STUDY ON WASTE TREATMENT AND RECYCLING PLAN OF SELECTED INDUSTRIES IN THE REGION OF SFAX IN THE REPUBLIC OF TUNISIA

FINAL REPORT

SEPTEMBER 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

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Preface

In response to a request from the Government of the Republic of Tunisia, the Government of Japan decided to conduct a study on Waste Treatment and Recycling Plan of Selected Industries in the Region of Sfax in the Republic of Tunisia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Republic of Tunisia a study team headed by Mr. Shigeshi Katayanagi, Mitsubishi Petrochemical Engineering Co., Ltd. six times between June 1991 and August 1993.

The team held discussions with the officials concerned of the Government of the Republic of Tunisia, and conducted field surveys at the study area. After the study team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute the waste treatment and recycling plan of selected industries in the region of Sfax in the Republic of Tunisia and to the enhancement of friendly relations between our two countries.

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

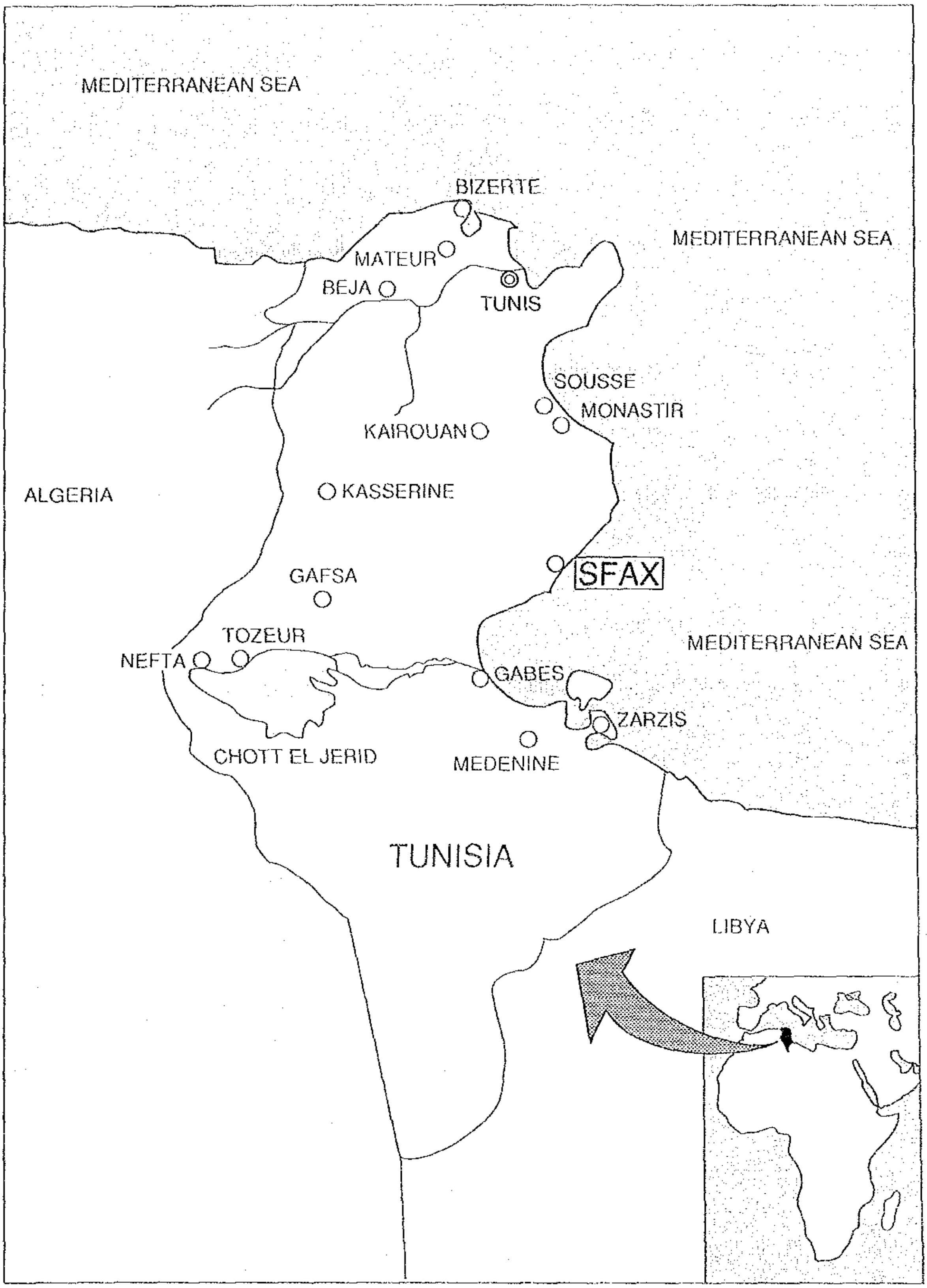
August 1993

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

LOCATION MAP

(SFAX CITY IN TUNISIA)



Abstract

1. Objective of the Study

The objective of this study is to contribute to regional environment protection and sound industrial development by formulating industrial pollution prevention plans in selected factories.

2. Period of the Study

From May 1991 till September 1993

3. Selected Factories of the Study: Sfax city and surrounding area in the Republic of Tunisia

(1) National phosphatic fertilizer factory (1 factory: SIAPE A)

(2) Sfax plant of national oil company (1 factory: SNDP)

(3) Olive oil factory (1 factory: UPOTS)

(4) Soap factory (2 factories: SIOS-ZITEX and SATHOP)

(5) Tanning factory (2 factories: SMCP and TMC)

(6) Dyeing factory (1 factory: STS)

(7) Sewage treatment plant (1 plant: ONAS)

4. Outline of Countermeasures

(1) Establishment of emission standard

① Waste water treatment

In Tunisia, there is a INNORPI standard specifying the discharged waste water. However, a tentative standard has been proposed, since a stepwise achievement of the standard is considered to be more realistic.

② Exhaust gas treatment

Since there is no exhaust gas emission standard in Tunisia, the Japanese emission standard has been referenced.

(2) Outline of antipollution facilities

Total discharge

Total waste water volume: 4,968 m^3/day

Total exhaust gas volume: 568,600 Nm^3/hr

Number of discharge points: 15 points

Method of treatment

① Case 1 (For waste water, tentative standard proposed by Japanese side)

Waste water: The waste water is to be pre-treated to be discharged to the ONAS sewage treatment plant except SIAPE. At SIAPE, the waste water is discharged to the sea after being treated.

Exhaust gas: At the sulfuric acid plant of SIAPE, the existing method has been modified to DCDA method. At the phosphoric acid plant and TSP plant, a wet scrubber type has been adopted and multi-cyclone has adopted for the boiler of these plants. Multi-cyclone has also be adopted at SIOS-ZITEX, SATHOP, and STS.

② Case 2 (for waste water, tentative standard proposed by Tunisian side)

Waste water: Waste water is treated up to the higher grade to be discharged to ONAS sewage treatment plant, except SIAPE. At SIAPE, the waste water is discharged to the sea after being treated.

Exhaust gas: Same as in Case 1.

③ Case 3 (for waste water, INNORPI standard)

Waste water: Waste water is treated up to the higher grade to be discharged to ONAS sewage treatment plant, except SIAPE. At SIAPE, the waste water is discharged to the sea after being treated.

Exhaust gas: Same as in Case 1.

(3) Total capital requirement

① Case 1 (for waste water, tentative standard proposed by Japanese side)

Waste water treatment: 15,782,600 TD

(construction cost: 14,550,000 TD)

Exhaust gas treatement:	17,386,400 TD
	(construction cost: 15,931,700 TD)
Total:	33,169,000 TD
	(construction cost: 30,481,700 TD)

② Case 2 (for waste water, tentative standard proposed by Tunisian side)

Waste water treatment:	24,329,600 TD
	(construciton cost: 22,537,100 TD)
Exhaust gas treatment:	17,386,400 TD
	(construciotn cost: 15,931,700 TD)
Total:	41,716,000 TD
	(construction cost: 38,468,800 TD)

③ Case 3 (for waste water, INNORPI standard)

Waste water treatment:	25,450,900 TD
	(construction cost: 23,581,000 TD)
Exhaust gas treatment:	17,386,400 TD
	(construction cost: 15,931,700 TD)
Total:	42,837,300 TD
	(construction cost: 39,512,700 TD)

(4) Construction period

Two years are required for the construction.

5. Financial and Economic Studies

Generally, investment on industrial antipollution countermeasures will not generate an output increase, so that it will not directly lead to a profit increase for the enterprises. Therefore, such investment does not fit in an ordinary financial or economic analysis. In the study, however, consideration has been given to the recent trend and the possible future reinforcement in Tunisia of the regulations and to the fact that some factories in Tunisia have been actually suspended from the operation because of the industrial pollution they caused. Thus, the influence by the number of suspended operation days has been evaluated, based on a concept of evasion of the suspension and evasion of output loss through the execution of the antipollution countermeasures. Along with the result of such evasions, an economic benefit has been taken into account such as reduction of the cost for exceeding the waste water quality standard and sewage treatment cost, value of the by-products, reduction of raw-material cost, and effect of tax exemption by special depreciation. These factors are included in the calculation of financial internal rate of return (F.IRR) and economic internal rate of return (E.IRR). The concept of economic benefit including the evasion of output loss is hardly considered to meet the essential objective of antipollution measures and industrial development, even though the IRR indicates a positive figure. Since the present study is intended for environmental countermeasures, the IRR cannot be used to determine the profitability of the investment. Instead, an even wider viewpoint should be taken to determine the appropriateness of the investment.

As a result of the financial and economic studies, the following conclusions can be reached:

(1) Prevention of pollution is significant to the community, by encouraging the industrial development and helping the enhancement of the residents' standard of living. Moreover, utilization of the useful material recovered from the treatment process will not only bring about an economic effect, but also offer the opportunity to acquire the techniques to improve the various production processes.

(2) At the stage of actual implementation, efforts should be made to reduce the cost of construction and operation to lighten the burden on each enterprise.

(3) By the introduction of the planned facilities, and opportunity for new employment will be offered not only to the direct personnel but also to the construction personnel.

6. Conclusions

The present study has been conducted for a regional conservation of environment through industrial antipollution countermeasures at the selected factories. Therefore, this study should be used as a model to be widespread to all Tunisian areas to establish the execution plans.

(1) Present state of selected factories

Except some factories, no countermeasures are taken for the industrial pollution at any factory. For the waster water, there is an established standard of INNORPI, but it has not been attained. For the exhaust gas, no emission standard has been provided.

(2) Conclusion of study

To protect the environment and enhance the economic efficiency of each enterprise, the cost of construction and operation for the antipollution facilities should be reduces. For this purpose, the following points should be examined as the key factors:

① Each factory discharges a large amount of polluting substances. By promoting a rationalisation within each factory, the valuable materials should be recoverd to reduce the polluted content in the waste water.

② Installation of the waste water treatment facilities should be studied according to the tentative standard proposed by Japanese side. While it is tentative, the standard satisfies the INNORPI standard, except SO4 which is discharged to the sea at SIAPE.

③ INNORPI standard also regulates the salts such as Cl and SO4.
Therefore a reexamination is required.

④ Treatment of the margin is a worldwide problem. In Tunisia, this report should be referenced to further study this problem.

⑤ SIAPE should increase the yield of sulfuric acid at the sulfuric acid plant, and at the same time endeavor to apply the DCDA method for the antipollution measures. Moreover, the scrubber should be improved to remove F for treating the exhaust gas from the phosphoric acid plant and TSP plant.

⑥ For the soap factory and dyeing factory, installation of cyclone is recommended for preventing the particles of soot. As a preparatory step, the method of controlling the combustion techniques should be improved.

CONTENTS

Page

Page

Page

Page

CONTENTS OF TABLES

Page

Page

Page

Page

CONTENTS OF FIGURES

Page

Page

ABBREVIATION LIST

MOE	Ministère de l'Environnement et de l'Aménagement du Territoire
ANPE	Agence Nationale de la Protection de l'Environnement
ENIS	Ecole Nationale d'Ingénieurs de Sfax
LARSEN	Laboratoire Régional des Sciences de l'Environment
INNORPI	Institut National de la Normalisation et de la Propriété Industrielle
ONAS	Office National de l'Assainissement
API	Agence de Promotion de l'Industrie
SIAPE	Société Industrielle pour la Fabrication de l'Acide Phosphorique et d'Engrais
SNDP	Société Nationale de la Distribution du Pétrole
UPOTS	Union des Producteurs Oleicoles de Tunisie-Sud
SIOS-ZITEX	Société Industrielle des Huiles d'Olives de Sfax
SATHOP	Société Anonyme Tunisienne des Huiles d' Olives Pures
SMCP	Société Moderne de Cuir et des Peaux
TMC	Tannerie Moderne de Cuir Sfax
STS	Société de Tissage de Sfax, Société de Tissage du Sud
ONH	Office National des Huiles

VOLUME I

INTRODUCTION

VOLUME I INTRODUCTION

1. Introduction

This report was compiled as a final report for "Study on Waste Treatment and Recycling Plan of Selected Industries in the Region of Sfax in the Republic of Tunisia", implemented by Japan International Cooperation Agency and scheduled from May 1991 to August 1993.

This report is based on, and revising the interim report prepared in Feburuary 1993, by incorporating the result of discussion at the fifth field survey and the result of the study in Japan continued thereafter.

2. Background of the Study

Key industries in the Republic of Tunisia are phosphate fertilizer and olive oil industries whose raw materials are produced abundantly in the country. Sfax, the second largest city (with a population of about 600,000), is one of the most industrialized in Tunisia, and environmental pollution, particularly caused by big projects like phosphate fertilizer factories, has been a serious problem for a long time.

Since Sfax is adjacent to the fishery industrial zone along the Gulf of Gabes and close to the tourist resorts of the Mediterranean Sea, the Tunisian government regarded the matter serious and set up Agence Nationale de Protection de l'Environnement (ANPE) in the Prime Minister's Office in 1988 to take countermeasures against environmental pollution, with priority given to industrial waste water treatment and exhaust fume removal. Under these circumstances, the Tunisian government requested Japan to cooperate in solving these problems.

In response to the request, Japan International Cooperation Agency (JICA) concluded the S/W Agreement concerning this study after confirming the subject matter of the request by the Tunisian government and conducting a general survey on selected factories.

The Study team started the study in May 1991.

3. Objective of the Study

The objective of this study is to contribute to regional environmental protection and sound industrial development by formulating industrial pollution prevention plans in selected factories.

Concretely, the followings will be carried out for selected eight factories.

① Planning of waste water treatment, recycling, and exhaust fume (particles of soot) removal

② Diagnosis of oil storage facilities (Measures against the leakage of petroleum)

Also the study team conducts this survey in cooperation with the Tunisian partner and implements the technical transfer of survey method to the counter-partner during the survey.

4. Selected Areas of the Study

(1) Selected areas: Sfax City in the Republic of Tunisia

(2) Selected factories: The locations of the following factories are indicated in Fig. -1.

① National phosphatic fertilizer factory (1 factory: SIAPE A)

② Sfax plant of national oil company (1 factory: SNDP)

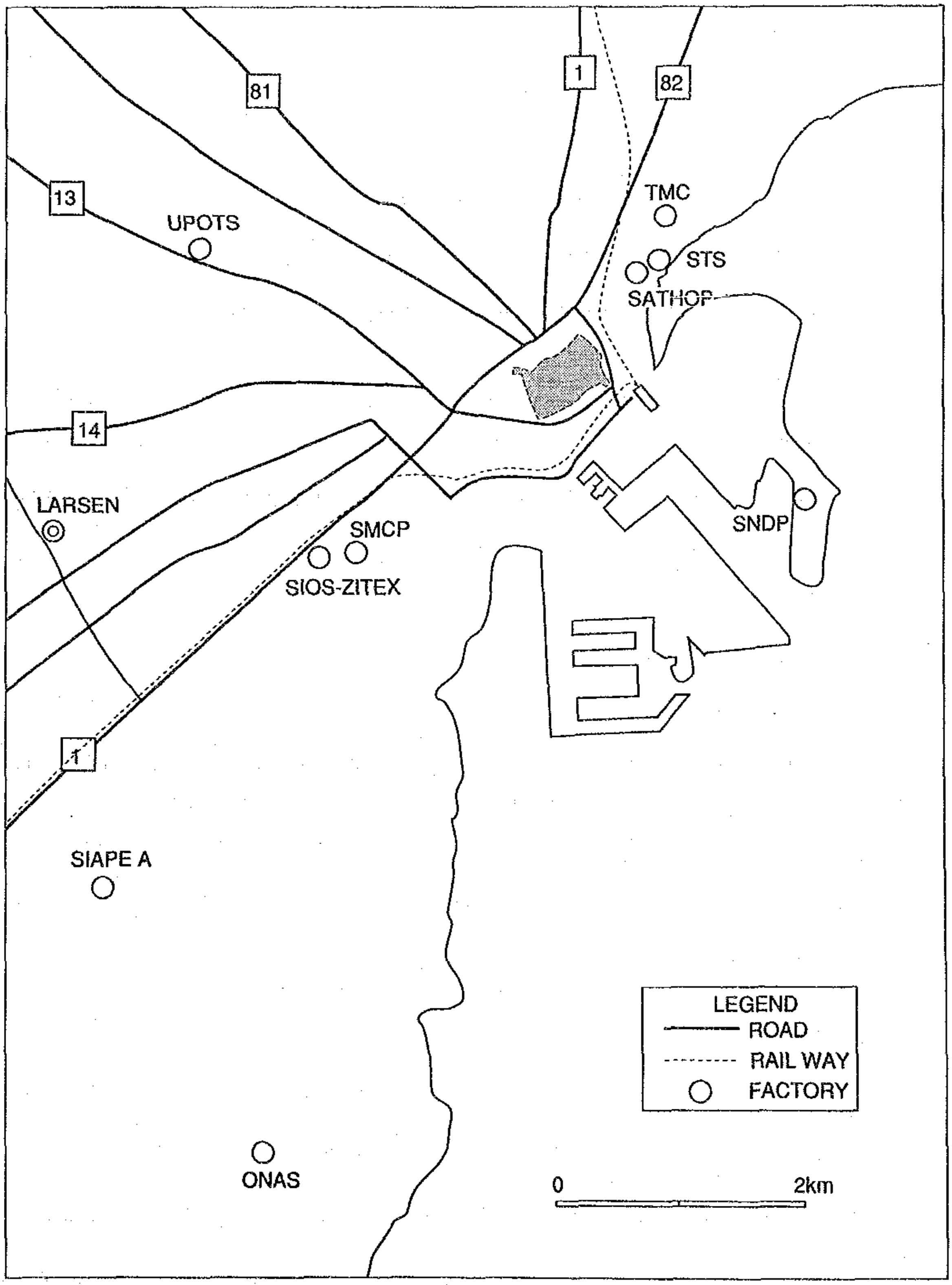
③ Olive oil factory (1 factory: UPOTS)

④ Soap factory (2 factories: SATHOP and SIOS-ZITEX)

⑤ Tanning factory (2 factories: SMCP and TMC)

⑥ Dyeing factory (1 factory: STS)

Fig. I-1 Location of Selected Factories



5. Scope of the Study

The following eight items were selected as major subjects for investigation related to this study, and the correlation of each item is shown in Fig. I-2: Flowchart of the study methods and procedures.

① Diagnosis of the present condition of production process

② Diagnosis of the present condition of supply water and waste water

③ Diagnosis of the present condition of exhaust fume

④ Setting of proper environmental standard and water quality standard

⑤ Making plans for improvement in production process and evaluation of economical efficiency

⑥ Making plans for waste water treatment and recycling, and evaluation of economical efficiency

⑦ Making plans for exhaust fume removal and evaluation of economical efficiency

⑧ Evaluation of entire economical efficiency and conclusion

6. Implementation Methods of the Study

6.1 Schedule of the Study

The working schedule of this study began in May, 1991 and will end in September, 1993 by submitting the final report. The working schedule is shown in Fig. I-3.

Fig. I-2 Flowchart of the Study Methods and Procedures

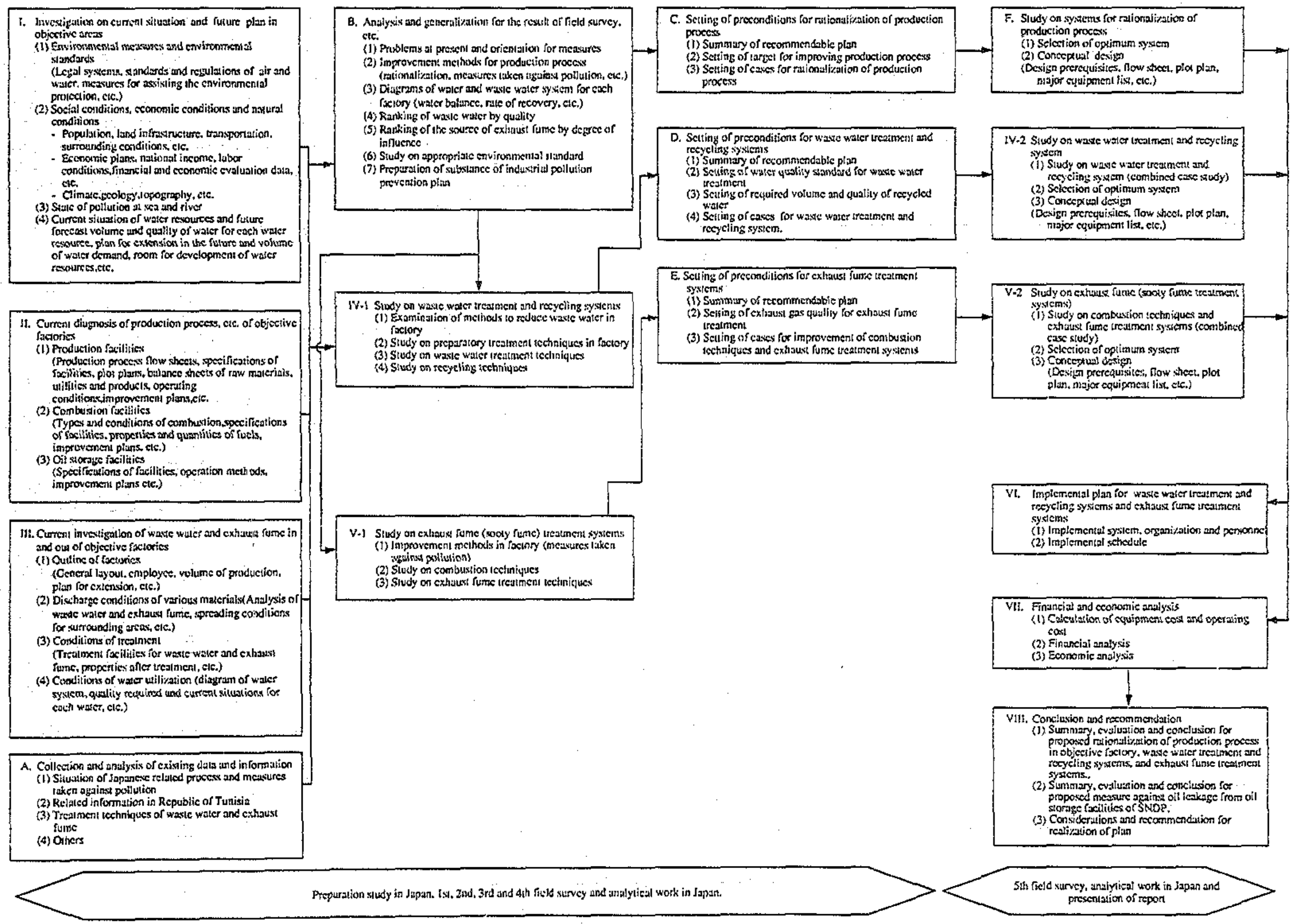
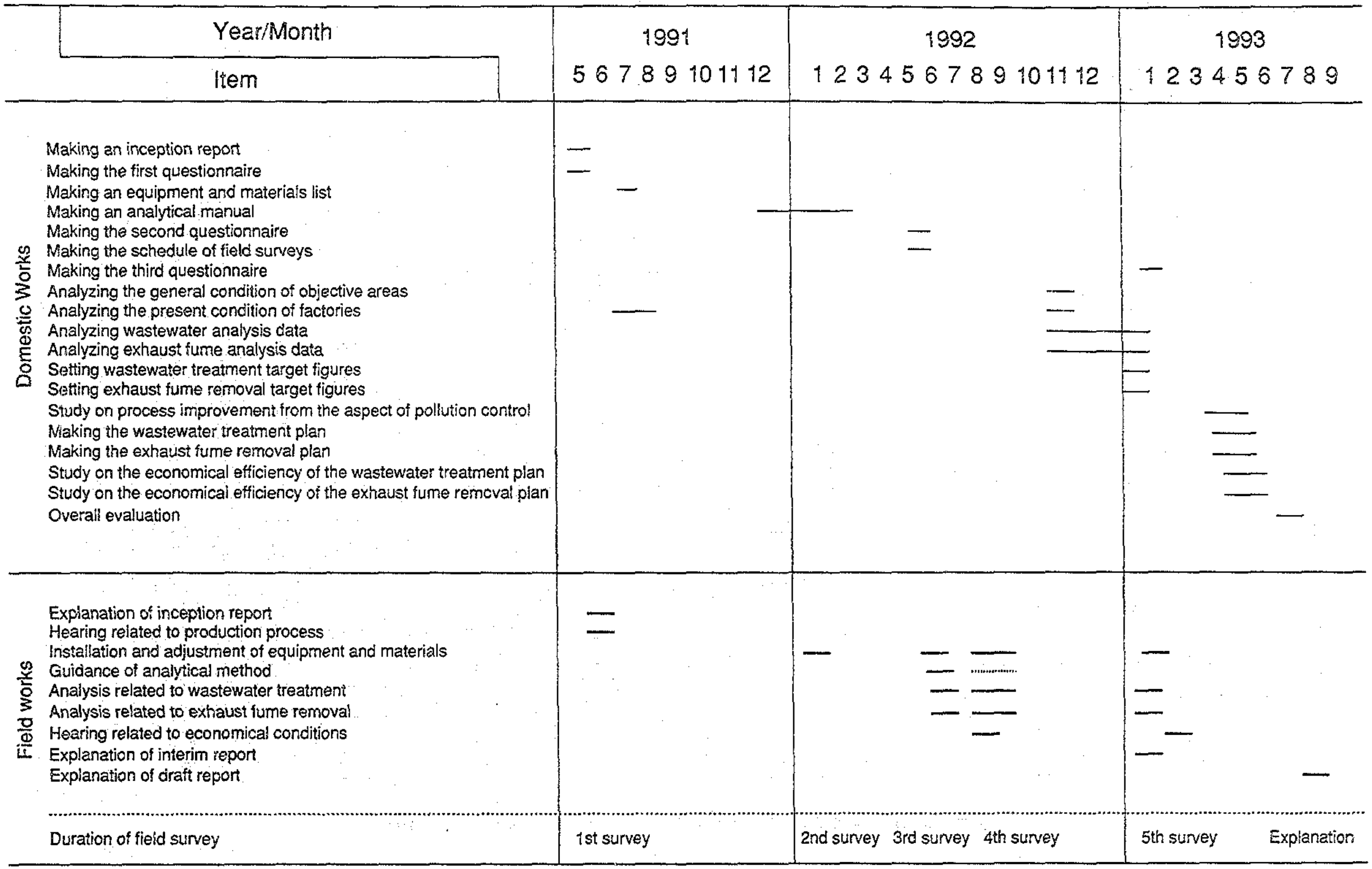


Fig. I-3 Working Schedule



6.2 Outline of the Study

(1) The First Field Survey (From June 7, 1991 through June 21, 1991)

① Explanation of entire study based on the inception report (Plan for the third field survey is included.)

② Survey of the present condition of selected factories from the aspect of production process

③ Survey of the points for waste water and exhaust gas analysis to be made in the third survey

④ Confirmation of the method of waste water and exhaust gas analysis to be made in the third survey

⑤ Holding a seminar related to processes in the selected factories

(2) The Second Field Survey (from January 18, 1992 through February 1, 1992)

① Explanation of supplied equipment and materials

② Confirmation of exhaust gas sampling points

③ Explanation of the methods and schedule of the third and fourth field surveys

(3) The Third Field Survey (from June 12, 1992 through July 29, 1992)

① Unpacking, installation and adjustment of supplied equipment and materials

② Guidance of exhaust gas and waste water analysis methods by using the analytical manual

③ Confirmation of construction works for exhaust gas sampling point

④ Making the flowchart of waste water of selected factories

⑤ Execution of sampling of waste water and simplified analysis

⑥ Execution of sampling and analysis of exhaust gas

(4) The Fourth Field Survey (September 5, 1992 through October 19, 1992)

① Collection of data for financial and economical analysis

② Investigation of the processes related to phosphoric acid factory and tanning factory

③ Execution of sampling of waste water and analysis of detailed daily variation analysis

④ Execution of sampling and analysis of exhaust gas

(5) The Fifth Field Survey (February 5, 1993 through March 6, 1993)

① Explanation and discussion of interim report

② Supplementary survey on selected factories

③ Unpacking, checking of quantity and adjustment of supplied equipment and materials

④ Guidance and discussion of analysis methods

(6) The Sixth Field survey (July 27, 1993 through August 9, 1993)

① Explanation and discussion of draft final report

6.3 Organization of the Study Team

(1) Japanese Study Team

Name	Allotted Work
Shigesi KATAYANAGI	Leader and overall coordination
Kinji KANEKO	Sub-leader, water treatment (physical chemistry)
Eiji MIYAKI	Analysis of water quality (organic)
Kazuki SAKAE	Analysis of water quality (inorganic)
Noriko ORITA	Analysis of water quality (biological)
Takemasa YASUKAWA	Water treatment (biological)
Isao ONO	Water treatment (biological)
Yoji MYOKEN	Measurement and removal of exhaust gas

Nobutaka KUBOTA	Plant design A
Shiro ICHIHARA	Plant design B
Katsuyuki EGAWA	Process (phosphoric acid)
Naoya KATOH	Process (tanning)
Masao KOMINAMI	Process (plant oil)
Hiroyuki SAGAMI	Process (dyeing)
Kunio SAKUMA	Combustion engineering
Mitsugu SASAKI	Oil storage facilities
Fumio IWASAKI	Calculation of equipment cost
Yoshio NIWAYAMA	Financial and economical analysis
Yoshinobu MATSUYA	Interpreter A
Kazuo ANDO	Interpreter B

(2) Tunisian Staff

1) MOE

Mr. Faiez AYED

Mr. Adel HENTATI

Mr. Houcine EL BECH

Mr. Noureddine BEN AISSA

Mr. Salah HASSINI

Mr. Rachid TRIKI

2) ANPE

Mr. Mohamed ENNABLI

Mr. Mounir FERCHICHI

3) TUNISIAN STUDY TEAM

*LARSE

Mr. Khaled MEDHIOUB	Leader and overall coordination
Mrs. Emna AMMAR	Water treatment (biological)
Mr. Jalel BOUZID	Water treatment
Mr. Mohamed SARBAJI	Water treatment
Miss Imen BELGUITH	Measurement and removal of exhaust gas
Mrs. Amel HACHICHA	Analysis of water quality
Mr. Ridha HACHICHA (IWRST)	Water treatment
Mr. Mohamed BEN JMAA	Analysis of water quality
Mr. Chafai AZRI	Measurement and removal of exhaust gas
Mr. Moncef KHADRAOUI	Analysis of water quality
Mr. Shems Eddine FESSI	Analysis of water quality
Miss Leila KHLIFI	Analysis of water quality
Miss Semia BEN ABDELKADER	Analysis of water quality
Mr. Foued KHMIRI (SIAPE)	Measurement and removal of exhaust gas

*Others

Mr. Morem AYADI	(ENIS, Dépr. Chimie)
Mr. Ridha ABDELHEDI	(ENIS, Dépr. Chimie)
Mr. Mengi FEKI	(ENIS, Dépr. Chimie)
Mr. Ali ABID	(ENIS, Dépr. Mécanique)
Mrs. Faika CHARFI	(FSEG, Dépr. Economie)

VOLUME II

PRESENT CONDITIONS OF SELECTED AREAS

VOLUME II PRESENT CONDITIONS OF SELECTED AREAS

1. Various Conditions of Selected Areas for the Study

1.1 Natural Conditions

1.1.1 Geographical Location

Sfax City is located between North Tunisia and South Tunisia and situated in lat. 34°43' N. and long. 10°46' E. It is in a distance of 267 km from Tunis, 128 km from Sousse, 136 km from Kairouan, 132 km from Sidi Bouzid, 169 km from Gafsa and 137 km from Gabes. Since Sfax City is in the almost equal distance from these active cites in Tunisia, it is committed to play a fundamental role in economical and administrative activities.

1.1.2 Weather Conditions

The Sfax region is dry with a great variety of seasonal changes owing to the Mediterranean climate. The air is dry in the hot season, which lasts after summer. Rainfall is irregular but frequent in fall and winter. Generally speaking, they have light and short showers.The north wind blows rather frequently from December through April.

(1) Atmospheric Temperature

Annual mean temperature:	20°C
Highest temperature in summer:	31°C
Lowest temperature in winter:	8°C

- The hottest month is August, and the highest mean temperature is 28.0°C.
- The coldest month is January, and the lowest mean temperature is 12.5°C.
- The temperature rarely falls below the freezing point. The lowest daily mean temperature of the region is 8.0°C.
- In the inland area, the temperature often rises unbearably high in summer, but in the Sfax region, the temperature drops owing to winds blowing from the sea in the daytime and blowing from the continent at night.

(2) Rainfall

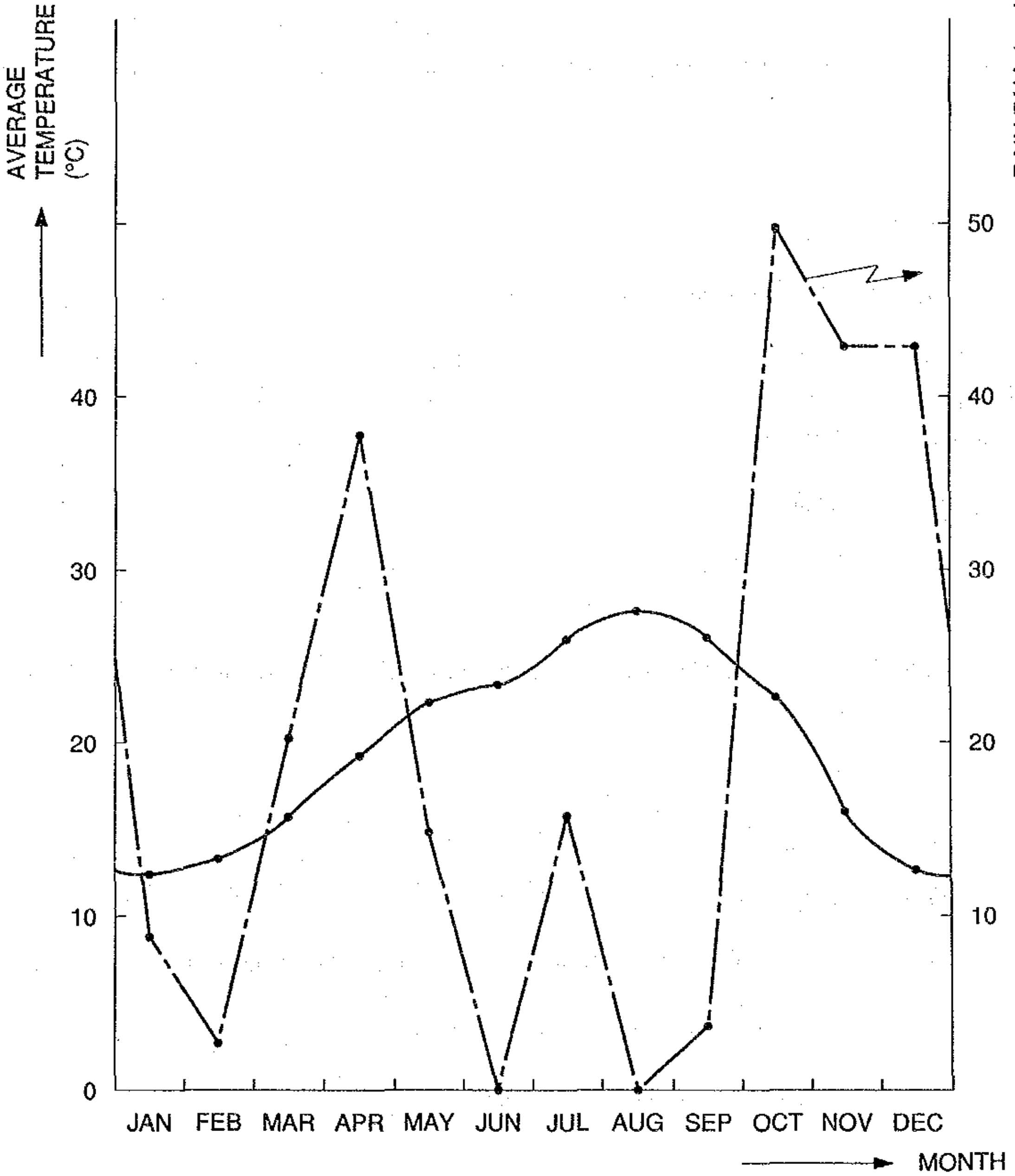
Annual rainfall: 242.2 mm

Max. monthly rainfall: 50.0 mm

The following features have been definitely shown by analyzing the curves shown in Fig. II-1.

- It is very humid in Sfax from October through December.
- The air is driest in summer.
- It rains most in fall, followed by spring and winter.
- Summer is a dry season, and it seldom rains.

Fig. II-1 Average Temperature and Rainfall Based on Climatic Data in 1986 by Sfax Meteorological Observatory



(3) Evaporation Capacity

Annual evaporation capacity: 1,898 mm

Max. monthly evaporation capacity: 253 mm

In addition to insufficient rainfall, evaporation influences the dryness. According to weather data (Sfax Weather Station, 1986), the annual evaporation capacity reaches 1,898 mm, 7.8 times as much as rainfall.

(4) Humidity

Highest monthly mean humidity :79.5% (74.0% in daytime, 85.0% at night) ·······November

Lowest monthly mean humidity :59.5% (54.0% in daytime, 65.0% at night) ········July

Although the evaporation capacity is very large compared with rainfall in the Sfax region, the humidity of atmosphere is comparatively high throughout the year because the Sfax region faces the sea.

(5) Wind Direction

The wind direction changes according to the season.
(North wind: 50%, southeast wind: 50%)

The Sfax region is influenced occasionally by a sirroco (a hot and dry wind blowing from the southwest.)

(6) Wind Speed

Annual average wind speed: 14.44 m/s

Max. monthly wind speed: 18.93 m/s

Weather data (Sfax Weather Station, 1986) is shown in Table II-1.

Table II-1 Weather data (Sfax Weather Station, 1986)

Month	Mean temp.	Highest temp.	Lowest temp.	Rainfall	Humidity Day, Night		Effective evaporation capacity	Wind direction	Wind speed
Jan.	12.5	17.0	8.0	9.0	71.0	84.0	127.0	NO	17.00
Feb.	13.6	17.8	8.4	3.0	71.5	84.5	121.0	NO	17.96
Mar.	16.0	18.6	13.5	21.0	71.0	84.0	114.0	NO	18.19
Apr.	19.7	22.3	17.2	38.0	70.3	81.3	137.0	N130	18.93
May	22.5	26.0	19.0	15.0	69.0	79.0	231.0	N130	18.00
June	23.6	26.5	20.7	00.0	58.0	70.0	243.0	N130	13.00
July	26.3	29.7	23.0	16.0	54.0	65.0	237.0	N130	11.00
Aug.	28.0	31.0	25.0	00.0	57.0	63.0	253.0	NO	9.00
Sept.	26.1	28.9	23.3	4.0	59.0	66.0	195.0	N130	8.33
Oct.	22.9	25.7	20.1	50.0	72.0	80.0	109.0	NO	13.32
Nov.	16.0	20.0	12.0	43.0	74.0	85.0	93.0	N130	14.60
Dec.	13.0	17.0	9.0	43.0	57.0	85.0	38.0	NO	14.00
Total	-	-	-	242.0mm	-	-	1,898.0mm	-	-

1.1.3 Geological Features and Landform

(1) Topography

The Sfax region is a part of sloping basin of Sahel (a hill in North Africa along the Mediterranean Sea). It is a low sloping plain along the sea partly facing the sea, and its highest place neighboring on the Gramda region is 39m above the sea level located 8 km away from the center of the city.

All factories and waste water treatment plants selected for this study are located on the flat sites.

(2) Bearing Capacity of Soil

We have made inquiries about the bearing capacity of soil, but it remained unexplained. Accordingly, we cannot express the soil bearing power numerically. However, the site where ONAS sewage treatment plant is located in the salt field which features a mud-state land. Moreover, the ground-water level of the ONAS area is said to be 2m.

1.2 Social Conditions

1.2.1 Population

(1) Sfax Prefecture is situated in the east-central part of Tunisia facing the sea and bordered by Mahdia Prefecture on the north, Kairoan, Sidi Bouzid and Gafsa Prefectures on the west, and Gabes Prefecture on the south. The gross area of Sfax Prefecture is 7,086 km^2.

Sfax City located in the east-central part of the prefecture faces the sea, and Kerkennah Island lies in the eastern offshore.

(2) Population of Sfax Prefecture

Its population is increasing gradually.

1988: 650,700

1989: 651,100

1990: 655,100

The increasing rate of population is about 2.2%, and some 53% of total population are living in the city.

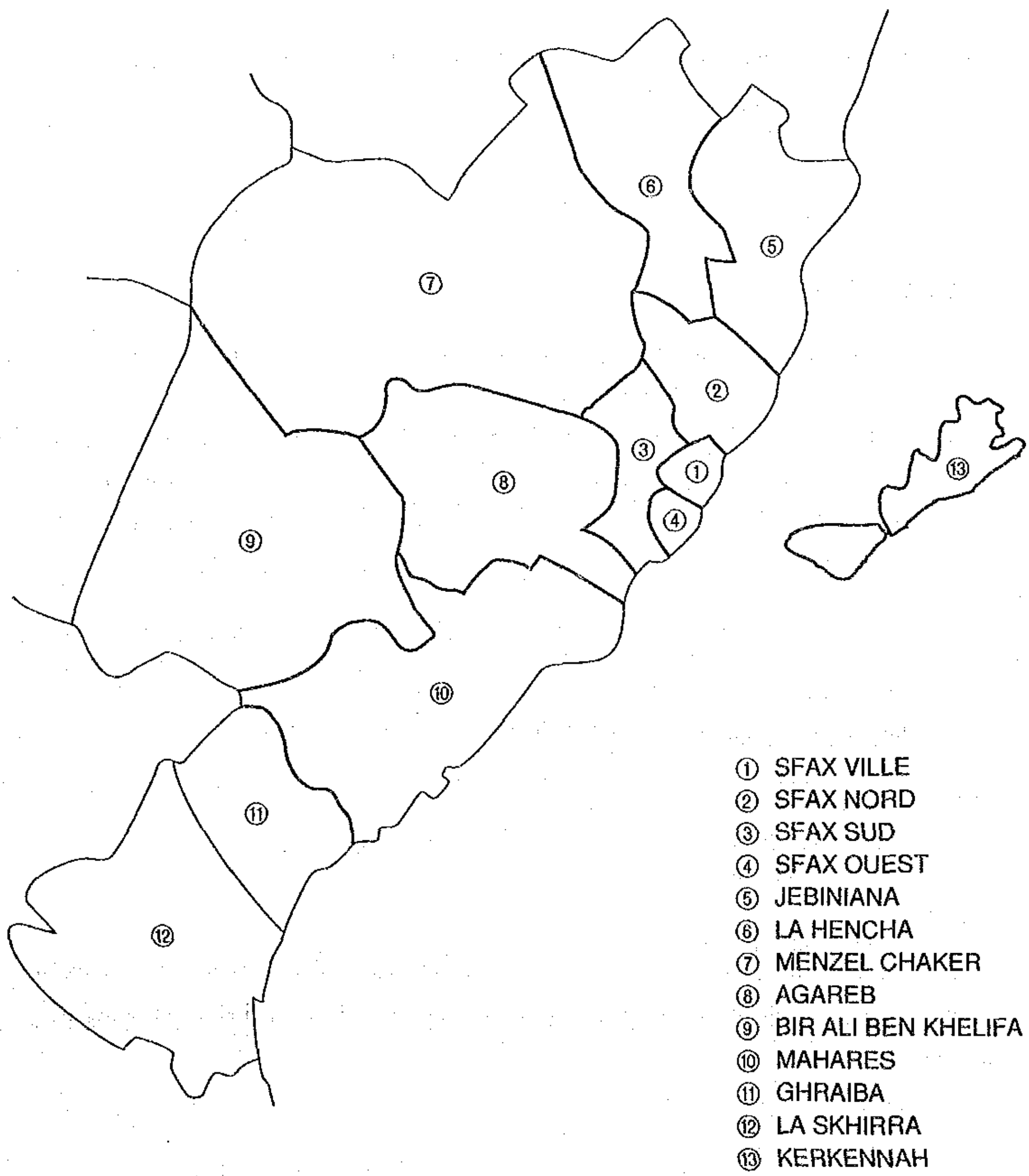
The relation between Sfax Prefecture and Sfax City is shown in Fig. II-2.

1.2.2 Land

(1) The gross area of Sfax Prefecture is 7,086 km^2 and is utilized as follows.

Vegetable farm:	1,390 km^2 (19.6%)
Forest land:	80 km^2 (1.1%)
Agricultural land:	4,906 km^2 (69.3%)
Other areas:	710 km^2 (10.0%)
Total	7,086 km^2 (100%)

Fig. II-2 Organization of Sfax Prefecture



Olive is the most abundant resource in Tunisia, and Sfax Prefecture is now planting 6,066,000 olive trees (3,085 km^2). The production of olive oil in Sfax Prefecture accounts for 35 to 40% of all olive production in Tunisia.

(2) Factories selected for this study are located around Sfax City as shown in Fig. I-1. Should new waste water treatment facilities be necessary to be installed, STS has find no space for them in the factory site, and the change of layout for the existing facilities is required.

(3) The price of real estate for plant in the Sfax region is described to be 30 TD/m^2 according to API (Agence de Promotion de l'Industrie) data in 1990, but the result of hearing at selected factories was from 40 to 100 TD/m^2.

(4) According to the master plan of Sfax City, the construction of the second sewage treatment plant in the northern part of Sfax City is under investigation. The plant site is flat, and the ground-water level of some 2m seems to be no problem for construction.

1.2.3 Supply of Utilities

(1) Electric Power

1) In Sfax City, electric power is supplied from the electric power station in Sousse, and the condition of electric power supply is favorable. Particularly, no power failure occurs, and in case of the maintenance or inspection of power transmission facilities, the electric power station will notify of power stoppage in advance. Accordingly, no factory among selected ones except SIAPE has private power generation facilities.

2) Electricity supplied by STEG (Tunisia Electric and Gas Company) is as follows.

High voltage:	225 kV, 150 kV, 90 kV
Medium voltage:	30 kV, 15 kV, 10 kV
Low voltage:	380V, 220V

The power frequency is 50 Hz and the number of phases is three.

(2) Fuel

The kind of used fuel varies depending on the factory and purpose. For example, SMCP is using butane gas, petroleum and heavy oil, while SATHOP is using grignon and heavy oil.

(3) Steam

1) Different kinds of fuels are used for steam boilers depending on the factories. SMCP, for example, is using heavy oil fired boilers. But at SATHOP, one unit of heavy oil fired steam boiler and six units of grignon fired steam boilers are in operation.

2) The capacity of steam boilers used by each factory does not have sufficient room. So, in case of planning new facilities, it is necessary to install a new steam boiler if steam is required.

1.2.4 Transportation Facilities

(1) Tunisia has harbors in Tunis, Goulette, Rades, Bizerte, Sousse, Sfax, Gabes and Zarzis. When equipment and materials are imported from abroad to selected factories in Sfax, first they arrive in Sfax Port, then they are generally carried in trucks on the main roads.

(2) Outline of Sfax Port

1) The approach channel to Sfax Port is dredged to be 6,150m long and 10.5m deep. Quays are thoroughly furnished with illuminating systems, and they are completely sheltered.

2) Maximum effective ship type
Length: 185m, Draft: 33ft, Depth of pier: 10.5m

3) Berth capacity

a) Commercial quay: 520m long ····For general cargo

b) Phosphate quay: 584m long ····For handling phosphates and sulfur

c) N.P.K quay: 150m long ····For loading superphosphates and unloading sulfur and coal

d) Soufrier quay: 220m long ····Expansion of NPK quay

4) Crane

60-ton floating crane: One unit
Mobile cranes of 10 to 40 tons: Many
Fork lifts of 2 to 10 tons: Many
Tractors can also be used.

5) Facilities for cargo in bulk: Belt conveyors

(3) Road Conditions

The road conditions are favorable because roads in Sfax City are paved and the road width is wide enough for transportation. SIAPE-A, ONAS, SIOS-ZITEX and STS are located within a 4-km radius from Sfax Port, and equipment and materials can be safely transported on the main roads.

Road restrictions are as follows.

Width: 2.4m
Height: 4.2m
Length: 12m

The height of the bed of a general truck is 1.2m, so that the height of a cargo can be as high as 3.0m with due regard to the above restrictions. When a truck with low bed of 50 cm high is used, a cargo as high as 3.7 m can be carried.

For a cargo exceeding the above limits, you can apply to the police station for permission to carry it by arranging escort cars before and behind the trailer.

1.3 Economic Conditions

1.3.1 Outline of Economy

During 1970s, Tunisia's economy grew favorable thanks to active investment by private enterprises as well as the development of light industries and tourist business, and the average annual growth rate of Tunisia's economy from 1971 through 1981 was high at 7.7%. The economic growth rate in 1982 was lower than that of the previous year because of a decrease in petroleum export caused by a sharp drop in the price of petroleum and sluggish agricultural production. Tunisia's economy was recovered in 1983 and registered an average annual growth of 5.4% until 1985.

In 1986, however, Tunisia's economy recorded a minus 1.4% growth rate because of a sharp drop of petroleum price, poor harvest of agricultural products and a decrease in tourist earnings. With a sharp turn for the worse in the balance of current account, and serious foreign exchange shortage, Tunisia was confronted with an economic crisis, but it could avoid economic breakdown by receiving urgent loans from IMF and the World Bank. In order to overcome these economic difficulties, the country carried out a policy to adjust the industrial structure based on economic liberalization under the guidance of IMF and the World Bank. In 1987, the economic growth rate recovered to 6.7% because of an improvement in the economic situation, in addition to the effect of the policy.

In 1988 and 1989 when a great deal of damage from a drought and migratory locusts was done to agricultural production, the economic growth rate dropped. In the following year, however, the economic growth rate reached 7.6%, mainly because of sharp recovery in agricultural production which was affected by any damage from a drought and locusts. As mentioned above, Tunisia's economy depends fully on agricultural production which is easily influenced by weather conditions.

In 1991, Tunisia had concern about the influence of the Gulf War, but the production of agricultural products and the export of textile and leather expanded favorably, and the economic growth is expected to have reached the 3.5% level, higher than projected by the Government.

Table II-2 Trend in Gross Domestic Product (GDP)

(Unit: 1 million Tunisian dinars, %)

	85	86	87	88	89	90	91e
NominalGDP	6,910	7,021	7,997	8,685	9,661	10,990	NA
Real GDP *	6,910	6,810	7,266	7,271	7,542	8,115	8,400
Real growth rate	5.7	-1.4	6.7	0.1	3.7	7.6	3.5

(Note) *: Calculated by the price in 1985 e: Estimate
(Source) IMF, IFS, Central Bank of Tunisia

1.3.2 Economic Development Plan

With a five-year plan as its basic policy and with guiding policies extending over a wide field, Tunisia's Social and Economic Development Plans has played an important role in promoting the structural improvement in its economy. The 7th Social and Economic Development Plan was completed in 1991, and the 8th Plan (1992-1996) is under way.

(1) The 7th Social and Economic Development Plan (1987-1991)

The basic guiding policies of the 7th Social and Economic Development Plan were the solution of employment problem, adjustment of regional differentials, and improvement in the balance of international payments. Along these targets, investments were made principally in the projects related to agriculture, tourist business and light industries which are regarded as effective to increase employment. At the same time, investments in the local manufacturing industry sector were promoted, and agricultural development was implemented under the guidance of Local Agricultural Development Commissionership. The promotion of export by expanding the exporting market and fostering the export-oriented manufacturing industry, reduction of import by establishing a food self-supplying system and priority investments in tourist section which is a major source for obtaining foreign currencies were also carried out.

(2) The 8th Social and Economic Development Plan (1992-1996)

When this study was made in September 1992, it was said that the 8th Social and Economic Development Plan had been written in only Arabic and had not been translated into French. According to information available, however, the basic policies of the 8th Social and Economic Development Plan follow those of the previous plan, but emphasis has been put on placing national enterprises under private management, liberalization of economy and introduction of foreign capital. The Tunisian Government is executing a plan to commit national enterprises in private hands in order to reduce its financial burden and is scheduled to carry out reforms over a wide field including liberalization of trade.

1.3.3 Industrial Structure

(1) Features of Industrial Structure

The agricultural sector has been given much weight in the Tunisian economy, but recently less weight has been laid on it so that the agricultural sector accounted for 16% of the gross domestic product (GDP) in 1990. The mine industry and petroleum/ gas sector together accounted for 9% of GDP in the same year. Although the main resources of Tunisia are phosphate rock and petroleum, the scale of resources is small and not necessarily prospective in the future.

On the contrary, the manufacturing industry sector, mainly labor- intensive light industries (textile, leather and food processing), is gradually increasing its component ratio in GDP, accounting for 17% in 1990. Textile and leather industries particularly showed a sharp growth and accounted for 5% of GDP. The service industry sector is being diversified extending over the fields of commerce and finance, centering around the tourist industry which is now one of the main sources of Tunisia acquiring foreign currencies. Tunisia has a comparatively balanced industrial structure for a developing country.

Table II-3 Trend in GDP Classified by Industry

Composition ratio

	80	90
Agriculture	17.6	16.3
Mine industry	0.9	1.0
Petroleum and gas	6.0	8.4
Manufacturing industry	13.0	16.9
Tourist industry	4.2	4.4
Commercial service	29.1	33.9
Government service	15.2	13.5
Total (others included)	100.0	100.0

(Source) Central Bank of Tunisia

(2) Agriculture

Agricultural production of Tunisia has a weakness to be influenced by the weather, because water for farming is largely dependent on rainfall. In 1988, agricultural production decreased about 25% from the previous year, mainly because of a drought. Major agricultural products are grain, olive, orange and vegetable. Grains such as wheat and barley are the main farm products of Tunisia, accounting for 20% of all agricultural production. Olive is processed mainly for olive oil and is one of the major export items.

Table II-4 Trend in the Production of Major Agricultural Products

(Unit: 1,000 tons)

	85	86	87	88	89	90
Wheat	1,380	474	1,360	220	420	1,122
Barley	699	158	569	69	215	511
Olive	95	105	114	100	54	130
Orange	196	252	250	230	260	237

(Source) Central Bank of Tunisia

(3) Mining Industry

Major mineral product of Tunisia is phosphate rock, and its output took the fifth place in the world in 1990. Phosphoric acid and phosphate fertilizer produced from phosphate rock are exported to European countries, Turkey and other countries. The output of the mining industry in 1990 accounted for only 1% of GDP but 9% of total export income. Mining industry of Tunisia is one of major sources to acquire foreign currency. However, since demands for these products in the world market is lagging and phosphate rock reserve in Tunisia is being exhausted, the output of phosphate rock remained on the same level.

Table II-5 Trend in the Output of Major Mineral Products

(Unit:1,000 tons)

	84	85	86	87	88	89	90
Phosphate rock	5,385	4,505	5,734	6,216	6,026	6,610	6,259
Iron ore	309	307	310	291	326	280	291

(Source) Central Bank of Tunisia

(4) Petroleum and Gas

The output of petroleum and gas accounted for 13% of GDP in 1983 when their production reached the peak, but the output declined after that. The component ratio of the petroleum and gas in total export value was over 40% during the first half of 1980s contributing largely to the balance of export and import. Due to a decrease in production and diversification of export products, the output started to decline in 1986 and accounted for 17% in 1990. Although the discovery and development of new oil wells have been promoted principally by a US oil company since the latter half of 1991, Tunisia is expected to be an importer country of petroleum in the 21st century because its domestic energy consumption is rapidly increasing.

Table II-6 Trend in Petroleum and Gas Production

(Unit: 1,000 barrels/day, 1 million m^3/year)

	85	86	87	88	89	90
Petroleum	108.6	105.4	100.1	98.6	98.9	90.4
Gas	403	399	331	306	314	277

(Source) Central Bank of Tunisia

(5) Manufacturing Industry

The manufacturing industry has been fostered since 1970's owing to the promotion of export industries, particularly light industries, and positive introduction of foreign capital. As a result, the output of the manufacturing industry accounted for 17% of GDP in 1990. The major sectors of the manufacturing industry are textile, leather and food processing, totally accounting for about 50%. The component ratio of national enterprises in the manufacturing industry is approximately 50%. The Tunisian Government is promoting a policy to place national enterprises under private management in order to foster enterprises competitive in export and to reduce the financial burden of the Government.

Table II-7 Trend in the Growth Rate of the Manufacturing Industry Classified by Sector

(Unit:%)

	84	85	86	87	88	89	90	Component ratio*
Food processing	18.6	-0.4	4.7	1.2	3.9	-3.9	12.8	19.5
Construction material	2.1	9.8	1.1	4.8	7.5	7.1	7.9	15.0
Machinery	7.5	5.5	0.4	-0.1	3.6	8.7	9.9	13.5
Chemistry	-0.3	6.7	14.9	5.7	14.6	3.2	-1.5	6.2
Textile/Leather	0.4	4.1	5.6	7.6	8.0	13.5	13.5	31.5
Others	9.5	8.3	4.2	5.0	5.2	7.8	6.1	14.3
Total	6.7	5.0	4.8	4.1	6.9	6.0	9.3	100.0

(Note) *: Component ratio of manufacturing industry in total production in 1990
(Source) Central Bank of Tunisia

(6) Touristic Industry

The touristic industry is also one of the important sources to acquire foreign currencies. As Tunisia is favored by geographical and climatic conditions, and is stable politically, many foreign tourists from European countries (France, Italy, Germany, etc.) and Libya, a neighboring country, are visiting Tunisia every year. Foreign tourists totaled 32 millions in 1990, and Tunisia could obtain about US$ 940 millions from the tourist industry.Since the tourist industry is an important sector to get foreign currencies and create new employment, the Tunisian Government is promoting the touristic industry by making public investments and encouraging private investments in the industry.

Table II-8 Trend of Tourist Industry Sector

(Unit: 1,000 persons, US$ 1 million)

	84	85	86	87	88	89	90
No. of tourists	1,580	2,003	1,502	1,875	3,468	3,222	3,204
Earnings from tourist business	461	499	486	687	1,166	928	943

(Source) Central Bank of Tunisia

1.3.4 Labor Force

Of the 660,000 population of Sfax Prefecture, about 400,000 people (about 62% of Sfax Prefecture) are living in Sfax City. Selected factories in the Sfax region can secure easily manpower required for carrying out their future projects.The educational level in Sfax is as follows.

Illiteracy rate: 31.2%

Primary school level: 43.2%

Middle school level: 22.3%

High school level: 3.0%

Others: 0.3%

It is capable of adopting people of educational level corresponding to the type of job.According to "Factor Cost of production in Tunisia" issued by API, labor expenses are as follows.

General manager: 650 TD/month•person

Production manager: 550 TD/month•person

Engineer: 450 TD/month•person

Skilled worker: 300 TD/month•person

Team head: 280 TD/month•person

Accountant: 280 TD/month•person

The labor expenses confirmed at the selected factories are almost same with the above data. Operator: 150-250 TD/month•person.

2. Environmental Control Policy and Environmental Standard

2.1 History in Environmental Policy

(1) The institutional framework for environmental control was formed in stages in 1960s to meet the growing needs of environmental protection generated by economic development. Consciousness of environmental control and institutional approach to environmental problems resulted in the establishment of DHMPE (Department of Environmental Hygiene and Protection), of which activities were limited to health.

In 1968, for example, decree No. 68-88 (dated March 28, 1968) of "Dangerous, Insanitary or Annoying Establishment" was issued from the Ministry of Youth, Sports and Social Affair, and policies for environmental control emphasizing the benefit and protection of workers in dangerous, insanitary or annoying establishments were stipulated, with more account paid to workers' health.

(2) In 1974, ONAS was created as an organization responsible for treating increasing factory and home waste water along the economic development, thus the body responsible for liquid waste, especially sewage, being clearly stipulated.

(3) "Water Code" was issued in 1975, and it plays the most important role in protecting inland waterways against pollution. This code includes a series of prohibitions to prevent the pollution of surface and underground water.

In Water Code, however, Government's financial assistance to industrial development imposes an obligation of installing appropriate water treatment facilities along the development. Water Code also specifies that all expenses required for the treatment of Waste water produced by development activities and installation of waste water treatment facilities should be paid in principle by polluters.

(4) Concerning public sewer systems, decree No. 79768 (dated September 8, 1979) of "Regulation of conditions of branch and slope of effluent in public sewer net" was legislated in 1979.

The obligation of installing branch for sewer and penalty provisions against the violation of regulation were specified clearly in this decree.

(5) Decree No. 82-1355 (dated October 16, 1982) of "Regulations of Recovery of Used Oil" was enacted in 1982. This decree prohibited to drain used oil into the sea, rivers, and sewers, and prescribed penal provisions against the violation of this decree.

(6) In 1985, decree No. 85-56 (dated January 2, 1985) concerning "Regulation of Abandonment of Waste Water and Waste in the Environment" was enacted.

This decree clearly stipulated regulations regarding waste water and waste drained to the environment and penal provisions against the violation of regulation.

(7) In 1988, law No. 88-91 (dated August 2, 1988) concerning the establishment of the National Environmental Protection Agency was legislated, and ANPE (Angence Nationale de Protection de l'Environnement) was organized.

This law prescribed the character, role and competence of the ANPE as well as promotional measures for environmental protection, obligations of individual and corporate polluters, inspection of waste water treatment and exhaust gas removal facilities and penal provisions against violators involved in environmental pollution.

Until ANPE was established, however, there was no integrated, authorized organization for a mounting environmental problem along Tunisia's economic development, and each organization took countermeasures against environmental pollution separately on the different level.

ANPE was established in order to solve the above-mentioned systematic problem effectively.

The establishment of ANPE has given new impetus which enable a great improvement in environmental pollution control on the institutional and regulatory levels. The strengthening of inter-departmental coodination in the area of environmental protection launched by ANPE has enabled an overall, integrated approach toward pollution control.

The Article 3 of the above-mentioned law No. 88-91 provides actually the role of ANPE, and the details are as follows.

- Participates in the enactment and execution of administrative programs associated with pollution control and environmental protection.
- Proposes general and individual measures for implementing national programs associated with pollution control and environmental protection to competent authority.
- Makes national emergency intervention plans against external dangers which may cause accidental pollution or threaten environmental balance and life quality, and monitors their execution.
- Prevents the occurrence of environmental pollution and all forms of environmental disruption.

- Establishes standards, in cooperation of the government offices and institutes concerned, to indicate the limits of wastes and pollutants in the business operations of industry, energy, city, agriculture and transportation, and monitors their execution.
- Approves investment in business operations with the object of contributing to pollution control and environmental protection.
- Supervises and monitors pollutants and waste treatment facilities.
- Promotes scientific, technological and economical research activities in cooperation with government offices and institutes concerned.

(8) The Tunisian Standard, N.T. 106.002, of "Environmental Protection - Waste Water Drained into the Ocean, Rivers and Sewers" was enacted in 1989.

This standard was set up by the Ministry of Agriculture, Ministry of Economics, Ministry of Public Health, and Ministry of Equipment, and the following three points were clearly stipulated.

1) Objects of application of waste water quality standard

2) Analysis of water quality and method of analysis

3) Standard of waste water drained into the sea area, rivers, and sewers

This standard backed up the "Government Ordinance Concerning Regulations of Abandonment of Waste Water and Waste in the Environment" legislated in 1985 and "Water Code" enacted in 1975 by indicating the standard of water quality categorized by the kind of environment (sea, river and sewer) receiving waste water.

(9) In 1990, decree No. 90-2273 (dated December 25,1990) "On the Status of Expert Inspector of ANPE" was enacted.

This decree included regulations made by ANPE as a result of reinforcing field works for monitoring industrial and ocean pollution and prescribed the functions of expert inspector. The decree was intended to ensure more effective supervisory works.

(10) In 1991, decree No. 91-362 (dated March 13,1991) of "Impact Studies (Environmental Assessment)" was enacted to impose an obligation of conducting environmental studies as a requirement before starting any project activities. It was made by ANPE and was adopted by the Government.

It is stated in this decree that "Government sanction of industrial, agricultural and commercial facilities which may be sources of environmental pollution or degradation requires of impact studies." No ministry concerned can approve the establishment of any facilities without confirming the establishment of facilities is not opposed by ANPE.

This decree became one of the most effective means to prevent environmental devastation. It is also stated that high regard must be paid to the environmental problem when economic and social plans are determined in all development projects, particularly in the fields of industry, energy, transportation and tourism.

(11) Following the above-stated impact studies, MOE was established in October 1991 to intensify the activities for environmental protection which ANPE is now carrying out.

2.2 System of Environmental Control Legislation

(1) There is no single integrated environmental control legislation for environmental protection in Tunisia, but rather scattered regulations (laws, decrees and decisions) covering various fields. Also because these regulations have been enacted over a long period of time and are not integrated, it is comparatively difficult to study and understand all these regulations.

(2) The Tunisian Environmental Control Legislation is roughly classified into three broad categories.

1) Protection of the Natural Environment:Soil, subsoil, forests, inland waterways, marine environment, air, flora and fauna

2) Protection of Human Property:Construction, archeological and historical heritage and national parks

3) Pollution Control:Waste, dangerous facilities, chemicals and dangerous substances, noise and harmful smells

(3) The quality of waste water is defined by the Tunisian Standard NT 106.002 of "Environmental Protection - Waste Water Drained into the Ocean, Rivers and Sewers" enacted in 1989 and decree No. 85-56 concerning "Regulation of Abandonment of Waste Water and Waste in the Environment" enacted in 1985, and also by other several other decrees for protecting the water quality.

(4) As to the air, no standard as that of waste water quality has not been formulated, and under the present circumstances, air pollution cannot be controlled by current laws and decrees.

2.3 Environmental Standard/Emission Standard to Be Applied

2.3.1 Emission Standard to Be Applied

(1) The Tunisian Standard is examined and formulated by the Ministry of Agriculture, Ministry of Economics, Ministry of Public Health and Ministry of Equipment, and N.T. 106.002 (INNORPI) was applied as waste water quality standard.

The waste water quality standard (N.T. 106.002) also prescribes waste water drained into the sea area, rivers and sewers as shown in Table II-9.

It also prescribes the method of measurement as shown in Table II-10.

(2) In addition to the water quality standard, decree No. 85-56 enacted in 1985 concerning "Regulation of Abandonment of Waste Water and Waste in the Environment" prescribes waste water drained to the environment and is applied.

(3) The waste water quality standard mentioned above prescribes numeric values concerning the density of water quality, but does not include the regulation of total quantity.

(4) The waste water quality standard is formulated like the above-mentioned Tunisian Standard, but no standard of exhaust gas emitted into the atmosphere does exist at present. According to ANPE, it is now under examination among the organizations concerned.

(5) There is no environmental standard in Tunisia like "the environmental standard concerning the protection of human health" or "the environmental standard for the protection of living environment."

Table II-9 Waste Water Quality Standard (1/2) (INNORPI)

NT: Tunisian Standard

Item	Sea area	River	Public sewer	Measuring method
Temperature at sampling (°C)	35°C or less	25°C or less	35°C or less	–
pH (hydrogen exponent)	6.5 < pH < 8.5	6.5 < pH < 8.5	6.5 < pH < 9	NT 09.05, NT 09.06
SS (mg/*l*)	30	30	400	NT 09.21
COD (mg/*l*)	90 (sea bathing and marineproduct areas)	90	1000	NT 09.23
BOD (mg/*l*)	30	30	400	NT 09.23
CI (mg/*l*)	–	600	700	NT 09.77
CI_2 (mg/*l*)	0.05	0.05	1	NT 01.31
CIO_2 (mg/*l*)	0.05	0.05	0.5	–
SO_4 (mg/*l*)	1000	600	400	NT 09.78
Mg (mg/*l*)	2000	200	300	NT 09.09
K (mg/*l*)	1000	50	50	NT 09.65, NT 09.66
Na (mg/*l*)	–	300	1000	NT 09.65, NT 09.66
Ca (mg/*l*)	–	500	–	NT 09.09, NT 09.10
Al (mg/*l*)	5	5	10	–
Colour (Pt/Co. No.)	100	70		NT 09.16
S (mg/*l*)	2	0.1	3	–
F (mg/*l*)	5	3	3	–
NO_3 (mg/*l*)	90	50	90	NT 09.30
NO_2 (mg/*l*)	5	0.5	10	–
Organic nitrogen and ammonia nitrogen (mg/*l*)	30	1	100	NT 09.18
PO_4 (mg/*l*)	0.1	0.05	10	–
Phenol (mg/*l*)	0.05	0.002	1	–
Oil content (mg/*l*)	20	10	30	–
Mineral, aliphatic and carbohydrate (mg/*l*)	10	2	10	–
B (mg/*l*)	20	2	2	–

Table II-9 Waste Water Quality Standard (2/2) (INNORPI)

Item	Sea area	River	Public sewer	Measuring method
Fe (mg/l)	1	1	5	NT 09.25
Cu (mg/l)	1.5	0.5	1	NT 09.07
Sn (mg/l)	2	2	2	–
Mn (mg/l)	1	0.5	1	NT 09.28
Zn (mg/l)	10	5	5	NT 09.07
Mo (mg/l)	5	0.5	5	–
Co (mg/l)	0.5	0.1	0.5	NT 09.07
Br2 (mg/l)	0.1	0.05	1	–
Ba (mg/l)	10	0.5	10	–
Ag (mg/l)	0.1	0.05	0.1	–
As (mg/l)	0.1	0.05	0.1	NT 09.08
Be (mg/l)	0.05	0.01	0.05	–
Cd (mg/l)	0.005	0.005	0.1	NT09.35
CN (mg/l)	0.05	0.05	0.5	NT09.41
Cr (VI) (mg/l) Cr (III) (mg/l)	0.5 2	0.01 0.5	0.5 2	– –
Sb (mg/l)	0.1	0.1	0.2	–
Ni (mg/l)	2	0.2	2	NT 09.07
Se (mg/l)	0.5	0.05	1	NT 09.36
Hg (mg/l)	0.001	0.001	0.01	NT 09.37
Pb (mg/l)	0.5	0.1	1	NT 09.07
Ti (mg/l)	0.001	0.001	0.01	–
Agricultural chemical, insecticide and herbicide (mg/l)	0.005	0.001	0.01	–
B-coli (100ml)	2000	2000		NT 16.21, NT 16.22
Streptococcus (100ml)	1000	1000		NT 16.23, NT 16.24
Salmonella (5000ml)	Not to be detected	Not to be detected		
Cholera bacterium (5000ml)	Not to be detected	Not to be detected		

Table II-10: Measuring Method

No.	Measuring method
NT. 09.05	pH colorimetry
NT. 09.06	pH potentiometry
NT. 09.07	Flame atomic absorption spectrometry - Co, Ni, Cu, Zn, Cd, Pb
NT. 09.08	As spectrometry (diethyldithiocarbon silver)
NT. 09.09	Ca, Mg atomic absorption spectrometry
NT. 09.10	Calcium capacity analysis
NT. 09.15	Turbidity measurement
NT. 09.16	HAZEN color comparison
NT. 09.17	Alkalinity measurement
NT. 09.18	Ammonia nitrogen
NT. 09.19	Hardness
NT. 09.20	BOD
NT. 09.21	Suspended solid
NT. 09.23	COD
NT. 09.25	Iron content, phenanthroline spectrometry
NT. 09.26	Ionic and nonionic materials
NT. 09.28	Magnesium and formaldexene spectrometry
NT. 09.30	Nitric ester
NT. 09.31	Nitrogen
NT. 09.34	Conductivity
NT. 09.35	Cadmium and flame atomic absorption spectrometry
NT. 09.36	Selenium spectrometry
NT. 09.37	Mercury and flame atomic absorption spectrometry
NT. 09.41	Cyanogen
NT. 09.65	Natrium and kalium flame spectrometry
NT. 09.66	Natrium and kalium atomic absorption spectrometry
NT. 09.77	Chlorometry and silver nitrate
NT. 09.78	Sulfate and gravity measurement
NT. 16.21	B-coli and incubation
NT. 16.22	B-coli and excrement
NT. 16.23	Streptococcus and filtration
NT. 16.24	Streptococcus

2.3.2 Penal Provisions for Exceeding the Standard

(1) The following article is described in the law No. 88-91enacted in 1988.

Article 8: Individual and corporate establishment which cause environmental pollution and contamination are responsible for removing and reducing of environmental pollution and recovering waste.

Penal provisions are described as follows.

Article 11: Those who violate Article 8 are punished with a fine above 100 TD and not exceeding 50,000 TD. The court of justice can order the closing of the facilities. ANPE can also negotiate or compromise with those (individual or corporation) who violate regulations.

Accordingly, in case of exceeding the standard, there is no quantitative penal provision as to the amount of fine to be paid. Basically, the decision by the court of justice is required on each occasion.

(2) Decree No. 85-56 of "Regulations of Abandonment of Waste Water and Waste in the Environment" prescribes as follows.

Should waste water or waste exceed the quantity specified by the waste water quality standard, detention from three months to one year and/or fine from 100 TD to 1,000 TD are imposed.

2.4 Actual Implementation of Legislation

2.4.1 Promotional Measures for Environmental Protection

As to promotional measures for carrying out environment legislations, ANPE considers as follows.

(1) Those who caused pollution or contamination should bear costs for preventing pollution and removing contamination. Accordingly, when an enterprise carries out an environmental pollution control program, the Government or Local Government will not afford any partial financial assistance to the enterprise.

(2) However, if the Government approves the project of installing pollution control facilities in the factory, the following favors will be granted for an investment in environmental protection as promotional measures according to the law No. 88-91, Article No.7.

1) Exemption of custom duty to be imposed on the import of equipment, facilities and products required for pollution control

2) Exemption of sales tax to be imposed on the purchase of equipment, facilities and products manufactured in the country

3) A loan is offered to an investment on special terms from the Central Bank. (It is reported a loan is made at the rate of 8% interest instead of ordinary 12%-14% interest.)

4) The rate of depreciation is set to 25% per year for invest ments related to pollution control. (Usually, the period of depreciation covers 10 years, but it is shortened for investments in pollution control.)

2.4.2 Actual Conditions of Legislation for Facility Installation

(1) Since there is no emission standard to control exhaust gas emitted into the atmosphere, should exhaust gas containing SO2, NOx or black fumes be emitted, no penal provision can be applied to control it, although publicly commented on.

(2) As to waste water, its density is prescribed by the waste water quality standard in the Tunisian Standard. The system of the law, however, is formulated so that the standard value may be cleared without decreasing the total quantity of contamination if waste water is diluted. According to ANPE, factories diluting waste water will lose money, because the quantity of used water increases in case of dilution, and because such a system that the water rate becomes higher progressively as the quantity of water increases is adopted in ONAS and SONEDE.

However, a regulation for the total quantity of waste water is required for environmental protection.

(3) As to regulations for receiving waste water at ONAS, the standard value is prescribed by the Tunisian Standard, but the quality of waste water actually received by ONAS sometimes exceeds the standard value.

(4) Various benefits are prescribed as promotional measures related to environmental protection by law No. 88-91 as mentioned in section 2.4.1. However, as long as the replies obtained through our interviews in selected factories are concerned, all factories are in opinion that they must bear in principle the cost of pollution control facilities because no assistance is given by the country.

(5) A fine from 100 TD to 50,000 TD is stipulated in law No.88-91, but there is no provision for calculating the amount of fine, and it is required to determine the method of calculation in all occasions through judgment at the court of justice.

In order to solve this problem, ANPE is planning to formulate a classification proportional to the difference between the density of waste water and the standard value, and the quantity of waste water, and determine the amount of fine according to the classification.

(6) In establishing a new factory, the construction of facilities is approved only when no objection is raised by ANPE according to impact studies based on decree No. 91-362 enacted in 1991. Accordingly, environmental protection has been largely promoted compared with the time prior to enactment of decree No. 91-362.

3. Present Conditions of Water Resources and Future Prospects

3.1 Present Conditions of Water Resources in Sfax Region

(1) Ninety percent of city water in the Sfax region is supplied by SONEDE (city water company). Water is taken in Jelma and Sbeitla in neighboring Kasserine prefecture (located 200 to 250 km northwest of Sfax) and sent to Sfax. This water is used as drinking water and factory water. The remaining 10% is taken from ground water and rainwater, and no water is supplied from a dam.

(2) Along growing demand for living, agricultural and industrial water, the Tunisian Government is carrying out a project to supply water to Sfax from the northern part of Tunisia to reinforce the water supply capacity. Forty percent of residents in the Sfax region are not using city water but using rainwater or ground water for drinking.

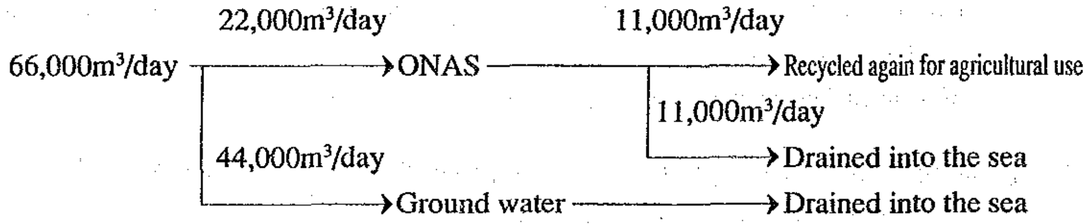
(3) The trends in the quantity of water supplied by SONEDE and the number of city water subscribers are shown in Fig. II-11. Both the diffusion rate of city water and quantity of supply water are increasing.

Table II-11 Trends in Quantity of Supply City Water and the Number of City Water Subscribers

		1985	1986	1987	1988	1989
SFAX 1 Inland area inside the canal	Quantity of water 10^3m^3/year	12,773	13,732	14,198	15,596	15,656
			7.5%	3.4%	9.8%	0.4%
	No. of subscribers	59,039	63,494	66,654	69,815	73,601
			7.5%	5%	4.7%	5.4%
SFAX 1 Seaside area outside the canal (Selected factories are included)	Quantity of water 10^3m^3/year	1,615	1,638	1,909	2,261	2,351
			1.4%	16.5%	18.4%	4%
	No. of subscribers	9,561	10,603	11,476	12,884	14,301
			10.9%	8.2%	12.3%	11%
	Total quantity of water	(14.388)				(18.007)

$$\frac{18.007}{14.388} = 1.25 \qquad \frac{25\%}{4} = 6.25\% \text{ per year}$$

(4) The quantity of water used in the Sfax region is about 66,000m³/day, and the flow of drainage is roughly described as follows.



(5) Selected factories in the Sfax region are using city water as their main source of water, and they are supplied with water enough for their demand. There is no problem at present as to the quantity of water supply.

Some factories are using well water for industrial use. There is no regulation for installing a well shallower than 50m. However, it is necessary to get an approval of the Prefectural Office to dig a well deeper than 50m.

3.2 Future Prospects for Water Resources in Sfax Region

(1) All of the selected factories in the Sfax region have no plan to expand their production facilities on a very extensive scale in the future. According to our survey, all factories think that no trouble will be caused in the supply of water unless the supply capacity of city water is decreased largely.

(2) Since Sfax is expanding in the fields of agriculture and industry as the second largest city in Tunisia as well as an increase in population, demand for living and industrial water is growing in recent years. Figure II-11 shows the quantity of city water supply increased 25% during the period of four years from 1985 to 1989, i.e. an annual 6.25% growth during the period. Should the demand for water continue to increase at the same rate in coming years, the total quantity of required water will be twice as much as the present quantity.

Supposing the annual growth rate is 4% in the future, the quantity of required water will be doubled in 20 years. Therefore, as long as the present conditions continue, it is anticipated that a serious problem will be caused in water resources.

4. Present Conditions of Air pollution

As mentioned above, Sfax is the second largest city in Tunisia and has a population of about 650,000 now, with annual population growth rate of about 2.2%.

Compared with other Tunisian cities, Sfax is more industrialized and active with production of olive oil and fertilizer - typical products of Tunisia. Traffic jam is seen in the morning and evening rush hours in Sfax City where business is very active. Almost all automobiles running in the city are of foreign make and old-fashioned because a high custom tax is imposed on automobiles imported from abroad. In Japan, switching from diesel-engine car to gasoline-powered car is going on because of air pollution control.

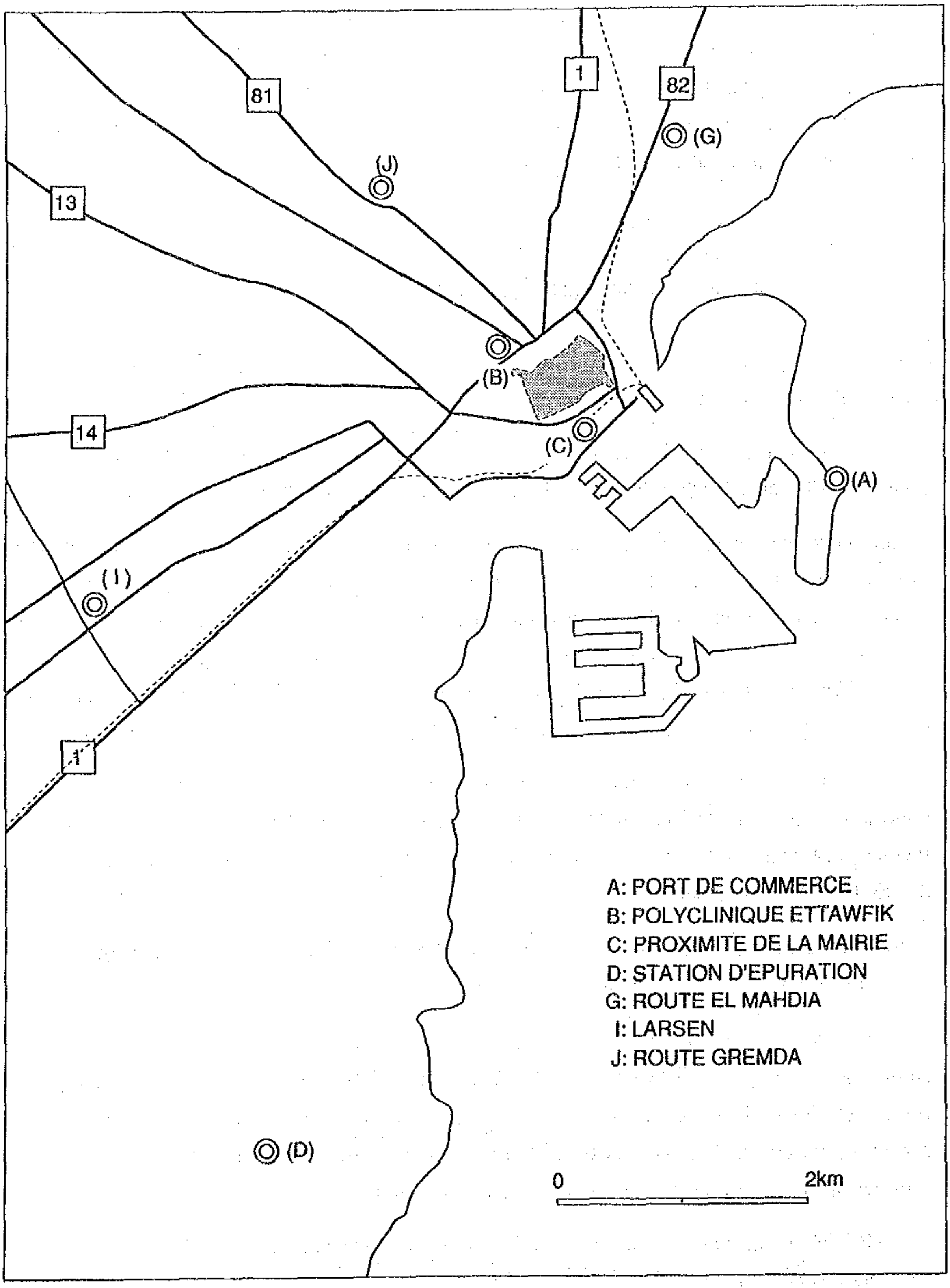
As we have seen, air pollution caused by industrial activities and exhaust gas from automobiles is more serious in Sfax than any other places in Tunisia. However, since no law has been legislated up to now for air pollution control in Tunisia, public organizations still do not have full information on air pollution at hand.

In autumn of 1991, the counterpartner of this study, LARSEN, started investigation on air pollution in Sfax City in cooperation with France.

LARSEN took samplings of air at ten locations in and around the city. Of these ten sampling points, seven locations are shown in Fig.II-3 below. Remaining three sampling points are located six to seven kilometers away from the midtown area. Collected air samplings will be analyzed partly by LARSEN and partly in France. The analysis of chlorine, chrome, iron, calcium, etc. has already been completed.

LARSEN seems to continue this activity, and when various kinds of data are analyzed, the conditions of air pollution in Sfax will be ascertained.

Fig. II-3 Sampling Point of Air Pollution



5. Present Conditions of Ocean and River Pollution

Phosphate rock treatment is one of the important industrial activities for the production of phosphoric acid and T.S.P. (triple-super phosphate) used for fertilizer.

A part of waste water containing acid and fluorine is drained from SIAPE factory into sea due to its industrial activities.

On the other hand, ONAS is draining waste water at a mean daily rate of 20,000 m^3 after primary and secondary treatments. A half of its waste water is used for agriculture, and the rest is abandoned to the ocean.

In the Sfax region, living water is drained to sewers, accounting for 30%, and the rest of waste water (70%) is drained through wells. As a result, the ground water zone is polluted, which seems to be flowing into the sea.

The sea along the Sfax region is polluted by waste water from factories, ONAS and wells. According to LARSEN, the following phenomena are apparent in this sea area.

- The turbidity of sea water is increased.
- A sea weed called "*posidonie*" disappeared.
- Fish called "rascas" is not found.

VOLUME III

PERSENT CONDITIONS OF SELECTED FACTORIES

VOLUME III PRESENT CONDITIONS OF SELECTED FACTORIES

1. SIAPE (Société Industrielle pour la Fabrication de l'Acide Phosphorique et d'Engrais)

1.1 Outline of Factory

SIAPE (Société Industrielle pour la Fabrication de l'Acide Phosphorique et d' Engrais) is a phosphatic fertilizer factory run by the government, with plant A and plant B located in Sfax city and three factories in Gafsa city. Phosphate rock, raw material for phosphatic fertilizer, is one of the materials most abundant in Tunisia and transported to the factories mentioned above by freight train from Gafsa city. On the other hand, sulfur is all imported in solid form from Canada, Mexico, Iran, Iraq, Poland, France and Saudi Arabia.

SIAPE was established in 1952, but SIAPE-B factory stopped producing sulfuric acid and phosphoric acid in 1988 according to a presidential decree due to environmental pollution. The factory continued producing TSP (triple superphosphate) after 1988, but it finally stopped the production of TSP in 1992. Accordingly, the object of the study on waste and recycling plan in Sfax city is limited to SIAPE-A factory. (Unless otherwise specified, SIAPE factory is identical with SIAPE-A factory.) The location of SIAPE factory is as shown in Fig. I-1.

1.1.1 Output

The output of each plant of SIAPE is as follows.

(1) Sulfuric Acid Plant

300 T/D x 1 train
750 T/D x 1 train

(2) Phosphoric Acid Plant

400 T/D x 1 train

(3) TSP (Triple Superphosphate) Plant

500 T/D x 1 train
600 T/D x 1 train

Annual production: 335,000 tons

1.1.2 Sales

Annual sales of entire SIAPE are US$300 million to US$350 million, and SIAPE is a Tunisian important source of obtaining foreign currencies. However, SIAPE is said to be suffering a loss since 1985. The main reasons for deficit are as follows.

(1) Rising cost of sulfur of raw material

(2) The unit price of TSP (triple superphosphate) has fallen, because the number of suppliers (Senegal, Morocco, Jordan, etc.) increased and USA has released its stock of TSP.

1.1.3 Number of Employees

As of April 1991, employees at SIAPE-A and -B factories totaled 786, while employees at SIAPE-A factory totaled 550. Since SIAPE-B factory was closed as explained above, SIAPE-A factory soaked up all its surplus labors. As of September 1992, however, the number of workers in each plant in SIAPE-A factory is as follows.

Sulfuric Acid Plant	:	26	
Phosphoric Acid Plant	:	41	(including those for Tabia)
TSP Plant	:	74	
Maintenance	:	190	
Total	:	331	

1.1.4 Factory Site and Layout of Facilities

The general drawing of SIAPE's factory site and the layout of major facilities are shown in Fig. III-1.

1.1.5 Future Plan

The future plan of SIAPE viewed from environmental pollution control is as follows.

(1) Sulfuric Acid Plant

To set up an element of "Brink Mist" to reduce acid mist from the absorbing tower.

(2) Phosphoric Acid Plant

1) To install a system to moisten phosphate rock at the inlet of the reactor to prevent dusting

2) To add facilities to scrub exhaust gas from the reactor

3) To install a recycling system of gypsum water

(3) TSP Plant

1) To install exhaust gas scrubbing facilities

2) To attach dusting prevention device to screening facilities

1.2 Present Conditions of Operation and Problems

1.2.1 Process Flow of Production

(1) Sulfuric Acid Plant

The process flow of the sulfuric acid plant is shown in Fig. III-2.

Sulfuric acid is produced in Monsant process and SCSA (single contact, single absorption) process. Sulfur delivered to the factory in solid form is melted in the melter and burnt in the furnace to be transformed into SO2. As shown in Fig. III-2, since combustion gas is processed in the SCSA process, the recovery rate of sulfur is lower as compared with that of the DCDA process, in other words SO2 is released into the atmosphere as exhaust gas. As far as the process is concerned, the object of environmental pollution is exhaust gas from the absorbing tower. No by-products are produced and waste water is not polluted processwise.

(2) Phosphoric Acid Plant

The process flow and the circulating water flow of the phosphoric acid plant are shown in Fig. III-3 and Fig. III-4 respectively.

Phosphoric acid is produced by a process originally developed by SIAPE. Basically, however, it is a dihydration wet process which digests phosphate rock with sulfuric acid produced in the plant. Supplied phosphate rock is ground to powder by a mill and sent to the process. Compared with other di-hydrate processes, more coarse grains (1mm or less) of phosphate rock can be used in SIAPE process. Accordingly, the process is more economical judging from grinding energy. On the other hand, it is lower in the yield of phosphate rock as compared with hemi-hydrate and di-hydrate process.

Fig. III-1 Plot Plan of SIAPE

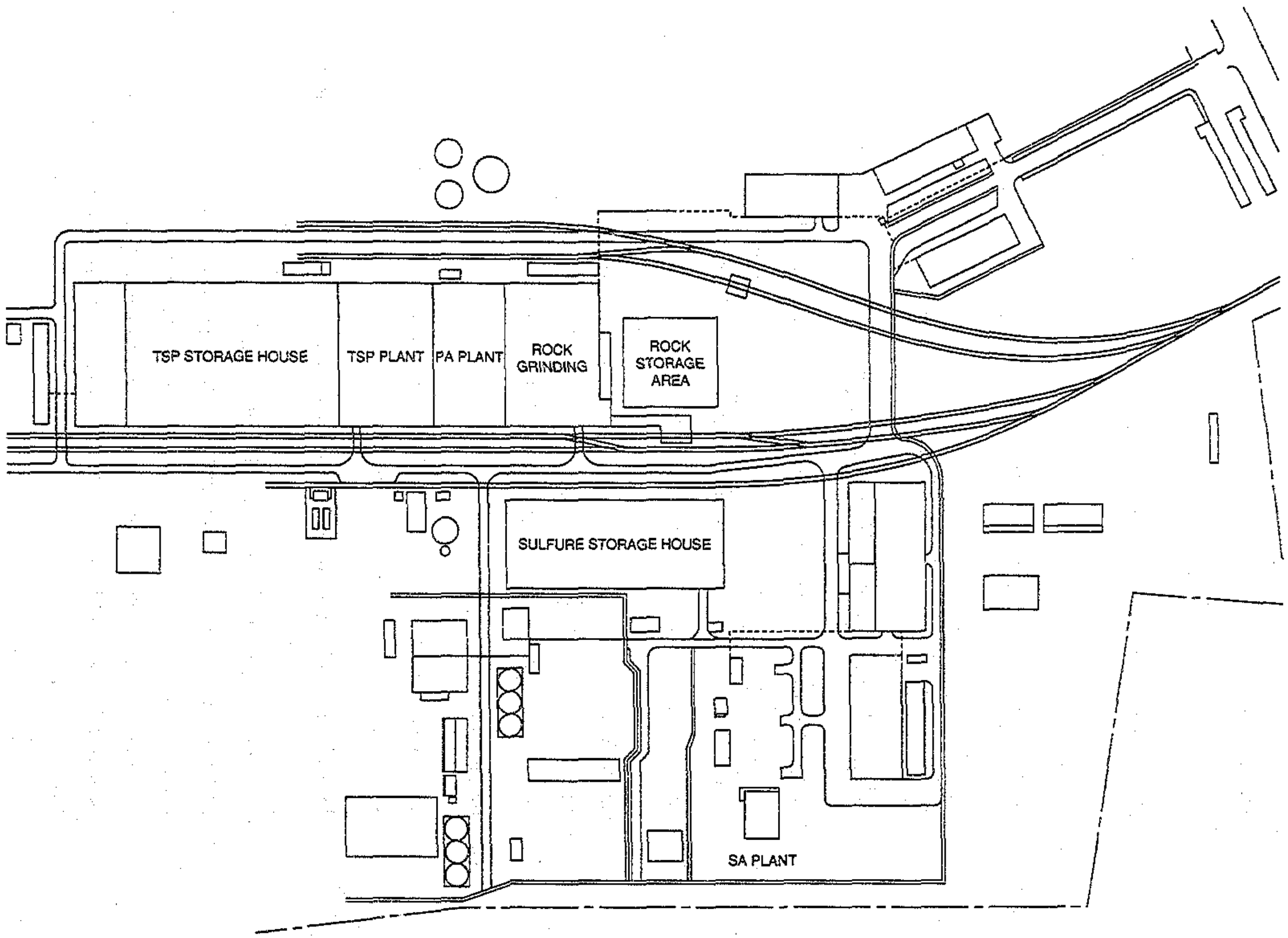


Fig. III-2 Process Flow of SA Plant

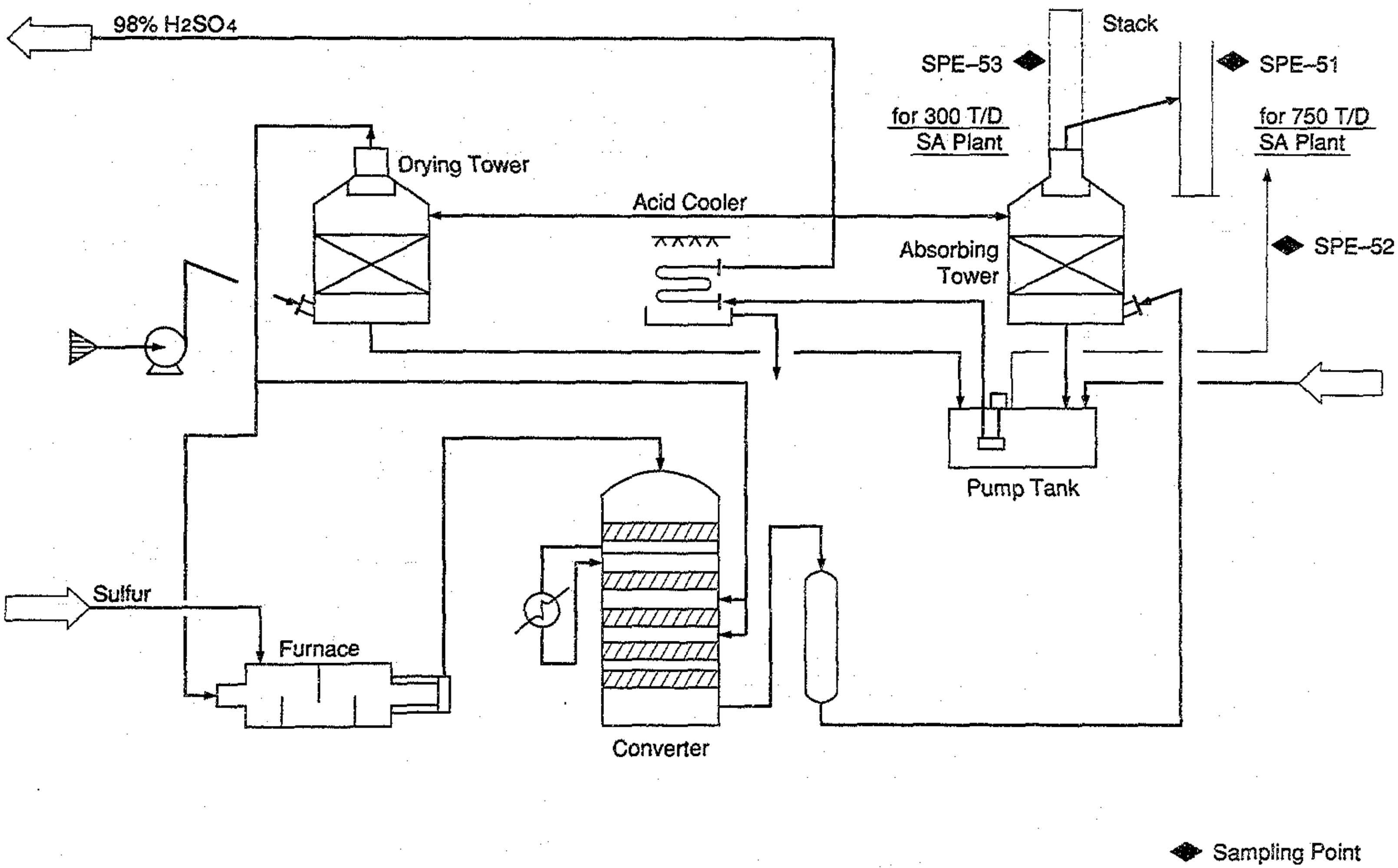


Fig. III-3 Process Flow of PA Plant

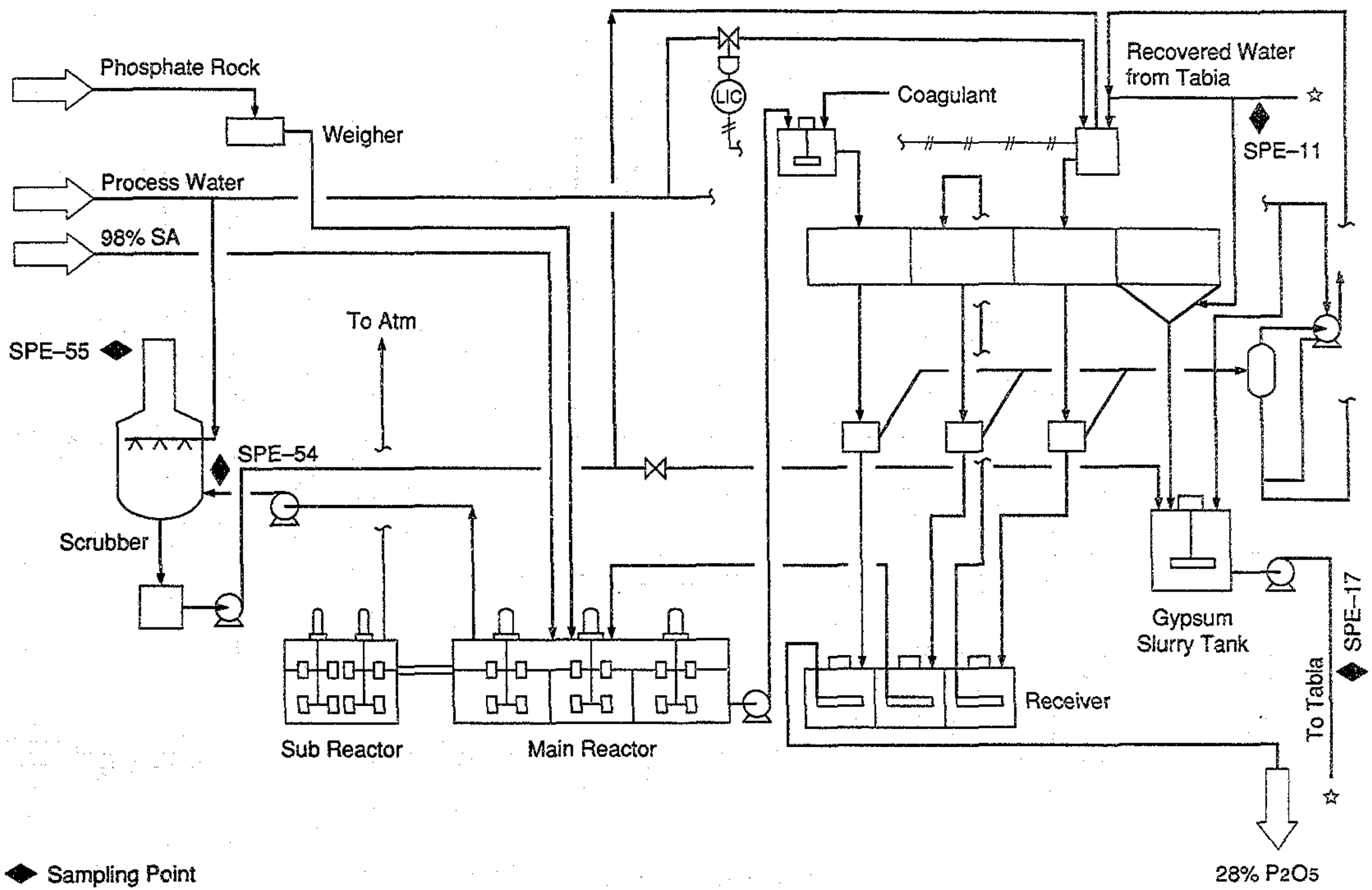
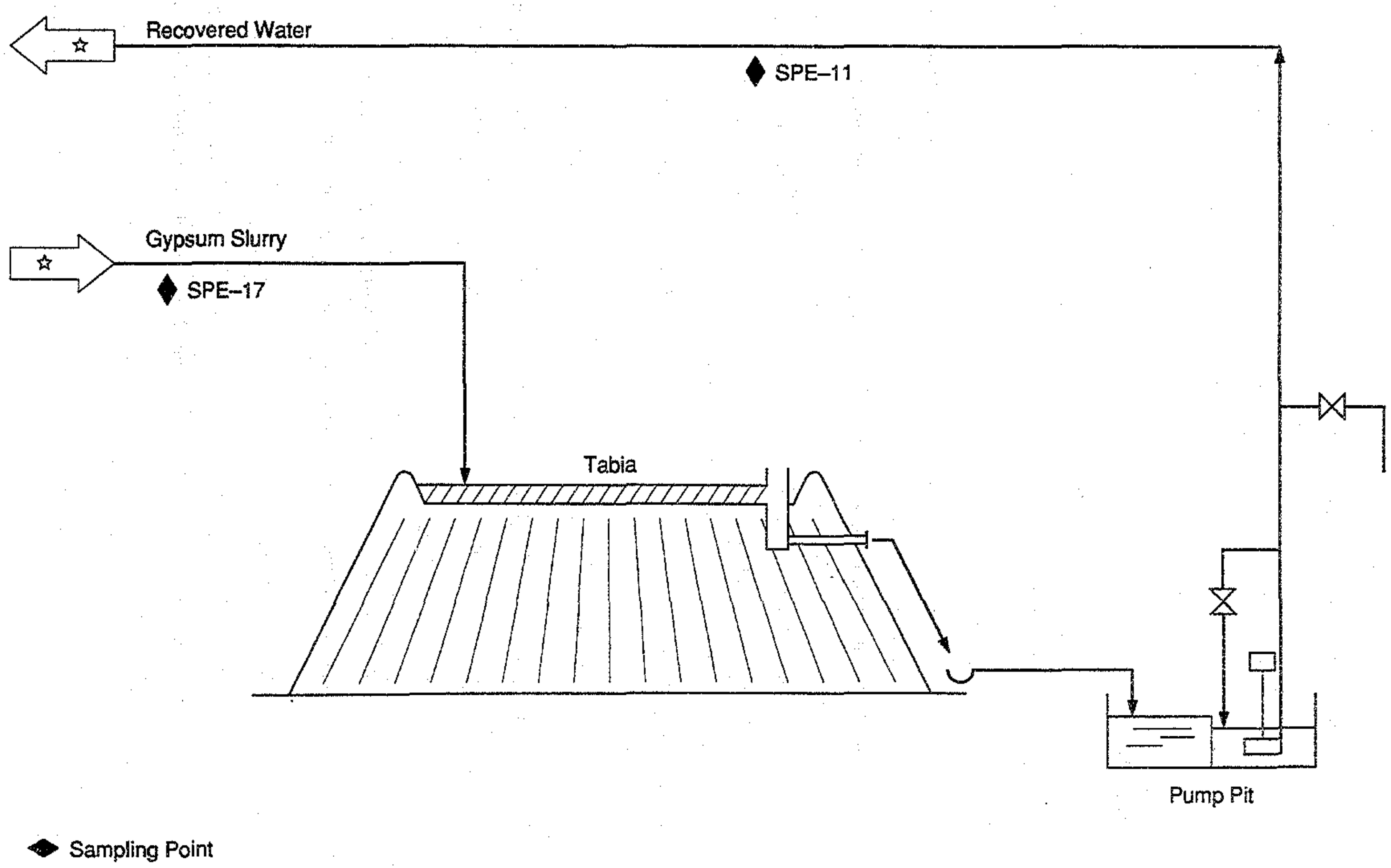


Fig. III-4 Circulating Water Flow of PA Plant



Gypsum produced as a by-product of wet process in the phosphoric acid plant is drained to Tabia as slurry with the aid of water. The objects of environmental pollution in the process are waste water from the scrubber, exhaust gas and impurities contained in gypsum. In case of SIAPE, water drained from the scrubber is recycled to the process and slurry of gypsum is drained to Tabia. At this time, since water circulates again, the drainage forms closed system under the operating condition in which water balance is kept.

(3) TSP Plant

The process flow and the exhaust gas flow of the TSP plant are shown in Fig. III-5 and Fig. III-6 respectively.

This process is a slurry process based on SIAPE process originally developed by SIAPE. Compared with other slurry processes, SIAPE process features no use of granulator, dual dryer functions for drying and granulating, and direct use of low-concentrated phosphoric acid (28% P2O5). The use of low-concentrated phosphoric acid indicates that the volume of water that can be taken into the process is limited because of a large content of water in phosphoric acid, supposing heat energy required for drying in the process is equivalent to those in other processes. In other words, there is a limit to digest the water to have been used for cleaning gas in the process. The objects of environmental pollution in the process are exhaust gas from the scrubber and waste water after gas cleaning.

(4) Exhaust Gas and WasteWater Treatment Facilities in SIAPE Factory

The process flows of production in SIAPE are as shown each. Particularly, the outlines of exhaust gas and waste water treatment facilities are described below.

1) Sulfuric Acid Plant

Exhaust gas from the absorbing tower in the sulfuric acid plant is not treated in particular but released from chimneys directly into the air.

2) Phosphoric Acid Plant

One unit of spray-type scrubber is installed to clean exhaust gas from the phosphoric acid plant not by chemical cleaning but by cleaning with process water (well water).

Fig. III-5 Process Flow of TSP Plant

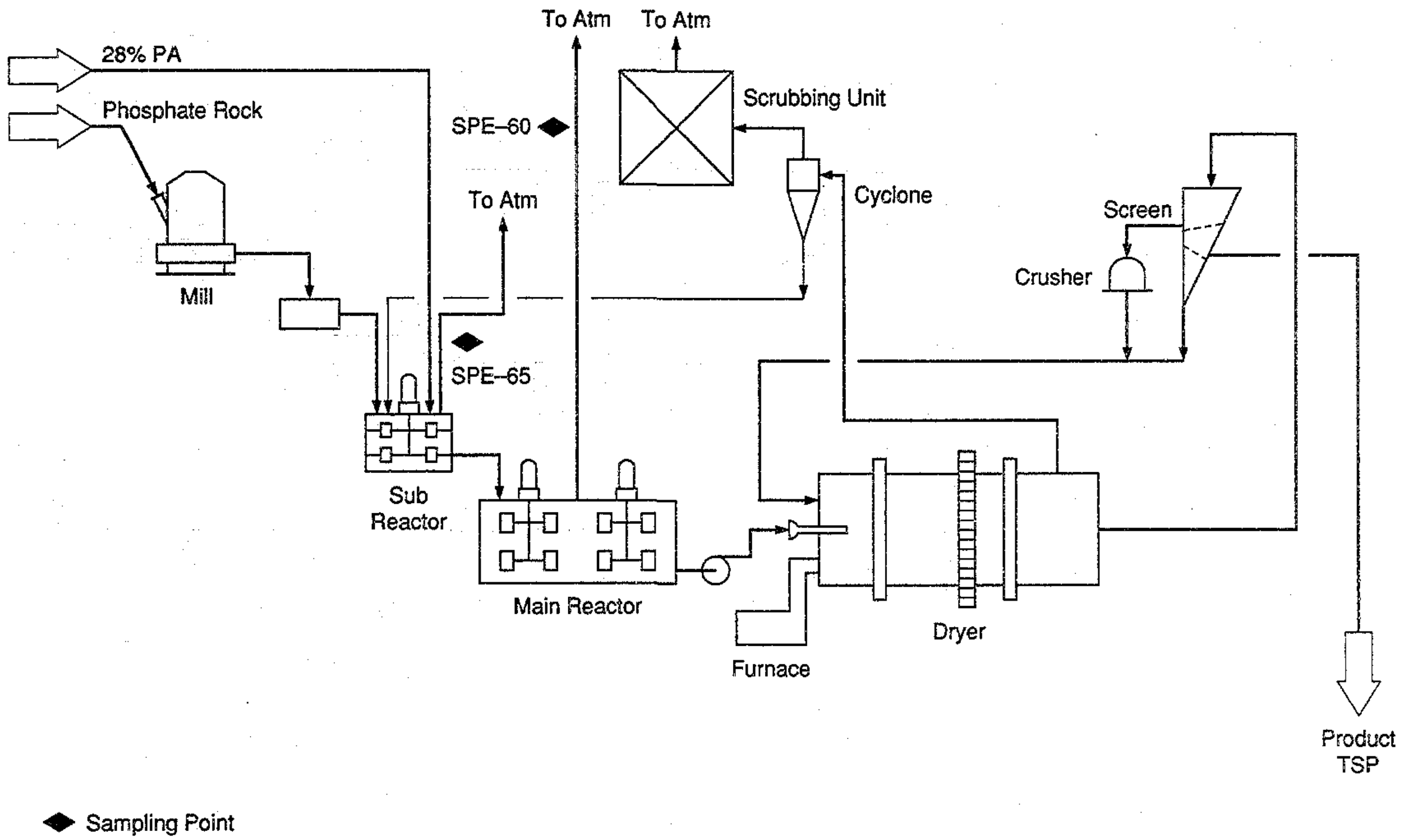
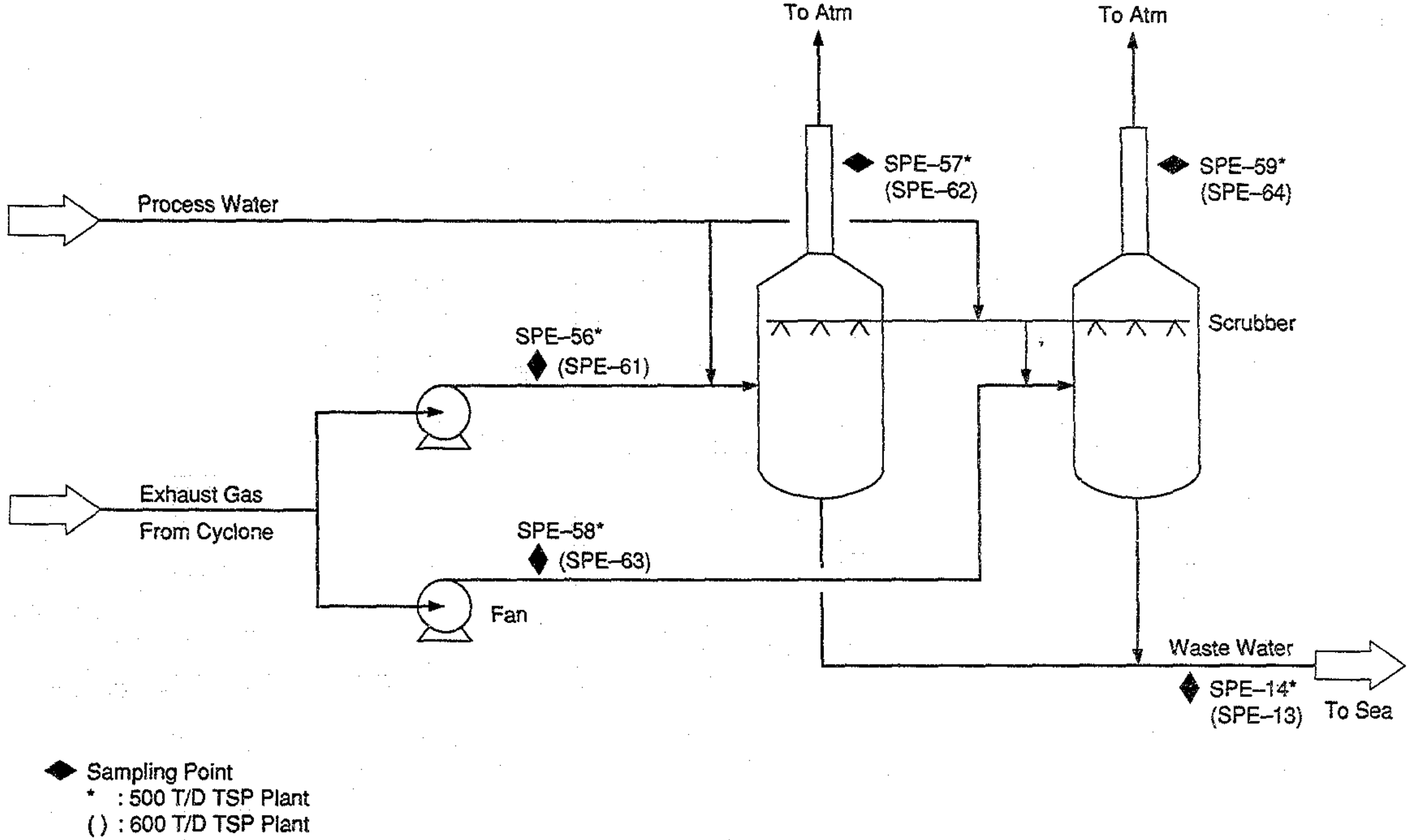


Fig. III-6 Exhaust Gas Flow of TSP Plant



3) TSP Plant

Exhaust gas from the TSP plant is treated each by two units of scrubber separately. Exhaust gas is cleaned only by single-stage treatment, that is, by the spray-system using process water (well water) as in PA plant, and not by the chemical cleaning system. On the other hand, waste water drained from the same scrubber does not remain in the process but drained into the sea.

4) As we explained above, exhaust gas and waste water which may become the objects of environmental pollution are treated partially, but not treated totally, and introduced pollution prevention facilities are rather simple.

1.2.2 Problems of Security and Working Environment

The facilities of SIAPE factory are outworn as a whole, and they have been repaired repeatedly. Each plant can increase its output to the level of full production, and there seems no matters that we must take into consideration as to the production process. On the other hand, however, there are some points which cannot be repaired easily along with the advancement of facility deterioration, and some facilities are still in operation under the conditions of gas, liquid and powder leakage. The present conditions of waste water and exhaust gas will be described later, but the problems of in-plant security and working environment of SIAPE factory are briefly described hereunder.

(1) Sulfuric Acid Plant

1) Sulfur in the form of powder is stored in the building. When stored in a building with a broken roof, sulfur dust is blown off from the broken roof and deteriorates the working environment. Sulfur is scattered or piled up on the ground around the storage building and the surroundings are not kept clean.

2) Leakage of gas from the top of the converter

3) Water is splashed on the electric circuits around the acid cooler.

4) Handrails of the steel structure around the absorbing tower are partly broken.

5) Almost all of safety covers of belts and coupling units of rotational machines are out of place.

6) Regulation for no smoking is very loose in the surrounding area of the sulfur storage house.

(2) Phosphoric Acid Plant

1) Location under worse working conditions due to phosphate rock dusting

- Around the wagon tippler
- Casing of backet elevator
- Connecting portion of each phosphate rock transport conveyers

2) The cover of rotator drive chain is removed.

3) Foreign matters lay scattered as a whole, and cleaning is not enough.

(3) TSP Plant

1) TSP which has been spilt from each TSP carriers.

2) TSP is piled up on the floor.

3) The safety cover of the heavy-duty fan is removed.

4) Dusting in the screening house

5) Dusting in the TSP warehouse

6) Dusting at shipping TSP

7) Broken handrail of steel structure

8) Untreated sludge

1.3 Present Conditions of Supply Water and Waste Water, and Problems

This section describes the present conditions of supply water and waste water and problems in SIAPE factory.

1.3.1 Present Conditions of Supply Water

The block flow sheet indicating the volume of supply water is shown in Fig. III-7.

Supply water is drawn from a deep well by pump and supplied to each plant. In SIAPE factory, a part of water contained in gypsum slurry is circulated and returned to the phosphoric acid plant from Tabia.

Fig. III-7 Block Flow Sheet for Supply Water & Waste Water of SIAPE

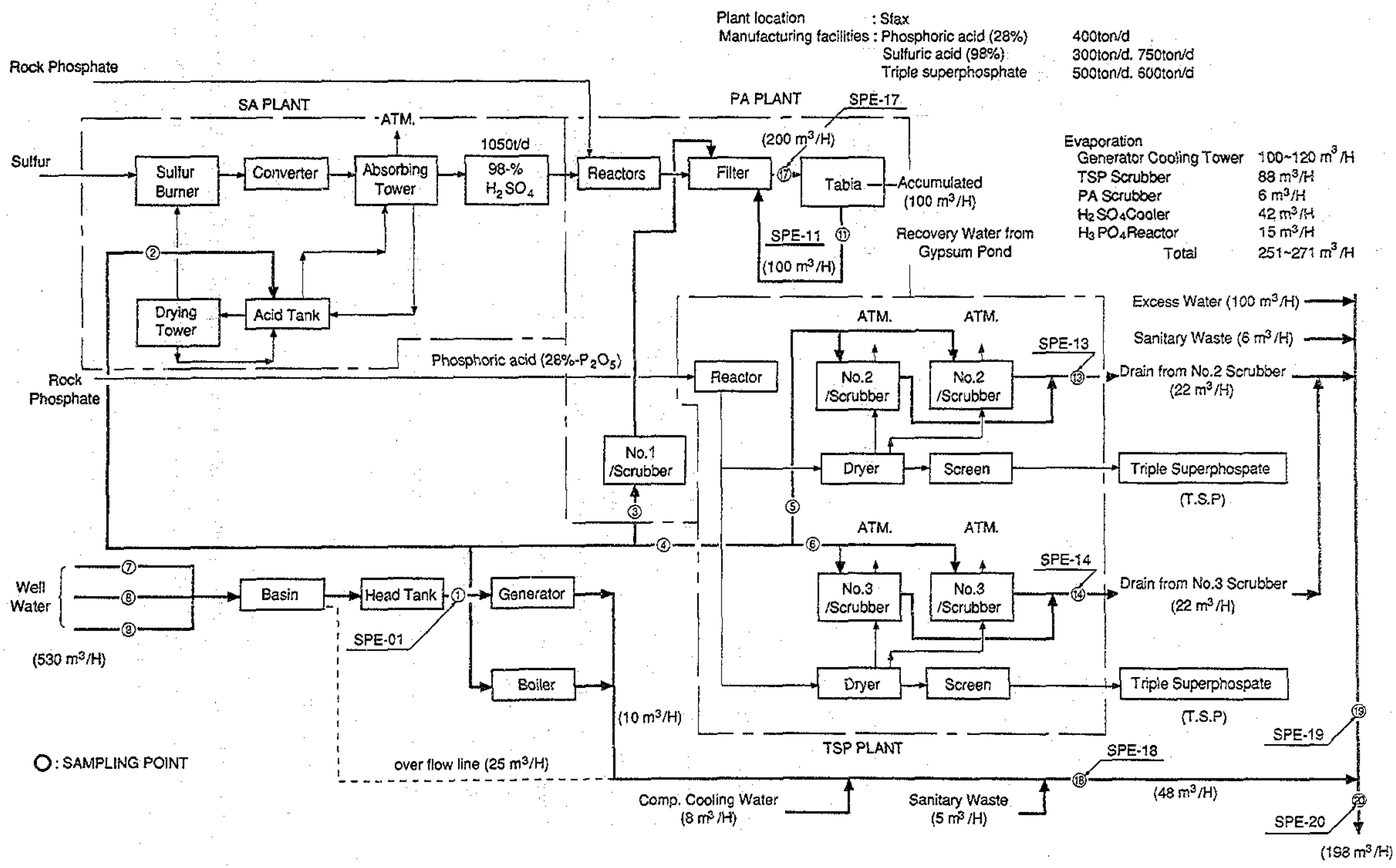


Table III-1 Balance of Water Supplied to SIAPE factory

		Volume of incoming water (m^3/hour)	Volume of outgoing water (m^3/hour)
Well water	:	530	
Volatileness	:		
- Cooling tower	:		100~120
- TSP scrubber	:		88
- Sulfuric acid cooler	:		42
- Reactor	:		15
- Phosphoric acid scrubber	:		6
Tabia	:		100
Waste water	:		198
Total		530	549~569

(Note) It is considered unbalance volume of water is probably due to the fact that no flow meter was used and the table is based on estimated values.

1.3.2 Present Conditions of Waste Water

The volume of water drained outside the factory, namely into the sea, is 198 m^3/h. The reason why we consider this drained water is polluted is that this water mainly comes from the scrubber in the TSP plant. And since the drainage channel is an open pit, it is considered that water used for cleaning the plant is one of the factors for pollution as it flows into the channel. Gypsum slurry drained to Tabia partly remains in it, partly recycled to the phosphoric acid plant and partly evaporates into the air. The influence of water remaining in Tabia has not been clarified in the field survey.

The result of water analysis at each sampling point is shown in Table III-2.

1.3.3 Problems

As compared with the Tunisian Standard, the result of each water analysis shown in Table III-2 indicates that items such as pH value, suspended solid, COD, F, SO4, total P, Cd and Fe exceed the Tunisian Standard as water quality. The followings describe the sources and causes of pollution.

(1) pH value

Materials handled in the factory include acid materials such as sulfuric acid, phosphoric acid and TSP, and it is considered a part of them is leaked or flowed out when cleaning the floors.

(2) Suspended solid material

In addition to handling solid materials such as gypsum and TSP, the entire factory is dusty, and drainage ditches are open. These are considered to be the reasons.

(3) COD

Some organic materials or materials of incomplete oxidation are considered to have been mixed.

(4) Fluorine and Total P

These are materials produced inevitably as long as the phosphoric acid plant is in operation.

(5) SO_4

The leakage from the sulfuric acid plant can be considered and also solution of SO_4^- such as solution of gypsum can be considered to be in existence in mixed condition.

(6) Cd

Cd is contained in phosphate rock (raw material for phosphoric acid) and natural sulfur, and they can be considered to be flowed out from the production process.

(7) Fe

The entire factory is handling phosphoric acid and sulfuric acid, and the existence of Fe can be considered due to corrosion.

Table III-2 Result of Water Analysis (SIAPE)

A. PRIMARY ANALYSIS

SAMPLING POINT	SAMPLING DATE	TURBIDITY	p H	CONDUCT'TY	S.SOLID	C O Dcr	B O D	n-HEX	D O
		ANALYSIS ITEMS(8)							
		deg.		ms/cm	mg/L	mg/L	mg/L	mg/L	mg/L
SPE-01	10/07/92	2	7.2	5.7	4	<6		5	1
SPE-01	15/07/92	13	7.2	5.5	5		1		1.4
SPE-11	10/07/92	130	2.0	22.0	82	190	--	3	4.5
SPE-11	15/07/92	51	2.0	19.9	29	120	--	4	3.7
SPE-13	10/07/92	30	1.2	48.0	10	240	--	16	3.5
SPE-13	15/07/92	6	1.3	38.7	2	240	--	4	3.5
SPE-14	10/07/92	2	1.1	59.0	3	350	9	3	6.8
SPE-14	15/07/92	6	1.2	57.7	4	270	--	9	2.8
SPE-17	10/07/92	>999	2.1	18.0	31000	8700	--	4	5.7
SPE-17	15/07/92	>999	2.0	19.5	210000	5400	2200	39	1.5
SPE-18	10/07/92	110	7.3	8.9	160	190	--	3	4.6
SPE-18	15/07/92	50	9.0	6.7	66	210	120	3	3.6
SPE-19	10/07/92	25	1.6	24.0	60	220	--	10	4.2
SPE-19	15/07/92	10	1.7	20.1	11	220	--	5	3.8
SPE-20	10/07/92	14	1.8	19.0	27	260	400	6	3.9
SPE-20	15/07/92	6	1.9	14.7	7	470	--	11	3.8

C. DAILY ANALYSIS SAMPLING POINT - SPE-20

SAMPLING DATE	SAMPLING HOUR	p H	CONDUCT'TY	S.SOLID	C O Dcr
		ANALYSIS ITEMS(4)			
			ms/cm	mg/L	mg/L
23/09/92	15:00	2.3	8.6	15	58
23/09/92	17:00	2.3	7.4	7	46
23/09/92	19:00	2.4	6.0	4	39
23/09/92	21:00	2.3	10.0	30	75
23/09/92	23:00	2.2	10.9	13	55
24/09/92	1:00	2.2	12.3	17	74
24/09/92	3:00	2.2	11.8	15	76
24/09/92	5:00	2.3	13.3	7	66
24/09/92	7:00	2.1	12.4	21	70
24/09/92	9:00	2.1	12.4	12	85
24/09/92	11:00	2.2	10.6	11	55
24/09/92	13:00	2.3	10.2	14	60

B. DETAILED ANALYSIS (SIAPE)

SAMPLING POINT		SPE-01	SPE-01	SPE-11	SPE-11	SPE-13-1	SPE-13-2	SPE-14-1	SPE-14-2	SPE-17	SPE-17	SPE-19	SPE-19	SPE-20	SPE-21
SAMPLING DATE		SEP. 14	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 14	SEP. 17	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 30
TURBIDITY	deg.	5	2	69	44	2	4	16		>999	>999	23	22	7	
p H		6.4	7.2	2.0	1.7	1.6	1.4	1.6		2.2	2.2	2.0	2.3	2.2	
CONDUCT'TY	ms/cm	5.7	5.4	21.1	27.2	36.4	39.5	32.6		13.9	14	17	9.3	12	
S.SOLID	mg/L	3	0	382	90	1		8	5.6	30400	247700	28	58	13	
C O Dcr	mg/L	54	8	77	5000	374	300	180	254	4500	4990	158	52	470	12
B O D	mg/L	31	2	220	-	268	30			10400		35	38		
n-HEXANE	mg/L	2	2	3	4	5	14		16	12		7	13	13	
F	mg/L	5.8	4.2	6500	5900	2900	6200	4900	9400	4700	4200	2200	480	550	
Cl	mg/L	1500	1300	1800	1700	4300	3300	3300	3900	1200	3600	5700	1700	1900	
SO4	mg/L	940	930	4500	9900	1100	1100	1100	1200	15000	5000	2100	1700	1500	
T-P	mg/L	0.1	0.1	3100	2500	130	98	92	110	2400	6900	1300	440	520	
T-Hg	mg/L	<0.0005	0.0014	0.0008	0.0007	<0.0005	0.001	0.0029	0.0022	0.0044	0.0018	0.0009	0.0011	<0.0005	
Ca	mg/L	94	99	190	170	76	53	50	48	180	180	110	110	92	
Cd	mg/L	<0.01	<0.01	0.68	7.9	<0.02	0.02	<0.02	<0.02	4.2	1	0.32	0.04	0.12	
Fe	mg/L	1.1	3.5	44	110	3.5	3.6	3.1	3.3	67	95	22	4.1	12	
T-Cr	mg/L	<0.05	<0.05	4.6	3.1	0.2	0.3	0.2	0.2	3.1	8.1	1	0.2	0.4	
Cr(VI)	mg/L	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Al	mg/L	<1.0													

1.4 Present Conditions of Exhaust Gas and Problems

1.4.1 Gas Exhaust Facilities

For the outline of gas exhaust facilities, refer to section 1.2.1 (4). This section additionally describes information offered from SIAPE.

(1) Outlet Gas from Absorption Tower of Sulfuric Acid Plant

			750 T/D plant	300 T/D plant
Design condition :	Volume of gas	:	95,000Nm^3/h	40,000Nm^3/h
Gas temperature		:	75°C	75°C
SO2		:	0.25vol%	0.25vol%

(2) Scrubber for Phosphoric Acid Plant

Design condition :	Gas treatment capacity	:	75,000 m^3/h
	Gas temperature	:	No Answer
	Material	:	FRP
	Cleaning method	:	Cleaning by spray Cleaning is done only by one pass.

(3) Scrubber for TSP Plant

Design condition :	Gas treatment capacity	:	150,000m^3/h
	Gas temperature	:	70°C
	Material	:	FRP Spray nozzle:UB6.
	Cleaning method	:	2-stage spray Cleaning is done only by one pass.
	Pressure loss	:	100 mm H2O
	Spray capacity	:	30m^3/h

1.4.2 Fuels

In SIAPE factory, heavy oil specified as follows is used for the dryer in the TSP plant and boiler.

Specifications of heavy oil used in SIAPE

LHV	:	9,700 kcal/kg
Sulfur content	:	3.0%
Water content	:	0.2%
Flash point	:	108°C
Kinematic viscosity	:	289.6 cSt (50°C)

Heavy oil consumed in the TSP plant weighs 70 kg/ton TSP. Exhaust gas is released from the scrubber outlet duct about 30m high from the ground.

On the other hand, the boiler facility features a capacity of 27.5 tons/hour (pressure: 27 kg/cm^{2}G, temperature: 410°C) and has four generators to supply power up to 5 MWH. When exhaust gas was measured at the factory, the operating load of the boiler was 15%, and fuel consumption at that time was 4 tons/hour. Exhaust gas was released from the 20m-high chimney.

1.4.3 Characteristics of Exhaust Gas

There is no definite description of standard values as to exhaust gas in Tunisian. Therefore, we set up our own standard values by reference to Japanese standard values. The details of reference values will be discussed in Volume IV.

Here, various kinds of data obtained through the field analysis are shown in Table III-3.

1.4.4 Problems

Exhaust gas from SIAPE factory was found out to be the one of worse quality by comparing the result of the field analysis with the operating conditions of Japanese factories. The direct cause is due to the incomplete gas treatment, but this section describes only the sources of air pollution.

(1) Dust

The type of dust for air pollution is considered to be fine particle handled in the various plants of SIAPE factory. In the phosphoric acid plant, phosphate rock and gypsum are handled. And in the TSP plant, TSP is handled and ash is produced by burning heavy oil.
These are considered to be the main components.

(2) SO_x and NO_x

SO_x and NO_x are exhausted from the TSP plant at where heavy oil is burnt and the sulfuric acid plant at where sulfur is burnt.

(3) F

Phosphate rock used in SIAPE factory contains about 2.8-3.4% fluorine. In the phosphoric acid plant and TSP plant where phosphate rock is used as raw material, fluorine gas is produced through reaction in each process, and it is partly exhausted into the atmosphere

Table III-3 Result of Exhaust Gas Analysis

FACTORY	SIAPE(H_2SO_4)				SIAPE(H_3PO_4)		S I A P E (TSP)		
SAMPLING POINT	SPE-51	SPE-52	SPE-53	SPE-53	SPE-54	SPE-55	SPE-56	SPE-57	
SAMPLING DATE	SEP/24/92	SEP/23/92	SEP/24/92	SEP/30/92	SEP/28/92	SEP/29/92		SEP/17/92	
FACILITY	750-ABSORB	CIRC.TANK	300-ABSORB	300-ABSORB	SCRUB.IN	SCRUB.OUT	TSP500-IN	TSP500-OUT	
FUEL	---	---	---	---	---	---	H.OIL	H.OIL	
GAS VOLUME									
ACTUAL m3/h	135000	300	41600	45600	75100	75200		76800	
WET GAS Nm3/h	107000	240	31100	34000	58800	58600		62200	
DRY GAS Nm3/h	107000	240	31000	34000	34800	34800		50300	
H_2O %	0.1	0.5	0.1	0.2	40.8	40.5		19.1	
GAS TEMP. °C	73	73	92	92	77	77		64	
CO_2 %	0	0	0	0	6.4	6.3		2.0	
O_2 %	9.2	18.1	11.7	12.6	19.8	20.0		18.6	
DUST mg/Nm3	770	700	230	110	30	60		290	
SOx ppm	4100	3300	2100	1620				220	
NOx ppm	11	<10	<10	<10					
TOTAL MIST mg/Nm3					47700	7000		---	
H_2SO_4 MIST mg/Nm3	250	630		140	700	170			
H_3PO_4 MIST mg/Nm3					40	22			
F COMPOUND mg/Nm3					3900	1510		154	
F MIST mg/Nm3					330	62			

FACTORY	S I A P E (TSP)								(BOILER)
SAMPLING POINT	SPE-58	SPE-59	SPE-60	SPE-61	SPE-62	SPE-63	SPE-64	SPE-65	SPE-66
SAMPLING DATE	SEP/18/92	SEP/18/92	SEP/16/92	SEP/14/92	SEP/14/92	SEP/15/92	SEP/15/92	OCT/21/92	OCT/28/92
FACILITY	TSP500-IN	TSP500-OUT	TSP-MAIN	TSP600-IN	TSP600-OUT	TSP600-IN	TSP600-OUT	TSP-SUB	E.G/BOILER
FUEL	H.OIL	H.OIL		H.OIL	H.OIL	H.OIL	H.OIL	---	H.OIL
GAS VOLUME									
ACTUAL m3/h	93100	64200	6300	119000	115000	121000	108000	3540	16700
WET GAS Nm3/h	63700	52900	5100	79900	84700	79800	85400	2960	10300
DRY GAS Nm3/h	50300	43400	4200	57900	61200	60900	64100	2610	9500
H_2O %	21.0	17.9	18.3	27.5	27.8	23.7	24.9	11.9	7.7
GAS TEMP. °C	130	58	66	138	98	145	73	53	169
CO_2 %	2.4	2.3	46.0	3.0	2.5	2.3	2.2	2.0	4.2
O_2 %	17.6	17.7	12.0	15.9	16.5	18.5	18.3	10.4	14.6
DUST mg/Nm3	580	310	890	1220	1110	580	1000	30	140
SOx ppm	400	260	1100	560	550	400	520	135	800
NOx ppm									108
TOTAL MIST mg/Nm3		1500			---		---		
H_2SO_4 MIST mg/Nm3									
H_3PO_4 MIST mg/Nm3		91							
F COMPOUND mg/Nm3	1850	130	33	1780	1250	1540	400	33	
F MIST mg/Nm3		64							

2. SNDP (Société Nationale de la Distribution du Pétrole)

2.1 Outline of Factory

SNDP factory is situated on the eastern coast of Sfax City, and occupies one part of the area around where the petroleum storage bases of ESSO, TOTAL and SHELL are located. SNDP was established in 1961, and additional facilities were set up in 1971. Oil is received from an oil tanker at the pier located in the southwest, several hundred meters away from the oil storage facilities, and is transfered to each oil storage tank through the pipeline. Since the same pipeline has been used for transferring different kinds of oil, the seawater used when changing the kind of oil has caused environmental pollution. For this reason, the construction of exclusive pipelines by kind of oil is now under way. Moreover, although flexible hoses are used for the connection of the tanker and pipe, it is said that the construction work for replacing them by loading arms has been started to be completed by the middle of the year of 1993. The conventional oil receiving piers were established by the above-mentioned companies separately, but once the exclusive pipelines are completed, each company will share them to use by kind of oil.

2.1.1 Kind of Product Oil and Storage Capacity

SNDP oil storage facilities in SFAX are handling the following six kinds of oil now, and total volume of oil products received in 1989 was about 460 million liters.

① Super gasoline

② Regular gasoline

③ Kerosene

④ Light oil

⑤ Household fuel oil

⑥ Heavy oil

The storage capacities of each kind of oil are shown in Table III-4 shown below.

Table III-4 List of SNDP Storage Tanks

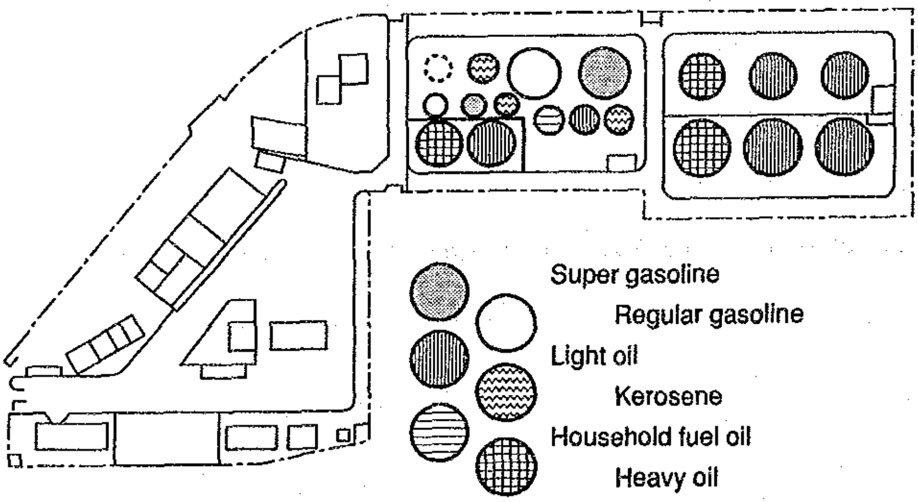
Kind of oil	No. of tanks	Capacity (m^3)
Super gasoline	1	125
Super gasoline	1	1860
Regular gasoline	1	125
Regular gasoline	1	1860
Kerosene	1	125
Kerosene	2	486 x 2 units
Light oil	1	3310
Light oil	2	486 x 2 units
Light oil	3	2170 x 3 units
Household fuel oil	1	486
Heavy oil	1	3310
Heavy oil	2	2170 x 2 units
Total	17	26699

Note: Household fuel oil means a mixture of light oil and heavy oil (98:2) which are blended in the oil storage facilities and stored in tanks.

2.1.2 Layout of Facilities

The layout of SNDP storage facilities is shown in Fig. III-8.

Fig. III-8 Plot Plan of SNDP



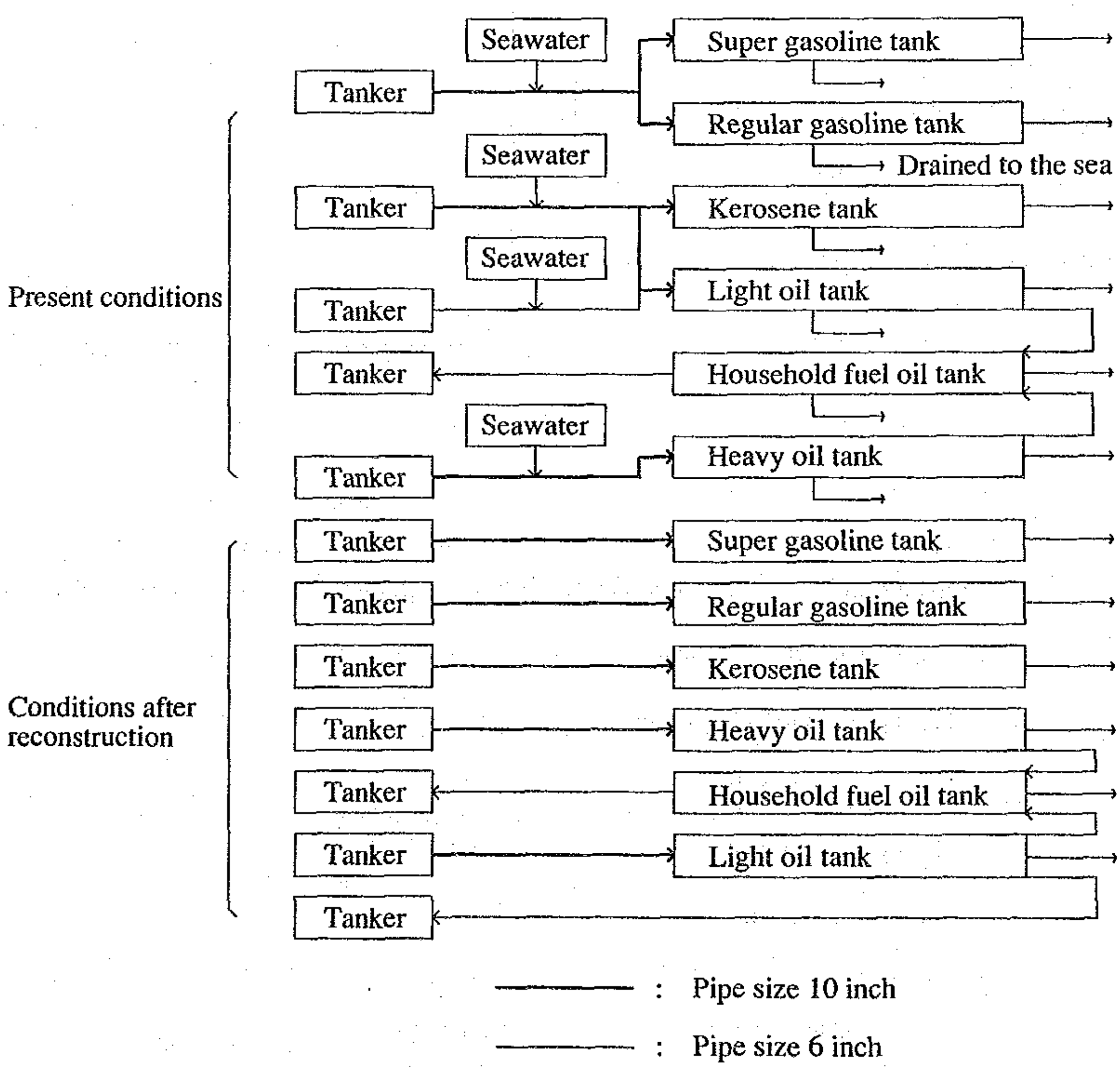
2.2 Present Conditions of Operation and Problems

2.2.1 Major Facilities

(1) Receiving Facilities

Reconstruction related to the receiving pipeline system is under way to rebuild the present multi-purpose pipelines into an exclusive pipeline to be used by kind of oil. The seawater used in pipeline for switching different kind of oil is no longer required when the construction is completed. Also the time spent for receiving oil can be significantly shortened.The present conditions and the conditions after reconstruction of the oil receiving pipeline system is completed are shown in Fig. III-9.

Fig. III-9 Receiving Pipeline System

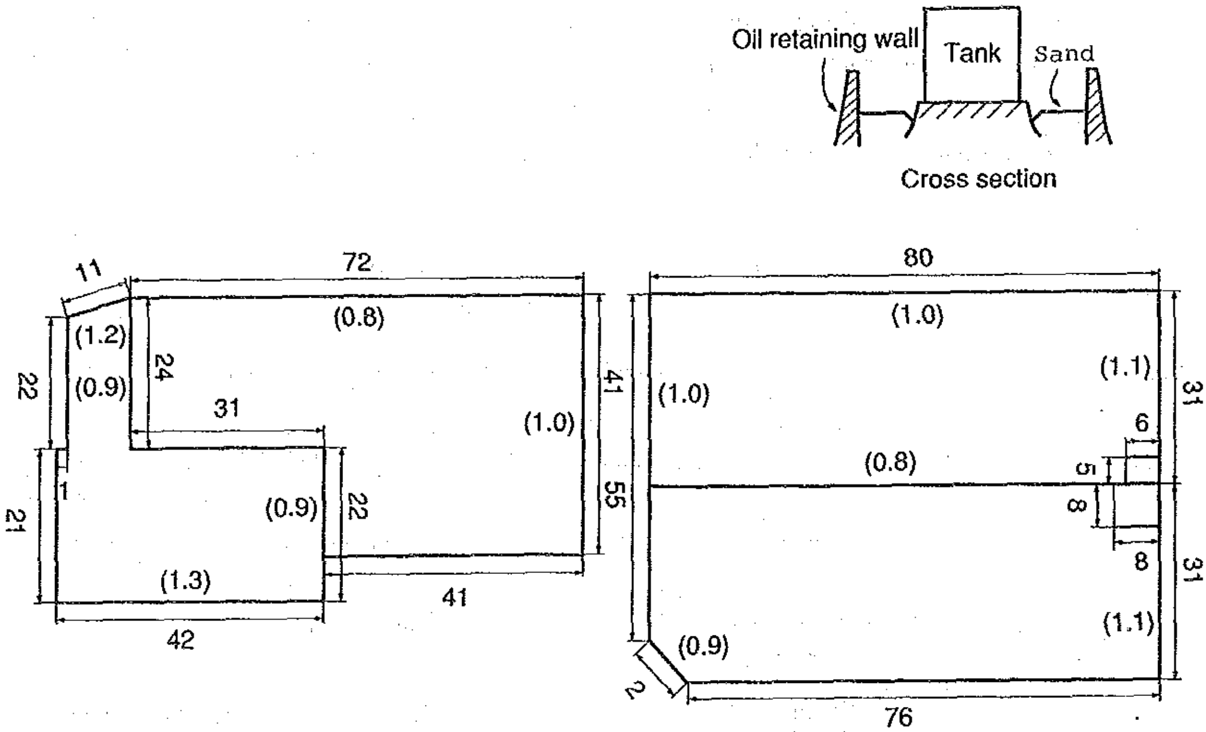


*Note: The seawater becomes not to be used usually.

(2) Oil Storage Facilities

As shown in Fig. III-8, the oil storage facilities are composed of 17 fixed cone roof tanks. Each tank is surrounded by the oil retaining wall indicated by Fig. III-10.

Fig. III-10 Dimensions of Oil Retaining Wall



(3) Pump Yard

In one area of each oil retaining wall, a pump yard is located, where oil transfer pumps are installed. The number of oil transfer pumps by kind of oil is as follows.

①	Pump for super gasoline	1 unit
②	Pump for regular gasoline	2 units
③	Pump for kerosene	1 unit
④	Pump for light oil	2 units
⑤	Pump for household fuel oil	1 unit
⑥	Pump for heavy oil	2 units
	Total	9 units

(4) Shipping Facilities

SNDP factory has shipping facilities for tank lorries and freight cars.

① Facilities for tank lorry: Facilities for 4 tank lorries

② Facilities for freight car: 1 set

(5) Oil Separator

SNDP factory is equipped with No.1 oil separator and No.2 oil separator.

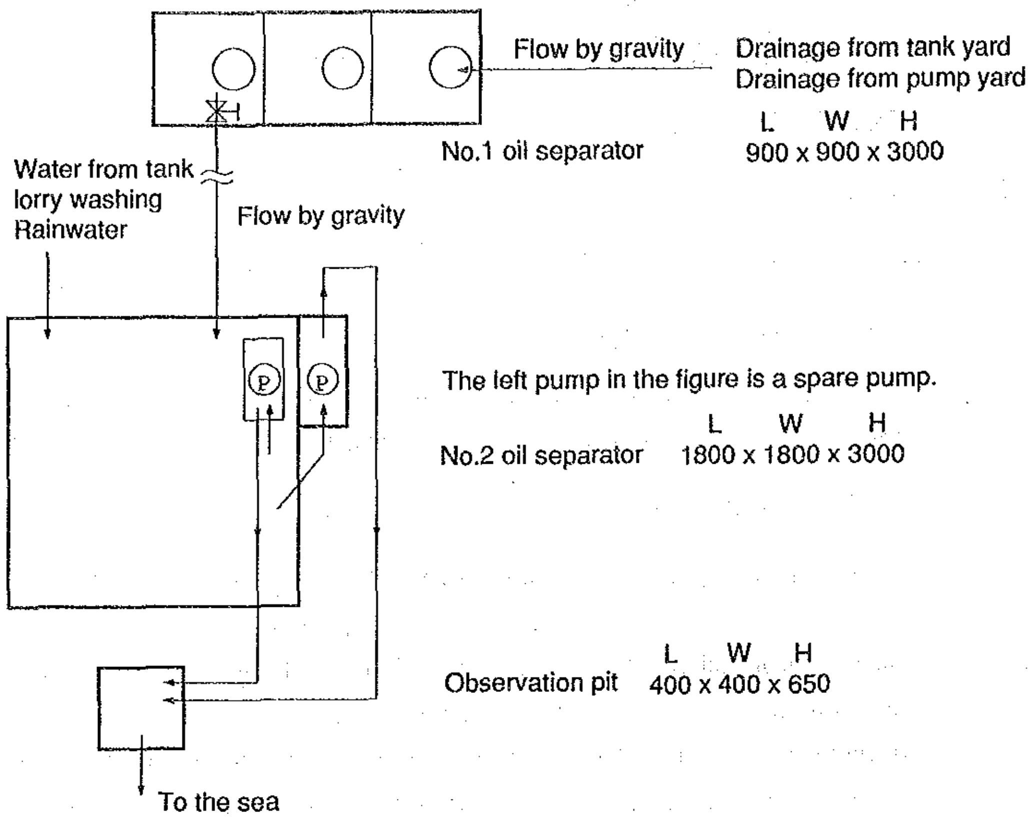
① No.1 oil separator: 1 unit

It is installed on the north side of the tank yard, and oily waste water in the tank and pump yard is conducted into this separator.

② No.2 oil separator: 1 unit

The No.2 oil separator is installed near the shipping facilities for tank lorry in the west side of the factory site. Primary separated waste water from the No.1 oil separator and waste water from tank lorry washing are received by the No.2 oil separator. Final waste water treatment is conducted here and treated water is drained into the sea. The No.2 oil separator is furnished with two pumps (20 m^3/hr-1 spare pump) to drain treated water. The oil separator is shown in Fig. III-11.

Fig. III-11 Dimensions of Oil Separators



2.2.2 State of Automatic Instrumentation

Receiving and shipping facilities and drainage pumps are partially automated, but they are mostly controlled by local instruments, and management by central control system has not yet been conducted.

2.2.3 Problems

(1) Since SNDP factory receives different kinds of oil through the same pipeline, the seawater is used in pipeline for switching different types of oil. That might be the main reason of oil outflow. However, now that the construction of exclusive pipelines by kind of oil is under way, the problem will be settled to a large extent.

(2) A construction work is going on to replace the flexible hoses used in connecting the tanker and the pipeline with loading arms. It will make great improvement over the leakage of oil. If new facilities which do not use seawater at all as mentioned above be completed, and if improvement in the operational method is fully achieved, the source of environmental pollution will be removed.

(3) Because SNDP factory stores a large volume of dangerous articles, the operation of facilities may be regulated by a fire law or any other laws related to storing petroleum. Various kinds of inspection may be conducted for keeping security in operation, but no record was found at the time of this survey.

2.3 Present Conditions of Waste Water and Problems

2.3.1 Source of Waste Water

The source of waste water are classified into four categories as follows. Items from (1) to (3) are the sources of pollution and the objects of treatment.

(1) Drain from Oil Product Tank

The following oil products are supplied to tanks.

1) Super gasoline

2) Regular gasoline

3) Kerosene

4) Light oil

5) Household fuel oil

6) Heavy oil

Above six kinds of oil are stored in 17 tanks. When products are supplied to the tanks, different kinds of oil are transferred through the same pipeline as shown in Fig. III-9.

Accordingly, after receiving one kind of oil is completed, sea water is used to extrude remaining oil in order to prevent the mixture of different kinds of oil and to increase the measurement accuracy of products received.

In the product tank, sea water is drained from the bottom of the tank into the open pit inside the oil retaining wall after certain hours to prevent the products from being mixed with sea water. This operation contaminates sea water with oil and it is becoming one of the causes for oil pollution.

(2) Rainwater in the Tank Yard

Rainwater in the tank yard is stored inside the oil retaining wall at first and then drained off. Drain from the product tank flows into the outside of the system through the open pit in the oil retaining wall. Since rainwater stored in the oil retaining wall uses the same open pit as for drain from the product tank, rainwater is polluted by oil.

(3) Rainwater in Oil Storage Facilities

Rainwater seems to be clean, but since different kinds of oil are handled in many places of the factory, it is polluted by oil.

(4) Drain from Pump Yard

Out of nine electric pumps for shipping oil products now in operation, two pumps used for heavy oil, have oil leaks because gland packings are used for these pumps. However, as this oil is received by recycle drum cans, it will not be the source of pollution.

2.3.2 Volume of Drain

Drain from the tank is flowing out at a rate of $9m^3$ in about three hours each time, and so the load to the oil separator is $3m^3/hr$. As to rainwater, its drain could not be calculated because there was no data on the ground space and intensity of rainfall.

2.3.3 Quality of Drain and Treated Water

Quality of water obtained in the field survey is shown in Table III-5.

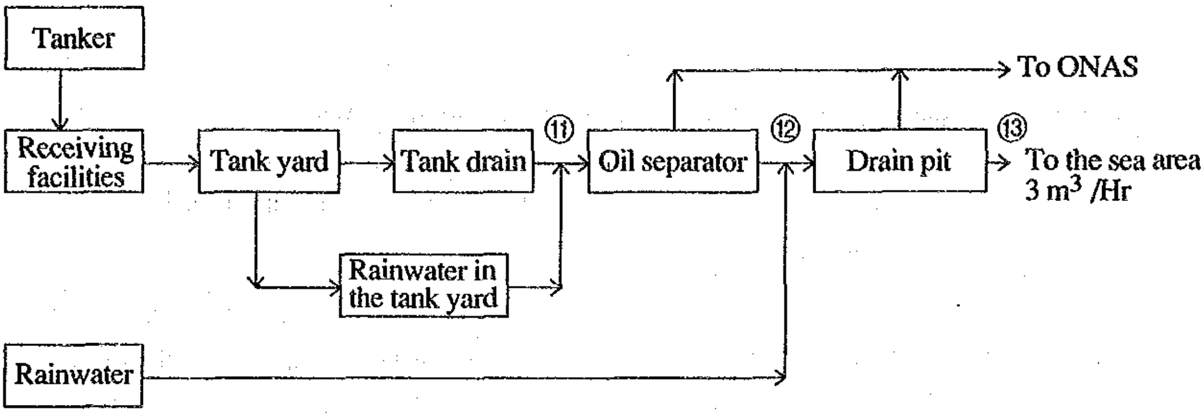
Table III-5 Result of Drain Analysis (SNDP)

Sampling point	Turbidity deg.	pH —	Electric conductivity ms/cm	Suspended solid mg/l	CODcr mg/l	BOD mg/l	n-Hexane Extract mg/l
⑪	79	7.9	62.0	60	240	290	60
⑫	72	7.3	51.0	20	550	140	34
⑬	63	7.4	57.0	10	510	150	57

2.3.4 Drainage System Diagram

The drainage system of SNDP factory is shown in Fig. III-12.

Fig. III-12 Drainage System Diagram



2.3.5 Problems

(1) Quality of Treated Water

Despite samples were taken in the dry season when no influence of rainwater is considered, CODcr, BOD, n-HEX extract, etc. exceeded the values defined by regulations of INNORPI. It is considered CODcr and BOD are partly caused by oil content but mainly by household waste water. SNDP facilities have been in operation for more than 30 years since they were established, so that entire oil storage facilities might be polluted by oil. When it rains, the holding time of waste water in the drain pit is shortened, and the quality of the drained water is more deteriorated.

(2) Treatment System

Water treatment facilities in SNDP factory are as shown in Fig. III-12 (Drain system diagram). Only the simplified oil separator built in 1961 is in operation, and its oil separating function is not effective. INNORPI regulation values will not be attained. To remove the extract of n-HEX, it is required to install APJ on CPI oil separators, and treat not only tank drain and rainwater in the tank yard but also oily rainwater in the entire facilities. There are no treatment facility of organic materials such as CODcr and BOD. Taking the source of waste water into consideration, septic tank must be installed in the household drainage system.