	58.2	60.4
4	MSG												
	Production	10^3t				8.1	10.0	21.6	20.0	21.8	33.5	30.2	32.7
	Consumption per capita	g				60	72	153	138	147	221	195	207

Table II-1.2 (CONTINUED)

No.	Item	Unit	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
5	Textile												
	Production	MMm	927	974	1,017	1,247	1,333	1,576	1,910	2,027	2,094	1,709	2,500
	Consumption per capita	m	7.3	7.5	7.7	9.2	9.6	11.1	13.2	13.7	13.8	11.1	15.8
6	Rayon												
	Demand	10^3t										-	35.7
	Production	"										-	28.8
7	Major Industry Requiring for Water Treatment												
	(a) Fertilizer												
	Urea Production	10^3t	116	209	387	406	990	1,437	1,827	1,985	2,007	1,944	1,971
	(b) Iron & Steel												
	Production (Ingot)	10^3t									-	693.5	762
	(c) Petroleum Refinery												
	Crude Throughput	10^6 bbl/y	118.7	119.3	112.8	113.7	152.4	161.4	186.0	192.8	212.1	233.3	256.7
	Local Throughput	"	115.1	91.6	81.7	83.1	112.2	105.2	120.3	129.3	162.5	181.8	224.5
	(d) Crude Oil												
	Production	10^3 bbl/d	1,268	1,447	1,231	1,504	1,686	1,635	1,595	1,576	1,067	1,325	1,325

Table II-1.3 UNIT CONSUMPTION OF NaOH & CL BY PRODUCT

Product	Unit	NaOH	CL
1. Soap	kg/t	150	
2. Detergent	kg/t	26	-
3. Pulp for Paper	kg/t	60 - 36	50 - 28
4. MSG (Fermentation Process)			
1976 - 1982	kg/t	400	160
1983	kg/t	300	"
1984 - 2000	kg/t	250	"
5. Textile	kg/MM m	3,200	500
6. Rayon	kg/t	750	-
7. Aluminium	-	-	-
8. Iron & Steel	kg/t	0.4	-
9. Fertilizer			
Urea	kg/t	1.50	0.3
TSP	kg/t	0.0045	-
ZA	kg/t	0.03	-
10. Crude Oil	$kg/10^6 bbl$	-	1.3
11. Petroleum Refinery	$kg/10^6 bbl$	14.4	0.6

(Note) 1. NaOH unit consumption for MSG is estimated as 500 kg/t if soda ash (Na_2CO_3) is not used. Since NaOH is gradually substituted by soda ash of cheaper price since 1980 in Indonesia, it is roughly assumed that NaOH unit consumption is 400 kg/t in 1976-1982, 300 kg/t in 1983, 250 kg/t in 1984-2000 based on the interview for the MSG manufacturer in Indonesia.

2. NaOH/CL unit consumptions for Pulp & Paper are estimated to be proportionately decreased in the period of 1984-2000.

Table II-1.4 HISTORICAL DEMAND OF NaOH (100%) & CL BY INDUSTRY
(OPTIMUM CASE)

(Unit: 1,000 t)

Industry	1976	1977	1978	1979	1980	1981	1982	1983
1. NaOH								
(1) Soap	26.3	29.2	32.8	30.4	32.0	31.2	42.0	43.6
(2) Detergent	0.9	1.0	1.1	1.2	1.4	1.7	1.7	1.8
(3) Pulp & Paper	2.6	3.0	2.9	4.3	4.9	6.9	8.3	9.9
(4) MSG	3.2	4.0	8.6	8.0	8.7	13.4	12.1	9.8
(5) Textile	4.0	4.3	5.0	6.1	6.5	6.7	5.5	8.0
(6) Rayon							-	21.6
(7) Water Treatment								
Fertilizer	0.6	1.5	2.2	2.7	3.0	3.0	2.9	3.0
Iron & Steel							0.3	0.3
Petroleum Refinery	1.2	1.6	1.5	1.7	1.9	2.3	2.6	3.2
(8) Others								
Food Industry	1.1	1.5	2.5	3.1	3.9	4.1	4.4	4.6
Miscellaneous	1.1	1.2	1.6	1.6	1.8	2.0	2.8	3.5
Total	41.0	47.3	58.2	59.1	64.1	71.3	82.6	109.3
2. CL								
(1) Pulp & Paper	2.2	2.5	2.4	3.6	4.1	5.8	7.0	8.3
(2) MSG	1.3	1.6	3.5	3.2	3.5	5.4	4.8	5.2
(3) Textile	0.6	0.7	0.8	1.0	1.0	1.0	0.9	1.3
(4) Water Treatment								
Fertilizer	0.1	0.3	0.4	0.5	0.6	0.6	0.6	0.6
Petroleum Refinery	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Crude Oil	0.7	0.8	0.8	0.8	0.7	0.5	0.6	0.6
City Water	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9
(5) Others								
Metal Industry	2.2	2.4	2.5	2.7	2.9	3.2	3.4	3.7
Miscellaneous	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.5
Total	8.7	10.1	12.2	13.7	14.9	18.7	19.7	22.2

Table II-1.5 HISTORICAL TOTAL DEMAND & DOMESTIC PRODUCTION OF NaOH & CL

(Unit: 1,000 t)

Product	1976	1977	1978	1979	1980	1981	1982	1983
1. NaOH (100%)								
Total Demand	41.0	47.3	58.2	59.1	64.1	71.3	82.6	109.3
Domestic Production	8.8	9.4	8.5	17.6	18.7	22.6	22.4	25.2
Balance	32.2	37.8	49.7	41.5	45.4	48.7	60.2	84.1
2. CL								
Total Demand	8.7	10.1	12.2	13.7	14.9	18.7	19.7	22.2
Domestic Production	7.7	8.4	7.4	15.5	16.5	19.9	19.7	22.2
Balance	1.0	1.7	4.8	-1.8	-1.6	-1.2	0	0

(Note) 1. Domestic production of NaOH in 1976-1981 is estimated with reference to "Industri Selayang Pandang (1982)" and the projection of PT. ISI.

2. Domestic production of NaOH in 1982-1983 is estimated by domestic production of CL/0.88 and domestic production of CL in 1982-1983 is assumed as equivalent to total demand of CL.

1.3 Demand Forecast

1.3.1 Basic method for demand forecast

First, production of the major products which use caustic soda and chlorine (including chlorine compounds) was projected. Second, demand for caustic soda and chlorine by each product was projected by multiplying unit consumption of caustic soda or chlorine to the above production figures. The following methods were used, when applicable, to project the production of each product.

(a) Regression analysis using real GDP or real GDP per capita as variables.

(b) Elasticity analysis versus real GDP or real GDP per capita.

(c) International cross-section analysis comparing consumption per capita and real GDP per capita.

Population and real GDP in Indonesia are projected as shown in the top of Table II-1.6 on the basis of projections by the World Bank and statistical data published by the government of Indonesia. The real GDP growth rate for 1984 onward is assumed as 7.5% per annum and the population is interpolated based on the forecast in increments of 5 years, as outlined below.

	1984	1990	1995	2000
Population (MM persons)	161.4	180.0	198.1	216.7
Real GDP Index (1976 = 1.00)	1.83	2.82	4.06	5.82

The major products (or the industries) which consume caustic soda and chlorine are as shown in Table II-1.3. As to the unit consumption, the figures used were collected through the survey in Indonesia, but for those unit consumptions which were not collected in Indonesia unit consumptions available in Japan were substituted.

The demand forecast for caustic soda and chlorine is made for up to 2000, and projection of the production of the major products was made for the three cases given below on the basis of the assumptions which are described in the following sections.

i) Optimum forecast which is supposed to have the highest possibility (Optimum Case)
ii) Optimistic (Maximum) forecast (Maximum Case)
iii) Pessimistic (Minimum) forecast (Minimum Case)

1.3.2 Growth forecast for the associated industries

The major users of caustic soda and chlorine are the following manufacturing industries, as described below.

(a) Soap
(b) Detergent
(c) Pulp for paper
(d) MSG (Monosodium Glutamate)
(e) Textiles
(f) Rayon
(g) Aluminium
(h) Water treatment in industry, others

Since the demand for caustic soda and chlorine will increase corresponding to the growth of these industries, the growth forecast for the associated industries is made as follows.

(a) Soap

Since per capita consumption of soap and detergent, taken singly or together, vary greatly according to the different lifestyles in various countries, it seems to be not proper to apply international cross-section analysis for the demand forecast of soap. It is believed that there are no other proper methods except to forecast such demand based on analysis of the individual pattern of consumption in each country. Per capita consumption of soap (Household hard soaps for bathing and washing) in Indonesia is about 1.8 kg in 1983, which is almost equivalent to the consumption level in the developed countries, so that it is supposed that the strong demand growth in the future can not be expected.

(Note) Per capita consumption of soap in Indonesia is projected by means of dividing the domestic production of soap by population disregarding the small amounts of imports and exports of soap.

Since the average growth rate of per capita consumption in the recent five-year period of 1978-1983 was 3.62% per annum, the real GDP per capita elasticity of per capita consumption becomes 0.66 and it is supposed that per capita consumption of soap will hit a ceiling in the near future in reflection of the demand increase of detergent. Hence, the per capita consumption in 1985 onward is projected as shown below on the basis of the information collected through interviews with soap manufactures in Indonesia.

ROJECTION OF PER CAPITA CONSUMPTION OF SOAP
(Unit: kg/Capita)

	1985	1987	1988	1990	1995	2000
Optimum Case	1.91	1.98	(2.00)	1.98	1.93	1.88
Maximum Case	1.91	1.99	2.03	(2.10)	2.00	1.90
Minimum Case	1.91	(1.95)	1.94	1.92	1.87	1.82

(Note) The figures in parentheses show the assumed maximum per capita consumption.

The total consumption is obtained by multiplying above per capita consumption by the population and is assumed as equivalent to the total production disregarding small quantities of imports and exports. The reason a decrease of per capita consumption of soap is projected in the future is attributed to the wide expansion of use of detergent.

(For reference) PER CAPITA CONSUMPTION OF SOAP IN 1980

(Unit: kg)

Japan	1.72	Norway	2.35
United Kingdom	1.79	Philippines	1.86
France	1.82	Thailand	0.48

(b) Detergent

Since it seems not proper as in the case of soap to apply international cross-section analysis for the demand forecast of detergent, the forecast is made by analyzing the consumption pattern of detergent in Indonesia.

Per capita consumption of detergent in Indonesia was about 0.44 kg in 1983, which seems very low compared with the consumption level in developed countries. It is supposed that demand will steadily increase corresponding to the popularization of electric washing machines. The annual growth rates of per capita consumption in the past five years are as shown below.

	Growth Rate of per Capita Consumption	Real per Capita GDP Elasticity
Detergent	7.26 (%)	1.33
Soap	3.62	0.66
Total Sum of Detergent & Soap	4.16	0.76

(Note) Per capita consumption of detergent in Indonesia is projected by means of dividing the domestic production of detergent by population disregarding imports and exports of detergent.

The detergent consumption is calculated by deducting the soap consumption from the total consumption of soap and detergent which is projected on the assumption that annual average growth rates of per capita consumption of total sum of detergent and soap are as shown below. Since import and export amounts of detergent are negligible in Indonesia, the production is assumed as equivalent to the consumption.

	Real per Capita GDP Growth Rate	Elasticity	Per Capita Consumption Growth Rate of Detergent & Soap
Optimum Case	5.55 (%)	0.85	4.72
Maximum Case	5.55	0.95	5.27
Minimum Case	5.55	0.75	4.16

(c) Pulp for paper

Since per capita consumption of paper in Indonesia was about 4.3 kg in 1983, which is very small when compared with the developed countries and other ASEAN countries, the demand for paper is expected to increase steadily in the future. The average annual growth rate of per capita consumption in the recent five year period of 1978-1983 is 9% and real per capita GDP elasticity is 1.65 which seems very high. Since expansion of production capacity has been aggressively promoted for both pulp and paper as shown in the following table, the domestic production capacity is expected to fully satisfy the demand increase of paper and pulp in the future.

PRODUCTION CAPACITY OF PULP AND PAPER

(Unit: ton)

	1983	Expansion Project	Total
Pulp	227,600	382,500	610,100
Paper	621,200	1,166,900	1,788,100

(Note) 1. The information was collected from The Pulp and Paper Association in Indonesia.

2. All of the expansion projects have been approved by the government.

As caustic soda and chlorine are mainly used for bleaching pulp for making paper, the production of pulp for paper in the Optimum Case is projected in the following manner.

1. Per capita consumption of paper is projected both by international cross-section analysis and regression analysis.

2. Domestic production of paper is projected by setting up the ratio of the domestic production to the total demand.

3. Demand for pulp is projected by setting up the unit consumption of pulp and recycled paper for the domestic production of paper.

4. Domestic production of pulp is projected by setting up the ratio of the domestic production to the total demand.

i) Demand forecast for paper

For the purpose of projecting per capita consumption of paper in 1984 onward, per capita consumption of paper in 66 countries and real per capita GDP, from "Pulp and Paper International, 1983 World Review Number" and "Statistical Yearbook, United Nation" are used and cross-section analysis is made as shown below.

$$\log Y = -1.7872 + 1.0044 \log X$$

where, Y: Per capita consumption of paper (kg/person)

X: Real per capita GDP (Constant US$ in 1975)

Coefficient of correlation: 0.85

In addition, the equation is obtained by the regression analysis on per capita paper consumption and real per capita GDP:

$$\log Y = 0.9034 + 1.3799 \log X$$

where, Y: Per capita consumption of paper (kg/person)

X: Real per capita GDP index (1.00 in 1976)

Coefficient of correlation: 0.71

The outcome of the projection by both methods is shown in the following table, which indicates nearly equal figures for 1995 onward, and the figures projected by the latter regression analysis are used as the effective projection due to the better continuity with the figures in the past.

COMPARISON OF PER CAPITA PAPER CONSUMPTION BY METHOD

(Unit: Kg/person)

	1985	1990	1995	2000
Cross-section Analysis	6.32	8.34	10.90	14.30
Regression Analysis	4.76	6.96	10.07	14.59

Hence, total demand of paper is calculated by multiplying population and per capita consumption.

(For reference) PER CAPITA CONSUMPTION IN 1982

(Unit: Kg)

USA	250	Thailand	11.5
Japan	146	Philippines	7
Malaysia	27	Pakistan	2

ii) Domestic production forecast for paper

Indonesia has imported a large quantity of paper, about 290,000 tons, which is equivalent to 53% of the total demand (546,000 tons) in 1981, but the domestic production has rapidly increased in recent years. The domestic production ratio of paper has improved from 15.0% in 1973 to 46.9% in 1981, which means a 19.4% annual average improvement of domestic production in 1976-1981. In Indonesia, the maximum domestic production ratio of paper is thought to be 95%. Assuming that the maximum domestic production ratio of 95% is achieved in 1995 onward in view of the current trend in the industry, the improvement ratio of domestic production is set as 5.17% per annum in 1981 onward. Hence, domestic production ratio and domestic production of paper are calculated as follows.

	Domestic Production Ratio (%)	Domestic Production of Paper (1000 ton)
1985	57.3	449
1990	73.7	923
1995	95.0	1,895
2000	95.0	3,004

iii) Domestic production forecast for pulp

Indonesia has imported a large quantity of pulp for paper, about 90,000 tons, which is equivalent of 44% of total demand (205,000 tons) in 1981, but the domestic production has rapidly increased in recent years. In Indonesia, the maximum domestic production ratio of pulp is thought to be 95% as in the case of paper. Assuming that the maximum domestic production ratio of 95% is achieved in 1995 onward, the improvement ratio of domestic production is set as 5.65% per annum in 1981 onward. Hence, the domestic production ratio and domestic production of pulp are calculated as follows.

	Domestic Production Ratio (%)	Domestic Production of Pulp (1000 ton)
1985	65.1	234
1990	78.6	580
1995	95.0	1,440
2000	95.0	2,283

But the unit consumptions of pulp and recycled paper in the production of paper in Indonesia are assumed as 0.8 and 0.2 respectively. The production forecasts in the three cases are projected on the following assumptions.

Optimum Case: Projections made above
Maximum Case: Optimum Case x 1.1
Minimum Case: Optimum Case x 0.9

(d) Monosodium glutamate (MSG)

Since per capita MSG consumption in Indonesia is about 210 g in 1983, which is calculated by means of dividing the domestic production of MSG by population disregarding the minute amount of imports of MSG.

If compared with per capita consumption of 610 g in Japan in 1982, big demand increase could not be expected in the future in view of the per capita income difference between two countries. One of the leading MSG manufactures in Indonesia has been projecting about 5% annual growth of total MSG demand in the future. Hence, the growth rate of total demand in 1984 onward are assumed as follows.

Optimum Case: 5.0 (%)
Maximum Case: 5.5
Minimum Case: 4.5

Assuming that import and export of MSG will be negligible in the future, total demand is projected as equivalent to total production.

(e) Textile

Since per capita textile demand in Indonesia is about 15.8 m/person in 1983, which is not high when compared with 58 m/person in Japan in 1982, it is supposed that there is room for demand to increase. It is generally said that per capita demand of fiber could be projected by international cross-section analysis. But this method of analysis is believed to be applicable for the demand forecast in the developed countries, but is not always applicable in the developing countries, especially in the low income tropical countries such as Indonesia. Hence, the demand forecast is made by regression analysis on per capita textile demand and real per capita GDP in past 10 years as follows.

$$Y = 9.0856 + 18.7628 \log X$$

where, Y: Per capita textile demand (m/person)

X: Real per capita GDP index (1.00 in 1976)

Coefficient of correlation: 0.96

FORECAST FOR PER CAPITA TEXTILE DEMAND

(Unit: m/person)

	1985	1990	1995	2000
Demand	18.0	23.2	28.2	33.3

Demand projections for 3 cases are assumed as follows.

Optimum Case: Projections made above
Maximum Case: Optimum Case x 1.1
Minimum Case: Optimum Case x 0.9

(f) Rayon

In Indonesia, the production of synthetic fibers has preceded the production of regenerated fibers. The production of rayon has started in recent years by the following two companies based on imports of pulp.

	Start-up	Current Capacity (t/y)
Indo-Bharat Rayon	June, 1982	18,000
South Pacific Viscose	Dec, 1982	18,000

Since the production ratio of rayon (including acetate) to synthetic fiber in the world is about 30%, the existing production capacity of rayon in Indonesia is thought to be well balanced as shown below.

(Unit: ton)

	Production Capacity	Production
Synthetic Fiber	148,300	116,100 (Actual in 1982)
Rayon	36,000	28,800 (Estimate in 1983)
Ratio	24%	25%

As there is little available statistical data regarding demand forecasts of rayon, for which production in Indonesia has just started, the production of rayon (assumed as equivalent to the demand) is projected on the assumption that the demand growth rate of the optimum case in 1984 onward is the same as the demand growth rate of the optimum case for textiles. It is believed that the production capacity will fully match the demand increase since there has been an announcement that the double expansion projects will be implemented around 1986/1987. The demand forecasts for the three cases are projected as follows.

Optimum Case: Projections made above
Maximum Case: Optimum Case x 1.1
Minimum Case: Optimum Case x 0.9

(g) Aluminium

The plant of 225,000 t/y production capacity of Asahan started operation at the end of 1982. Although it was initially planned that all alumina, the raw material of aluminium, would be supplied by domestic production, the switchover to importation of all alumina was later made in view of the lower quality and the higher price of domestically produced alumina, which eliminated potential caustic soda demand for alumina production from bauxite.

Since the Asahan plant was constructed as an export-oriented project, it is absolutely necessary to be internationally competitive in both product quality and price. Since the domestic demand for aluminium in Indonesia is limited to about 20,000 tons as of 1983, it is assumed that all requirements of alumina are to continue to be imported and there will be no alumina-processing demand for caustic demand in the future.

(For reference)

1. Unit consumption for alumina: Bauxite 2.0, caustic soda 0.08

2. Unit consumption for aluminium: Alumina 1.94

(h) Industry using caustic soda and chlorine for water treatment

In the following, examination is made on the industries which use large quantities of caustic soda and chlorine for water treatment.

i) Fertilizer

In Indonesia, urea is widely used rather than TSP (Triple Super Phosphate) and ZA (Ammonium Sulphate). In the demand forecast of urea, the projection made by UNICO International Corporation is used. As to TSP and ZA, the demand forecasts are omitted since the unit consumption of caustic soda and chlorine for water treatment in the production plants are rather small. Urea production in 1984 onwards is projected as follows assuming that the production capacity will be increased to fully meet the demand.

Optimum Case: Projections made above
Maximum Case: Optimum Case x 1.2
Minimum Case: Optimum Case x 0.8

ii) Iron & steel

The plant of 1,100,000 t/y production capacity at Krakatau started operation in 1979. Ingot demand in 1983 was announced as 950,000 ton and the demand is expected to increase gradually hereafter. Assuming that the expansion project will not be implemented up to 2000 years in view of the current situation of the industry, the production is projected as 1,100,000 t/y from 1987 on, the year when the capacity utilization is supposed to reach 100%. The production forecast is assumed as the same among the three cases.

iii) Petroleum refining

In Indonesia, the output of the domestic refineries has not fully met the domestic demand due to the shortage of production capacity, and the refining contracted to Singapore has been made heretofore to the extent of 150,000 bbl/d on the average.

The annual average growth rate of crude oil refining including the refining contracted to Singapore has been 9.72% in a recent five-year period and the real GDP elasticity is 1.25.

It is well known that energy consumption in each country in the world has a high correlation with real GDP, and real GDP elasticity is below 1.0 in the same five-year period in the developed countries. However, it is believed that in Indonesia the real GDP elasticity of energy consumption will be above 1.0 even in the future due to the priority policy for promoting energy-intensive industries, but the elasticity is expected to gradually approach 1.0 in accordance with the progress of energy conservation technology. Hence, assuming that the real GDP elasticity of crude oil refining in 1984 onward is equivalent ot the real GDP elasticity of energy consumption, crude oil refining is projected based on the following elasticity.

	1984-1990	1990-1995	1995-2000
Optimum Case	1.25	1.20	1.15
Maximum Case	1.30	1.25	1.20
Minimum Case	1.20	1.15	1.10

The capacity of domestic refineries in Indonesia in 1984 is 871,000 bbl/d following completion of the expansion projects in two refineries as follows.

	Expansion (bbl/d)	Start-up
Cilacap	200,000	Aug, 1983
Balikpapan	200,000	Oct, 1983

It is difficult to forecast the scale of crude oil refining up to 2000 in Indonesia since refining will be greatly influenced by such factors financing capability on the huge amount of capital to be required for the expansion projects, the basic policy of the government and the scale of refining entrusted to other countries. However, since it is estimated that the extent of the error of the forecast which could affect the total demand of caustic soda and chlorine in Indonesia is relatively small and for the sake of avoiding use of a complicated forecast method, the crude oil refining quantity in Indonesia is simply assumed as 90% of the total quantity of crude oil to be refined. This takes into account the actual results in the past and the refining capacities in the near-by contractor or would-be-contractor countries such as Singapore, but nevertheless the maximum capacity up to 1988 is herein assumed to be the current refining capacity of 317.9 x 10^6 bbl/y.

iv) Crude oil

The life of proven crude oil reserves in Indonesia is said to be about 20 years if the current rate of lifting continues, and there will be little possibility to make a substantial increase in production unless discovery of large-scale reserves is made in the future. The crude oil production capacity in recent years in Indonesia is said to be 1,600 x 10^3 bbl/d and the production quota for Indonesia set by OPEC on March, 1982 was 1,300 x 10^3 bbl/d. It is supposed that the crude oil production in 1982 and 1983 in Indonesia were made in accordance with the quota.

It is believed that the production in 1984 onward will be much affected by both international economic trends and OPEC strategy. Using the 2.0% annual growth rate of crude oil demand in the 1980s in the world, forecast by the World Bank, the annual growth rates of the production in Indonesia from 1984 on are projected as follows, until the production reaches the ceiling of 1,600 x 10^3 bbl/d.

Optimum Case: 2.0 (%)
Maximum Case: 2.5
Minimum Case: 1.5

v) City water

As the government of Indonesia has been promoting city water renovation and expansion projects on a nationwide scale, it is supposed that demand for liquefied chlorine for city water treatment will steadily increase. For example, the city water corporation in Jakarta has estimated that an average of 7% annual growth of supply is necessary for the next decade and is planning to expand the current supply capacity of 6 t/s to 10 t/s in 1987.

Hence, the average supply growth rates of city water supply for the entire country in 1984 onward are assumed as follows.

Optimum Case: Growth Rate of Jakarta x 80% = 5.6%
Maximum Case: Growth Rate of Jakarta x 100%= 7.0%
Minimum Case: Growth Rate of Jakarta x 60% = 4.2%

vi) Others

- Food industry

According to "Statistik Industri" (1982), the demand for caustic soda in 1980 was as follows:

Cooking Oil	1,058 (ton)
Sugar	808
Seasoning	1,902
Malt Liquor	18
Soft Drink	149
Total	3,935

The demand for caustic soda in and before 1979 was projected based on information from PT.ISI and the demand in 1981 onward is projected as follows:

Optimum Case: Demand grwoth rate is the same as the real per capita GDP growth rate

Maximum Case: Optimum Case x 1.2

Minimum Case: Optimum Case x 0.8

– Metal industry

Hydrochloric acid (33%) is used for processing pipe, galvanized plate, wire and zinc chloride, etc.

The demand for HCl in 1984 onward is projected as follows.

Optimum Case: Demand grwoth rate is the same as the real GDP growth rate of 7.5%

Maximum Case: Annual grwoth rate of 10%

Minimum Case: Annual growth rate of 6%

– Miscellaneous

The demand growth rate of caustic soda and chlorine for miscellaneous industries is assumed to be the same as in the case of HCl in the metal industry.

1.3.3 Demand forecast of caustic soda and chlorine in Indonesia

Table II-1.6 shows the production of the major products by industries, which are projected by means of the method described above.

Table II-1.7 shows the total demand for caustic soda and chlorine for the Optimum Case; it is calculated by multiplying the production of each major product by the unit consumption in Table II-1.3.

Table II-1.8 shows the demand forecast in three cases, which are also shown graphically in Figure II-1.1 for convenience of use. The outlook for demand is as shown below.

TOTAL DEMAND IN INDONESIA

(Unit: 1,000 t)

	1985	1990	1995	2000
NaOH (100%)	128.6	180.9	254.0	323.1
CL	27.2	45.1	78.1	102.0

As stated in detail in Appendix II-2, chlorine conversion demand of $CaCl_2$, $ZnCl_2$ and NH_4Cl is as shown at the bottom of Table II-1.7; these products are supposed to be easily produced domestically in Indonesia, among various imported inorganic chlorine compounds.

This chlorine conversion demand cannot be deemed as an effective demand in the demand forecast, but will be one index of chlorine market cultivation in the future.

The following table shows the change of demand structure in each industry by means of the indices of the growth rates and the composition ratios for 1984 and 2000.

Industry	1984 Composition(%) NaOH	CL	2000 Composition(%) NaOH	CL	Growth Rate(%) NaOH	CL
Soap	38.2	-	18.9	-	1.9	-
Detergent	1.9	-	5.5	-	13.9	-
Pulp	9.7	38.9	25.4	62.6	13.1	13.1
MSG	7.3	22.5	5.8	11.8	5.0	5.0
Textile	7.4	5.7	7.1	3.5	6.2	6.2
Rayon	22.4	-	23.9	-	6.9	-
Water Treatment	5.9	9.8	6.1	4.8	6.6	4.6
Others	7.2	23.1	7.3	17.3	6.5	7.4
Total	100.0	100.0	100.0	100.0	6.5	9.4

It is observed in the table that demand for both caustic soda and chlorine is expected to increase corresponding to the increase of domestic production of pulp following the increase of paper demand.

On the other hand, the demand for soap will hit a ceiling (growth rate 1.9%) and may be replaced by detergent (growth rate 13.95). Consumption in other industries is projected to grow at rates a little lower than the GDP growth rate.

It is also observed that chlorine demand growth rate is higher than the caustic soda demand growth rate, and it is to be expected that chlorine demand will expand further in the event that domestic production of inorganic chlorine compounds is begun as anticipated above.

1.3.4 Effective demand for PT. ISI

PT. ISI has marketed the following products in Indonesia.

NaOH (40 - 50%)
L-CL (99%)
HCL (33%)
BLN (12% CL)
BLC (8% CL)

In the previous section, the total demand for caustic soda and chlorine in Indonesia is projected. It would be too optimistic to assume that the entire increase in demand will be to the benefit of PT. ISI, since it is supposed that there will be new entries and expansion of production capacity in the existing electrolysis plants.

Hence, the effective demand to be shared by PT. ISI out of the total demand in the Optimum Case is projected as follows.

(1) Caustic soda

The demand/supply gap in Indonesia is so big even after the renovation project is implemented that all caustic soda to be produced by PT. ISI can be fully absorbed in the market, so that detailed discussion on the effective demand for PT.ISI is omitted.

(2) Chlorine

PT. ISI has made a detailed forecast on its potential market in 1984 and 1987 by each industry and customer. As the conclusion of a comprehensive review of the study, the survey team finds the forecast of PT. ISI to be appropriate in view of the historical market and the expansion plans of the customers as well as the information obtained through interviews with the customers, and decided to use the fore-caste without modification. In the forecast for 1987, the demand increment to be expected from the expansion projects of the customers is included.

As to the forecast of the potential market in 1988 - 2000, the projection is made on the following assumptions on the basis of the forecast for 1987 made by PT. ISI.

(a) Liquefied chlorine (L-CL)

The share of PT. ISI in 1984 and 1987 of the demand at major customers such as city water corporations and fertilizer companies is so high as shown below that it is almost deemed monopolistic. As far as the current government policy continues in force, which suggests that the state-owned companies or national corporation are to be preferentially supplied by PT. ISI (a national corporation), this monoplistic status of PT. ISI is expected to continue in the future.

THE FORECAST OF MARKET SHARE OF PT. ISI

(Unit : %)

	1984	1987
City Water Corporation	93	91
Fertilizer Company	94	89

i) Fertilizer

The five big fertilizer companies in Indonesia are Pusri, Kujang, Kaltim, AAF and Petrokimia Gresik, all of which are state-owned companies and the customers of PT.ISI. Most L-CL consumed by them is used for process water treatment.

The quantity of L-CL sold to these companies in 1988 onward is assumed to increase in proportion to the increase in fertilizer production.

ii) City water

The quantity of L-CL to be sold for treatment of city water in 1988 onward is assumed to increase in proportion to the demand increase of total water processing by all city water corporations in Indonesia.

iii) Others

The sales amount for other industries in 1988 onward is assumed to increase in proportion to the increase in production of the major products using L-CL in the industries.

(b) HCL

It is supposed that the demand for HCl will steadily increase in keeping with the progress of industrialization in Indonesia. Hence, the quantity sold in 1988 onward is asumed to increase in proportion to the production increase of the major products using HCl in each industry.

(c) BLN

The customers of PT. ISI for BLN are the five textile companies in central Jawa. The quantity sold in 1988 onward is assumed to increase in proportion to the increase of production of their textiles.

(d) BLC

The customers of PT. ISI for BLC are pulp & paper companies and various other industries. Hence, the quantity sold is assumed to increase at the same rate as the annual growth of real GDP growth rate of 7.5%.

The outcome of estimation of the potential market for chlorine products and the chlorine equivalent is as shown in Table II-1.9 and Figure II-1.2, and summarized in the following table.

FORECAST OF POTENTIAL MARKET FOR CL PRODUCTS OF PT. ISI
(Optimum Case)

(Unit: ton)

	1985	1990	1995	2000
Potential Market for PT.ISI				
L-CL	1,820	2,540	3,190	3,850
HCL (33%)	24,690	33,400	42,630	54,660
BLN (12% CL)	650	910	1,210	1,570
BLC (8% CL)	2,630	3,850	5,530	7,940
CL Equivalent of Products	9,940	13,650	17,420	22,170

(3) Ratio of chlorine demand for PT. ISI to total Indonesia demand

The following table shows the potential chlorine market for PT.ISI in comparison with total demand for chlorine in Indonesia.

(Unit : 1,000 t)

	1985	1990	1995	2000
Indonesia	27.2	45.1	78.1	102.0
PT.ISI	9.9	13.7	17.4	22.2
Ratio (%)	36.4	30.4	22.3	21.7

The figures in 1985 are almost the same as the figures in 1984, which indicates a 36.4% share for PT. ISI.

The projected share of PT. ISI in the total demand decreases gradually, to 21.7% in 2000, this projection being made on the assumption that the demand increase for PT.ISI will be limited to no more than the demand increase at the existing customers.

Conversely speaking, it can be said taht the forecast of the potential market for PT.ISI projected above is rather conservative and on the safe side.

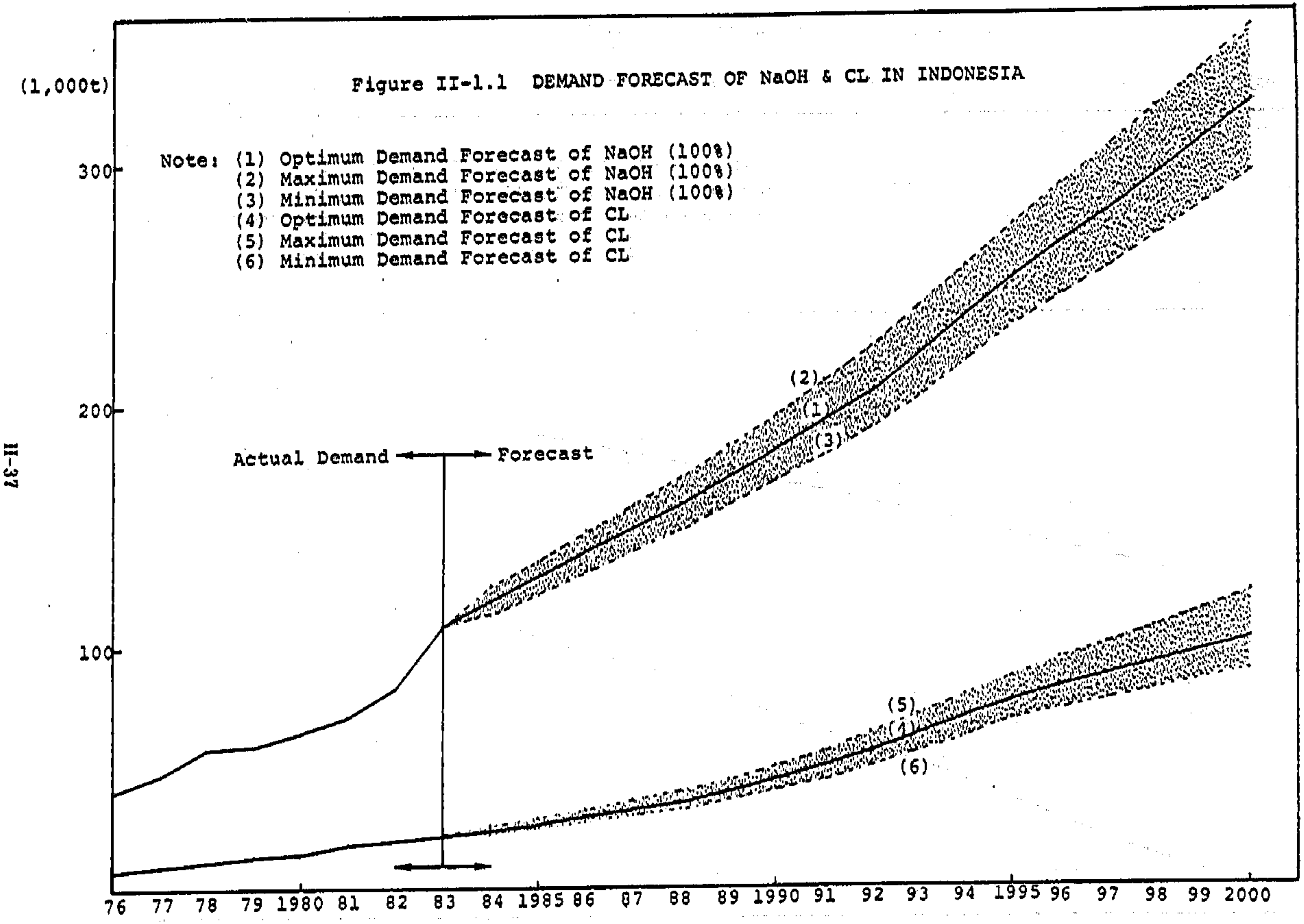

Figure II-1.1 DEMAND FORECAST OF NaOH & CL IN INDONESIA

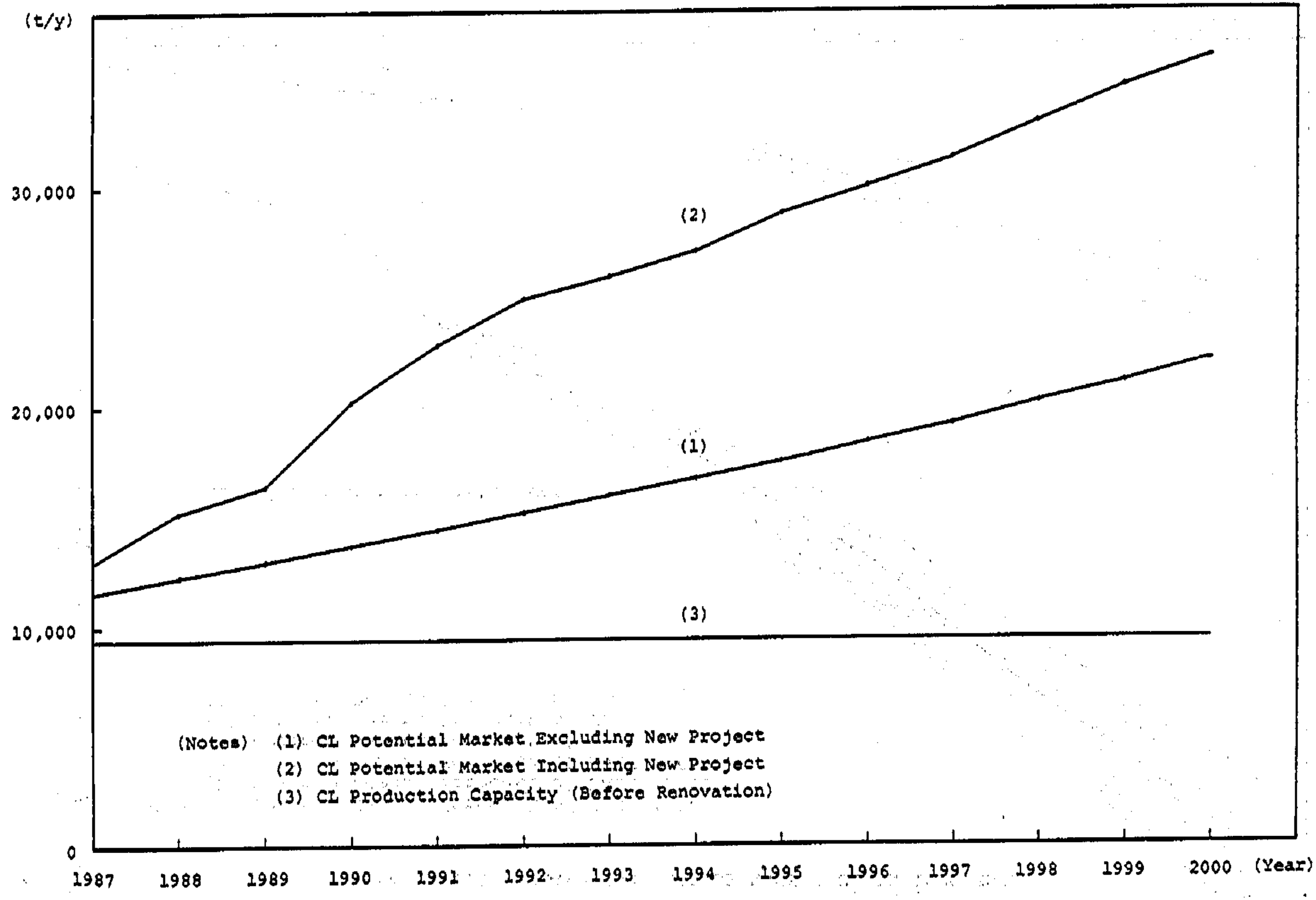

Figure II-1.2 CL POTENTIAL MARKET FOR PT. ISI (OPTIMUM CASE)

Table II-1.6 PRODUCTION FORECAST OF CHLOR/ALKALI INDUSTRIAL PRODUCTS (OPTIMUM CASE)

	Unit	1984	1985	1986	1987	1988	1989	1990	1995	2000
[Major Assumption]										
1. Population	MM	161.4	164.8	168.1	171.5	174.8	178.2	180.0	198.1	216.7
2. Real GDP Index		1.83	1.97	2.12	2.27	2.44	2.63	2.82	4.06	5.82
3. Real GDP per Capita (1975)	US$	359	377	398	420	443	466	497	649	851
4. Index of Real GDP per Capita		1.53	1.61	1.70	1.79	1.89	1.99	2.12	2.77	3.63
[Industry]										
1. Soal										
Production	10^3t	301.8	314.8	327.8	339.6	349.6	354.6	356.4	382.3	447.4
Consumption per Capita	kg	1.87	1.91	1.95	1.98	2.00	1.99	1.98	1.93	1.88
2. Detergent										
Production	10^3t	83.9	97.2	112.6	130.3	152.1	181.8	210.6	404.2	680.4
Production (Soap+Detergent)	10^3t	385.7	412.0	440.4	469.9	501.7	536.4	567.0	786.5	1,087.8
Consumption (Soap+Detergent) per Capita	kg	2.39	2.50	2.62	2.74	2.87	3.01	3.15	3.97	5.02
Consumption (Detergent) per Capita	kg	0.52	0.59	0.67	0.76	0.87	1.02	1.17	2.04	3.14
3. Pulp & Paper										
Demand (Paper)	10^3t	717	784	867	948	1,037	1,133	1,253	1,995	3,162
Local Production (Paper)	10^3t	391	449	523	601	692	794	923	1,895	3,004
Local Production Ratio (Paper)	%	54.5	57.3	60.3	63.4	66.7	70.1	73.7	95.0	95.0
Consumption (Paper) per Capita	kg	4.44	4.76	5.16	5.53	5.93	6.36	6.96	10.07	14.59
Demand (Pulp)	10^3t	313	359	418	481	554	635	738	1,516	2,403
Local Production (Pulp)	10^3t	196	234	283	338	404	481	580	1,440	2,283
Local Production Ratio (Pulp)	%	62.7	65.1	67.6	70.2	72.9	75.7	78.6	95.0	95.0

Table II-1.6 (CONTINUED)

	Unit	1984	1985	1986	1987	1988	1989	1990	1995	2000
4. MSG										
Production	10^3t	34.3	36.0	37.8	39.7	41.7	43.8	46.0	58.7	74.9
Consumption per Capita	g	213	218	225	231	239	246	256	296	346
5. Textile										
Production	MMm	2,760	2,966	3,194	3,430	3,671	3,920	4,176	5,586	7.216
Consumption per Capita	m	17.1	18.0	19.0	20.0	21.0	22.0	23.2	28.2	33.3
6. Rayon										
Demand	10^3t	39.4	42.4	45.6	49.0	52.4	56.0	59.6	79.8	103.0
Production	10^3t	35.5	40.3	45.6	49.0	52.4	56.0	59.6	79.8	103.0
7. Major Industry Requiring for Water Treatment										
(a) Fertilizer										
Urea Production	10^3t	2,056	2,146	2,260	2,356	2,461	2,558	2,655	2,962	3,161
(b) Iron & Steel										
Production	10^3t	800	1,000	1,100	2,356	2,461	2,558	2,655	2,962	3,161
(c) Petroleum Refinery										
Crude Throughput	10^6 bbl/y	280.8	307.1	335.9	367.4	401.9	439.6	480.8	739.8	1,119.0
Local Throughput	10^6 bbl/y	252.7	276.4	302.3	317.9	317.9	395.6	432.7	665.8	1,007.1
(d) Crude Oil										
Production	10^3 bbl/d	1,352	1,379	1,407	1,435	1,464	1,493	1,523	665.8	1,007.1

Table II-1.7 DEMAND FORECAST OF NaOH & CL BY INDUSTRY (OPTIMUM CASE)

(Unit: 1,000 t as 100% NaOH & CL)

Item	1984	1985	1986	1987	1988	1989	1990	1995	2000
1. NaOH									
(1) Soap	45.3	47.2	49.2	50.9	52.4	53.2	53.5	57.3	61.1
(2) Detergent	2.2	2.5	2.9	3.4	4.0	4.7	5.5	10.5	17.7
(3) Pulp for Paper	11.5	13.4	15.8	18.4	21.4	24.8	29.1	62.2	82.2
(4) MSG	8.6	9.0	9.5	9.9	10.4	11.0	11.5	14.7	18.7
(5) Textile	8.8	9.5	10.2	11.0	11.7	12.5	13.4	17.9	23.1
(6) Rayon	26.6	30.2	34.2	36.8	39.3	42.0	44.7	59.9	77.3
(7) Water Treatment									
Fertilizer	3.1	3.2	3.4	3.5	3.7	3.8	4.0	4.4	4.7
Iron & Steel	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Petroleum Refinery	3.6	4.0	4.4	4.6	4.6	5.7	6.2	9.6	14.5
(8) Others									
Food Industry	4.8	5.1	5.4	5.6	6.0	6.3	6.7	8.7	11.4
Miscellaneous	3.8	4.1	4.4	4.7	5.1	5.5	5.9	7.8	12.0
Total	118.6	128.6	139.8	149.2	159.0	169.9	180.9	254.0	323.1
2. CL									
(1) Pulp for Paper	9.5	11.2	13.0	15.1	17.6	20.3	23.7	49.5	63.9
(2) MSG	5.5	5.8	6.0	6.4	6.7	7.0	7.4	9.4	12.0
(3) Textile	1.4	1.5	1.6	1.7	1.8	2.0	2.1	2.8	3.6
(4) Water Treatment									
Fertilizer	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.9
Petroleum Refinery	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.6
Crude Oil	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8
City Water	1.0	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.6
(5) Others									
Metal Industry	4.0	4.3	4.6	4.9	5.3	5.7	6.1	8.8	12.7
Miscellaneous	1.6	1.7	1.8	1.9	2.0	2.2	2.4	3.2	4.9
Total	24.4	27.2	29.8	32.9	36.4	40.4	45.1	78.1	102.0
3. New Products (CL-Equivalent)									
(1) $CaCl_2$				0.3	0.5	1.1	1.6	2.6	2.6
(2) $ZnCl_2$				0.3	0.6	0.8	1.2	2.4	3.5
(3) NH_4Cl				0.9	1.7	2.7	3.8	6.4	7.7
Total				1.5	2.8	4.6	6.6	11.4	13.8

TABLE II-1.8 DEMAND FORECAST OF NaOH & CL BY CASE

(Unit: 1,000 t)

Year	NaOH (100%)			CL		
	OPT	MAX	MIN	OPT	MAX	MIN
1984	118.6	125.1	112.3	24.4	26.0	23.1
1985	128.6	135.7	121.6	27.2	29.0	25.2
1986	139.8	147.9	131.5	29.8	32.4	27.7
1987	149.2	158.4	139.9	32.9	35.9	30.4
1988	159.0	169.5	148.1	36.4	40.1	33.4
1989	169.6	182.9	157.8	40.4	44.8	36.9
1990	180.9	195.8	167.7	45.1	50.3	40.8
1991	193.4	209.6	178.5	50.0	56.1	45.1
1992	206.6	224.1	190.3	56.0	62.9	50.1
1993	221.1	240.1	203.3	62.5	70.7	55.8
1994	236.8	257.3	217.5	69.7	79.2	62.0
1995	254.0	276.1	233.0	78.1	89.1	69.6
1996	266.3	289.9	244.1	82.3	94.3	72.9
1997	278.8	303.7	255.3	86.8	100.1	76.7
1998	274.1	320.9	268.9	92.3	107.1	81.4
1999	308.7	337.2	281.9	97.3	113.8	85.5
2000	323.1	353.5	294.9	102.0	120.5	89.4

Table II-1.9 CL POTENTIAL MARKET FOR PT. ISI
(OPTIMUM CASE)

(Unit: ton)

Item	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1. Potential Market for PT. ISI																	
(1) L-CL	1,780	1,820	1,890	1,950	2,270	2,410	2,540	2,670	2,800	2,930	3,060	3,170	3,320	3,450	3,580	3,710	3,850
(2) 33% HCL	23,000	24,690	26,680	28,730	30,240	31,790	33,400	35,140	36,930	38,710	40,630	42,630	44,770	47,000	47,420	51,930	54,660
(3) 12% BLN	600	650	750	750	800	850	910	970	1,030	1,090	1,150	1,210	1,280	1,340	1,420	1,490	1,570
(4) 8% BLC	2,500	2,630	2,890	3,100	3,330	3,580	3,850	4,140	4,450	4,790	5,150	5,530	5,950	6,390	6,870	7,390	7,740
2. CL Equivalent of Product																	
(1) L-CL	1,780	1,810	1,890	1,950	2,270	2,410	2,540	2,670	2,800	2,930	3,060	3,190	3,320	3,450	3,580	3,710	3,850
(2) HCL	7,360	7,840	8,540	9,190	9,680	10,170	10,690	11,250	11,820	12,390	13,000	13,640	14,330	15,040	15,810	16,620	17,490
(3) BLN	70	80	80	90	100	100	110	120	120	130	140	150	150	160	170	180	190
(4) BLC	200	210	230	250	270	290	310	330	360	380	410	440	480	510	550	590	640
Total	9,410	9,940	10,740	11,480	12,320	12,970	13,650	14,370	15,100	15,830	16,610	17,420	18,280	19,160	20,110	21,100	22,170

(Notes) CL production capacity (as CL ton) excluding plant losses.
Existing capacity: 8,468 ton/y
After renovation:
Case 1 12,690 ton/y
Case 2 12,967 ton/y
Case 3 17,380 ton/y

1.4 Supply Forecast

1.4.1 Method of forecast

The supply forecast of caustic soda and chlorine is intended to project the increase of supply capacity in the future in terms of both the supply capacity of the existing electrolysis plants and the capacity of newly installed plants. However, it is very difficult to make a reliable forecast of when and in what capacity those future expansion projects are implemented. Hence, the supply forecast in this report is made on the basis of the following basic concept.

(a) There are two kinds of electrolysis plant; that is, plants which are not integrated with other industries such as the plants of PT. ISI and PT.Soda Sumatra, and plants which are integrated with user industries.

(b) It is thought that the integrated plants will expand their capacity in proportion to the production increase of the user plants, but is also supposed that a portion of caustic soda and chlorine demand will be supplied as before by the non-integrated plants.

(c) The production of the integrated plants will be scheduled to match the chlorine demand of the user plants since it is difficult and expensive to transport chlorine.

(d) The user plants which have the integrated electrolysis plants and consume a large quantity of chlorine are the plants manufacturing pulp for paper and MSG. The big manufacturers in the pulp & paper industry have announced that they will expand the capacity of integrated electrolysis plants together with the expansion of pulp and paper capacity, but there are many small scale manufacturer which do not have integrated electrolysis plants.

In the MSG industry, two companies out of the four large scale companies have electrolysis plants, but it is believed that they are not positively inclined toward expansion of electrolysis plants since the substitution of caustic soda by the cheaper imported soda ash has progressed while there has been slow growth of the demand for MSG.

(e) On the basis of the above circumstances, the captive-supply ratios of chlorine in the pulp and MSG industries are set as follows.

Pulp for paper	:	80%
MSG	:	50%

Assuming that the integrated electrolysis plants will be expanded in order to maintain these captive-supply ratios in the future, the chlorine supply forecast is made by adding the chlorine production capacity of the existing non-integrated plants to chlorine production of the integrated plants projected by using the above captive-supply ratios.

(f) Caustic soda supply forecat is made by dividing the caustic soda supply quantity by 0.88.

(Notes)

1. New expansion projects of the non-integrated plants are not included in the supply forecast, since the object of the supply forecast is to determine the demand/supply gap on the assumption that the non-integrated plants are not expanded.

2. The production capacity of the integrated plants will not be expanded by only small increments in each year. Even if a certain scale of expansion in a certain interval of years is assumed, the reliability of the supply forecast cannot be expected to be improved,

while the calculations would be made more troublesome without the compensation of better results. Hence, the projected annual increase of production is assumed to be the same as the annual expanded supply capacity of the integrated plants.

1.4.2 Outcome of supply forecast

Table II-1.10 shows the outcome of the supply forecast, an outline of which is shown below.

SUPPLY FORECAST

(Unit: 1,000 t)

CL (100%)	1985	1990	1995	2000
Integrated (Existing + Expansion)				
Pulp for paper	8.9	19.0	39.6	51.1
MSG	2.9	3.7	4.7	6.0
Non-Integrated (Existing)				
PT.ISI	9.5	9.5	9.5	9.5
PT.Soda Sumatra	5.3	5.3	5.3	5.3
CL Total	26.6	37.5	59.1	71.9
NaOH (100%) Total	30.2	42.6	67.2	81.7

Table II-1.10 NaOH/CL SUPPLY CAPACITY AND DEMAND BALANCE FORECAST IN INDONESIA

(Unit : 1000 t)

			1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1. NaOH (100%)																			
Total Demand	A	Table II-1.7	118.6	128.6	139.8	149.2	159.0	169.9	180.9	193.4	206.6	221.1	236.8	254.0	266.3	278.8	294.1	308.7	323.1
Total Supply	B	C + F	28.6	30.2	32.0	34.2	36.7	39.2	42.6	46.1	50.8	55.3	60.7	67.2	69.8	72.4	76.0	79.0	81.7
(Integrated)	C	D + E	11.8	13.4	15.2	17.4	19.9	22.4	25.8	29.3	33.6	38.5	43.9	50.3	53.0	55.6	59.2	62.2	64.9
Pulp & Paper	D	M/0.88	8.6	10.1	11.8	13.7	16.0	18.4	21.6	24.9	29.0	33.6	38.7	45.0	47.3	49.7	53.0	55.7	58.1
MSG	E	N/0.88	3.2	3.3	3.4	3.6	3.9	4.0	4.2	4.4	4.7	4.9	5.1	5.3	5.7	5.9	6.2	6.5	6.8
(Non-Integrated)	F	G + H	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8
PT. ISI	G	36 t/d x 300 d/y	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8
PT. Soda Sumatra	H	Q/0.88	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Demand/Supply Balance	I	A-B	90.0	98.4	107.8	115.0	122.3	130.7	138.3	147.3	155.8	165.8	176.1	186.8	196.5	206.4	218.1	229.7	241.4
2. CL																			
Total Demand	J	Table II-1.7	24.4	27.0	29.8	32.9	36.4	40.0	45.1	50.0	56.0	62.5	69.7	78.1	82.3	86.8	92.3	97.3	102.0
Total Supply	K	L + O	25.2	26.6	28.2	30.1	32.3	34.5	37.5	40.6	44.4	48.7	53.4	57.1	61.4	63.7	66.9	69.5	71.9
(Integrated)	L	M + N	10.4	11.8	13.4	15.3	17.5	19.7	22.7	25.8	29.6	33.9	38.6	44.3	46.6	48.9	52.1	54.7	57.1
Pulp & Paper	M	Demand x 0.8	7.6	8.9	10.4	12.1	14.1	16.2	19.0	21.9	25.5	29.6	34.1	39.6	41.6	43.7	46.6	49.0	51.1
MSG	N	Demand x 0.5	2.8	2.9	3.0	3.2	3.4	3.5	3.7	3.9	4.1	4.3	4.5	4.7	5.0	5.2	5.5	5.7	6.0
(Non-Integrated)	O	P + Q	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
PT. ISI	P	1/	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
PT. Soda Sumatra	Q	2/	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Demand/Supply Balance	R	J-K	-0.8	0.4	1.6	2.8	4.1	5.9	7.6	9.4	11.6	13.8	16.3	19.0	20.9	23.1	25.4	27.8	30.1
Potential Market for PT. ISI	S	Table II-1.9	9.4	9.9	10.7	11.5	12.3	13.0	13.7	14.4	15.1	15.8	16.6	17.4	18.3	19.2	20.1	21.1	22.2
Additional Demand for PT. ISI	T	S-P	0	0.4	1.2	2.0	2.8	3.5	4.2	4.9	5.6	6.3	7.1	7.9	8.8	9.7	10.6	11.6	12.7

Note: 1/ P (9.5) = 36 t/d x 0.88 x 300 d = 9.5 x 10^3t (PT.ISI)

2/ Q (5.3) = 20 t/d x 0.88 x 300 d = 5.3 x 10^3t (PT. Soda Sumatra)

1.5 Demand/Supply Balance and Sales Plan of PT. ISI

1.5.1 Demand/supply balance

Thus far, separate studies have been made on demand and supply, and in this section, the forecast of demand/supply balance in Indonesia, and the forecast of production and potential sales market of PT. ISI, are examined.

The demand/supply balance is summarized as follows, based on Table II-1.10.

(1) Demand/supply balance of chlorine

(Unit: 1,000 t Cl)

	1985	1990	1995	2000
Demand				
Indonesia 1/	27.2	45.1	78.1	102.0
for PT. ISI 2/	9.9	13.7	17.4	22.2
Supply Capacity				
Indonesia	26.6	37.5	59.1	71.9
for PT. ISI 3/	9.5	9.5	9.5	9.5
Balance (Demand/Supply Gap)				
Indonesia	0.6	7.6	19.0	30.1
for PT. ISI 4/	0.4	4.2	7.9	12.7

(Notes)
1/ "Indonesia" includes figures "for PT. ISI".
2/ "Demand for PT. ISI" means total potential market for PT. ISI.
3/ "Supply for PT. ISI" means the existing capacity of PT. ISI Waru.
4/ "Balance for PT. ISI" is additional potential market to PT. ISI existing capacity.

As chlorine supply capacity is in surplus to the extent of 800 t/y in 1984 (see Table II-1.10), it is projected that chlorine supply capacity will be almost equivalent to the demand in 1985, assuming that the existing plants of non-integrated companies are operated at 100% of capacity. In a long-term view, the existing production capacity is not able to satisy chlorine demand in Indonesia. It was apparently observed in the past that the non-integrated companies were obliged to operate the plants at low levels of capacity utilization due to a shortage of chlorine demand and as a consequence, the financial situations of these companies deteriorated. But in medium and long range views, chlorine demand will steadily increase and according to projection the existing production capacity is expected to become unable to fulfill the total demand.

(2) Demand/supply balance of caustic soda

As shown below, an absolute shortage of supply capacity is projected, since supply capacity is calculated as chlorine supply capacity/0.88.

DEMAND/SUPPLY BALANCE OF NAOH IN INDONESIA

(Unit: 1,000 ton as 100% NaOH)

	1985	1990	1995	2000
Demand	128.6	180.9	254.0	323.1
Supply Capacity	30.2	42.6	67.2	81.7
(Supply Capacity of PT.ISI)	(10.8)	(10.8)	(10.8)	(10.8)
Balance (Demand/Supply Gap)	98.4	138.3	186.8	241.4

At this point it is necessary to discuss the question of whether or not caustic soda supply will come to be in surplus as has been seen in the developed countries, in the event that an electrolysis plant is constructed together with the VCM plant in the future and whether or not the non-integrated companies such as PT. ISI are oblized to reduce capacity utilization to conform to caustic soda demand.

It is anticipated that the start-up year of the VCM plant will be 1988 at the earliest and that production capacity will be less than 150,000 t/y. In this case, the production of caustic soda which may be released to the market as surplus production is estimated as about 106,000 tons/year. On the other hand, a caustic soda shortage in 1988 is projected, as 122,300 t/y, as shown in Table II-1.10, so that the balance becomes 16,300 t/y or 54.3 t/d, which will be marketable room by PT. ISI in addition to the existing production capacity of 36 t/d.

Hence, as stated above, chlorine demand is projected to be a factor limiting the capacity utilization after the renovation project of PT. ISI.

1.5.2 Production and sales plan of PT. ISI

(1) Production capacity

As stated in Part III, three cases are discussed for the renovation project, and the production capacity of each case is as shown below. The maximum operating days of the existing plant is regarded to be 300 days a year if the renovation project is not implemented.

It is supposed that the possible operating days of the plant will become 330 days a year after the renovation. The production capacity as chlorine equivalent of chlorine products is designed to be 1.4 times greater than the generated chlorine gas since it is a common design practice to have such a surplus capacity in an electrolysis plant for the purpose of enabling flexible operations.

PRODUCTION CAPAICTY OF PT. ISI

(ton as 100% NaOH & CL)

	Existing	Case 1	Case 2	Case 3
a. NaOH	10,800 1/	15,180 2/	15,510 3/	20,790 4/
b. CL gas 5/	9,500	13,358	13,649	18,296
b-1) L-CL	1,800	4,950	4,950	4,950
b-2) HCL	24,900	41,250	42,900	66,000
b-3) BLN	1,200	1,650	1,650	1,650
b-4) BLC	7,500	9,900	9,900	9,900

(Notes):
1/ 36 t/d x 300 d/y
2/ 46 t/d x 330 d/y
3/ 47 t/d x 330 d/y
4/ 63 t/d x 330 d/y
5/ (a) x 0.88

(2) Production plan for each case

The production plan for each product for the three renovation project cases is established on the basis of the following concept.

(a) Operation will be performed to satisfy chlorine demand (chlorine equivalent demand of chlorine products) for PT. ISI, assuming the chlorine conversion ratio into chlorine products is 90% in the existing plant and 95% in the renovation plants.

(b) For the sake of stable and safe plant operation to absorb unreacted chlorine gas, BLN and BLC will be preferentially produced to within a 5% of total chlorine gas production.

(c) The production of liquefied chlorine will be given second priority since it is almost an exclusive market for PT.ISI.

(d) After preferential production the remaining chlorine gas will be used for HCl production. Net production of HCl will be projected by subtracting the captive-consumption for brine treatment from the gross production.

(e) Production adjustments will be made so as to not exceed the potential market and production capacity of PT.ISI.

(f) Caustic soda production will be projected as equivalent to generated chlorine gas production which is divided by 0.88.

Net production of caustic soda will be projected by subtracting the captive-consumption for brine treatment and BLN/BLC production from the gross production.

The production plan made on the above concept is as shown in Table II-1.11. The capacity utilization of electrolytic cells for each case is as shown below.

(Unit: %)

	Existing	Case 1	Case 2	Case 3
1984	90	-	-	-
1985	90	-	-	-
1986	90	-	-	-
1987	90	-	-	-
1988	90	90	90	73
1989	90	100	100	76
1990	90	100	100	80
1991	90	100	100	84
1992	90	100	100	88
1993	90	100	100	93
1994	90	100	100	97
1995	90	100	100	100
2000	90	100	100	100

(Note) The capacity utilization in Case 1 and Case 2 in 1988 is assumed to be 90%, taking into account the warming up stage in view of the plant operation technique in the initial start-up year.

(3) Effect on forecast variations

The study has been made so far for the Optimum Case which is assumed to be the most highly possible projection. But taking into consideration an uncertainty of the projection, the following sensitivity analysis was made as to the financial effects on the renovation projects due to projected variation in the Minimum and Maximum Cases.

(a) Caustic soda

In case of a Minimum Case demand the supply/demand balance in Indonesia is as shown below (see Table II-1.8).

	1985	1990	1995	2000
Supply 1/	19.4	31.8	56.3	70.9
Demand	121.6	167.7	233.0	294.0
Balance	101.6	135.9	176.6	224.0

(Note) 1/ Excluding supply from PT. ISI.

On the other hand, the maximum supply capacity of PT. ISI after renovation is projected as follows.

Case 1 46t/d x 330 d/y = 15,180 t/y
Case 2 47t/d x 330 d/y = 15,510 t/y
Case 3 63t/d x 330 d/y = 20,790 t/y

Therefore, even if a demand is realized as in the Minimum Case, all PT. ISI production can be fully absorbed in the market.

In the Case 3 renovation project which has the maximum production capacity of the three cases, for example, the share ratio is estimated to be only 15.2% in 1990, and even though approx. 100,000 t/y of surplus caustic soda will be released into the market form the newlyconstructed VCM plant (integrated with an electrolysis plant), it is projected that PT. ISI is able to sell all of its caustic soda production on the market.

(b) Chlorine

It is assumed that potential chlorine markets in the Minimum and Maximum Cases for PT.ISI have the same ratios as in the cases projected among total chlorine demands in the three cases as shown below.

CL POTENTIAL MARKET FOR PT. ISI

(1,000 t as Cl_2)

	1988	1989	1990	1995	2000
Minimum	11.3	11.8	12.3	15.3	19.4
Maximum	13.6	14.4	15.7	19.9	26.2
Optimum	12.3	13.0	13.7	17.4	22.2

On the other hand, chlorine production after the renovation will be as follows; this indicates salable chlorine amounts produced by PT.ISI, which are calculated by deducting 7% of total chlorine production in the form of loss and captively consumed HCl within the plant.

Case 1 46 t/d x 330 d/y x 0.88 x 0.93 = 12,420 t/y
Case 2 47 t/d x 330 d/y x 0.88 x 0.93 = 12,690 t/y
Case 3 63 t/d x 330 d/y x 0.88 x 0.93 = 17,010 t/y

Capacity utilization in Case 1 and Case 2 renovation projects in the 1988 start-up year is assumed to be 90% due to warming-up operations, and 100% from 1989 onward. From this point of view, capacity utilization assumed above in Case 1 and Case 2 need not be reduced even in the Minimum Case except in 1989 when capacity utilization is to be 95%. But it is possible to sustain 100% operation from 1990 onward.

(Note) The small surplus to be produced will be stored initially as inventory and will not be released to the market.

In Case 3, since capacity utilization of the Optimum Case is expected to reach 100% in 1995, analysis is made as to the financial effect on demand both in Minimum and Maximum Cases.

The following table shows capacity utilization for Case 3.

CAPACITY UTILIZATION FOR CASE 3

(Unit: %)

	Optimum	Maximum	Minimum
1988	73	80	67
1989	76	85	70
1990	80	93	73
1991	84	95	77
1992	88	100	80
1993	93	100	83
1994	97	100	87
1995	100	100	90
1996	100	100	96
1997 -	100	100	100

In view of the above table, if the potential market for PT. ISI is assumed as in the Maximum Case, capacity utilization will reach 100% in 1992, which is earlier than the Optimum Case by 3 years, but if assumed as in the Minimum Case, it will reach 100% in 1997, later than the Optimum Case by 2 years. From a probability standpoint the Maximum Case demand will be more feasible than that of the Minimum Case, since the potential demand for PT. ISI is projected exclusively on the basis of a demand increase of existing customers, so that a further demand increase can be expected if new customers are found and the inorganic chlorine compounds are produced in Indonesia in the futrue.

Table XI-1.11 PRODUCTION AND SALES PLAN
(EXISTING, CASE 1, CASE 2 & CASE 3)

(Unit: ton)

Item	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1. EXISTING PLANT																	
(1) NaOH (100%) Gross Production	10,692	10,692	10,692	10,692	10,692	10,692	10,692	10,692	10,692	10,692	10,692	10,692	10,692	10,692	10,692	10,692	10,692
Own Use	527	541	541	556	570	570	516	473	445	428	428	428	428	428	428	428	428
Production for Sale	10,165	10,151	10,151	10,136	10,122	10,122	10,176	10,219	10,247	10,264	10,264	10,264	10,264	10,264	10,264	10,264	10,264
(2) L-CL	1,780	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800
(3) HCL (33%) Gross Production	19,448	19,297	19,267	19,176	19,085	19,024	19,018	19,018	19,018	19,018	19,018	19,018	19,018	19,018	19,018	19,018	19,018
Own Use	481	481	481	481	481	481	481	481	481	481	481	481	481	481	481	481	481
Production for Sale	18,967	18,816	18,786	18,695	18,604	18,543	18,537	18,537	18,537	18,537	18,537	18,537	18,537	18,537	18,537	18,537	18,537
(4) BLN (12%)	583	667	667	750	833	833	517	267	100	0	0	0	0	0	0	0	0
(5) BLC (8%)	2,500	2,750	2,875	3,125	3,375	3,625	4,125	4,500	4,750	4,900	4,900	4,900	4,900	4,900	4,900	4,900	4,900
2. CASE 1 RENOVATION																	
(1) NaOH (100%) Gross Production					13,662	15,180	15,180	15,180	15,180	15,180	15,180	15,180	15,180	15,180	15,180	15,180	15,180
Own Use					587	637	651	665	679	693	693	708	708	672	615	573	495
Production for Sale					13,075	14,264	14,529	14,515	14,501	14,487	14,487	14,472	14,472	14,508	14,565	14,607	14,685
(2) L-CL					2,270	2,410	2,540	2,670	2,800	2,930	3,060	3,190	3,320	3,450	3,580	3,710	3,850
(3) HCL (33%) Gross Production					26,612	29,970	29,485	29,000	28,485	28,000	27,515	27,000	26,485	26,076	25,682	25,258	24,864
Own Use					664	738	738	738	738	738	738	738	738	738	738	738	738
Production for Sale					25,948	29,232	28,747	28,262	27,747	27,262	26,777	26,262	25,747	25,338	24,944	24,520	24,126
(4) BLN (12%)					833	833	917	1,000	1,083	1,167	1,167	1,250	1,250	1,042	708	458	0
(5) BLC (8%)					3,375	3,625	3,875	4,125	4,500	4,750	5,125	5,500	6,000	6,375	6,875	7,375	7,938

Note: Due to the plant shutdown for RENOVATION PROJECT, NaOH gross production (10,692 t/y) of existing plant in 1987 will be reduced by 1,375 t/y in CASE 1 RENOVATION or 1,713 t/y in CASE 2 and CASE 3 RENOVATION.
The production of other products will be reduced in due proportion.

Table II-1.11 (CONTINUED)

(Unit: ton)

Item	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3. CASE 2 RENOVATION																	
(1) NaOH (100%) Gross Production					13,959	15,510	15,510	15,510	15,510	15,510	15,510	15,510	15,510	15,510	15,510	15,510	15,510
Own Use					597	648	662	676	676	690	704	719	719	702	645	588	517
Production for Sale					13,362	14,862	14,848	14,834	14,834	14,820	14,806	14,791	14,791	14,808	14,865	14,922	14,993
(2) L-CL					2,270	2,410	2,540	2,670	2,800	2,930	3,060	3,190	3,320	3,450	3,580	3,710	3,850
(3) HLC (33%) Gross Production					27,355	30,809	30,324	29,839	29,355	28,870	28,355	27,839	27,324	26,876	26,482	26,088	25,664
Own Use					678	754	754	754	754	754	754	754	754	754	754	754	754
Production for Sale					26,677	30,055	29,570	29,085	28,601	28,116	27,601	27,085	26,570	26,122	25,728	25,334	24,910
(4) BLN (12%)					833	833	917	1,000	1,000	1,083	1,167	1,250	1,250	1,150	817	483	67
(5) BLC (8%)					3,375	3,625	3,875	4,125	4,500	4,750	5,125	5,500	6,000	6,375	6,875	7,375	8,000
4. CASE 3 RENOVATION																	
(1) NaOH (100%) Gross Production					15,177	15,800	16,632	17,464	18,295	19,335	20,166	20,790	20,790	20,790	20,790	20,790	20,790
Own Use					637	657	698	739	766	814	855	891	891	905	919	933	919
Production for Sale					14,540	15,143	15,934	16,725	17,529	18,521	19,311	19,899	19,899	19,885	19,871	19,857	19,871
(2) L-CL					2,270	2,410	2,540	2,670	2,800	2,930	3,060	3,190	3,320	3,450	3,580	3,710	3,850
(3) HCL (33%) Gross Production					30,448	31,542	33,164	34,788	36,409	38,558	40,148	41,212	40,697	40,182	39,636	39,091	38,545
Own Use					738	768	808	849	889	940	980	1,010	1,010	1,010	1,010	1,010	1,010
Production for Sale					29,710	30,774	32,356	33,939	35,520	37,618	39,168	40,202	39,687	39,172	38,626	38,081	37,535
(4) BLN (12%)					833	833	917	1,000	1,000	1,083	1,167	1,250	1,250	1,333	1,417	1,500	1,417
(5) BLC (8%)					3,375	3,625	3,875	4,125	4,500	4,750	5,125	5,500	6,000	6,375	6,875	7,375	8,000

Chapter 2 Price Forecast

2.1 Historical Trend of Sales Price

As stated in Chapter 1, "Demand Forecast", the chlor-alkali industry in Indonesia has expanded the production capacity and operated the plants to such an extent as to meet the domestic chlorine demand, and the problem of the resulting short fall of caustic soda supply has been solved by imports. In 1984, while the domestic production is estimated as about 28,000 tons, it is projected that the import quantity of caustic soda will reach about 90,000 tons which is more than 3 times scale of the domestic production. Hence, caustic soda sales price of PT. ISI has varied almost in accordance with the price of a large amount of imported caustic soda as shown in Figure II-2.1.

After the second oil shock, a decrease of chlorine demand in the USA has caused a tight supply of caustic soda which brought about extreme change of the price correlation for both products. While the actual price of L-Cl has dropped to US$85/t for a while although list price was US$170/t, actual price of caustic soda (100%) has jumped to US$300/t, about 2 times the previous price. But with the trend of economic recovery in 1983 onward, it is said that the recovery of the chlorine price as well as the decline of the caustic soda price have recently been observed. In reflection of the above circumstance, the export price of caustic soda has risen in international trade, so that the import price in Indonesia has jumped. In accordance with these trends, the sales prices of PT. ISI have risen for all products except BLC, but this trend reversed and started to decline after hitting a ceiling in 1980 - 1981.

Table II-2.1 shows the actual sales prices (ex-factory price including tax) of PT. ISI in 1976 - 1983 and the analysis is made on the sales prices of PT. ISI's products in the following sections.

2.1.1 Trend of pair ton price

As caustic soda and chlorine are co-products, Figure II-2.2 shows the trend of pair ton price (caustic soda price/t plus chlorine gas (G-Cl) price/t x 0.88), assuming that the G-Cl price is equivalent to the L-Cl price divided by 1.2 which is commonly accepted in the historical price trend of view. It is observed in the figure that the pair ton sales prices of PT. ISI in 1976 - 1983 on the average are more than 2 times the pair ton price in Japan (ex-factory price) or in the USA (List price), but have been declining from 1982 onward.

As the fluctuation of pair ton price was very large in 1976 - 1983, the average price line is projected by the method of least squres, which indicates US$942/t of pair ton price in 1984. The international comparison of pair ton price in 1983 is as shown below.

COMPARISON OF PAIR TON PRICE IN 1983

(Unit: US$/t)

	PT. ISI	USA	Japan
NaOH	293	330	270
CL gas	514	133	210
Pair Ton	745	447	455

(Note) PT. ISI : Ex-factory price including tax
USA : List price (CMR)
Japan : Ex-factory price (Yearbook of Chemical Industries Statistics)

2.1.2 Trend of caustic soda (100%) price

As shown in Figure II-2.1, the caustic soda sales price of PT. ISI in 1976 - 1983 (ex-factory price including tax) hit a ceiling of US$490/t in 1981 and has varied in correlation with CIF Indonesia. Caustic soda price in Indonesia seems to have been established through price competition with a large quantities of imported caustic soda. The sales price of

PT. ISI in dollars declined in 1978 due to the depreciation of the exchange rate although it showed a slight increase in rupias.

As shown in the table, the caustic soda sales price of PT. ISI in 1976 - 1983 on the average was 1.4 times higher than the ex-factory price in Japan, which ex-factory price is generally said to be more costly than the ex-factory price in the USA. Since the FOB of Japan in 1983 was US$127/t as shown in Figure II-2.1, the CIF Indonesia price comes to about US$150/t by adding US$20/t of freight and insurance expense to FOB price of Japan.

The major exporter in Japan who has been exporting caustic soda to Indonesia said that the CIF price in Indonesia was about US$140-150/t in 1983, so that the delivered caustic soda price to the customers can be projected by adding the tax, handling and in-land transportation expenses and the agent's margin. The international comaprison of caustic soda price in 1981 - 1983 is as shown below.

(Unit: US$/t)

	1981	1982	1983
PT. ISI	490	395	293
USA	250	330	330
Japan	262	262	270

(Note) PT. ISI : Ex-factory price including tax
USA : List price (CMR)
Japan : Ex-factory price (Yearbook of Chemical Industries Statistics)

2.1.3 Trend of chlorine product price

The price of chlorine products of PT. ISI, the USA and Japan in 1983 was as follows.

(Unit: US$/t)

	PT. ISI	USA	Japan
L-CL	617	160	252
HCL	108	75	72
BLN	95	n.a.	89
BLC	14	n.a.	56

(Note) PT. ISI : Ex-factory price including tax
USA : List price (CMR)
Japan : Ex-factory price (Yearbook of Chemical Industries Statistics)

The sales prices of PT. ISI are higher than the prices in the USA and Japan except for BLC, and especially it is much higher in the case of L-Cl: 3.5 times that in the USA and 2.5 times that in Japan, which price has greatly increased with the price increase of caustic soda after the second oil shock despite the decline in chlorine price in the USA.

L-Cl sales price of PT. ISI was on the average 2.8 times the ex-factory price in Japan in 1976 - 1983, which is the principal cause for the pair ton price of PT. ISI to stay more than two times the international price level.

The reason the sales price of BLC was abnormally cheap was that from time to time surplus Cl was produced when the PT. ISI plant was operated to meet the demand of caustic soda, and in this case, BLC was manufactured as a means to dispose of surplus chlorine; a portion was discarded to the river and the rest was sold for practically nothing.

According to the import statistics of Indonesia, the import quantity and price of chlorine products are as shown below;

they are thought to have had no relation to the sales price of PT. ISI in view of the small quantity of imports, although the import prices were relatively higher.

IMPORTS OF CL PRODUCTS IN INDONESIA

(Unit: ton, US$/t)

Product	1981 Quantity	1981 Unit Price	1982 Quantity	1982 Unit Price
L-CL	194	1,241	108	1,144
HCL (35%)	952	486	383	692
BLN (12%)	127	789	285	1,054
BLC (8%)	355	970	259	1,187

(Note) It is thought that the import price became much higher than the sales price of PT. ISI, since the costs for transportation and container were included in the import price.

2.1.4 Special feature of pricing mechanism in Indonesia

The following table shows the price ratios of products by country assuming the caustic soda price is 1.00 as the basis for comparison.

PRICE RATIOS OF PRODUCTS

	PT.ISI 1/	USA 2/	Japan 2/
NaOH (100%)	1.00	1.00	1.00
L-CL	2.03	0.48	0.93
HCL	0.34	0.22	0.26
BLN (12%)	0.42	n.a.	0.33
BLC (8%)	0.12	n.a.	0.21

(Note) 1/ The simple average in 1976 - 183
2/ In 1983

As shown in the table, the extremely high price of L-Cl is a feature of the situation in Indonesia. The reason is thought to be as follows: The market for L-Cl was formed as a seller's market due to the monopolistic status of PT. ISI and based on the higher price of the imported price (about 1.7 times of PT. ISI's sales price in 1982) caused by the difficulty of transportation. Furthermore, there were financial circumstances in the administration of the company which made it necessary to depend on the profit arised from L-Cl since the caustic soda price was depressed by price competition with the imported caustic soda.

The other chlorine products seem rather high in price but can be deemed to be within the appropriate range. Hence, in summing up the above discussions, it is able to observe that the price of L-Cl has been independently determined and maintained in a high range without bearing any relation with the price of the other products.

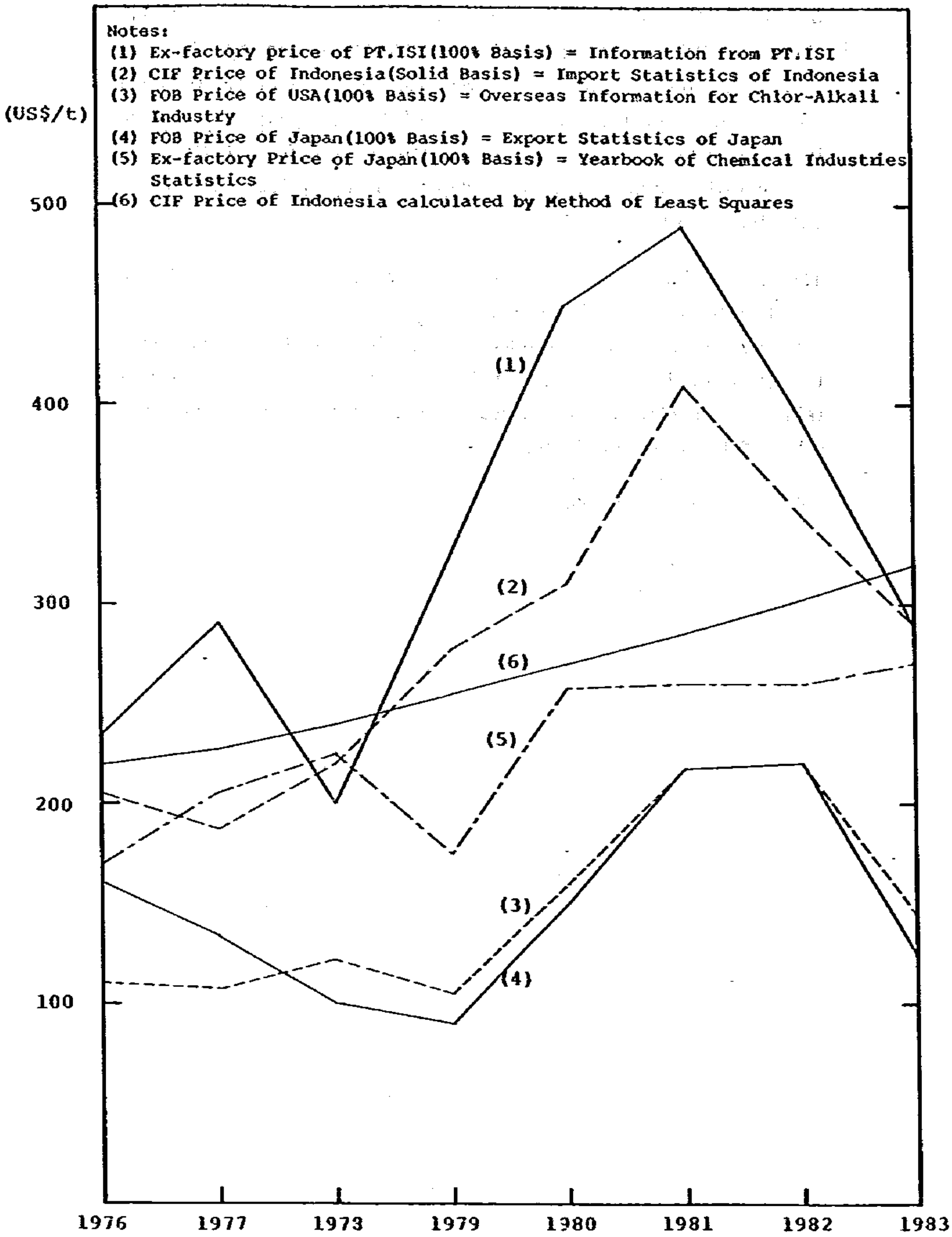

Figure II-2.1 HISTORICAL PRICE TREND OF NaOH

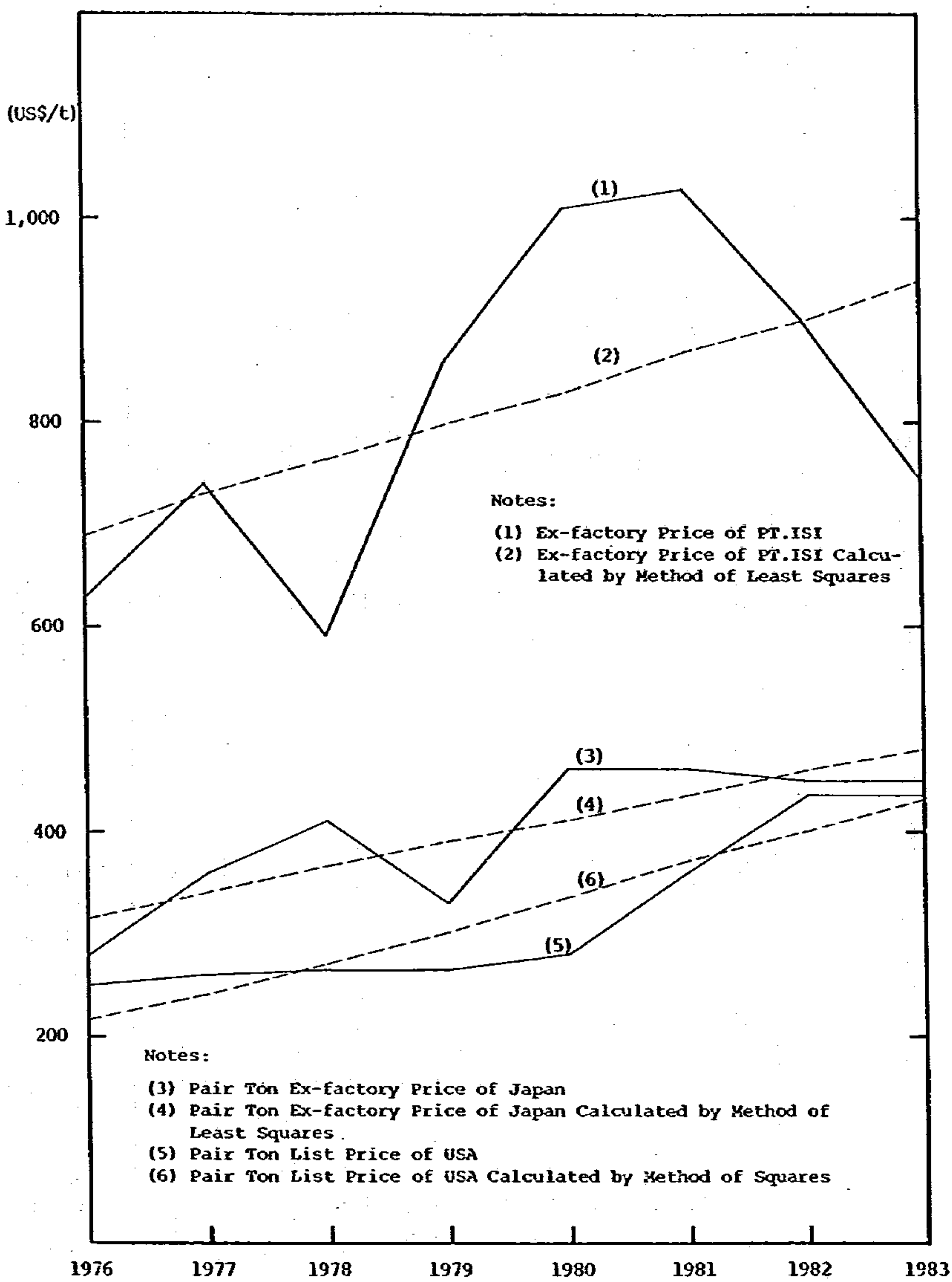

Figure II-2.2 HISTORICAL PRICE TREND OF PAIR TON

Table II-2.1 HISTORICAL EX-FACTORY PRICE (INCL. TAX) OF PT. ISI

(Unit: US$/t)

	1976	1977	1978	1979	1980	1981	1982	1983
1. NaOH (100%)	235	290	200	328	450	490	395	293
2. L-CL (99%)	548	619	535	736	775	735	690	617
3. HCL (33%)	97	173	72	89	143	96	86	108
4. BLN (12%)	156	173	115	123	146	157	137	95
5. BLC (8%)	70	75	44	42	40	22	19	14
6. PAIR TON	637	744	592	868	1,018	1,029	901	745
(NaOH Price for Reference)								
1. CIF Indonesia (incl Tax)	207	187	221	279	310	410	344	290
2. Ex-Factory Japan	168	207	224	174	257	262	262	270
3. FOB Japan	162	134	100	90	152	218	218	128
4. FOB USA	110	109	118	104	160	217	220	147

(Notes) 1. CIF Indonesia: Solid NaOH

2. Ex-Factory Japan, FOB Japan, FOB USA: Converted to 100% NaOH

2.2 Forecast of Sales Price

2.2.1 Caustic soda

As shown in the previous section, one of the price leaders for pricing caustic soda in Indonesia has been the imported caustic soda (solid caustic soda except in these years) and the domestic price of caustic soda (aqueous caustic soda) has varied under the influence of the import price as mentioned above.

The other price leader will be the surplus caustic soda at a VCM plant to be constructed in the near future. It is said that the annual demand for VCM in Indonesia at present is between 100,000 and 150,000 tons, and an electrolysis plant which can produce 100,000 tons of caustic soda will be necessary to satisfy chlorine demand for VCM. In this case, almost all caustic soda as co-product will be produced as surplus and released to the market, and which is supposed to occupy most of the market in view of the quantity. For example, 100,000 tons of caustic soda is projected to be equivalent to 55% of the total demand and 75% of the net shortage in 1990 in Indonesia (see Table II-1.10). In the event that this situation occurs, it is evident that the key deciding factor for caustic soda price will be the said surplus caustic soda.

For reference, the production cost of an electrolysis plant which will be constructed together with VCM plant and can produce 100,000 tons of caustic soda (100%) is estimated as shown in Table II-2.2. The unit prices of salt and electricity which are the major cost elements are assumed as the same as these prices of PT. ISI.

As a matter of fact, it is expected that salt imports at cheaper price and having higher quality will be approved for the use of an electrolysis plant as the consumption of raw salt will reach the high level of 170,000 tons/year.

But since fair competition cannot be expected in this case unless the same import approval for salt is given to PT. ISI, the price of domestically produced salt is used for the cost calculation for the sake of comparison.

It is also assumed that ROI is 20% of the total project cost as an appropriate profit, the start-up year of the plant is in 1988 and the capacity utilization is 90%.

The production cost including ROI will be US$58,302,000 in 1988 which is equivalent to US$647.8 per pair ton. For the sake of comparison, the pair ton price of US$647.8 is deflated to the price of US$540.7 in 1984 by the use of the inflation rate mentioned in Part V. Then, US$288 per ton of caustic soda is projected by dividing the pair ton price of US$540.7 by 1.88, so that the calculated caustic soda sales price by a price leader can be projected as US$299 by adding 4% of sales tax to US$288, which is supposed to be realized if an electrolysis plant for VCM were to be constructed.

The following table shows caustic soda sales prices collected from various sources.

	US$/ton of 100% NaOH
PT. ISI (1983)	293
PT. ISI (The former half of 1984)	260
Imported aqueous NaOH (1983)	290
Calculated price (1984)	299

It is generally forecast in Indonesia that the caustic soda price will increase in the latter half of 1984 since the caustic soda price of US$260/t in the former half of 1984 is believed to be a spot low price.

In view of the comprehensive review of the above data and discussions, US$300/t is adopted as the caustic soda price in 1984 for long term price forecasting which is a real object of this report. Hence, it is assumed that the price in 1985 onward will rise in proportion to the inflation rate and the ex-factory price for the use of financial analysis is US$288/t in 1984 which is the price excluding 4% sales tax from US$300/t.

The necessity of protection of domestic caustic soda from imprortation might be studied in the future by Indonesian government in accordance with the industrial development plan, in case that imporeted products would be priced so lower than the projected one as to destroy the chlor-alkali industry in Indonesia.

2.2.2 Chlorine gas (G-Cl) and chlorine products

(1) Basic concept

Electrolysis of salt water yields caustic soda, G-Cl and H_2, and L-Cl is produced by cooling G-Cl, HCl by reaction of G-Cl with H_2, BLN by reaction of G-Cl with caustic soda and BLC by reaction of G-Cl with purchased $Ca(OH)_2$. G-Cl can be sold to outside users in the case of the non-integrated plants such as PT. ISI, and be supplied for direct use through pipelines in the case of the integrated plants such as pulp and paper plants. Since caustic soda and chlorine are simultaneously produced in the same electrolytic cells, it is very difficult to appropriately allocate shares of the production cost to each product. It is one of the commonly accepted practice to divide the production cost equally per ton of the product.

In countries which have a relatively stable market, the sales prices of L-Cl, HCl, BLN and BLC have almost constant ratios to G-Cl in the long term although they fluctuate in the short term, and these ratios are approximately equivalent to the ratios of the production cost.

In Indonesia, it is observed as already mentioned that the price of L-Cl is at a very high level and the price of BLC is conversely at a very low level which are very far from the ratios of the production cost mentioned above.

From the above standpoint, the price forecast is made in this report on the basis of the following concept.

(a) The production cost ratios of each product for G-Cl are to be projected on the basis of the production cost analysis of PT. ISI.

(b) The price per ton of G-Cl is to be assumed as equal to the price per ton of caustic soda which already has been projected.

(c) The price adjustment is to be made as needed taking into account the special features of the market in Indonesia.

(Note) The production cost of PT. ISI is used as the basis of the price forecast in Indonesia since it is supposed that PT. ISI is a leading company to establish these prices due to the high market share of PT. ISI.

(2) Ratio of production cost and calculated price

According to the production cost in 1983 (refer to Table AV-1.10 in Annex V), the annual total of general expense and caustic soda production cost is assumed as the total production cost of the electrolysis plant excluding the production cost of the other affiliated plants for Cl products. Since G-Cl is produced in the ratio of 0.88 of caustic soda, the total production cost is divided by 1.88, and is allocated a portion of 1.0 as caustic soda production cost and a portion of 0.88 as G-Cl production cost. If each prodcution cost is divided by each production quantity, the unit production cost of each product is calculated as the same cost. Since the allocation of the production costs which are as shown in Table AV-1.10 due to the consumption of Cl and caustic soda is not made, the allocation is made in proportion to the unit consumptions as follows:

PRODUCTION COST FOR EACH PRODUCT OF PT. ISI IN 1983

(Unit: US$/t)

	Cost Element	NaOH	HCL	L-CL	BLN	BLC
(1)	Variable Cost	270.3	114.1	374.4	100.6	47.9
(2)	Salaries & Wages	43.1	1.4	7.5	6.6	3.1
(3)	Social Welfare	26.7	0.7	3.6	2.5	1.3
(4)	Maintenance Cost	24.9	2.6	18.5	13.1	1.2
(5)	Depreciation	73.4	3.7	45.9	2.7	1.8
(4)	Cost Allocation	160.6	-	-	-	-
	Unit Cost	318.6 1/	122.5	449.9	125.5	55.3
	Price Ratio	1.00	0.38	1.41	0.39	0.17

(Note) 1/ Cost elements for NaOH show the cost of a PAIR TON. Therefore, total cost of NaOH is calculated as PAIR TON cost (US$599.0)/1.88 which is equivalent to the unit cost of CL.

The calculated sales prices and the actual prices both inclusive of sales tax are as shown below.

	Calculated Price in 1984	Cost Ratio for G-CL	Actual Price in 1983
NaOH (=G-CL)	US$300/t	1.00 (basis)	US$293/t
HCL	US$114/t	0.38	US$108/t
L-CL	US$423/t 1/	1.41 1/	US$617/t
BLN	US$117/t	0.39	US$ 95/t
BLC	US$ 51/t	0.17	US$ 14/t

(Note) If the price ratio of 1.2 which is commonly accepted as appropriate is applied, US$360/t is projected.

(3) Sales price projection of chlorine products

(a) HCl and BLN

Since the calculated prices of these two products seem appropriate when compared with the actual prices, these calculation prices are assumed as the sales prices.

(b) L-Cl

The actual price is higher than the calculated price by 46% and by 71% if the price ratio of 1.2 is applied for the calculated price. Since the actual price is determined in the perspective of the demand/supply balance in Indonesia, and other factors which will make the actual price rapidly approach to the calculated price cannot be currently found, the calculation price has to be adjusted.

It will be appropriate to assume that the expansion of the electrolysis plants to satisy chlorine domestic demand in Indonesia will be implemented in the future as in the past, which may be achieved by the installation either of the non-integrated plant or the integrated plant with VCM or the other industries which will be capable to supply surplus chlorine to the market.

As a consequence, the price competition for marketing L-Cl will be made and the market price is supposed to eventually approach the calculated price. Hence, it is assumed that the price in 1984 is 2.0 times the price of G-Cl (= caustic soda) in the context of historical prices, but will be decreased by the same amount in each year up to 1.4 times of the price ratio in 2000.

(c) BLC

BLC is currently produced as a means of disposal of surplus chlorine, so that the production cost is not reflected in the sales price of BLC. If the demand for chlorine increases in the future, it is thought that the price will be gradually recovered with reflection of the real values as in 1970s. Hence, it is assumed that the sales price in 1984 is set as US$18/t and will be increased by the same amount in each year up to 0.17 times of the price ratio in 1990 onward.

(d) Tabulation of sales price

Summing up the above discussions, the inflated sales prices are as shown in Table II-2.3. Hence, the ex-factory prices of PT.ISI are assumed as the prices by deducting 4% sales tax from the above projected prices. The outlook of the sales prices are as shown below.

SALES PRICE FORECAST FOR EACH PRODUCT
(including 4% sales tax)

(Unit: US$/t)

	1984 (actual)	1988	1990	1995	2000
1. NaOH (100%)	300	359	403	540	722
2. L-CL	600	703	754	883	1,011
3. HCL (33%)	114	136	153	205	274
4. BLN (12%)	117	140	157	211	282
5. BLC (8%)	18	44	69	92	123
6. Pair Ton	740	875	956	1,188	1,463

Table II-2.2 ESTIMATED PRODUCTION COST OF STANDARD ELECTROLYSIS PLANT IN INDONESIA (1988)

(Unit: 1000US$, US$/t)

Cost Item	Calculation	Annual Cost	Unit Cost per Pair Ton
1. Variable Cost			
Salt	US$40.2/t x 1.7 x 90,000	6,151	68.3
Electricity	US$0.0605/kwh x 2,300 kwh/t x 90,000	12,524	139.2
Chemicals	US$21.5/t x 90,000	1,935	21.5
Fuel Oil	US$12.0/t x 90,000	1,080	12.0
Hydrogen	US$12.8/t x 90,000	-1,152	-12.8
Others	US$24.3/t x 90,000	2,187	24.3
(Sub-Total)		22,725	252.5
2. Fixed Cost			
Direct labour Cost	US$2,908/person x 143	416	4.6
Depreciation	US$55,800x$10^3$x1/10+US$18,250x10^3x1/30	6,188	68.8
Maintenance	US$74,050 x 10^3 X 0.05	3,703	41.1
Tax & Insurance	US$74,050 x 10^3 x 0.005	370	4.1
(Sub-Total)		10,677	118.6
3. Interest on Loan	US$102,423 x 10^3 x 0.7 x 0.1 x 1/2	3,585	39.8
4. Administration	Direct Labour Cost x 0.6	250	2.8
5. Sales Expense	Sales Revenue x 0.01	580	6.4
(Total)		37,817	420.2
6. ROI	US$102,423 x 10^3 x 0.2	20,485	227.6
(Grand Total)		58,302	647.8

(Notes) 1. Annual production: 100,000 t/y x 90% = 90,000 t/y as 100% NaOH

2. Unit prices of the materials are assumed as same as those for PT. ISI.

Table II-2.3 EX-FACTORY PRICE FORECAST OF PT. ISI (INCL. TAX)

(Unit: US$/t)

Product	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(Escalation Index)	0.8347	0.8639	0.8985	0.9434	1.0000	1.0600	1.1236	1.1910	1.2625	1.3382	1.4185	1.5036	1.5938	1.6895	1.7908	1.8982	2.0122
1. NaOH (100%)	300	310	323	339	359	381	403	428	453	480	509	540	572	607	643	681	722
2. HCL (33%)	114	118	123	129	136	145	153	163	172	182	193	205	217	231	244	259	274
3. BLN (12%)	117	121	126	132	140	149	157	167	177	187	199	211	223	237	251	266	282
4. BLC (8%)	18	22	28	35	44	55	69	73	77	82	87	92	97	103	109	116	123
5. L-CL	600	626	651	677	703	728	754	780	806	831	857	883	908	934	960	985	1,011
6. PAIR TON	740	769	800	835	875	915	956	1,000	1,044	1,089	1,137	1,188	1,238	1,292	1,347	1,403	1,463

(Note) Pair Ton price is calculated as NaOH + L-CL/1.2 x 0.88

Chapter 3. Rationalization of Transport

3.1 Traffic Service in Indonesia and Sales Area of PT. ISI

Since Indonesia comprises 13,700 islands including small ones as well as large ones, which cover an area of about 1,920,000 km^2, transport services have not yet developed. Although the total length of the roads in 1981 is 154,000 km, the paved ratio is only 40%. The road length per square km is 316 m in Jawa, 103 m in Sumatra, 21 km in Kalimantan and 80 m in the nationwide average which is about 2.5% of 3,114 m in Japan. On the other hand, there are a total 5,481 km of the railway, out of which 4,142 km are in Jawa and 1,339 km are in Sumatra, and most of them are deemed as superannuated. Because of the above circumstances, transport services are concentrated in the marine sector so that the current cargo transport ratios are estimated as 26.5% by truck, 3% by railway and 70.5% by vessel. The geographical distribution of the industry in Indonesia shows a pattern of being centered in the islands of Jawa and Sumatra, followed by the Kalimantan district, and it is supposed that the industrial development plan in the future will not change very much from the above situation. Hence, it is projected that the basic materials for industries such as caustic soda and chlorine will be exclusively consumed in those three regions in the future as in the past.

Since PT.Soda Sumatra has been operating at Sumatra Island, it will be advisable for PT. ISI to concentrate its marketing activity on the regions of Jawa and Kalimantan except L-Cl which PT.Soda Sumatra has not yet produced.

3.2 Product Transport Mode of PT. ISI

Table II-3.1 shows the comparison of transport mode and cost which have been commonly used by PT. ISI and in Japan. The transport costs are compared for the distance of 800 km which is almost equivalent to the distance between Surabaya and Jakarta where the cargo movement is said to be the maximum in Indonesia. As shown in the table, the feature of the transport mode used by PT. ISI is that small-lot consignments carried on a tank lorry, jerry cans on a truck or a mixed-cargo vessel occupies the major share of transport while the utilization of a tank ferry or railway tank wagon is limited. In view of the transport service situation and small amount of cargo movement in Indonesia if compared with Japan the current transport mode of PT. ISI is supposed to conform well to the proper transport feature in Indonesia. It is observed in Table II-3.1 that the average transport costs in Indonesia when compared with the same transport mode of Japan are less than half of those in Japan excluding the transport of L-Cl in pressure cylinders.

However, in the case of small lot sales in jerry cans which are rarely recovered for re-use, the price of a jerry can and a wooden crate which can accommodate two jerry cans is very expensive, to the extent of 58% and 75% of total cost as shown below when compared with the contents of caustic soda (40%) and HCl (33%) respectively. Hence, study and action are necessary for the improvement of transport systems for small lot sales.

PRICE OF CONTAINER PER TON OF PRODUCT (1984)

(Unit: US$/t of content)

	NaOH (40%)	HCl(33%)
Jerry can	48.7	57.8
Crate	17.1	20.3
Handling Expense	2.5	2.5
Total (A)	68.3	80.6
Content (B)	117.0	108.0
Ratio (A/B)	58%	75%

(Note) Price of jerry can (1984):
Indonesia US$1.85/piece, Japan US$2.60/piece

Table II-3.1 COMPARISON OF DELIVERY MODE AND COST

Product	Delivery Mode	Net Content	Utilization		Delivery Cost (US$/t)	
			PT.ISI	Japan	PT.ISI	Japan
1. NaOH (40 ~ 50%)	Tank Ferry	100 ~ 2,500t	X	O	-	12
	Tank Wagon	15t, 35t	X	O	-	45
	Tank Lorry	5 ~ 12t	O	O	40	100
	Drum	280 ~ 300 kg	X	O	-	NA
	Jerry Can	25 ~ 30 kg	O	X	80	200
2. L-CL	Tank Wagon	15t, 25t	X	O	-	60
	Tank Lorry	5 ~ 10t	X	O	-	110
	Cylinder	50 kg, 1t	O	O	325	150
3. HCL (33 ~ 35%)	Tank Ferry	50 ~ 100t	X	O	-	18
	Tank Wagon	15t, 35t	X	O	-	45
	Tank Lorry	5 ~ 12t	O	O	40	100
	Bulk Container	1t	O	X	NA	NA
	Jerry Can	25 ~ 30 kg	O	O	80	200
4. BLN (12%)	Tank Lorry	5 ~ 12t	X	O	-	85
	Bulk Container	500 kg	O	X	40	NA
	Jerry Can	25 ~ 30 kg	O	O	80	200
5. BLC (8%)	Tank Ferry	50t	X	O	-	18
	Tank Wagon	30t	X	O	-	45
	Tank Lorry	5 ~ 10t	O	O	40	85
	Drum	300 kg	X	O	-	NA
	Glass Pot	30 kg	X	O	-	200

(Notes) 1. Delivery coat is estimated for 800 km which is almost equivalent to the distance between Surabaya and Jakarta.
2. Delivery cost in Japan shows the average cost.

3.3 Study on Rationalization of Transport

3.3.1 Utilization of railway

Since PT. ISI is located just beside the railway, it is advisable to review the possibility of use of the railway. In case of installing a sidetrack at the works, installation expense is supposed to be a small amount due to a short distance from the main truck. Assuming that a tank wagon having 25 m^3 of capacity and 35 ton of load is available as part of the service of the railway, it may become necessary either to install storage tanks in the vicinitiy of Jakarta station and the other major stations, or obtain joint use of the existing tanks located at Jakarta port and the other major ports. In the event that the service of a tank wagon is not available or the installation of the storage tanks is difficult, the direct transport to the customers is to be studied; in this case, use would be made of a tank container which can be carried by goods wagons from the works of PT. ISI. The capacity of a tank container will be 5-10 m^3 in view of the demand quantity of the customers and the convenience for transport by a truck from the arrival stations.

As to the inner living of the steel containers, it is to be designed so that a tank container is able to accommodate any and all the products of PT. ISI by selecting the proper materials such as synthetic rubber unless there are no legal regulations.

3.3.2 Marine transportation by tank container

It is advisable that a transport system using tank containers be studied for rationalization of small lot transport since use of this system would not require storage tanks at the loading and unloadig ports.

3.3.3 Study on swap sales of caustic soda

As shown in the demand forecast of Chapter 1, it is projected that the demand for caustic soda in 1984 in Indonesia will reach 119,000 tons, out of which 28,000 tons are to be supplied by domestic production and 91,000 tons by imports. In Indonesia, solid caustic soda occupied the major portion of caustic soda imports in the past, but the import of aqueous caustic soda has been dominant in recent years, and it is forecast that in the imports of caustic soda in 1984, aqueous caustic soda will be 70,000 tons while solid caustic soda is 20,000 tons.

Hence, aqueous caustic soda storage tanks have been installed at the major import ports in Indonesia such as Jakarta and Surabaya, as follows.

INSTALLATION OF AQUEOUS CAUSTIC SODA STORAGE TANKS

	No.of Tanks	Capacity (ton)	Reference
Jakarat	9	25,000	
Merak	1	3,000	
Surabaya	1	4,000	
Palembang	(1)	3,000	Be completed in Sept.,1984
Medan	(1)	3,000	Be completed in Dec., 1984
Total	13	38,000	

PT. Cahaya Aveka Kimia Perkasa is a big import agent for aquous caustic soda in Indonesia, which has sold caustic soda through the sales agents of Aneka Kimia Roya and Sinar Dunia Thirta Kimia in the islands of Jawa and Sumatra as the major marketing area. Hence, for reduction of the transport cost, it is advisable to review the strategy such as a swap of caustic soda between the distribution networks of the import agent as mentioned above and of PT. ISI which is the largest caustic soda producer in Indonesia.

Chapter 4 Proposal for Sales Promotion Plan

Comments on the sales promotion activity of PT. ISI are as follows.

(1) Cultivation of new customers

In the organization of PT. ISI, the entire sales department personnel consists of only 6 persons out of 106 persons in the office and the total of 282 employees.

Though the sales department is functionally divided into a distribution section and a market development section, the current assignment in the department is two persons for the manager, four persons for a distribution section and now no one is assigned to a market development section.

According to the impressions felt when the interviews were made at the companies located in Surabaya and Jakarta districts which use the products of electrolysis, there will be a sufficient marketing potential for PT. ISI to cultivate new customers as mentioned in the footnotes. As to the import products in Indonesia which are shown in the table in section 2.1.3, the request is to be made for the substitution of the imported products by the products of PT. ISI by way of the door to door visits to these importing companies.

Furthermore, as there are many companies which use caustic soda and chlorine products as the raw materials in the companies listed in "Directory 1981" (Basic Chemical Industries of Indonesia), it is necessary for PT. ISI to make door to door visits to these companies even if they are small scale companies as a part of intensive maketing activities.

For this purpose, it is necessary to assign 2 - 3 marketing specialists to a market development section. They should have adequate knowledge of the associated products of PT. ISI and be in positions equivalent to that of manager.

Especially in Jakarta where there is competition with PT. Soda Sumatra since there are many customers located close together there, it will be advisable to establish a branch of the sales department with a specialist for marketing development, to collect information regarding either plans for the expansion projects of the customers or new projects, which information should be quickly exploited for the marketing activities.

(Notes) 1. PT.GS, Battery Inc. has imported flaked caustic soda in the quantity of 3 tons/month at the price of 430 RP/kg for waste water treatment.

As the consumption is expected to increase in the future due to the strong recovery for lead, the company wishes to use aqueous caustic soda if it is available in place of flaked caustic soda since it is not necessary to dissolve flaked caustic soda for use.

2. PT.Southern Cross Textile Industry has imported 50% caustic soda in the quantity of 5 tons/month at the price of 180 RP/kg, and also purchased high-test hypochlorite (HTH) in the quantity of 1 ton/month at the price of 4,500 RP/kg for the purpose of removing iron content from the underground water. The company wishes to purchase L-Cl in place of HTH if the stable supply is available due to the convenience for handling.

(2) Study on development of new products

The study on the production of chlorine compounds in Indonesia is as shown in the Annex II-2. It is proposed that the production of NH_4Cl (not for fertilizer) on a commercial basis has to be prudently and objectively reviewed.

(3) Rationalization strategy for transport

It is necessary to review intensively the following items as advised in Chapter 3, "Rationalization of Transport".

(a) Rationalization of transport

Rationalization of transport could be made by the use of tank containers in place of jerry cans carried on a truck for small lot sales.

(b) Study on swap sales of caustic soda

Swap sales of caustic soda has to be reviewed as a means of reducing transport cost by means of an effective use of the storage tanks which are owned by the importing agent of aqueous caustic soda at the major ports in Indonesia.

PART III TECHNICAL ASPECTS

PART III TECHNICAL ASPECTS

Chapter 1 Present Status of PT. ISI

1.1 Circumstances Under Which PI. ISI was Established

PT. ISI was established during a period of from 1953 to 1956 as a first state-owned plant making chlor-alkali from solar salt which is produced in the Madura region. The plant is situated at Waru 8 kilometers from Surabaya. It was installed by Asahi Glass Co., Ltd.

All machinery and equipment of the plant were imported from Japan. Its electrolysis is based on the mercury process. The commercial production started on June 17, 1956.

The plant capacity is shown as follows:

Caustic soda:	10 t/d (in terms of 100% caustic soda)
Hydrochloric acid:	10 t/d (in terms of 33% hydrochloric acid)
Bleaching powder:	10 t/d (in terms of 32% bleaching powder)
BHCr-isomer	700 kg/m (in terms of 100% BHCr-isomer)

1.2 History of the Plant

The demand for hydrochloric acid was little for a while after the commencement of production, so the output was restricted. In 1961 the demand for caustic soda and chlorine products increased, but the machinery and equipment were in a bad condition and the production was not satisfactory.

The rate of operation at that time was less than 30% of the designed figure. Accordingly, the machinery and equipment were repaired from 1969 to 1971, and the electrolyzer (mercury process), hydrochloric acid synthesizer, rectifier, diesel-engine generator and desalted water equipment were replaced with new ones. Existing No. 1 train consist of these machinery and equipment. The brine refiner was improved while making use of the original tank. The repairing work was done by Asahi Glass Co., Ltd. During that time a chlorine liquefier and a bleaching liquor facilities were newly installed by Tomen Co., Ltd.

In and after 1972 the demand for caustic soda and chlorine products increased rapidly, and a shortage of production capacity was felt. Therefore, an expansion plan was worked out, and the mercury electrolyzers using carbon electrode were installed from 1977 to 1978 for the No. 2 Cell Unit. And the equipment having a production capacity of 20 tons of caustic soda a day (in terms of 100% NaOH) was installed by Wah Chang International Corporation (Taiwan).

The electrolyzer was supplied by Pestalozza (Italy), rectifier by Toshiba, chlorine liquefier by Tajiri Machine, and hydrochloric acid equipment by Kyowa Carbon.

With the completion of the No. 2 Cell Unit, purified brine was supplied from new brine purifier facility to both No. 1 Cell Unit and No. 2 Cell Unit.

In 1983 improvement was made in the No. 2 Cell Unit by replacing the carbon anode of the electrolyzer with the titanium anode, and by installing an electrode automatic controller as well as a safety device. The electrolyzer was improved by UHDE (West Germany), electrode by Sigri Gmbh (West Germany), automatic controller and safety device by Siemens-AG (West Germany).

The improvement of the electrolyzer in the No. 2 Cell Unit resulted in the increase of electrolytic current and in the expansion of capacity from 20 t/d to 30 t/d. With this, Toshiba's rectifier capacity was also augmented.

Figure III-1.1 shows an outline of PT. ISI's present facilities and designed capacities. Asahi Glass' electrolyzer is still being operated, but its superannuation and a shortage of spare parts are making it impossible to perform appropriate maintenance, and consequently, the rate of operation has declined. The production capacity is about 60% of the designed figure. It needs to repair in order to restore the designed capacity.

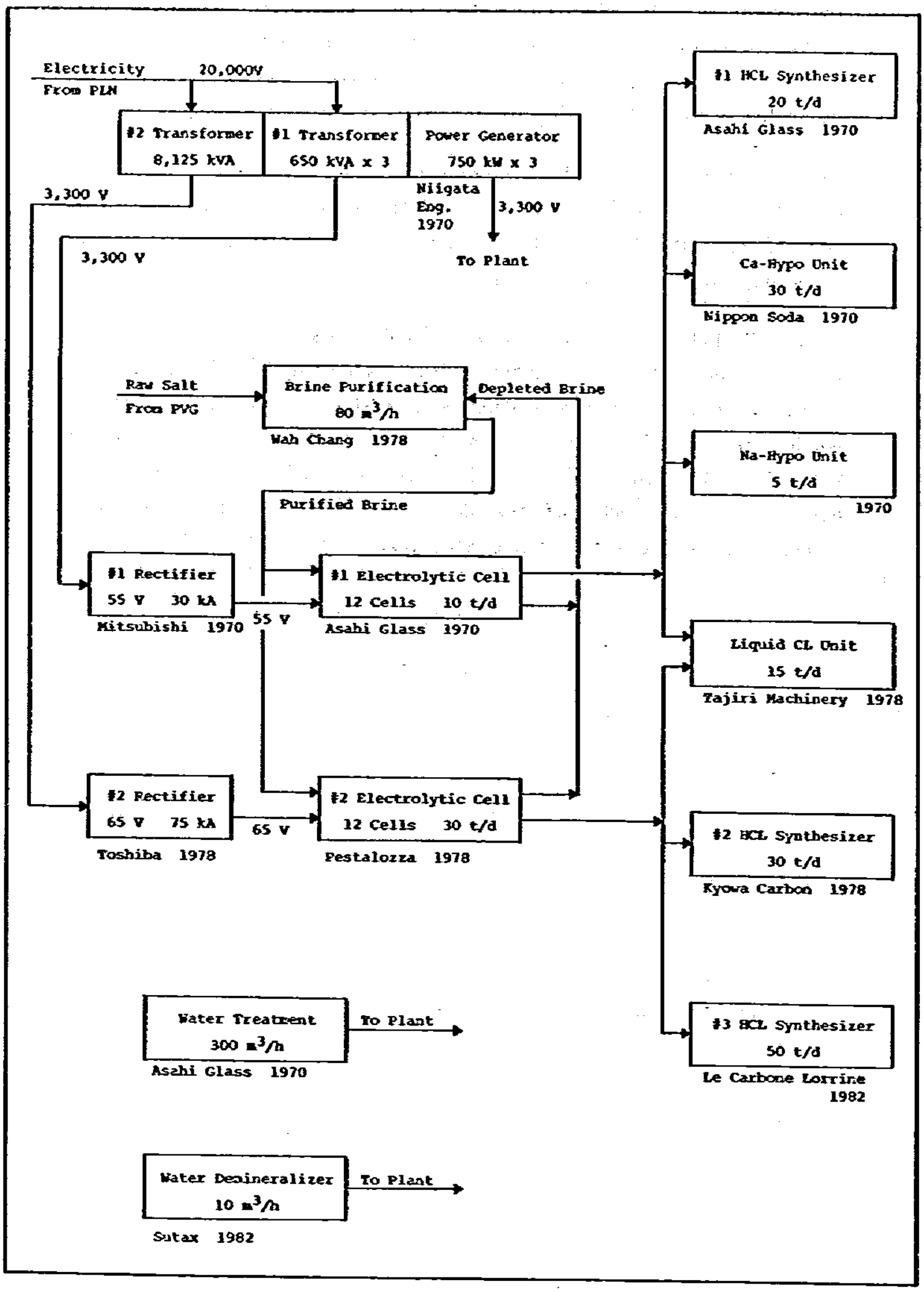

Figure III-1.1 BLOCK DIAGRAM OF PT. ISI

1.3 Outline of the Existing Plant

(1) Outline

The following shows the state of PT. ISI as of 1983:

Capital: Paid-up capital is 3,200 million Rp, authorized capital is 10,000 million Rp.

Shareholder: 100% by the Indonesian government

Production and sales (t/y)	Production	Sales
Caustic soda (in terms of 100% NaOH)	6,595	5,608
Hydrochloric acid (in terms of 33%)	11,043	9,937
Liquid chlorine (in terms of 99%)	1,065	1,078
Sodium hypochlorite (in terms of 12% CL)	588	556
Bleaching liquid (in terms of 8% CL)	2,494	2,520

Profit: -328 million Rp

Employees: 256

(2) Outline of facilities

The following shows an outline of PT. ISI's facilities as of 1984 when the survey was conducted:

(a) Brine purifier

80 m^3/hr. provided by Wah Chang. Common use for No. 1 and No. 2 Cell Unit.
Present capacity: 80 m^3/hr. Purity of purified brine is not good.

(b) Electrolyzer

No. 1 Cell Unit:	Mercury process with carbon electrode provided by Asahi Glass. Designed: 10 t/d 12 cells 55 V 30 KA At present: 6 t/d - 8 t/d, 8 cells under operation
No. 2 Cell Unit:	Mercury process with titanium electrode was provided by Wah Chang Designed: 30 t/d, 12 cells 65 V 75KA At present: 25 t/d Caustic soda, concentration does not exceed 47%

(c) Hydrochloric acid synthesizer

1st train:	Provided by Asahi Glass in 1970, 20 t/d At present: 16 t/d. Automatic controller is superannuated.
2nd train:	Provided by Kyowa Carbon, 2 x 15 t/d At present: 12 t/d. One reaction tower is damaged.
3rd train:	Provided by Le Carbone Lorrine, 50 t/d At present: 50 t/d. Blower capacity is insufficient

(d) Chlorine liquefier

Provided by Wah Chang in 1978, 15 t/d

At present: 6 t/d. Automatic controller is superannuated.

(e) Bleaching liquor facility

Provided by Nippon Soda in 1970, 30 t/d

At present: It is playing two roles simultaneously, making of bleaching liquor and treatment of chlorine gas for disposal.

(f) Sodium hypochlorite facility

5 t/d

At present: 4 t/d. Cooling cpacity is insufficient.

(g) Utilities

Water treatment: Provided by Asahi Glass in 1970, 300 m^3/h

At present: 250 m^3/h. Capacity changes depending on the quality of intake water.

Power source: Received from PLN at 20 kV,

Diesel-engine generator, 700 kW x 3 provided by Niigata Tekko

Transformer in the No. 1 train: 20 kV/ 3,300 V, 650 kVA x 3

Transformer in the No. 2 train: 20 kV/ 3,300 V, 8,125 kVA

Rectifier:

No. 1 train: Mitsubishi Silicone rectifier, provided by Asahi Glass in 1970, 30 kA, 55 V

Automatic controller is out of order, and the capacity is less than 23 kA.

No. 2 train: Toshiba silicone rectifier provided by Wah Chang in 1978, 75 kA, 65 V

Capacity was increased from 50 kA to 75 kA in 1983.

Air compressor: 420 l/min x 3 7 kg/cm^2
400 l/min x 1 7 kg/cm^2

There is no dryer for the instruments air device, and is causing the instrument to get out of order.

(h) Mercury still 150 kg/d

Superannuation can be seen, as was described above, in the brine refiner, electrolyzer in the No. 1 Cell Unit, hydrochloric acid facilities, chlorine liquefier, No. 1 silicone rectifier and in the instrument air device. They should be repaired.

(3) Outline of production

Table V-1.1 in Part V indicates the chronological output. Augmentation of the No. 2 train was made in 1979, and the designed capacity of the plant became 9,000 tons a year. However, the output of caustic soda is leveling off due to the low rate of operation. The superannuation of the No. 1 train caused the production to decrease. The reduced output in 1983 was brought about by the suspension of operation of the No. 2 Cell Unit for two months because of improvement. The expanded capacity of the No. 2 train may show its effectiveness in the future.

Table III-1.1 shows the output of each product. The percentage of the actual output of each product against the target figure is shown below.

PERCENTAGE OF ACTUAL PRODUCTION AGAINST TARGET FIGURE

	1981	1982	1983
NaOH	84%	82%	87%
HCl	73	68	80
BLC	87	122	66
BLN	51	22	98

The percentage of actual production of chlorine products is low. Also, the percentage of actual production of liquefied chlorine and sodium hypochlorite is varied. These may be due to the unstable demand for them. The following shows a comparison of the quantity of chlorine generated and the quantity of chlorine utilized (t/y). (See Part V, Table V-1.1)

UTILIZATION OF CHLORINE IN THE PT. ISI FACTORY

	1981	1982	1983
Generated Chlorine (ton)	5,508	5,804	5,804
Consumption (ton)			
HCL (0.35 t/t)	3,396	3,942	3,865
CL (1.10 t/t)	977	1,140	1,172
BLN (0.145 t/t)	220	52	85
BLC (0.10 t/t)	122	154	252
Chlorine in Products	4,715	5,288	5,374
Unutilized Chlorine	793	516	430

The generated quantity of chlorine gas was calculated by multiplying 0.88 by the production volume of caustic soda, and each chlorine product was calculated by multiplying the output by the unit consumption of chlorine. As the above Table indicates 7 - 15% of chlorine is discharged each year without being used for turning out a product. This chlorine is discharged into a drain in terms of BLC, and the bleaching liquor device is acting the role of adjusting the production balance between caustic soda and chlorine products. PT. ISI's production is influenced by the sales amount of chlorine products. The quantity of BLC to be discarded for keeping the production balance should be fixed by taking into consideration the sales price of caustic soda.

Table III-1.2 indicates the annual operation hours and the causes for the suspension of operation. That the actual operation hours exceeds the target figure shows that the plant stops its operation whenever necessary without making periodical repairing. There being many electrolyzers, the plant stops the operation of only such electrolyzers that work badly and repairs them without suspending the operation entirely.

Also, the plant has three systems of hydrochloric acid equipment, so these operation rate is high. Despite the fact that the number of operation hours surpasses the target figure, the production is lower than the target figure. This is caused by the inefficiency of each equipment, becoming lower than the designed production. This requires to improve the equipment and the operation method. Operation is mostly suspended by the relationship between demand and supply and consequent restriction of production. The repairing of machinery is one of the reasons that suspended operation too. 10 - 15% suspension of operation is caused by a failure of electric supply. Although the suspension hour is short, suspension has occurred as below.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983	3	1	2	1	5	4	-	-	-	2	1	3
1984	2	1	1	2	na							

The operation was stopped 22 times, totalling 80 hours in 1983, and 6 times totalling 24 hours from January up to April in 1984. At present the 20 kV circuit is being utilized by PT. ISI, by many other factories as well as by general households. Electric troubles occurring in these factories may be causing a number of failures of electric supply. The suspension of operation can be avoided by changing the receiving circuit from 20 kV to 70 kV. Therefore, it ought to study the change of incoming voltage from the points of economy and stable operation.

Table III-1.3 indicates the unit consumption of PT. ISI. Compared with the target figure of the unit consumption of caustic soda, the quantity of use of NaOH and HCL is much larger. This may be due to the fact that raw material salt contains much Mg, and the damaged instruments are causing an excessive consumption of NaOH. The unit consumption of electricity in the electrolyzer is affected by the output by each electrolyzer, and it cannot be evaluated equally. But the consumption unit may almost be appropriate. A large current is being used for the large electrolyzers in the No. 2 Cell Unit to increase production, and the current density on the surface of electrode being large, consequently, the consumption unit is getting bad. However, the improvements including the conversion to the titanium electrode in 1983 have greatly ameliorated the electricity unit consumption. In 1983 cost of $BaCl_2$ decreased drastically. $BaCl_2$ is used for the cost of SO_4 in the brine. The titanium electrode being strong against SO_4, it will serve to remove SO_4 in the brine. However, the electrolyzer in the No. 1 Cell unit is using carbon electrode, SO_4 greatly damages the electrode and deteriorates the unit consumption of electricity.

The unit consumption of chlorine gas in the synthesizing of hydrochloric acid is too much, but it will pose no problem in the balance because chlorine gas tends to exceed. The unit consumption of chlorine gas in the liquefied chlorine is irrational, which is due to the damage of a meter and to the supply of non-condensed gas to bleaching liquor as well as due to measuring inaccuracy. The unit consumption of mercury is lower than the target figure, and it needs to reduce the consumption unit more than that when the environmental problem is taken into account.

Table III-1.4 indicates the quality of products. As regards caustic soda, its concentration is as low as 40 - 42%, while the content of impurities satisfies both the Indonesia's standard and Japan's chemical fiber standard. (JIS mercury process)

	Indonesia's standard	JIS standard for chemical fiber	Example of Japanese mercury process
NaCl max %	0.07	0.07	0.002%
Na_2CO_3 "	0.035	0.3	0.027
Fe_2O_3 "	0.003	0.003	0.00006
SO_4^{2-} "	0.020		0.001
SiO_2 "	0.0075	0.03	0.0017
CaO "	0.005	0.005	0.0003
MgO "	0.0030		0.0003
Al_2O_3 "		0.02	0.0002

The quality of hydrochloric acid is good, and also the qualities of chlorine, bleaching liquor and sodium hypochlorite are good.

Table III-1.1 ANNUAL PRODUCTION OF EACH PRODUCT

Item		1981		1982		1983	
		Target	Actual	Target	Actual	Target	Actual
NaOH	100%	7,450	6,259	8,032	6,596	7,570	6,595
HCL	33%	13,216	9,704	16,491	11,264	13,807	11,043
LC	99%	1,000	888	852	1,036	1,620	1,065
BLN	12% CL	3,000	1,520	1,644	361	600	588
BLC	8% CL	-	1,215	-	1,537	-	2,520

Table III-1.2 ANNUAL OPERATING HOURS OF SHUTDOWN

	Operation (hr)		
	Target	Actual	Shutdown (hr)
(1981)			
#1 Electrolizer	7,200	8,022	737
#2 Electrolizer	7,200	7,796	964
HCL Unit	7,200	7,707	963
(1982)			
#1 Electrolizer	7,488	8,220	640
#2 Electrolizer	6,816	7,655	1,105
HCL Unit	7,488	7,682	1,178
(1983)			
#1 Electrolizer	7,200	7,325	1,434
#2 Electrolizer	6,120	6,566	2,194
HCL Unit	7,488	7,682	1,178

Reason of Plant Shudown (%)

	1981	1982	1983
Marketing	60	55	40
Power Failure	15	10	15
Technical	25	35	45

Table III-1.3 UNIT MATERIAL CONSUMPTION

NaOH 100%	Unit	1981	1982	1983	Standard
Electricity AC	kWh/t				
No. 1		3,090	3,130	3,200	3,200
No. 2		3,565	3,800	3,240	3,300
NaOH 100%	kg/t	46.6	37.0	60	30
HCL 33%	kg/t	47	41	65	30
Na2CO3	kg/t	10	2.5	15	12
BaCl2	kg/t	11.4	6.1	1.04	7
Stanch	kg/t	2.3	1.14	1.48	2
Kunifloc	kg/t			0.01	0.002
Carbon	kg/t	2.4	2.54	2.52	2.5
Graphite Media	kg/t	-	-	-	-
Electricity for Motor of Lighting	kWh/t	36	36	50	
Compressed Air	m3/t				
Demineralized Water	m3/t	1.92	1.95	1.97	1.85
Average Current	kA				
No. 1		23	23	20	
No. 2		45	45	65	
Mercury	kg/t		0.17-0.18		0.2
HCL 33%					
Cl2 Gas	kg/t	360	368	350	350
Demineralized Water	m3/t	0.68	0.67	0.66	0.65
NaClO 12%					
NaOH 100%	kg/t	170	172	170	175
Cl2 Gas	kg/t	166	158	162	145
Freon-22	kg/t	0.17	-	-	-
Process Water	m3/t	-	-	-	-
Liquid Cl2					
Cl2 Gas	kg/t	1,100	980	860	1,100
H2SO4	kg/t	70	79	90	81
Freon-22	kg/t	0.92	0.62	0.75	0.60
Ca Hypo 8%					
Cl2 Gas	kg/t	100	100	100	100
Lime	kg/t	200	206	200	200
Process Water	m3/t	1.12	1.12	1.12	0.96

Table III-1.4 QUALITY OF PRODUCTS

Item	Unit	Standard	1983	1984
NaOH	%	40-50	40.19	42.47
NaCL	max %	0.07	0.0214	0.0129
Na2CO3	max %	0.035	0.0226	0.0143
Fe2O3	max %	0.003	0.00039	0.00054
SO4=	max %	0.02	0.0025	0.0063
SiO2	max %	0.0075	0.0084	0.0097
CaO	max %	0.005	0.0055	0.0039
Mgo	max %	0.03	0.0022	0.0024
HCL				
HCL	%	33-35	33.41	33.18
Fe	max %	0.004	0.00024	0.00034
SO4=	max %	0.012	0.0049	0.0053
Heavy Metal (as Pb)	max %	0.0005	0.0004	0.00029
Igniton Residue (as SO4=)	max %	0.1	0.0414	0.0347
CL				
Cl2	min %	99	99.65	99.55
BLN				
Air Cl2	%	12	13.62	13.26
Excess NaOH	g/ℓ	5-10	7.50	5.18
BLC				
Av. Cl2	%	8	7.1	7.38

1.4 PT. ISI's Management System and Problems

PT. ISI is a state-owned company under the jurisdiction of the Ministry of Industry. PT. ISI's duty is to supply caustic soda and chlorine in a stabilized way so as to maintain the stability of market and to develop society. To attain these objects, PT. ISI is making efforts to train capable men as below:

- mentally cultivation
- improvement of technical and managerial abilities
- improvement of employee's welfare and prosperity
- upgrading and training.

1.4.1 Managing system and assignment of personnel

PT. ISI's staff consists of 283 persons including president.

Figure III-1.2 shows PT. ISI's present managing system.

PT. ISI is divided into the head office and factory. Directors in charge of the financial affairs and of technology assist the president. The General Affairs Department, Internal Control Department, Research and Development Department and Securities Department under direct control of the president. The No. 1 production department is in charge of the electrolytic division, and the No. 2 production department is in charge of the division of chlorine products. Diesel-engine generators and silicone rectifiers are maintained and controlled by the Technical Department. Daily maintenance and management are done by the Production Department and the Technical Department. The Maintenance Department analyzes the important problems on machinery, electricity, civil engineering and construction, P.M. (preventive maintenance), replacement of equipment, and gives orders to outside manufacturers.

As was described above, PT. ISI has a well organized managing system as a state-owned company. Nevertheless, in order to produce good results, the system must be operated organically. PT. ISI is in a business slump at present. To surmount it will require a regular general conference, and all departments should have a common critical mind, and set their respective target, so that they can ameliorate their works. 50% of the recent suspension of operation is due to a decrease in demand (Table III-1.2). To increase sales is an essential problem for PT. ISI. The Marketing Department has a market development section in it, but no one has yet been assigned to run the section. Until recently, PT. ISI had its all products handled by its agents, but a direct sale has been started. In order to increase sales, PT. ISI itself must make efforts to atain it. Arrangements must also be made to improve the market development section and to promote sales.

In the factory the engineers are assigned to each production section and to each technical section, and technical problems are being solved in each section. It will be more efficient if the operation section devotes itself to operation and gives some of the engineers to the technical department so as to have them tackle the technical problems by themselves. following shows a number of persons in a certain Japanese factory having a capacity of producing 26,400 tons of NaOH per year (this is about 2.5 times the scale of PT. ISI).

The Internal Control Department is engaged in adjusting things between each department and in giving orders to outside manufacturers. The Personnel Department, Financial Department and the Logistic Department concurrently perform the works of the factory. The warehouse belongs to the Logistic Department, and controls the stocks of products, raw materials and spare parts. The Marketing Department has two sections, i.e. sales and market development. No person has yet been assigned to the market development section, as was mentioned earlier.

A total number of persons engaging in clerical work is 106 including senior staffs of the factory, 3 directors, and 10 managers and deputy-managers as well as 26 managerial officers. The factory is organized as below. The position of the plant manager is concurrently held by a director in charge of the Technical Department; and a deputy-manager assists him. The safety and pollution control and laboratory are belonging under the plant manager independently of each department.

- Factory Manager (176 persons in all)
  - Sub-manager (1)
  - Protection of environment: 5 persons
  - Analysis: 6 persons
  - 1st Production Dept. (41)
    - Chief: 1
    - Sub-chief: 1
    - Staff: 1
    - 1st electrolysis (21 persons)
      - Section Chief: 2 Staff: 6
    - 2nd electrolysis (17 person)
      - Section Chief: 1 Staff: 3
  - 2nd Production Dept. (41)
    - Chief: 1
    - Sub-chief: 1
    - Staff: 1
    - Hydrochloric acid, liquefied chlorine (17 persons)
      - Section Chief: 1 Staff: 3
    - Water treatment (21 persons)
      - Section Chief: 2 Staff: 3
  - Technical Dept. (32)
    - Chief: 1
    - Sub-chief: 1
    - Power station (15 persons)
      - Section Chief: 2 Staff: 3
    - Rectifier (10 persons)
      - Section Chief: 1 Staff: 2
    - Instrument (4 persons)
      - Section Chief: 2 Staff: 2
  - Engineer's Dept. (50)
    - Chief: 1
    - Sub-chief: 1
    - Staff: 3
    - Machinery, civil engineering and construction (28 persons)
      - Section Chief: 2 Staff: 1
    - Electricity (17 persons)
      - Section Chief: 2 Staff: 1

Department chief and sub-chief: 9

Section chief and Sub-chief: 15

Staff: 29

The following shows a number of persons in a certain Japanese factory having a capacity of producing 26,400 tons of NaOH per year (this is about 2.5 times the scale of PT. ISI).

(Unit: Persons)

	Workers	Clerks	Engineers
Caustic soda	22	0	0
Hydrochloric acid	4	0	2
Bleaching liquid	4	0	1
Liquefied chlorine	10	0	1
Other chlorides	8	0	1
Common field	19	3	9
Work	5	16	0
	72	9	4

These total is only 105. Hence, PT. ISI's 176 is an excessive number of employees. The promotion of employment is one of the duties of a state-owned enterprise. Further, the state of affairs in Indonesia differs from that in Japan. However, it may not be reasonable to compare the mere figures. Nevertheless, as will be mentioned in Part V, the expansion of personnel expense is worsening the profitability. Accordingly, an increase of personnel in an easygoing way ought to be avoided even when the renovation plan was carried out. With the present number of personnel, it is possible to operate the plant satisfactorily even after the renovation.

1.4.2 Operation control

The Survey Team inspected the operation control being done by PT. ISI. The following is the Team's comments.

(1) Manual and flow sheet

PT. ISI uses the manual and flow sheet prepared respectively by Asahi Glass and Wah Chang. The manual written in English will well meet the needs of engineers, but the workers, who are engaged directly in operation may find it inconvenient to use it as it is. The survey mission, therefore recommends to compile a new manual written in Indonesian on the basis of the manual presented by the contractor by adding thereto PT. ISI's experiences in the operation, and to keep this newly compiled manual in each control panel room. It needs to have manuals cover the following things:

i) Process flow sheet: to write the instrument system, conditions for process, and flow rate

ii) Machinery and equipment list: to write briefly the specifications of machinery and equipment

iii) Process description

iv) Operation procedure

Start-up procedure

Normal operation condition

Shutdown procedure

Emergency shutdown-procedure:
This is to be made for the suspension of electrical and water supplies and trouble in instrument air respectively.

Unit operation procedure:
This is to write a procedure of how to handle each machinery and equipment. It will be convenient if rough drawings are added.

The operation procedure should be prepared in the flow chart system, not in a descriptive style. If a flow chart is made for each process, it can be used as a check sheet of the procedure, which will help make confirmation after the completion of procedure. Figure III-1.3 indicates an example of the flow chart.

v) Trouble shooting

Measures to be taken against predictable troubles are written.

(2) Operation records

Each plant has forms to keep records, and operation records are kept after patrols which are done every two hours or four hours. The handling over of duties is being performed well. The analysis records have an approval column by the section supervisor, while the operation records have no such column. The approval column should be prepared so that the section supervisor can give his approval. If the standard operation condition and the items to be measured are written in the recording form, a new operator can easily find out a trouble. The purpose of operation record is to discover a trouble and to take a necessary measure against it. Therefore, inspection and taking a measure are required.

(3) Quality control

The quality control is being done on the basis of the figure obtained by analysis. Daily analysis of operation control are performed at each production section, and analysis of product quality at the plant's laboratory room. The liason between the laboratory room and the production section is being kept well. The product quality is good as is shown in Table III-1.4. On the quality-control, the mission would like to suggest that the product analysis done every day should be shown in a graphic so that quality dispersion can be checked up and the quality of products can be raised.

(4) Operation control at night

PT. ISI has a person who is responsible for the operation at night. He is authorized to stop operation. This is a good system and is highly appraised. Emergency stoppage is necessary for safety, and the man responsible for the night operation is required to make an appropriate judgment by himself.

(5) Suggestions by the survey Team

To raise the achievements of the plant it is necessary to heighten the will of work on the part of the employees. For this purpose, the mission wishes to make the following suggestions.

i) The president or the plant manager makes a regular inspection of the job sites, and makes evaluation on the findings of inspection.

ii) All the employees are furnished with the monthly result obtained by each plant, and each section holds a meeting where the business result of plant is announced. To have the employees get cost-consciousness will be the first step to the improvement in the operation results.

1.4.3 Education and training

It is PT. ISI's motto to educate and train and whereby to foster capable men.

(1) The present state of PT. ISI's education and training

The Production Department is performing the following education and training for the stable operation, safety of employees and protection of environment.

(a) Education of new employees

The Section Supervisor and Staff concerned explain the process, how to operate and how to maintain safety (particularly on liquefied chlorine).

(b) Annual education

Education on process, electricity and chemical are made.

(c) Safety education

Education on chlorine gas, nature of mercury and environmental disruption.

(d) Education of customers using liquefied chlorine

The client's employees are informed of the toxicity of chlorine gas, and trained how to handle cylinders when liquefied chlorine is filled on the site.

(2) Suggestions by the Survey Team

In the chlor-alkali plant a minor operational failure often causes injury, accident on the equipment or pollution, and a minor change in the operating condition lowers the quality of products, and results in economic loss. These problems should be solved by enhancing the ability of each employee through education. PT. ISI works out a plan for education and training of employees, and thus is attaining a good result. If the following are taken into consideration, it will be more effective.

(a) PT. ISI's new employees will be secondary school graduates, and most of the existing workers are graduates of primary school. Therefore, in addition to the classroom education, actual training must be given.

(b) Safety education

In the plant such poisonous substances as chlorine gas, caustic soda and mercury being handled, it is necessary to have the employees informed of the nature of these things, and the first-aid training must be done preparing for an occasion when an employee gets poisoned. This first-aid training should be carried out periodically.

(c) Education of new employees

After finishing the classroom education, the new employees should be trained for a month or so by a senior operator concerning patrol, handling of valves, startup and stoppage of rotating machines. OJT training is necessary.

(d) Report on accidents

When operation is suspended, an equipment is damaged, injury occured or pollution problem arised through mishandling or disorder of a machine, its cause must be clarified, the procedure that has been taken, and the countermeasure which has been considered for its prevention are to be mentioned in a report. Then, the report is to be distributed to each section of the production department so as to educate employees thereby in order to avoid recurrence in the future. If all the accident's reports are gathered together, it will furnish the best educational materials.

(e) Arrangement of educational materials

To carry out the above education, it is necessary to keep the educational materials in good order. These materials should be compiled by PT. ISI's managerial persons and staff. These materials must always be kept at the control panel room so that the operators can peruse them whenever they want.

(f) Assuming emergencies like below, a regular training for such emergencies should be performed.

i) Leakage of liquefied chlorine

ii) Spill of caustic soda or hydrochloric acid from a tank.

iii) Fire

iv) Suspension of water or electric supply

v) Stoppage of the instrument compressor

(3) QC activities

PT. ISI started its QC circle activities from March 1984, with the following themes:

(a) Reduction of a loss of raw material salt in the brine refining

(b) Decrease in the maintenance cost of motors

(c) Lengthening of the life of bearings

(d) Speeding up of the compilation of reports (by a group of the accounting dept.)

The QC activities are one of the most effective means to enlighten the workers themselves, and will bring a great benefit to the plant. It will take several years until these activities will take root, during the time the senior members of the plant must endeavor to have the activities come to stay.

(a) Workers being inexperienced in solving a problem, the senior members of the plant should consider the problem together with them and teach them how to solve it.

(b) In the initial stage let workers pick up a theme by themselves and settle it among them so that they will be able to enjoy what they did.

(c) Managers and supervisors always ought to have a theme themselves and give it to workers.

(d) A meeting should be held regularly so that the results of activities can be made public before the senior members of the plant.

(e) When a theme is completed, it is evaluated, and a good one should be put in to practice immediately, and then its benefit is evaluated and is made known to all employees.

In Japan QC activities started in 1960 or so, and came to stay in about 1970, whereby the enterprises are able to get a great profit and enhance the level of workers. It will be essential for PT. ISI to foster QC activities to lift the level of its workers.

1.4.4 Performance of maintenance

In PT. ISI the Production Department and the Technical Department are engaged in the daily maintenance of each plant belonging to their departments. The Maintenance Department investigates and analyzes a problem at the request of the Operation Department and gives an order to an outside manufacturer to do construction work. The department performs the preventive maintenance (PM) by conducting a regular inspection from its own stand.

(1) Present performance of maintenance

(a) Maintenance when a trouble happened

When anything abnormal or a failure was discovered in the Production Department and when the department finds it impossible to handle it itself, the department is to ask the Technical Department or the Maintenance Department to perform maintenance through the deputy plant manager. In an emergency the Production Department makes this request directly.

(b) Preventive maintenance (PM)

The Maintenance Department prepares a PM program for major machinery and equipment and is performing inspection and overhaul. Table III-1.5 indicates examples.

(c) Register for machinery and equipment

A register for each of the machinery and equipment in the plant is kept to note in it the result of PM and the record of repairing so that the past records of each of the machinery and equipment can be made clear.

(d) Control of spare parts

The spare parts are under the control of the warehouse section of the Logistic Department. The minimum number of spare parts to be stored is fixed by the discussion between the Production Department and the Maintenance Department. Each department sends its inspector every day to the warehouse to examine the number of spares being stored and reports it to his section chief. In case of a shortage, the Maintenance Department asks the Logistic Department to buy and covers up the shortage. Then, the Logistic Department issues a purchase slip. The Financial Department approves it and the Internal Control Department adjusts it, and then the president and vice president decide on its purchase. As regards imported goods, an order is given a year before. When the economic situation of the company is not good, no purchase may be made. A shortage of spare parts makes it difficult to maintain of the plant.

(e) Maintenance standard

PT. ISI is performing the maintenance according to the explanation presented by the manufacturers of machinery and equipment, but is now compiling the maintenance standard based on its own experiences while referring to the said explanation.

(f) Periodical repairing

There being no law or regulations concerning repairing. PT. ISI does not perform maintenance by stopping operation once a year. The stoppage of operation is decided on after discussions whenever it's necessity is occurred.

(2) Suggestions by the Survey Team

PT. ISI is making efforts to perform well organized maintenance. As a matter of fact, however, PT. ISI is faced with making a large-scale repairing. Hence, the maintenance system must be considered by taking this point into account.

(a) Duty of the Production Department

As the Production Department is well acquainted with the condition of each of the manufacturing equipment because they handle it every day, and as it is the department, that is inconvenienced, when the equipment gets out of order. The department ought to be primarily responsible for the maintenance.

Both the Technical Department and the maintenance Department should function as a group of specialist, who clarify a specific problem, give an order to an outside manufacturer, control spare parts, fix the repairing budget, and to control a large-scale construction work.

The production department ought to conduct the following maintenance works daily:

i) To put the plant in good order and to clean the machinery and equipment

ii) To discover whether or not the rotating machines and instruments are functioning abnormally

iii) To grasp the state of being corroded on the exterior of each equipment

iv) To lubricate the rotation machinery

v) To discover leakage of gas or liquid from facilities

vi) To test the performance of spare rotation machinery

vii) To prevent the valve handle from sticking

viii) To supervise safety when the Maintenance Department performs maintenance work.

Before operation of the plant the machinery and equipment should be washed and cleaned, the concentration of remaining gas and liquid should be inspected, the shutoff of power should be confirmed, the safety during the work should be ensured. After construction or repairing, the equipment should be tested.

(b) PM work

The inspection of important machinery and equipment is being made through the regular PM work, but the result of inspection is not being utilized. For instance, the temperature at the inlet and outlet of the rectifier cooler was inspected and the difference in the temperatures showed a very small figure. This indicates that the cooling water side of the cooler has become fouled, but the fouling is left as it is. If it is left without being cleaned, the rectifier will decrease in its capacity and the cooler will get corroded. When the power factor and efficiency are calculated from the operation records of the rectifier a figure over 100% can be obtained. This proves that the ammeter and the wattmeter are out of order. Keeping the records and the performance of PM daily are done to find out a fault as soon as possible and to get it right. Unless the result of inspection is examined and necessary procedure is taken, the PM work will have no meaning.

The following should be added to PM work.

i) Inspection of the function of automatic instrumentations

ii) Inspection and restoration of such measuring instruments as pressure detector, thermometer and electric meters.

iii) Inspection of heat exchanger as to whether or not it is fouled (measuring of the coefficient of the overall heat coefficient)

iv) Inspection of the performance of safety valve and inspection of the first-aid facilities

The result of PM inspection must be conveyed to the Production Department for its examination.

(c) Standard for maintenance work

The instruction manual on the handling of the machinery and equipment provided by manufacturers is intended for the engineers, and not for the specialists in the plant. It is quite advisable that PT. ISI is now planning to compile a new standard of work by adding its own experiences. If the compilation is made by skilled specialists, their ability will be enhanced. The Maintenance Department will find a good QC theme to adopt.

(d) Periodical repairing

PT. ISI has not yet performed periodical repairing. However, periodical repairing is one of the best PM work. It will serve to work out the annual production and sales plans. Major works to be done in periodical repairing are as below:

i) Overhaul of the rotation machinery and electric equipment that have no spares.

ii) Cleaning of heat exchangers

iii) Inspection and repairing of the interior of towers and tanks

iv) Planned repairing of faults

v) Inspectation and repairing of the interior of utility facilities

vi) All members of the Production Department are expected to enter into day service. Taking this opportunity, education and training as well as cleaning of the inside of the plant should be performed.

(e) Clarification of mechanical trouble

It is the Maintenance Department that is suposed to clarify mechanical troubles. The mechanical trouble should be traced its cause and countermeasures must be taken so that a similar trouble will not occur again. If a similar trouble repeats itself, it will shorten the life of the machinery and equipment. The mechanical trouble has a close connection with the way of handling in the Production Department. Therefore, good contact must be established with the Production Department so as to make clear the cause of trouble and to prevent recurrence of such trouble.

(f) Spare parts

A shortage of spare parts is often seen in the imported goods, and the whole plant is expected to make efforts to secure such imported spare parts. However, the machine industry in Indonesia is enjoying a higher level compared with other developing nations, and the level is still being raised. As a state-owned plant, PT. ISI is playing an important role in the industrial technology of Indonesia. Hence, PT. ISI should survey the domestic market and develop domestic products without merely looking for imported spare parts. In case domestic spare parts are inferior in quality, a joint research should be made so as to improve the quality.

Finally, the survey mission would like to suggest that the plant be kept in good and fine condition, because if the plant is in disorder, the workers will get used to it and are liable to neglect the duty of cleaning. They may also be apt to ignore a leakage from the process. These will result in shortening the life of machinery and equipment and in lowering the unit consumption of raw materials.

i) Removal of unnecessary machines and equipment

There being unnecessary machinery and equipment in various places of the plant, which is making it impossible to set the plant in good order.

ii) Regular painting of machinery and equipment, structure and piping

In the chlor-alkali plant it is inevitable that a very little amount of chlorine and hydrochloric acid gas leaks because of the characteristic of this plant, and in consequence of this the above-mentioned facilities in the plant are getting corroded. In the hydrochloric acid plant the ladders and handrails have got corroded and are in a dangerous condition. The structure of 1st hydrochloric acid synthesizing tower is corroded. The synthesizing tower itself is made of unpenetrate graphite and is still usable, nevertheless, it needs to replace the whole. If painting would not be perfectly done after the repairing work, it would result in performing the replacement work again.

iii) Prevention of leakage of chlorine gas

In case of chlorine gas or hydrochloric acid gas would leak, it must be stopped at once, because if not, the problem of corrosion cited above and the damage of instruments and electric facilities will occur.

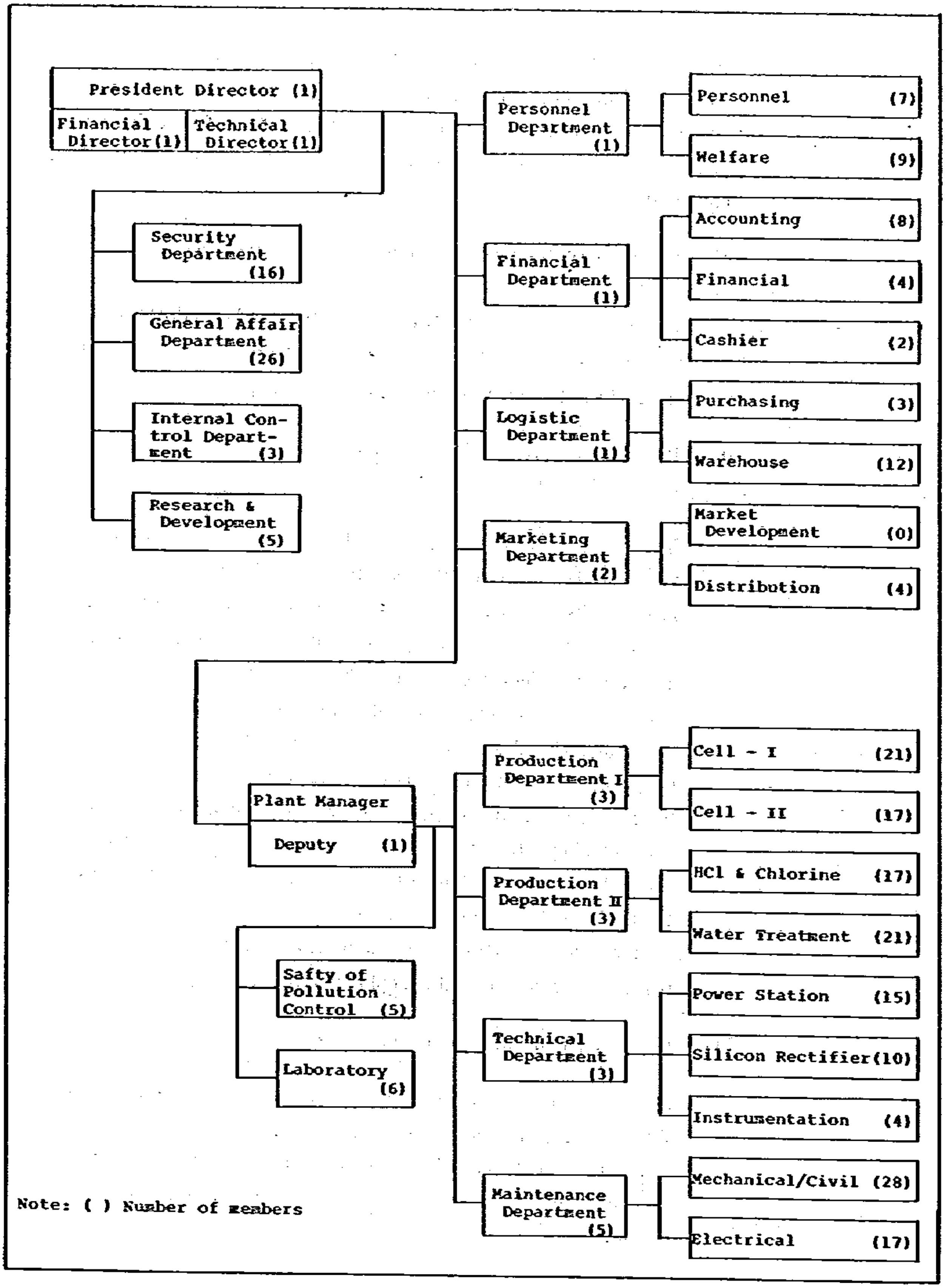

Figure III-1.2 ORGANIZATION CHART OF PT. ISI AS OF 1984

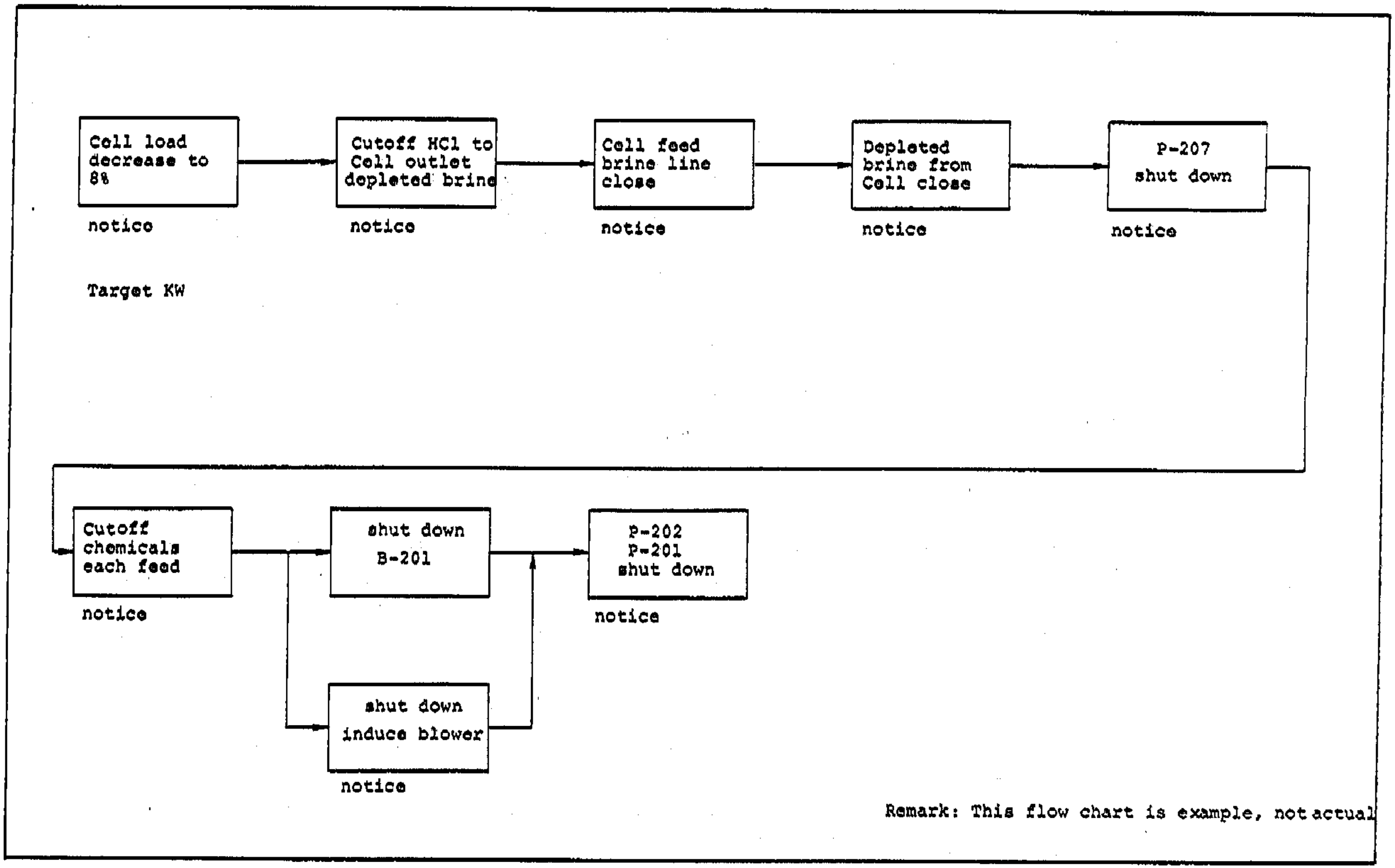

Figure III-1.3 SAMPLE OF FLOW CHART (NORMAL SHUT DOWN PROCEDURE OF BRINE SECTION)

Table III-1.5 PREVENTIVE MAINTENANCE SCHEDULE SILICON RECTIFORMER

No.	NAME OF JOB	MONTH												REMARK
		1	2	3	4	5	6	7	8	9	10	11	12	
1.	Check for dirt and abnormal noise	o	o	o	o	o	o	o	o	o	o	o	o	Daily checking (three times a day)
2.	Input voltage, Current, Electric power, WH, Power factor, Output voltage, Output current	o	o	o	o	o	o	o	o	o	o	o	o	
3.	Temperature of Silicon rect, on load tap changer, Transformer	o	o	o	o	o	o	o	o	o	o	o	o	
4.	Check temperature oil cooler	o	o	o	o	o	o	o	o	o	o	o	o	Once a week and also every up and down load
5.	Check temperature interphase reactor	o	o	o	o	o	o	o	o	o	o	o	o	
6.	Check temperature bus bar	o	o	o	o	o	o	o	o	o	o	o	o	
7.	Check neutral point of cells	o	o	o	o	o	o	o	o	o	o	o	o	Once of month
8.	Check current balance silicon rect.	o	o	o	o	o	o	o	o	o	o	o	o	
9.	Check voltage of Si thyristor with ossiloscope	o	o	o	o	o	o	o	o	o	o	o	o	
10.	Check voltage drop "DC"	o	o	o	o	o	o	o	o	o	o	o	o	
11.	Service air cooler and oil cooler		o						o					Every six month
12.	Voltage with stand test of oil (OCB)			o						o				
13.	Voltage with stand test of oil (Rectiformer)				o						o			
14.	Current drop test of cells electrolys					o						o		
15.	Whole overhaul						o							Every year
16.	Painting		o											
17.	Check condition of silicogel	o	o	o	o	o	o	o	o	o	o	o	o	Every month

Chapter 2 A Technical Diagnosis of the Existing Plant

2.1 Process Description of the Existing Plant

2.1.1 General

The production process of PT. ISI consists of mercury process for brine electrolysis and processes for hydrochloric acid, liquefied chlorine, sodium hypochlorite and bleach liquor as measures for utilizing chlorine produced by electrolysis. The production process includes also rectification, filtration of produced caustic soda solution, hydrogen washing and cooling, and recovery of mercury. There are also auxiliary sections such as water treatment, cooling water, demineralized water, power substation, and compressed air to supply required utilities to each process mentioned above.

Description of each process is given below according Figure III-2.1.

2.1.2 Brine process

This process consists of dissolving the raw salt and purifying the saturated brine. A definite amount of the raw salt in proportion to the caustic production quantity is supplied into the brine saturator every 4 hours by the belt conveyor, and is dissolved into the depleted brine (treated by dechlorination) sent back from No. 1 and No. 2 series electrolyzers, forming the saturated brine. The saturated brine is continuously sent to the first reactor and then to the second reactor. Into the first reactor a instructed amount of barium chloride solution (for eliminating SO_4^{2-} in the brine), caustic soda solution (for eliminating Mg^{2+}, Fe^{3+}, etc.), and soda ash solution (for eliminating Ca^{2+}) are added, and the contents are agitated, thereby creating an impurity eliminating reaction. The addition of the above-mentioned agents is manually controlled so as to assure the excess concentration of caustic soda and soda ash in the brine to be 0.002 N and 0.004 N, respectively.

In the reactor the impurities in the brine mentioned above form fine precipitations of hardly soluble magnesium hydroxide $Mg(OH)_2$, ferric hydroxide ($Fe(OH)_3$ calcium carbonate ($CaCO_3$), barium sulfate ($BaSO_4$), etc., which are suspended in the brine. The brine leaving the reactor, to which a instructed amount of settling accelerator (KURI floc PA-312) is added in the midway of its pipeline, and enters the clarifier.

In the clarifier the settled sediment flocs are scraped together at the center of the bottom by rakes which rotate slowly and are discharged outside the tank as a brine mud slurry every fixed hours. The brine mud slurry, to which water is added, separates the sediment again through standing in the concrete pit, enabling recovery of part of the extracted brine.

The supernatant of the brine in the clarifier overflows to the trough on the top of the tank and is gathered into the receiver. After being pressurized by the pump and filtrated through the sand filter, it is neutralized by hydrochloric acid until free alkali in the brine becomes nearly neutral and is supplied to the electrolysers as purified brine.

As shown in Table III-2.1, the content of Mg^{2+} and Ca^{2+} in the purified brine at PT. ISI is 20-60 ppm and 15-50 ppm, respectively, and these values are very high compared with the operating standard which instructs less than 3 ppm for Mg^{2+}, and less than 10 ppm for Ca^{2+}. This is partly due to the infeior quality of the raw salt.

2.1.3 Electrolytic process

(1) No. 1 series electrolyzers

No. 1 series electrolyzers consist of twelve horizontal mercury cathode electrolyzers and decomposers as shown in Figure III-2.2. The feed brine purified in the brine proces is supplied to the cell.

By swiching on direct current, sodium chloride in brine is electrolyzed, and sodium ions are discharged on the surface of the flowing cathode mercury to form sodium amalgam, which flows on the bottom of the cell toward the end box.

The brine which runs through the electrolytic cell flows from the overflow outlet in the end box into the outside pipeline as depleted brine, and returns to the dechlorination tower of the brine treatment section.

The bubbles of chlorine gas which deposited on the surface of the anode due to the electrolysis of sodium chloride flow upward in the brine and are sent from the chlorine gas outlet fitted on the front of the cell cover to the facilities for chlorine derivatives.

Sodium amalgam which reached the end box is completely separated from the brine here due to the difference of their specific gravities and is introduced to the decomposer, where sodium amalgam is uniformly dispersed by the amalgram dispersion tray and dropps through the graphite packing layer as drizzle. On the other hand, demineralized water is introduced in the decomposer. During flowing downward through the bed of the in the graphite grains, sodium in the amalgam reacts with the demineralized water on the graphite surface and forms caustic soda solution, concurrently producing hydrogen gas.

The caustic soda solution on the decomposer is separated from hydrogen gas by the sealing device and is discharged from the overflow outlet to the outside of the decomposer. The produced hydrogen gas is introduced into the water cooled heat exchanger (small cooling tower) installed on the top of the decomposer, where most of the entrained steam and mercury vapor condense and are returned to the decomposer as drains.

Mercury which was regenerated by amalgam decomposition and dropped to the bottom of the decomposer is returned by the installed mercury pump through the pipeline to the top box of the cell.

The concentration of the caustic soda produced in the decomposer is usually maintained at 50% by controlling the feed rate of the demineralized water. The caustic soda solution discharged from the decomposer is press-filitrated.

The recent operating data at 20 KA have been generally satisfactory except its slightly high cell voltage. The analyzed data for the period (May 18, '84 - May 22, '84) when survey was made by the survey team was as follows:

Cathode current density (DK):	35.71 A/dm^2
Average cell voltage :	4.18 V
Average cell temperature :	65.5°C
Average brine flow rate :	0.925 m^3/h. cell
Average brine temperature :	51.5°C
Aeverage amalgam concentraion (cell inlet) :	0.00%
Average amalgam concentration (cell outlet):	0.206%
Average caustic soda concentration :	51%
Average purity of chlorine gas :	91.0%
Average hydrogen content of chlorine gas :	0.1%

Abnormally low purity of chlorine gas among the above-mentioned data is supposed to be due to out of order of instrumentation device. Figure III-2.4 shows a voltage-current curve for No. 1 Unit.

(2) No. 2 series electrolyzers

No. 2 series electrolyzers consist of twelve cells with the same type of horizontal mercury cathode electrolyzers and decomposers as that of No. 1 series and its process is also almost same as that of No. 1 series.

A big characteristic the electrolyzers is that the dimensionally stable metal anodes enables automatic electrode gap control, thus allowing to control the cell voltage low by controlling the distance between the undersurface of the anode and the mercury surface lower than before. Therefore, No. 2 series electrolyzers, despite being a so-called "high current density electolyzer", have a remarkable effect for improve power consumption because of the lower gradient of increase in the cell voltage caused by current density increase as shown in Figure III-2.3.

Typical examples of the recent operation data for No. 2 series electrolyzers are shown below. In the table "n" indicates the number of measurement on the day.

Current (KA)	:	35	70
Cathode current density Dk (A/dm^2)	:	50.27	100.54
Average terminal voltagew (V)	:	3.900 (n=65)	4.595 (n=45)
Average cell temeprature (°C)	:	64.3 (n=65)	81.4 (n=54)
Average amalgam concentration (cell inlet) (%)	:	0.008	0.008
Average amalgam concentration (cell outlet) (%)	:	0.072 (n=65)	0.136 (n=54)
Average caustic soda concentration (%)	:	39.3 (n=64)	42.8 (n=54)
Average purity of chlorine gas (%)	:	96.9 (n=65)	96.8 (n=54)
Hydrogen content in chlorine gas (%)	:	0.1 (n=65)	0.1 (n=54)
Date of determination	:	May 24, 1984	Apr. 29,1984

The above-mentioned table is for caustic soda concentration of about 40% and the measurement data for caustic soda concentration of about 50% at current of 50 KA are shown below:

Current (KA)	:	50
Cathode current density Dk (A/Dm^2)	:	71.82 A/dm^2
Average terminal voltage (V)	:	4.242 (n=60)
Average cell temperature (%)	:	77.3 (n=66)
Average amalgam concentration (cell inlet) (%)	:	0.045 (n=66)
Average amalgam concentration (cell outlet) (%)	:	0.145 (n=66)
Average caustic soda concentration (%)	:	49.5 (n=66)
Average purity of chlorine gas (%)	:	97.1 (n=66)
Average hydrogen content in chlorine gas (%)	:	0.1 (n=66)
Date of determination:		Feb. 10, 1984

From the above data it is found that increased concentration of caustic soda solution increases the undecomposed amalgam concentration. According to the operation data on that day, amalgam concentration at cell inlet (undecomposed amalgam concentration) abnormally increased and the measured values showing the undecomposed amalgam concentration of 0.02% and above came up to 22 in number out of total 66 measurements, among which the highest value was 0.406%. The increase of the undecomposed amalgam concentration inevitably brings about increase of the amalgam concentration at the cell outlet, increase of the hydrogen content in the chlorine gas and decrease of the current efficiency, and in the worst case it may bring the electrolyzer into inoperatable.

There would be some problem about analytical data on the hydrogen content in chlorine gas, but this item will be discussed in 2.2.2.(2)(b)(iii).

The increase of the undecomposed amalgam concentration with the increase of the caustic soda concentration up to 50% is supposed to be due to shortage of the capacity of decomposer, because the original design of No. 2 series electrolyzers' decomposer was made for the caustic soda concentration of 40%.

2.1.4 Process for chlorine derivatives

(1) Liquefied chlorine

Production of liquefied chlorine roughly consists of washing, cooling and drying process for chlorine gas; pressuring, cooling and liquefaction process for dry gas; compressing, cooling and expansion process for refrigerant; and filling process for liquefied gas. (See Figure III-2.5)

(a) Washing, cooling and drying

Chlorine gas from the cell is sent by the blower to the water washing tower where it is washed and cooled, and then enter the three drying towers connected in series. In each drying tower, contacting the concentrated sulfuric acid sprinkled from the top of the tower, the chlorine gas is dehydrated and dried. The concentration of the sulfuric acid in the last drying tower is the highest (98 - 93%) and the sulfuric acid of which concentration decreased is transferred to No. 2 tower and then to No. 1 tower. The sulfuric acid in No. 1 tower is used until its concentration decrease to about 70%. The sulfuric acid for drying is cooled by water in the heat-exchanger installed in the pump circulation circuit because it generates heat and raises its temperature due to heat of dilution generated by dehydration of chlorine.

(b) Pressuring, cooling and liquefaction

Being pressurized to about 1.7 kg/cm^{2}G by the Nash pump, the dry chlorine gas, of which sulfuric acid mist is removed by the demister, is cooled by the refrigerant R-22 in the chlorine condenser (Shell & Tube type) and liquefied. The incondensible gases (hydrogen, air, carbon dioxide and oxygen) containing chlorine corresponding its vapor pressure at the liquefaction temperature are separated from the liquefied chlorine in the trap and sent to the bleach liquor process as waste gas. The liquefied chlorine is pressure-fed into the storage tank through the receiver by dry compressed air.

(c) Compression, cooling and expansion of refrigerant

After being pressurized to about 16 kg/cm^{2}G by the compressor, the refrigerant gas which was warmed by heat exchange with chlorine in the chlorine condenser is condensed by cooling water in the refrigerant condenser and returned to the receiver. The refrigerant in the receiver is sent again to the chlorine condenser, where it adiabatically expands through the expansion valve, thereby bringing its temperature drop to about -30°C and heat-exchange with chlorine.

(d) Filling pressure vessels with liquefied chlorine

The liquefied chlorine transferred from the liquefied chlorine tank is charged into cylinders which previously passed inspections on residual pressure, residual gas evacuation, body and valve condition, etc. until it reaches the individual specified quantity. Platform scales are used for weighing in filling cylinders and the waste gas in filling is sent to the bleach liquor production facility by the local ventilation apparatus. The liquefied chlorine is forced to be transferred through the pipeline by the dry compressed air which increases pressure on the liquid surface in the tank. The cylinders used in this plant are classified into two size of cylinders, one containing 50 kg of chlorine and one containing 1 t of chlorine.

(2) Hydrochloric acid

The hydrochloric acid production facility in this plant consists of 3 series of synthesis apparatus, one provided by Asahi Glass (Co.) in 1970 (designed capacity: 10 t/d x 2 sets, manufactured by Toyo Carbon (Co.)), one provided by Wah Chang International Corp. in 1978 (designed capacity: 15 t/d x 2 sets, manufactured by Kyowa Carbon (Co.)) and one provided by Le Carbone Loraine (Co.) in 1982 (designed capacity: 50 t/d x 1 set). Among these, the synthesis apparatus manufactured by Le Carbone (Co.), different from other two series, is a so-called single tower type hydrochloric acid synthesis apparatus of integrated structure placing a combustion tower in the upper section equipped with burners on the tower top directing flare downward contrary to conventional apparatus and a wet wall type of absorber in the lower section composed of multi-layers of cylindrical short graphite blocks. (See Figure III-2.5)

The chlorine gas which was produced in the cell and transferred by the blower and the hydrogen gas which was similarly transferred from the cell by the blower are introduced to the burner nozzles at the bottom of the combustion tower (on the top of the combustion tower for the apparatus manufactured by Le Carbone), where the chlorine gas burns in the hydrogen gas and forms hydrogen chloride gas. The hydrogen chloride gas leaving the combustion tower passes through the pre-cooling duct and enters the cooling tower, where it is absorbed by the dilute hydrochloric acid obtained at the recovery tower to become the product.

Unabsorbed gas from the cooling tower is almost completely absorbed by water in the recovery tower, and the recovered liquid is supplied to the cooling tower.

The quality of hydrochloric acid in 1983 and 1984 and the raw material unit consumption for the period from 1981 to 1983 are as follows:

(a) Product quality

	HCl Concentration (%)	Fe (%)	SO_4 (%)
1983	33.41	0.00024	0.0049
1984	33.18	0.00034	0.0053
Standard	33 - 35	less than 0.004	less than 0.012

(b) Raw material unit consumption

	Chlorine Gas (Kg/t prod.)	Demineralized Water (t/t Prod.)
1981	360	0.68
1982	368	0.67
1983	350	0.66
Standard	350	0.65

(3) Sodium hypochlorite

Sodium hypochlorite is produced as a solution containing available chlorine concentration of 12% and above when chlorine gas is supplied and absorbed into the caustic soda solution of a fixed concentration circulating through the reactor, reactant liquid receiver and heat-exchanger, followed by reaction with caustic soda.

$$2NaOH + Cl_2 = NaClO + NaCl + H_2O$$

To prevent sodium hypochlorite from decomposes due to increase of the reaction temperature, the liquid temperature is maintained at 40°C and below by cooling the circulating reactant liquid in the heat-exchanger.

The quality of sodium hypochlorite in 1983 and 1984 and the raw material unit consumption for the period from 1981 to 1983 in this plant are as follows:

(a) Product quality

	Available chlorine concentration	Free caustic soda concentration (g/l)
1983	13.62	7.50
1984	13.26	5.18
Standard	12	5 - 10

(b) Raw material unit consumption

	Caustic Soda (100%) kg/t	Chlorine (kg/t)	Flon-22 (kg/t)
1981	170	166	0.17
1982	172	158	-
1983	170	162	-
Standard	175	145	-

(4) Bleach liquor

The existing bleach liquor production facility consists of 4 series of the slaked lime dissolving tanks, absorber, receivers, lime milk circulation pumps, heat-exchangers for cooling reactant liquid and reaction-completed slurry setter.

This process receives the waste gas from liquefied chlorine production, waste gas in transferring and charging the liquefied chlorine, waste gas from dechlorination of depleted brine and waste gas from the cell end box as raw materials.

Outline of this process is as follows:

Slurry liquid which contains about 17% concentration of slaked lime is prepared by suspending raw slaked lime in water in the dissolving tank.

By circulating this slurry liquid between the reactor and the receiver by the circulation pump and by blowing the above-mentioned chlorine containing gas into the bottom of the reactor so as to make it be absorbed into and react with the lime milk sprinkled from the top of the tower, the slurry which contains calcium hypochlorite is produced.

$$2Ca(OH)_2 + 2Cl_2 = Ca(OCl)_2 + CaCl_2 + 2H_2O$$

Because the reaction mentioned above is exothermic, the liquid temperature is controlled below 40°C by cooling the circulating reactant liquid through the water cooled heat-exchanger to prevent decomposition due to increase of the reaction temperature.

The reaction-completed slurry is transferred to the settler, where sludges containing unreacted slaked lime and other insoluble residuals are settled and separated while the supernatant becomes a product. The standard of the product's available chlorine concentration is 8%.

The product quality in 1983 and 1984, and the raw material unit consumption for the period from 1981 to 1983 in this plant are as follows: