3.6.3 Waste Water Treatment

1) Present conditions

All waste water is discharged to the sewerage from waste water pits installed in three locations.

Waste water from the meat factory is discharged through the oil separators installed in two of the above three locations.

2) Pretreatment

Without pretreatment, oil in waste water may not clear regulations for sewerage discharge. The existing oil separators function adequately in this regard and no more separators are necessary.

3) Waste water treatment

It must be noted that regulations are strict for P in cases of direct river discharge. The factory site has sufficient space to install a waste water treatment system.

(1) Design base of system

Amount of waste water : 400m^3/day
Waste water inlet time : 10 hours/day
Water treatment time : 24 hours/day Dehydrator : 8 hours/day

Water quality		Intake	Discharge	Emission standard
Temp	℃	15	20	30
pH		6-8	6.5-8	6.5-9
COD	mg/l	1,500	26	120
BOD	mg/l	1,000	5	25
Fat	mg/l	100	4	20
SS	mg/l	1,000	14	80
NH4-N	mg/l	100	5	10
Total N	mg/l	200	7.5	-
Total P	mg/l	40	0.5	2

(2) Waste water treatment system flow

(waste water)→Collecting pit (present)→Stabilization tank→Neutralization tank → Anaerobic tank → Aeration tank → 1st. Sedimentation tank →

Coagulation tank→2nd. Sedimentation tank→Sand filter→Ozonizing tube→ Activated carbon absorber→Treated water tank→Discharge to the river

(coagulated sludge)→Sludge storage tank→Sludge dehydrator →Cake hopper→Truck

4) Reasons for waste water treatment system

① The slaughterhouse falls under the general category of emission standards. Since the factory's waste water pollutants are basically organic, the activated sludge treatment system that is adopted by the public treatment center serves well here.

② There are strict regulations concerning direct discharge to the river of N and P. This problem is solved by a waste water system designed so that N, P, BOD, COD, SS, and oil may clear emission standards.

③ NH_4-N is easily reduced by activated sludge treatment. NOH_3-N, converted from NH_4-N, is removed by anaerobic denitrification.

④ P is removed by coagulation and sedimentation.

⑤ Emission standards for SS and COD are such that sand filter and activated carbon absorption are unnecessary.

⑥ Since waste water from the slaughter house fluctuates greatly in concentration and quantity over time, treatment is stabilized by installing a stabilization tank of daily capacity. The oil load is reduced by placing an oil separator in the collecting pit. Effluent can be sent directly to the stabilization tank bypassing the above process. This reduces the amount of time in removing scum. A pressure floatation tank is also necessary.

5) Facility specifications and reference figures

The facility specifications are summarized in the following table and figures.

Table 3.6.5	Equipment list
Fig. 3.6.8	Material balance sheet
Fig. 3.6.9	Flow sheet
Fig. 3.6.10	Layout
Fig. 3.6.11	Structure drawings of major equipment

6) Facility cost

(1) Equipment

	Thousand SIT
(a) Pumps, blowers, agitators, decelerator, dehydrator	43,575
(b) Instrumentation	4,775
(c) Other equipment	74,275

(2) Site works

(d) Equipment installation, piping work	25,793
(e) Electrical work	20,431
(f) Painting work	1,437
(g) Civil engineering work	61,031
(h) Building work	50,359
(i) Site supervision cost	6,188
(j) Trial run cost	3,150

(3) Design cost	5,062
Total	296,076

(4) Annual depreciation, interest

(a) Civil work related	40 year repayment	111,390/40 = 2,785T-SIT/y
(b) Non civil work	15 year repayment	184,686/15 = 12,312
(c) Facility interest 10%	Average 5%	296,076 x 0.05 = 14,804
Total		29,901

(5) Repayment per water amount, interest

(Divided by annual water treatment of 100,000m^3) 299 SIT/m^3

7) Running costs

(1) Chemical costs

			Thousand SIT/y
(a) PAC (11%)	160 kg/day x 74.7 SIT/kg x 250 days	=	2,988
(b) MeOH (%)	16 kg/day x 70 x 250	=	280
(c) NaOH (100%)	32 kg/day x 83.2 x 250	=	665.6
(d) Polymer A (powder)	2.8 kg/day x 990 x 250	=	693
(e) Polymer K (powder)	2 kg/day x 2,000 x 250	=	1,000
Subtotal		=	5,626.6

(2) Electricity charge

0.8 x 2,179 kwh/day x 15 SIT/kwh x 250 = 6,537

(3) Sludge disposal cost

2.7 m^3/day x 1,423 SIT/m^3 x 250 = 960.5

(4) Water charge

10 m^3/day x 200 SIT/m^3 x 250 = 500

(5) Kerosene charge

164 l/day x 60 SIT/l x 90 = 885.6

(6) Maintenance cost

The cost of maintenance is assumed to be 5% of the equipment cost.
198,303 T- SIT x 0.05 = 9,234.3

(7) Personnel expenses

2 staff/year x 16,280 DM/y x 87.5 SIT/DM = 2,849

Total 26,592

(8) Operation cost per water volume

Divided by annual water treatment 100,000m^3 = 272.7 SIT/m^3

8) Economic comment (the normal economic evaluation is described in 3.6.4)

Here, in order to compare with the other model factories for which a normal economic evaluation is not carried out, the same simple economic evaluation that was performed on those factories shall be conducted.

(a) Conditions

① Depreciation period : equipment 15 years
: civil engineering, building 40 years
② Interest : 10%/annum
③ Depreciation method : uniform depreciation
④ WWTP discharge charge : 160 SIT/m^3
⑤ River discharg : 0
⑥ Annual waste water treatment volume : 100,000 m^3/year

(b) Treatment cost per 1 m^3 of waste water

Item		Contents (SIT/year)			Cost (SIT/m^3)
Depreciation	Machinery	184,004,000 SIT ÷ 15 years	=	12,312,000	123
	Building, civil engineering	111,390,000 SIT ÷ 40 years	=	2,785,000	28
Interest		507,117,000 SIT x 0.06	=	30,367,000	148
Running cost				26,592,000	266
Total					565

9) Conclusion

In the case of river discharge, because the discharge standards are so harsh, the equipment cost and running cost would both be expensive. As a result, it would be more advantageous for this factory to pay the charge for sewerage system discharge rather than independently install waste water treatment facilities.

Table 3.6.5 Equipment List of Waste Water Treatment System

No.	Item	Q'ty	Material	Specification	Remark
1	Influent pit	1	RC	Capacity 30 m^3	Existing
	Pump (submersion)	1+1	FC		
	Level switch	1	PVC		
2	Stabilization tank	1	RC	Capacity 400 m^3 (1 day)	
				9.6m×11m×4.5m(4.0m)D	
	pumps (submersion)	1+1	FC	80A×0.5m^3/min×8m×2.2kw	
	blower (roots)	1	FC	125A×8.8Nm^3/min×0.5kg/cm2×15kw	
	air difuser pipe	1	SUS		
	level switch	1	PVC	Float type	
	flow meter	1	PVC	V-notch Box type 5 - 30m^3/hr	
3	Pressure floation tank	1	SS	Capacity 16.7 m^3 (30 min)	
				Surface load 3m/h,circulation 100%	
				5m×2.5m×2.5m(actual 2m)D	
	skimmer	1	SS	chain drive 0.4kw	
	compressor	1	SS	200Nl/min, 7kg/cm2, 1.5kw	
	pressure tank	1	SS	2m3, 1.2mφ×2.4mH	
	slurry pump	1	FC	80/50A×0.3m3/min×40m 1.5kw	
	water flowmeter	1	FC	80A area type	
	air flowmeter	1	FC	40A orifice type	
4	Mixing tank	1	RC	78m3 (4hr)	
				7.5m×2.6m×4.5m(actual 4m)D	
	circulator	1	FC	8 direct 50A 2.2kw	

No.	Item	Q'ty	Material	Specification	Remark
5	#1 Aeration tank	1	RC	Capacity 249 m^3 (14hr)	
				8.3m×7.5m×4.5m(4.0m)D	
	air difuser	1	SUS		
	air flow meter	1	FC	100A	
	blower				
6	#1 Thickner tank	1	RC	Capacity 30m^3 Surface 20 m^2	
				4.5m×4.5m×4.5m(1.5m)D	
	return sludge pump	1	FC	airlift type 80A	
	sludge meter	1	PVC	V notch type	
7	#2 aeration tank	1	RC	Capacity 77 m^3 (4.5hr)	
				4.5m×4.5m×4.5m(3.8m)D	
	air difuser	1	SUS		
	air flow meter	1	FC		
8	#2 Thickner tank	1	RC	Capacity 30 m^3 Surface 10 m^2	
				4.5m×4.5m×4.5m(1.5m)D	
	return sludge pump	1	FC	airlift type	
	sludge meter	1	PVC	V notch type	

No.	Item	Q'ty	Material	Specification	Remark
9	#1 Sedimentation tank	1	RC	Capacity 84m³ (4.5hr)	
				7.5m×7.5m×4.5m(1.5m)D	
	sludge collector	1	SS	rake type torque 120kgm 0.4kw	
	return sludge pump	1	FC	airlift type 80A	
	sludge meter	1	PVC	V notch type	
10	Contact aeration tank	1	RC	Capacity 129m³ (7.5hr)	
				2.7m×14.1m×4.5m(3.4m)D	
	contact bed	1	PE	40m³	
	air flow meter	1	FC	orifice 80A	
	pH meter/controler	1			
11	#2 Sedimentation tank	1	RC	Capacity 84 m³ Surface 56 m²	
				7.5m×7.5m×4.5m(1.5m)D	
	sludge collector	1	SS	rake type torque 120kgm 0.4kw	
	return sludge pump	1	FC	airlift type	
	sludge meter	1	PVC	V notch type	

No.	Item	Q'ty	Material	Specification	Remark
12	De-N pump tank	1	RC	Capacity 19 m³ (1hr)	
				3.3m×1.8m×4.5m(3.2m)D	
	pump	1	FC	80A×0.5m³/min×8m×2.2kw	
	level switch	1	PVC	float type	
13	De-N tank	1	RC	Capacity 130 m³ (7.5hr)	
				3.3m×9.9m×4.5m(4m)D	
	contact media	1	PE	12m³	
14	Oxidation tank	1	RC	Capacity 36 m³ (3 hr)	
				1.8m×5.7m×4.5m(3.8m)D	
	blower	1	FC	150A×6.1Nm³/min×0.5kg/cm2×15kw	
	air flow meter	1	FC		
	difuser	1	SS		
15	Reaction tank	1	RC	Capacity 5.8 m³ (20min)	
			acid coating	1.8m×1.8m×2.5m(1.8m)D	
	Agitator	1	SS SUS	Vertical 295rpm 2.2 kw	
16	pH control tank	1	RC	Capacity 5.8 m³ (20min)	
			acid coating	1.8m×1.8m×2.5m(1.8m)D	
	Agitator	1	SS SUS	Vertical 295rpm 2.2 kw	
	pH meter	1		Dip type pH 0～14	

No.	Item	Q'ty	Material	Specification	Remark
17	Coagulation tank	1	RC	Capacity 5.8 m^3 (20min)	
				1.8m×1.8m×2.5m(1.8m)D	
	agitator	1	SUS	Vertical puddle 88rpm 3.7 kw	
18	#3 Sedimentation tank	1	RC	Capacity 54 m^3 Surface 36 m^2	
				6m×6m×4.5m(1.5m)D	
	sludge collector	1	SS	rake type 0.4 kw	
	sludge pump	1	FC	airlift type 80A	
	sludge meter	1	PVC	V notch type	
19	Treated water tank	1	RC	Capacity 40 m^3	
				1.8m×7.5m×4.5m(3m)D	
	pump (submersion)	1+1	FC	80A×0.5m^3/min×8m×2.2kw	
	level switch	2	PVC	float type	
	water flow meter	1	FC	tefron coated	
	pH meter	1			
20	Sludge storage tank	1	RC	Capacity 40 m^3	
				5.7m×3.9m×4.5m(3.6m)D	
	sludge pump	1	FC	80A×0.5m^3/min×8m×2.2kw	
	blower (roots)	1	FC	80A×1.8Nm^3/min×5m×5.5kw	
	level switch	1	SUS	float type	
	air flow meter	1	SS		

No.	Item	Q'ty	Material	Specification	Remark
21	Dehydrator	1	SS	Belt press type, 55kg/hr, 6.7kw	
				0.4t/day(99%) cake(85%)	
	sludge coagulation tank	1	SS	$0.64m^3$ with agitator 88rpm	
	belt convayer	1	SS NBR	0.4m width 8m length	
	cake hopper	1	SS	$10m^3$ 0.2kW	
22	Methanol tank	1	PE/FRP	$1m^3$ $1.065m\phi \times 1.4mH$	
	feed pump	1	SUS	diaphram 6 - 60cc/min 0.1kw	
	level switch	1	PVC	float type	
23	PAC tank	1	PE FRP	Capacity $10\ m^3$	
				$2.35m\phi \times 2.9mH$	
	pump (diaphram)	1	PVC	$100 - 1,000cc/min \times 3kg/cm^2 \times 0.4kw$	
	level switch	1	PVC	float type	
24	NaOH tank	1	PE FRP	Capacity $4\ m^3$	
				$1.85m\phi \times 2.065mH$	
	Pump (diaphram)	1	PVC	$14\ 140cc/min \times 13kg/cm^2 \times 0.1kw$	
	Level switch	1	SUS	Electrode type	
25	Polymer(A) solving tank	1	PE FRP	Capacity $10\ m^3$	
				$2.35m\phi \times 2.9mH$	
	powder solver	1	PVC	3 - 9 kg/hr 0.06kw	
	Agitator	1	SUS	Vertical 88rpm 5.5kw	
	Pump (roots)	1	FC	$65/50A \times 0.31m^3/min \times 10m \times 2.2kw$	

No.	Item	Q'ty	Material	Specification	Remark
26	Polymer(A) solving tank	1	PE FRP	Capacity 10 m^3	
				2.35mφ×2.9mH	
	powder solver	1	PVC	3 - 9 kg/hr 0.06kw	
	Agitator	1	SUS	Vertical 88rpm 5.5kw	
	Pump (diaphram)	2	PVC	500 - 5,000cc/min×3kg/cm^2×0.4kw	
	Level switch	1	SUS	Electrode type	
27	Polymer(K) solving tank	1	PE FRP	Capacity 10 m^3	
				2.35mφ×2.9mH	
	powder solver	1	PVC	3 - 9 kg/hr 0.06kw	
	Agitator	1	SUS	Vertical 88rpm 5.5kw	
	Pump (roots)	1	FC	65/50A×0.31m^3/min×10m×2.2kw	
28	Control panel	1		Indoor Self-standing enclosed type	
				1.6m×0.6m×2mH	
				AC 400V×50Hz	
				Push button switches	
				Alarm lamps	
				pH indicators	
				Do indicator	

Fig. 3.6.8 Material Balance Sheet of Waste Water Treatment

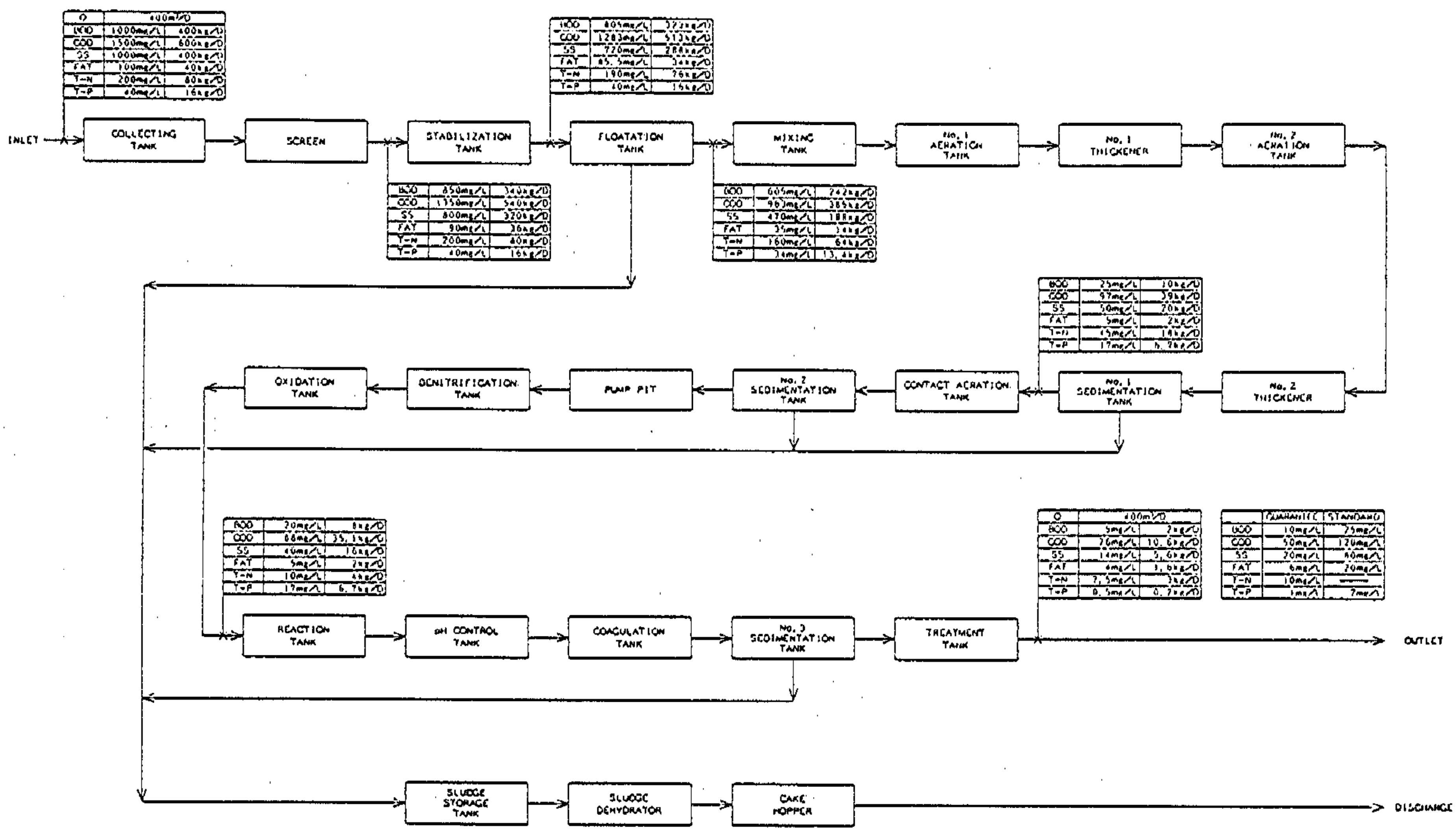


Fig. 3.6.9 Flow Sheet of Waste Water Treatment System

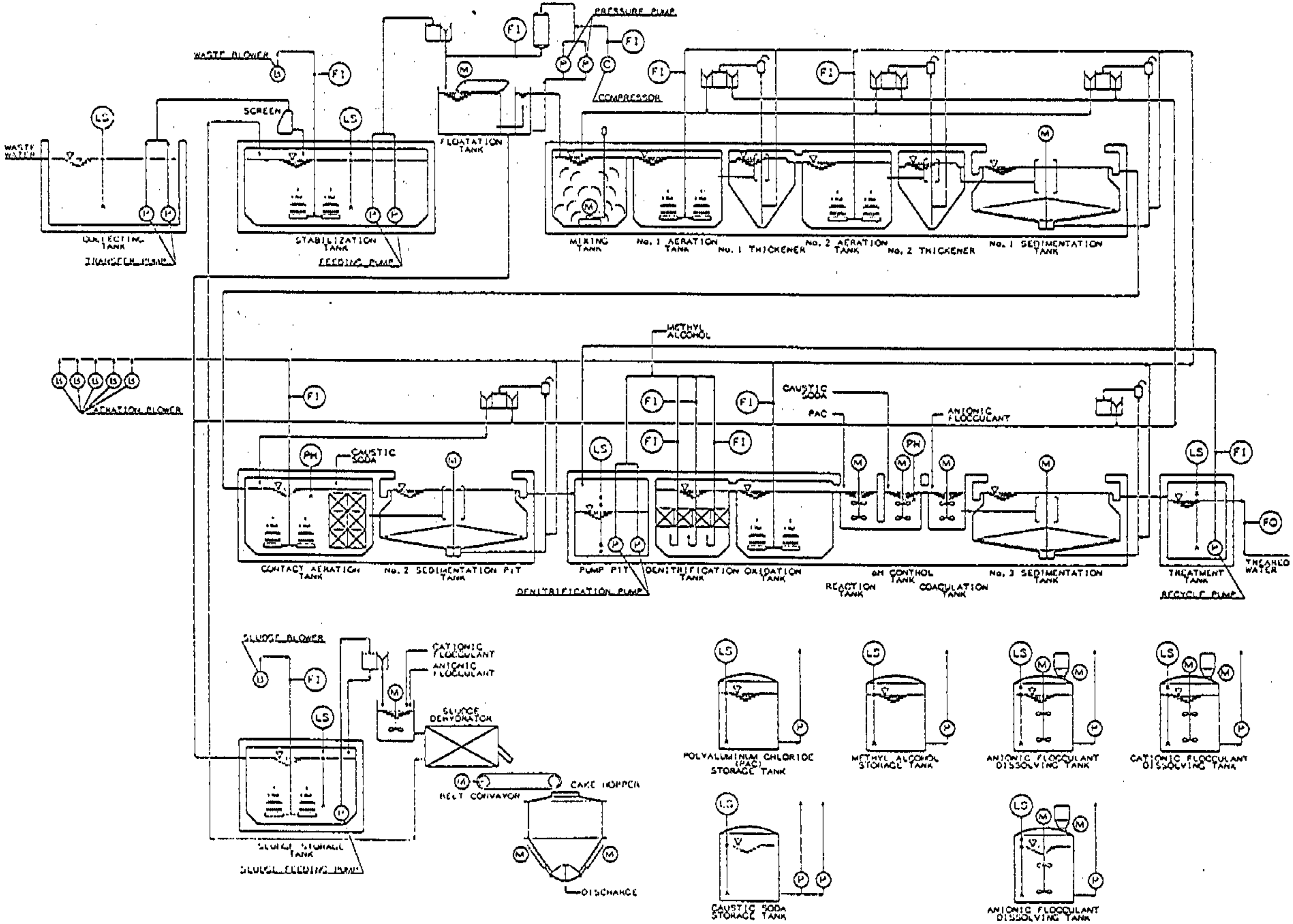
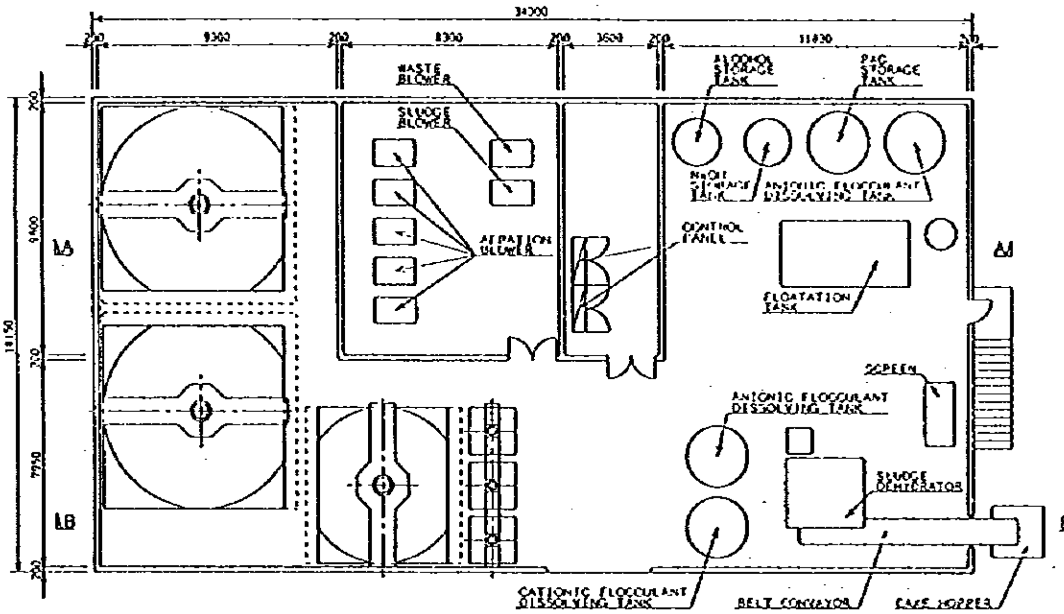


Fig. 3.6.10 Layout of Waste Water Treatment System



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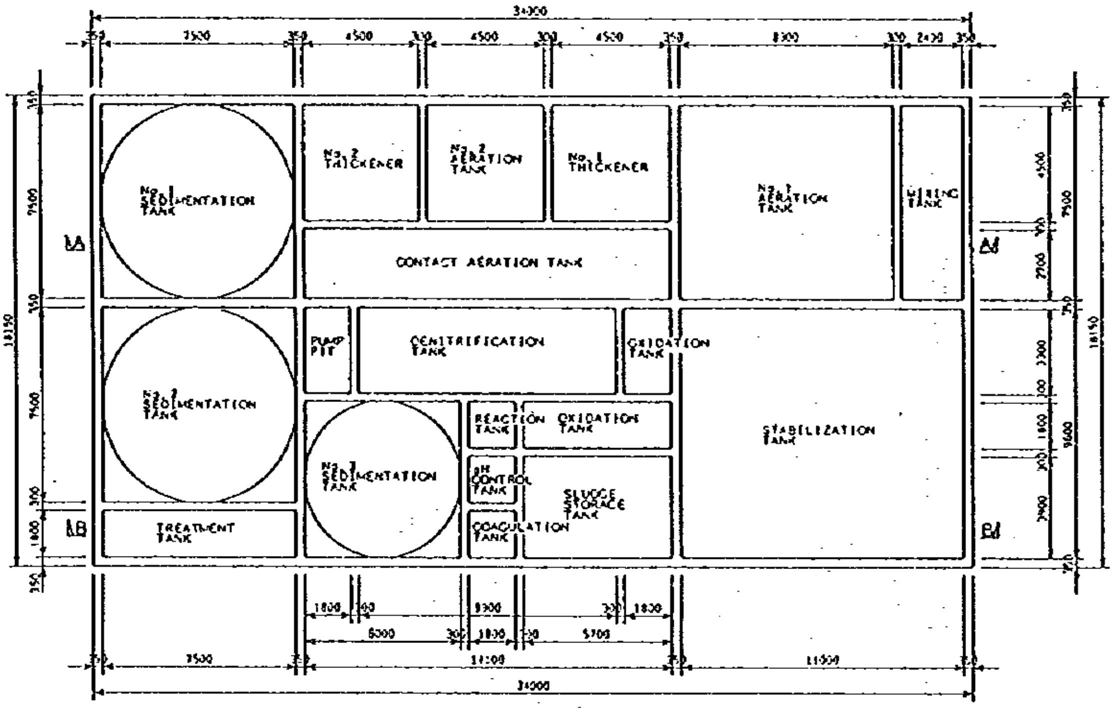
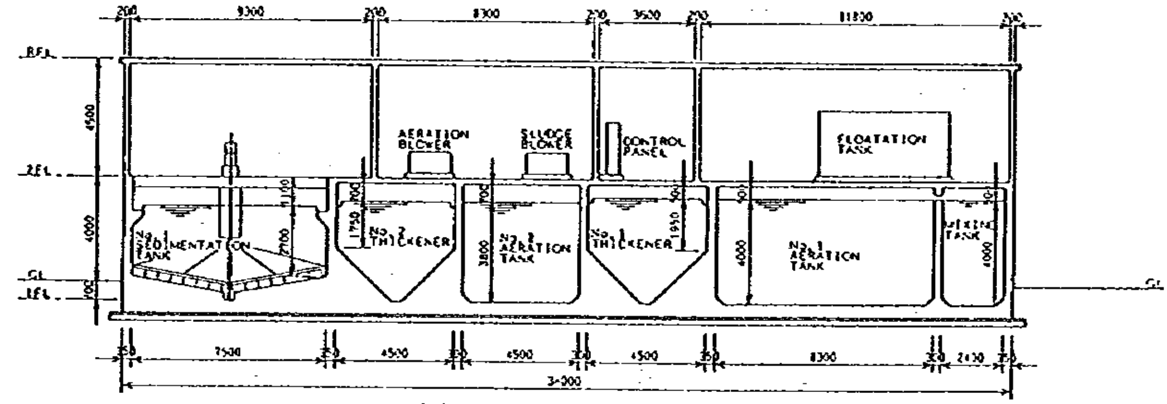
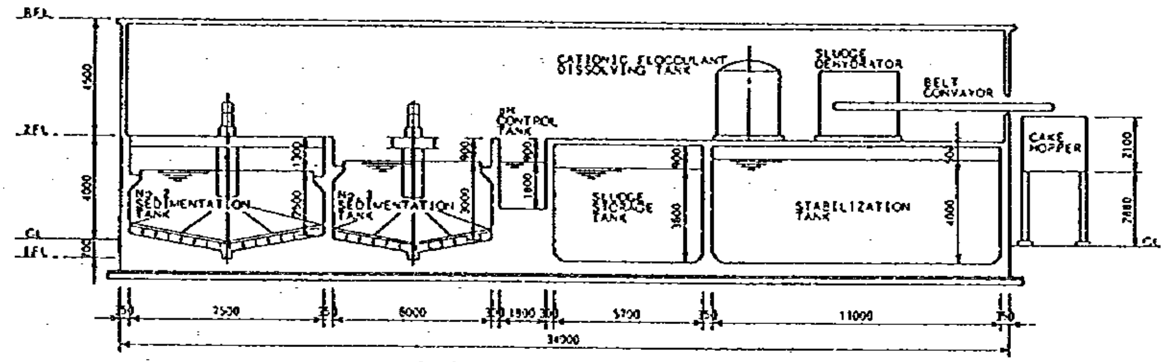


1FL S:1/200

Fig. 3.6.11 Section of Waste Water Treatment System



SECTION A-A S:1/200



SECTION B-B S:1/200

3.6.4 Financial Analysis

1) Preconditions

(1) Project case

As a result of the technical comment described above, it was found that no additional waste water treatment costs would arise in Case 2 (sewerage system discharge) because the existing oil and fat separator can be kept functioning and discharge can be conducted without carrying out pretreatment. Therefore, the financial analysis shall center on the case of river discharge (Case 1).

(2) Waste water treatment capacity

Waste water treatment capacity : 100,000 m^3/year
Operating days : 250 days/year

(3) Required funds

In addition to the plant construction cost estimated in the previous section, the funds required based on the preconditions given in 1.4.1 are as shown in the following table. For the purpose of calculating the interest during construction, the construction period is assumed to be one year in Case 1.

Breakdown of required funds

(Unit: DEM, 1,000)

Item	Case 1	Case 2
Plant construction cost	3,458	0
Facilities and equipment	2,157	0
Civil engineering and building	1,301	0
Interest during construction	207	0
Total	3,665	0

(4) Fund raising

In the case of Kosaki, the required funds shall be raised by means of a long-term loan. The rate of interest shall be 12%.

The preconditions including the above-mentioned items for Case 1 are indicated in Table 3.6.6.

2) Financial analysis

The detailed breakdown of waste water treatment cost based on the above-mentioned preconditions is shown in Table 3.6.7, and the statement of cash income and disbursement is shown in Table 3.6.8.

The results of the financial analysis are outlined in the following paragraphs. The breakdown of the waste water treatment cost in 2010 is as follows.

Breakdown of waste water treatment cost

(Unit: DEM/m³)

Item	Case 1	Case 2
Variable cost	1.62	0.00
Direct fixed cost	1.91	2.29*
Treatment cost excluding depreciation and interest	(3.53)	(2.29)
Depreciation and interest	4.10	0.00
Treatment cost including depreciation and interest (Total cost)	7.63	2.29

Note: Sewage charge (1.780 DEM/m³) + City pollution tax (0.453 DEM/m³)
+ Water use tax (0.053 DEM/m³)

In the case of discharge into the sewerage system (Case 2), there are no additional costs incurred in waste water treatment, however, it is necessary to pay an extra 2.29 DEM/m³ as the sewage charge and the pollution tax.

As for the case of river discharge (Case 1), it can be seen that the total cost of waste water treatment, including depreciation cost and interest payment, is 7.63 DEM/m³, which is 5.34 DEM/m³ more expensive than the cost in Case 2.

In terms of the largest cost factors in each case, the depreciation cost and interest payment in Cases 1 accounts for 54% of the total cost. This suggests that the high investment cost will be a factor in raising the cost.

With regard to fund management in Case 1, the ability to repay the long-term debt (DSR) in 2010 is shown below.

Long-term debt service capacity

Case	(A) Cash DEM 1,000	(B) Debt DEM 1,000	(C) DSR (A)/(B)
Case 1	410.0	386.4	0.70

(Note) (A) is the numerator of the formula shown in 1.4.5, and (B) is the denominator.

Because the DSR is only 0.70, this indicates that there is a lack of cash to service the debt.

As a result of the above basic cases, sensitivity analysis using the FIRR and DSR shall be carried out to examine cases of fluctuations in important factors such as the plant construction cost and the chemicals cost.

Sensitivity analysis chart

(Unit: FIRR, % (DSR, ratio))

Item	Plant construction cost	Chemicals
Case 1		
20% down	13.83% (0.92)	9.77% (0.72)
0% (basic case)	9.32 % (0.70)	9.32% (0.70)
20% up	6.10% (0.55)	8.85% (0.68)

This shows that the chemicals cost is more sensitive to fluctuations than the plant construction cost.

Furthermore, investigation shall be carried out into the case where low-interest funding can be utilized in the future. Here, it is assumed that the interest rate is reduced from 12% to 6%. The ability to repay the long-term debt (DSR) in 2010 in this case is shown below.

The ability to repay the long-term debt (DSR) in 2010 in this case is shown below.

Long-term debt service capacity

Case	(A) Cash DEM 1,000	(B) Debt DEM 1,000	(C) DSR (A)/(B)
Case 1	410.0	463.1	0.89

(Note) (A) is the numerator of the formula shown in 1.4.5, and (B) is the denominator.

This shows that, if low-interest funding can be utilized, the effect of this in terms of the plant construction cost is the same as a 20% reduction.

As a result of the analyses described here, it was found that the case of sewerage system discharge, which does not require pretreatment, is more economically advantageous than the case of direct river discharge.

Table 3.6.6 Project Profile and Assumptions for Financial Projection (1/3)

1 Project

Title	:	Wastewater Treatment Project
Factory	:	Kosaki Tovarna Mesnih Izdelkov p.o. (M-6)
Location	:	Maribor, Slovenia
Project Case	:	Base Case 1: Discharge to River
Annual Production	:	Food/Butchery: 54,500 heads/y
Maximum Operable Days	:	(365.25 - 115.25) x 100% = 250.00 DPY
Treatment Capacity (100%)	:	250.00 DPY x 400 m^3/d = 100,000 m^3/y
Operation Start Year	:	2005
Monetary Unit	:	DEM in Terms of Fixed Price in 1996
Exchange Rates	:	1.0 DEM = 89.89 SIT as of June, 1996

2 Schedule

Start of Project Implementation	:	January 01, 2004
Project Completion	:	December 31, 2004
Commercial Operation	:	January 01, 2005
Project Phase Out	:	December 31, 2019
Project Life	:	15.0 Years from Start of Commercial Operation
Project Year	:	From January 01 to December 31
Construction and Commissioning	:	1.0 Year from Start of Project Implementation

3 Financing Required and Financing Plan - 1996

Financing Required	DEM, '000
Land/Site Development	-
Plant Construction Cost*	3,458.00
- Equipment & Machinery	2,157.00
- Civil & Building	1,301.00
Interest during Construction	207.00
Fixed Capital Cost	3,665.00
Initial Working Capital	0.00
Total Capital Requirement	3,665.00

Financing Plan		DEM, '000
Equity	: 0.00 %	0.00
Long Term Loan	: 100.00 %	3,665.00
- Interest	: 12.00 %	
Short Term Loan	:	-
Total Project Financing Cost		3,665.00

* Including Sales Tax of 5%.

Table 3.6.6 Project Profile and Assumptions for Financial Projection (2/3)

4 Inputs and Costing
(CIF at the Plant with Full Capacity Utilization in 1996)

Inputs	Unit		Per Sewage		Annual	
	Unit	Price (DEM/Unit)	Consumption (Unit/m^3)	Cost (DEM/m^3)	Consumption ('000, Unit)	Cost DEM, '000
Chemicals			-	0.626	-	62.598
- PAC (11%)	kg	0.831	0.4000	0.332	40.0000	33.240
- MeOH	kg	0.779	0.0400	0.031	4.0000	3.116
- NaOH (100%)	kg	0.926	0.0800	0.074	8.0000	7.408
- A Polymer (powder)	kg	11.013	0.0070	0.077	0.7000	7.709
- K Polymer (powder)	kg	22.249	0.0050	0.111	0.5000	11.125
Utility Cost			-	0.989	-	98.871
- Electricity	kWH	0.167	4.3580	0.728	435.8000	72.779
- Sludge Disposal	m^3	15.830	0.0068	0.107	0.6750	10.685
- Water	m^3	2.225	0.0250	0.056	2.5000	5.563
- Fuel	Ltr.	0.667	0.1476	0.098	14.7600	9.845
Variable Cost	-	-	-	1.615	100.0000	161.469
Personnel	Man-Year	16,280		0.326	2.0000	32.560
Maintenance	Equipment & Machinery x 5.0%			1.079	-	107.850
Government Charge	m^3	0.053	1.000	0.053	100.0000	5.300
Local Pollution Tax	m^3	0.453	1.000	0.453	100.0000	45.300
Direct Fixed Cost	-	-	-	1.910	-	191.010
Cash Treatment Cost		-	-	3.525	100.0000	352.479

5 Outputs and Pricing
(FOB at the Plant with Full Capacity Utilization in 1996)

Outputs	Unit		Per Sewage		Annual	
	Unit	Price (DEM/Unit)	Treatment (Unit/m^3)	Price (DEM/m^3)	Treatment ('000, Unit)	Sales DEM, '000
Treatment Fee	m^3	7.625	1.0000	7.625	100.0000	762.504

Table 3.6.6 Project Profile and Assumptions for Financial Projection (3/3)

6 Operation Schedule

(Unit: %)

Items	Project Year (-)1 04	1 05	2 06	3 07	4 08	.....15 2019	Total/ Average
Financing Disbursement	100						100
Sewage Treatment							
- Rated Capacity Utilization		100	100	100	100	100	1,500

Depreciation (Plant & Machinery)	15 Years Straight Line Method
Depreciation (Civil & Building)	40 Years Straight Line Method
Amortization (Interest during Const.)	15 Years Straight Line Method

Debt Service

Loan Type		Maximum Grace + Maturity	Annual Interest Rate, %
- Bank Loan/Local		(1 + 10) Years	12.00
- Short Term Loan/Local	Not considered.		

Corporate Income Tax	Zero
Sales Tax	5.00%

7 Financial Performance

Treatment Fee			
- Base Case, DEM/m^3-year	7.63 - 2005	7.63 - 2010	7.63 - 2014
Treatment Cost including D&I			
- Base Case, DEM/m^3-year	9.82 - 2005	7.63 - 2010	5.87 - 2014
Sensitivity Analysis using FIRR	(-20%)	(0%)	(+20%)
- Investment Cost, %	13.83	9.32	6.10
- Chemical Cost, %	9.77	9.32	8.86
Sensitivity Analysis using DSR as of 2010	(-20%)	(0%)	(+20%)
- Investment Cost, times	0.92	0.7	0.55
- Chemical Cost, times	0.72	0.7	0.68
Debt Service Ratio (DSR), times-year			
- Base Case, @12% interest	0.51 - 2005	0.70 - 2010	1.00 - 2014
- Alt. Case, @6% interest	0.72 - 2005	0.89 - 2010	1.09 - 2014

Table 3.6.7 Wastewater Treatment Cost Statements

*** WASTEWATER TREATMENT PROJECT IN KOSAKI (K-6) ***
WASTEWATER TREATMENT COST STATEMENTS
- CASE 1: DISCHARGE TO RIVER - (YEN. 1000)

YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
WASTEWATER TREATMENT (1000M3/Y)	0.0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CHEMICAL COST	0.0	62.60	62.60	62.60	62.60	62.60	62.60	62.60	62.60	62.60
PAC	0.0	33.24	33.24	33.24	33.24	33.24	33.24	33.24	33.24	33.24
MEOH	0.0	3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12
NAOH	0.0	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
A POLYMER	0.0	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71
K POLYMER	0.0	11.12	11.12	11.12	11.12	11.12	11.12	11.12	11.12	11.12
UTILITIES COST	0.0	98.87	98.87	98.87	98.87	98.87	98.87	98.87	98.87	98.87
ELECTRICITY	0.0	72.78	72.78	72.78	72.78	72.78	72.78	72.78	72.78	72.78
SLUDGE DISPOSAL	0.0	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69
WATER	0.0	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
FUEL	0.0	9.84	9.84	9.84	9.84	9.84	9.84	9.84	9.84	9.84
VARIABLE COST	0.0	161.47	161.47	161.47	161.47	161.47	161.47	161.47	161.47	161.47
EMPLOYMENT COST	0.0	32.56	32.56	32.56	32.56	32.56	32.56	32.56	32.56	32.56
MAINTENANCE COST	0.0	107.85	107.85	107.85	107.85	107.85	107.85	107.85	107.85	107.85
GOVERNMENT CHARGE	0.0	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30
LOCAL POLLUTION TAX	0.0	45.30	45.30	45.30	45.30	45.30	45.30	45.30	45.30	45.30
DIRECT FIXED COST	0.0	191.01	191.01	191.01	191.01	191.01	191.01	191.01	191.01	191.01
CASH TREATMENT COST	0.0	352.48	352.48	352.48	352.48	352.48	352.48	352.48	352.48	352.48
EQUIPMENT & MACHINERY	0.0	143.80	143.80	143.80	143.80	143.80	143.80	143.80	143.80	143.80
CIVIL & BUILDING	0.0	32.52	32.52	32.52	32.52	32.52	32.52	32.52	32.52	32.52
INTEREST DRG. CONSTRUCTION	0.0	13.80	13.80	13.80	13.80	13.80	13.80	13.80	13.80	13.80
DEPRECIATION AND AMORTIZATION	0.0	190.12	190.12	190.12	190.12	190.12	190.12	190.12	190.12	190.12
TOTAL TREATMENT COST	0.0	542.60	542.60	542.60	542.60	542.60	542.60	542.60	542.60	542.60
UNIT TREATMENT COST	0.0	5.4260	5.4260	5.4260	5.4260	5.4260	5.4260	5.4260	5.4260	5.4260
INTEREST ON LONG TERM DEBT	0.0	439.80	395.82	351.84	307.86	263.88	219.90	175.92	131.94	87.96
INTEREST ON SHORT TERM DEBT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL TREATMENT COST	0.0	982.40	938.42	894.44	850.46	806.48	762.50	718.52	674.54	630.56
UNIT TREATMENT COST	0.0	9.8240	9.3842	8.9444	8.5046	8.0648	7.6250	7.1852	6.7454	6.3056

YEAR	2014	2015	2016	2017	2018	2019
WASTEWATER TREATMENT (1000M3/Y)	100.00	100.00	100.00	100.00	100.00	100.00
CHEMICAL COST	62.60	62.60	62.60	62.60	62.60	62.60
PAC	33.24	33.24	33.24	33.24	33.24	33.24
MEOH	3.12	3.12	3.12	3.12	3.12	3.12
NAOH	7.41	7.41	7.41	7.41	7.41	7.41
A POLYMER	7.71	7.71	7.71	7.71	7.71	7.71
K POLYMER	11.12	11.12	11.12	11.12	11.12	11.12
UTILITIES COST	98.87	98.87	98.87	98.87	98.87	98.87
ELECTRICITY	72.78	72.78	72.78	72.78	72.78	72.78
SLUDGE DISPOSAL	10.69	10.69	10.69	10.69	10.69	10.69
WATER	5.56	5.56	5.56	5.56	5.56	5.56
FUEL	9.84	9.84	9.84	9.84	9.84	9.84
VARIABLE COST	161.47	161.47	161.47	161.47	161.47	161.47
EMPLOYMENT COST	32.56	32.56	32.56	32.56	32.56	32.56
MAINTENANCE COST	107.85	107.85	107.85	107.85	107.85	107.85
GOVERNMENT CHARGE	5.30	5.30	5.30	5.30	5.30	5.30
LOCAL POLLUTION TAX	45.30	45.30	45.30	45.30	45.30	45.30
DIRECT FIXED COST	191.01	191.01	191.01	191.01	191.01	191.01
CASH TREATMENT COST	352.48	352.48	352.48	352.48	352.48	352.48
EQUIPMENT & MACHINERY	143.80	143.80	143.80	143.80	143.80	143.80
CIVIL & BUILDING	32.52	32.52	32.52	32.52	32.52	32.52
INTEREST DRG. CONSTRUCTION	13.80	13.80	13.80	13.80	13.80	13.80
DEPRECIATION AND AMORTIZATION	190.12	190.12	190.12	190.12	190.12	190.12
TOTAL TREATMENT COST	542.60	542.60	542.60	542.60	542.60	542.60
UNIT TREATMENT COST	5.4260	5.4260	5.4260	5.4260	5.4260	5.4260
INTEREST ON LONG TERM DEBT	43.98	0.0	0.0	0.0	0.0	0.0
INTEREST ON SHORT TERM DEBT	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL TREATMENT COST	586.58	542.60	542.60	542.60	542.60	542.60
UNIT TREATMENT COST	5.8658	5.4260	5.4260	5.4260	5.4260	5.4260

Table 3.6.8 Funds Flow Statements

*** WASTEWATER TREATMENT PROJECT IN KOSAKI (K-6) ***
FUNDS FLOW STATEMENTS
- CASE 1: DISCHARGE TO RIVER - (DEM. 1000)

YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
SOURCE OF FUNDS	3665.00	410.02	410.02	410.02	410.02	410.02	410.02	410.02	410.02	410.02
CASH GENERATED FROM OPERATION	0.0	410.02	410.02	410.02	410.02	410.02	410.02	410.02	410.02	410.02
PROFIT AFT. TAX. BFR INT.	0.0	219.90	219.90	219.90	219.90	219.90	219.90	219.90	219.90	219.90
DEPRECIATION AND AMORTIZATION	0.0	190.12	190.12	190.12	190.12	190.12	190.12	190.12	190.12	190.12
FINANCIAL RESOURCES	3665.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SHARE CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LONG TERM LOAN	3665.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SHORT TERM DEBT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
USES OF FUNDS	3665.00	806.30	762.32	718.34	674.36	630.38	586.40	542.42	498.44	454.46
FIXED CAPITAL EXPENDITURE	3665.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NON-DEPRECIABLE ASSETS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DEPRECIABLE FIXED ASSETS	3458.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INTEREST DURING CONSTRUCTION	207.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHANGE IN WORKING CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DEBT SERVICES	0.0	806.30	762.32	718.34	674.36	630.38	586.40	542.42	498.44	454.46
REPAYMENT OF LONG TERM DEBT	0.0	366.50	366.50	366.50	366.50	366.50	366.50	366.50	366.50	366.50
REPAYMENT OF SHORT TERM DEBT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INTEREST ON LONG TERM DEBT	0.0	439.80	395.82	351.84	307.86	263.88	219.90	175.92	131.94	87.96
INTEREST ON SHORT TERM DEBT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DIVIDENDS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CASH INCREASE OR (DECREASE)	0.0	-396.28	-352.30	-308.32	-264.34	-220.36	-176.38	-132.40	-88.42	-44.44
BEGINNING CASH BALANCE	0.0	0.0	-396.28	-748.58	-1056.90	-1321.23	-1541.59	-1717.97	-1850.37	-1938.79
ENDING CASH BALANCE	0.0	-396.28	-748.58	-1056.90	-1321.23	-1541.59	-1717.97	-1850.37	-1938.79	-1983.23

YEAR	2014	2015	2016	2017	2018	2019
SOURCE OF FUNDS	410.02	410.02	410.02	410.02	410.02	410.02
CASH GENERATED FROM OPERATION	410.02	410.02	410.02	410.02	410.02	410.02
PROFIT AFT. TAX. BFR INT.	219.90	219.90	219.90	219.90	219.90	219.90
DEPRECIATION AND AMORTIZATION	190.12	190.12	190.12	190.12	190.12	190.12
FINANCIAL RESOURCES	0.0	0.0	0.0	0.0	0.0	0.0
SHARE CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0
LONG TERM LOAN	0.0	0.0	0.0	0.0	0.0	0.0
SHORT TERM DEBT	0.0	0.0	0.0	0.0	0.0	0.0
USES OF FUNDS	410.48	0.0	0.0	0.0	0.0	0.0
FIXED CAPITAL EXPENDITURE	0.0	0.0	0.0	0.0	0.0	0.0
NON-DEPRECIABLE ASSETS	0.0	0.0	0.0	0.0	0.0	0.0
DEPRECIABLE FIXED ASSETS	0.0	0.0	0.0	0.0	0.0	0.0
INTEREST DURING CONSTRUCTION	0.0	0.0	0.0	0.0	0.0	0.0
CHANGE IN WORKING CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0
DEBT SERVICES	410.48	0.0	0.0	0.0	0.0	0.0
REPAYMENT OF LONG TERM DEBT	366.50	0.0	0.0	0.0	0.0	0.0
REPAYMENT OF SHORT TERM DEBT	0.0	0.0	0.0	0.0	0.0	0.0
INTEREST ON LONG TERM DEBT	43.98	0.0	0.0	0.0	0.0	0.0
INTEREST ON SHORT TERM DEBT	0.0	0.0	0.0	0.0	0.0	0.0
DIVIDENDS	0.0	0.0	0.0	0.0	0.0	0.0
CASH INCREASE OR (DECREASE)	-0.46	410.02	410.02	410.02	410.02	410.02
BEGINNING CASH BALANCE	-1983.23	-1983.69	-1573.67	-1163.65	-753.62	-343.60
ENDING CASH BALANCE	-1983.69	-1573.67	-1163.65	-753.62	-343.60	66.42

*** WASTEWATER TREATMENT PROJECT IN KOSAKI (K-6) ***
RETURN ON INVESTMENT (IN 1998 FIXED PRICE)
- CASE 1: DISCHARGE TO RIVER - (DEM. 1000)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
(1) GROSS CAPITAL EXPENDITURE	3458.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(2) GROSS CASH IN-FLOW	0.0	410.02	410.02	410.02	410.02	410.02	410.02	410.02	410.02	410.02
OPERATING PROFIT	0.0	219.90	219.90	219.90	219.90	219.90	219.90	219.90	219.90	219.90
DEPRECIATION & AMORTIZATION	0.0	190.12	190.12	190.12	190.12	190.12	190.12	190.12	190.12	190.12
(4) BFR-TAX NET IN-FLOW (2)-(1)	-3458.00	410.02	410.02	410.02	410.02	410.02	410.02	410.02	410.02	410.02

	2014	2015	2016	2017	2018	2019
(1) GROSS CAPITAL EXPENDITURE	0.0	0.0	0.0	0.0	0.0	-813.12
(2) GROSS CASH IN-FLOW	410.02	410.02	410.02	410.02	410.02	410.02
OPERATING PROFIT	219.90	219.90	219.90	219.90	219.90	219.90
DEPRECIATION & AMORTIZATION	190.12	190.12	190.12	190.12	190.12	190.12
(4) BFR-TAX NET IN-FLOW (2)-(1)	410.02	410.02	410.02	410.02	410.02	1223.15

INTERNAL RATE OF RETURN

ON (4) BFR-TAX NET IN-FLOW (2)-(1) 8.32 PER CENT

3.6.5 Pretreatment for Reduction of the Pollution Load

1) Background

Because the foregoing report was based on the survey conducted up until June 1996 and assumed the total renewal of facilities with emphasis placed on the case of direct river discharge, the analysis of water quality was conducted on water before the existing oil separator. In this examination, however, because the emphasis is placed on a pretreatment system for discharge into the sewerage system and it is assumed that the oil separator will be used, analysis were carried out on the quality of water after the oil separator.

According to existing water quality analysis data, the quality of treated water from the oil separator satisfies the oil and fat discharge standard of 100 mg/l, and the fact was confirmed in the analysis this time too. In other words, the existing oil separator is capable of satisfying the standards for discharge into the sewerage system.

2) Selection of pretreatment system

In the case where further reduction of the pollution load is demanded, coagulation and pressure flotation shall be added. In order to avoid placing too great a load on the waste water treatment plant, which will utilize biological treatment methods, physical rather than biological pretreatment methods shall be employed. The reason why coagulation and pressure flotation is chosen ahead of coagulation sedimentation is due to consideration of the removal of oil and fat, the inherent nature of which is to float anyway.

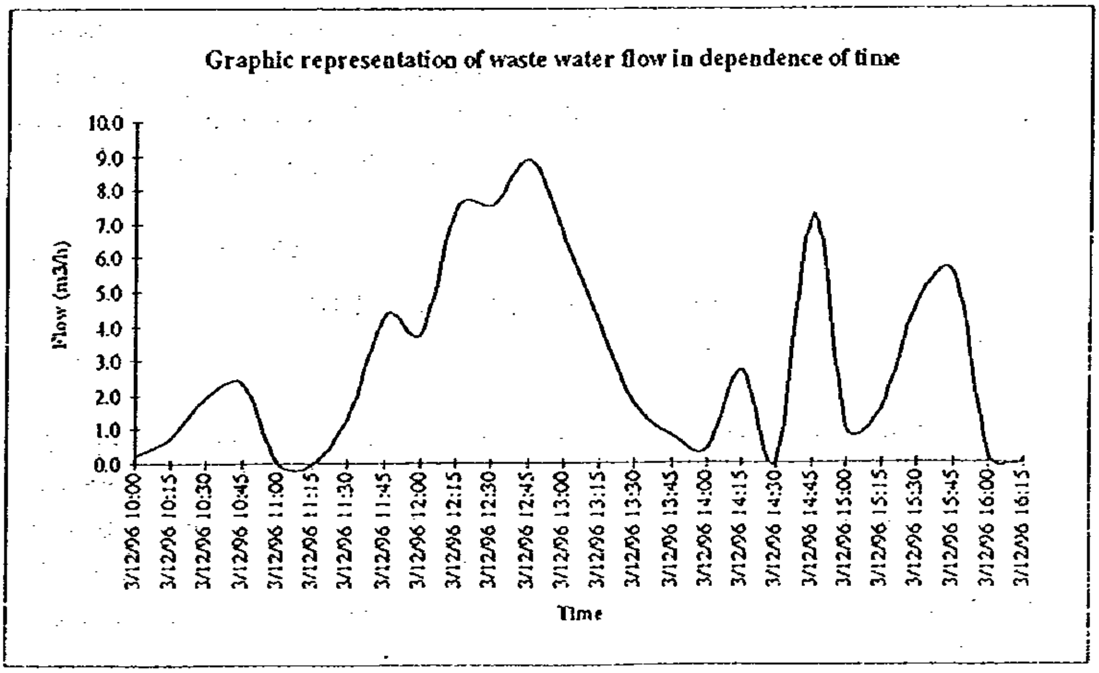
3) Coagulation treatment test

An experiment was carried out on a sample of actual waste water to confirm the effectiveness of coagulation. The results are shown in Table 3.6.9. The experiment conditions were equivalent to ideal batch treatment, however, as can be inferred from the reduction in COD to approximately 1/3 and the reduction in oil and fat to approximately 1/4, the effect in terms of reducing the pollution load was considerable. However, because the waste water treatment system in reality would be continuous, the water quality would become slightly worse than these experiment results suggest.

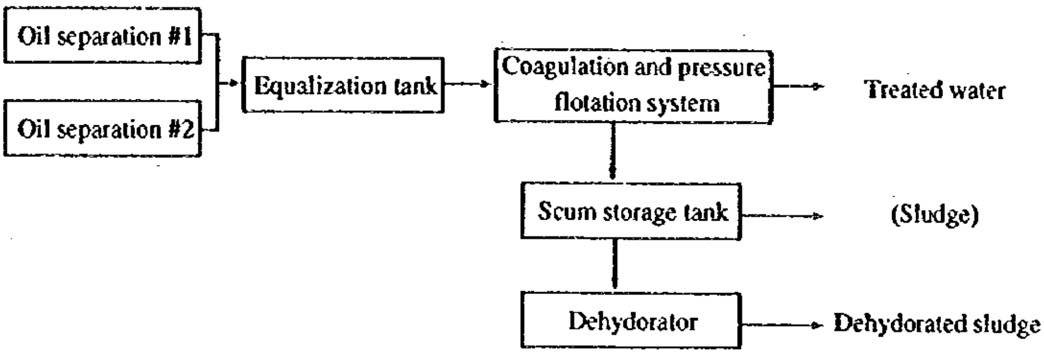
Table 3.6.9 Result of Coagulation Test

Effluent of the Slaughter Factory		Sampling	Coagulation Test
Note		03.12.1996 11:00 - 16:15 Flow-proportional	PAC 100 ppm Anion P 200 Cation P 0
			Floc size Large Settling time 30sec
Parameter			
pH		7.7	6.6
SS	mg/l	520	< 30
Color		red	light red
α (436nm)	1/m	82	26
α (525nm)		72	12
α (620nm)		60	5
t - N	mg/l		69
t - P	mg/l	11	< 0.5
COD_{Cr}	mg/l	2,400	930
COD_{Mn}	mg/l	770	250
BOD_5	mg/l	1,200	
t - Fat	mg/l	80	22

Fig. 3.6.12 Flow of Waste Water



4) Outline of pretreatment system



Case 1: oil separator only

Oil separation can sufficiently be handled by the existing separator. Regarding the treatment of floating oil and fat, a collection specialist currently comes to collect it once per week for delivery as a raw material to a soap factory. The present treatment cost (or income) is zero.

Case 2/3: addition of coagulation and press flotation system

Nighttime personnel expenses can be eliminated by making the system operate for less than 12 hours per day. The next choice is whether or not to use a dehydorator. If there is no dehydorator, not only will the equipment cost naturally be cut, but the operating effort and cost of coagulant for dehydoration will also be unnecessary.

Furthermore, regarding the treatment of dehydorated sludge, it was found in the June survey that this can be disposed of at a small cost by SNAGA. As for the case of disposing of scum without installing and operating a dehydorator, it is up to NIGRAD to decide the feasibility of this and the costs that would be incurred if it were feasible. This matter is not settled as of the current point in time.

Case 3: addition of fixed floor catalytic oxidation and biological treatment system

In the case where further reduction of COD and BOD is required, biological treatment shall be carried out.

Anaerobic biological treatment is often adopted in cases of high pollution load, however, this does not work well when there are high levels of oil and fat. It is advantageous to carry out aerobic biological treatment after conducting coagulation and pressure flotation, when the pollution load of the water is low. Because SS levels are low, fixed floor catalytic oxidation and biological treatment is highly suited.

5) Economic feasibility of the pretreatment system for reduction of the pollution load

Table 3.6.10 shows the water quality that can be obtained from pretreatment and the estimated cost of the system. The same figures in the case of a system of waste water treatment for direct river discharge are also shown for reference. In the case of direct river discharge, the waste water treatment cost becomes very expensive due to the strict discharge standards. In fact, the treatment cost in this case is so expensive that it cannot even be compared with the sewage charge in the case of sewerage system discharge.

Treatment by coagulation and pressure flotation does cause remarkable reduction in the pollution load, however, the treatment cost is roughly the same as the standard sewage charge. Unless a progressive charge system, in which the sewage charge becomes twice as high as the standard charge when pollution loads are high, is established, a pretreatment system designed to reduce the pollution load would not be economically feasible. In other words, so long as the additional sewage charge is small, it is more economic to discharge into the sewerage system and accept the higher sewage charge.

Table 3.6.10 Quality and Pollution Loads of Waste Water and Treated Water

Kind of wastewater	Quantity m3/d	CODcr mg/L (kg/d)	BOD mg/L (kg/d)	Fat mg/L ( )	SS mg/L (kg/d)	T-N mg/L (kg/d)	T-P mg/L (kg/d)
*1 Case-1 Oil separator	400	1,500 (600)	800 (320)	60 (24)	600 (240)		20 (8)
*2 CASE-2/3 + Coagulation & floatation	400	800 (320)	400 (160)	20 (8)	< 30 (12)		< 2
*3 CASE-4 + Contact Oxidation	400	250 (80)	100 (40)	10 (4)	< 30 (12)		< 2

Note) * Case 1: case where oil separation is carried out as pretreatment
* Case 2: case of further adding coagulation and press flotation (with dewaterer)
* Case 3 (with no dewaterer)
* Case 4: case where catalytic oxidation is added to Case 2

Table 3.6.11 Equipment and Running Costs of the Treatment System

	Equipment cost SIT	Depreciation & Interest SIT/m³	Running Cost SIT/m³	Total treatment cost SIT/m³
CASE-1	exsited	0	0	0
CASE-2	50,000,000	55	85	140
CASE-3	43,000,000	48	72	120
CASE-4	80,000,000	88	100	188
to River	296,076,000	299	266	565

3.7 M-7 MARIBORSKA MLEKARNA, p.o. MM
MARIBORSKA MLEKARNA, d.o.o.

3.7.1 Factory Outline

1) Outline

Mariborska Mlekarna p.o. is an integrated manufacturer of milk and fermented milk packed in paper cartons and various cheeses, etc. The volume of raw milk it uses has been increasing at a rate of approximately 3.5% every year, and it is able to produce a wide range of products in small quantities through the use of modern and hygienic production equipment. Some of its products are exported to Croatia and other countries.

The factory layout of Mariborska Mlekarna p.o. is shown in Fig. 3.7.1.

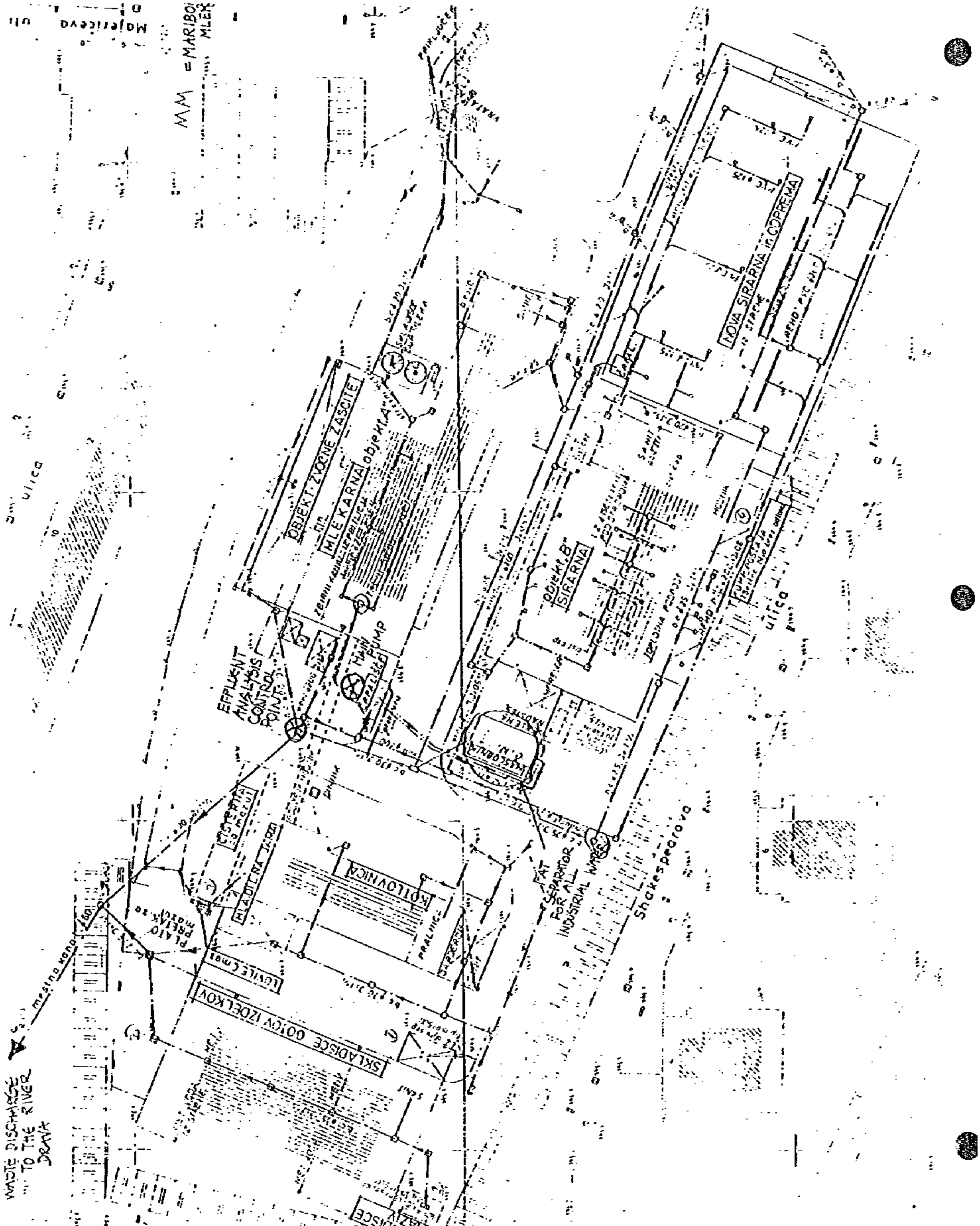
2) Volume of water usage by water source and purpose of use

The volume of water usage and waste water by water source and purpose of use is shown in Table 3.7.1.

Table 3.7.1 Volume of Water Usage by Water Source and Purpose of Usage

Use \ Source	Well Water	City Water	River Water	Sub-Total	Recovered Water	Total
Boiler Feed		20		20	30	50
Raw Material						
Washing		210		210		
Cooling		15		15	(250)	(265)
Air Conditioning						
Miscellaneous		231		231		231
Total		476		476	(280)	(756)
				Recovered Water/Total		(37.0)%

Fig. 3.7.1 Factory Layout



3) Water supply and waste water discharge flow diagrams

The water balance at the factory is shown in Fig. 3.7.2.

(1) Water supply facilities

Of the water used in the production processes, the boiler water comes from that which has been treated in a softener. 4% HCl and 12% NaCl are used in the softener, and regenerated waste water is produced two times per week.

(2) Manufacturing processes and sources of waste water generation

The major manufacturing processes are shown in Fig. 3.7.3.
The major items of equipment on the milk product production line are raw milk storage tanks, the manufacturing system and product storage tanks. The manufacturing system consists of a homogenizer, fermentation tank, mixing tank, plate pasteurizer, filling machine, milk pumps, and so on.
These items of equipment plus the piping that connects them are washed by an automatically controlled washing system known as CIP (cleaning in place). The washing cycle of the CIP consists of the following.

(Water rinse)→(Alkali washing)→(Hot water washing)→(Acid washing)→(Water rinse)→(H_2O_2 pasteurization)

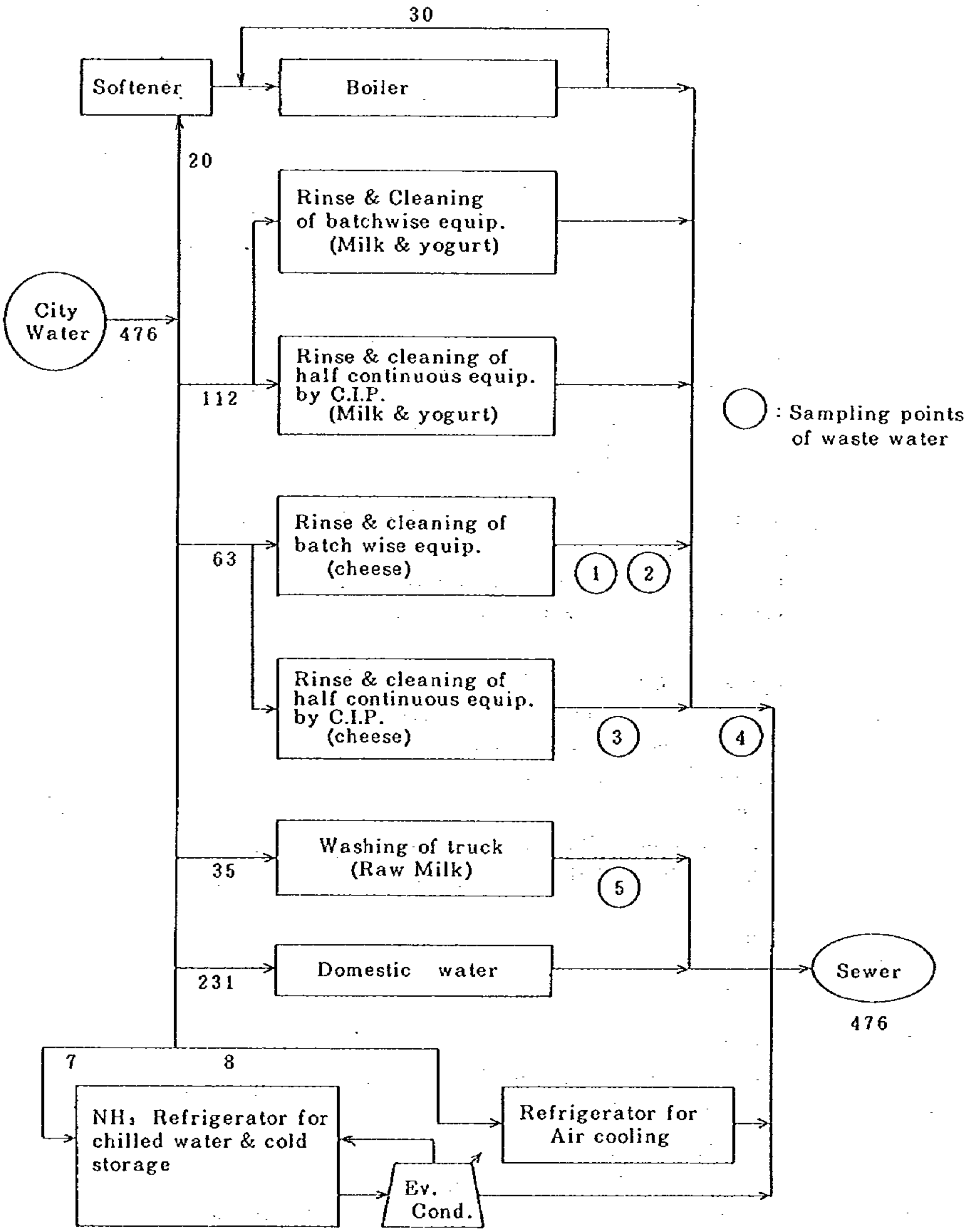
Approximately rinse water, hot washing water, one-quarter of alkali washing liquid and one-quarter of acid washing liquid is generated as CIP waste water.
The cooling of equipment is carried out by a system of indirect cooling with cooling water. A little waste water is discharged by the refrigerator used to make this cooling water, but it contains no pollution.
During milk production, some leaked raw milk is generated as waste water and, similarly, in the cheese making process, some whey also comes off as waste water.
At the end of work, the tanks, conveyor belts, machinery and floors are all washed, and this generates washing waste water.

a. Raw milk acceptance

Raw milk that is delivered to the factory by tank lorry, and is first cold stored in a storage tank. The procedure for acceptance of raw material milk is as follows.

Raw milk→(Inspection)→(Filtration)→(Weighing)→Raw material milk

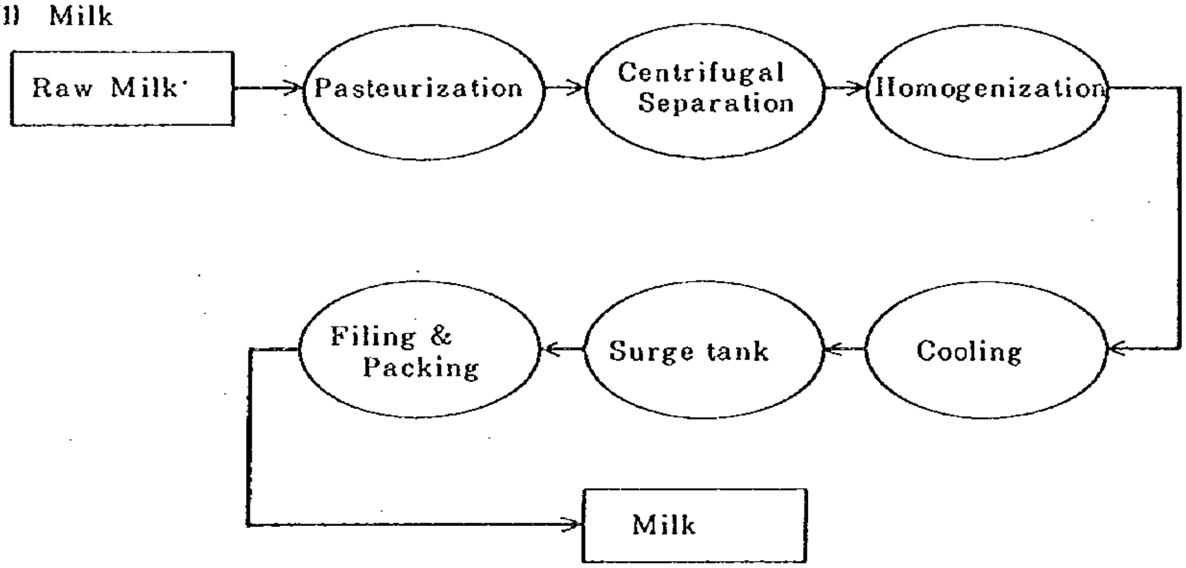
Fig. 3.7.2 Water Balance at the Factory (m³ / day)



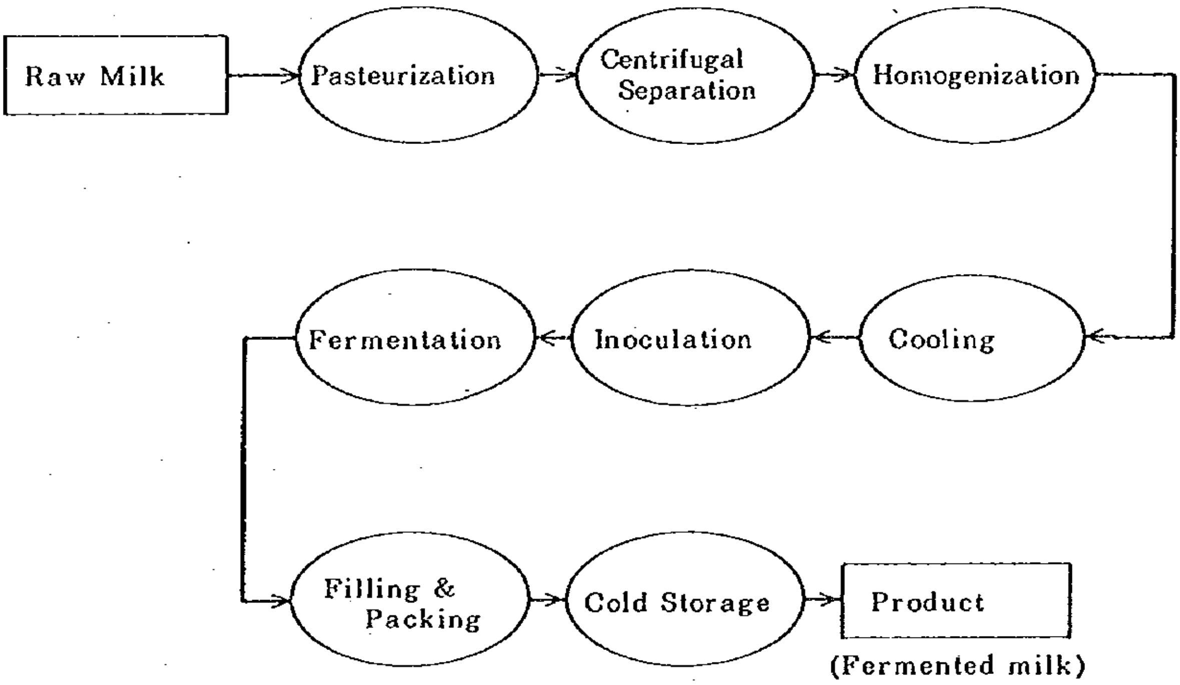
Note : a) Ev. Cond. is Evaporated Condenser.

Fig. 3.7.3 Manufacturing Processes (1/2)

(1) Milk



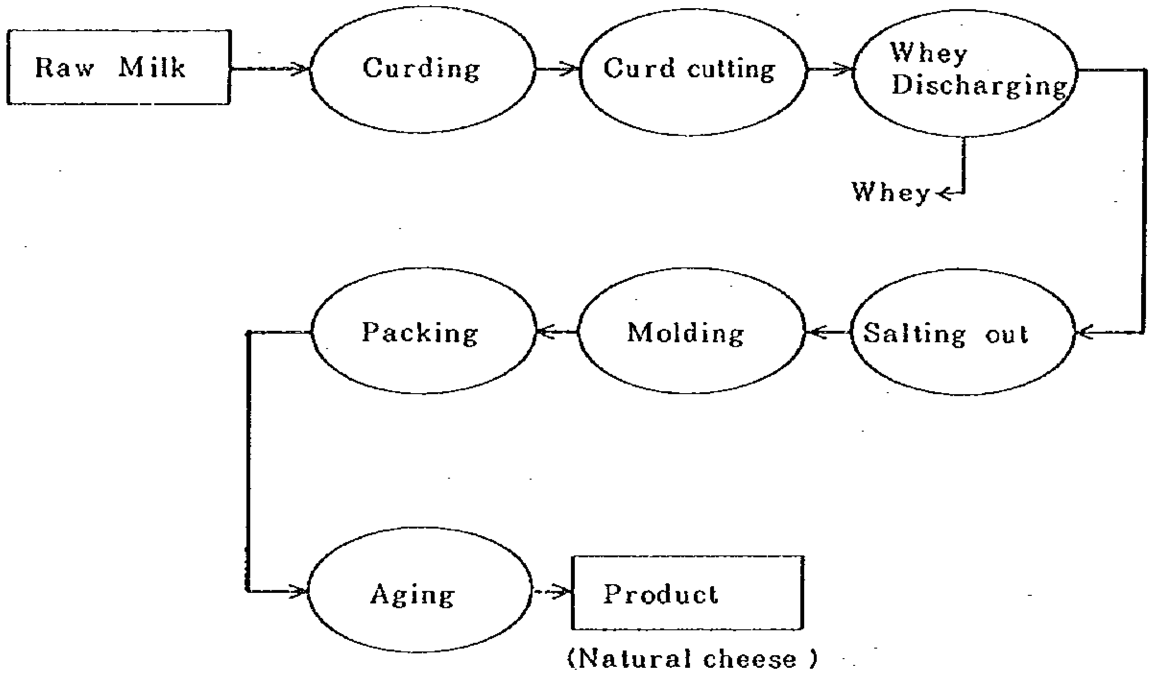
(2) Fermented Milk



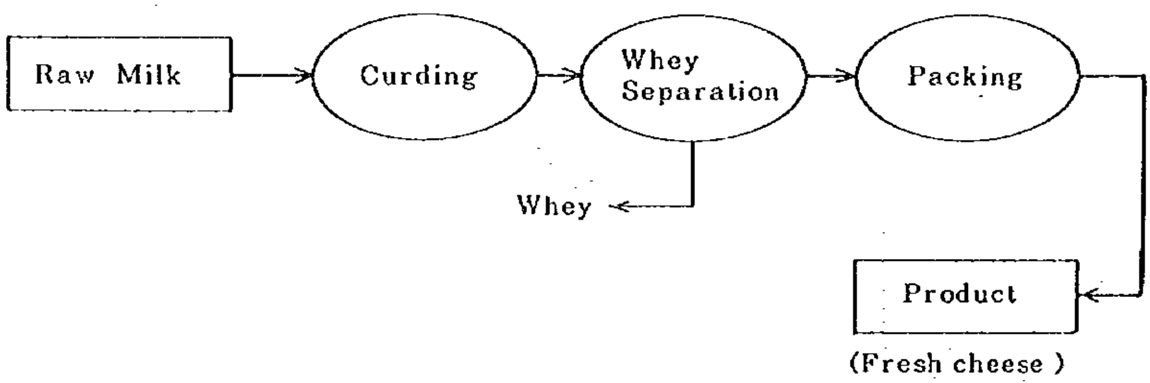
Note : a) Chilled water system is applied for the cooling process.

Fig. 3.7.3 Manufacturing Processes (2/2)

(3) Natural cheese



(4) Fresh cheese



Note : a) The whey is sold for making food of livestock.

①Carrying in of raw milk

When raw milk is carried in to the factory by tank lorry, it is sent to the inspection room to receive the various designated inspections. Raw milk that passes the inspections is filtered, weighed and stored in a storage tank. In this process, waste water is generated from the CIP washing of the tank lorry tanks and the washing of vehicles.

② Filtration and storage tanks

The filtration is designed to extract any foreign substances from the raw milk. Waste water is generated from the CIP washing of the filter and milk storage tanks.

b. Milk manufacturing process

The basic manufacturing process for milk is as follows.

Raw material milk→(Pasteurization)→(Centrifugal separation)→(Homogenization)→(Cooling)→(Holding)→(Filling)→Milk

① Pasteurization

In this process, the raw milk is pasteurized by heating to 60℃ for a short period and then cooling. Here, waste water is generated from the CIP washing of the pasteurization equipment.

② Centrifugal separation

In this process, minute foreign substances are separated from the milk in a centrifugal separator. Here, waste water is generated from the CIP washing of the centrifugal separator.

③ Homogenization

In this process, skimmed milk is homogenized to the milk composition. Here, waste water is generated from the CIP washing of the homogenizer.

④ Cooling

In this process, the homogenized milk is cooled down. Here, waste water is generated from the CIP washing of the cooling equipment.

⑤ Holding

In this process, the cooled milk is temporarily stored in tanks ready for filling into cartons. Here, waste water is generated from the CIP washing of the tanks.

⑥ Filling

In this process, the milk is filled into cartons. Here, waste water is generated from the CIP washing of the filling equipment.

c. Fermented milk manufacturing process

The basic manufacturing process for fermented milk is as follows.

Raw material milk→(Pasteurization)→(Centrifugal separation)→(Homogenization)→(Cooling)→(Inoculation)→(Fermentation)→(Holding)→(Filling)→Fermented milk

From the pasteurization through to cooling, the waste water generation is the same as described above (①-④).

⑤ Inoculation

In this process, the cooled milk is inoculated.

⑥ Fermentation

The milk is fermented by means of lactic acid bacilli. Here, waste water is generated from the water washing of the fermentation tank.

⑦ Filling

In this process, the fermented milk is filled into cartons. Here, waste water is generated from the CIP washing of the filling equipment.

d. Natural cheese manufacturing process

The basic manufacturing process for natural cheese is as follows.

Raw material milk → (Curding) → (Dehydration) → (Curd cutting) → (Molding)→(Packing)→(Aging)→Cheese

① Curding

In this process, pasteurized raw material milk is fermented and hardened by adding rennet. Here, waste water is generated from the water washing of the curding tank.

② Curd cutting

In this process, the curd is placed in a mold and cut to the desired size after the whey has been filtered off. In the dehydration process, there are whey leaks, and waste water containing pieces of cheese is generated.

③ Molding

In this process, the cut cheese is placed in salt water and molded through the application of pressure. The salt water is newly replaced once per year. At this time, the salt water becomes waste water.

④ Packing

In this process, the molded cheese is wrapped. As water is not used in this process, no waste water is generated.

⑤ Aging

In this process, the wrapped cheese is given a long time to mature. As water is not used in this process, no waste water is generated.

e. Fresh cheese manufacturing process

The basic manufacturing process for fresh cheese is as follows.

Raw material milk→(Curding)→(Dehydration)→(Packing)→(Aging)→Cheese

The above four processes are the same as in the case of natural cheese.

(3) Waste water treatment plant

An oil separator has been installed but is not currently in use.

4) Quality of make-up water and waste water

(1) Quality of make-up water

The make-up water used consists of both city water and treated water from the softener.

The quality of the make-up water is shown in Table 3.7.2.

Table 3.7.2 Quality of Make-up Water

Items \ Name of Sample \ No.	① City Water	② Outlet of Softener
Fe (mg/ℓ)	15	15
Mg (mg/ℓ)	7.5	7.5
T-Hardness* (°dH)	12.4	0.02
M-Alkalinity (mmol/ℓ)		
Cℓ (mg/ℓ)	8	—
TDS (mg/ℓ)	< 0.05	0

(NOTE) * : mmol/ℓ as CaO

(2) Quality of waste water

a. Features of waste water discharge

① Waste water from the carrying in of raw milk (35 m^3/day)

During the process of transfer of raw milk from tank lorries into the storage tanks, waste water is generated from the CIP washing of the lorry tanks, leaked raw material milk and the CIP washing of filtration equipment and milk storage tanks.

② Waste water from the milk manufacturing process (58 m^3/day)

During the process of making milk from the raw material milk in tanks, waste water is generated from the CIP washing of equipment and the water washing of the floor.

③ Waste water from the fermented milk manufacturing process (54 m^3/day)

During the process of making fermented milk from the raw material milk in tanks, waste water is generated from the CIP, the washing of equipment and the water washing of floors.

④ Waste water from the natural cheese manufacturing process (40 m^3/day)

During the process of making natural cheese from the raw milk in tanks, waste water is generated from the CIP, the washing of equipment and the water washing of floors.

⑤ Waste water from the fresh cheese manufacturing process (23 m^3/day)

During the process of making fresh cheese from the raw milk in tanks, waste water is generated from the CIP, the washing of equipment and the water washing of floors.

⑥ Domestic waste water, etc. (231 m^3/day)

There are 286 employees. This figure includes regenerated waste water from the softener and waste water from the washing of vehicles, etc.

⑦ Boiler blow water (20 m^3/day)

This waste water contains hardly any pollution at all.

b. Volume of waste water disposal overall

① Of the overall waste water sampled, the results of measurement of the volume of vehicle washing waste water (including regenerated waste water from the make-up water softener) are shown in Fig. 3.7.4.

② The volume of waste water by manufacturing process and by month (1995), according to materials presented by the factory side, is shown in Fig. 3.7.5.

c. Quality of waste water

The quality of each type of waste water and waste water overall is shown in Table 3.7.3. The sample No.'s and sampling points are as follows.

(No. 1) : Milk manufacturing process waste water
(No. 2) : Natural cheese manufacturing process waste water
(No. 3) : Fresh cheese manufacturing process waste water
(No. 4) : Manufacturing waste water (composite sample)
(No. 5) : Vehicle washing waste water (composite sample)

Also, an example of the quality of waste water overall (27-28 March, 1996) was presented by the factory side and is shown in Table 3.7.4.

Fig. 3.7.4 Results of Measurement of the Volume of Vehicle Washing Waste Water

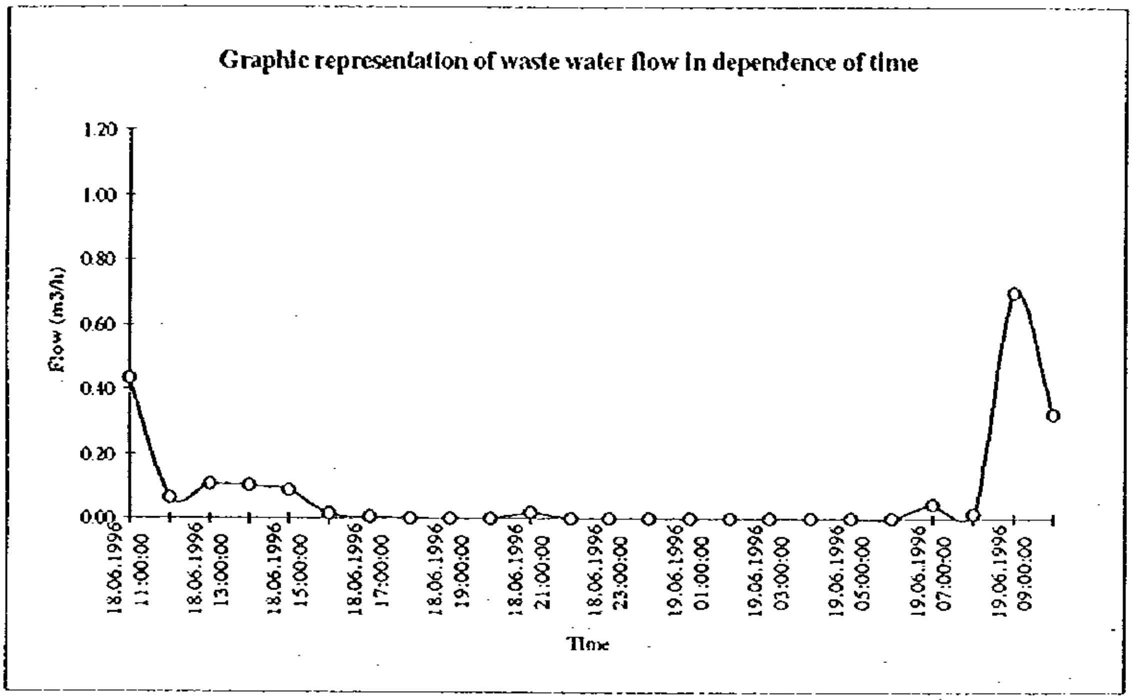


Fig. 3.7.5 Volume of Waste Water by Manufacturing Process and Month (1995)

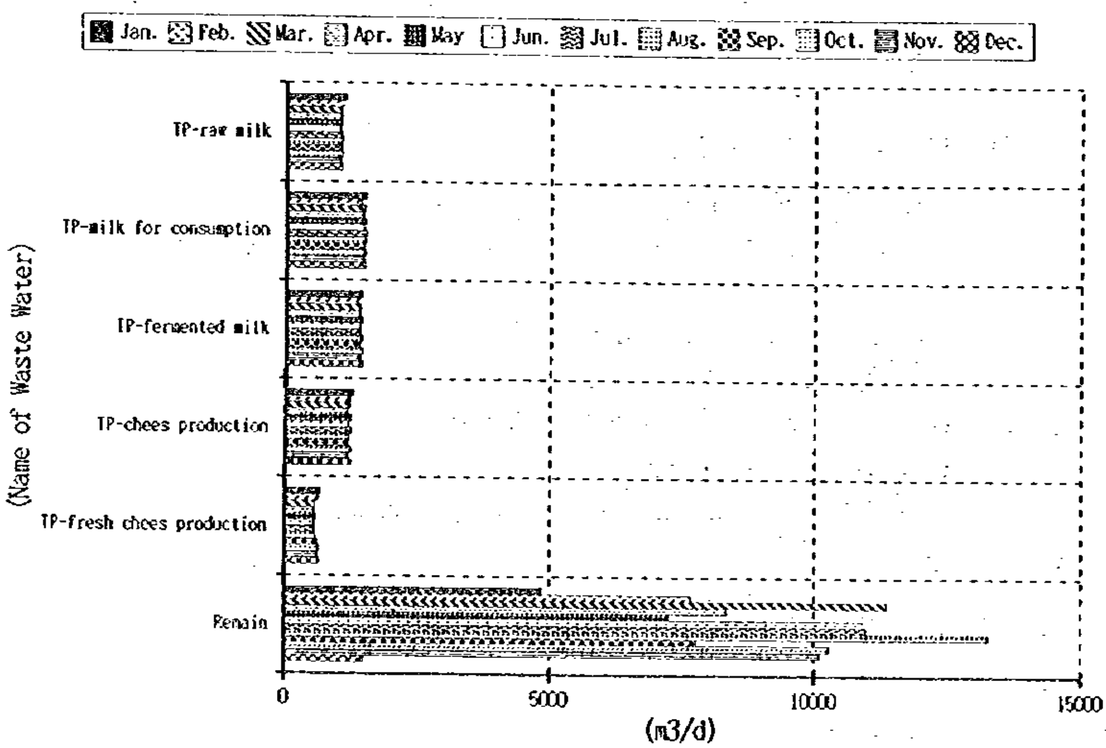


Table 3.7.3 Quality of Each Type of Waste Water and Waste Water Overall

No.	1	2	3	4	5
Items / Name of Sample	TP-milk for consumption	TP-chees production	TP-fresh chees production	Effluent from production	Effluent from car washing
Temp. (℃)	29	29	27	22*	22*
pH (−)	9.5	7.1	8.1	4.2	8.6
SS (mg/ℓ)	<30	2,000	70	930	630
Settable solids (mg/ℓ)	−	−	−	<0.1	−
TOC* (mg/ℓ)	−	−	--	500	--
Cl_2* (mg/ℓ)	<0.05	<0.05	<0.05	1.4	<0.05
T-N (mg/ℓ)	14.3	165	23.5	255	46
$N-NH_3$ (mg/ℓ)	0.06	2.3	1.9	3.6	4.4
N-Kjeldahl (mg/ℓ)	7.8	150	14	230	28
$N-NO_2$ (mg/ℓ)	<0.1	4.2	0.1	15	1.4
$N-NO_3$ (mg/ℓ)	6.5	11	9.4	10	17
T-P (mg/ℓ)	20	48	10	11	130
COD_{cr} (mg/ℓ)	50	14,000	200	5,700	2,100
BOD (mg/ℓ)	20	3,500	100	2,000	450
T-fat (mg/ℓ)	<5	<5	<5	300	500
Anionic surfactants (mg/ℓ)	<0.05	<0.05	<0.05	1.2	<0.05

(Note) * : Measured in spot sample

Table 3.7.4 Quality of Waste Water Overall (27-28 March, 1996) from Presented Materials

No.	①	②	③	④	⑤
Items \ Name of Sample	composite 24 h	spot	composite 6:30～14:30	composite 15:30～22:30	composite 22:30～ 5:30
Temp. (℃)	4 ～ 22	—	—	—	—
pH (—)	—	—	5.1	9.3	9.3
SS (mg/ℓ)	—	—	1,158	528	34
Settable solids (mg/ℓ)	—	—	30	8	<1
TDS (mg/ℓ)	—	—	—	2,691	353
$N-NH_3$ (mg/ℓ)	160	—	10	2	17
$N-NO_2$ (mg/ℓ)	4	—	4.4	1	5.1
$N-NO_3$ (mg/ℓ)	4	—	—	—	—
COD_{Cr} (mg/ℓ)	8,624	5,500	14,520	3,256	264
BOD (mg/ℓ)	4,650	3,350	5,140	2,760	63
TOC (mg/ℓ)	3,700	—	17	—	<5

3.7.2 Water Conservation

1) Current conditions of water usage and conservation

(1) Features of water use

① The city water supply is the only source of water, and the volume of usage is measured.

② Reliability regarding the breakdown of water usage is low, but, approximately 44% is used for washing and product treatment, approximately 49% is used for miscellaneous purposes, and the rest is used as boiler water and cooling water.

③ The large percentage and volume of the water used for miscellaneous purposes is a feature, and these values are too large even considering the work force of 286.

④ Water used for washing and product treatment is mainly used in the washing of process equipment and product transportation vehicles, and the fully automatic CIP equipment, too, also uses it. Approximately 60% of the boiler water is recovered for repeated use.

⑤ The consumption of water in recent years is shown in Table 3.7.5.

Table 3.7.5 Unit Consumption of Water (Water Usage/Raw Milk)

Year	1990	1991	1992	1993	1994	1995
Consumption (l/l)	4.6	4.0	3.6	4.4	4.1	3.5

The main reason for the variation probably lies in changing product lines.

(2) Current condition of conservation

① The partial implementation of water saving can be witnessed in the recovery use of boiler water, the adoption of a evaporative condenser for refrigerator and the adoption of a fully automatic CIP, etc.

② However, the control of water usage cannot be described as satisfactory. For example, hand control valves are attached to hardly any of the floor and equipment washing hoses, and minor water leaks and the wasteful use of water were observed during the survey.

③ The volume of miscellaneous water usage (231 m^3/day) is equivalent to the amount used by approximately 800 (l/person/day) and shows that the control of water usage is not good enough. Having said that, this does mean that it would be possible to reduce water usage through making a water saving effort.

④ The difference between the total water usage and the equipment water usage is classed as miscellaneous water usage, and this suggests that the there is no accurate grasp of the amount of water used on each item of equipment. Consequently, achieving as detailed an understanding as possible of the water balance on each area of equipment is considered the first important step to carrying out a water saving program.

2) Examination and evaluation

(1) Technical comment

① In consideration of the current condition of water conservation described above, it is necessary to grasp as accurately as possible the water usage situation on each area of equipment and investigate whether or not the current water usage levels are appropriate.

By optimizing equipment water usage through making some slight investments in the equipment based on the survey results, a water saving of approximately 10-15% (approximately 50 m^3/day) could be achieved.

② The staff and equipment investment required to achieve water conservation, and the resulting water saving effect are supposed as follows.

Engineers	:	2
Period	:	1 year (spending 50% of time on current work and 50% on water conservation)
Facility cost	:	1,000,000 SIT (hand control valves, piping parts, instrumentation, etc.)
Water conservation	:	50 m^3/day

③ The engineers (two) and period (one year) shall be limited and, following the implementation period, the engineers will revert back to their normal duties and water saving will be carried out as a routine practice based on the use of manuals, etc.

(2) Economic comment

① The trial calculation of the economic effect based on the above conditions is shown below.

(a) Investment in one year

Personnel expenses	: 3,000,000 x 2 engineers x 50%
	= 3,000,000 SIT/year
Equipment cost	: 1,000,000 SIT/year
Total	: 4,000,000 SIT/year

(b) Forecast water saving effect

50 m^3/day x 200 SIT/m^3 x 365 days = 3,650,000 SIT/year

It can be seen that the investment can be retrieved inside one year, showing that it would be economically feasible to carry out water conservation.

3.7.3 Pretreatment that Satisfy WWTP Discharge Standards, and Waste Water Treatment

1) Current condition of waste water

Judging from the current characteristics of waste water discharge, waste water is divided up into the following types.

a. Waste water that requires treatment

① Waste water from the manufacturing processes

Waste water from the manufacturing processes is organic and can be broadly divided into equipment washing waste water and floor washing waste water. Washing waste water is further divided into waste water from CIP washing and waste water from manual washing. The CIP waste water from tank lorries combines with these types to give the total waste water from manufacturing processes.

Incidentally, because the mixing of cheese pieces and whey from the manufacturing processes into the waste water increases the pollutant load to the waste water treatment plant. To reduce the size of the plant, this should be avoided as much as possible.

② Regenerated waste water from softener

As a result of regeneration using HCl, the waste water is acidic.

③ Vehicle washing waste water

This is waste water from the washing of tank lorries that have completed CIP washing. For the same reasons as described in (a), it is necessary to conduct water conservation in order to reduce the volume of waste water from vehicle washing and other miscellaneous sources.

④ Domestic waste water

This is generated by the work force of 286.

b. Waste water that does not require treatment

① Cooling water

This is boiler blow water and contains hardly any pollution at all.

2) Pre-treatment plant

(1) Basis for system selection

The waste water in need of treatment is that from the manufacturing processes, regenerated waste water from the softener, waste water from vehicle washing and domestic waste water. These types of waste water do not contain substances that can hinder treatment in the WWTP, however, depending on the conditions of discharge, there are cases where the pH value may deviate from standard. Put another way, the CIP waste water and regenerated waste water from the softener contain acid and alkali. Also, when waste water containing raw cows' milk putrefies, the released organic acid reduces the pH value. Thus, it is necessary to first neutralize these types of waste water before discharging them into the WWTP.

(2) Outline of pre-treatment system

① Waste water from manufacturing processes

After passing the waste water through a screen to remove foreign material, it is fed into a waste water storage tank. From there, a set amount of waste water is fed by storage pump into a neutralization tank, where neutralization is carried out through addition of NaOH under control by a pH meter installed in the tank. Following neutralization, the waste water is discharged into the WWTP.

② Regenerated waste water from softener

The regenerated waste water is first stored in the waste water storage tank. From there, it is fed in set amounts to the neutralization tank, where the same process as that described above takes place. After that, the waste water is in discharged into the WWTP.

③ Other waste water

Other waste water is discharged directly into the WWTP.

(3) Design conditions

a. Quality of waste water

The quality of waste water is shown in Table 3.7.6.

Table 3.7.6 Quality of Waste Water

Item		Waste water type				
		Manufacturing waste water	Regenerated waste water	Domestic waste water	Vehicle washing waste water	Cooling water
pH	(mg/l)	7-9	2-3	6-8	6-8	6-8
COD	(mg/l)	5,700	-	400	2,100	-
BOD	(mg/l)	2,000	-	200	450	-
T-P	(mg/l)	11	-	-	130	-
T-fat	(mg/l)	300	-	-	500	-
SS	(mg/l)	930	-	50	650	-

b. Volume of treated water

The volume of treated water is 474 m^3/day.

① Waste water that requires treatment
Manufacturing process waste water : 175 m^3/day
Regenerated waste water : 13 m^3/day
(32 m^3/time ÷ 2.5 days/time = 12.8 m^3/hour)

② Waste water that does not require treatment
Domestic waste water : 231 m^3/day
Vehicle washing waste water : 35 m^3/day
Cooling water : 20 m^3/day

c. Waste water inflow time

8 hours/day

d. Operating time

8 hours/day

e. Quality of treated water

The water quality standards for the case of river discharge and the case of WWTP discharge are shown in Table 3.7.7.

Table 3.7.7 Quality Standards of Waste Water

	Item	unit	River	Sewage
1	Temperature	℃	30	40
2	pH	–	6.5--9.0	6.5--9.5
3	SS	mg/l	80	(a)
4	SV_{30}	ml/l	0.5	10
5	SAK(Color unit)			
	436nm	m^{-1}	7.0	
	525nm	m^{-1}	5.0	(b)
	620nm	m^{-1}	3.0	
6	Toxicity test (SD)	mg/l	3	–
7	Biodegradation	%	–	(c)
8	B	mg/l	1.0	10.0
9	Al	mg/l	3.0	(d)
10	As	mg/l	0.1	0.1
11	Cu	mg/l	0.5	0.5
12	Ba	mg/l	5.0	5.0
13	Zn	mg/l	2.0	2.0
14	Cd	mg/l	0.1	0.1
15	Co	mg/l	1.0	1.0
16	Sn	mg/l	2.0	2.0
17	T-Cr	mg/l	0.5	0.5
18	Cr^{6+}	mg/l	0.1	0.1
19	Ni	mg/l	0.5	0.5
20	Ag	mg/l	0.1	0.1
21	Pb	mg/l	0.5	0.5
22	Fe	mg/l	2.0	(d)
23	Hg	mg/l	0.01	0.01
24	Cl_2(Free chlorine)	mg/l	0.2	0.5
25	Cl_2(Total effective chlorine)	mg/l	0.5	1.0
26	$N\text{-}NH_3$	mg/l	10	(e)
27	$N\text{-}NO_2$	mg/l	1.0	10
28	$N\text{-}NO_3$	mg/l	(f)	–
29	T-CN	mg/l	0.5	10
30	Free CN	mg/l	0.1	0.1
31	F	mg/l	10	20
32	Cl^-	mg/l	(g)	–
33	T-P	mg/l	2.0(1.0(h))	–
34	SO_4	mg/l	(f)	300
35	S	mg/l	0.1	1.0
36	SO_3	mg/l	1.0	10
37	TOC	mg/l	30	–
38	COD_{Cr}	mg/l	120	–
39	BOD_5	mg/l	25	–
40	Total oil and fat	mg/l	20	100
41	THC	mg/l	10	20
42	Aromatic organic chlorine	mg/l	0.1	1.0
43	Absorbent organic chlorine	mg/l	0.5	0.5
44	Volatile organic chlorine	mg/l	0.1	0.1
45	Aqueous organic chlorine	mg/l	(k)	(l)
46	Phenol	mg/l	0.1	10
47	Surfactant	mg/l	1.0	–

(3) Equipment specifications

a. Flow sheet

The pre-treatment plant flow sheet is shown in Fig. 3.7.6.

b. Layout

The pre-treatment plant layout is shown in Fig. 3.7.7.

c. Equipment list

The pre-treatment plant equipment list is shown in Table 3.7.8.

d. Design calculations sheet

• Manufacturing process waste water screens

One rough screen and one fine screen each shall be put in place.

Finally decided value : One 20 mm bar screen, One 1.5 m/m automatic screen

• Manufacturing process waste water storage tank

With respect to the maximum hourly inflow, a retention time of 10 minutes shall be set.
$25 m^3/h \times 2.5 \times 10 min./60 min. = 10.4 m^3$

Finally decided value : $12 m^3$

• Regenerated waste water receiving tank

The tank shall be large enough to hold one batch of regenerated waste water.
$32 m^3/time \times 1 time = 32 m^3$

Finally decided value : $35 m^3$

• Neutralization tank

With respect to the maximum hourly inflow, a retention time of five minutes shall be set.
$28.5 m^3/hour \times 2.5 \times 5 min./60 min. = 5.9 m^3$

Finally decided value : $6 m^3$

Fig. 3.7.6 Pretreatment Plant Flow Sheet

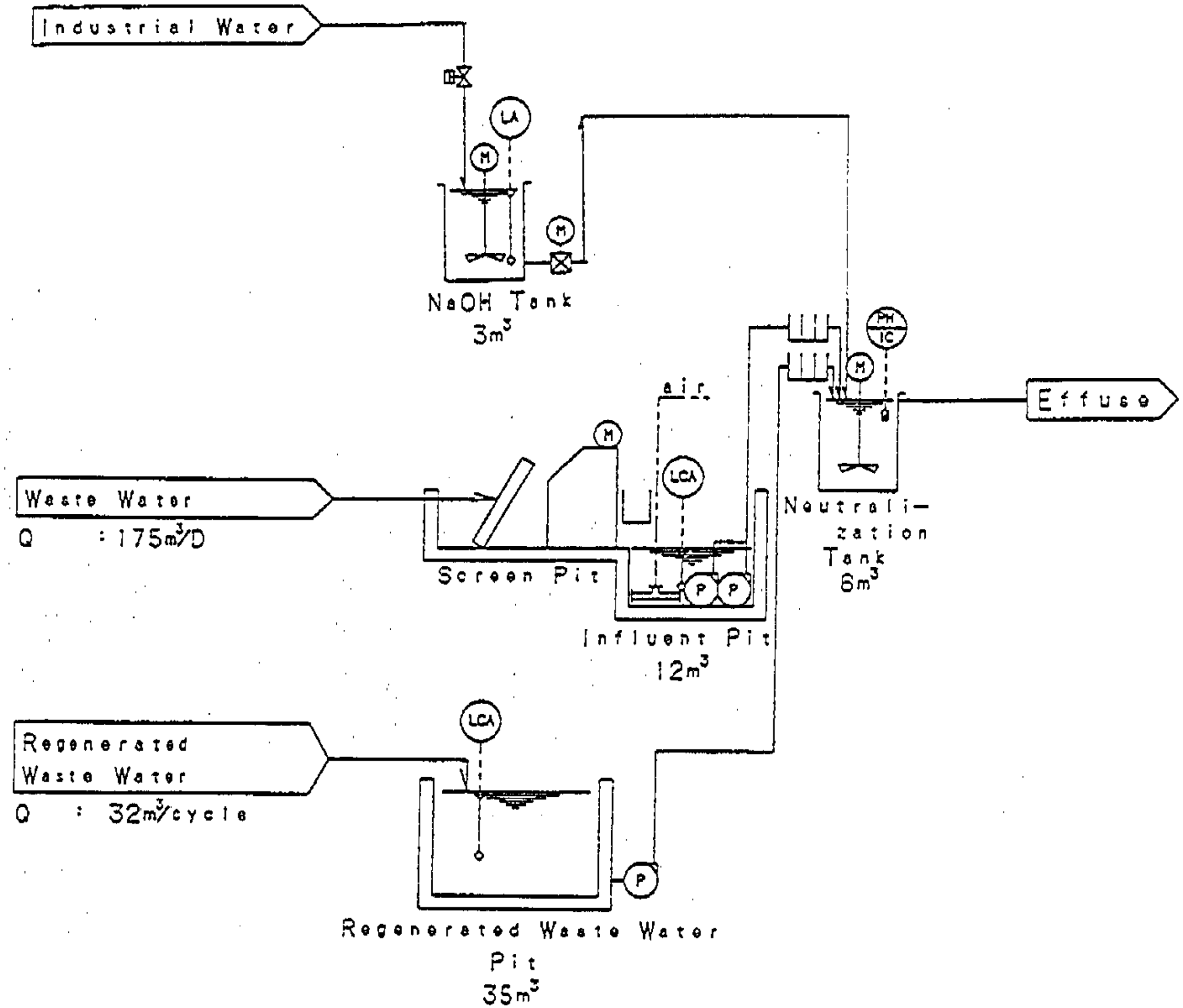
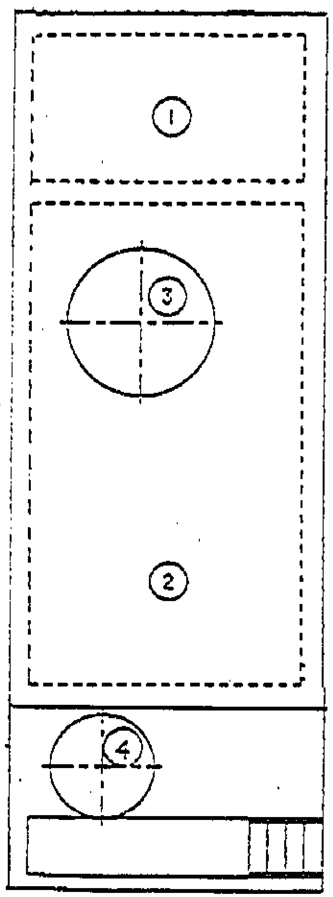


Fig. 3.7.7 Pretreatment Plant Lyout



No	Descriptions	Remarks
1	Influent Pit	
2	Regenerated Waste Water Pit	
3	Neutralization Tank	
4	NaOH Tank	

Table 3.7.8 Equipment List (1/2)

No.	Item	Q'ty	Material	Specification	Remark
1	Screen Pit	1	RC		
	Bar Screen	1	SUS	Slit 20 mm	
	Auto Scree	1	SUS	Slit 1.5mm×0.1kw	
2	Influent Pit	1	RC	Capacity : 12 m³	
				Shape : 3.7mW×2.0mL×2.5mD	
				with air diffuser	
	Pump	2	FC	100φ×1m³/min×10m×3.7kw	
				Submersion type	
	Flow Meter	1	PVC	Box type	
	Level Switch	1	PVC	Float type	
3	Regenerated Waste Water	1	RC+FRP	Capacity : 35 m³	
	Pit			Shape : 3.7mW×6.5mL×2.5mD	
	Pump	1	PVC	40φ×100ℓ/min×10m×1.5kw	
				Centrifugal type	
	Flow Meter	1	PVC	Box type	
	Level Switch	1	PVC	Float type	
4	Neutralization Tank	1	FRP	Capacity : 6 m³	
				Shape : 2.0mφ×2.4mH	
	Agitator	1	CS+RL	Vertical type 2.2 kw	
	pH Meter	1		Dip type, 0~14, 4~20mA	
5	NaOH Tank	1	FRP	Capacity : 3 m³	
				Shape : 1.6mφ×2.0mH	

Table 3.7.8 Equipment List (2/2)

No.	Item	Q'ty	Material	Specification	Remark
	Agitator	1	SUS	Vertical type 0.75 kw	
	Pump	1	PVC	25φ×3ℓ/min×5kg/cm^2×0.2kw	
				Diaphram type	
	Level Switch	1	SUS	Electrode type	

• NaOH tank (10% concentration)

A retention period of seven days shall be set.

Volume used :	Amount equivalent to PAC	18.9 kg/day as dry solid
	For neutralization	28 kg/day as dry solid
(Total)		46.9 kg/day as dry solid

46.9 kg/day ÷ 10% = 469 l/day

Capacity : 414 l/day x 7 days = 3,283 l

Finally decided value : 3 m^3

(4) Equipment cost

The equipment cost is 13,605,000 SIT.
The equipment cost is indicated in Table 3.7.9.

Table 3.7.9 Equipment Cost

Equipment	SIT
Agitator	5,341,000
Instrumentation	429,000
Others (tanks)	2,163,000
Subtotal	(7,933,000)
Site works	
Equipment installation and piping	1,521,000
Electrical work	889,000
Painting work	7,000
Civil work	1,616,000
Building work	1,031,000
Site supervision	134,000
Trial operation	68,000
Subtotal	(5,266,000)
Design cost	406,000
Total	13,605,000

(5) Operating cost

The operating cost is 3,394,000 SIT/year.
The operating cost is shown in Table 3.7.10.

Table 3.7.10 Operating Cost

Item	Contents		Chemical costs SIT/Year
NaOH	41.1 kg/day x 83.2 SIT/kg x 365 d/y	=	1,248,125
Electricity Charge	128 kWh/day x 15 SIT/kWh x 365 d/y	=	700,800
Maintenance Cost	13,605,000 SIT x 0.05	=	680,250
Kerosene	36l/day x 60 SIT/l x 90 days	=	194,400
Personnel Expenses	1,425,000 SIT/y-person x 2 Person/y x 0.2	=	570,000
	Total	=	3,393,575

(6) Economic evaluation

a. Conditions

① Depreciation period : Equipment 15 years
: Building, civil 40 years
② Rate of interest : 10% per annum
③ Depreciation method : Equal depreciation
④ WWTP discharge charge : 176.56 SIT/m^3
⑤ River discharge : 0 SIT/m^3
⑥ Annual waste water treatment volume :
188 m^3/day x 365 days/year = 68,620 m^3/year

b. Treatment cost per 1 m^3 of waste water

The treatment cost per 1 m^3 of waste water is 76 SIT/m^3.
The breakdown of this unit treatment cost is shown in Table 3.7.11.
Therefore, the cost of treating one cubic meter of waste water is as follows.
(①+②+③+④) + (474 m^3/day x 365 days/year) + 176.56 SIT/m^3
= 205 SIT/m^3

Table 3.7.11 Breakdown of Treatment Cost per 1 m^3 of Waste Water

Items		Contents		Cost	
Depreciation period	Equipment	10,958,000 SIT+15 years	①	730,533	SIT/year
	Buildings, Civil works	2,647,000 SIT+40years	②	66,175	SIT/year
Rate of interest	13,605,000 x 0.05		③	680,250	SIT/year
Running cost			④	3,394,000	SIT/year
(①+②+③+④) + 68,620				71	SIT/m^3

3) Waste water treatment plant

(1) Basis for system selection

The types of waste water that require treatment all contain organic matter. The central unit process within an organic waste water treatment system is biological treatment. Because waste water about to undergo biological treatment must be in a neutral state, the pre-treatment plant described previously is required.

Biological treatment can either involve anaerobic treatment or aerobic treatment. Generally speaking, the former is used to pre-treat waste water of medium-to-high concentration, and the latter is used to treat medium-to-low-concentration waste water. When the representative aerobic treatment process of activated sludge treatment is performed, waste water that contains cows' milk is known to be vulnerable to the phenomenon known as bulking, whereby abnormal quantities of filamentose bacteria occur. Because the activated sludge with these filamentose bacteria do not has sedimentation. The sedimentation separation of active sludge following aeration becomes difficult and, as a result, the treatment becomes impossible. Thus, it is necessary to select a unit process in which it is difficult for bulking to occur. Available methods here are 1) anaerobic/aerobic method, 2) sequencing batchwise activated sludge method, and 3) selector-based system. Of these processes, the first two have a good effect in terms of removing nitrogen and phosphorous. However, because measurements of the waste water volume found it to be discharged over relatively long periods of time, it becomes difficult to select the sequencing batchwise activated sludge method, when viewing the matter from the viewpoint of treatment plant operating time. In view of the above, it is decided to adopt the anaerobic/aerobic approach. Moreover, the treatment tank needs to possess a high BOD capacity load in order to treat the lactose contained in milk.

(2) Outline of treatment system

① Waste water from manufacturing processes

After being neutralized in the pre-treatment process, the waste water is fed into the stabilization tank, from where a set amount is transferred by storage pump into anaerobic/aerobic tanks. While organic matter is treated in both tanks, nitrogen and phosphorous are simultaneously removed in the anaerobic tank and aerobic tank respectively. The treated waste water is next fed into a sedimentation tank, where sludge is separated by sedimentation. The supernatant undergoes coagulation and sedimentation in order to remove residual phosphorous. Then, in the reaction tank, a set amount of PAC and NaOH controlled by a pH meter are added. Here, any residual phosphate in the waste water is converted into aluminum phosphate ($Al_2(SO_4)_3$). In the subsequent coagulation tank, high polymer coagulant is added to form floc. The waste water containing floc is then fed into the next sedimentation tank, where the separation of liquid and solids takes place. The resulting supernatant is then fed into a sterilization tank for sterilization, from where it naturally flows by gravity into a monitoring tank. After the pH value is automatically recorded and monitored, the treated water is finally discharged into the Drava River. If an abnormal pH value is measured in the monitoring tank, an alarm will be raised. Incidentally, part of the separated sludge sediment is sent back to the aeration tank, and excess sludge is sent to the sludge storage tank.

② Regenerated water from the softener

A set amount of the waste water in the waste water storage tank is fed by storage pump into the neutralization tank, where it undergoes the same treatment as the manufacturing process waste water.

③ Domestic waste water

After passing through a screen to remove foreign material, domestic waste water is sent to the waste water storage tank. A set amount of the waste water is then sent to the stabilization tank, where it undergoes the same treatment as the manufacturing process waste water.

④ Vehicle washing waste water

The vehicle washing waste water is directly discharged into the stabilization tank, where it undergoes the same treatment as the manufacturing process waste water.

⑤ Other waste water

The boiler blow water and cooling water is directly discharged into the sterilization tank.

(3) Design conditions

a. Quality of waste water

The quality of waste water is shown in Table 3.7.6.

b. Volume of treated water

The volume of treated water is 474 m^3/day.

① Waste water that requires treatment

Waste water from manufacturing processes : 175 m^3/day
Regenerated waste water : 13 m^3/day
(32 m^3/time ÷ 2.5 days/time = 13 m^3/hour)
Domestic waste water : 231 m^3/day
Vehicle washing waste water : 35 m^3/day

② Waste water that does not require treatment

Cooling water : 20 m^3/day

c. Waste water inflow time

8 hours/day

d. Operating time

24 hours/day (dehydrator operates for 8 hours/day)

e. Quality of treated water

See Table 3.7.7.

(3) Equipment specifications

a. Flow sheet

The waste water treatment plant flow sheet is shown in Fig. 3.7.8.

b. Layout

The waste water treatment plant layout is shown in Fig. 3.7.9.

c. Material balance

The material balance of the waste water treatment plant is shown in Fig. 3.7.10.

d. Equipment list

The waste water treatment system equipment list is shown in Table 3.7.12.

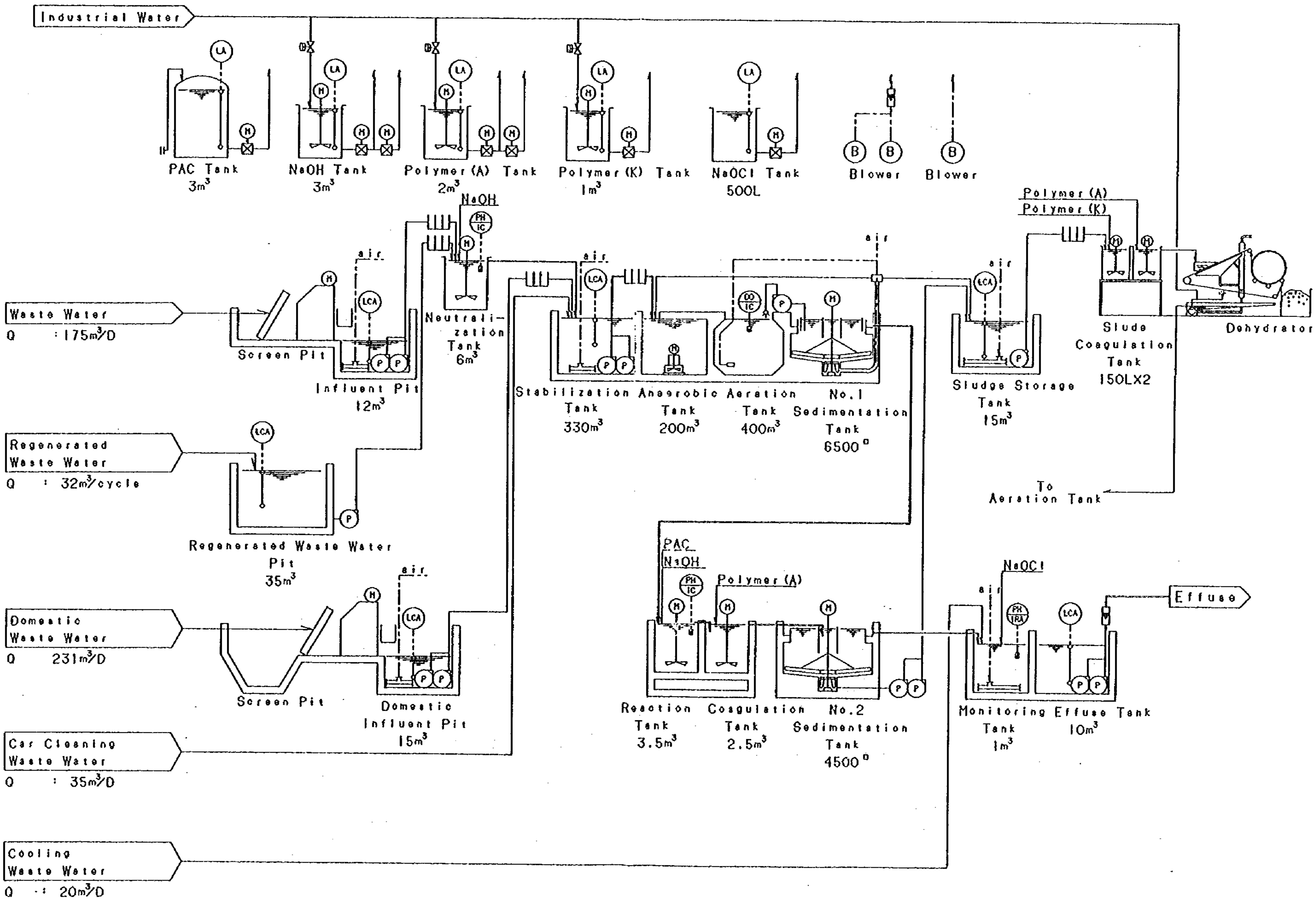
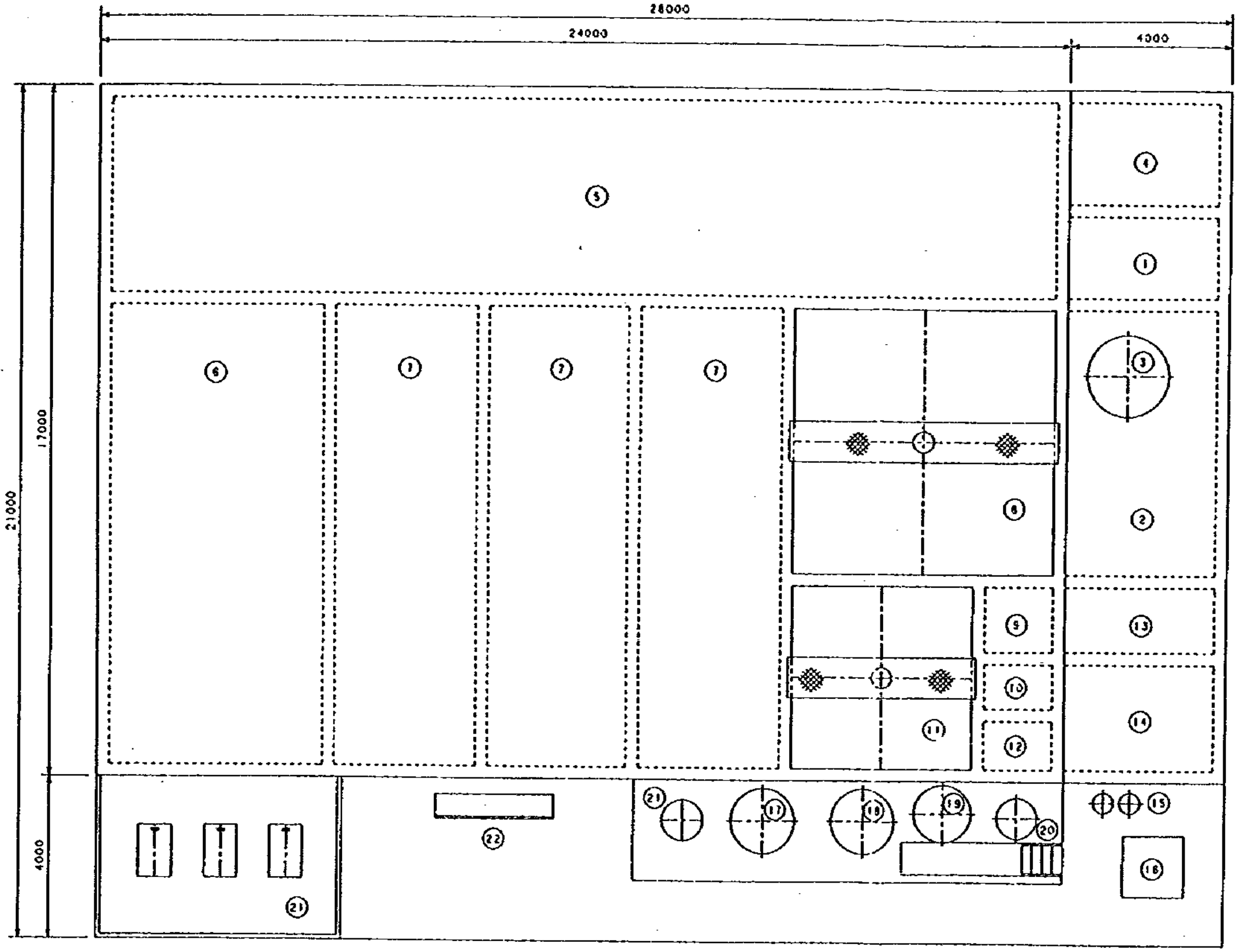


Fig. 3.7.8 Waste Water Treatment Plant Flow Sheet



No	Descriptions	Remarks
1	Influent Pit	
2	Regenerated Waste Water Pit	
3	Neutralization Tank	
4	Domestic Influent Pit	
5	Stabilization Tank	
6	Anaerobic Tank	
7	Aeration Tank	
8	No.1 Sedimentation Tank	
9	Reaction Tank	
10	Coagulation Tank	
11	No.2 Sedimentation Tank	
12	Monitoring Tank	
13	Effuse Tank	
14	Sludge Storage Tank	
15	Sludge Coagulation Tank	
16	Dehydrator	
17	PAC Tank	
18	NaOH Tank	
19	Polymer (A) Tank	
20	Polymer (K) Tank	
21	NaOCl Tank	
22	Blower Room	
23	Control Panel	

Fig. 3.7.9 Waste Water Treatment Plant Layout

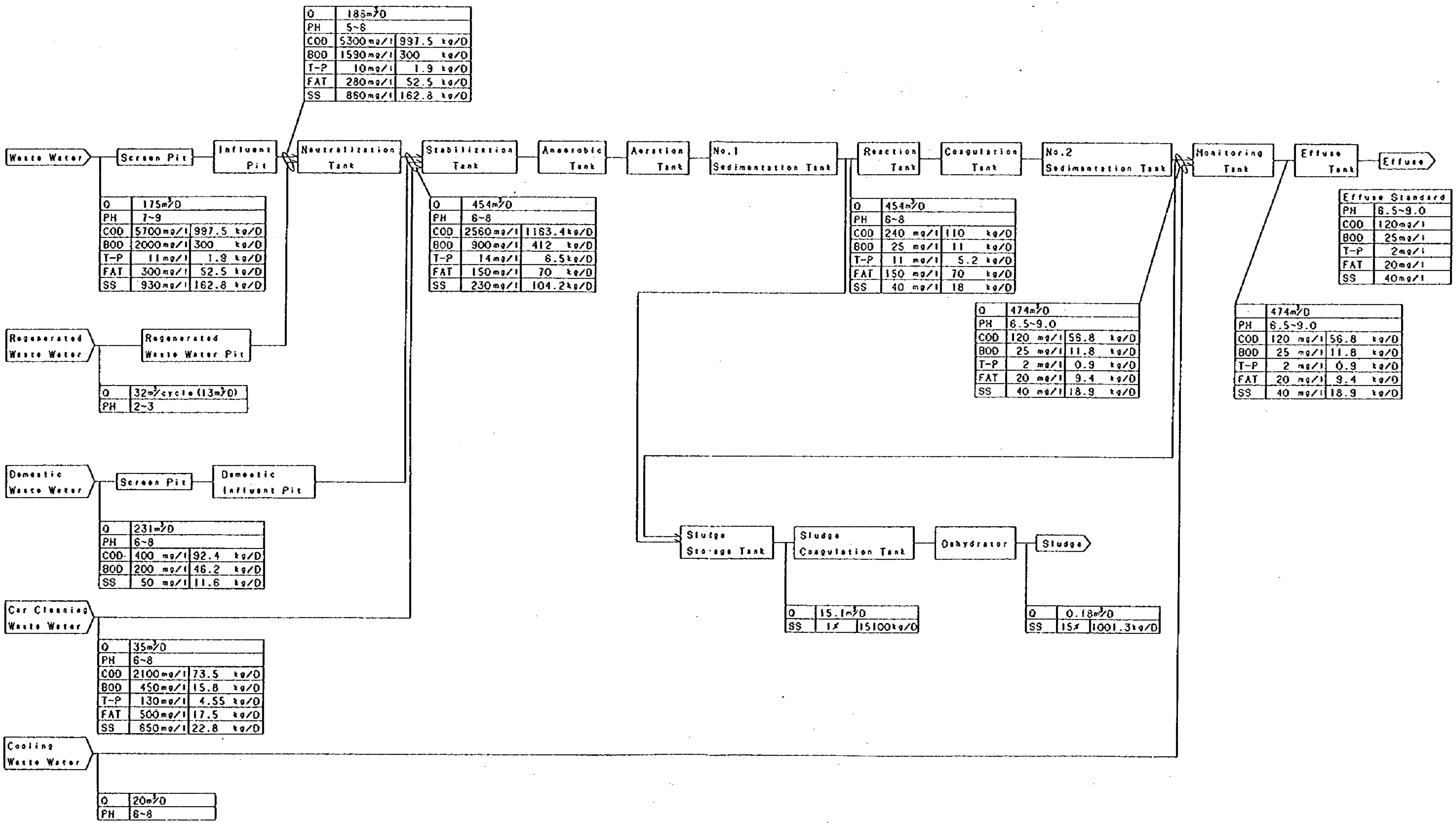


Fig. 3.7.10 Material Balance of Waste Water Treatment Plant

Table 3.7.12 Equipment List (1/7)

No.	Item	Q'ty	Material	Specification	Remark
1	Screen Pit	1	RC		
	Bar Screen	1	SUS	Slit 20 mm	
	Auto Scree	1	SUS	Slit 1.5mm×0.1kw	
2	Influent Pit	1	RC	Capacity : 12 m^3	
				Shape : 3.7mW×2.0mL×2.5mD	
				with air diffuser	
	Pump	2	FC	100φ×1m^3/min×10m×3.7kw	
				Submersion type	
	Flow Meter	1	PVC	Box type	
	Level Switch	1	PVC	Float type	
3	Regenerated Waste Water Pit	1	RC+FRP	Capacity : 35 m^3	
				Shape : 3.7mW×6.5mL×2.5mD	
	Pump	1	PVC	40φ×100ℓ/min×10m×1.5kw	
				Centrifugal type	
	Flow Meter	1	PVC	Box type	
	Level Switch	1	PVC	Float type	
4	Neutralization Tank	1	FRP	Capacity : 6 m^3	
				Shape : 2.0mφ×2.4mH	
	Agitator	1	CS+RL	Vertical type 2.2 kw	
	pH Meter	1		Dip type, 0～14, 4～20mA	
5	Screen Pit	1	RC		
	Bar Screen	1	SUS	Slit 20 m/m	

Table 3.7.12 Equipment List (2/7)

No.	Item	Q'ty	Material	Specification	Remark
	Auto Screen	1	SUS	Slit 1.5m/m×0.1kw	
6	Domestic Influent Pit	1	RC	Capacity 15 m³	
				Shape : 3.7mW×2.5mL×2.5mD	
				with air diffuser	
	Pump	2	RC	100φ×1.4m³/min×10m×5.5kw	
				Submension type	
	Flow Meter	1	PVC	Box type	
	Level Switch	1	PVC	Float type	
7	Stabilization Tank	1	RC	Capacity : 330 m³	
				Shape : 23.4mW×4.8mL×4.0mD	
				with air diffuser	
	Pump	2	FC	80φ×400ℓ/min×10m×2.2kw	
				Submersion type	
	Flow Meter	1	PVC	Box type	
	Level Switch	1	PVC	Float type	
8	Anaerobic Tank	1	RC	Capacity : 200 m³	
				Shape : 5.2mW×11.3mL×4.0mD	
	Agitator	2	SUS	Submersion type 3.7 kw	
9	Aeration Tank	1	RC	Capacity : 400 m³	
				Shape:3.5mW×11.3mL×4.0mD×3lines	
				with air diffuser	
	DO Meter	1		Dip type, 0～20mg/ℓ, 4～20mA	

Table 3.7.12 Equipment List (3/7)

No.	Item	Q'ty	Material	Specification	Remark
10	No. 1 Sedimentation Tank	1	RC	Surface area : 42 m²	
				Shape:6.5m×6.5m×3mD	
	Sludge Collector	1	CS	Rake type 0.4 kw	
	Pump	1	CS	Airlift type Max 38m³/Hr	
	Pump	1	FC	50φ×250ℓ/min×15m×2.2kw	
				Centrifugal type	
11	Reaction Tank	1	RC+FRP	Capacity : 3.5 m³	
				Shape : 1.7mW×1.6mL×2.0mD	
	Agitator	1	CS+RL	Vertical type 1.5 kw	
	pH Meter	1		Dip type, 0～14, 4～20mA	
12	Coagulation Tank	1	RC	Capacity : 2.5 m³	
				Shape : 1.7mW×1.1mL×2.0mD	
	Agitator	1	SUS	Vertical type 0.4 kw	
13	No. 2 Sedimentation Tank	1	RC	Surface area 20 m²	
				Shape : 4.5m×4.5m×3mD	
	Sludge Collector	1	CS	Rake type 0.2 kw	
	Pump	2	FC	25/20φ×30ℓ/min×10m×0.75kw	
				Centrifugal type for slurry	
14	Monitoring Tank	1	RC	Capacity : 1 m³	
				Shape : 1.7mW×1.2mL×4.0mD	
				with air diffuser	
	pH Meter	1		Dip type, 0～14, 4～20mA	

Table 3.7.12 Equipment List (4/7)

No.	Item	Q'ty	Material	Specification	Remark
1 5	Effuse Tank	1	RC	Capacity 10 m³	
				Shape : 3.7mW×1.6mL×2.5mD	
	Pump	2	FC	80φ ×420ℓ/min×12m×2.2kw	
				Submersion type	
	Flow Meter	1	CS	Area type	
	Level Switch	1	PVC	Float type	
1 6	Sludge Storage Tank	1	RC	Capacity : 15 m³	
				Shape : 3.7mW×2.6mL×2.5mD	
				with air diffuser	
	Pump	1	FC	50φ ×50ℓ/min×12m×0.75kw	
				Submersion type	
	Flow Meter	1	PVC	Box type	
	Level Switch	1	SUS	Electrode type	
1 7	Sludge Coagulation Tank	2	CS	Capacity : 200	
				Shape : 0.6mφ ×0.9mH	
	Agitator	2	SUS	Portable type 0.1 kw	
1 8	Dehydrator	1		Belt press type	
				Filter wide 500 m/m	
				Sludge box 1 m³	
1 9	PAC Tank	1	FRP	Capacity : 3 m³	
				Shape : 1.6mφ ×2.0mH	

Table 3.7.12 Equipment List (5/7)

No.	Item	Q'ty	Material	Specification	Remark
	Pump	1	PVC	20 φ × 0.2 ℓ /min × 10kg/cm^2 × 0.2kw	
				Diaphram type	
	Level Switch	1	PVC	Float type	
2 0	NaOH Tank	1	FRP	Capacity : 3 m^3	
				Shape : 1.6m φ × 2.0mH	
	Agitator	1	SUS	Vertical type 0.75 kw	
	Pump	1	PVC	25 φ × 3 ℓ /min × 5kg/cm^2 × 0.2kw	
				Diaphram type	
	Pump	1	PVC	20 φ × 0.5 ℓ /min × 10kg/cm^2 × 0.2kw	
				Diaphram type	
	Level Switch	1	SUS	Electrode type	
2 1	Polymer(A) Tank	1	FRP	Capacity : 2 m^3	
				Shape : 1.5m φ × 1.6mH	
	Agitator	1	SUS	Vertical type 0.75 kw	
	Pump	1	PVC	20 φ × 2 ℓ /min × 8kg/cm^2 × 0.2kw	
				Diaphram type	
	Pump	1	PVC	25 φ × 7 ℓ /min × 3kg/cm^2 × 0.2kw	
				Diaphram type	
	Level Switch	1	SUS	Electrode type	
2 2	Polymer(K) Tank	1	FRP	Capacity : 1 m^3	
				Shape : 1.2m φ × 1.3mH	
	Agitator	1	SUS	Vertical type 0.4 kw	

Table 3.7.12 Equipment List (6/7)

No.	Item	Q'ty	Material	Specification	Remark
	Pump	1	PVC	25φ × 7 ℓ/min × 3kg/cm² × 0.2kw	
				Diaphram type	
	Level Switch	1	SUS	Electrode type	
2 3	NaOCl Tank	1	FRP	Capacity : 500	
				Shape : 1.0mφ × 0.8mH	
	Pump	1	PVC	20φ × 0.2 ℓ/min × 10kg/cm² × 0.2kw	
				Diaphram type	
	Level Switch	1	SUS	Electrode type	
2 4	Blower				
	for Aeration	2	FC	150φ × 17m³/min × 0.45kg/cm² × 30kw	
	Flow Meter	1	CS	Area type	
	for Agitation	1	FC	125φ × 12m³/min × 0.45kg/cm² × 15kw	
2 5	Control Panel	1		Indoor self-standing enclosed type	
				2.4m × 0.6m × 2mH	
				Push button switch	
				Alarm lamp	
				pH indicator	
				Do indicator	
2 6	Pipe				
	Raw waste water line		VP		
	Treated water line		VP		
	Chemical dosing line		VP		

Table 3.7.12 Equipment List (7/7)

No.	Item	Q'ty	Material	Specification	Remark
	Air line		SGP		
2 7	Bilding		steel frame &	588 m^2 X 7H	
			slate roof		

e. Design calculations sheet

- Manufacturing process waste water screens

One rough screen and one fine screen each shall be put in place.

Finally decided value : One 20 mm bar screen, One 1.5 mm automatic screen

- Manufacturing process waste water storage tank

With respect to the maximum hourly inflow, a retention time of 10 minutes shall be set.

$25\ m^3/h \times 2.5 \times 10\ min./60\ min. = 10.4\ m^3$

Finally decided value : $12\ m^3$

- Regenerated waste water receiving tank

The tank shall be large enough to hold one batch of regenerated waste water.

$32\ m^3/time \times 1\ time = 32\ m^3$

Finally decided value : $35\ m^3$

- Neutralization tank

With respect to the maximum hourly inflow, a retention time of five minutes shall be set.

$28.5\ m^3/hour \times 2.5 \times 5\ min./60\ min. = 5.9\ m^3$

Finally decided value : $6\ m^3$

- Domestic waste water screens

One rough screen and one fine screen each shall be put in place.

Finally decided value : One 20 mm bar screen, One 1.5 mm automatic screen

- Domestic waste water storage tank

With respect to the maximum hourly inflow, a retention time of 10 minutes shall be set.

$33\ m^3/h \times 2.5 \times 10\ min./60\ min. = 13.75\ m^3$

Finally decided value : $15\ m^3$

- Stabilization tank

The tank shall be able to hold the difference between the waste water inflow time and the treatment time.

(175 m³/day + 32 m³/time/2.5 days + 231 m³/day + 35 m³/day) + 24 hours/day x (24 hours - 7 hours) = 321.6 m³

Finally decided value : 330 m³

• Anaerobic tank and aerobic tank

With respect to the incoming BOD volume, a treatment BOD capacity load of 0.8 kg-BOD/m³/day shall be assumed, and the capacity ratio between the anaerobic tank and aerobic tank shall be 1/3 to 2/3.

412 kg-BOD/day + 0.8 kg-BOD/m³/day = 512 m³

512 m³ x 1/3 = 171.6 m³

512 x 2/3 = 343.3 m³

Finally decided value : Anaerobic tank 200 m³, Aerobic tank 400 m³

(BOD capacity load : 0.687 kg-BOD/m³/day)

• No. 1 sedimentation tank

A surface area load of 12 m³/m2/day shall be assumed.

Surface area : 454 m³/day + 12 m³/m²/day = 37.8 m²

Finally decided value : 6.5 m x 6.5 m (42.2 m²)

• Reaction tank

With respect to the hourly average treatment volume, a retention time of 10 minutes shall be set.

18.9 m³/hour x 10 min./60 min. = 3.2 m³

Finally decided value : 3.5 m³

• Coagulation tank

With respect to the hourly average treatment volume, a retention time of five minutes shall be set.

18.9 m³/hour x 5 min./60 min. = 1.6 m³

Finally decided value : 2.5 m³

• No. 2 sedimentation tank

A surface area load of 24 m³/m²/day shall be assumed.

Surface area : 454 m³/day + 24 m³/m²/day = 18.9 m²

Finally decided value : 4.5 m x 4.5 m (20.2 m²)

• Monitoring tank

With respect to the hourly average treatment volume, a retention time of two minutes shall be set.

21.8 m^3/hour x 2 min./60 min. = 0.73 m^3

Finally decided value : 1 m^3

• Discharge tank

With respect to the hourly average treatment volume, a retention time of 20 minutes shall be set.

21.8 m^3/hour x 20 min./60 min. = 7.3 m^3

Finally decided value : 10 m^3

• Sludge tank

Daily sludge volume :
412 kg/day x 0.3 = 123.6 kg/day
Sludge sediment (PAC added 137 kg/day, P = 6.5 kg/day)
137 kg/day x 0.153 = 21.0 kg/day (when all PAC becomes $Al(OH)_3$)
6.5 kg/day x 122/31 = 25.6 kg/day (when all P becomes $AlPO_4$)
21.0 kg/day x 27/78 = 25.6 kg/day x 27/22
= 1.6 kg/day (excess amount of Al)
1.6 kg/day x 78/27 = 46 kg/day (SS generated as $Al(OH)_3$)
Total : 123.6 kg/day + 25.6 kg/day + 4.6 kg/day
= 153.8 kg/day (as dry solid)
Assuming a retention period of one day :
Excess sludge volume : 12.4 m^3/day
Sludge floc volume : 3 m^3/day
Sludge concentration : 1%
(12.4 m^3/day + 3 m^3/day) x 1 day = 15.4 m^3

Finally decided value : 15 m^3

• Dehydration equipment

Sludge coagulation tank
With respect to the treatment volume, a retention time of five minutes shall be set.
15.4 m^3/day ÷ 8 hours/day x 5 min./60 min. = 0.16 m^3

Finally decided value : 0.2 m^3

• Dehydrator

Sludge treatment volume : 153.8 kg/day as dry solid
Dehydrated sludge : 85% (water content)
Treatment capacity : 150.2 kg/day ÷ 8 hours/day = 19.2 kg/hour as dry solid

Finally decided value : Belt press type, 20 kg/-dry/hour/day

Dehydrated sludge volume : 153.8 kg/day ÷ 0.15 = 1,025 kg/day

• PAC tank

With respect to the amount used per day, a retention period of seven days shall be set.
Volume used : 137 kg/day (300 mg/l added)
Capacity : 137 kg/day + 1.2 kg/l x 7 days = 800

Finally decided value : 3 m^3

• NaOH tank (10% concentration)

With respect to the amount used per day, a retention period of seven days shall be set.

Volume used:	Amount equivalent to PAC	18.9 kg/day as dry solid
	For neutralization	28 kg/day as dry solid
	(Total)	46.9 kg/day as dry solid

46.9 kg/day + 10% = 469 l/day
Capacity : 469 l/day x 7 days = 3,283 l

Finally decided value : 3 m^3

• Polymer (A) tank (0.1% concentration)

With respect to the amount used per day, a retention period of one day shall be set.
Volume used :

For waste water	0.91 kg/day as dry solid (2 mg/l added)
For dehydration	0.77 kg/day as dry solid (0.5% of SS volume added)
(Total)	1.68 kg/day as dry solid

1.68 kg/day + 0.1% = 1,680 l
Capacity : 1,680 l/day x 1 day = 1,680 l

Finally decided value : 2 m^3

• Polymer tank (K) (0.1% concentration)

With respect to the amount used per day, a retention period of one day shall be set.

Volume used : 0.77 kg/day as dry solid (0.5% of SS volume added)

0.77 kg/day ÷ 0.1% = 770 l

Capacity : 770 l/day x 1 day = 770 l

| Finally decided value : 1 m^3 |

• NaClO tank

With respect to the amount used per day, a retention period of seven days shall be set.

Volume used : 48 kg/day (100 mg/l added)

Capacity : 48 kg/day x 7 days = 336 l

| Finally decided value : 500 l |

• Aeration blower

Oxygen for BOD degrading : 484 kg/day x 1 kg - O_2/kg = 484 kg - O_2/day

Oxygen for MLSS degrading : 600 m^3 x 5.38 kg/m^3 x 0.12 kg - O_2/kg/day = 387.4 kg - O_2/day

Oxygen for N oxidation : 42 kg/day x 64/14 x 5 x 10 x 22.4 ÷ 32 = 6,720 m^3/day

For air lift : 465 m^3/day x 2 x 3 = 2,790 m^3/day

(484 kg/day + 387.4 kg/day) ÷ 32 x 22.4 ÷ 0.21 ÷ 0.1 = 13,397 m^3/day

(13,397 m^3/day + 6,720 m^3/day + 2,790 m^3/day) ÷ 24 hours/day ÷ 60 min./hour = 15.9 m^3/min.

| Finally decided value : 17 m^3/min. x 0.45 kg/cm2 x 30 kW |

• Agitation blower

The total tank capacity required for agitation shall be set at a minimum of 20 l/m^3/min.

373 m^3 x 20 l/min. = 7,460 l/min. = 7.4 m^3/min.

| Finally decided value : 8 m^3/min. x 0.45 kg/cm^2 x 15 kW |

(4) Equipment cost

The equipment cost is 148,120,000 SIT.

The equipment cost is indicated in Table 3.7.13.

(5) Operating cost

The operating cost is 20,719,000 SIT/year.
The operating cost is shown in Table 3.7.14.

Table 3.7.13 Equipment Cost

Item	Contents	Cost (SIT)
Equipment		
Pumps, blowers, agitators, decelerator, dehydrator		26,808,000
Instrumentation		4,050,000
Others (tanks)		29,275,000
Subtotal		(60,133,000)
Site works		
Equipment installation and piping		19,749,000
Electrical work		11,550,000
Painting work		125,000
Civil engineering work		29,375,000
Building work		18,750,000
Site supervision		1,350,000
Trial operation		2,475,000
Subtotal		(83,374,000)
Design cost		4,613,000
	Total	148,120,000

Table 3.7.14 Operating Cost

Item	Contents	Cost (SIT/y)
Chemical costs		
PAC (11%)	91 kg/day x 74.7 SIT/kg x 365 d/y	= 2,481,161
NaOH	41.4 kg/day x 83.2 SIT/kg x 365 d/y	= 1,257,235
Polymer A (powder)	1,681 kg/day x 990 SIT/kg x 365 d/y	= 654,044
Polymer K (powder)	0.77 kg/day x 2,000 SIT/kg x 365 d/y	= 562,100
Subtotal		(5,900,620)
Electricity charge	998 kwh/day x 15 SIT/kwh x 365 days	= 5,464,050
Sludge disposal	1,025 m^3/day x 1,423 SIT/m^3 x 365 days	= 532,380
Kerosene charge	180 l/day x 60 SIT/l x 90 days	= 972,000
Maintenance cost	99,995,000 SIT x 0.05	= 4,999,750
Personnel expenses	1,425,000 SIT/y person x 2 person/y	= 2,850,000
	Total	20,718,800

(6) Economic comment

a. Conditions

(a) Depreciation period	:	Equipment	15 years
		Building, Civil	40 years
(b) Rate of interest	:	10% per annum	
(c) Depreciation method	:	Equal depreciation	
(d) WWTP discharge charge	:	176.56 SIT/m³	
(e) River discharge	:	0 SIT/m³	

(f) Annual waste water treatment volume:

$454\ m^3/day \times 365\ days/year = 165,710\ m^3/year$

b. Treatment cost per 1 m^3 of waste water

The treatment cost per 1 m^3 of waste water is 217 SIT/m^3.
The breakdown of this unit treatment cost is shown in Table 3.7.15.
Therefore, the cost of treating one cubic meter of all of the waste water is as follows.
(①+②+③+④) ÷ (474 m^3/day x 365 days/year) = 208 SIT/m^3

Table 3.7.15 Breakdown of Treatment Cost per 1 m^3 of Waste Water

Items		Contents		Cost	
Depreciation period	Equipment	9,995,000 SIT÷15 years	①	6,666,333	SIT/year
	Buildings, Civil works	48,125,000 SIT÷40years	②	1,203,125	SIT/year
Rate of interest	148,120,000 x 0.05		③	7,406,000	SIT/year
Running cost			④	20,718,800	SIT/year
(①+②+③+④) ÷ 165,710				271	SIT/m^3

3.7.4 Pretreatment for Reduction of the Pollution Load

Here, a pretreatment system for reducing the pollution load for the case of WWTP discharge is introduced.

1) Selection of pretreatment system

Waste water from milk and cheese manufacturing processes can broadly be divided into equipment washing waste water and floor washing waste water. In both cases, because the waste water contains raw milk, cheese fragments and whey, etc., it is characterized as being highly organic and possessing relatively high concentrations of COD and BOD. Furthermore, regarding the washing of CPI manufacturing equipment, because acid, alkali and surface active agent are used for this, the resulting waste water contains varying levels of pH when it comes to be discharged. However, except for this pH, the waste water does not contain any substances that may hinder WWTP treatment. Consequently, the treatment system that utilizes the neutralization pretreatment described in 3.7.3 shall be assumed as Case 1 here.

Next, for the manufacturing process waste water, a pretreatment system that reduces the pollutant load caused by organic substances shall be examined.
It is expected that a biological treatment method would be adopted in the WWTP treatment, however, the operation of such a treatment process could be obstructed by the high oil and fat content of the waste water. It is, therefore, necessary to install a pretreatment system for removing this oil and fat content, and it is most common to adopt the pressurized-air flotation method for this purpose. This pressurized-air flotation shall be adopted as Case 2 and shall comprise the following method of pretreatment for the biological treatment process as described below.

Anaerobic biological treatment is often adopted for the pretreatment of waste water containing high organic concentrations. The reasons for this are listed as follows:

① Anaerobic bacteria are suited to the treatment of highly organic waste water,
② Equipment and running costs both increase if highly organic waste water is treated by the aerobic process alone,
③ Anaerobic biological treatment involves a compact system that makes it easy to retrieve energy,
④ It is impossible to achieve a water quality that satisfies river discharge standards by performing anaerobic biological treatment alone, so it is necessary to use it as a pretreatment method for aerobic biological treatment.

Consequently, a pretreatment system consisting of the UASB method of anaerobic biological treatment shall be adopted as Case 3.

Furthermore, regarding bio-film filtration for aerobic biological treatment, various bulking agents that do not cause blocking are being developed. Using this method as the pretreatment process would prove advantageous in terms of the following two points: ① bulking would not occur in the later stage activated sludge treatment and, ② pretreatment could easily be performed without hindering operation if the appropriate media were selected. Therefore, a pretreatment system consisting of bio-film filtration shall be adopted as Case 4.

Incidentally, in consideration of the load on the WWTP, it is desirable not to use a surface active agent that contains phosphorous. Thus, the removal of P shall not be considered in examination of the pretreatment system here.

2) Outline of the pretreatment system

a. Case 1

The Case 1 pretreatment system is indicated in 3.7.3.

b. Case 2

The flow sheet of the Case 2 pretreatment system is illustrated in Fig. 3.7.11. In this system, the proteins, oil and fat content and SS formed by these substances are removed from the waste water and the pH is neutralized.

After adjusting the waste water pH and performing coagulation treatment, the formed sludge is separated by flotation in the subsequent pressurized-air flotation tank. SS and Part of the soluble pollutants are removed as a result of this treatment, and the treated water is then fed into the water quality monitoring tank and discharged into the WWTP. An alarm is raised if abnormal levels of pH are measured in the monitoring tank. The sludge obtained by flotation separation is passed through the sludge storage tank into the dewaterer for dewatering, and the resulting sludge cake is then carried out to the landfill for final disposal.

c. Case 3

The flow sheet of the Case 3 pretreatment system is illustrated in Fig. 3.7.12. Here, the UASB method of anaerobic biological treatment has been added to the Case 2 system to remove BOD and COD from the treated water. A removal rate of 80% has been assumed.

d. Case 4

The flow sheet of the Case 4 pretreatment system is illustrated in Fig. 3.7.13. Here the bio-film filtration method of aerobic biological treatment has been added to the Case 2 system to remove BOD and COD from the treated water. A removal rate of 67% has been assumed.

Fig. 3.7.11 Flow Sheet of the Case 2 Pretreatment System

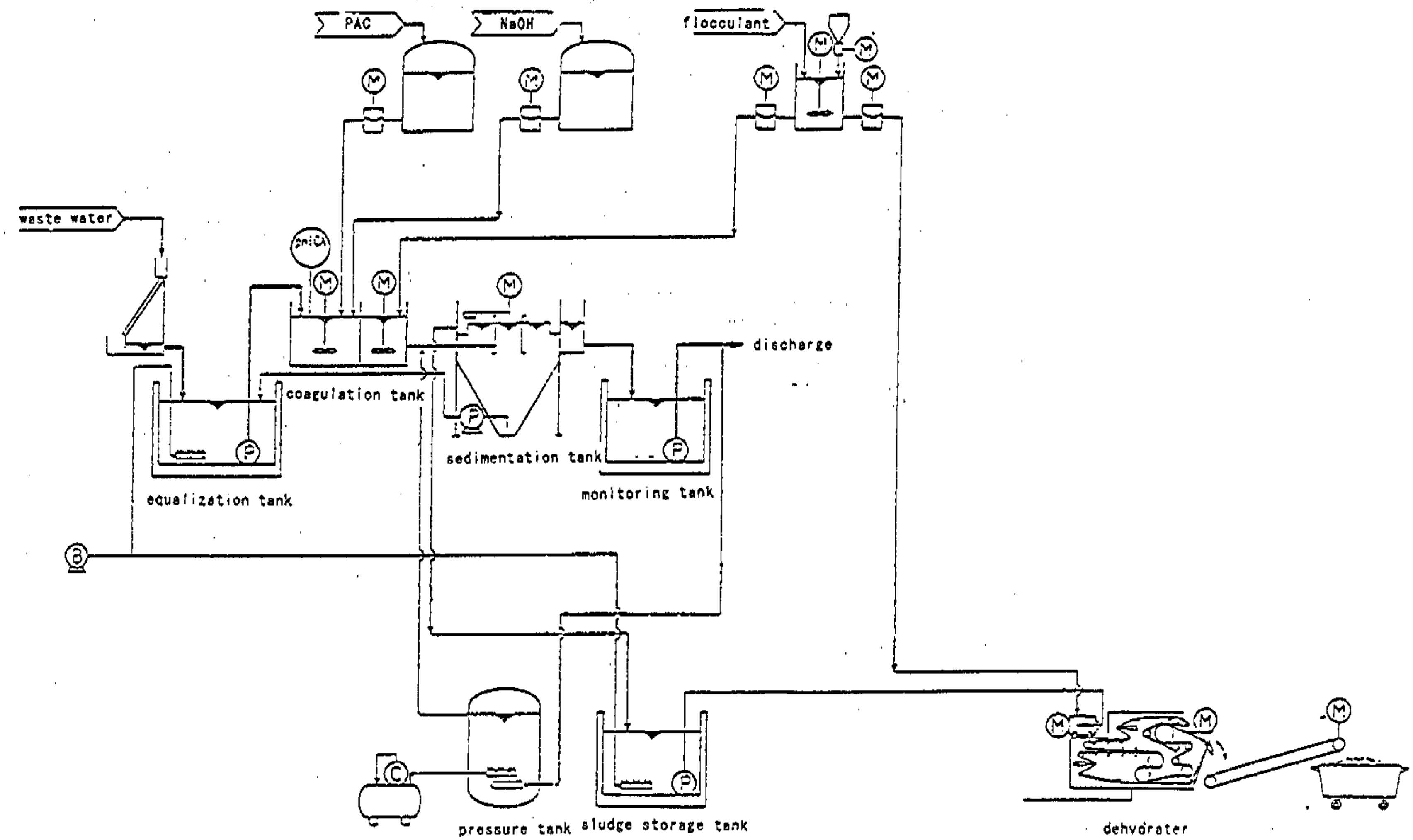


Fig. 3.7.12 Flow Sheet of the Case 3 Pretreatment System

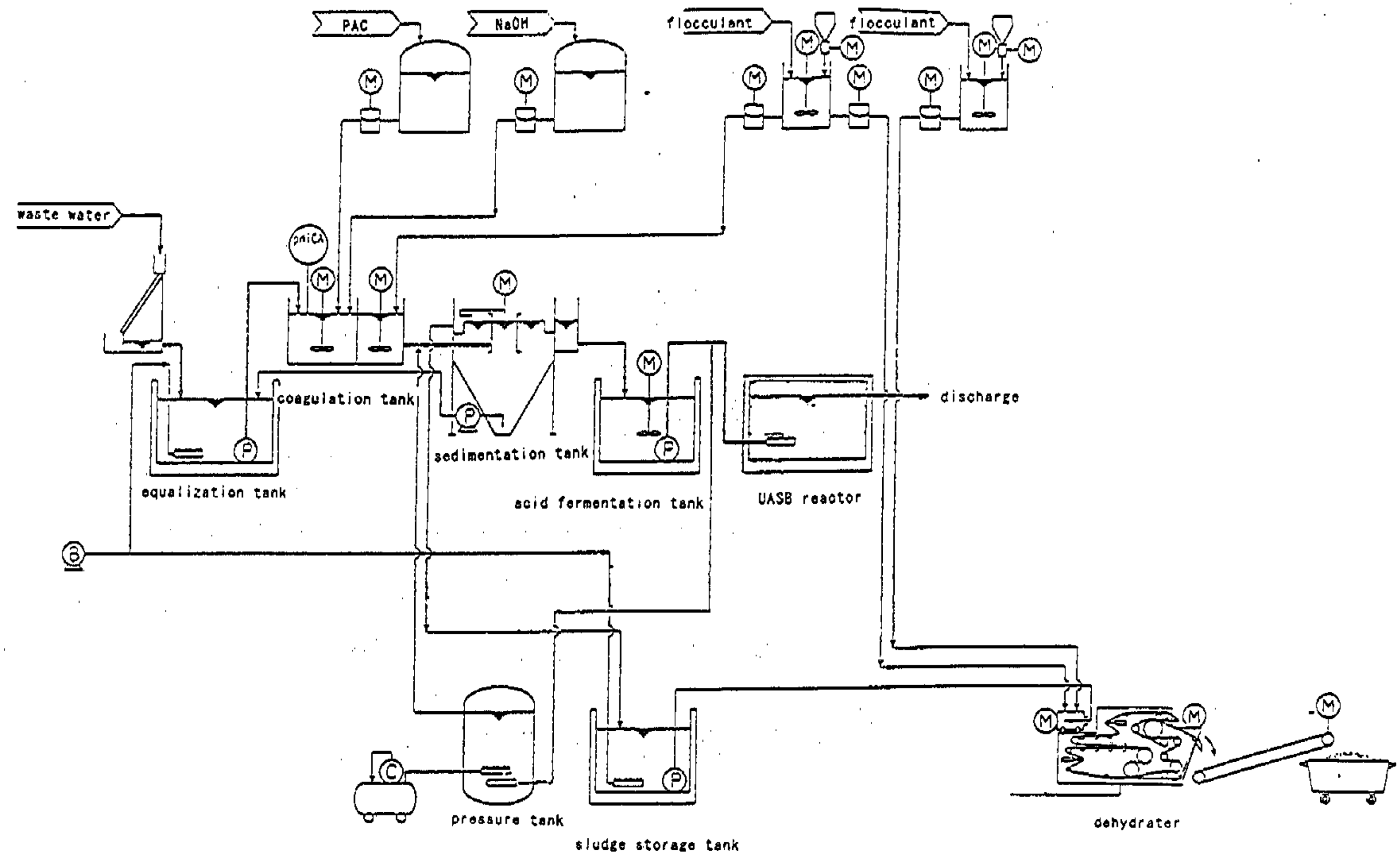
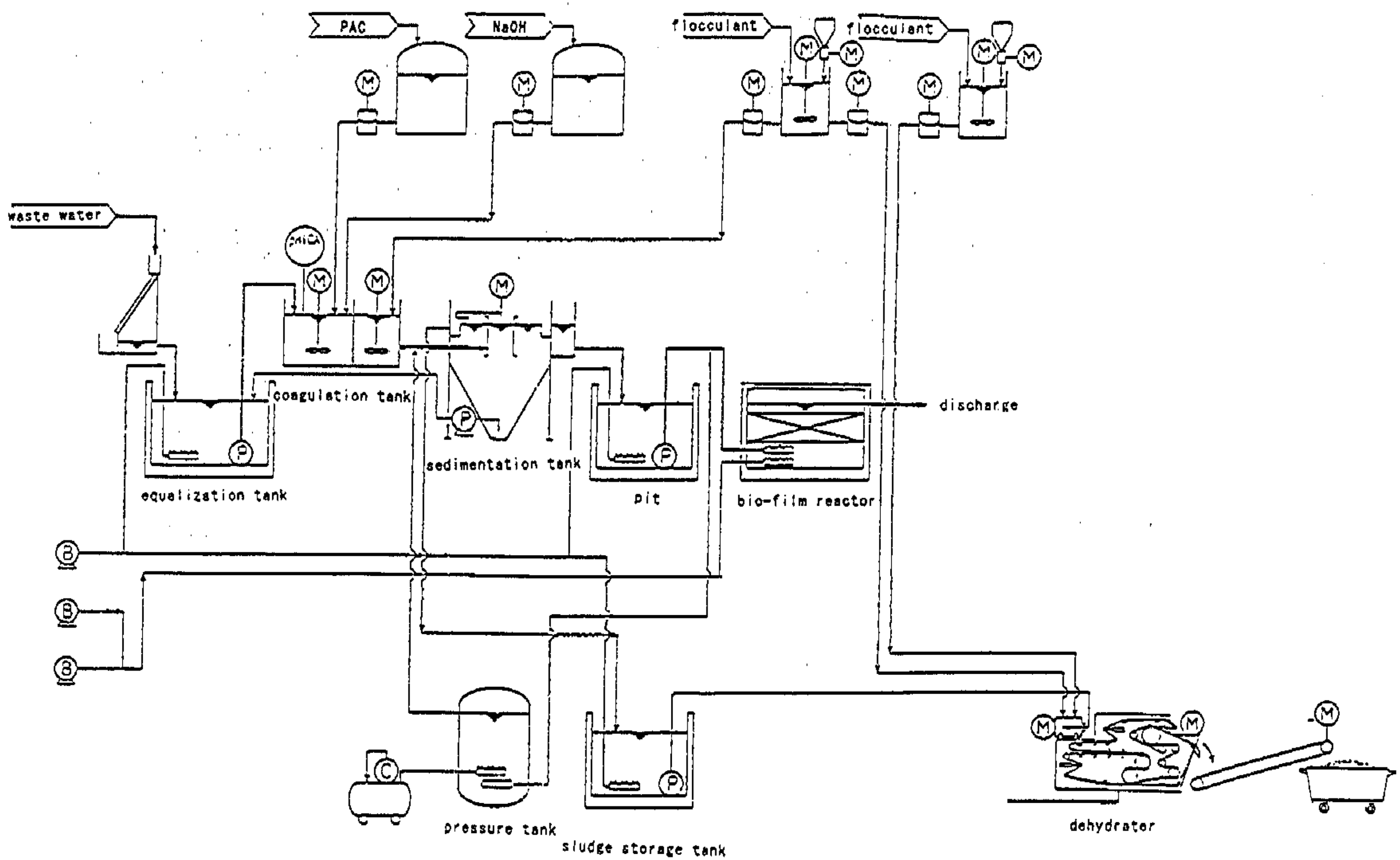


Fig. 3.7.13 Flow Sheet of the Case 4 Pretreatment System



3) Results of examination

(1) Technical comment

The quality, volumes and pollution loads of the waste water and treated water are shown in Table 3.7.16.

Table 3.7.16 Volumes, Quality and Pollution Loads of Waste Water and Treated Water

Kind of Waste Water	Case	Quantity m³/d	pH	COD_{cr} mg/ℓ (kg/d)	BOD mg/ℓ (kg/d)	SS mg/ℓ (kg/d)	FAT mg/ℓ (kg/d)	T-P mg/ℓ (kg/d)
Waste water from manufacturing process	Raw Waste Water	175	7	5,700 (998)	2,000 (300)	930 (163)	300 (52.5)	11 (1.9)
	Case-1			5,700 (998)	2,000 (300)	930 (163)	300 (53.5)	11 (1.9)
	Case-2			2,850 (499)	1,000 (175)	30 (5.25)	10 (1.75)	11 (1.93)
	Case-3			570 (100)	100 (17.5)	30 (5.25)	10 (1.75)	10 (1.75)
	Case-4			1,900 (333)	100 (17.5)	30 (5.25)	10 (1.75)	10 (1.75)
Car Washing	Raw Waste Water	35	7	2,100 (73.5)	450 (15.8)	650 (22.8)	500 (17.5)	130 (4.55)
	Case-3			570 (20)	100 (3.50)	30 (1.05)	10 (0.35)	10 (0.35)
	Case-4			1,900 (66.5)	100 (3.50)	30 (1.05)	10 (0.35)	10 (0.35)
Domestic	Raw Waste Water	231	7	400 (92.4)	200 (46.2)	50 (11.6)	— ( )	— ( )
Total Waste Water	Raw Waste Water	476	5	2,443 (1163)	866 (412)	414 (197)	147 (70)	14 (6.45)
	Case-1		7	2,443 (1163)	866 (412)	414 (197)	147 (70)	13 (6.45)
	Case-2		7	1,397 (665)	464 (221)	13 (6.41)	6 (2.96)	10 (4.93)
	Case-3		7	446 (212)	141 (67.1)	38 (17.9)	4.4 (2.1)	4.4 (2.1)
	Case-4		7	1,032 (491)	473 (225)	38 (17.9)	4.4 (2.1)	4.4 (2.1)
	Discharge to River		7	119 (56.8)	25 (11.8)	40 (18.9)	4.4 (2.1)	2.0 (0.95)

As pretreatment methods for dealing with the high organic concentrations of the waste water, the UASB method of anaerobic biological treatment and the bio-film filtration method of aerobic biological treatment have been proposed. The optimum temperature of the waste water in either case is 36-38 C. In the case of aerobic biological treatment, because a blower is used for aeration, lowering of the water temperature is prevented, however, in the case of anaerobic biological treatment, heating becomes necessary when the temperature falls below the optimum level, and this results in higher running costs. In the case of this factory, where the waste water temperature is not so high, it is considered preferable to adopt the bio-film filtration method.

(2) Economic comment

The equipment and running costs of the systems are shown in Table 3.7.17.

Aerobic biological treatment is cheaper than aerobic biological treatment in terms of both equipment cost and running cost. This is because of the higher cost ratio of the heat source needed to heat the waste water in the UASB method of anaerobic biological treatment.

Table 3.7.17 Equipment and Running Costs of Treatment Systems

		Equipment Cost SIT	Depreciation & Interest SIT/m^3 ①	Running Cost SIT/m^3 ②	Total Treatment Cost SIT/m^3 ①+②
Pretreatment	Case-1	13,605,000	8	20	28
	Case-2	19,000,000	34	31	65
	Case-3	40,000,000	50	102	158
	Case-4	36,000,000	47	49	106
Dicharge to Rever (Design Base)		148,120,000	88	120	208

4) Conclusion

If river discharge standards are aimed for, it is necessary to treat the total waste water and install a coagulating sedimentation system for removing the P content. Consequently, the waste water treatment system would be expensive in terms of both equipment and running costs. If WWTP discharge standards are aimed for, because the waste water does not contain harmful substances, it is only necessary to consider a pretreatment system for reducing the pollution load of organic substances.

Depending on movements in WWTP discharge standards, it may be necessary to advance step by step the examination of a coagulation flotation treatment system for removing oil and fat content and biological treatment systems for reducing pollution loads (especially COD). In readiness for such occasions, it is desirable to adopt a biological treatment method in which it is possible to increase the removal rate through simply altering the mode of operation.