3. UPOTS (Union des Producteurs Oleicoles des Tunisie-Sud)

3.1 Outline of Factory

UPOTS is producing olive oil which is one of the main export items of Tunisia. Particularly, Sfax region is the center of olive production, and the number of olive oil factories in this region occupies 25% of Tunisia.

Olive oil is produced mainly for food but partly used for soap material and medicine. UPOTS was established in 1950 in cooperation with France, equipped with four crushers (capable of processing raw olives about 50 tons per day). In 1964, UPOTS became independent from joint operation with France and started management by itself, and at the same time UPOTS expanded its production facilities.

At present, seven crushers are in operation, with a production capacity of 100 tons/day (substantial output is about 75 tons/day), which is equivalent to an olive oil production capacity of 20 tons/day (substantial output is about 16 or 17 tons/day). The factory is run by a union and most of its output is supplied to ONH . When olive oil is extracted, Grignon frais (lees of olive), is produced as a by-product. It is sold to soap makers as a raw material for soap or it is made into refined oil. When olive oil is produced by a centrifugal separator, sludge called margin is separated. At present, there is no other way to treat it as waste and margin is carried to ONAS sewage treatment plant by tank car. However, ONAS is worried about the treatment of margin. Now ONAS stores it in the exclusive holding pond, but it is becoming a serious pollution problem. In the future, however, producers are duty-bound to treat wastewater, and it is inevitable for olive oil producers to take countermeasures seriously against pollution.

3.1.1 Products and Output

For the production of olive oil, raw olives must be processed in 72 hours after collection. UPOTS is now purchasing raw olives from farmers in the neighborhood to make olive oil. The volume of raw olives used in 1991 and the purchase price are as follows.

- Volume of raw olives used: 5,633 tons
- Total purchase price: 260,000 TD

Ordinary olive oil, high acid value olive oil and grignon frais are produced from raw olives, and output of each product and sales amount are shown in Table III-6.

Table III-6 Output of Olive Oil and Sales Amount

Product name	Output (1991)	Sales amount (1991)	Remarks
Olive oil	1,162t	1,536,000TD	The main analysis item of olive oil is acid value. Iodine number, color, methyl-ester reaction etc. are also measured.
High acid value olive oil	40t	15,600TD	Oil with acid value of more than 20
Grignon frais	2,519t	12,594TD	Water content is from 24% to 28% and oil content is from 8% to 9%.
Total		1,564,194TD	

The buyers of olive oil are categorized as follows according to the acid value.

1) Acid No. of 4 or less: Sold to ONH as food oil.

2) Acid No. of 4-20: Blended with other refined oil and sold to ONH as food oil.

3) Acid No. of 20 or above: Sold to soap factories as material.

3.1.2 Number of Employees

Olive oil is produced only in the harvest season of raw olives and its operating conditions are as follows.

① Production period : November - February (about 100 days/year)

② Operating time : 24 hours, 3 shifts

Under these operating conditions, employees including seasonal labors total about 200, and they are classified as follows.

① Administration Division : 5 (President, technical person, accounting, warehouse and foreman)

② Production Control Division : 21

③ Skilled workers : 2

④ General workers : 170 (including seasonal labors)

3.1.3 Layout of Facilities

In the UPOTS factory site of 8,739 square meters, a space of 6,739 square meters is actually used at present, and the remaining space of 2,000 square meters is used as an old abandoning area of margin. In 6.739 square meters, the building site occupies 1,000 square meters.

The overall layout of the factory and the location of facilities in the building for extracting process are shown in Fig. III-13. The major facilities, particularly those shown in the layout of facilities, are listed in Table III-7.

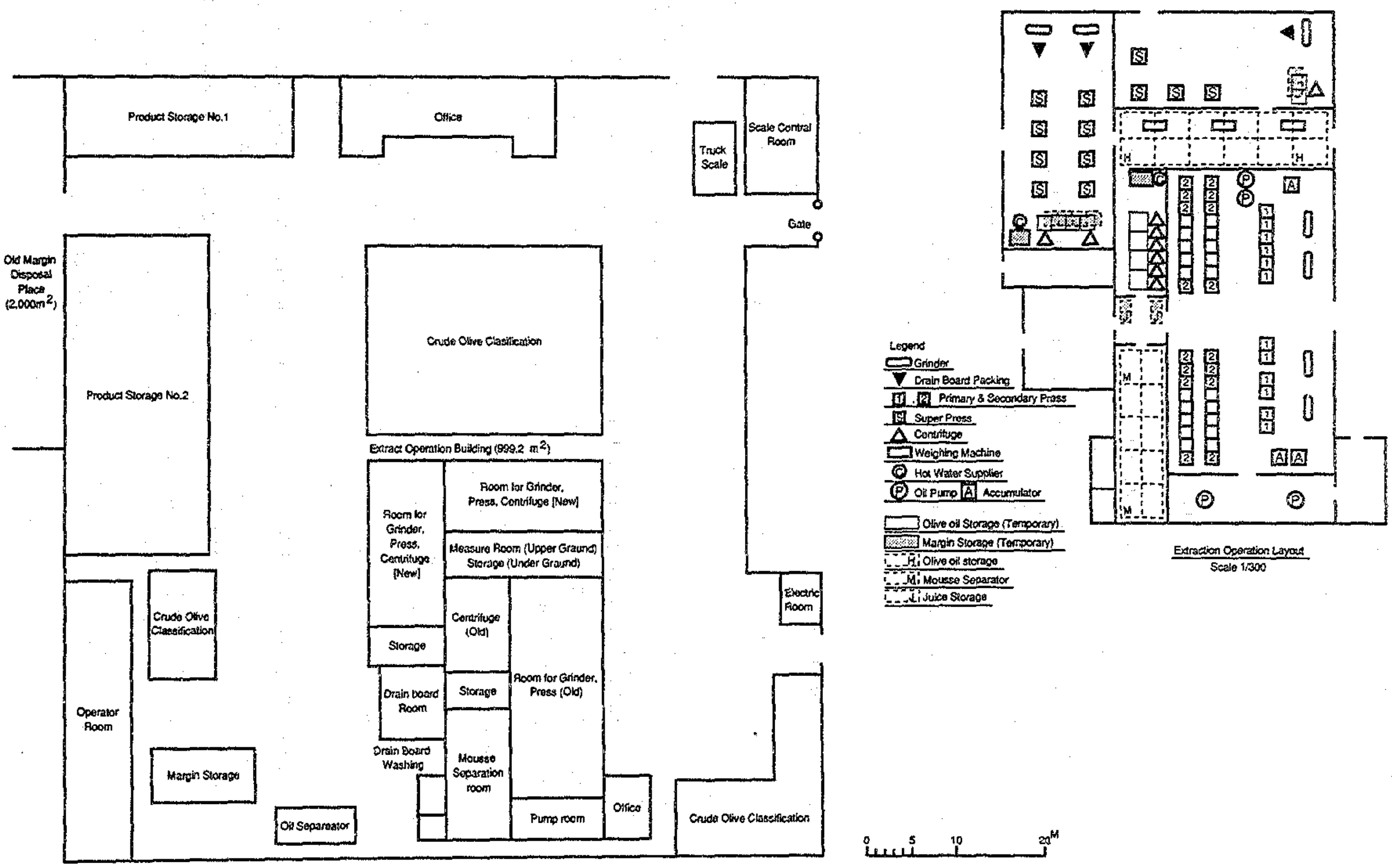
Table III-7 Major Equipment and Facilities

Equipment	No. of units	Specification
1) Crusher	7	Capacity: 700 kg/batch x 1 unit
2) Hurdle filler	3	Automatic type
3) Super press	12	Capacity: 300 kg/batch x 1 unit
4) Centrifugal separator	9	Disk separation type
5) Product tank		
Under ground tank	62	Total storage capacity: 1,550 tons
Ground cylindrical tank	11	Total storage capacity: 330 tons
Temporary reserving tank	12	Total storage capacity: 150 tons
6) Oil separator	1	Dimensions: 3.0 x 6.5 x 2.2(H)m
7) Margin reserving tank	1	Dimensions: 6.5 x 17.0 x 2.2(H)m

3.1.4 Future Plan

UPOTS factory does not have any special plan to invest in equipment and facilities in the factory, but it intends to establish a small-scale extracting factory in the place which connects the producing center of raw olives. However, its details have not been fixed yet. In the olive oil industry, the most serious problem is the treatment of margin, and it is urgently required to install new treatment facilities.

Fig. III-13 Plot Plan of UPOTS



3.2 Present Conditions of Operation and Problems

Raw olives, which are carried in from neighboring farmers, are weighed by truck scale and then classified by quality.

- Superior-quality olives (fresh olives taken directly from the olive tree): Green card
- Inferior-quality olives (olives fallen on the ground and collected): Pink card

The assortment warehouse can stock raw olives up to 300 tons, and rooms are partitioned for each contract farmers. It is desirable that raw olives are processed in 72 hours (three days) after collection. As the time passes, the acid value increases, and the quality of raw olive deteriorates. There are two production methods of olive oil in general—one is an extracting method and the other is a pressing method. This factory adopts the pressing method which applies physical pressure to raw olives to squeeze olive oil. Raw olives weighing about 6,000 tons are processed to produce 1,200 tons of olive oil.

3.2.1 Production Process

The production process in the factory is given in Fig. III-14, and its outline is as follows.

(1) Crushing

Raw olives are carried from the hopper in the open air to the crusher by workers. The volume of raw olives put into the crusher and water added is determined from experience according to the quality of raw olives. The crushing time varies according to the quality of olives.

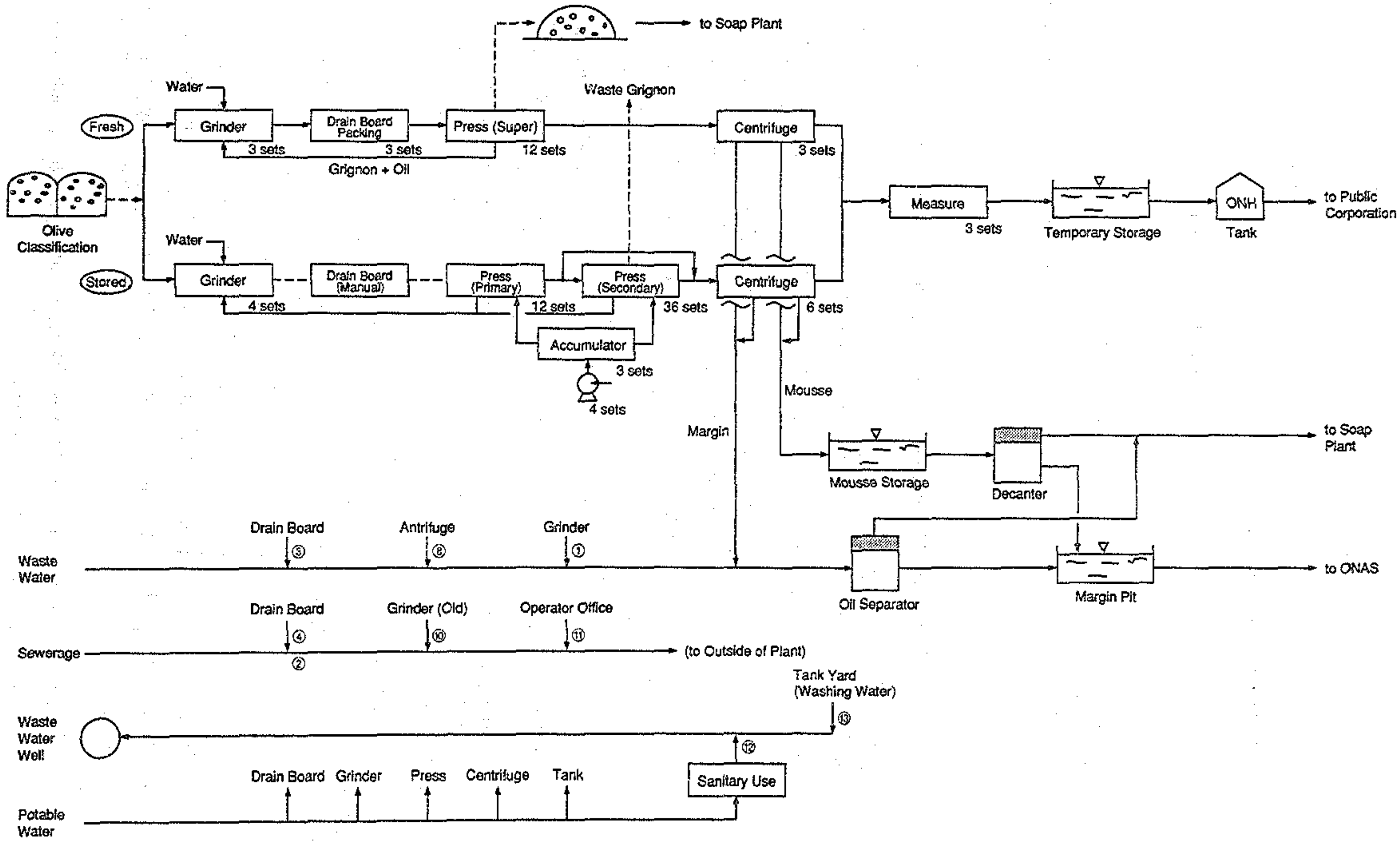
(Example)

Superior-quality olives: 500 kg → Crushed for 40 minutes

Inferior-quality olives: 300 kg + water (0-50%) (average 20%) → Crushed for 60 minutes

Superior-quality olives are processed in the old manufacturing process, while inferior-quality olives are processed in the new manufacturing process. Should superior-quality olives be processed after inferior-quality olives, caution for washing the related production line is taken to prevent the inclusion of inferior oil.

Fig. III-14 Process & Water Flow of UPOTS



(2) Filling Hurdle with Raw Olives

<New Process>: Automatic Hurdle Filler

The automatic hurdle filler weighs almost uniform volume of crushed olives and puts them evenly on the nylon hurdle.

Filling machine is washed in processing superior-quality olive after inferior-quality olive is processed.

<Old Process>: Manual Filling Hurdle with Raw Olives

Crushed olives are spread evenly over the hurdle made of "Alpha" (a kind of African gramineous grass) or nylon. Since nylon hurdle gives a smell of nylon, the "Alpha" hurdle is used in processing superior-quality olives.

To prevent new "Alpha" hurdles from absorbing oil, they are soaked in the water for 24-48 hours (in large or small soaking tanks). It is necessary to note that if "alpha" hurdles are soaked in water for a long time, water is spoiled. So, water should be changed in every operation. However, no change of water is required for nylon hurdles.

Nylon hurdles can be used for two or three years ("Alpha" hurdles can be used for five or six days only.) Normally, the hurdles filled with grignon frais (flees) caused by pressing raw olives are used again by removing grignon by tapping them with hands in the hurdle room.

Nylon hurdles are washed very rarely after olives with high acid value are processed. (Hurdle Washing). There is no washing process for "Alpha" hurdles.

A mixture of warm water and vinegar is used for washing hurdles.

(3) Pressing

<New Process>: Super-press

The hurdles loaded with crushed olives are piled up on the truck, a vehicle attached to the press.

A single operation can press crushed olives of 60 to 80 sheets of hurdles. About three to five kilograms of crushed olives are piled on one hurdle, and it is processed under a pressure of 350 kg/cm^2 for one or two hours. The super-press is equipped with an accumulator.

Oil attached to hurdles can be washed off by the shower (attached to the super-press), and collected as much as possible.

<Old Process>

The hurdles loaded with crushed olives are placed on the handcar prepared in the work house and set manually to the 1st press. After 1st pressing is completed, the hurdles are set manually to the 2nd press by use of handcar again.

Difference between the 1st pressing and the 2nd pressing is shown in Table III-8.

Table III-8 Difference between 1st Pressing and 2nd Pressing

	No. of hurdles to be processed	Processing pressure	Processing time	Amount of extract	Quality of extracted oil
1st pressing	About 40 sheets	160kg/cm^2	30-40 min.	90%	Superior
2nd pressing	35	220	3-4 Hr	10	Inferior

The presses used in the old process are not equipped with accumulator, and pressure is applied to each press from three accumulators.

Superior-quality olives are processed in a combination of old process and "Alpha" hurdle, and oil produced by the 1st pressing is best in quality.

The lees left on the hurdle are called "grignon" (oil content: 6-8%) and sold to soap makers as soap material. Grignon is added to olive juice remained at the bottom of the press to absorb it after pressing is completed, then it is recovered by being put into the crusher again.

Olive juice processed separately by quality is sent to different centrifuging processes through separate routes without causing a mixture of superior and inferior-quality olive oil.

(4) Centrifuging

Olive juice obtained from the pressing process is sent to the temporary storage tank via the oil collecting pit and supplied to the centrifugal separator by pump. Olive juice processed by quality is also separated in the centrifugal separator by quality.

A series of processes from crushing to centrifuging is divided into seven systems (three new systems and four old systems). Light-weight oil and heavy weight oil are separated by the centrifugal separator, and yellow-colored, light-weight supernatant oil is sent to the weighing room as product. The heavy-weight oil content (including oil, water, organic substances, etc.) is called "margin" and is supplied to the oil separator.

Olive product oil (about 30%) is produced from olive juice (100%) through centrifuging, and the rest (about 70%) is called "margin." The margin still contains about 5% of oil. When a centrifugal separator does not operate normally due to dirt or impurities or when processing olive juice of higher quality, it is washed with warm water.

The acid value of separated product oil is measured at the chemical laboratory of the factory. (Sampling is made from the temporary storage tank before the centrifugal separator.)

(5) From Weighing to Storage

Separated product oil is classified by quality, weighed by three platform weighing machines and stored temporarily in underground storage tanks (12 units) in the same room. Then it is supplied by pump to the storage tanks in another house controlled by ONH, and sealed. There is only one product oil feed pipe installed, so product oil is sent from the higher grade in order. After product oil is stocked in the storage tank, a layer of lamp oil (huile lampante) or piled oil (huile de pile) remains at the bottom of the storage tank. It is sold to soap makers as a raw material of quality soap (under the control of ONH). Water used for cleaning the storage tank is drained into drainage wells.

(6) Decantation of Mousse

After centrifugal separation is completed, a layer of foams containing comparatively a large volume of oil is produced (by the centrifugal separator) in the supernatant portion in the temporary margin storage tank, and it is called "Mousse."

Mousse foamed in the temporary margin storage tank is drawn up with bucket and supplied to the mousse separating tank. Keeping it still in the tank for several months (it is required to pass through the summer season), the oil content is sold to soap makers as high acid value oil, while the margin is stored in the margin pit and carried to ONAS by tank lorry.

(7) Oil Separator

The margin produced through centrifugal separation, and water used for cleaning centrifugal separators, crushers, automatic hurdle fillers are supplied to the oil separator. A small volume of supernatant oil collected by the oil separator which is partitioned into three tanks is sold to soap makers as high acid value oil. The margin is conveyed to the margin pit and carried to ONAS.

3.2.2 Outline of Incidental Processes

There are no large incidental facility, and the outline of incidental facilities is as follows.

(1) City Water

City water is used as living water and process water (water for washing machines is included.) 20 to 30m^3/Day of water is used.

(2) Margin Pit

The margin which is separated from acid oil in the oil separator and the margin separated through the mousse decantation are stored temporarily in the margin pit until they are carried to ONAS by tank lorry. Margin pit is the concrete rectangular pit with a capacity of 240m^3, and the margin can be stored there for about ten days.

(3) Drainage Well

Drainage wells are seldom seen in Japan, but they can be seen very often in Tunisia. Waste water (living drainage) which is comparatively less polluted is drained into wells. Waste water is expected to be purified under the ground.

3.2.3 Problems

(1) Process and Operation

In spite of a short period of production, a large number of people (compared with its output) are at work busily during the season. It may be inevitable, because almost all processes are batch-controlled and operated manually. There are some makers who adopted automated and continuous systems. They seem to be producing high-quality olive oil with a smaller number of workers (owing to the shorter time of exposure to the air and lower acid value). As to its flavor, however, olive oil produced by automated systems is said to be a little inferior-quality.

For this reason, some of the makers furnished with automated and continuous systems adopt a batch system at the same time. Besides the pressing method, the olive oil production method includes the extraction method (which is furthermore divided into solvent extraction method, enzymation method, etc.) and there are some makers which adopt the extraction method.

(2) Security and Working Environment

UPOTS factory is furnished with a number of stone mill type crushers, presses, and other machines with exposed movable parts. Safety devices (such as protection nets and safety switches) are not provided thorughly and adequately for each machine.

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

There are about 55 million olive trees planted in Tunisia, and the space of all olive farms (about 1 million to 1.4 million hectares) accounts for one third of entire cultivated land.

One million people accounting for about 20 to 30% of all agricultural population are engaged in olive plantation and related works. Total number of working days is from 20 million to 25 million days, and the sales of olive industry accounts for 40% of all exports of agricultural products. The yearly output of raw olives are 500 thousand tons, and the yearly output of olive oil is 100 thousand tons. Because of this, margin is produced 200 thousand to 300 thousand tons yearly (according to ONAS, 1990). The production quantity of olive oil and discharged volume of margin in Tunisia are shown in Table III-9.

Table III-9 Production Trend of Olive Oil and Margin

(Unit: 1,000 tons)

	Olive oil	Margin
'84~'85	95	194
'85~'86	105	215
'86~'87	120	245
'87~'88	95	194
'88~'89	58	119
'89~'90	110	225

On the other hand, the number of olive oil factories is over 1,000, and the location and number of these factories are shown in Table III-10.

Table III-10 No. of Factories in Each District

	District	No. of factories
North Tunisia	Tunis	3
	Ariana	16
	Ben Arous	12
	Bizerte	18
	Béja	19
	Jendouba	10
	Le Kef	7
	Siliana	14
	Zaghouan	21
	Nabeul	51
	Sub-total	(171)
Central Tunisia	Sousse	182
	Monastir	163
	Mahdia	152
	Kairouan	72
	Ksserine	9
	Sub-total	(578)
South Tunisia	◎ Sfax	244
	Sidi Bouzid	35
	Gafsa	26
	Gabès	10
	Mednine	87
	Sub-total	(402)
	Grand total	1,151

It is generally considered that adding water (30) to raw olives (100) produce olive oil (20), grignon (lees) (40) and margin (70).

The margin contains water (83%), organic substances (15% such as oil, carbohydrate, etc.), and non-organic substances (20% such as K^+, N^+, etc.) Pollution indexes are roughly as follows.

COD: 60,000 - 90,000 mg/*l*

BOD: 20,000 - 30,000 mg/*l*

SS: 1,000 - 5,000 mg/*l*

Oil: 1,000 - 10,000 mg/*l*

The margin contains a high percentage of them, and it is not appropriate to drain the margin into the public water areas or scatter it over the soil.

In short, environmental pollution caused by the margin is calculated tentatively to be equivalent to the living drainage of 4 millions people.

3.3.1 Present Conditions of Supply Water and Waste Water

(1) Volume of Supply Water

The volume of raw olives processed in UPOTS factory was 5,633 tons in 1991 fiscal year, i.e. daily from 80 tons to 90 tons. The output of olive oil was 16 or 17 tons daily.

The pressing method (batch processing) is adopted for the production of olive oil, but it is not so complicated. City water is considered to be the only one as utility except electricity. The required volume of city water accounts for 20 to 30% of raw olives used (depending on its freshness), and water to be mixed with product is calculated as follow.

$$(80\text{-}90 \text{ tons/day}) \times (20\text{-}30\%) = 16\text{-}27 \text{ tons/day}$$

Including water for washing machines, living water, etc., the total required quantity of water is from 30 tons to 60 tons daily, i.e. 40 tons/day on the average.

(2) Volume of Waste Water

The ratio of margin waste water to olive is 70 to 20 in condition after olive pressing is completed.

Therefore,

$$(16\text{-}17 \text{ tons/day}) \times \frac{70}{20} = 56\text{-}60 \text{ tons/day}$$

The volume of margin waste water on average is considered to be about 60 tons daily.

Other than margin waste water, water used for washing machines and living drainage are included in waste water, and only the margin waste water is carried to ONAS. Accordingly, our study was directed to the margin waste water.

3.3.2 System Diagram of Supply Water and Waste Water

The system of supply water and waste water is shown in Fig. III-14 above.

UPOTS factory has three drainage systems.

1) Margin waste water is carried to ONAS by tank lorry.

2) Living drainage is drained into wells for drainage.

3) Water used for washing machines is drained to ONAS by drainage ditch.

Margin waste water is drained to the outdoor oil separator (3 x 6.5 x 2.2 (H) m, 43 m^3, 3 rooms) via temporary margin storage tanks (four places) in the extracting plant. The oil content is separated in the outdoor oil separator.

The water content is drained to the margin pit and carried to ONAS by tank lorry, while the oil content is sold to soap makers.

3.3.3 Quality of Margin

The margin is characterized by a high concentration of contamination containing poly-phenol content and a large quantity of potassium salinity.

The margin is black and formed like tar in the storage pond, and it appears black while stored in the ONAS' solar pond, and its surface is covered with high-viscosity, thick oil film (10-15 mm thick). The margin under the oil film is protected by the film and evaporates slowly. It will take about then years before the margin is dried.

The margin changes into grains and is easy to handle when it is dried completely. The quality of margin is said to be varied exceedingly depending on the factory or the time it is produced.

It is very difficult to define reference values for the quality of margin. They are roughly defined as follows by studying some documents (out of several hundreds of documents). The values quoted from these documents are shown in Table III-11.

PH	5	Polyphenol content	5,000-10,000mg/*l*
COD	60,000-90,000mg/*l*	K+	3,000-10,000mg/*l*
BOD	20,000-30,000mg/*l*	T-P	500-1,000mg/*l*
SS	1,000-5,000mg/*l*	T-N	1,000-2,000mg/*l*
Oil content	1,000-10,000mg/*l*	Ash content	5,000-15,000mg/*l*

Table III-11 Quality of Margin in Various Documents

	• Document No. • Author • Year, Country • Remarks		① Hartmann, L. '84 Italy	② Catalano, M. '85 Italy	③ Vigo, F. '90 Italy	④ '92 Tunisia	⑤ Tunisia	⑥ Ranalli, A. '91 Italy Pressing	⑦ Ranalli, A. '91 Italy Continuous	⑧ Aveni, A. '84 Italy	⑨ Fiéstas, J. A. etc. '80 Espanish Pressing	⑩ Fiéstas, J. A. etc. '80 Espanish Continuous	⑪ Pietro, C. etc. '88 Italy	⑫ Annesini, Mc. '83 Italy	⑬ Bradley, R. M. etc. '80 Italy Pressing	⑭ Bradley, R. M. etc. '80 Italy Continuous
Basic Index	• PH	—	5.5	5.0	4.8		5.2			5.4	4.5 ~ 5.0	5.0		4 ~ 5	4.9	5.0
	• COD	mg/ℓ	58,640	160,000	41,800	300,000	196,150	148,000	85,100	110,000 ~ 150,000	120,000 ~ 130,000	40,000	100,000 ~ 150,000	50,000 ~ 100,000	92,800	60,000
	• BOD	mg/ℓ	15,600	40,000	13,800	50,000 ~ 100,000	75,000	67,100	39,800		90,000 ~ 100,000	33,000	30,000 ~ 60,000	40,000 ~ 50,000	29,200	18,600
	• Oil	mg/ℓ	23,400	1,800		1,000 ~ 30,000					300 ~ 10,000	10,000	2,000 ~ 5,000	3,000 ~ 10,000		
	• SS	mg/ℓ		4,000		15,000 ~ 16,000	172,000				1,000	9,000	20,000 ~ 60,000	40,000 ~ 50,000	600	400
Organic Content	• TOC	mg/ℓ		78,000				94,600	55,400		105,000	26,000		150,000		
	• Suger Content	mg/ℓ	20,000			20,000 ~ 80,000		35,200	17,300		20,000 ~ 80,000	10,000	20,000 ~ 40,000	20,000 ~ 90,000		
	• Organic Acid	mg/ℓ						45,600	30,500		5,000 ~ 10,000		1,000 ~ 5,000	5,000 ~ 15,000	1,800	930
	• Polyphenol	mg/ℓ			4,550	20,000					10,000 ~ 24,000	5,000	10,000 ~ 15,000			
	• Polyol	mg/ℓ									10,000 ~ 15,000	11,000				
	• Pectin, Coloring Matter	mg/ℓ									10,000	3,700	10,000 ~ 15,000	10,000 ~ 15,000		
Inorganic Content	• TIC	mg/ℓ		14,000										10,000 ~ 15,000		
	• T-P	mg/ℓ	225		1,020		314			950 ~ 500	1,100	96				
	• T-N	mg/ℓ		3,800	935					550 ~ 800	5,000 ~ 20,000	2,800	12,000 ~ 14,000	12,000 ~ 24,000		
	• Na^{+}	mg/ℓ		280			7,230			150 ~ 350	900	45	1,000 ~ 1,500			
	• K^{+}	mg/ℓ		6,200			10,800			8,500 ~ 10,000	7,200	1,200	6,000 ~ 8,000			
	• Ca^{++}	mg/ℓ		510			726				700	120	1,000 ~ 1,500			
	• Cl^{-}	mg/ℓ		470							300					
	• SO_4^{--}	mg/ℓ		370			420				400					
	• PO_4^{---}	mg/ℓ		1,040			939									
Others	• Ignition Residue	mg/ℓ	89,800	105,000							120,000	30,000			60,000	32,000
	• Ash	mg/ℓ		13,700				19,500	5,800				110,000			

The Source

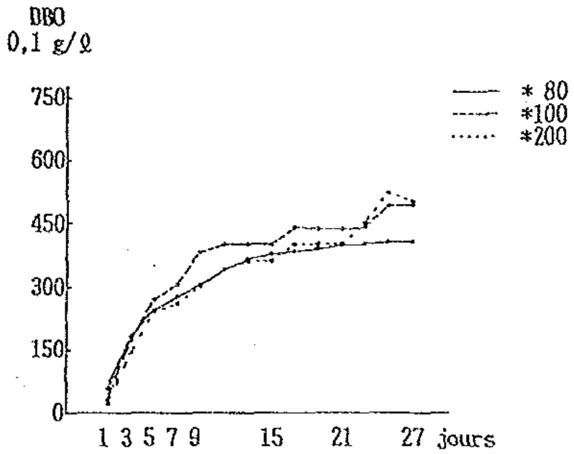
① Hartmann, L. Anaerobic Digestion and Carbohydrate Hydrolysis. (PP. 307/317, '84)
② Catalano, M. etc. Inquinamento (Vol. 27, No. 2, PP. 87/90, '85)
③ Vigo, F. etc. Riv. Ital Sustanze Grasse (Vol. 67, No. 3, PP. 131/137, '90)
④ ENIS. ('91/1) Memo of Mr.Jalel Bouzid
⑤ ENIS. ('92/9) Document received from Mis.Emma
⑥ Ranalli, A. Olivae (No. 37, PP. 30/39, '91/6)
⑦ Ranalli, A. Olivae (No. 37, PP. 30/39, '91/6)
⑧ Aveni, A., Anaerobic Digestion and Carbohydrate Hydrolysis. (PP. 489/491, '84)
⑨ Fiéstas, J. A., Differentes Utilisations Des Margins (PP. 93/107)
⑩ Fiéstas, J. A., Differentes Utilisations Des Margins (PP. 93/107)
⑪ Pietro, C. etc. Water Research (Vol. 22, No. 12, PP. 1491/1494, '88)
⑫ Annesini, Mc. etc. Effluent and Water Treatment J. ('83/6)
⑬ Bradley, R. M. etc. Effluent and Water Treatment J. ('80/4)
⑭ Bradley, R. M. etc. Effluent and Water Treatment J. ('80/4)

Table III-12 Analysis Data of Margine

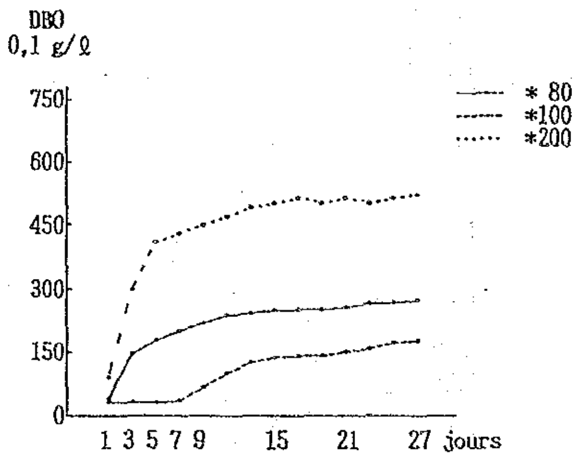
FACTORY		UPOTS		UPOTS		Ben Ayad		ONAS	Japan Olive
SAMPLING POINT				Oil Sep.	Marg. Pit	Continuous	Batch	Sun Dry	Continuous
SAMPLING DATE		91.7	91.7	92.1	92.1	92.1	92.1	92.1	91.12
p H		5.4	5.1	5.3	5.3	4.9	5.2	5.1	4.9
B O D	mg/L	67,000	41,000	69,000	63,000	46,000	82,000	69,000	47,000
C O Dcr	mg/L	160,000	108,000	72,000	62,000	40,000	89,000	59,000	49,000
S.SOLID	mg/L	25,000	63,000	11,000	7,700	18,000	14,000	210,000	32,000
T-P	mg/L	500	300	420	400	410	540	570	
T-N	mg/L	1,200	600	970	880	680	1,000	2,300	
n-HEXANE	mg/L			2,500	3,300	7,100	37,000	260,000	7,900
PHENOL	mg/L								
SOLID	wt%			10.0	9.1	6.0	15.0	35.0	8.0
CALORIFIC VALUE	cal/g			4,090	4,020	4,970	5,110	6,690	5,020

Fig. III-15 Change of BOD by Lapse of Time

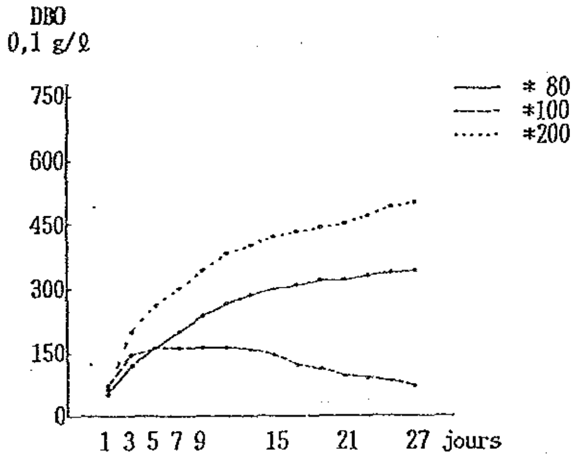
① UPOTS Oil Separater



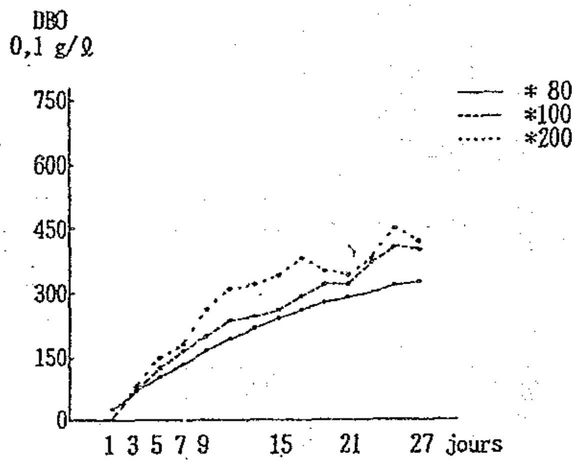
② UPOTS Margign Pit



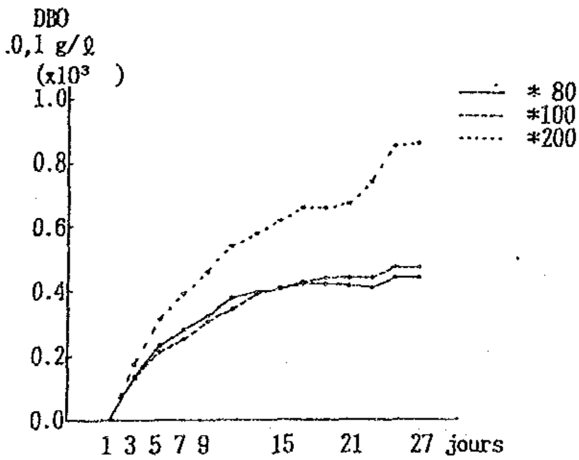
③ Ben Ayad Continuous Process



④ Ben Ayad Batch Process



⑤ ONAS Sun Dry Pit



Source : LARSEN Analysis Data

Comparing the pressing system with the continuous system, waste water from the latter system generally seems to be low in concentration. It is partly because the shorter time of exposure to the air owing to the short processing time does not deteriorate the oil content and partly because waste water is diluted as a whole with a large quantity of city water used in the process.

The values of waste water from UPOTS analyzed in this study are shown in Table III-12.

The samples were taken simultaneously by LARSEN, and a survey was made on the successive changes of BOD. The results were given in Fig. III-15. There may be some problems in measurement (according to ENIS), but we can find out the following points from the data.

① The BOD value continues to increase even on and after the fifth day, and becomes stable about one month later.

② The value changes according to the dilution rate.

This shows how difficult it is to measure BOD. The problem in the treatment of margin is its high concentration and inclusion of polyphenol content as explained before, and they hinder bio-treatment of waste water at the same time.

On the other hand, investigation of organic and inorganic substances shows that the ratio of substances with high nutritive values or valuable matters contained in the margin is comparatively high. Based on this fact, various researches have been conducted for recycling the margin and converting it into a pollution-free material.

i.e.

① Direct use of margin (especially its mineral content) or use of margin after biotreatment.

② Separation of effective substances through physical or chemical treatment.

③ Conversion of margin into a new substance by applying bio technology.

4. SIOS-ZITEX (Société Industrielle des Huiles d'Olieves de Sfax)

4.1 Outline of Factory

There are three soap factories in Sfax City including SIOS-ZITEX. Of three factories, we made survey on two factories. Both of them were established to make solid soap for home use from Grignon frais produced by pressing raw olive in the olive oil factory.

SIOS-ZITEX was established in 1926, and its facilities were improved in 1961. It purchases Grignon frais and inferior-quality olive oil which can not be sold as refined oil as raw materials for soap. The production process consists of ① "Extracting Process" where oil is extracted from Grignon frais, ② "Refinery Process" where oil is refined to produce refined oil and ③ "Soap Production Process" where soap is produced through saponificational reaction of oil by caustic soda. Facilities in SIOS-ZITEX factory are partly old and partly new, and the layout of its facilities is complicated. Its "new" facilities were introduced several ten years ago, but they seem to be reliable and dependable as compared with those of SATHOP factory, and the management of factory at SIOS-ZITEX seems to be better.

In the refinery process, olive oil is refined not to make a material for soap but to produce olive oil for sale. SIOS-ZITEX refines not only olive oil but also soybean oil purchased from the outside, and ship them for sale.

In 1990, its processing capacity of Grignon frais in the "Extracting Process" reached about 50,000 tons/year (extracted oil: about 3,500 tons/year), and its production capacity of refined oil in the "Refinery Process" and product soap in the "Soap Production Process" were about.13,000 tons/year and 21,000 tons/year, respectively.

The causes of environmental pollution were in waste water from above three processes and exhaust fume from steam boilers where residual after extracting oil from Grignon frais is burnt.

4.1.1 Output

As mentioned before, SIOS-ZITEX uses Grignon frais and soybeans as raw materials for producing soap and refined oil. The consumption of Grignon frais and other raw materials in 1991 is shown in Table III-13.

Final products made from these raw materials are shown in Table III-14 and the total sales in 1991 amounted to2,679,000 TD/year.

Table III-13 Main Raw Materials and Consumption (1991)

Raw material	Consumption (t/year)	Price (TD)	Remarks
① Grignon frais	51,000	315,000	
② Acid oil	1,050	315,000	Raw material of soap
③ Caustic soda	420	206,000	
④ NaCl	262	20,000	
⑤ Clay	120	57,000	
⑥ Phosphoric acid	12	17,000	
⑦ Sodium carbonate	5	1,000	
⑧ Hexane	424kl	107,000	
⑨ Soybean oil	11,000	———	Consignment of oil refinement

Table III-14 Products and Output (1991)

Product	Output (t)	Shipping Amount (t)	Sales Amount (TD)
① Refined oil	12,885	12,885	772,000
② Oil extracted from grignon	3,500	2,126	941,000
③ Soap	2,100	2,080	888,000
④ Grignon frais	30,000	10,353	78,000
⑤ Total			2,679,000

4.1.2 Number of Employees

SIOS-ZITEX factory is in operation throughout the year, and the operating time is 24 hours in three shifts. The number of employees is about 160 at its peak, and a half of them are seasonal labors. The details are as follows.

1) Total number of employees

Regular employees	:	80
Seasonal labors	:	about 80 (variable)

2) Details of regular employees

Administration Division	:	19 (President, Vice-president, Manager of Sales Division, Manager of General Affairs Division, Accounting Division 4, Sales Division 2, Secretary 1, Warehouse 3, Weighing Section 1, Driver 1 and Security Guard 3)
Production Division	:	61 (Mechanical Engineer 1, Maintenance 7, Parts Production 2 and Workers 51) (Seasonal labors: about 80)

4.1.3 Layout of Facilities

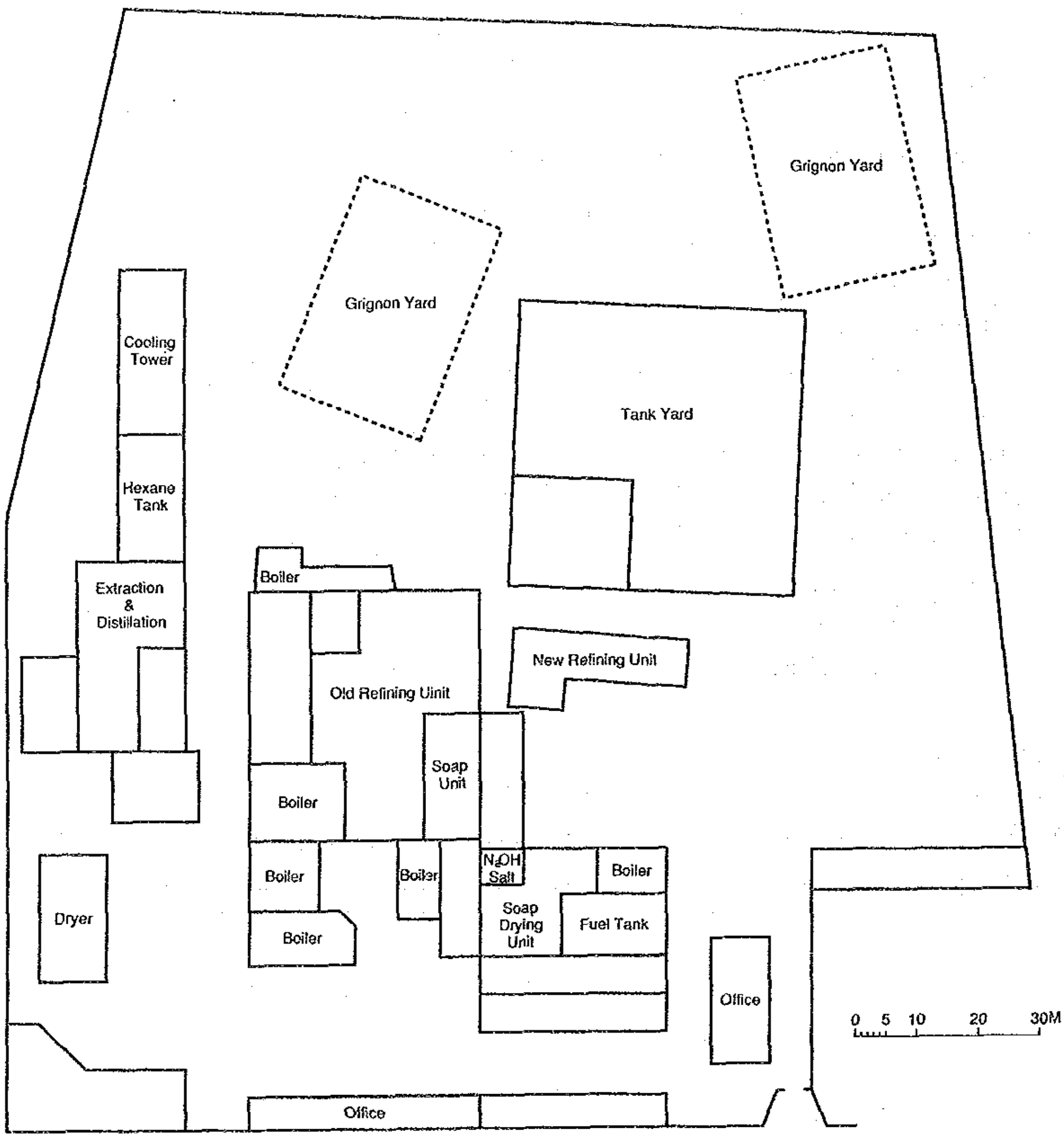
The factory site is 30,000 square meters and the building site occupies a space of 6,500 square meters.

The layout of the factory is shown in the Fig. III-16. The major facilities in the extracting, refinery and soap production processes categorized by process are given in Table III-15.

Table III-15 Specifications of Major Facilities

Equipment	No. of units	Specifications
1) Extracting Process		Capacity (Grignon processing capacity) 170 tons/day
① Crusher	2	Hammer type
② Dryer	3	Rotary dryer
③ Extraction tower	12 set	Extraction by hexane
④ Distillation facilities	1 set	Recovery of hexane
2) Refinery Process		Capacity: 60 tons/day
① Decoloring equipment	1 set	Clay absorbing type
(Mixer: 1 unit)		
(Leaf Filter: 2 units)		
② Deodorization tower	2	Pressure-reducing steam distillation type
③ Centrifugal separator	6	Alfa-Laval
3) Soap Production Process		Capacity: 10 tons/day
① Saponification reactor	4	$26m^3$ x 1, $14m^3$ x 1, $13m^3$ x 2
② Salting-out tank	1	
③ Soap molding facilities	1 set	
(Centrifugal dehydrator)		
(Centrifugal decanter)		
(Molding machine)		
(Cutter)		
4) Steam Boiler		
Heavy oil fuel, smoke tube	3	Evaporation: 4 tons/hr (per unit), Pressure: 15 kg
type Grignon burning boiler	5	Automatic Grignon supplying system

Fig. III-16 Plot Plan of SIOS-ZITEX



4.1.4 Future Plan

There are no plans to expand or rebuild production facilities for time being. In the future, however, the factory intends to shift its emphasis to high-value-added products like toilet soap from solid laundry soap.

4.2 Present Conditions of Operation and Problems

As previously stated, three soap factories are in operation in the Sfax region including SIOS-ZITEX and SATHOP which we will explain in the next chapter. They are using three kinds of oil, i.e. Grignon frais or lees of olive oil (oil content: 5-7%), soybean oil, rape seed oil and acid oil obtained from olive oil factories, to produce soap for home use and edible oil. Their production facilities and processes are almost same, and the scale of SIOS-ZITEX facilities is two or three times as large as those of SATHOP.

4.2.1 Production Process

The production process is categorized roughly into three processes.

(1) Grignon extracting distillation process

(2) Refinery process

① New refinery process

② Old refinery process

(3) Soap production process

The flow of entire production process is given in Fig. III-17.

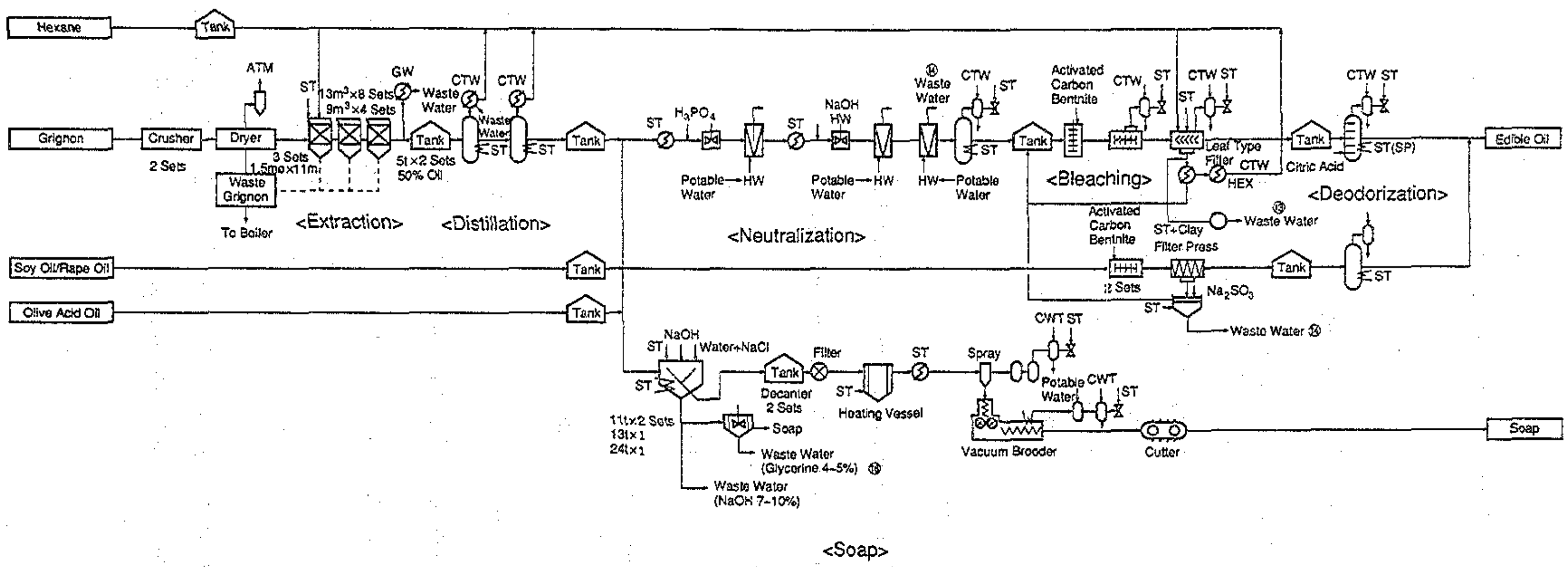
(1) Grignon Extracting and Distillation Process

Extraction of hexane from Grignon (oil content: 6-7%) is the fundamental process, which consists of three sub-processes as follows.

1) Drying

About 70 to 90 tons of raw Grignon is crushed daily by two crushers and the water content is removed by three driers (50°C, 1.5m dia. x 11m long, burning waste Grignon).

Fig. III-17 Process Flow of SIOS-ZITEX



2) Extraction of Hexane

Hexane and Grignon are contacted directly in each pair of three extraction towers ($13m^3$ x 8 units, $9m^3$ x 4 units), and hexane is always in a state of fluid and heightens the extracting effect.

Extracted, undiluted solution is called "Micella" containing oil by 50%. In the extraction process, the oil content is removed from Grignon until it reaches the range from 0.5% to 1.5% taking economical efficiency into account. The extraction tower is vertical and cylindrical type and hermetically sealed, with a filter set at the bottom, and blowing steam into the tower allows it easy to extract hexane.

3) Distillation

Micella is heated inside the distillation tower, so that hexane and oil are separated, and hexane is removed thoroughly in the reaction-finishing tower through vacuum deaeration. Oil obtained in the preceding process is stored in the tank until it is conveyed to the refinery process.

Hexane is condensed, collected and reused after water content is removed. The removed water content is drained. Grignon after extraction, with hexane removed by steam purging in the extraction tower, is stored as waste Grignon and used as a fuel for rotary driers and Grignon burning boilers.

The extracting process is batch-operated, and one process cycle is six hours and a half.

• Supplying and heating of Grignon/hexane:	1 hour
• Recycling of hexane:	2 hours
• Purge:	0.5 hour
• Hexane purging:	2 hours
• Raking Grignon out:	1 hour
	Total 6.5 hours

(2) Refinery Process

Refinery process is controlled to assure the quality (improve the flavor, odor and color) of oil supplied from ONH as edible oil and includes the following actions.

- Lowering viscosity (degumming)
- Neutralization (decreasing acidity)
- Decolorization (bleaching)
- Deodorization

(Lowering viscosity through Deodorization — New refinery unit; Decolorization and Deodorization — Old refinery unit)

The factory is furnished with these two refinery units.

1) New Refinery Unit

① Lowering Viscosity (Degumming)

Oil, especially vegetable oil, contains a complicated compound of phosphoric oil content called "gum" as its central constituent.

Although degumming is done partly by NaOH in the process of neutralization, degumming is performed before other operations, because there are some problems related to product quality and refining operation.

Degumming is conducted by centrifuging after adding citric acid, phosphoric acid, etc. to oil, and the level of degumming is judged by measuring phosphorus residuum. Should degumming be insufficient, the flavor and odor of oil are deteriorated while it is reserved as edible oil, and especially in the case of soybean oil, its flavor turns strong or sour.

② Neutralization (Decreasing Acidity)

Oil at this stage contains free fatty acid, and if it is not removed here, a trouble may occur in the next operation of decolorization. Both SIOS-ZITEX and SATHOP factory adopt Alpha Laval's continuous system and use centrifugal separators so that the quantity of NaOH is controlled automatically. Oil is mixed with NaOH instantly in the centrifugal separator, then oil is separated and cleaned with warm water. This operation is repeated in two stages, and water is removed under vacuum.

This is a simple method which can remove impurities and coloring matters unnecessary for soap reaction.

③ Decolorization

Some of the coloring matters are removed in the previous operation.

However, active clay (bentonite) or activated carbon are used to remove impurities more (especially those which may cause worse reaction during storage.) Contained impurities are soap content, various kinds of oxide, polymer, etc. For decolorization, dried white clay is used and stirred for 10 to 15 minutes at a temperature from 80°C to 100°C in vacuum (with caution to keep airtight.) The oil content and clay are separated by filtering.

④ Deodorization

Even after neutralization and decolorization, flavor and odor of oil may not be good enough. The odor of oil turns favorable through deodorization without deteriorating triglyceride. For this reason, distillation is conducted under comparatively high vacuum with blowing superheated steam.

2) Old Refinery Unit

Old refinery units, installed in parallel with new refinery units, feature only operations of decolorization and deodorization, and they are used for comparatively high-quality raw oil.

(3) Soap Production Process

Soap is a salt of fatty acid (fatty acid + NaOH/KOH), and the carbon No. of fatty acid is from 8 to 20.

The saponificational reaction of triglyceride consists of following two stages.

①

$$\begin{array}{l} R{-}COO{-}CH_2 \\ \quad | \\ R{-}COO{-}CH + 3H_2O \\ \quad | \\ R{-}COO{-}CH_2 \end{array} \xrightarrow[\text{Heating}]{} \begin{array}{l} CH_2{-}OH \\ \quad | \\ CH{-}OH + 3R{\cdot}COOH \\ \quad | \\ CH_2{-}OH \end{array} \quad \text{Hydrolysis}$$

②

$$3R{\cdot}COOH + 3NaOH \longrightarrow 3R{\cdot}COONa + 3H_2O \quad \text{Neutralization}$$

$$(OCOR)_3{\cdot}C_3H_5 + 3NaOH \longrightarrow C_3H_5(OH)_3 + 3RCOONa$$

(Triglyceride) (Caustic soda) (Glyceline) (Soap)

In the first stage, fatty acid and glyceline are produced through hydrolysis, but the reaction rate is not so fast due to equillibrium reaction.In the second stage, the reaction rate is fast due to ordinary fatty acid reaction. Both soap factories are using reactors and batch processing system.

Their processes are divided broadly into three processes as follows.

1) Saponificational Reacting

In the reactors (four units) heated by steam, NaOH (50°B) and fatty acid are boiled for one hour to one hour and a half: In the meantime, water used for reaction is vaporized.

The state of NaOH and fatty acid in the reactor becomes soft and sticky like paste. It is required to separate glyceline produced and unreacted raw materials and auxiliary agents simultaneously.When reaction is well done, unreacted materials account for 0.2% or less, and by adding NaOH and heating for a while, the percentage of unreacted materials will be decreased to 0.1% or less. (Most of them are impurities which are not able to be reacted any more.) Adding a little more quantity of NaOH quickens reaction, however, it is not so economical, if taking the loss of NaOH into account.

2) Salting Out

By adding NaCl (22°B), soap emulsion is destroyed and semi-liquid soap buds like floating ash is formed on the surface. The liquid-like portion of the lower part is drained. Drained water contains about 3% of NaOH and 2 to 3% of NaCl, and the operation of salting out is conducted two or three times depending on the type of soap and the quantity of glyceline.

3) Solidification

This is the final process, where soft water is added for cleaning (two or three times). The viscosity of soap is determined by the quality of water added at this stage.

After this, soap material is conveyed to the solidification process to condense the water content to 20% or less (normaly 10 to 15%) by using vacuum atomizer and centrifugal separator, and dried. Now it is poured into molds, then soap for home use is produced.

The time required for entire processing is 34 hours, two hours for reaction and 32 hours for standing. For instance, by adding 2.5-3 tons of NaOH (30%) and 0.4-0.5 tons of NaCl to 10 tons of raw oil, 13-14 tones of soap can be produced

4.2.2 Outline of Incidental Process

The following are major utility processes to support the production process.

- Boilers
- Cooling towers
- Others (city water, well water, etc.)

1) Three heavy oil fired boilers (capacity: 4-5 tons/hour each, quantity of heavy oil used: 400-500 tons/month) and five waste Grignon fired boilers (quantity of Grignon used: 10,000 tons/year) are installed and used for heating, injecting, etc. for reboilers of distillation towers, heat exchangers, ejectors of vacuum facility and reactors.

2) While there are three cooling towers and each cooling tower is broadly assigned to bear its share of job as follows.

   No. 1 cooling tower (180m3/hour): Extracting process

   No. 2 cooling tower (160m3/hour): Refinery process (mainly for ejectors)

   No. 3 cooling tower (220m3/hour): Soap production process (mainly for ejectors)

3) About 130m^3 of city water is supplied and used for boilers through water softening towers. City water is also used for the part to be contacted with products directly such as neutralization, washing etc. and for drinking of course.

4.2.3 Problems

(1) Process and Operation

The quality of product is controlled and secured by conducting various kinds of analysis and measurement. However, other operation control, i.e. the control of the ratios of consumption and output for raw materials, auxiliary agents, and utilities does not seem to be performed carefully. If this control is performed well, the points for rationalization often become cleared. In the same manner, from the point of view for maintenance, if the relation between the operating conditions of machines and equipment and the expenses for maintenance is controlled, the key points of maintenance may be clarified, and the possession of spare parts and updating of equipment can be done rationally.

(2) Layout

Operation control may be simplified and the number of employees can be decreased by integrating or removing some of the equipment and facilities (e.g. boilers).

(3) Security and Operating Environment

- Each operator should put on safety and protection devices (helmets, goggles, etc.) a little more for safety's sake.
- From the point of view for operating environment, the working area of boilers should be improved to a certain extent, because a large quantity of dust are flown up there

The floor of the refinery process room is slippery and seems dangerous because of the splashed oil content.

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

4.3.1 Flowsheet of Supply Water and Waste Water and the Quality of Water

The flowsheet of waste water, which was made through our visiting the factory several times, is given in Fig. III-18. The quality of water obtained through sampling and analysis is shown in Table III-16.

4.3.2 Present Conditions of Supply Water

SIOS-ZITEX factory is using city water and well water. About 130m^3/day of city water is used for the new refinery process, soap production process, use as living water and partly for boilers through water softener. About 150m^3/day of well water is cooled in the cooling tower and used as cooling water in circulation.

Outline of cooling tower is as follows.

	Type	Quantity of Circulation	Usage	Volume of water tank
No.1 cooling tower	Draft type	180m^3/Hr	Extracting process	200m^3
No.2 cooling tower	Draft type	45m^3/Hr	Soap production process	160m^3
No.3 cooling tower	Draft type	270m^3/Hr	Refinery process	50m^3

No.1 and No.2 cooling towers stand close by each other. The blowdown of No. 2 cooling tower always flows into the water tank of No. 1 cooling tower and is discharged outside the factory with the blowdown of No. 1 cooling tower.

4.3.3 Present Condition of Waste Water

Waste water from extracting, refinery and soap production processes flows out directly into the sea through the same exhaust port together with the blowdown of cooling towers, recycled waste water from water softener and living drainage.

Waste water from extracting, refinery and soap production processes vary extremely because of the batch operation system adopted partly in the processes, and its turbidity is always very high. The turbidity of waste water from refinery and soap production processes is particularly high featuring a COD value from several ten thousand to several hundred thousand milligrams per liter. The high COD value of waste water indicates that valuables are flowing out. We found oil pits established or under construction in various places of the factory, which indicate its effort for recovering valuables in waste water. The factory produces soap by adding caustic soda to triglyceride in soap production process. Glycerine produced concurrently with soap production is discharged in waste water at present.

At present two systems are available to cool water; one system is to discharge water used for ejectors to produce a vacuum as wastewater and another system is to recycle water used for ejectors to the cooling water. Since the latter system is adopted by SIOS-ZITEX, cooling water is contaminated, so that the cooling water line was observed to be cleaned at intervals after suspending operation of the plant.

Fig. III-18 Water Flow of SIOS-ZITEX

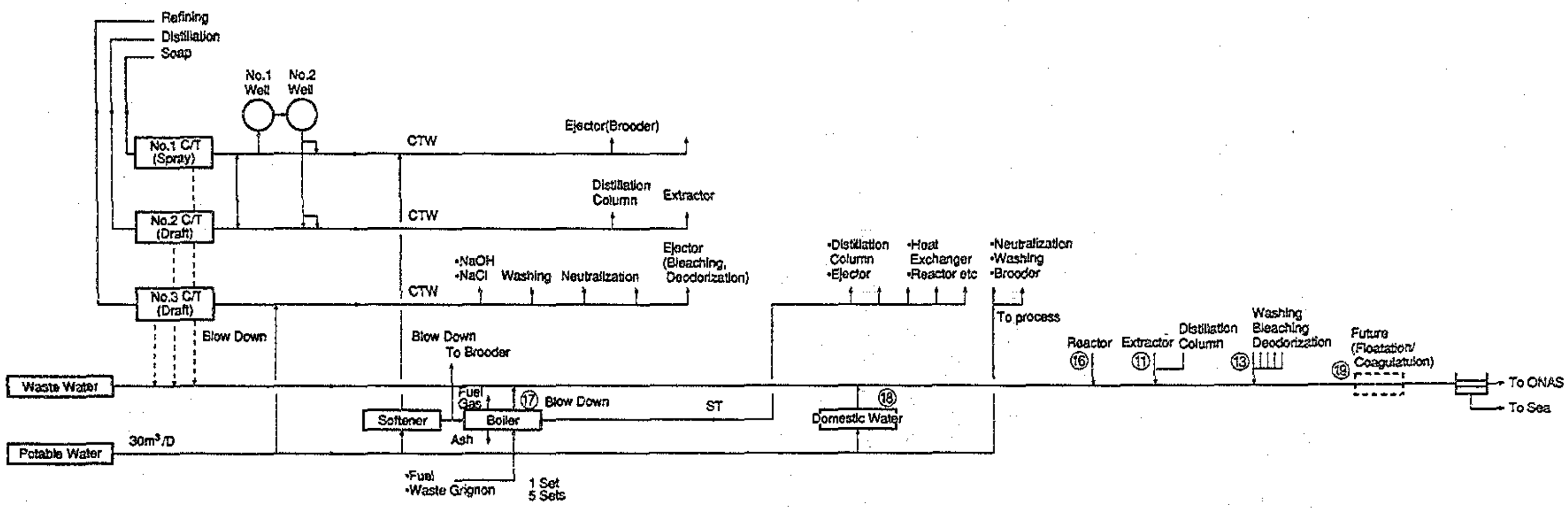


Table III-16 Result of Water Analysis (SIOS-ZITEX)

SAMPLING POINT	SAMPLING DATE	ANALYSIS ITEMS(8) TURBIDITY deg.	p H	CONDUCT'TY ms/cm	S.SOLID mg/L	C O Dcr mg/L	B O D mg/L	n-HEX mg/L	D O mg/L
SZT-01	14/07/92	0	7.7	2.1	<1	2	5	-	4.2
SZT-09	11/07/92	10	6.7	21.9	1	24	3	3	2.4
SZT-09	14/07/92	1	6.9	14.0	18	170	33	-	2.3
SZT-11	11/07/92	6	7.7	16.9	8	230		2	3.3
SZT-11	14/07/92	1	7.8	17.9	5	530	30	4	3.5
SZT-12	11/07/92	1	4.3	14.2	36	2000	700	23	3.3
SZT-12	14/07/92	20	4.6	15.6	57	2000	12	39	
SZT-13	12/07/92	>999	8.9	14.0	220000	170000	27000	18000	0.3
SZT-13	14/07/92								
SZT-14	11/07/92	695	6.3	2.5	20000	65000	23000	1800	1.8
SZT-14	14/07/92								
SZT-15	11/07/92	31	7.5	30.6	28	1600	160	14	0.7
SZT-15	14/07/92	27	7.8	24.5	26	1600	13	5	0.3
SZT-16	11/07/92	>999	12.3	91.7	740	44000	16000	9800	0.5
SZT-16	14/07/92	>999	12.6	>100	2600	29000	13000	5500	0
SZT-17	11/07/92	715	11.7	35.0	590	620	140	34	2.3
SZT-17	14/07/92	980	12.0	58.3	1300	550	450	20	1.5
SZT-18	11/07/92	10	8.5	2.6	1	130	26	4	4.9
SZT-18	14/07/92	2	8.0	2.5	1	32	170	4	3.9
SZT-19	11/07/92	110	5.7	14.0	70	940	530	4	3
SZT-19	14/07/92	700	6.1	14	2900	6400	2300	33	0.2
SZT-20	11/07/92	10	6.8	2.4	4	64	6	6	5
SZT-20	14/07/92	165	7.8	2.3	3	330	250	27	

DETAILED ANALYSIS (SIOS-ZITEX)

SAMPLING POINT		SZT-09	SZT-00	SZT-12	SZT-12	SZT-13	SZT-13	SZT-14	SZT-14	SZT-16	SZT-16	SZT-21
SAMPLING DATE		SEP. 14	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 17	OCT.1
TURBIDITY	deg.	0	0	50	121	>999	>999	130	78	>999	>999	
p H		7.0	6.8	4.6	4.0	11.8	8.2	8.4	7.6	11.2	11.8	
CONDUCT'TY	ms/cm	20.9	21	17.3	15.2	9.6	7.8	35.6	28.3	51.1	40.7	
S.SOLID	mg/L			32	70	2600	684	146	91	5400	1054	15
C O Dcr	mg/L			1660	1800	13286	2470	318	210	1765	165	690
B O D	mg/L			4000	2290	10800	3000	480	137	2350	40	
n-HEXANE	mg/L			60	26	1464	154	18	5	600	23	
Cl	mg/L			4500	3000	1200	1600	12000	11000	12000	8300	
SO4	mg/L			3400	3100	380	99	960	1100	7900	8800	
NaOH	mg/L							1600	1600			
ALKALINITY (as CaCO3)	mg/L	180	180									

SAMPLING POINT - SZT-19

SAMPLING DATE	SAMPLING HOUR	ANALYSIS ITEMS(4) p H	CONDUCT'TY ms/cm	S.SOLID mg/L	C O Dcr mg/L
23/09/92	12:00	8.0	15.0	5200	10500
23/09/92	14:00	8.3	13.1	900	2558
23/09/92	16:00	7.2	12.3	745	3722
23/09/92	18:00	6.1	12.3	300	1620
23/09/92	20:00	5.9	11.9	170	1000
23/09/92	22:00	8.2	13.0	630	1800
23/09/92	24:00	4.3	12.2	25	1620
24/09/92	2:00	4.1	11.6	80	2275
24/09/92	4:00	4.1	11.7	80	2330
24/09/92	6:00	4.8	12.5	125	2068
24/09/92	8:00	12.1	23.2	1680	3040
24/09/92	10:00	10.3	7.8	1020	1800

4.3.4 Problems

The most critical problem of wastewater from SIOS-ZITEX is high concentration in quality of water. The result of 24-hour sampling of entire wastewater (SZT-19) indicates a COD value of approximately 3,000 mg/l. An attempt not to flow valuables into the drainage system will help to decrease the load of drainage as well as not to waste valuables.

The factory needs to review the operation of production process and examine the installation of recycling pits in detail. It is considered recovering of glycerine produced in the soap production process is also helpful to decrease the pollution load of waste water.

No one can absolutely tell which is better, the system to discharge water used for ejectors or the system to recycle water to the cooling system. The former system removes the contamination of cooling water. The COD concentration of entire waste water is diluted, but the quantity of waste water increases resulting in a rise of water treatment cost. The latter system adopted by SIOS-ZITEX is effective to decrease the quantity of supply water and discharged water, but it pollutes the cooling water system including cooling towers with organic substances, thus the factory is required of periodical cleaning of the water cooling system and water treatment after cleaning.

4.4 Present Conditions of Exhaust Gas and Problems

4.4.1 Gas Exhaust Facilities

The gas exhaust facilities we surveyed for this study include three drying furnaces and four boilers. The outline of each facility is as follows.

(1) Drying Furnaces

Three drying furnaces are in operation continuously for 24 hours.

Drying capacity	: Grignon frais 20 tons/day/unit
Type	: Hot-air rotary type
Dimensions	: 1.5m (diameter) x 12m (L) (drying section)
Fuel feed	: Mechanical type underfeeding stoker
Blower	: 2HP (forced draft fan), 5.5HP (induced draft fan)
Fuel	: Grignon (residual of oil-extracted Grignon frais)
Fuel used	: 2 tons/day/unit
Sampling point of exhaust gas	: SZT-51, SZT-52, SZT-53

(2) Boilers

Ten boiler-related combustion furnaces are installed in the factory, and their specifications are as follows. We measured exhaust gas emitted from four combustion furnaces of them.

Table III-17 List of Boiler-Related Combustion Furnaces

No.	Capacity (T/h)	Fuel	Manufacturing Year	Manufacturer	Remarks
1	6	Grignon	1948	Babcock	Exhaust gas measurement (SZT-56)
2	6	Grignon	1948		
3	6	Grignon	1948		
4	8	Grignon	1981	Standard Forzel	Exhaust gas measurement (SZT-56)
5	3	Grignon	1971	Ponemazool	Exhaust gas measurement (SZT-56)
6	4	Heavy oil			Exhaust gas measurement (SZT-56)
7	4	Heavy oil			
8	4	Heavy oil			
9		Heavy oil			
10		Heavy oil			

Note: ( ) in the "remarks" column indicate sampling points.

4.4.2 Fuel

The fuel used in the factory includes heavy oil (liquid fuel) and grignon (solid fuel). Heavy oil is imported, but its import seems to be controlled by the Government. The quality of heavy oil is as explained in the section of SIAPE factory, however, heavy oil may be high in viscosity depending on the time it is imported. Grignon frais supplied by olive oil factories contains oil by 8 to 9%. The factory uses a n-hexane as a solvent to extract the oil content and uses its residual (Grignon) as a fuel for boilers and other purposes.

4.4.3 Characteristics of Exhaust Gas

The result of exhaust gas analysis executed at the factory is given in Table III-18. Figures of SZT-51 to SZT-53 are the results of exhaust gas analysis of drying furnaces. Those from SZT-54 to SZT-56 are the results of exhaust gas analysis of Grignon fired boilers. The SZT-57 indicates the result of heavy oil fired boilers.

Table III-18 Result of Exhaust Gas Measurement (SIOS-ZITEX)

FACTORY		S I O S - Z I T E X							
SAMPLING POINT		SZT-51	SZT-52	SZT-53	SZT-54	SZT-54	SZT-55	SZT-56	SZT-57
SAMPLING DATE		JUL/13/92	JUL/13/92	JUL/13/92	JUL/14/92	OCT/1/92	JUL/15/92	JUL/14/92	JUL/15/92
FACILITY		R. KILN	R. KILN	R. KILN	BOILER	BOILER	BOILER	BOILER	BOILER
FUEL		GRIGNON	GRIGNON	GRIGNON	GRIGNON	GRIGNON	GRIGNON	GRIGNON	H.OIL
GAS VOLUME									
ACTUAL	m3/h	13100	11500	12000	12400	16100	2020	6250	1860
WET GAS	Nm3/h	11000	9830	10200	8280	10100	1670	3850	1370
DRY GAS	Nm3/h	10000	9130	9400	7830	9500	1540	3570	1240
H2O	%	8.8	7.1	8.2	5.5	5.6	7.7	7.2	9.4
GAS TEMP.	°C	52	46	48	137	163	58	170	99
CO2	%	0.3	0.3	0.9	4.9	4.8	1.8	2.6	10.0
O2	%	19.9	20.3	19.9	15.7	15.2	18.7	17.8	8.0
DUST	mg/Nm3	43	160	100	2800	3100	1900	720	1300
SOx	ppm	<11	<11	<11	<11	21	<11	<11	1000
NOx	ppm	<12	<12	22	46	63	22	55	290

4.4.4 Problems

The measurement of exhaust gas emitted from combustion facilities has never been done before in Tunisia. Accordingly, each factory has no analysis data of its exhaust gas.

For this reason, it is important to check the actual condition of black fumes emitted from the factory stack, and we requested each factory to continue normal operation (combustion) at the time of our measurement. For some operational reasons, however, there were several measuring points at where operations did not seem to be as usual at the time of our measurement. Since there is no other analysis data of these measurement points, we used our data as values for our study.

Japanese Air Pollution Control Law will be described later in Volume VI However, classification of regulation varies depending on the facility and fuel used. Based on these premises, we examined the values measured at each factory carefully.

The result of measurement at SIOS-ZITEX factory is as follows.

Combustion facilities in operation are drying furnaces and boilers. A solid fuel is used for drying furnaces and both solid and liquid fuels are used for boilers. Substances exhausted from these facilities and causing air pollution are SOX, NOX, and particles of soots. SOX is generated from sulfur contained in fuel. We will describe it after explaining the concept of regulations.

By the way, the amount of NOX and particles of soots varies depending on the condition of combustion. The evaluation on the result of measurement of these two substances is as follows.

(1) Drying Furnace

Little quantity of NOX and particles of soots is exhausted. Even if Japanese regulations are applied, the values are satisfactory. It is likely that a heat loss is incurred after all, because the three drying furnaces are in operation, with about 20% of oxygen remaining in exhaust gas, almost the same condition as the air. The percentage of oxygen that remains in exhaust gas emitted from a drying furnace is about 16% in Japan.

(2) Solid Fuel Fired Boiler

A large quantity of particles of soots is exhausted, and countermeasures against it must be taken in the future. In Japan, oxygen remaining in exhaust gas accounts for about 6% of exhaust gas, but it accounts for high value such as 15-18% in Tunisia.

(3) Liquid Fuel Fired Boiler

Heavy oil contains about 3% of sulfur (6% according to other sources), and further examination including the height of stack is required.

As compared with Japanese regulations, both of the particles of soots and NOX from liquid fuel fired boilers show rather high values.

5. SATHOP (Société Anonyme Tunisienne des Huiles d'Olives Pures)

5.1 Outline of Factory

SATHOP was established in 1927 for the production of household solid laundry soap from Grignon frais produced by pressing raw olives just as before-mentioned SIOS-ZITEX. Just like SIOS-ZITEX, this company's production process is categorized broadly into three groups; (1) "Extracting Process" of oil from Grignon frais, (2) "Refinery Process" where oil deoxidation, degumming, decolorization and deodorization are conducted, and (3) "Soap Production Process" where soap is produced from oil. The company refines not only raw oil for soap production but also olive oil and soybean oil for sale as refined oil.

The production facilities of SATHOP are outdated and not so good as those of SIOS-ZITEX. Consequently, it is not avoidable to give an unfavorable impression on its operation control. Soap production at SATHOP is actually not so profitable that the company cannot invest in production facilities and equipment. It is said, however, that the company has an investment plan to double its production capacity of refinery process.

As production capacity, in 1990, SATHOP processed about 14,000 tons of Grignon frais (about 1,000 tons of extracted oil), refined about 5,500 tons of oil and produced about 2,200 tons of soap.

The sources of environmental pollution at SATHOP are wastewater discharged from each production process and fumes emitted from steam boilers which use the residual of Grignon frais as fuel.

For SATHOP with a low profitability, investment in pollution prevention facilities will exert an unfavorable influence on its management, and it is doubtful whether the factory can continue its operation as an enterprise.

5.1.1 Output

SATHOP is producing refined oil, extracted oil of Grignon and soap. Raw materials consumed for the production of these products are shown in Table III-19, and the output of final products in 1991 is given in Table III-20.

Table III-19 Main Raw Materials and Consumption

Raw material	Consumption (t/year)	Value (TD)	Remarks
① Grignon frais	14,273	102,702	
② Acid oil	1,580	377,600	Raw material of soap
③ Caustic soda	69	36,000	
④ NaCl	132	10,000	
⑤ Clay	73	48,000	
⑥ Phosphoric acid	8.2	12,200	
⑦ Hexane	198	94,640	
⑧ Sodium carbonate	12	4,800	
⑨ Soybean oil & Rape seed oil	5,473	———	Consignment of oil refinement by ONH

Table III-20 Products and Output

Product	Output (t)	Sales Amount (TD)	Salest Amount (TD)
① Refined oil	5,473	319,759	Consignment of refinement of soyabean oil and rape seed oil mainly by ONH
② Oil extracted from Grignon	1,000		
③ Soap	2,230		
④ Total		1,433,834	

5.1.2 Number of Employees

SATHOP factory hires seasonal workers same as SIOS-ZITEX. The factory is in operation throughout the year and continuously for 24 hours in three shifts. The details of employees are as follows.

1) Total Number of Employees

Regular employees : 74

Seasonal labors : about 40 (variable)

2) Details of regular employees

Administration division: 14 (President, Manager, Accounting division 2, Weighing section 1, Security guards 3, Drivers 3 and Assistant drivers 3)

Production division : 60 (Boiler 2, Mechanical engineers 7, and Workers 51) and Seasonal workers about 40

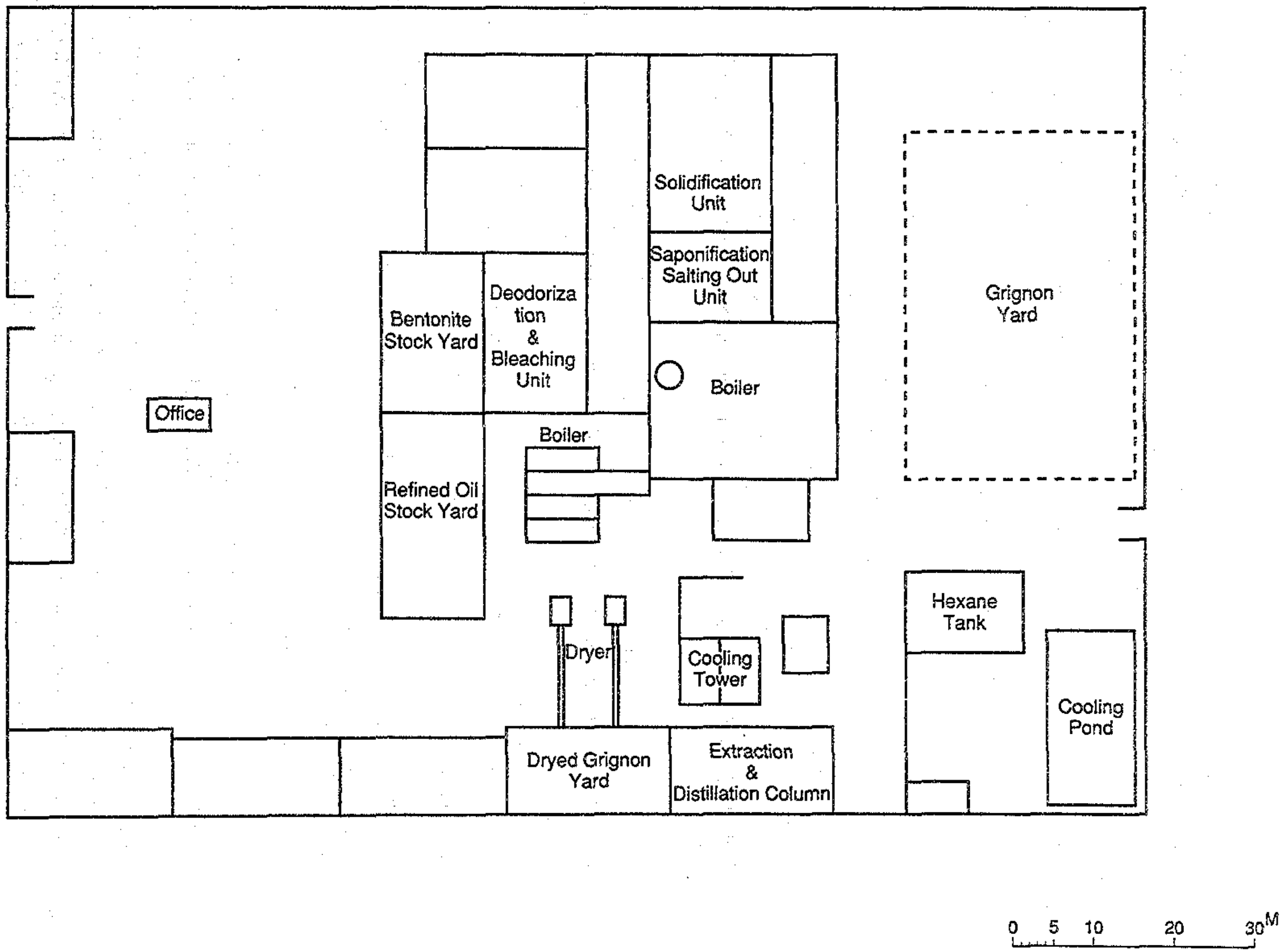
5.1.3 Layout of Facilities

The factory site is 10,000 square meters, and the building site occupies a space of 5,000 square meters. The layout of facilities is given in Fig. III-19. Major facilities in extracting, refinery and soap production processes categorized by process are given in Table III-21.

Table III-21 Major Facilities

Equipment	No. of units	Specifications
1) Extracting Process		Capacity (Grignon processing capacity) 80 tons/day
① Crusher	1	Hammer type
② Dryer	2	Rotary dryer
③ Extraction tower	6	Extraction by hexane
④ Distillation facilities	1 set	Recovery of hexane
2) Refinery Process		Capacity: 30 tons/day
① Decoloring equipment (Mixer: 1 unit) (Filter press: 2 units)	1 set	Clay absorbing type
② Deodorization tower	2	Pressure-reducing steam distillation type
③ Centrifugal separator	3	Alfa Laval
3) Soap Production Process		Capacity: 12 tons/day
① Saponification reactor	4	$40m^3$ tons/unit
② Salting-out tank	1	
③ Soap molding facilities (Vacuum dehydrator) (Centrifugal decanter) (Molding machine) (Cutter)	1 set	
4) Steam Boiler Heavy oil fired, smoke tube type Grignon hand firing type	1 6	

Fig. III-19 Plot Plan of SATHOP



5.1.4 Future Plan

As compared with SIOS-ZITEX in the same business line, the percentage at SATHOP is greater in the production of less-valuable soap than in the production of refined oil. This is considered to be the cause to put the factory in financial difficulties. SATHOP is planning to expand its facilities for refinery process (about 30 tons/day — as large as the present production scale) and will start construction as soon as financing for investment is authorized. The budget for investment will total 1.5 million TD (1.3 million TD for equipment and materials and 200 thousand TD for construction). The existing building will be utilized.

5.2 Present Conditions of Operation and Problems

5.2.1 Production Process

Although the scale of production is small, the processes are almost same as those of SIOS-ZITEX. The production process is described below by centering the points which are different largely.

The output of soap at SATHOP factory is almost equivalent to that of SIOS-ZITEX, but the output of refined oil and extracted oil of Grignon is about one half to one third of those of SIOS-ZITEX.

The flow of SATHOP production process is given in Fig. III-20.

(1) Grignon Extracting and Distillation Processes

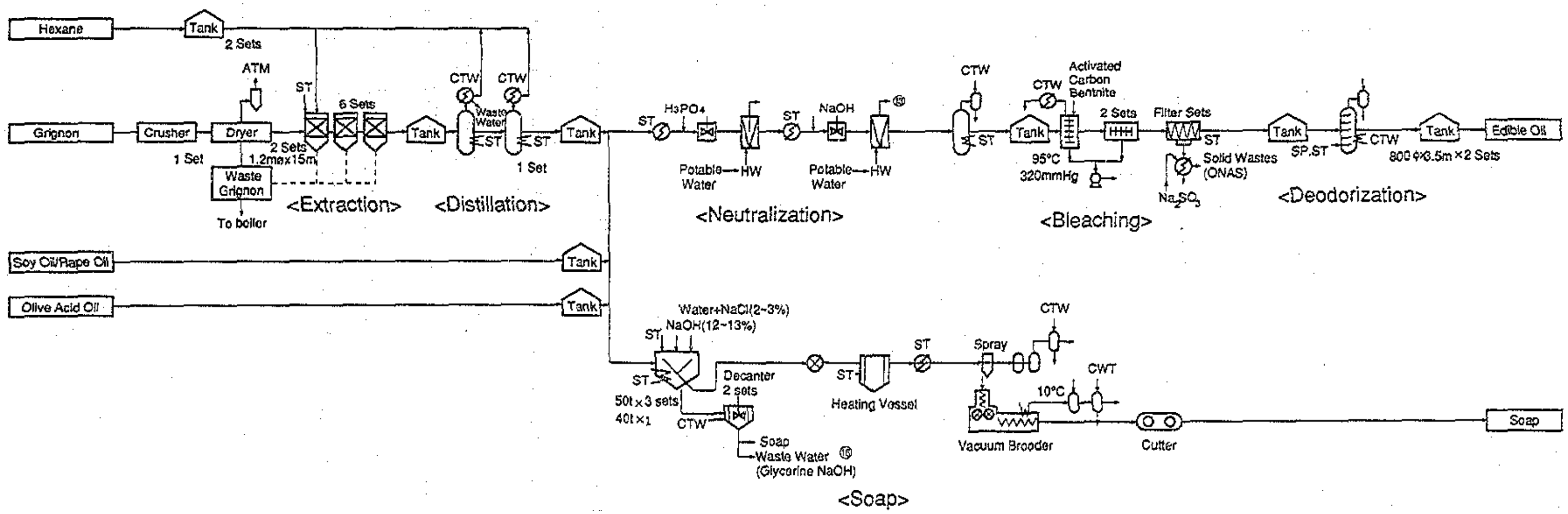
The scale of equipment is smaller as compared with that of SIOS-ZITEX. The process flow is almost same.

(2) Refinery Process

SATHOP has only one line of refinery process equal to the new refinery process of SIOS-ZITEX, and has no system like the old refinery process of SIOS-ZITEX.

The number of centrifugal separator for neutralization and cleaning units in SATHOP is one unit fewer than that of SIOS-ZITEX. The type of deodorizing equipment seems to be slightly different. The difference is also found in the fact that SATHOP is using vacuum pumps to create a vacuum, while SIOS-ZITEX is using ejectors to create a vacuum.

Fig. III-20 Process Flow of SATHOP



(3) Soap Production Process

The number and size of reactors are different between the two factories, but the soap production process is almost same.

The time schedule of entire reaction is as follows.

• Feeding and heating of oil • Feeding of NaOH and NaCl	1.5 Hr ↕	① Boiling and saponification
• Standing	16 Hr ↕	② Salting-out
• Draining • Feeding oil and reheating	1.5 Hr ↕	③ Finish boiling
• Feeding of NaOH	16 Hr ↕	④ Finish salting out
• Standing		
• pH adjustment, softwater cleaning and product extracting		

Total: 3 hours for reaction and 32 hours for standing

For 16-18 tons of raw oil, 2.5-3 tons (15-16%) of NaOH and 0.3-0.4 ton (2-3%) of NaCl are used.

5.2.2 Incidental Process

Incidental process includes boilers, cooling towers and water related facilities.

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

5.3.1 Flowsheet of Supply Water and Waste Water, and Quality of Water

The flowsheet we made by visiting the factory several times for hearing is given in Fig. III-21. The result of water sampling and analysis in this study is shown in Table III-22.

However, SATHOP factory was not in operation at the time of our survey, and any simplified analysis was not conducted this time. Data are from the detail analysis.

Fig. III-21 Water Flow of SATHOP

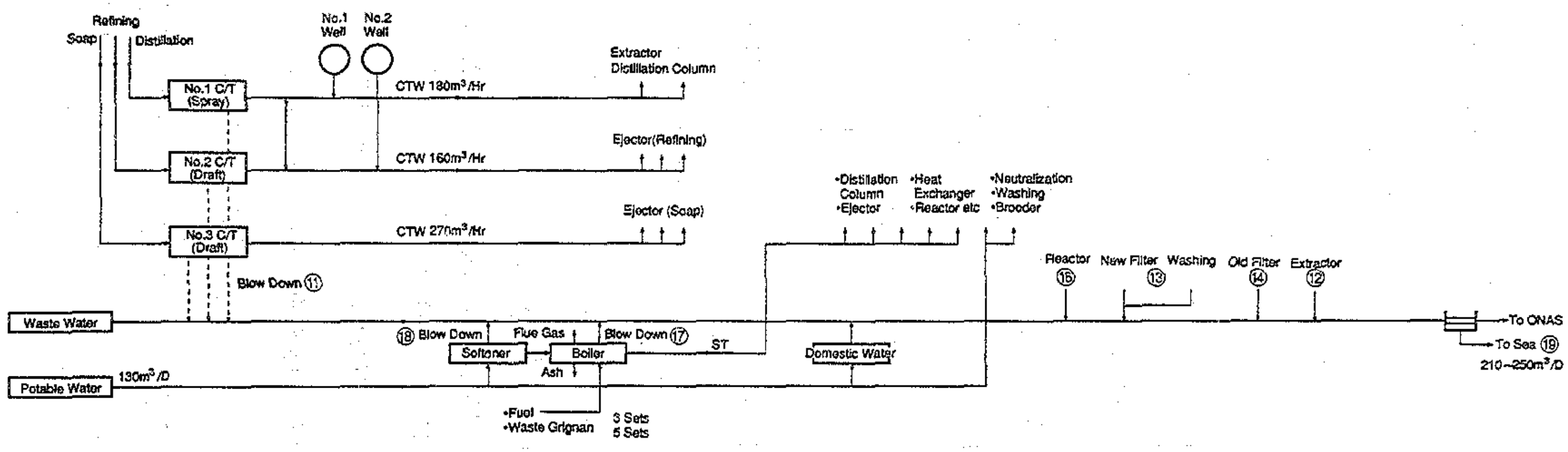


Table III-22 Result of Water Analysis (SATHOP)

DETAILED ANALYSIS (SATHOP)

SAMPLING POINT		STP-07	STP-07	STP-13	STP-13	STP-16	STP-16
SAMPLING DATE		SEP. 14	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 17
TURBIDITY	deg.	330		>999		87	
p H		7.7		10.5		>12	
CONDUCT'TY	ms/cm	27		5		81.6	
S.SOLID	mg/L		20	2600	840	224	42
C O Dcr	mg/L		130	58000	65900	189000	95000
B O D	mg/L	===	45	214000	54910	287200	34000
n-HEXANE	mg/L	===	===	===	===	1400	1643
Cl	mg/L	11000		1800	1800	43000	37000
SO4	mg/L			3000	280	350	30
ALKALINITY (as CaCO3)	mg/L	180	500				

SAMPLING POINT		STP-20	STP-20	STP-21	STP-22	STP-19	STP-23
SAMPLING DATE		SEP. 14	SEP. 17	OCT.3	OCT.3	OCT.6	OCT.6
TURBIDITY	deg.	320					
p H		8.2					
CONDUCT'TY	ms/cm	28.6					
S.SOLID	mg/L	17.5	19				
C O Dcr	mg/L	249	160			9900	11000
B O D	mg/L	280	70				
n-HEXANE	mg/L	4.5	2				
Cl	mg/L	11000		410	6800		
SO4	mg/L						
ALKALINITY (as CaCO3)	mg/L						

5.3.2 Present Conditions of Supply Water

The water supply process of SATHOP is almost the same with that of SIOS-ZITEX. City water and well water are used as supply water.

The specifications of cooling towers are shown as follows.

	Type	Quantity of Circulation	Usage
No.1 cooling tower	Spray type	90m³/Hr	Soap production process
No.2 cooling tower	Draft type	30m³/Hr	Extracting process
No.3 cooling tower	Draft type		Refinery process

The difference in cooling tower between SIOS-ZITEX and SATHOP is as follows.

(1) No.1 cooling tower of SATHOP is a spray type tower.

SIOS-ZITEX is using draft-type cooling towers only, while SATHOP is using one spray-type cooling tower in addition to two draft-type cooling towers. The spray-type cooling tower is more simplified but its cooling effect is lower than that of the draft-type cooling tower.

(2) Return cooling water in SATHOP is fed back to wells.SATHOP adopts the direct cooling system which uses cooling water to operate ejectors, then recycle it to the cooling tower in the same way as at SIOS-ZITEX factory. SATHOP puts the overflow from No.1 cooling tower into No. 1 well and sends it to No. 2 cooling tower via No. 2 well to use it as cooling water for extracting and soap production processes. Examining the quality of cooling water (STP-7) which is transferred from No. 2 well to No. 2 cooling tower we can find out the COD value of 130 mg/l, i.e. the dirtiness of cooling water is less than that of cooling water used in SIOS-ZITEX, and cooling water is considered to be leaking out into the ground.

5.3.3 Present Conditions of Waste Water

SATHOP is draining waste water from extracting, refinery and soap production processes into the sea through the same exhaust port together with the blowdown of boilers and living drainage just like SIOS-ZITEX. Recycled waste water from water softener flows into the well passing through the spray type cooling tower. The comparison of COD values between SIOS-ZITEX and SATHOP is as follows.

Table III-23 Comparison of COD Values between Two Factories

	SIOS-ZITEX	SATHOP
Extracting process COD (mg/l)	2,000	
	2,000	
Refinery process (mg/l)	170,000	58,000
	65,000	65,900
Soap production process (mg/l)	44,000	189,000
	29,000	95,000
Entire waste water (mg/l)	940	9,9000
	6,400	

Waste water from the refinery process is almost same between the two factories. Waste-water from SATHOP is higher in concentration in soap production process, and COD of entire waste water is also higher as compared with that of SIOS-ZITEX.

5.3.4 Problems

SATHOP is required to promote recovery of valuables in waste water to help to reduce the pollution load of final effluent, as well as to promote recovery of glycerine in the soap production process.

Since SATHOP adopts the direct cooling system which makes circulating cooling water contact the raw material, polluted cooling water is leaking out into the ground. This will pollute underwater resulting in a serious problem in a long period of time. SATHOP should consider to recycle cooling water to the cooling tower after conducting a simple treatment, because organic substances mixed in the cooling water cause a trouble of scaling.

5.4 Present Conditions of Exhaust Gas and Problems

5.4.1 Gas Exhaust Facilities

Gas exhaust facilities installed at SATHOP factory include two rotary-type hot-air drying furnaces, six Grignon fired boilers and one heavy oil combustion boiler. Each drying furnace is equipped with a stack. Boilers are equipped with a centralized stack (about 30m high). It was difficult to measure exhaust gas at each boiler so that we measured it at the stack. Accordingly, we could not find out the condition of each boiler.

The outline of each facility is as follows.

① Rotary-type, hot-air drying furnace (2 units):
- Dimensions: 1.2m (diameter) x 15m (L) (drying section)
- Blower: 3/10 HP (forced and induced draft fans)
- Fuel feed: Mechanical-type underfeeding stocker
- Fuel Grignon used: 15 tons/day/unit
- Exhaust gas sampling point: STP-51 and STP-52

② Grignon boilers (6 units):
- Capacity of each boiler is not available.
- Hand fixed grate firing
- Fuel Grignon used: 6,000 tons/year

③ Heavy oil firing heater (1 unit): This is used to heat the deodoring process

Capacity of facility is not available.

Heavy oil used: 250-300 tons/year

Note: Combustion exhaust gas ② and ③ are sampled at the centralized stack (STP-53).

5.4.2 Characteristics of Exhaust Gas

The result of exhaust gas analysis made at the factory is given in Table III-24. Since the factory stopped its operation for maintenance at the time of exhaust gas measurement during the summer season when this study was planed to execute, no analysis was made at the exhaust gas measuring point of STP-52. Measurements at STP-53 were conducted during the combustion of heavy oil and at the time when combustion was stopped, total two times.

Table III-24 Result of Exhaust Gas Measurement (SATHOP)

FACTORY		SATHOP			
SAMPLING POINT		STP-51	STP-52	STP-53	STP-53
SAMPLING DATE		SEP/11/92		SEP/11/92	OCT/1/92
FACILITY		R. KILN	R. KILN	BOILER	BOILER
FUEL		GRIGNON	GRIGNON	GRI./OIL	GRIGNON
GAS VOLUME					
ACTUAL	m3/h	4410		43800	42100
WET GAS	Nm3/h	3770		28500	25000
DRY GAS	Nm3/h	3100		26900	23300
H2O	%	17.9		5.6	6.7
GAS TEMP.	°C	46		147	186
CO2	%	5.6		5.6	4.2
O2	%	15.4		15.4	14.8
DUST	mg/Nm3	1360		360	610
SOx	ppm	7		110	38
NOx	ppm	19		16	30

5.4.3 Problems

(1) Drying Furnace

Judging from the analysis value of exhaust gas, it is clear that a large quantity of particles of soots is generated. A cyclone separator is set to the bottom of the stack to collect particles of soots, but exhaust gas is blowing out from its crevices resulting in environmental pollution. The oxygen remaining in exhaust gas is favorably 15.4%, and because the combustion temperature is low owing to the operation of the drying furnace (the temperature of drying part is lower than 50°C), NOX is generated little.

(2) Boiler

NOX and particles of soots do not matter according to the analysis value.

The stack which usually emitted black smoke did emit less smoke at the time of measurement. The analysis value of exhaust gas shows that about 15% of oxygen is remaining in exhaust gas, and it seemed to be burnt at excess air rate.

6. SMCP/TMC (Société Moderne de Cuir et des Peaux/Tannerie Moderne de Cuir Sfax)

6.1 Outline of Factory

SMCP (Société Moderne de Cuir et des Peaux) was established about a century ago, and the present owner is the 5th direct descendant of the founder. The factory is the largest among the tanning makers in Sfax City. Actual business is being carried out under the cooperative management of three directors, sons of the owner. When the first field survey was made (June 1991), SMCP had a factory house with a floor space of about 2,000 square meters built in a site of 2,500 square meters. The factory was narrow, and there was no extra space so that things were pilled pell-mell in the factory. It was not an object to rationalize and update its production facilities or to conduct industrial environment pollution control, despite of enthusiasm shown by the top management.

Its plan to establish a new factory (TMC) was already going on at the time of the first field survey. Immediately after that, the construction of its new factory was initiated and will be completed before long. The transfer of facilities and equipment from the old factory to the new factory is expected to have been finished by the end of 1992.

6.1.1 Present Conditions of Factory

In the old factory, only the Tanning Section is in operation now. It is producing wet blue in the conventional process. In other part of the factory, waste skin is piled and outdated machines are left unused. SMCP is planning to utilize the old factory mainly as a warehouse and partly for finishing work in the future. The layout drawing of old factory is given in Fig. III-22.

The new factory is being furnished with equipment and facilities step by step, and all processes after tanning are conducted in the new factory. The inside of the factory was in disorder at the time of our survey, and there were many machines which are under repair. Facilities for waste water treatment was under construction, and the layout drawing of new factory is given in Fig. III-23.

Fig. III-22 Plot Plan of SMCP

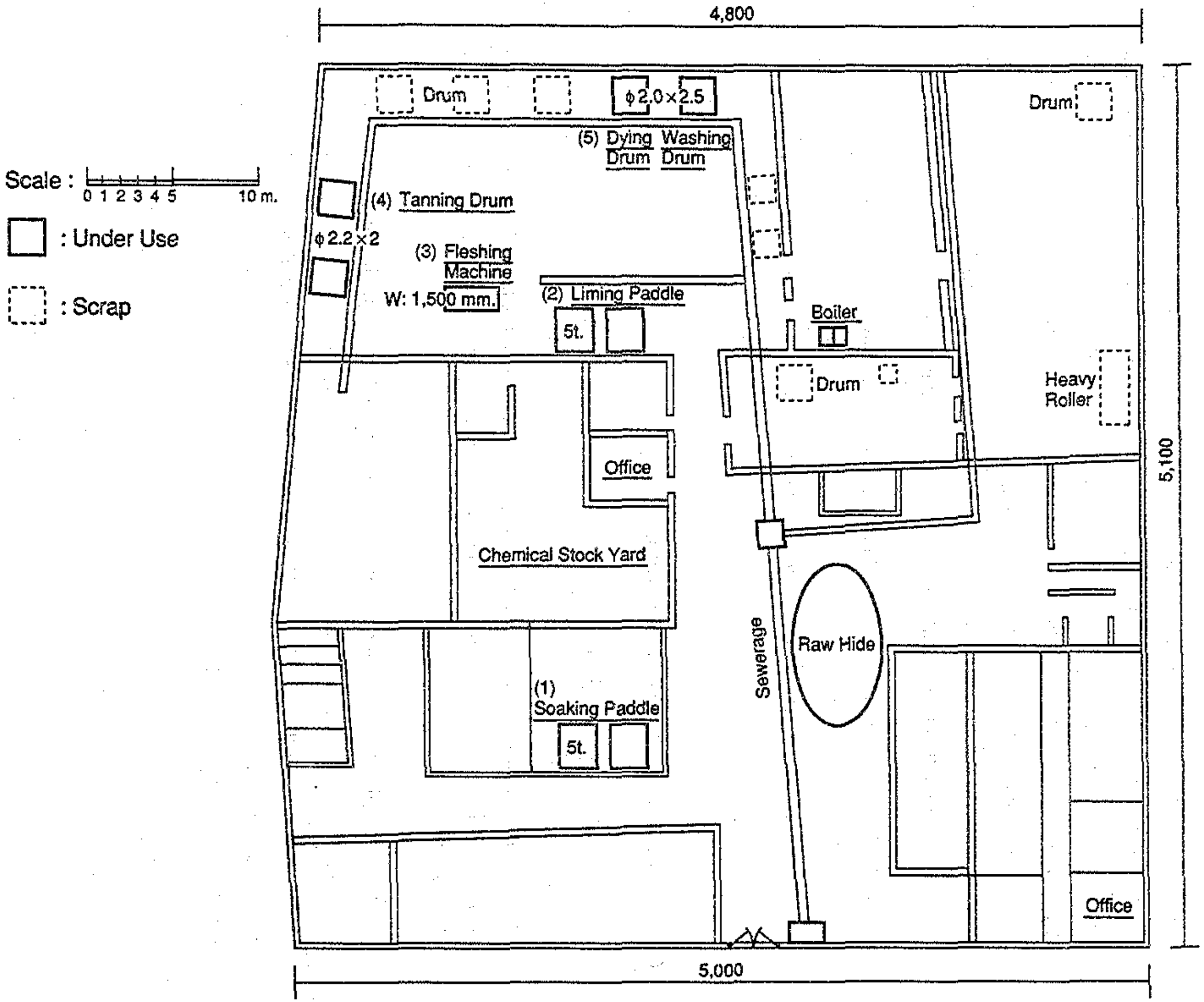
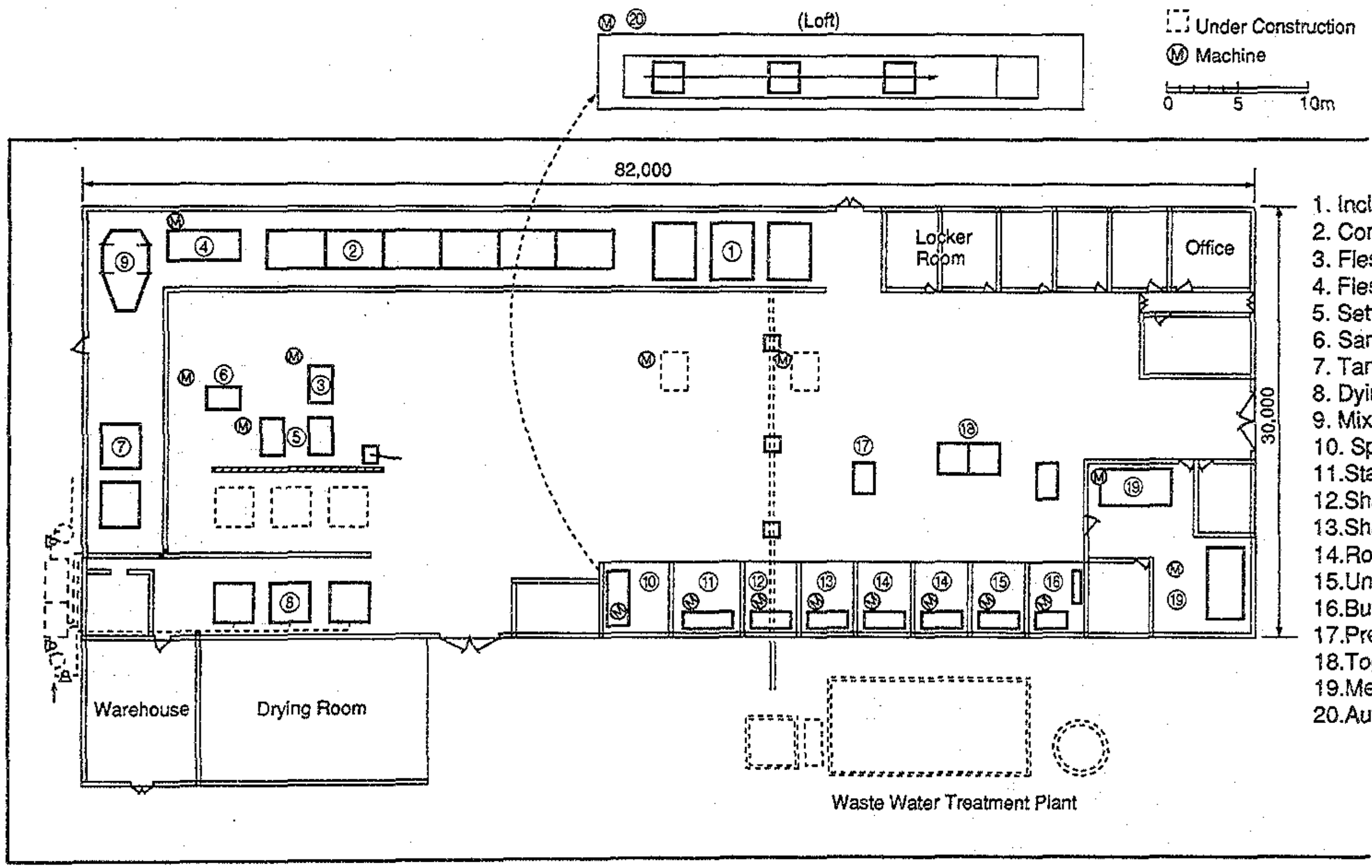


Fig. III-23 Plot Plan of TMC



1. Inclining Paddle
2. Concrete Paddle
3. Fleshing Machine
4. Fleshing Machine
5. Setting out Machine
6. Samming Machine
7. Tanning Drum
8. Dying Drum
9. Mixer
10. Splitting Machine
11. Staking Machine
12. Shaving Machine
13. Shaving Machine
14. Rollironic Machine
15. Universal Staking Machine
16. Buffing Machine
17. Press
18. Toggling Dryer
19. Measuring Machine
20. Automatic Spraying Machine

6.1.2 Production and Sales

According to the first field survey, its annual production of raw skin was 200,000 sheets (daily production: 700 sheets). Now the yearly production reached the level of 250,000 sheets (daily production: 800 sheets). Composition ratio of raw skin is unchanged, with sheepskin accounting for 70%, goatskin for 20% and cowhide for 10%. Output is subject to seasonal fluctuation, and it starts decreasing in February and starts increasing again in June. Its output stays on a high level during two months from July to August, and is in full swing in October. This pattern is repeated yearly. It seems that the fluctuation of production is affected by the tourist season. The output and volume of secondary materials used in year of 1990 are shown in Tables III-25 and III-26.

6.1.3 Layout of Facilities

The layout drawings of existing facilities are given in Fig. III-22 (old factory) and Fig. III-23 (new factory). Many machines are newly installed, but several machines are old and outdated. Some of them are being repaired and other machines need maintenance in the future. It must be considered as an inevitable consequence of the circumstances that the names of manufacturers and prices of equipment are not made clear. The specifications of machines and equipment are given in Table III-27.

6.1.4 Future Plan

Sales are subject to sharp fluctuations owing to the demand of domestic and overseas markets. The export value of SMCP ranked top in the leather industry but it seems to have been greatly influenced by the Gulf War. The amount of its export accounted for 50% of its total production in 1989 decreased to 20% in 1990 and 10% in 1991. Inevitably, SMCP has to adopt a business strategy with more emphasis on domestic demand, and increases the output of value-added final finished goods as a result. To cope with the diversified demand, the company also must shift its production to produce many kinds of products, and the development of new products is urgently required.

Under these circumstances, production shifted from manual operation to mechanical (automatic) operation, and facilities have been updated to produce various kinds of goods including double-face skin (both sides of wool and back skin are usable), suede, chamois and cowhide for shoes. Included are large-scale fleshing machines, wet-blue squeezing machines, shaving machines, splitting machines, buffing machines and tanning drums dedicated for chamois. Of course, all of these machines are not in operation now, but many of them will be ready for use to diversify its products and inprove to achieve high efficiency of the production facilities in the near future after maintenance is completed. SMCP is required to cope technically with them as a matter of course. It is also one of international trends in the leather industry to expand the scale of production technology and to improve to achieve high production efficiency.

Table III-25 Output of SMCP (1990)

Product	Production capacity	Supply	Selling price (Supply)	Optimum storage	Quality
Leather for clothes (sheep)	600 sheets/day	90%	1st group : 1.710TD tax-free price/square foot), 60% 2nd group : 1.282TD tax-free price/square foot), 30% 3rd group : 0.855TD tax-free price/square foot), 10% *Tax exemption: 17%	10%	The present quality conforms to the codes and standards of Tunisian National Standard Bureau (3 kinds)
Leather for shoes (Goat)	200 sheets/day	70%	1st group : 1.282TD tax-free price/square foot), 60% 2nd group : 1.025TD tax-free price/square foot), 30% 3rd group : 0.855TD tax-free price/square foot), 10% *Tax exemption: 17%	30%	The present quality conforms to the codes and standards of Tunisian National Standard Bureau (3 kinds)
By-product : Wool *An average 300g of wool can be obtained from a sheep.	100-150 tons/year	0%	The price is variable. 1.2TD/1kg (1989) 0.8TD/1kg (1990)	100% (1990 and 1991)	
Estimated output of new factory	End of the year 1992 : 1,500 sheets/day End of the year 1994 : 2,000 sheets/day End of the year 1996 : 2,500 sheets/day				

Table III-26 Secondary Materials (1990)

Material	Process	Form	Annual consumption (t)	Value (yearly, TD)
Slaked lime	Lime painting	Powder	60	8,220
Sodium sulfide		Flake	39	31,200
Slaked lime	Liming	Powder	15	2,055
Ammonium sulfate	Deliming	Powder	7.5	2,887
Enzyme agent	Bating	Powder	2.4	4,080
Kerosene	Degreasing	Liquid	18 (m^3)	3,240
Emulsifier		Liquid	3	9,300
Salt	Pickling	Powder	30	2,100
Formic acid		Liquid	2.1	2,520
Sulfuric acid		Liquid	2.1	315
Chromium sulfate	Tanning	Powder	22.5	33,750
Sodium bicarbonate		Powder	6	2,880
Degreasing agent	Degreasing	Liquid	2.4	6,720
Sodium formate	Neutralization	Powder	2.1	1,155
Sodium bicarbonate		Powder	2.1	1,008
Retanning agent	Retanning	Powder	7.5	20,250
Dye	Dyeing	Powder	6	96,000
Fatliquoring agent	Stuffing	Liquid	15	37,500
Formic acid		Liquid	7.5	9,000
Pigment	Finishing	Liquid	2.4	8,400
Wax		Liquid	6	18,000

Table III-27 Specifications of Main Facilities (1/3)

(New factory)

No.	Production Process	Equipment and facilities	Quantity	Specification	Manufacturer	Price/unit	Capacity (facility/actual operation)	Remarks
1	Sookin	Inclining paddle	3	15t	KOSTROJ (YOUGOSLAVIE)			Not in operation
2	Liming	concrete paddle	6	10t	Domestic product			Not in operation
3	Fleshing	Fleshing M	1	Working width 1,600mm	MERCIER (FRANCE)			Under maintenance
4	Fleshing	Fleshing M	1	Working width 2,700mm	MOSCONI (ITALIE)			Under maintenance
5	Sotting	Setting out. M	2	Working width 1,600mm	MERCIER (FRANCE)	17,000TD (1992)	200 Sheets/day	
6	Sammying	Sammying. M	1	Working width 1,500mm				
7	Tanning	Tanning Druom	2	$\phi 2.5 \times 2m$				
8	Retanning ~ Fatliquoring	Dying Drum	3	$\phi 2.5 \times 2m$	VENTURA (ESPAGNE)			Dedicated for chamois production (not in operation)
9	Tanning	Mixer (Hide procsser)	1		KOSTROJ (YOUGOSLAVIE)			Not in operation
10	Splitting	Splitting M.	1		MERCIER (FRANCE)			Under maintenance
11	Staking	Staking M.	1	Working width 1,500mm	MERCIER (FRANCE)	17,000TD	1,500 Sheets/day 1,200 Sheets/day	Cylinder type

Table III-27 Specifications of Main Facilities (2/3)

(New factory)

No.	Production Process	Equipment and facilities	Quantity	Specification	Manufacturer	Price/unit	Capacity (facility/actual operation)	Remarks
12	Shaving	shaving M.	1	Working width 1,500mm	MERCIER (FRANCE)			Dedicated for dry shaving
13	Shaving	shaving	1	Working width 1,3 00mm	TURNER (FRANCE)		1,500 Sheets/day 1,200 Sheets/day	Dedicated for wet shaving
14	Finishing	Rollironing M.	2	Working width 1,800mm	MERCIER (FRANCE)			Under maintenance
15	Staking	universal staking	1	Working width 1,300mm	KELA (ALLEMAGNE)			Universal type
16	Buffing	Buffing M.	1		MERCIER (FRANCE)			
17	Finishing	Press. (Hydraulic press)	1					
18	Toggling	Toggling dryer	2					
19	Meassuring	Messuring M. Elestronic	2		MIRETE (YOUGOSLAVIE)			Not in operation
20	Finishing	Automatic Spraying M.	1		CHARVOT (FRANCE)		1,500 Sheets/day 1,200 Sheets/day	Under maintenance

Table III-27 Specifications of Main Facilities (3/3)

(Old factory)

No.	Production Process	Equipment and facilities	Quantity	Specification	Manufacturer	Price/unit	Capacity (facility/actual operation)	Remarks
1	Soaking	paddle	2	5t	Domestic product	1,000TD (1992)	400 Sheets/day 400 Sheets/day	Wooden–made
2	Liming	paddle	2	5t	Domestic product	1,000TD (1992)	400 Sheets/day 400 Sheets/day	Wooden–made
3	Fleshing	Fleshing M.	1	Working width 1,600mm	MERCIER (FRANCE)	16,900TD (1980)	2000 Sheets/day 1200 Sheets/day	Under maintenance
4	Tanning	Tanning Drum	2	ø2.2×2m	Domestic product	5,000TD (1992)	500 Sheets/day	Wooden–made
5	Soaking	Soaking Drum	1	ø2.0×2.5m	Domestic product	5,000TD (1992)	500 Sheets/day	Wooden–made

6.2 Present Conditions of Operation and Problems

The present condition is that factory facilities are in the midst of moving from the old factory to the new factory and the new factory has not been completed thoroughly. And the equipment are under preparation for near future. Therefore operational condition at this stage is far from 100%.

An increase in the type of goods to be produced and in the volume of production will inevitably result in more complicated production process, expansion of facilities and increased number of employees, thus factory management may occur problems in the future.

Viewed from the production process, there is an essential difference between the preparatory (including shaving) and tanning processes and the successive dyeing and finishing processes.

Removing furs with calcium hydroxide and sulfide, refining collagen by dissolving unwanted protein and treating with a chrome tanning agent are entirely chemical processes.

Operations of the second half including and after dyeing process mainly include physical operations and absorption, and they are related to fashionable aspects of products and are more or less complicated, although the product lot size is small. The factory concerned must make the most of its originality to complete its final products.

Therefore, it is more profitable to conduct treatment mechanically, rationally, concentratedly and scientifically in the first half of the production process, while treatment with an aesthetic sense is required for the second half of the production process.

Under these circumstances, the essential points of factory management such as new product development (improvement of economical efficiency), environmental pollution control, quality control, and improvement of production technology and working environment, do not seem to be achieved easily by a small-scale tanning factory.

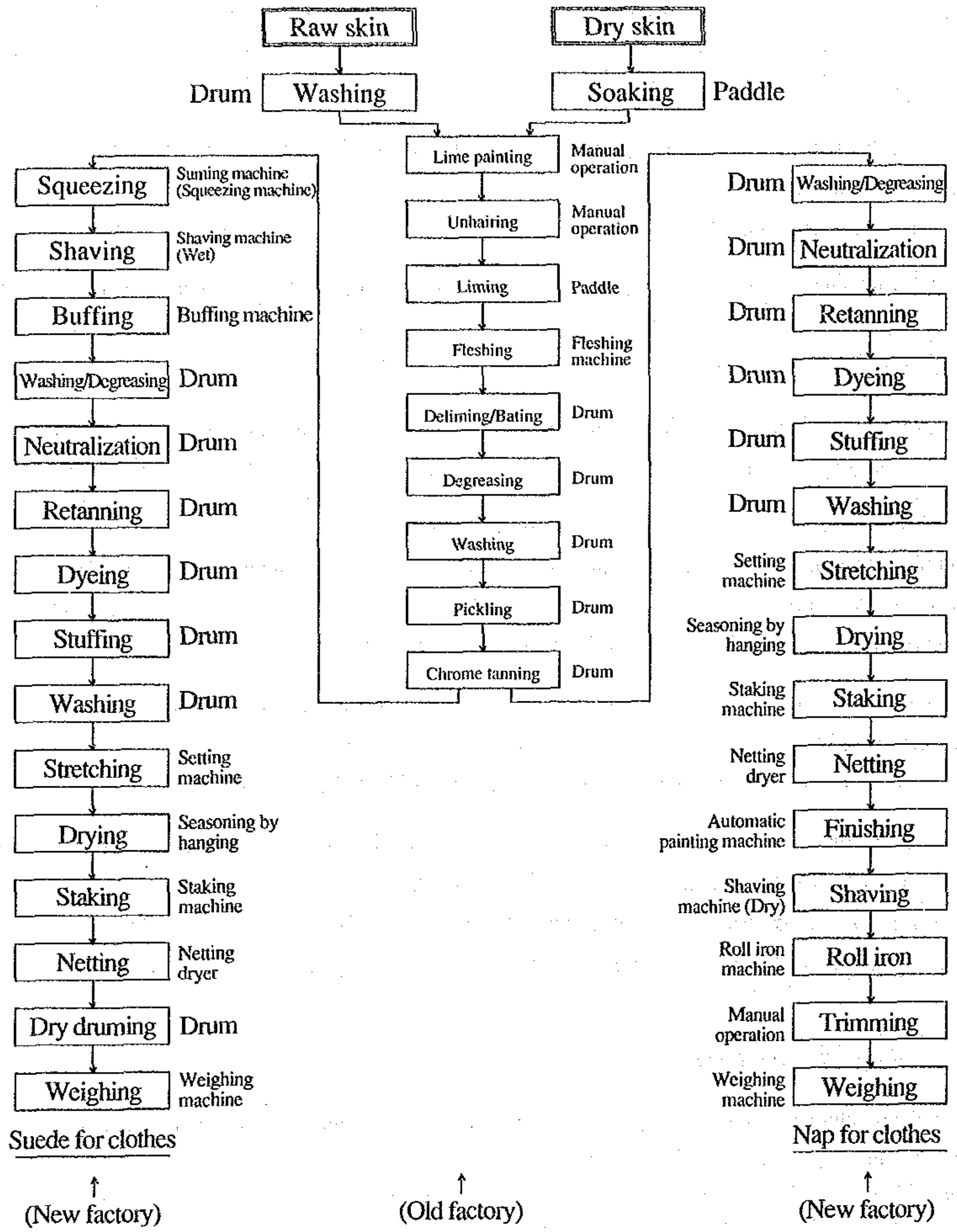
6.2.1 Flow of Production

The production process of SMCP's main production items, i.e. sheepskin nap and suede for clothes, is outlined in Fig. III-24.

As mentioned before, processes up to chrome tanning are conducted in the old factory, and processes after that are conducted in the new factory. However, all of them is scheduled to be done in the new factory in the near future.

Besides, SMCP produces leather for shoes (goatskin and cow-hide) and is planning to produce double-face skin and chamois (sheepskin). Through our field survey, we try to make a guess about the production of these goods in the factory.

Fig. III-24 Production Process of Nap and Suede for Wool Clothes



At present, lime painting is conducted manually in the old factory, but it is expected to be automated in the new factory by introducing new lime painting machines. Unhairing machines will be introduced for automated unhairing. The volume of water used for soaking and liming has never been measured by the factory, but it was explained as "filling a paddle full." By measuring the paddle actually, its capacity proved to be about $5m^3$, which is insufficient as compared with the volume to be treated. Conversely speaking, too much skin is rammed into the paddle to cause an insufficient volume of water, thus a bad influence is exerted especially on the liming process. Anyhow, as the new factory is equipped with large paddles, this problem will be settled in case of moving to the new factory.

There will be no serious problem as long as the present average output is maintained and each machine or facility continues normal operation. Of course, when developing new products through completely different process, it is required to draw a flowchart, carry out a survey of relationship with other products and examine the entire process of production in the factory again.

The operating time is set to seven hours, i.e. from 7:30 to 14:30 for the first group and from 10:00 to 17:00 for the second group (20 minutes for noon break), totaling 40 hours a week and 300 days a year. For the peak of production in around October, another operating time from 14:30 to 22:00 is prepared for the seasonal worker group so that the operability of facilities and equipment is increased.

Figure III-25 shows the flow chart which indicates how skin (leather) moves on the production line of the factory. The production line in the preparatory and tanning sections is well-equipped, but the finishing section is divided into small partitions for the installation of machines, and the production lines cross each other before the finishing section, especially in case of producing many kinds of products.

6.2.2 Security and Working Environment

With regard to security and working environment, as the new factory has not been arranged in order yet, it is impossible to judge at present the conditions of the time when normal operation has been started after the completion of the movement of the equipment. As compared with the old factory, the new factory has a high ceiling, and has a broad space and is bright. Production facilities are installed in the factory so that raw skin (leather) can be made into finished products after moving around in the factory. If things are put in order or the factory is cleaned carefully, there will be no trouble for time being.

The process from the storage of raw skin to soaking and fleshing will become dirty most easily and easily become to be a source of bad smell. It is one of the key points to keep this process clean. Above all, since the processes of lime painting, unhairing and fleshing waste treatment are positioned on the same floor, the greatest care must be taken in treatment, otherwise a bad effect may be exerted on other operations.

It is natural that a large running stock for each process will be piled up in various places of the factory. It is necessary to examine how and where to carry a running stock, and which type of vehicle to use. Which is more appropriate, flat car or pallet? What is the best size? How many vehicles are required? How do you secure the passage? All of them must be studied concretely and in detail.

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

Supply and waste water and solid waste of SMCP have never been measured up to now. By working in close cooperation with SMCP for the study, we measured the quantity of wastewater and waste according to the basic treatment of nap for clothes which is one of the main products of the factory. The outline is given in Fig. III-26.

As to solid waste produced as by-product, we can use only data of 330g wool/sheet from SMCP. Accordingly, we estimated the volume of solid waste by referring to a comprehensive study on by-waste in the Japanese leather industry (Japan Leather Technology Association, 1977 edition). The water content of fleshing waste was calculated at 87%, the water content of dry-shaving waste and trimming waste at 16.5%, respectively. Converting in terms of absolute dry weight, fleshing waste accounts for 5.5% of raw skin (100%), dry-shaving waste for 5.6%, trimming waste for 0.5-1.0%, and only 17.6% is going to leather used for final products.

Fig. III-25 Product Flow Chart of TMC

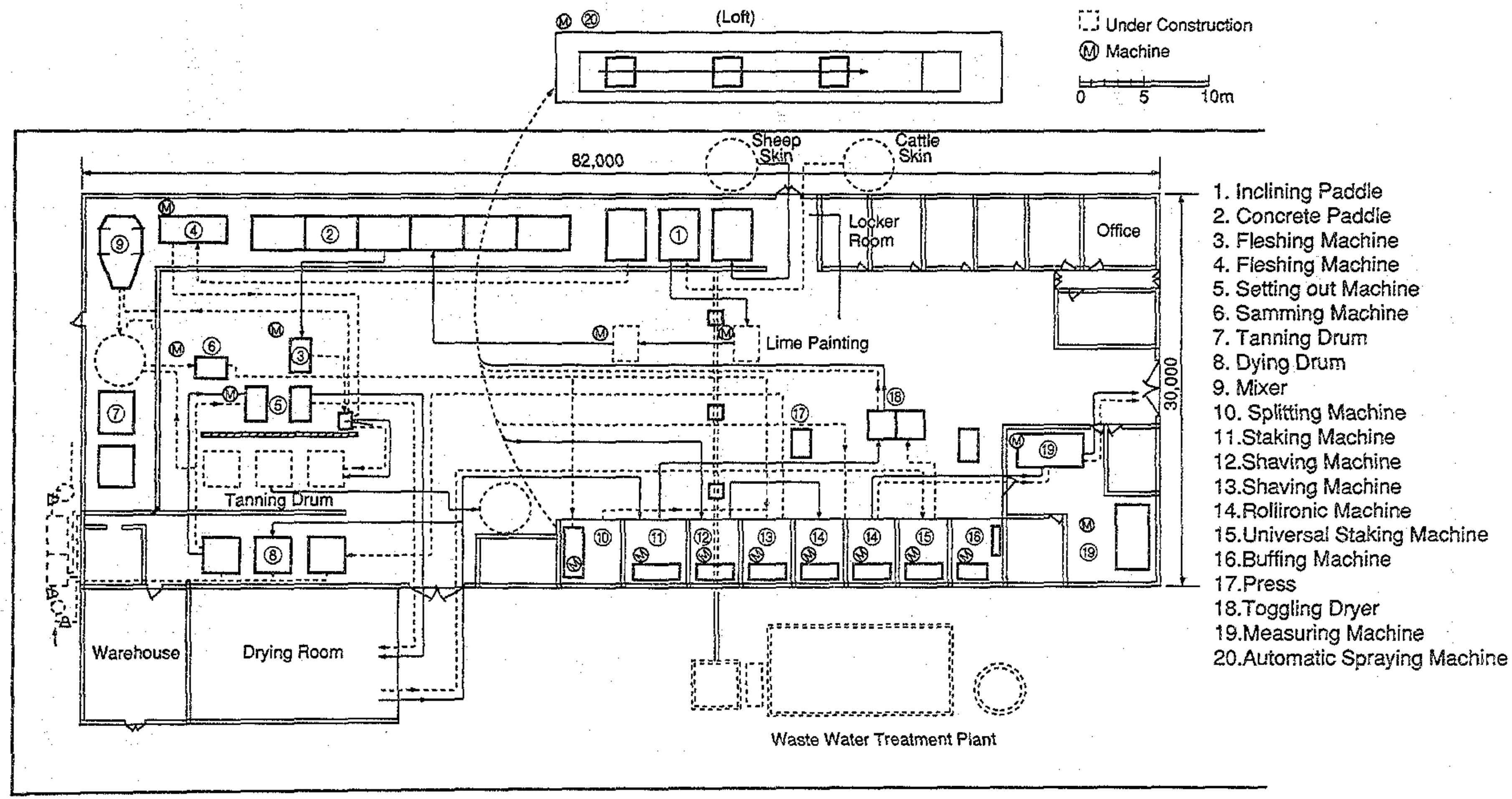
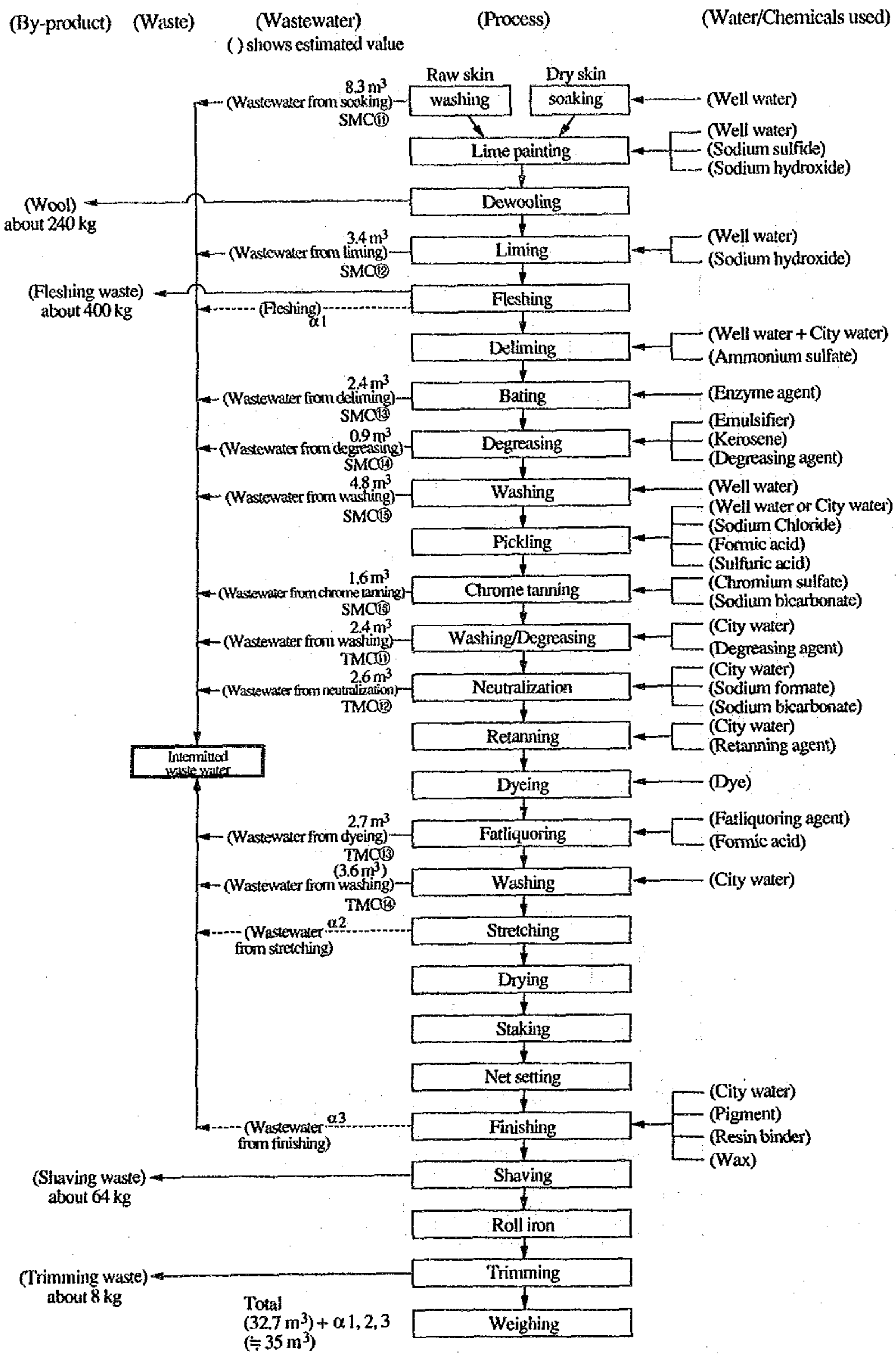


Fig. III-26 Production Process of Nap for Clothes, and Outline of Discharging Waste Water and Waste



6.3.1 Quantity of Supply Water and Wastewater, and Quality

When skin and leather are produced, all quantity of water is used for treatment. It is drained as wastewater intermittently after each treatment is completed. In addition to water for these processes, almost the same quantity of water is used, mainly for cleaning machines and working areas. The quantity of wastewater for processes in SMCP is given in Table III-28.

Table III-28 Quantity of Waste Water for Processes in SMCP

Process	Quantity of Wastewater	Supply water	Sampling No. of waste water
Soaking/Washing	8.3 m^3	Well water	SMC. 11
Liming	3.4 m^3	Well water	SMC. 12
Deliming	2.4 m^3	Well water + City water	SMC. 13
Degreasing	0.9 m^3	Well water + City water	SMC. 14
Washing	4.8 m^3	Well water + City water	SMC. 15
Chrome tanning	1.6 m^3	Well water + City water	TMC. 16
Washing	2.4 m^3	City water	TMC. 11
Neutralization	2.6 m^3	City water	TMC. 12
Dyeing/Fatliquoring	2.7 m^3	City water	TMC. 13
Washing	3.6 m^3	City water	TMC. 14
(Total)	32.7 m^3		
Miscellaneous a (1 + 2 + 3)	a	(Wastewater from fleshing, showering by lime painting machine, stretching and squeezing)	
(Grand total)	(≒ 350 m^3)		

The result of primary analysis of these wastewater is shown in Table III-29.

Table III-29 Result of Waste Water Analysis (SMCP)

A. PRIMARY ANALYSIS

SAMPLING POINT	SAMPLING DATE	ANALYSIS ITEMS(8) TURBIDITY							
		TURBIDITY	p H	CONDUCT'TY	S. SOLID	C O Dcr	B O D	n-HEX	D O
		deg.		ms/cm	mg/L	mg/L	mg/L	mg/L	mg/L
SMC-01	09/07/92	94	7.4	12.5	1	15	1	<1	
SMC-01	14/07/92	0	7.1	12.0	<1	27	16	--	3.5
SMC-11	09/07/92	>999	6.8	18.4	2700	50000	5200	270	
SMC-11	14/07/92	500	7.1	15.0	99	4600	13000	210	1.9
SMC-12	09/07/92	>999	>12	25.3	7200	740000	170000	260	
SMC-12	14/07/92	>999	12.0	18.0	9700	8800	6000	310	0.1
SMC-13	09/07/92	>999	8.7	31.1	1700	550000	59000	490	
SMC-13	14/07/92	>999	8.4	25.7	820	6000	112000	510	1.9
SMC-14	09/07/92	>999	8.7	16.5	3200	640000	170000	42000	
SMC-14	14/07/92	>999	8.4	12.5	1300	190000	140000	41000	6.4
SMC-15	09/07/92	>999	8.4	15.6	420	48000	8000	330	
SMC-15	14/07/92	>999	7.8	13.0	440	4100	2700	230	1.5
SMC-16	09/07/92	288	3.0	77.6	360	11000	2400	260	
SMC-16	14/07/92	440	3.6	76.0	180	720	1900	330	1.4
TMC-01	09/07/92	3	7.7	2.0	2	8	0.4	2	
TMC-01	14/07/92	0	6.6	2.3	0.8	4			5.4
TMC-11	09/07/92	>999	3.2	36.0	690	9700	7	990	
TMC-11	14/07/92	>999	3.4	27.0	260	7200	2300	1200	4.3
TMC-12	09/07/92	>999	4.9	36.0	690	5300	1200	810	
TMC-12	14/07/92	>999	5.0	31.0	280	10000	1800	1600	4.3
TMC-13	09/07/92	63	3.6	25.0	54	6400	2900	21	
TMC-13	15/07/92	125	3.2	19.3	37	10000	6500	19	3.9

C. DAILY ANALYSIS SAMPLING POINT - SMCP-20

SAMPLING DATE	SAMPLING HOUR	ANALYSIS ITEMS(4) p H			
		p H	CONDUCT'TY	S. SOLID	C O Dcr
			ms/cm	mg/L	mg/L
26/09/92	6:30	7.6	12.7	655	4510
26/09/92	7:30	9.5	12.5	2680	7562
26/09/92	8:30	8.2	11.9	254	1350
26/09/92	9:30	7.4	19.7	3660	4510
26/09/92	10:30	8.2	12.3	285	760
26/09/92	11:30	8.0	11.7	325	6032
26/09/92	12:30	8.8	12.1	1260	4300
26/09/92	13:30	7.9	10.9	775	870
26/09/92	14:30	9.2	12.1	715	3500
26/09/92	15:30	7.9	12.5	652	4800
26/09/92	16:30	7.6	14.6	282	4400
26/09/92	17:30	8.1	3.4	20	153

B. DETAILED ANALYSIS (SMCP)

SAMPLING POINT		SMC-11	SMC-11	SMC-12	SMC-12	SMC-13	SMC-13	SMC-14	SMC-14	SMC-15	SMC-15	SMC-16	SMC-16
SAMPLING DATE		SEP. 14	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 17
FLOW RATE	m3/D	20		20		11		0.3		10		0.5	
TURBIDITY	deg.	290	677	>999	>999	960	68	>999	>999	>999	957	110	113
p H		7.1	7.0	11.2	11.9	8.2	8.1	8.2	8.1	7.6	7.6	4.0	4.0
CONDUCT'TY	ms/cm	15.7	17.3	15.5	20.6	36.6	33.9	22.9	21.2	18.2	14.2	76.5	63.8
S. SOLID	mg/L	117	74		9520	456	200	360	830	198	121	840	108
C O Dcr	mg/L	1740	3640	15000	18100	3800	1740	44600	55500	6228	900	7680	2600
B O D	mg/L	1360	4576	35000	9406	5380	785	28600	14900	20500	790	2900	400
n-HEXANE	mg/L	56	39	111	116	108	49		6355	402	98	2592	33
S--	mg/L			240	520	4.9	2.7						
T-N(Kj)	mg/L	130	270	1500	1400	4200	4300	2800	3100	660	170	340	390
NH4	mg/L	53	150	140	130	4100	4000	3000	950	670	140	320	380
T-Cr	mg/L	<0.1	<0.1	0.9	0.6	6.6	1.3	6.8	6.6	0.8	0.5	6600	5200
Cr(VI)	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	0.2	0.2
IG. RSD	mg/L	2000	3600	12000	11000	17000	21000	22000	26000	4100	1600	13000	27000

6.3.2 System Diagram of Supply Water and Waste Water

The system diagram of supply water and waste water is shown in Fig. III-27 and Fig. III-28.

6.3.3 Problems

In the processes of soaking, washing and liming, the quantity of water is extremely reduced because of limited paddle capacity, and pollution load is very high because of the above reason.

Since a large paddle is installed in the new factory, a normal quantity of water can be supplied for soaking, washing and liming processes. The quantity of water is expected to increase from present 8.3m^3 to about 14m^3 for soaking and washing processes, and from present 3.4m^3 to about 14m^3 for the liming process. The total quantity of water from all processes will be about 50m^3, excluding water for miscellaneous usage.

In the new factory, wastewater treatment facilities are under construction based on proposals from a consulting company, Chemical Service Company (ESC). Wastewater from chrome tanning is used in circulation and the solvent in wastewater from degreasing is recovered. About 300m^3 of normal wastewater containing discharged water from liming is treated daily by wastewater treatment facilities with a coagulator. This process is to discharge wastewater into the sewerage after purifying it to the level of the ONAS standards. The production of raw skin will be about 2,500 sheets daily, more than three times of the present output, when the installation of all these equipment is completed. What matters most is whether this wastewater treatment can be performed.

As seen from the result of above analysis, the pollution load of each process is very high. The discharge of wastewater into the sewerage through the treatment facilities now under construction is likely to cause a problem so long as the ESC report is examined. Including the contents of consultation by ESC, it is necessary to make a detailed analysis based on analytical data. SMCP must study to take a measure to decrease the pollution load, in addition to the utilization of circulating chrome tanning solution and recovery of solvent in wastewater from degreasing.

Fig. III-27 Water Flow of SMCP

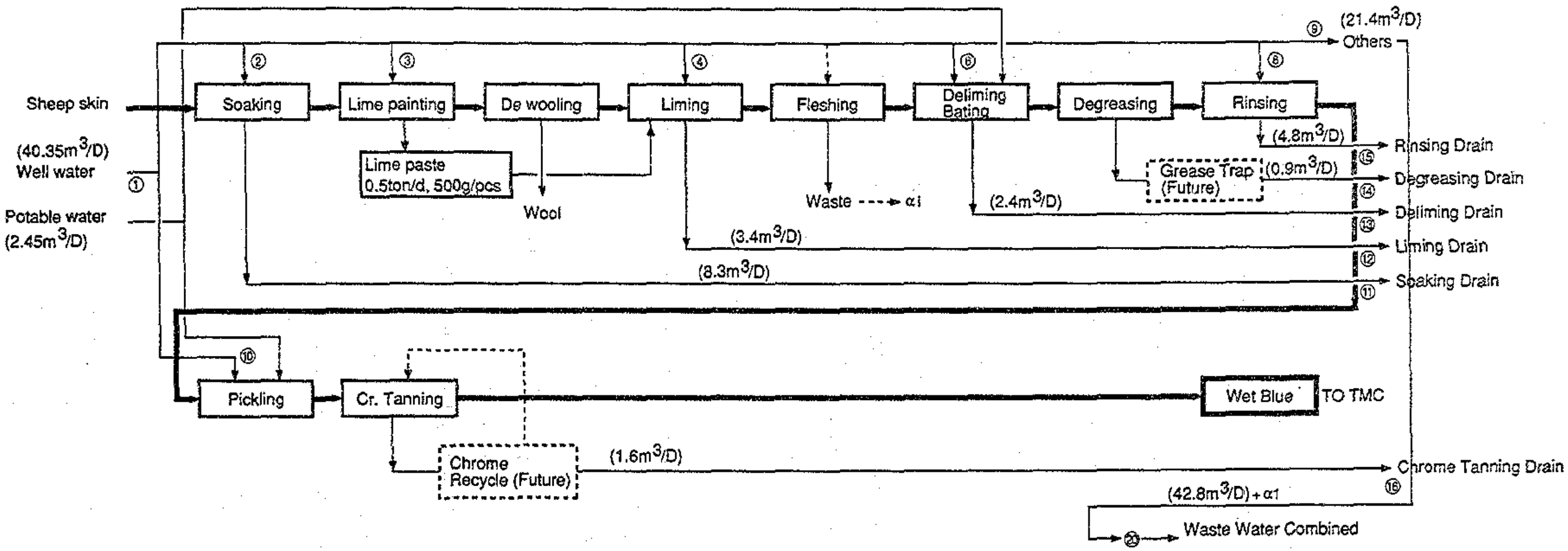
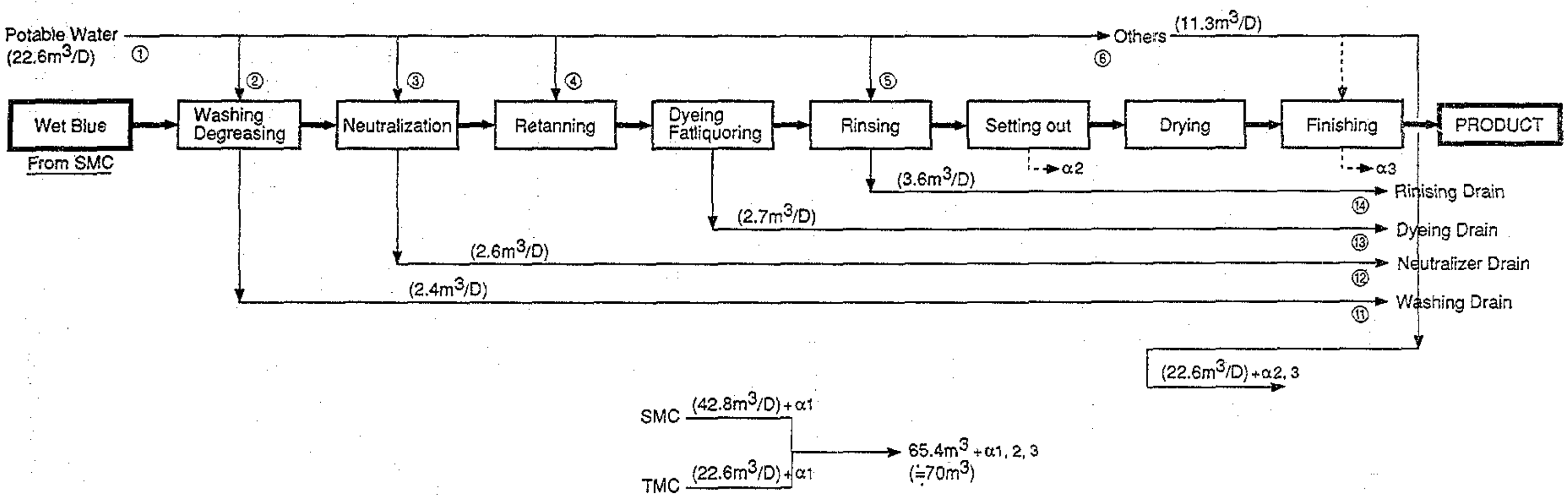


Fig. III-28 Water Flow of TMC



7. STS (Société de Tissage du Sud)

7.1 Outline of Factory

STS was founded as a textile company in 1959, and dyeing and textile finishing processes were added in 1970 and 1975, respectively. STS is the only company equipped with the dyeing process in Sfax City.

The textile industry is one of the major export-oriented industries in Tunisia. STS is a leading company in the Tunisian industry in respect to its output, technology and quality of products, and highly competitive on the domestic market.

When the owner of the company changed in August 1992, the name of the company also changed from Société de Tissage de Sfax to Société de Tissage du Sud, but its abbreviation (STS) remained the same.

STS purchases about 200 tons of raw cotton yarns. It adopts two dyeing systems, i.e. "forward dyeing" which is conducted at the stage of cotton yarns and "afterward dyeing" which is conducted after yarns are woven into cloth.

The yearly volume of forward dyeing is about 50 tons, and that of afterward dyeing is about 150 tons. However, the volume of forward dyeing is inclined to decrease.

Environmental pollution is caused mainly by waste water drained from the dyeing and finishing processes. Since more water and chemicals are used for dyeing yarns than for dyeing cloth, waste water from the yarn dyeing process exerts a large influence on environmental pollution. (Now waste water is drained into the sea without any treatment.)

The company's dyeing equipment have been used for more than 20 years, so that the depreciation of them is almost nothing. All equipment are well maintained and serviced, and there is no special obstacle for operating them.

Environmental pollution is caused not only by waste water drained from the above-mentioned dyeing equipment but also by waste water and exhaust gas emitted from the heavy oil firing steam boiler and heated oil circulating boiler. STS has not sufficient outdoor space, and it seems very difficult to install wastewater treatment facilities in the limited space. STS has to make a choice whether to secure a space by re-arranging existing dyeing facilities or to purchase a private land contiguous to the factory site.

7.1.1 Production

STS is in the line of dyeing cotton cloth and yarns. It is also dyeing and processing customers' yarns and cloth on consignment basis. Raw materials used for these operations are given in Table III-30, and their products and sales amount are shown in Table III-31.

Table III-30 Raw Materials

Raw material	Amount used (1990) (kg)	Value (1990) (TD)	Remarks
Cotton cloth	193,000	676,000	
Dyes	6,600	100,000	Sulfur, reactive, cube and direct dyes
Chemicals		49,267	Hydrogen peroxide, sodium hypochlorite, caustic soda, starch, etc.
Total		825,267	

Table III-31 Products and Output

Product	Production (1990) (m)	Sales (1990) (TD)	Remarks
5. Cotton cloth	1.4m to 1.8 m		Major items for quality control Product strength and appearance Durability and flexibility Chlorine-bleaching-proof agent Sunlight-proof, washing-proof
① Blue/indigo-colored cloth (jeans and working clothes)	266,323	680,024	
② Sheets (bleaching-proof agent)	141,931	293,293	
③ For mattress	59,472	122,945	
④ For dress fabrics	23,127	48,233	
⑤ For shoe cloth	41,147	92,505	
⑥ Dyeing and processing service (Yarn dyeing) (Fabric dyeing) (Acrylic and polyester fabric dyeing)	———	57,713	Materials are carried in by customers.
⑦ Other cotton cloth		6,122	
Total	532,000	1,300,835	

Note: The above-mentioned output is one half of its equipment production capacity.

7.1.2 Number of Employees

STS factory is operated for 16 hours daily in two shifts and in six days weekly. Its employees total about 100, and the details are shown below.

- Management Div.: 7
- Engineers: 2 (One Section leader and one machine engineer)
- Technicians: 10
- Workers: 80

7.1.3 Layout of Facilities

The factory site is about 4,000 square meters, where a building of about 3,000 square meters and a warehouse of 500 square meters are built. The layout of the factory is shown in Fig. III-29, and a private house is located in a part of the factory site. The equipment of the factory in operation are shown in Table III-32.

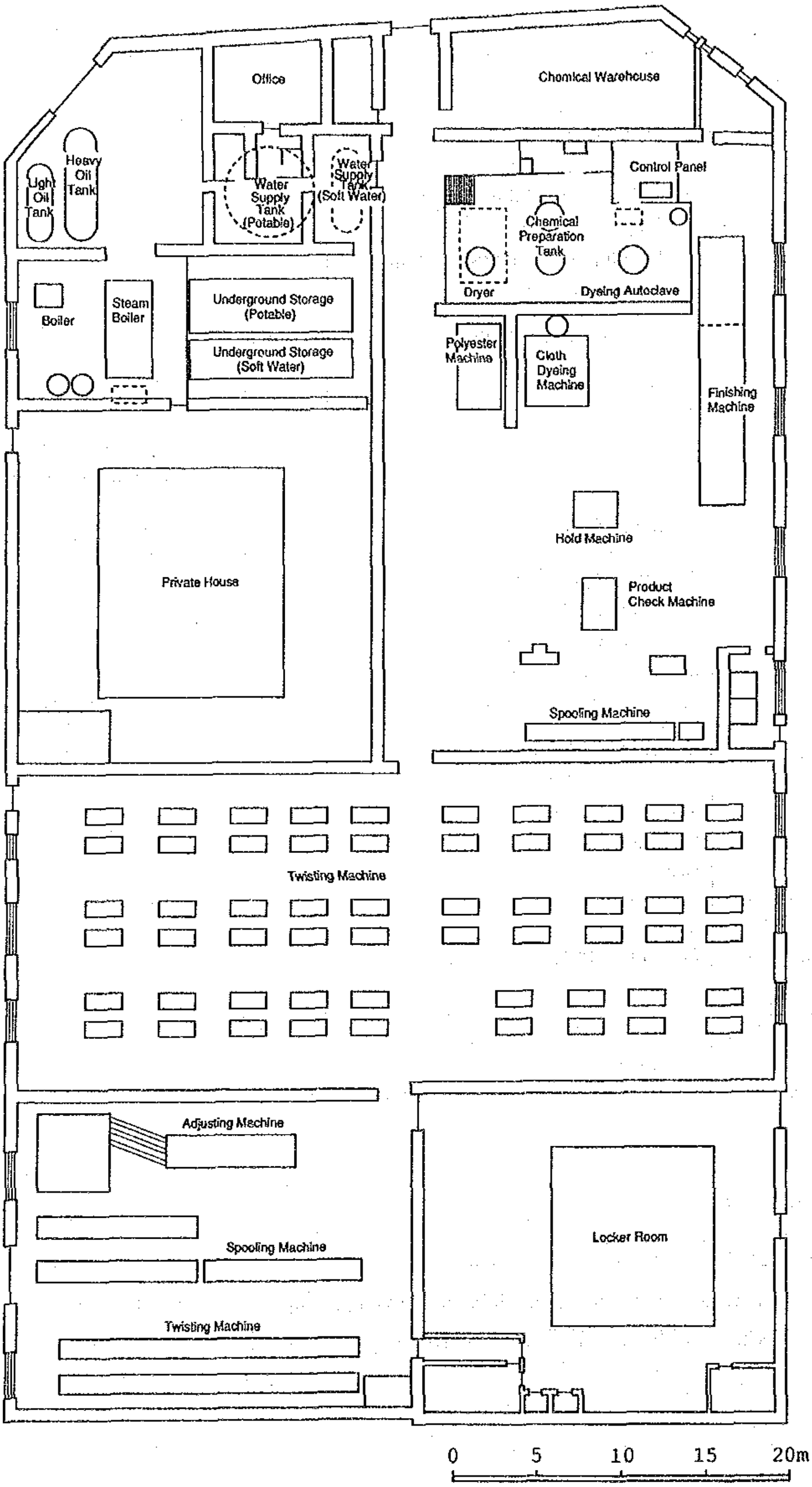
Table III-32 Specifications of Major Facilities

Process	Equipment	No. of units	Specifications
Dyeing process	Yarn dyeing equipment	1 set	
	┌ Autoclave	1	
	│ Dye preparatory tank	1	
	│ Chemical preparatory tank	2	
	│ Drying equipment (Drying oven and heat exchanger)	1 set	
	└ Vacuum pump	1	
	Cloth dyeing equipment	1 set	
	Steam boiler	1	Heavy oil firing, horizontal smoke-tube type Capacity: 2 t/H, Pressure: 10 kg
	Water softener	1	Capacity: 50 t/d
Finishing process	Thermal-type fixer (Finishing dryer)	1	
	Chemical preparatory tank for thermal-type fixer	1	
	Heated oil circulating boiler	1	Heavy oil firing type
Weaving process	Weaving machine	1	
	Shuttle winder	1	
	Shuttle cleaner	2	
	Product Checker	2	
	Folder	1	
Preparatory process	Twiner	2	
	Bobbin winder	3	
	Warper	1	
Others	Polyester pill remover	1	
	Water supply tower	1	

7.1.4 Future Plan

The present production capacity is almost one half of equipment capacity, but STS has no special plan to increase its capacity now. However, the installation of wastewater treatment facilities is inevitable, and STS intends to carry forward the project positively.

Fig. III-29 Plot Plan of STS



7.2 Present Conditions of Operation and Problems

STS purchases about 200 tons of raw cotton yarns. It adopts two dyeing systems, "forward dyeing" to dye cotton yarns and "afterward dyeing" to dye after yarns are woven into texture. The present output accounts for one half of its production capacity, and STS is not going to increase its output. The throughput of forward dyeing is on the downward trend as compared with that of afterward dyeing. The throughput of the forward dyeing process was about 50 tons (200 kg/time x 244 times) and the one of the afterward dyeing process was 150 tons (200 kg/time x 744 times) in 1991. Comparing the dyeing costs of both systems, the yarn dyeing method needs water about $2m^3$ for each process, while the cloth dyeing method requires water about $0.6m^3$. Accordingly, the yarn dyeing method needs more water than the cloth dyeing method does. Inevitably, more chemicals are used to adjust the chemical solution of the same concentration, thus the yarn dyeing method is comparatively high in cost.

7.2.1 Flow of Production

In general, textile dyeing is classified into two large groups, i.e. forward dyeing and afterward dyeing process. The yarn dyeing method is to soak yarn in the normal dye tank. When dyeing texture, two methods, soak dyeing and textile printing, are available. STS adopts the soak dyeing method for both the forward dyeing and afterward dyeing processes.

The flow of dyeing is shown in Fig. III-30

STS products are highly competitive on the Tunisian domestic market. Its reasons are as follows

① STS, established 33 years ago, has made a satisfactory business results up to now, and it is highly competitive in marketing.

② STS has less fixed charges, since the depreciation of equipment is almost nothing.

③ STS has technically completed processes.

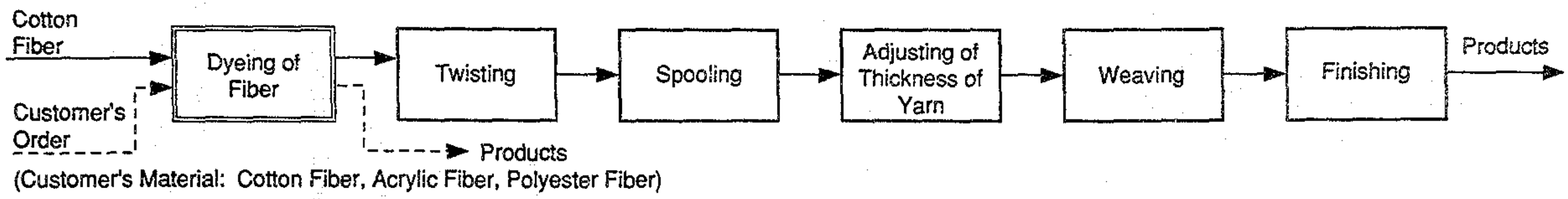
④ The quality of STS products is highly appreciated on the Tunisian market.

⑤ Human relation is kept well inside the factory.

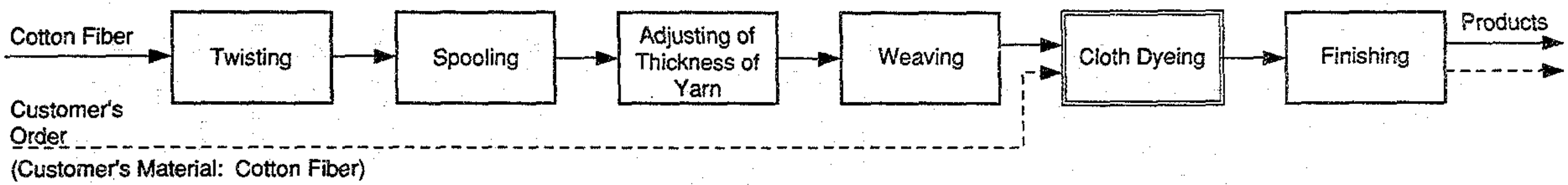
The output accounts for almost 50% of its production capacity,but STS has no plan to increase its output now. If it is resulted from the quality of waste water, output can be increased by installing waste water treatment facilities (including ONAS's treatment) so as to pay out its expenses.

Fig. III-30 Process Flow of STS

Fiber Dyeing Process



Cloth Dyeing Process



It was confirmed by the questionnaire that almost all equipment were installed more than 20 years ago but they are still in operation, with consumed parts repaired and operation partly altered as follows.

- Heat Recovery System

This system recovers the heat of steam returned from the boiler as much as possible to economize the fuel used. However, this system is out of order and steam returned from the boiler is being discharged as waste water.

- Chemical Preparatory Tank (Equipped with Pump) of Cloth Dyeing Equipment

Since the pump is out of order, chemicals and dyes are poured directly into the chemical solution tank of the dyeing equipment with bucket. After soft water is supplied, steam is introduced in directly to raise the temperature to the specified point.

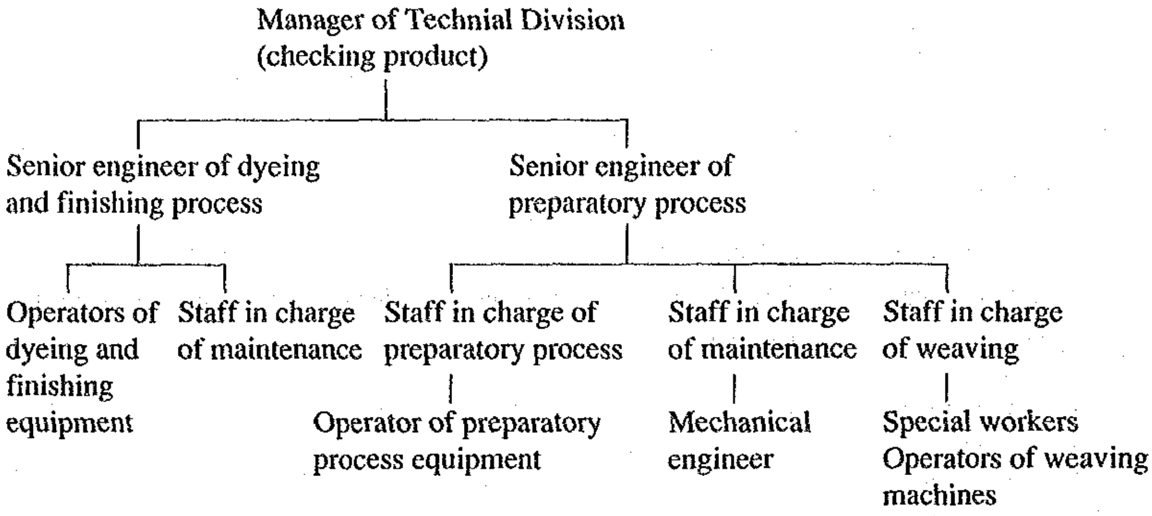
- Water Supply Tower (City Water)

When the water supply tower was built, it was covered with a hood. However, since the tower is laid open now, dead birds, soot from the boiler and oil droplets often get mixed into the tower frequently. Accordingly, the factory set a kind of filter into the one part of feed pipes to cope with these troubles.

7.2.2 Product Control and Maintenance

The daily operating time is 16 hours in two shifts (from 5:00 to 13:00 and from 13:00 to 21:00). The factory is operated for six days a week, and it is closed on Sunday and public holidays. The factory stops all operations during the summer vacation which lasts for 18 days. It undergoes inspection of important equipment such as boiler, water softener, dyeing equipment and finishing equipment. The factory conducts the periodical inspection once a year.

Daily maintenance includes inspection, greasing, oil-level adjustment and cleaning. The following is the system of instructions for production.



The organization has no problem for time being, and maintenance for such troubles as described in section 7.2.1.is desirable to be implemented yearly when all equipment are not in operation.

7.2.3 Security and Working Environment

Chemicals are poured with bucket directly into the chemical preparatory tank attached to the cloth dyeing equipment. This is not desirable in respect to security and working environment, and the pump must be repaired to avoid manual operation.

The factory is kept clean except for facilities related to waste water such as drainage pits.

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

7.3.1 Flowchart of Supply Water and Waste Water, and Quality of water

The flowchart of waste water is given in Fig. III-31, and the quality of water measured this time is given in Table III-33.

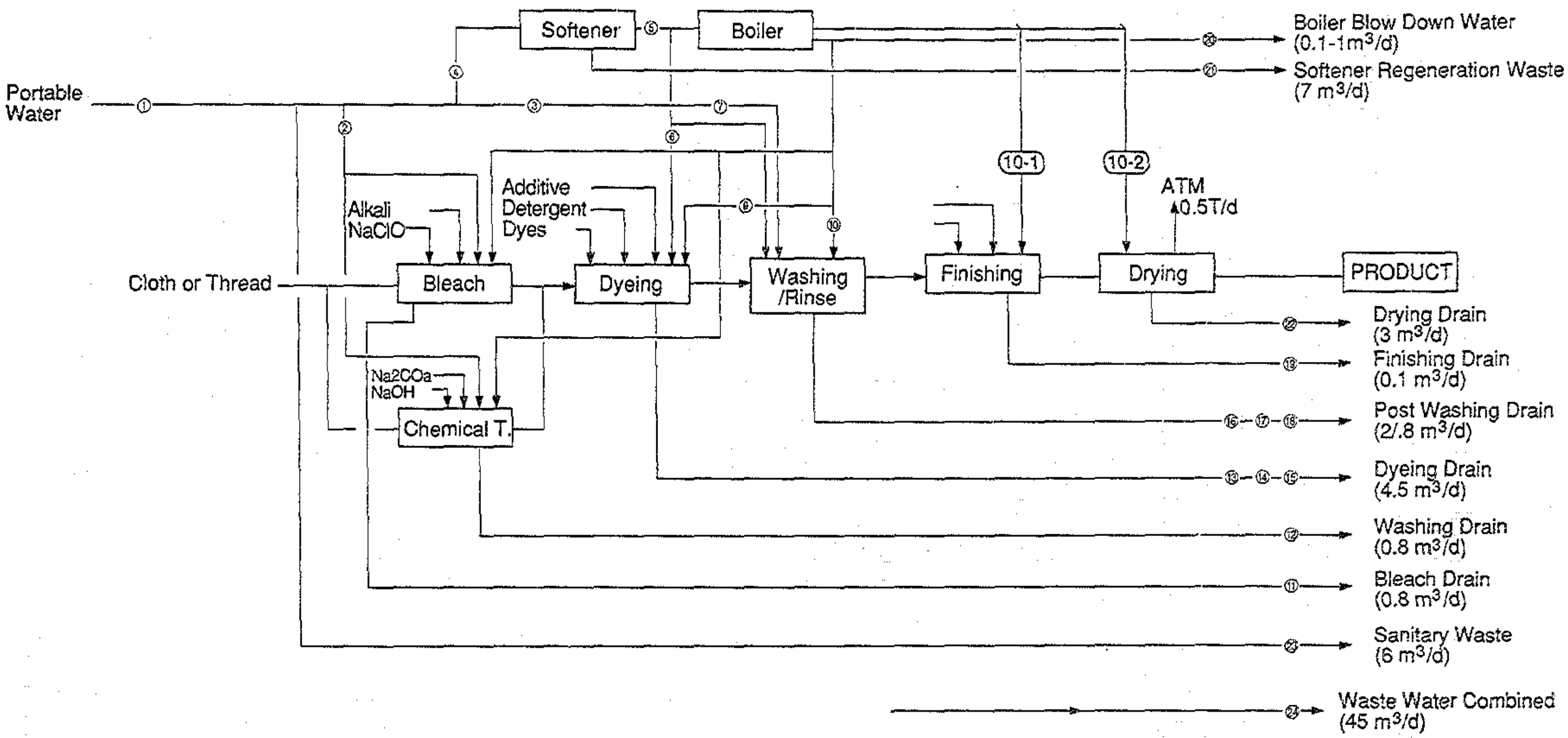
Table III-33 Result of Water Analysis (STS)

SAMPLING POINT	SAMPLING DATE	ANALYSIS ITEMS(8)							
		TURBIDITY	p H	CONDUCT' TY	S.SOLID	C O Dcr	B O D	n-HEX	D O
		deg.		ms/cm	mg/L	mg/L	mg/L	mg/L	mg/L
STS-01	10/07/92				<1	<6	0.1	3	
STS-01	15/07/92	0	8.0	2.3	<1	<6	<6	--	4.8
STS-13	10/07/92	>999	10.3	17.0	770	19000	--	760	
STS-13	15/07/92	>999	11.3	22.0	110	2.1	48000	400	0
STS-16	10/07/92	0	8.8	2.6	12	160	--	3	
STS-16	15/07/92	20	9.8	2.9	6	410	130	4	4.2
STS-19	10/07/92	>999	5.4	2.6	30000	130000	1	230	
STS-19	15/07/92	>999	7.8	2.8	37000	160000	100000	7	0.7
STS-20	10/07/92	28	11.3	12.0	36	510	--	7	
STS-20	15/07/92	10	11.1	5.2	13	54	47	200	4.2
STS-21	09/07/92	10	7.3	34.0	<1	2000	--	4	
STS-21	15/07/92	0	7.3	35.0	2	15	7	--	4.6

DETAILED ANALYSIS (STS)

SAMPLING POINT		STS-13	STS-15	STS-16	STS-18	STS-19
SAMPLING DATE		OCT.1	SEP.30	OCT.1	SEP.30	OCT.1
TURBIDITY	deg.					
p H						
CONDUCT' TY	ms/cm					
S.SOLID	mg/L	20	6.8	8.2	0.2	6300
C O Dcr	mg/L	2585	1270	178	32	35200
B O D	mg/L					
n-HEXANE	mg/L	49	21	172	4	17
CN	mg/L	<0.2	<0.2	<0.2		<0.2
Cl	mg/L	===	===	310		540
T-Cr	mg/L	<0.1	<0.1	<0.1		<0.1
Cr(VI)	mg/L	<0.1	<0.1	<0.1		<0.1

Fig. III-31 Water Flow of STS



7.3.2 Present Conditions of Supply Water and Waste Water

STS is a dyeing and textile factory, and uses water in the dyeing process but uses scarcely any water in the weaving process. It uses only city water. Waste water includes water drained from bleaching, dyeing, washing, finishing and drying processes, as well as blowdown of boiler, recycled water from softener and living sewage. Generally, the dyeing factory uses different kinds of dyes and chemicals depending on the type of fiber, color and method of processing. The condition of waste water usually changes constantly in both of quantity and quality depending not only on seasonal factors, but also on the time it is used within a day.

All kinds of waste water from STS factory are collected and drained into the sea through the same exit port.

7.3.3 Problems

In the dyeing and finishing processes of the factory, various kinds of dyes, auxiliary materials which are several times to several ten times as many as dyes, and chemicals are used. Most of dyes and processing agents are fixed on fibers but all chemicals are drained. In addition to these, fiber waste fallen off from yarns and clothes and other dissolved polluted components are mixed in waste water, thus they become pollutant sources like pH, SS, BOD and COD. Dyes not fixed on fibers give colors to waste water, making it appear more polluted than it actually is.

Waste water from scouring and cleaning processes contains oil, wax, pectic substance and pigments, and it looks as if highly polluted, while waste water from the bleaching process is features high alkalinity because hydrogen peroxide is used. In case of STS factory, the STS-11 and STS-12 in the flowchart correspond to waste water drained from the above-mentioned processes, but no sampling was made in this survey.

Concerning the waste water from the dyeing process, its quality and quantity vary significantly because the dyes and chemicals used vary largely depending on the type of fiber, use of product, method of dyeing and the specifications change more frequently in case of a small-lot dyeing. Dyes themselves are generally have small BOD values, but some of the chemicals used as auxiliary agents show high COD values. In case of STS factory, the STS-13 corresponds to this and the BOD value shows the value of 48,000 mg/l which is extremely high as compared with a BOD value of about 2,000 mg/1 shown in Japan.

The finishing process uses resin, oil and sizing agent to provide various features to fibers, and most of them are fixed on fibers. Therefore, waste water is not highly polluted except for some special cases, but treatment of processing agents, which remained after operation is completed, will be a serious matter. The STS-19 corresponds to this case, and the COD value is very high at about from 130,000 to 160,000 mg/l. This is likely a result of inferior of operation or the effect of agents disposal after operation is completed.

Overall waste water from STS factory are deteriorated because the above-mentioned STS-13 and STS-19 are highly polluted. It should be considered to reduce the volume of pollutant materials at the STS-13 and STS-19 by improving the production process and operation method. Should waste water from the STS-13 and STS-19 be treated separately because its quantity is rather small, other pollution loads may be reduced significantly.

7.4 Present Conditions of Exhaust Gas and Problems

7.4.1 Gas Exhaust Facilities

STS factory uses a steam boiler for bleaching, dyeing and drying processes and a heating-medium heater for heating in finishing process as combustion equipment.

The steam boiler is operated for 16 hours a day, and almost half of steam produced is used for the drying process. The drying process uses steam indirectly, and condensed water is drained as waste water. It is because the capacity of the feed water pump is too small to supply high-temperature water. Since steam is also used indirectly in the dyeing process, it is possible to recover condensed water but it is drained as waste water for the same reason as in the drying process. In other processes, steam is used for direct heating and discharged as waste water.The general description of combustion equipment used in STS factory is as follows.

① Boiler

Capacity	: 1,680 kg/hour
Steam pressure	: 10 bars
Manufacturing year	: 1971
Fuel used	: Heavy oil
Operating time	: 16 hours/day

② Heating-medium heater

Max. temperature	: 300°C
Max. pressure	: 3.0 bars
Heating-medium temp.	: 220°C (outlet), 150°C (return)
Heating-medium pressure	: 2.6 bars (outlet), 1.0 bar (return)
Manufacturing year	: 1974
Fuel used	: Heavy oil
Operating time	: 8 hours/day

7.4.2 Characteristics of Exhaust Gas

The factory has two combustion equipment, and both of them use light oil at the start of combustion, and once combustion becomes stable, light oil is replaced by heavy oil. Heavy oil was burnt at the time of exhaust gas measurement in this survey.

About one half of steam produced by the boiler is consumed in the drying process. The steam boiler repeats ignition and extinction as the steam consumption decreases producing black smokes.

The result of exhaust gas measurement is given in Table III-34.

Table III-34 Result of Exhaust Gas Measurement (STS)

FACTORY		S T S	
SAMPLING POINT		STS-51	STS-52
SAMPLING DATE		JUL/7/92	JUL/7/92
FACILITY		BOILER	BOILER
FUEL		H. OIL	H. OIL
GAS VOLUME			
ACTUAL	m3/h	2870	720
WET GAS	Nm3/h	1370	380
DRY GAS	Nm3/h	1230	350
H2O	%	10.5	7.9
GAS TEMP.	°C	298	248
CO2	%	7.8	11.6
O2	%	11.0	8.2
DUST	mg/Nm3	1200	1000
SOx	ppm	560	900
NOx	ppm	170	180

7.4.3 Problems

By observing exhaust gas emitted from the factory, particles of soot and SOx may be regarded as causes of pollution. A large volume of particles of soot is produced when steam consumption varies sharply and the steam boiler repeats ignition and extinction.

SOx is created from the sulfur content in fuel. In Tunisia, the import of heavy oil is controlled by the Government, and it seems very difficult to use fuel with less sulfur content.

8. ONAS (Office National de l'Assainissement)

8. 1. Outline of Sewage Treatment Plant

ONAS sewage treatment plant, a national sewage treatment plant situated along the southern coast of Sfax City, started operation in 1975. It accepts living sewage and partially industrial waste water at the same time to conduct biological treatment.

ONAS has 20 pump stations in the city, and the total length of sewer pipe is 322 km with 25,100 branches. It now treats waste water in one sewage treatment plant, but another new sewage treatment plant is scheduled to be established in the future (three years later).

ONAS sewage treatment plant was established in 1973 after designs by Sweden to meet demands for waste water treatment until 1996. It can treat waste water up to 32,000m^3 daily, and it adopts the lagoon biological treatment system. Treated water is partly used for agricultural purpose, and the rest is drained directly into the sea. Produced sludge is dried in the solar drying bed to be used as fertilizer.

The cost for establishing sewage treatment plant totaled 5 million to 6 million TD. It is now operated by 11 regular employees (one engineer and 10 operators) and seven temporary workers.

8.1.1 Designe Treatment Capacity and Quality of Waste Water

The quantity of sewage treatment and quality of waste water flowing in and out were as follows when ONAS sewage treatment plant was designed.

- Quantity of waste water treatment

Daily average waste water:	20,300m^3/day
Daily maximum waste water:	32,000m^3/day
Time-maximum waste water:	2,000m^3/Hr

- Quality of waste water

	Influent	Effluent
BOD mg/*l*	390	35
COD mg/*l*	900	200
SS mg/*l*	350	35

In the objective district, the number of houses is 38,536 and the number of factories is 434 and the number of hotels is 16.

8.1.2 Specifications of ONAS Sewage Treatment Plant

The layout drawing of ONAS sewage treatment plant and flow sheet are given in Fig. III-32 and Fig. III-33.

Sewage flown into the plant is pumped up by a screw pump, screenings are removed, and then rather large suspended solid and grit are removed in the grit chamber. Waste water flows into the lagoon pond equipped with an aerator, where organic substances are dissolved by biological oxidation. After that, sludge is removed from waste water in the sedimentation tank and supernatant liquid is used partly as agricultural water, and the rest is drained directly into the sea.

Sludge deposited in the sedimentation tank is concentrated in the sludge thickener, filtered on the drying bed, and water content is removed through evaporation. Remained solid substances are used as fertilizer.

The specifications of each equipment are given in Table III-35.

Table III-35 Specifications of Facilities (ONAS)

Inlet pump:	3,250m³/Hr, 55 kW x 3 units
Grit chamber:	8 (W) x 17 (L) x 6 (D)m
	Capacity: 820m³
Lagoon pond:	72 (W) x 630 (L) x 3.2 (D)m
	Capacity: 143,000m³
	Aerator: 15 kW x 14 units
Sedimentation tank:	18 (W) x 80 (L) x 2 (D)m x 2 units
	Capacity: 6,200m³
Sludge thickener:	8 (dia.) x 4 (D) x 2 units
	Capacity: 400m³
Solar drying bed:	18 (W) x 80 (L) x 0.5 (D)m x 8 units
	Capacity: 5,000m³

8.1.3 Present Conditions of Sewage Treatment

With regard to the volume and quality of influent and effluent at the ONAS sewage-treatment plant, the monthly mean values and SO_4 were calculated from data and conductance for 13 months from June 1991 through June 1992 and were shown in Table III-36. Additionally, total mean values of 13 months, designed values of water quality and emission standards to sewage and public sea specified in INNORPI in 1980 are described in the

Fig. III-32 Plot Plan of ONAS

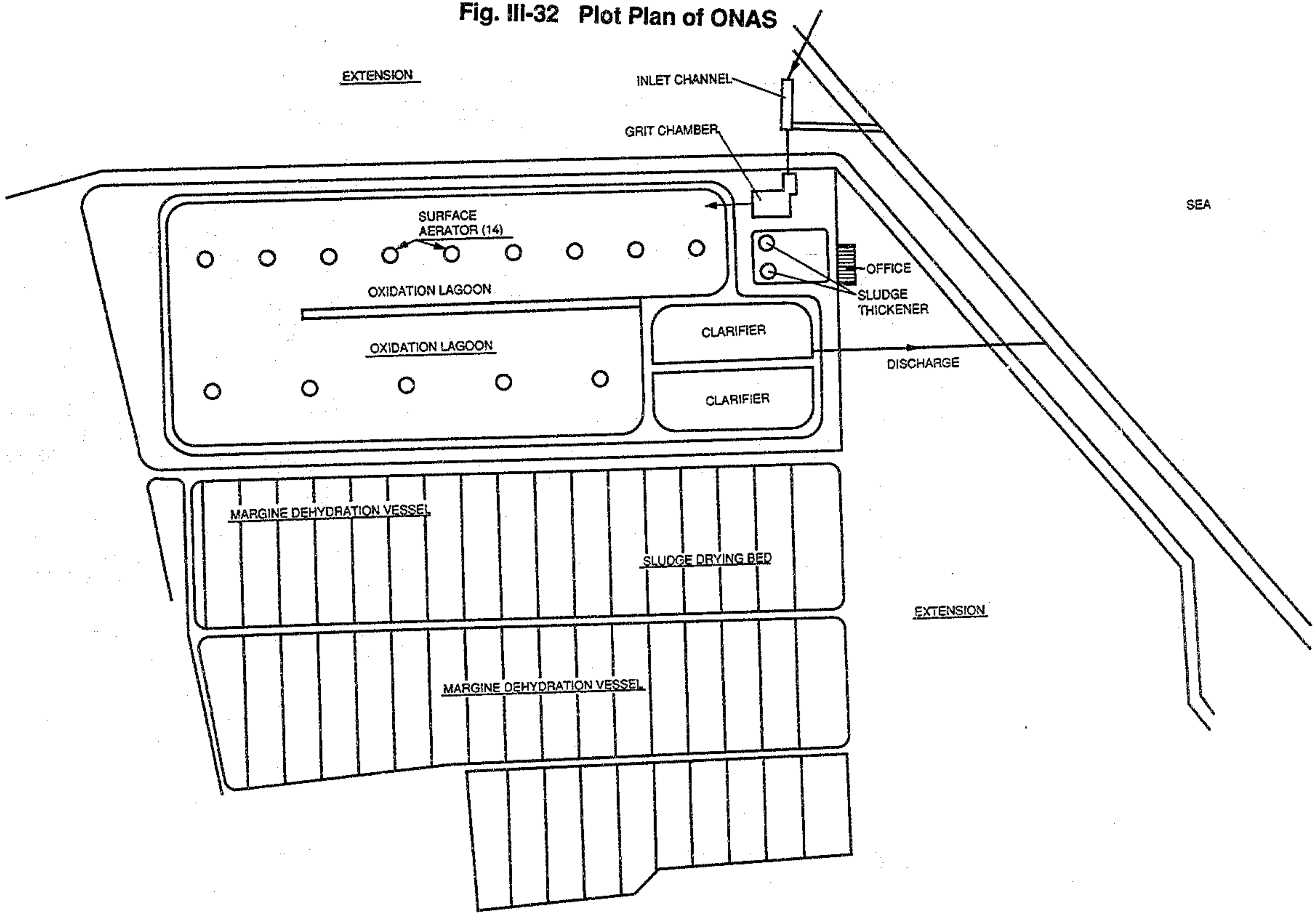


Fig. III-33 Flowsheet of Sewage Treasment Plant (ONAS)

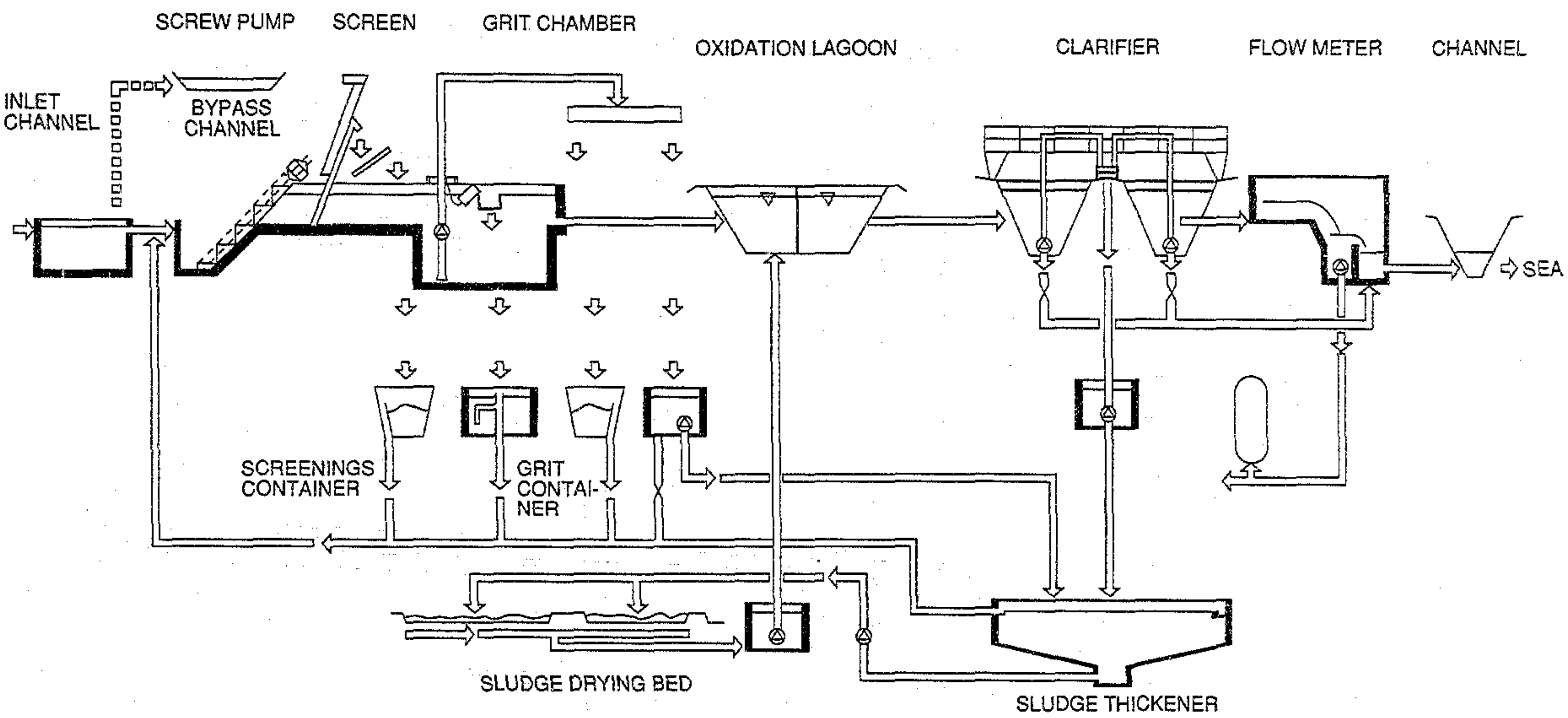


Table III-36 Water Quality of ONAS (Monthly Average)

DATE	TEMPERATURE IN (°C)	TEMPERATURE OUT (°C)	FLOW (m3/D)	SS IN (mg/L)	SS OUT (mg/L)	SS RED. (%)	COD IN (mg/L)	COD OUT (mg/L)	COD RED. (%)	BOD IN (mg/L)	BOD OUT (mg/L)	BOD RED. (%)	BOD LOAD (Kg/m3d)	Cl- IN (mg/L)	Cl- OUT (mg/L)	CONDUCTIVITY IN (μs/cm)	CONDUCTIVITY OUT (μs/cm)	SO4-- IN (mg/L)	SO4-- OUT (mg/L)	IRRIG. (m3/D)
1991. 6	27	25	19220	288	35	87.9	854	133	84.5	440	36	91.9	0.059	1091	1065	4825	4958	319	396	14258
7	28	26	19932	524	29	94.4	1493	142	90.5	458	35	92.3	0.064	1030	1037	4741	4802	364	377	19038
8	29	28	19186	297	33	88.8	807	140	82.7	367	39	89.4	0.049	993	1070	4731	4730	406	312	17957
9	29	28	23452	362	34	90.6	926	139	85.0	324	28	91.4	0.053	929	985	4702	4706	475	408	10046
10	26	25	25110	383	43	88.9	701	202	71.2	364	45	87.6	0.064	984	1024	4678	4765	400	380	8589
11	28	26	21380	371	35	90.6	956	151	84.2	391	37	90.6	0.058	1005	1036	4735	4792	393	374	13978
12	22	14	16074	272	43	84.3	772	249	67.7	473	84	82.3	0.053	1010	981	5142	5038	527	527	8893
1992. 1	17	14	14838	294	35	88.0	939	322	65.7	528	98	81.4	0.055	1016	1131	5010	5174	475	389	7489
2	17	14	17496	329	52	84.3	760	260	65.8	521	78	85.1	0.064	1018	1078	5259	4998	558	394	4849
3	18	16	18191	295	57	80.7	920	335	63.6	528	68	87.1	0.067	1082	1113	5227	5625	468	567	2197
4	21	19	16673	295	30	89.8	775	297	61.7	485	57	88.4	0.057	1070	1147	5279	5396	501	446	6606
5	22	22	19993	315	32	90.0	696	265	61.9	370	53	85.7	0.052	1056	1047	4873	4944	378	413	7729
6	26	25	22662	314	44	85.9	818	324	60.4	462	46	90.0	0.073	1056	1073	4685	4861	314	352	
AVE.	23.7	21.6	19554	334	39	88.4	878	227	74.1	439	54	87.7	0.060	1026	1061	4914	4984	429	410	
DESIGN BASE			20300	350	35	90.0	900	200	77.8	390	35	91.0	0.055							
INNORPI				400	30	92.5	1000	90	91.0	400	30	92.5		700	-	-	-	400	1000	

SO4 Value Calculated from Conductivity

Table III-37 Result of Waste Water Analysis (ONAS)

A. PRIMARY ANALYSIS

SAMPLING POINT	SAMPLING DATE	ANALYSIS ITEMS(8)							
		TURBIDITY deg.	pH	CONDUCT'TY ms/cm	S.SOLID mg/L	C O Dcr mg/L	B O D mg/L	n-HEX mg/L	D O mg/L
ONS-11	10/07/92	220	7.3	6.2	100	240	45	9	1.4
ONS-11	13/07/92	180	7.6	5.0	200	360	230	73	0.5
ONS-11	14/07/92	650	7.3	4.6	770			140	0
ONS-11	16/07/92	160	7.6	6.0	150	340	280	--	0.6
ONS-12	10/07/92	220	7.8	5.5	140	210	39	7	0.5
ONS-12	13/07/92	200	7.8	5.3	110	190	71	12	2.3
ONS-12	14/07/92	230	7.7	5.2	130			9	1.8
ONS-12	16/07/92	280	7.8	5.3	130	280	160	--	4.6
ONS-13	10/07/92	120	7.9	5.5	13	410	74	4	2.3
ONS-13	13/07/92	150	7.8	5.2	42	230	43	8	3.8
ONS-13	14/07/92	180	7.8	5.2	50			4	3.7
ONS-13	16/07/92	200	7.9	5.5	24	210	86	--	4.5

B. DETAILED ANALYSIS

SAMPLING POINT		ONS-11	ONS-11	ONS-12	ONS-12	ONS-13	ONS-13
SAMPLING DATE		SEP. 14	SEP. 17	SEP. 14	SEP. 17	SEP. 14	SEP. 17
TURBIDITY	deg.	21		90		50	
pH		7.5		7.8		7.9	
CONDUCT'TY	ms/cm	4.4		4.2		4.9	
S.SOLID	mg/L	306	80	83	94	21	16.5
C O Dcr	mg/L	680	152	230	140	170	97
B O D	mg/L	2200	76	130	22	110	24
n-HEXANE	mg/L	59	39	9	4	2	1
SO4	mg/L						
Cl	mg/L						
Kj-N	mg/L						
T-P	mg/L						
K	mg/L						
T-Hg	mg/L						
Ca	mg/L						
C6H5OH	mg/L						
IG.RSD	mg/L	124	39	16	30	3.5	0.5
Com.BCT	No./L	500000	1000000	92000	200000	48000	150000
C.G.BCT	No./L	110000	41000	25000	140000	14000	19000

C. DAILY ANALYSIS SAMPLING POINT - ONS-13

SAMPLING DATE	SAMPLING HOUR	ANALYSIS ITEMS(4)			
		pH	CONDUCT'TY ms/cm	S.SOLID mg/L	C O Dcr mg/L
23/09/92	12:00	7.8	3.4	15.5	131
23/09/92	14:00	7.9	3.4	15	152
23/09/92	16:00	7.9	3.3	19	197
23/09/92	18:00	7.9	3.4	14	151
23/09/92	20:00	8.0	3.6	16	144
23/09/92	22:00	8.0	3.6	17.5	128
23/09/92	24:00	8.0	3.6	18.5	130
24/09/92	2:00	7.9	3.9	13.5	126
24/09/92	4:00	7.9	3.7	14	137
24/09/92	6:00	7.9	3.5	18	137
24/09/92	8:00	7.8	3.7	17	153
24/09/92	10:00	7.9	3.6	13	162

above table. The data measured by study team is shown in Table III-37. Sampling points in the table are given as follows.

ONS11: Waste water flowing into the sewage treatment plant

ONS12: Quality of waste water in the lagoon pond

ONS13: Waste water flowing out from the sewage treatment plant

8.2 Present Conditions of Operation and Problems

8.2.1 Conditions of Operation

(1) Quality of Water

Of figures shown in Table III-38, the monthly values of SS, COD and BOD of effluent are given in Fig. III-34, and monthly removal ratios of them are given in Fig. III-35.

These figures indicate the following points.

1) The values of SS, COD and BOD of waste water drained into the sea area were over the INNORPI regulation values of SS at 30 mg/*l*, COD at 90 mg/*l* and BOD at 30 mg/*l*. The COD value exceeded the regulation value extremely. In many months, the values of SS, COD and BOD in the sewage treatment plant went beyond the design values of SS at 35 mg/*l*, COD at 200 mg/*l* and BOD at 35 mg/*l*. BOD in waste water flowing into the sewage treatment plant exceeded the design value of BOD at 390 mg/*l*, partly causing deterioration of sewage treatment.

2) The quality of waste water has been worse since December 1991, especially the COD value has been worsened.

3) Chloride of salt contained in influent is about 1,000 mg/l and exceeds the ONAS influent standard of 700 mg/l. The value of SO_4 calculated from the conductance is about 430 mg/l and exceeds the influent standard of 400 mg/l slightly. There is no emission standards of chloride into the sea areas, and the emission standard of SO_4 is 1,000 mg/l. Therefore the influent to the sea can be considered to be satisfactory.

(2) Load and Quality of Waste Water

The correlation between the BOD volume load and the BOD removal ratio is given in Fig. III-36. However, it does not indicate any specific correlation between the volume load and the removal ratio.

Fig. III-34 Transition of Effluent

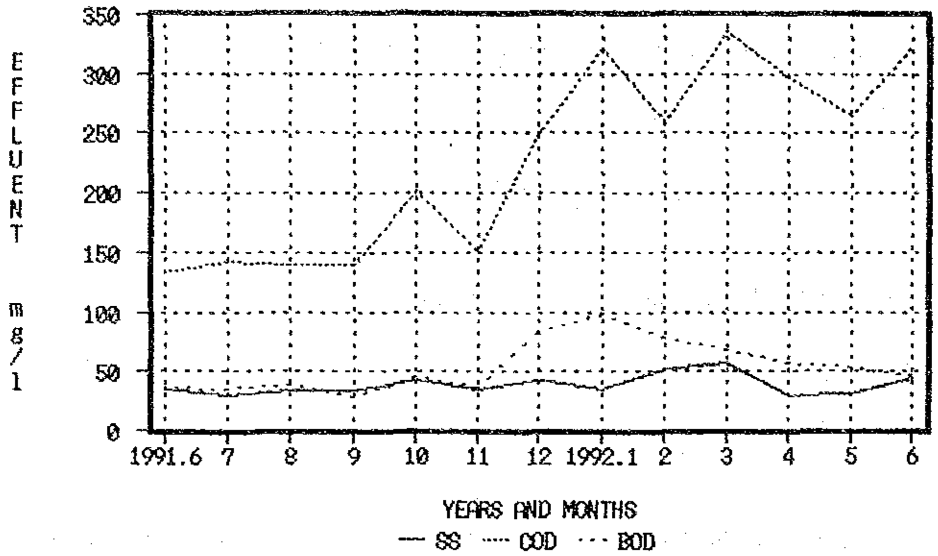


Fig. III-35 Transition of Reduction Ratio

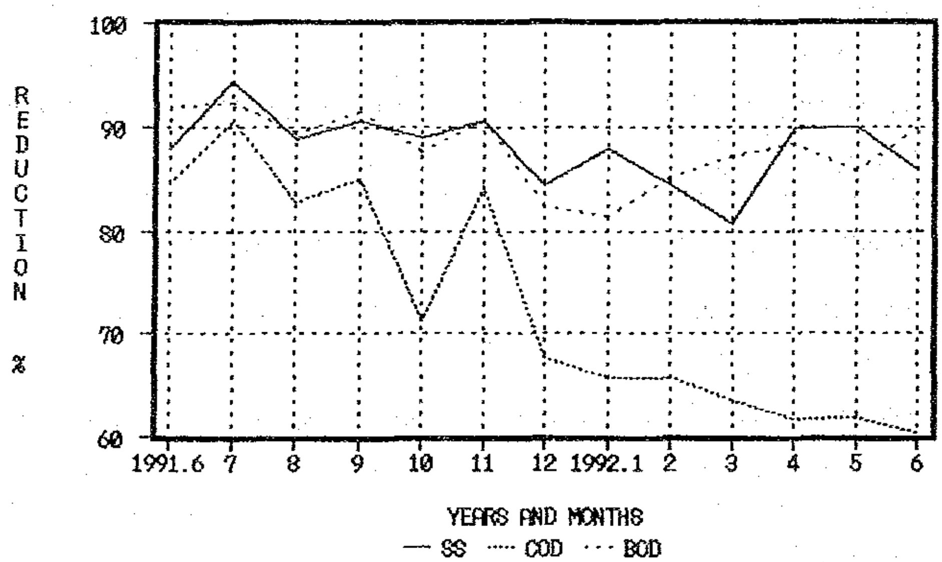


Fig. III-36 Correlation between BOD Loading and BOD Reduction Ratio

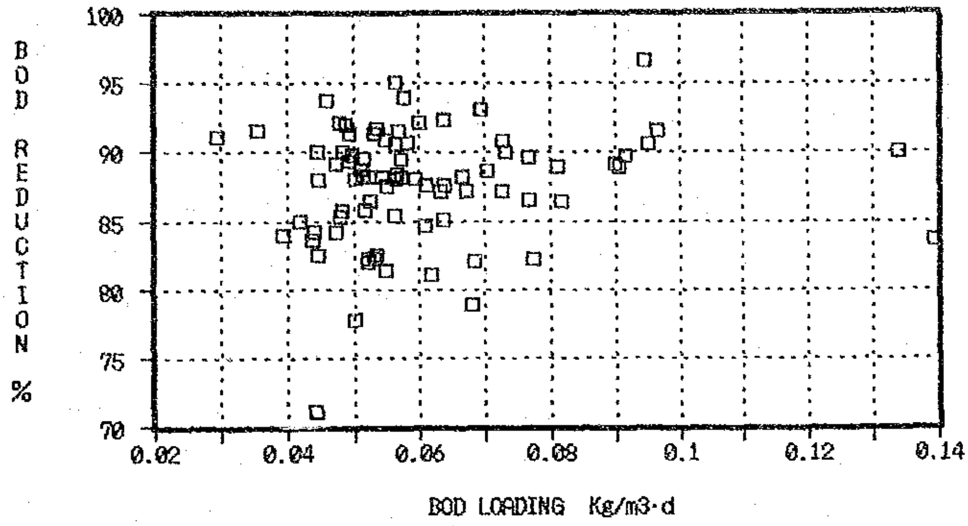
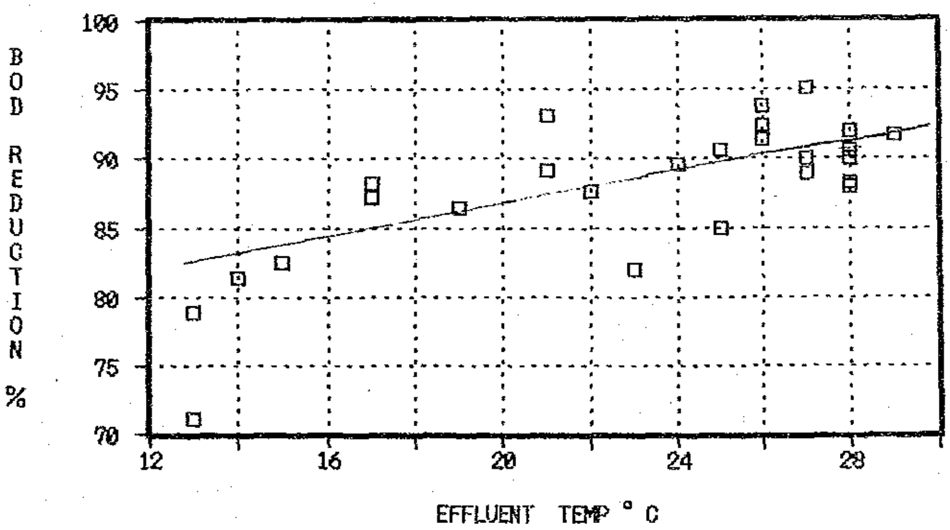


Fig. III-37 Effluent Temp. and BOD Reduction Ratio



(3) Influence of Water Temperature

AS seen in Table III-38, the water temperature changes in summer and winter. In the summer period from April through October, the mean temperatures of water flowing in and out are 26°C and 25°C, respectively. The mean temperatures of water flowing in and out in the winter period from November through March are 19°C and 15°C, respectively. The drop in temperature from water flowing in to water flowing out is larger in the winter period. Accordingly , the correlation between the temperature of water flowing out and BOD removal ratio is given in Fig. III-37 and outstanding correlation is observed.

The BOD removal ratio is 83% when the water temperature is 14°C, and the BOD removal ratio rises to 91% if the water temperature rises to 28°C. Now, if the BOD removal through biological reaction conforms to first order, it can be expressed as:

$$\frac{dL}{dt} = KL$$

L: BOD concentration

t: Time

K: Removal speed coefficient

After integration

$$ln\frac{L_o}{L_e} = KT$$

Le: BOD concentration of influent

Lo: BOD concentration of effluent

If the BOD removal ratio is n,

$ln\,(1-n)=Kt$

Now, if BOD removal ratio and removal speed coefficient at the temperature of T1 and T2 are $n1$, $n2$, K1 and K2, respectively.

$ln\,(1-n1) = K1t$

$ln\,(1-n2) = K2t$

Therefore, the ratio of removal speed coefficient of K2 /K1, is expressed as:

$$\frac{K2}{K1} = \frac{ln\,(1-n1)}{ln\,(1-n2)}$$

If $n1$=83% when T1=14°C, and $n2$=91% when T2=28°C,

$$\frac{K2}{K1} = 1.36$$

Namely, the removal speed at 28°C is 1.36 times as fast as at 14°C.

In general, the effect of water temperature is expressed by the following formula.

$$\frac{1}{K}\frac{dK}{dT} = \frac{\Delta E}{RT^2}$$

R: Gas coefficient

T: Absolute temperature

ΔE: Constant

After integration

$$ln \frac{K2}{K1} = \frac{\Delta E}{R} \frac{T2 - T1}{T2 \times T1}$$

The result can be expressed briefly by the following formula.

$$\frac{K2}{K1} = \theta^{(T_2 - T_1)}$$

θ: Temperature coefficient

Calculate θ by entering K2/K1=1.36, T1=14°C and T2=28°C.

Generally, θ = 1.022 is in the range from 1.016 to 1.047.

The main part of biological treatment in ONAS sewage treatment plant is the lagoon pond. Surface aeration is adopted to supply oxygen into the lagoon pond. This is a method to aerate the surface of water and disperse water droplets to dissolve oxygen in the air into the water. At this time, the water temperature drops because water evaporates, taking off the latent heat of evaporation. This is a reason why the temperature of waste water flowing out is lower than that of waste water flowing in.

8.2.2 Problems

(1) Daily influent of sewage treatment plant has reached the 20,300m³/day level, and the BOD value of influent is over the design value of BOD at 390 mg/l, and the quality of effluent exceeds the wastewater quality standard for the INNORPI sea area.

(2) Sludge after biological treatment is accumulated at the bottom of the lagoon pond, thus reducing the volume of the lagoon pond and decreasing the efficiency of the treatment. The aerator in the lagoon pond is likely to be turned on and off according to the DO value in the pond. Taking the flow pattern of the lagoon pond into account, flexible operation must be carried on.

(3) Wastewater stays in the lagoon pond for seven days, and the operation factor of the pond is only ON/OFF operation of the aerator. Taking the expansion of sewage treatment plant and efficient operation of facilities into consideration, activated sludge process equiped with return sludge must be converted.

(4) The drying bed is used to dehydrate sludge, and this may be the most appropriate method in Tunisia because no energy is required and because rainfall is very rare. This method requires a large space and the volume of sludge may increase in the future, so that we need to examine the introduction of mechanical dehydration is required to examine.

ONAS sewage treatment plant was established in 1983 and is the only sewage treatment plant in operation in Sfax City. We think the plant has reached the limit by judging from the quantity and quality of waste water it can treat. It does not seem to have no extra capacity now. Taking the further expansion of the sewer system and more inflow of industrial waste water into consideration, it is urgently required to expand the sewage treatment plant or to construct a new sewage treatment plant in the future.

VOLUME IV

PROPOSAL ON PRODUCTION PROCESS