3.2 M-2 MARLES HOLDING ,d.d. MARLES POHISTVO, d.o.o.

3.2.1 Factory Outline

1) Outline

Marles Holding Maribor d.o.o. is a group company in the housing sector which carries out all processes from general timber sawing through to veneer manufacture, wooden furniture making and wooden building construction. Within the group, Marles Zaga d.o.o. carries out timber manufacture, Marles Hise d.o.o. is in charge of wooden building construction, Marles Pohistvo d.o.o. manufactures wooden furniture and Marles Storitive provides services to the overall group.

30% of the painted furniture (tables, chairs, shelves, kitchen tops, etc.) produced at Marles Pohistvo d.o.o. is exported to countries such as Austria, and so on.

The factory layout of Marles Holding Maribor d.d. is shown in Fig. 3.2.1.

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

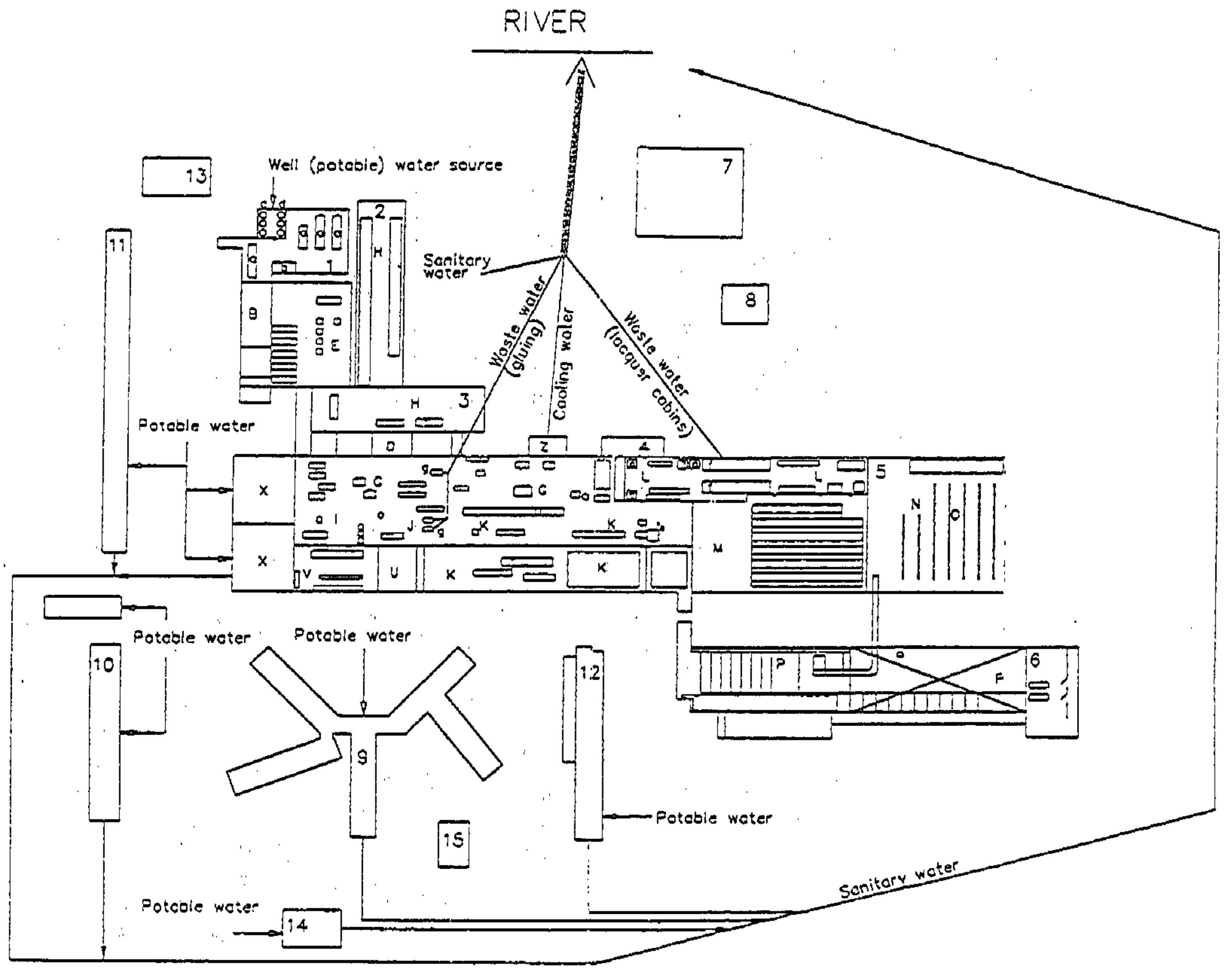
The volume of water usage and waste water by water source and purpose of use is shown in Table 3.2.1.

Table 3.2.1 Volume of Water Usage by Water Source and Purpose of Use

(m^3/day)

Use \ Source	Well Water	City Water	River Water	Sub-Total	Recovered Water	Total
Boiler Feed	181.6			181.6	222.0	403.6
Raw Material						
Washing	1.3			1.3		1.3
Cooling	44.7			44.7		44.7
Air Conditioning						
Miscellaneous	70.1			70.1		70.1
Total	297.7			372	222.0	519.7
				Recovered Water/Total		42.7 %

Fig. 3.2.1 Factory Layout



3) Water supply and waste water discharge flow diagrams

The water balance at the factory is shown in Fig. 3.2.2.

(1) Water supply facilities

(a) Water tower

The factory grounds contain a well of 28 m in depth. Water is pumped by storage pump at a rate of 40 l/sec from the well into the water tower (capacity : 150 m^3), from where it is distributed to the whole factory for use in production, as domestic water and for fire prevention.

(b) Softener

Of the water used in production, boiler water is treated in a softener. NaCl is used in the softening system, which carries out regeneration after approximately every 115 m^3 of well water has been treated.

(2) Manufacturing processes and sources of waste water generation

The major manufacturing processes are shown in Fig. 3.2.3.
Although this factory is a wooden furniture maker, it has divided its manufacturing process into general timber sawing, veneer manufacture and furniture making (see below for an outline) with the aim of becoming a model timber and wooden product maker.

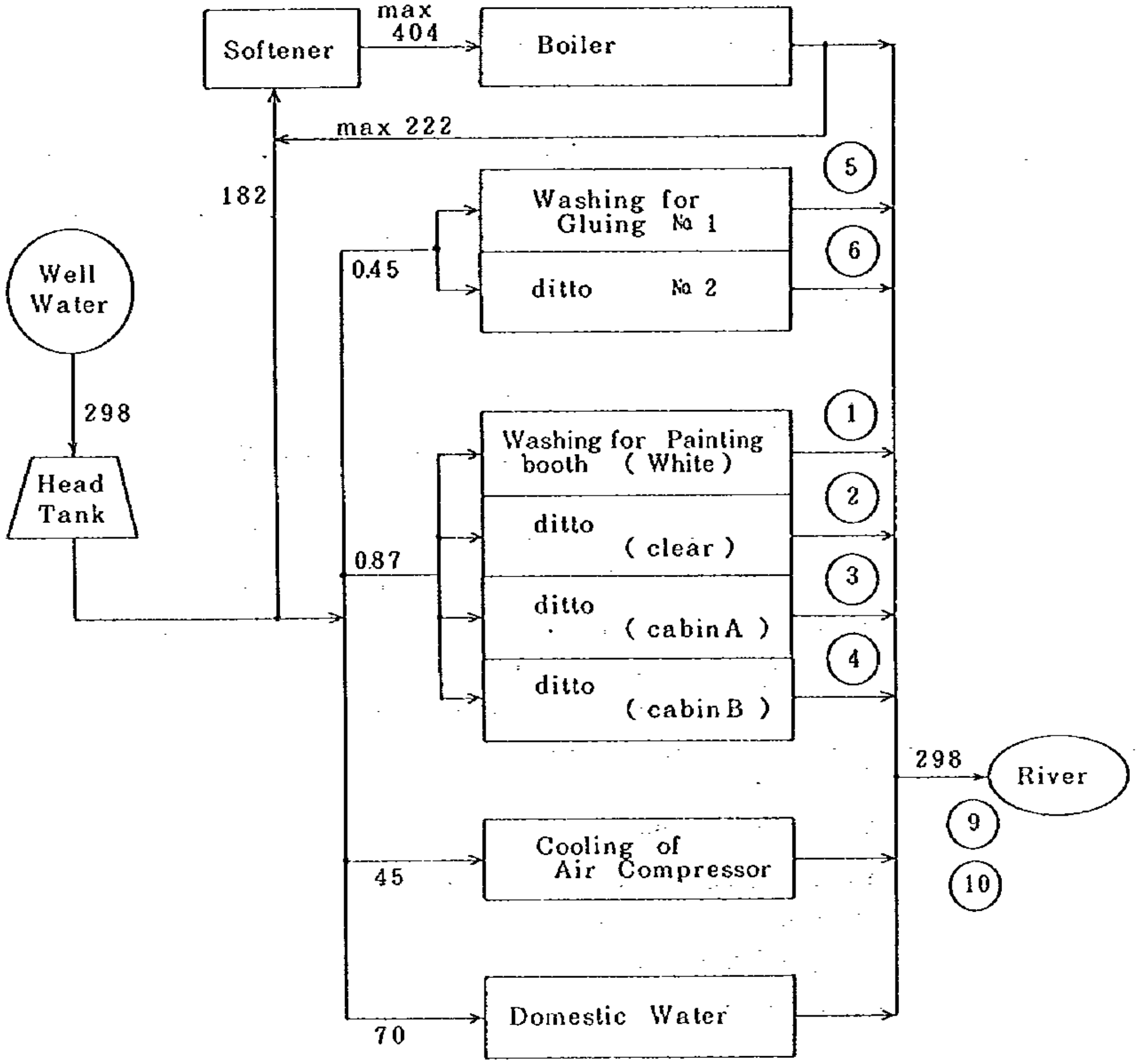
a. General timber sawing process

The general timber sawing process aims to exploit the toughness and stability of timber fiber so as to produce all forms of wooden raw materials for use in industry. The basic process for manufacturing general timber is as shown below.

Log →(Peeling of bark) →(Round cutting)→(Finish) →(Sawing)→(Sorting)→(Marking)→Product

- Log → Outdoors
- (Peeling of bark) → Bark → Outdoors
- (Round cutting) → Sawdust
- (Sawing) → Sawdust
- Product → Collection → Outdoors

Fig. 3.2.2 Water Balance at the Factory



○ : Sampling points of Waste Water

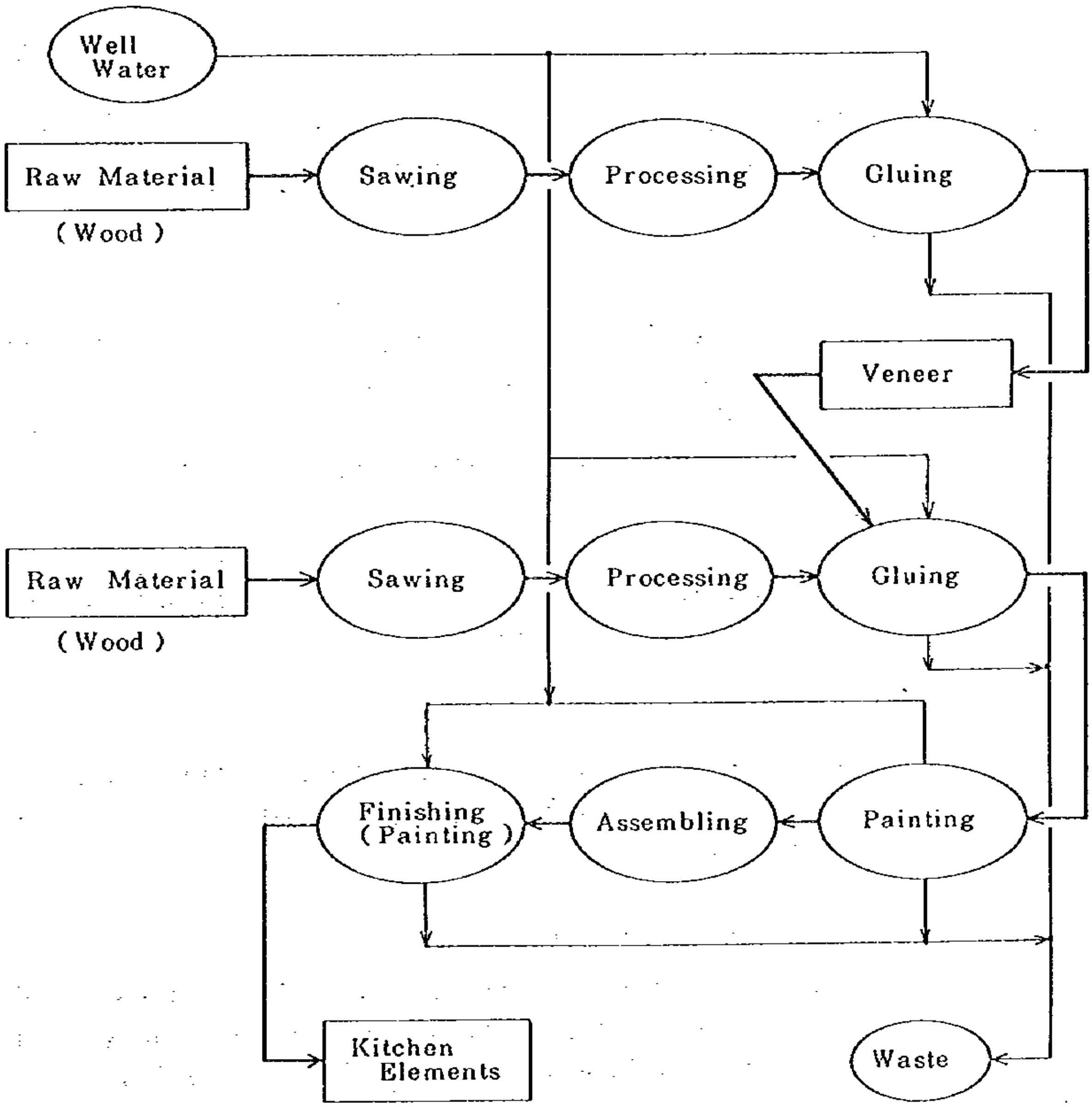
In Table 2.9

(7) Composite Samples of 1 ~ 4

(8) : Treated Samples of 7 with coagulation

Note : a) No flow meter is applied for the well water.

Fig. 3.2.3 Manufacturing Process Diagram



(a) Wood storage

In this process, the raw timber logs are stored in the storage yard. Timber can either be stored on land or on water. In the case of land storage, the raw logs need to be sprayed with water in order to prevent cracking caused by drying. Waste water is generated from this spraying and also when wood is stored on the surface of water. This waste water contains soil, etc. attached to the bark and other pollutants such as soluble materials contained in the wood. The level of such pollution varies according to the amount of time the sprayed water or storing water is retained.

(b) Bark peeling

In this process, the outer surface of the raw wood is peeled off. The peeling can be done either manually or mechanically. In the case of mechanical peeling, hydraulic barkers and ring barkers are used.
If the peeled bark is left to accumulate outdoors, rain will cause the soluble matter in the bark to percolate out and run into stormwater ditches.

(c) Sawing

In this process, the raw wood is sawed into boards. Because water is not used here, no waste water is generated.

(d) Timber collection

In this process, the cut boards are collected together. When the timber is collected outdoors, sawdust that has stuck to forklifts and the timber is washed away into drains by the rain.

b. Veneer manufacturing process

In the veneer manufacturing process, thinly stripped sheets of wood (veneer) are glued together so that the direction of their grains almost totally cross in order to make laminated board. The basic processes involved are as shown below.

(Veneer manufacturing process)

Raw wood→(Flat cutting)→(Peeling)→(Boiling)→(Slicing)→(Drying)→*

(Laminate manufacturing process)

*→(Processing)→(Gluing)→(Cutting)→(Polishing)→Product

(a) Boiling

In this process, after the raw wood has been horizontally cut and peeled of its bark, it is boiled in order to make it more suited to slicing. Here, because lignin and other soluble substances come out of the wood, the generated waste water is brown in color.

(b) Gluing

In this process, depending on the species of timber and quality of the veneer, the veneer boards are divided into face, back and interior veneer, and three or five boards are glued together in a gluing machine to attain the required laminate thickness. Here, waste water is generated from the washing of the gluing machine.
Because the adhesive used needs to be changed depending on the species of timber and requirements concerning strength and resistance to water, etc., the mixer, spreader, roll and connecting pumps and pipes need to be washed every time the adhesive is changed. Normally, the waste water from this washing is emitted with the water used to wash the spreader.

c. Wooden furniture manufacturing process

Wooden furniture is broadly divided into leg items such as tables, chairs and desks, etc.; box items such as shelves and cupboards, etc.; and small items like work tops, and so on, and all such varieties of furniture are manufactured in this factory. The basic process of furniture manufacture is as shown below.

Laminate / Particle board ──┐

Board→(Drying)→(Wood processing)→(Member processing)→(Gluing)→(Painting)
→(Assembly)→(Finish painting)→Product

(a) Board adjusting

In this process, the moisture content of timber with the same thickness as the board is adjusted by carrying out natural drying and artificial drying over long periods of time.

(b) Wood and member processing

In this process, surface material, frames, edges, etc. from the board are sawed to the required dimensions, shaved and sanded.

(c) Gluing of surface veneer

In this process, veneer is glued to the inner wood in such a way so as to show the grain of the wood or give a high class image, and so on. Alternatively, decorative laminated sheet printed with artificial wood grain may be glued to the veneer. Here, as in the veneer gluing process, waste water is generated from the washing of the gluing machine. Also, unlike the mass production of a similar materials, because the raw materials used here vary greatly according to purpose, the adhesive used is often changed.

(d) Gluing for assembly

Unlike in the process of surface veneer gluing, because this process involves the gluing together of members for assembly, there is much partial gluing and various adhesives are used in different areas. Because almost all of the work is done by hand, not much waste water is generated. The waste water that does occur comes from the washing of the gluing machine.

(e) Painting

The painting process consists of the following steps :

Undercoat painting of surface material→Sanding→Polishing→Middle coat →Finish coat

Because the products have curves and complex surfaces, the painting is done by spray gun. This means that a lot of the paint misses the product and is sprayed around the surrounding area, causing the solvent to vaporize and resulting in paint mist and paint film dust. Painting is thus performed in painting booths to avoid this, and the water from the washing of the booths is discharged as waste water.

(3) Waste water treatment plant

The waste water treatment plant consist of a filter. However, this is currently not in use.

(4) Waste water treatment and water usage control setup

The control of water usage and waste water treatment is carried out by one water controller under the guidance of chemical researchers. Also, the collection of materials relating to raw materials and sub-materials is carried out.

4) Quality of make-up water and waste water

(1) Quality of make-up water

The quality of make-up water at the factory is shown in Table 3.2.2.

Table 3.2.2 Quality of Make-up Water

Items \ Name of Sample \ No.	1	2
	Well Water	Outlet of Softener
Temp. (℃)	15	15
pH (−)	7.5	7.5
COD_{cr} (mg/ℓ)	1.5	−
T-Hardness* (°dH)	12.4	0.02
Cℓ (mg/ℓ)	8	−
T-Fe (mg/ℓ)	< 0.05	0

No. 1: Well water used as make-up water
No. 2: Well water used after being treated in the softener

(2) Quality of waste water

a. Characteristics of waste water discharge

① Painting booth washing waste water (0.87 m^3/day)

The painting booths consist of two booths of 2.4 m^3, two booths of 3.7 m^3 and four booths of 3.4 m^3. Of these, white polyurethane lacquer is constantly used in one of the 3.4 m^3 booths (Sample No.3), and transparent polyurethane lacquer is constantly used in one of the 3.7 m^3 booths (Sample No.4). The other booths are used whenever there are orders for painting. At the time of the survey on June 10, 1996, two 2.4 m^3 tanks, Booth A (sample No.5), and Booth B (Sample No.6) were in use.

Waste water is discharged at a rate of approximately two booths per month, however, this is not regular.
The waste water from washing of the booths contains paint that is composed of various high polymer compounds, pigments, surface active agents, solvents and plasticizers, etc. The factory, however, pays the utmost care to these substances, and materials on the following substances were presented to the survey team.

- Lacquers : xylene, cyclohexane, toluene, etc.
- Dye paints : methyl glycol, ethyl glycol, butyl glycol, butyl alcohol, aromatic compound, xylene, toluene, chrome, cobalt, etc.
- Stiffeners : butyl alcohol, methyl ethyl ketone, toluene di-isocianate, etc.
- Solvents : butyl alcohol, xylene, toluene, methyl ethyl ketone, ethyl glycol acetate, etc.

② Gluing machine washing waste water (0.45m^3/day)

There are two gluing machines. They are washed every day after work has finished, and the waste water (Sample No.6 & No.7) is discharged after washing.

③ Domestic waste water (70m^3/day)

There are 482 employees.

④ Boiler blow water (182m^3/day)

This waste water contains hardly any pollution at all.

⑤ Compressor cooling water (45m^3/day)

This waste water contains hardly any pollution at all.

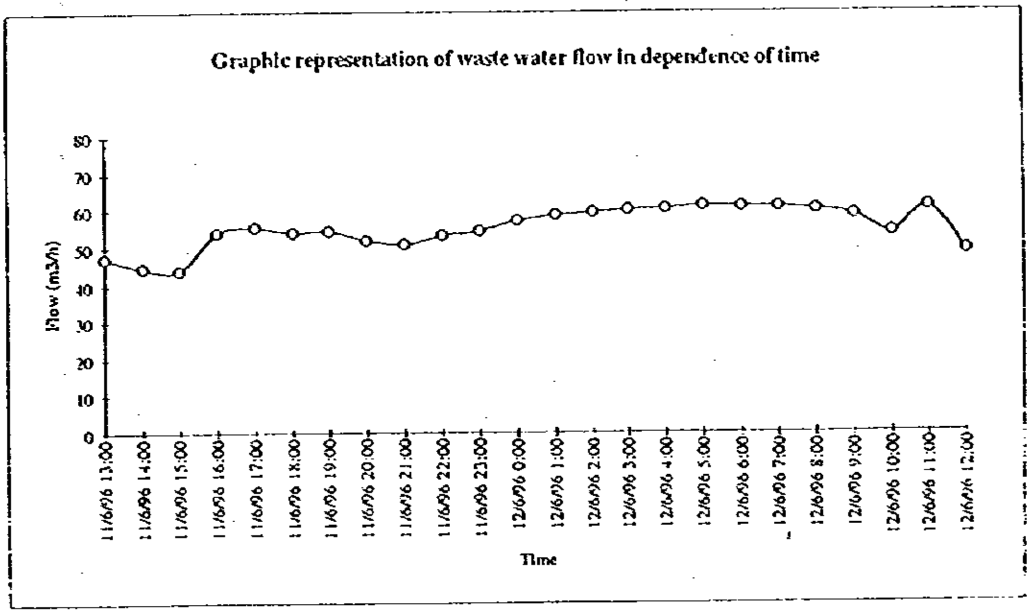
⑥ Other waste water

Waste water is discharged from the timber storage yard and the softener.

b. Volume of waste water discharge overall

The results of measuring the volume of the overall waste water at the time of the sampling are shown in Fig. 3.2.4.

Fig. 3.2.4 Results of Measurement of the Volume of Waste Water Discharge Overall



c. Quality of waste water

The quality of each type of waste water is shown with the quality of waste water overall in Table 3.2.3. The sample No.'s and sampling points are as described below.

(No. 3-6) : Painting booth washing waste water
(No. 7-8) : Gluing machine washing waste water
(No. 9) : Overall waste water during factory operation (composite sample)
(No. 10) : Overall waste water while factory is closed (composite sample)

Table 3.2.3 Quality of Each Type of Waste Water and Waste Water Overall (1/2)

No.	3	4	5	6	7
Items \ Name of Sample	Lacquer line (white)	Lacquer line (clear)	Lacquer Room (Cabine A)	Lacquer Room (Cabine B)	Gluing Machine A
Temp. (℃)	24	25	22	22	—
pH (－)	6.7	6.9	7.5	6.7	7.1
SS (mg/ℓ)	160	700	880	250	27,000
T-N (mg/ℓ)	56	59	55	54	4,000
$N-NH_3$ (mg/ℓ)	0.18	0.25	0.4	4.7	17
N-Kjeldahl (mg/ℓ)	22	34	22	24	4,000
$N-NO_2$ (mg/ℓ)	<0.1	<0.1	<0.1	<0.1	<0.1
$N-NO_3$ (mg/ℓ)	34	25	33	30	7
T-P (mg/ℓ)	1.2	2.2	1.7	1.7	6.1
COD_{cr} (mg/ℓ)	4,000	7,000	11,500	10,000	19,500
BOD (mg/ℓ)	<5	600	610	630	<5
T-fat (mg/ℓ)	8	19	17	48	<5
$CHCℓ_3$* (mg/ℓ)	<0.01	<0.01	<0.01	<0.01	<0.01
$CH_2Cℓ_2$* (mg/ℓ)	<0.01	<0.01	<0.01	<0.01	<0.01
$CCℓ_4$* (mg/ℓ)	<0.01	<0.01	<0.01	<0.01	<0.01
$Cℓ_2CHCHCℓ_2$* (mg/ℓ)	<0.01	<0.01	<0.01	<0.01	<0.01
$Cℓ_2CHCH_2Cℓ$* (mg/ℓ)	<0.01	<0.01	<0.01	<0.01	<0.01
$CH_3CCℓ_3$* (mg/ℓ)	<0.01	<0.01	<0.01	<0.01	<0.01
C_6H_6 (mg/ℓ)	<0.05	<0.05	<0.05	<0.05	<0.05
C_7H_8 (mg/ℓ)	7.1	0.3	0.3	0.06	<0.05
$C_6H_4(CH_3)_2$ (mg/ℓ)	19	3.0	3.2	0.47	<0.05
Anionic surfactants (mg/ℓ)	<0.05	3.2	8.4	6.2	0.6

(Note) * : Expression as Cℓ

Table 3.2.3 Quality of Each Type of Waste Water and Waste Water Overall (2/2)

No.	8	9	10
Items / Name of Sample	Gluing Machine B	Effluent working time	Effluent out of working
Temp. (℃)	—	16	17
pH (−)	7.4	7.1	6.9
SS (mg/ℓ)	1,500	35	30
T-N (mg/ℓ)	76	18.5	19.1
$N\text{-}NH_3$ (mg/ℓ)	0.11	0.72	1.0
N-Kjeldahl (mg/ℓ)	13	16	17
$N\text{-}NO_2$ (mg/ℓ)	<0.1	0.1	0.1
$N\text{-}NO_3$ (mg/ℓ)	63	2.4	2.0
T-P (mg/ℓ)	3.3	8.5	2.1
COD_{cr} (mg/ℓ)	11,000	20	27
BOD (mg/ℓ)	100	<5	<5
T-fat (mg/ℓ)	130	<5	<5
$CHCl_3$* (mg/ℓ)	<0.01	<0.01	<0.01
CH_2Cl_2* (mg/ℓ)	<0.01	<0.01	<0.01
CCl_4* (mg/ℓ)	<0.01	<0.01	<0.01
$Cl_2CHCHCl_2$* (mg/ℓ)	<0.01	<0.01	<0.01
Cl_2CHCH_2Cl* (mg/ℓ)	<0.01	<0.01	<0.01
CH_3CCl_3* (mg/ℓ)	<0.01	<0.01	<0.01
C_6H_6 (mg/ℓ)	<0.05	<0.05	<0.01
C_7H_8 (mg/ℓ)	<0.05	<0.05	<0.01
$C_6H_4(CH_3)_2$ (mg/ℓ)	<0.05	<0.05	<0.01
Anionic surfactants (mg/ℓ)	2.7	<0.05	<0.01

(Note) * : Expression as Cℓ

(3) Coagulation treatment test of painting booth waste water in the painting process

a. Purpose of test

Waste water from the painting booths is small in volume and accounts for a minute share of the overall waste water. However, because it is highly polluted and contains organic solvents, it needs to be treated for river water quality preservation reasons. Coagulation floatation is commonly adopted as the pre-treatment method for painting booth waste water. Thus, a coagulation treatment test was carried out on the painting booth waste water with the aim of confirming the effectiveness of such treatment.

b. Test method

Waste water from booths No. 3-6 was mixed with overall waste water in its actual ratio to make the test sample. $Al_2(SO_4)_3$ was added to the sample waste water as the inorganic coagulant to coagulate and then pH valve was adjusted by dosing alkaline. The resulting supernatant was taken as the treated water sample and its quality was measured to assess the effectiveness of the treatment.

c. Test results

① Quality of target waste water

The quality of the waste water mix prepared as the test sample is shown in Table 3.2.4.

② Amount of $Al_2(SO_4)_3$ added

150 mg/l of inorganic coagulant was added. (as Al)

③ Quality of treated water

The quality of the treated water is shown in Table 3.2.5.

④ Toxicity test (Sp)

The toxicity level of the waste water sample was 2, and that of the treated water was below 2.

⑤ Biodegradation characteristics test (DOC)

The results for the waste water sample are shown in Fig. 3.2.5, and the results for the treated water are shown in Fig. 3.2.6.

d. Comment on results

① The SS value of the treated water was high. Thus, it is thought that the SS value of the supernatant can be reduced to zero by continuing to investigate the optimum volume of coagulation assistant that should be added. When the optimum amount is achieved, it is forecast that the quality of the treated water will display low COD and other values.

② The COD level of the coagulation treated water decreased, resulting in a higher BOD/COD ratio. This shows that biodegradability can be obtained from carrying out the coagulation process.

③ The coagulation treatment was recognized to remove organic solvent. However, a small amount did remain at the end.

e. Conclusion

By performing coagulation treatment on waste water from the painting booths, it is possible to achieve treated water quality that allows biological treatment to be performed.

Table 3.2.4 Quality of Sample Waste Water

Items \ Name of Sample \ No.	11
	Lacquer Waste Water
Setable Solids (mg/ℓ)	0.5
As (mg/ℓ)	<0.05
Cu (mg/ℓ)	<0.05
Zn (mg/ℓ)	<0.05
Co (mg/ℓ)	0.61
T-Cr (mg/ℓ)	0.11
Fe (mg/ℓ)	27
Hg (mg/ℓ)	0.005
TOC (mg/ℓ)	2,600
C_6H_6 (mg/ℓ)	0.57

Table 3.2.5 Quality of Treated Water

Items \ Name of Sample \ No.	12
	Treated Waste Water
pH (−)	7.8
SS (mg/ℓ)	220
T-N (mg/ℓ)	61
$N-NH_3$ (mg/ℓ)	3.6
N-Kjeldahl (mg/ℓ)	32
$N-NO_2$ (mg/ℓ)	<0.1
$N-NO_3$ (mg/ℓ)	29
T-P	1.8
COD_{Cr} (mg/ℓ)	5,300
BOD (mg/ℓ)	650
T-fat (mg/ℓ)	9
$CHC\ell_3$* (mg/ℓ)	<0.01
$CH_2C\ell_2$* (mg/ℓ)	<0.01
$CC\ell_4$* (mg/ℓ)	<0.01
$C\ell_2CHCHC\ell_2$* (mg/ℓ)	<0.01
$C\ell_2CHCH_2C\ell$* (mg/ℓ)	<0.01
$CH_3CC\ell_3$* (mg/ℓ)	<0.01
C_6H_6 (mg/ℓ)	<0.05
C_7H_8 (mg/ℓ)	0.4
$C_6H_4(CH_3)_2$ (mg/ℓ)	1.2
Anionic surfactants (mg/ℓ)	1.4
Zn (mg/ℓ)	0.71

(Note) * : Expression as Cℓ

Fig. 3.2.5 Biodegradation of Painting Booth Waste Water

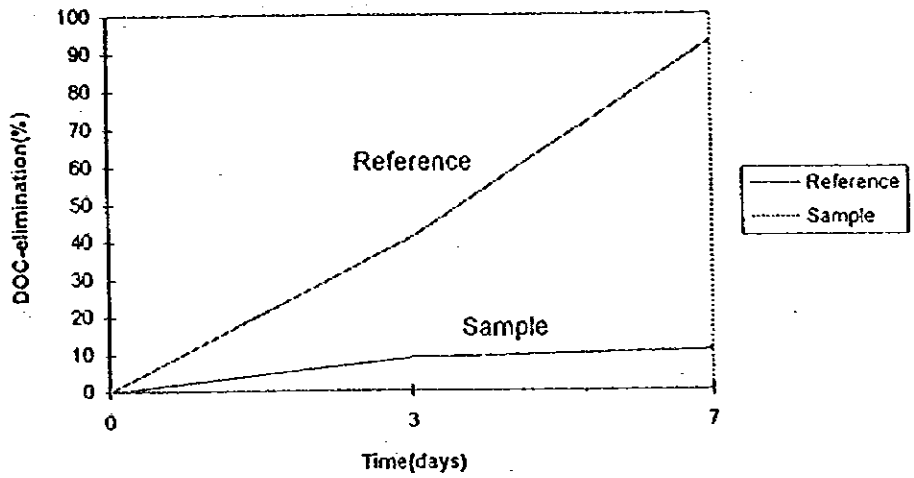
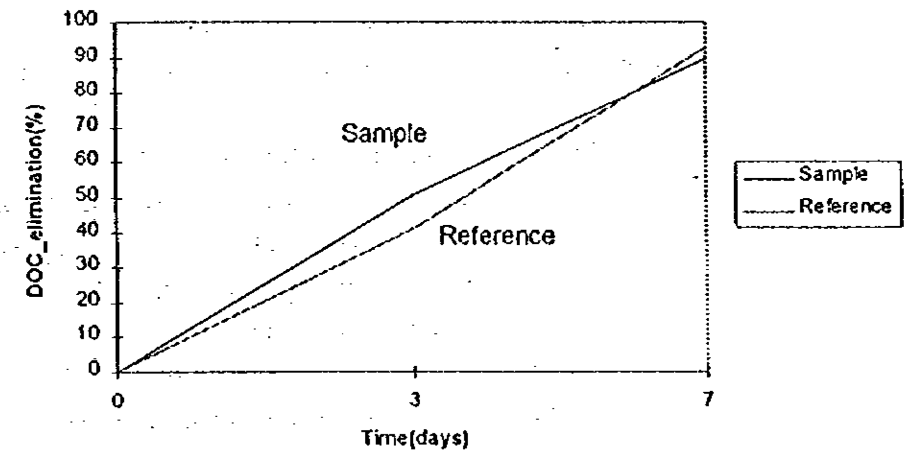


Fig. 3.2.6 Biodegradation of Coagulation Treated Painting Booth Waste Water



3.2.2 Water Conservation

1) Current condition of water usage and conservation

(1) Features of water usage

① One well is the factory's only source of water. The well water is pumped to an elevated water tank, from where it is then distributed throughout the whole factory.

② Steam condensate from the boiler is recovered and used again. However, apart from that, all other water is discharged after being used only once.

③ Boiler water accounts for a large percentage of the total water usage (approximately 61%), and this is followed by domestic water (approximately 23%) and cooling water (approximately 15%). However, as will be described later, doubts exist with regard to the amount of water used by the boiler.

④ The only water directly used on the production processes is the very small amount (1.3 m^3/day) used in the washing of the painting booths, etc.

⑤ Cooling water is used for compressor cooling and is discharged after being used only once.

⑥ The volume of domestic waste water (70 m^3/day) is large compared to the number of employees (482). However, this is thought to be because all waste water that was unaccounted for at the time of calculation of the overall water balance was classed under this heading.

(2) Current condition of water conservation

① A flow meter has not been installed in the well, and the volume of water usage is estimated from the time of pump operation.

② Because there is an elevated water tank, there is no over-pumping up of well water.

③ Approximately 55% of the boiler steam condensate is recovered for reuse. However, the volume of water and recovery rate shown here are design values calculated for the case where all the boilers (three boilers, evaporative capacity 16.9 tons/hour) operate for 24 hours. Thus, the figures are a poor reflection of the actual situation.

④ The existing boiler operating conditions are as follows :

- Summer (April-October) : 2.0-2.5 tons/hour x 5 days/week x 24 hours/day
- Winter (November-March) : 8 tons/hour x 2 boilers x 50% operation x 24 hours/day

⑤ The volume of water measured at the outlet was approximately 60 m^3/h, and the daily volume can exceed 1,000 m^3. This is a much greater volume than the figure indicated (298 m^3/day).

It is suspected that this is due to the fact that water from the timber conveying canal flow out into the drainage ditch.

⑥ There are a number of question marks concerning the water volumes given on the questionnaire, and it is possible that actual values are smaller than these.

2) Planning of water conservation system

(1) Implementation of water usage control

In the current situation, the amount of water pumped from the well is not measured and there is practically no control of water usage at all. A flow meter must first be fitted in the well and the control of water usage must be implemented throughout the whole factory. These are the basic conditions for water conservation.

In the aforementioned current situation where the volume of water usage is considered to be greatly inaccurate, there is little point in examining individual means of water conservation.

(2) Recycling of indirect cooling water for air compressor

(a) Outline of plan

The indirect cooling water used in the compressor is currently discharged after being used only once. The plan is to recycle this waste water for further use by means of a cooling tower.

As the water temperature at the outlet is unknown, it has been assumed as 20℃. Moreover, the plan here was compiled assuming the amount of water entered on the questionnaire to be correct.

(b) Basic conditions

The basic conditions are indicated in Table 3.2.6.

Table 3.2.6 Basic Conditions

		Present	plan
Water quantity (m^3/d)		45	45
Operation time (h/d)		8	8
Water quantity (m^3/h)		5.6	5.6
Water temperature ℃	inlet	15	25
	outlet	25	35
Recovery rate %			95
Saving quantity (m^3/d)			42.8
Cooling load (Kcal/h)		56,000	56,000
Annual operating days :		239	239

(c) Outline specifications of equipment

The outline equipment specifications are shown in Table 3.2.7.

Table 3.2.7 Outline Specifications of Equipment

Item	Number of Unit	Specifications
Cooling tower	1	78,000 Kcal/h Fan power 0.6 kw
Circulation pump	2 (including 1 standby)	Diameter 40 ϕ, Power 1.5 kw
Instrumentation and Controller	1 set	Electrical conductivity indicator
Piping	1 set	Circulation piping 65 ϕ Discharge piping 25 ϕ Water supply piping 15 ϕ

(d) Schematic flow sheet and layout drawing

The schematic flow sheet is shown in Fig. 3.2.7 and the layout drawing is shown in Fig. 3.2.8.

Fig. 3.2.7 Schematic Flow Sheet

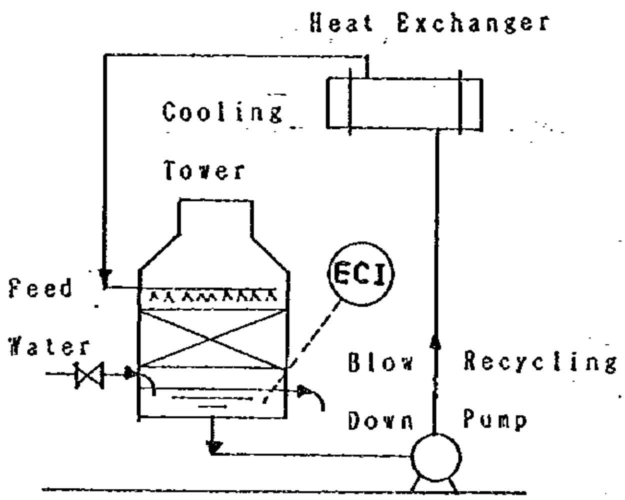
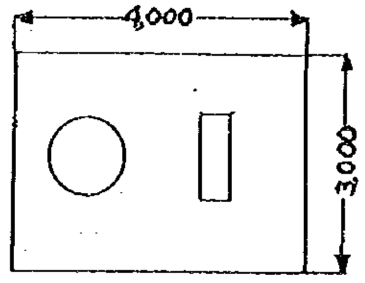


Fig. 3.2.8 Piping Diagram



(e) Rough estimation of required cost

- Equipment cost

The equipment cost is indicated in Table 3.2.8.

Table 3.2.8 Equipment Cost

Item	Unit price (Thousand SIT)	Number	Price (Thousand SIT)
Cooling tower	460	1	460
Circulation pumps	180	2	360
Instrumentation controller		1 set	100
Piping		1 set	687
Installation and other site works		1 set	276
Total			1,883

- Operating cost

The operating cost is indicated in Table 3.2.9.

Table 3.2.9 Operating Cost

Item	Required amount	Unit price	Required cost (SIT/d)	Required cost (Thousand SIT/y)	Cost per Unit of recoverd water (SIT/m³)
Electricity	2.1kw x 8h/d x 0.8	15SIT/kw · h	202	48.2	4.7
Labor cost	Concurrent with other work				
Chemicals			171	40.9	4.0
Total			373	89.1	8.7

- Required cost

The required cost is indicated in Table 3.2.10

Table 3.2.10 Required Cost

Item	Annual cost (Thousand SIT)	Cost per recovered water (SIT/m³)	Remarks
Fixed cost			
Equipment depreciation	126.2		Equal depreciation over 15 years
Interest	94.2		10%
Equipment maintenance cost	94.2		5% of equipment cost/year
Subtotal	314.6	30.8	
Operation cost	89.1	8.7	
Total	403.7	39.5	

(f) Technical comment

① The temperature of the currently used cooling water is approximately 15°C. The temperature that can be obtained from the cooling tower in the hottest part of summer is approximately 25°C. Thus, there is a risk that the cooling of oil during this short summer period may not be sufficient.
In this case, it would be necessary to temporarily increase the amount of water from the well or to change over to well water completely. However, as it is imagined that the period in question would last around two months, it is considered that the water saving effect would be sufficiently high.

② The well water is fairly hard (approximately 12 dH). Therefore, if the degree of circulation (usually expressed as the degree of concentration) in the cooling tower is raised, there is a risk that scale would appear and cause corrosion. Judging from the quality of the well water, it is thought that the cooling tower could be operated with a concentration degree of two times. Based on this precondition, the cooling tower operating conditions were assumed in the following manner.

- The cooling temperature difference is 10°C, and the equivalent evaporation rate is approximately 2%.
- The blow down rate (discharge rate) required for a concentration degree of two times is approximately 2%.
- The overall rate of water loss including flyaway loss is approximately 5%. Thus, the ratio of make-up water from the well is also 5%.
- Based on the above assumptions, a recovery rate (equivalent to the water saving rate) of 95% can be achieved.

(g) Economic comment

The cost per unit of water saved in this system is approximately 40 SIT/m^3. This figure shall be examined under the following conditions.

① In the current situation, because 62.9 SIT/m^3 is being spent on water usage and waste water matters, the use of water recycling is clearly advantageous. Moreover, according to state and municipal regulations, this cost should come to approximately 57 SIT/m^3.

② In the future case where waste water comes to be discharged into the sewerage system, an additional sewage charge of at least 100 SIT/m^3 will come to be charged. Thus, the use of water recycling would become even more advantageous.

③ In the case where waste water is continued to be discharged into the river, it is thought that tax for water use of approximately 41 SIT/m^3 will need to be paid. Thus, again, the use of water recycling would be economically feasible.

(h) Other problems

Because the amount of polluted waste water generated from the factory is small (1.3 m^3/day), any polluted waste water must be largely diluted by discharged cooling water. If the amount of discharged cooling water is reduced through the adoption of a water recycling system, this dilution effect will disappear and there is a possibility that the whole waste water treatment system will be affected.

(2) Reclamation of waste water

① The volume of waste water generated from the washing of the painting booths is extremely small, however, the degree of pollution is very high. Consequently, the reclamation of waste water is totally inappropriate.

② Because the sewage charge is so cheap, it is almost certain that the reclamation of domestic waste water would not be economically feasible.

(3) Other possibilities of water conservation

In view of the large volume of water used for domestic purposes, saving can be considered here. Possible methods in this area are as follows :

①Use of water saving toilets

②Installation of automatic washing devices on men's urinals

③Provision of water saving disk and orifices, etc. on faucets and showers.

Each of the above methods is simple to implement, and it is desirable that such improvements be carried out without fail on all newly installed facilities and successively on existing facilities, too.

The fact that the volume of domestic water is large compared to the number of employees was pointed out earlier.

(4) Summary of the water conservation plan

The water conservation plan is indicated in Table 3.2.11.

Table 3.2.11 Summary of the Water Conservation Plan

No.	Contents of conservation plan	Water saving amount m^3/day	Cost per recovered water SIT/m^3
1	Recycling of indirect cooling water for air compressor by a cooling tower	42.8	39.5
	Total	42.8	39.5

		Now	After water conservation
Volume of water usage	m^3/day	298	257
Unit consumption of water	m^3/set	0.74	0.64

Note : Production of kitchen sets 96,552/y, 404/d
Water saving rate 13.7%

3.2.3 Pretreatment that Satisfies WWTP Discharge Standards, and Waste Water Treatment

1) Current condition of waste water

Marles Holding Maribor d.d. is composed of a general timber sawing factory, a veneer factory, a furniture factory and a wooden building factory. Measurement of the combined waste water volume at the time of the sampling found it to be greatly in excess of the waste water discharged by the furniture factory, and it is guessed that waste water from the timber storage yard at the sawing factory was discharged at the time. The quality of the discharged water is well within the WWTP and river discharge standards, and there is no need to install a waste water treatment plant at the present time. However, depending on the conditions of waste water discharge from the furniture factory, there is a risk that the waste water quality may exceed standard levels in future.

The waste water discharged from the furniture factory is only small in volume, but it contains a high concentration of organic matter. Therefore, it would be economically advantageous to treat this waste water at the point of generation before it comes to be diluted with the other low concentration waste water.
The waste water generated from the furniture factory is composed of the following types.

a. Waste water that requires treatment

① Painting booth washing waste water

This contains a high concentration of organic matter, and is discharged in extremely small quantities at irregular intervals.

② Gluing machine washing waste water

This contains a high concentration of organic matter, and is discharged in extremely small quantities at the end of every working day.

③ Domestic waste water

This is discharged all the time.

b. Waste water that does not require treatment

① Boiler blow water

This waste water contains hardly any pollution at all.

② Compressor cooling water

This waste water contains hardly any pollution at all.

2) Pre-treatment plant

(1) Basis for system selection

Waste water treatment in the furniture manufacturing process is centered around the washing waste water from the painting booths and the gluing machines. This waste water is highly organic and contains a high degree of COD, but it is discharged in very small quantities. COD can be treated by means of the following processes :

① Physical treatment methods such as coagulation and sedimentation, etc.
② Chemical treatment methods such as Fenton oxidation, etc.
③ Combustion treatment
④ Wet oxidation, etc.

As the results of the coagulation treatment test showed, the treated water possesses biodegradability. Because this method is commonly adopted and involves cheap initial and running costs, it shall be adopted here.

Atomized firing can be said to be a suitable method in view of the small volume of waste water and the fact that it leaves no difficulties for later waste water treatment. However, this would entail problems in that operation is not easy and there is a risk of combustion products causing secondary pollution because of the organic chlorine compounds contained (albeit in minute quantities) in the waste water. Similar problems exist in the case of wet oxidation, too.

Chemical processing through the Phenton oxidation method, etc. is problematic in that more oxidant than theoretically planned becomes necessary and there is a risk of intermediate oxidation products causing secondary pollution when total oxidation is aimed for. These problems could be overcome by combining the process with a unit operation method such as active carbon adsorption, etc., however, this is more costly than the coagulation and sedimentation method.

(2) Outline of pre-treatment system

The pre-treatment targets the waste water from the washing of the painting booths and gluing machines and involves the batchwise treatment of these waste waters mixed together. The waste water is discharged into a waste water receiving tank, where it is homogenized. From there, it is fed by storage pump into a reaction tank. Here, a set amount of $Al_2(SO_4)_3$ is added and, moreover, NaOH is added under control by a pH meter installed in the tank in order to neutralize the water. Next, anionic high polymer coagulant is added to form floc, and this completes the coagulation process.

Following that, the floc is left to separate by sedimentation. After more anionic high polymer coagulant has been added to the sludge sediment, the sludge is dehydrated in a dehydrator, and the resulting dehydrated cake is then carried out.

The quality of water in the stabilization tank will probably vary with each batch of waste water from the painting booths, and it will be necessary to have an accurate grasp during the operation of the optimum amount of $Al_2(SO_4)_3$ that needs to be added.

(3) Design conditions

a. Quality of waste water

The quality and volumes of waste water are shown in Table 3.2.12.

Table 3.2.12 Quality of Waste Water

	Waste Water of Painting Booth	Waste Water of Gluing Machine
pH	6.7～7.5	6.9～7.1
COD (mg/ℓ)	4,000～11,500	11,000～19,500
BOD (mg/ℓ)	(600～630)	(100)
SS (mg/ℓ)	160～880	1,500～27,000
T-fat (mg/ℓ)	8～48	130
$N-NH_3$ (mg/ℓ)	0.1～4.7	0.11～17
$N-NO_2$ (mg/ℓ)	<0.1	<0.1
T-P (mg/ℓ)	1.2～2.2	3.3～6.1
㎥/day	0.87	0.45

b. Volume of treated water

The volume of treated water is 304 m^3/day.

① Waste water that requires treatment

Gluing machine washing waste water : 0.45m^3/day
Painting booth washing waste water : 0.87m^3/day
Regenerated water from a softener : 8m^3/day

② Waste water that does not require treatment

Domestic waste water : 70m^3/day
Boiler blow water : 180m^3/day
Compressor cooling water : 45m^3/day

c. Waste water inflow time

12 hours/day

d. Operating time

12 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 3.2.13.

Table 3.2.13 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	–

Note: (a)-(l): not applicable in this factory.

(3) Equipment specifications

a. Flow sheet

The pre-treatment plant flow sheet is shown in Fig. 3.2.9.

b. Layout

The pre-treatment plant layout is shown in Fig. 3.2.10.

c. Equipment list

The pre-treatment plant equipment list is shown in Table 3.2.14.

Fig. 3.2.9 Pretreatment Plant Flow Sheet

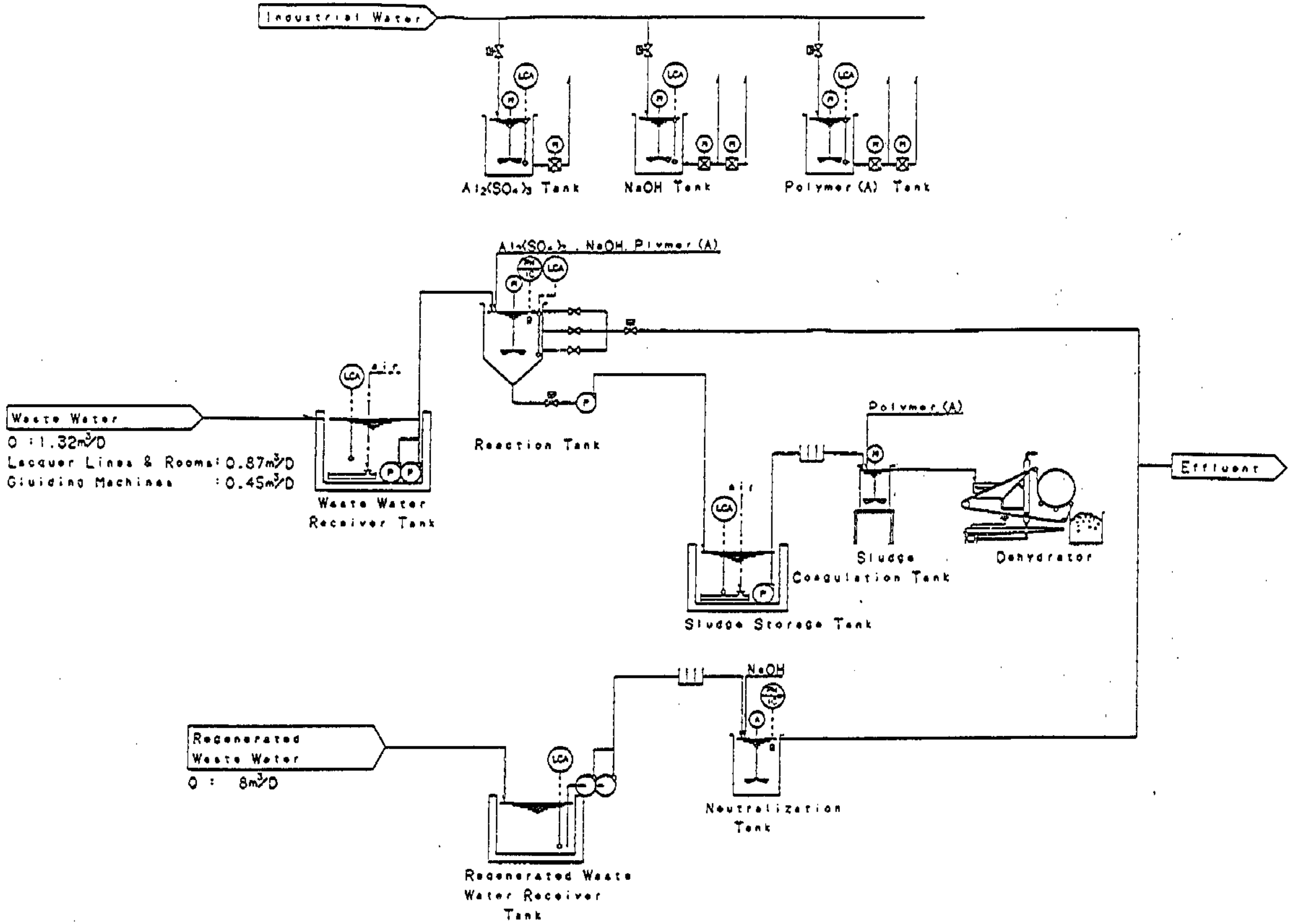
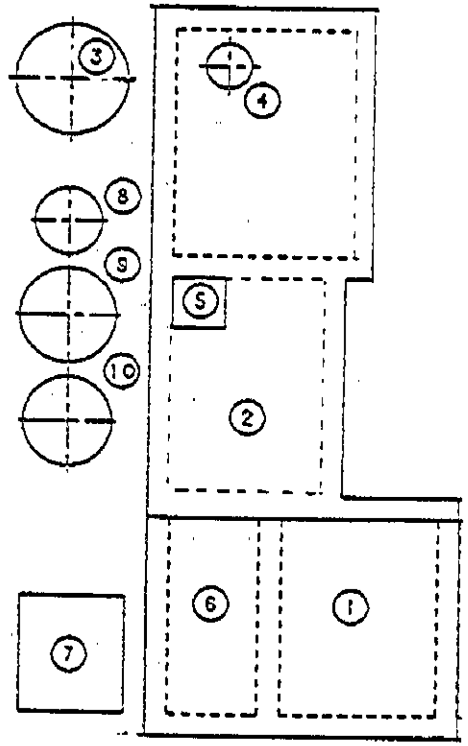


Fig. 3.2.10 Pretreatment Plant Layout



No.	Description	Remarks
1	W.W.Receiver Tank	
2	R.W.W.Receiver Tank	
3	No.1 Reaction Tank	
4	Neutralization Tank	
5	Coagulation Tank	
6	Sludge Storage Tank	
7	Dehydrator	
8	$Al_2(SO_4)_3$ Tank	
9	NaOH Tank	
10	Polymer Tank A	

Table 3.2.14 Equipment List (1/4)

No.	Item	Q'ty	Material	Specification	Remark
1	Waste Water				
	Receiver Tank	1	RC	Capacity : $5m^3$	
				Shape : 2.7mW×1.8mL×2.0mD	
				with air diffuser	
	Pump	2	FC	50φ×120ℓ/min×8m×1.5kw	
				Submersion type	
	Level Switch	1	PVC	Float type	
2	No1 Reaction Tank	1	FRP	Capacity : $2m^3$	
				Shape : 1.5φm×1.8mH	
				Coan type	
	Pump	1	CS+R/L	40φ×100ℓ/min×8m×0.4kw	
				Centrifugal type for slurry	
	Agitator	1	CS+R/L	Vertical type 0.75kw	
	pH Meter	1		Dip type	
	Level Switch	1	PVC	Float type	
3	Regenerated Waste Water	1	RC+FRP	Capacity : 10㎥	
	Tank			Shape : 3.1mW×2.4mL×3mD	
	Level Switch	1	PVC	Float type	
	Pump	2	PVC	25φ×20ℓ/min×8m×0.75kw	
4	Neutralization Tank	1	FRP	Capacity : 200ℓ	
	Agitator	1	SS+R/L	Portable type 0.1kW	
	pH Meter	1		Dip type, 0~14, 4~20mA	

Table 3.2.14 Equipment List (2/4)

No.	Item	Q'ty	Material	Specification	Remark
5	Sludge Storage Tank	1	RC	Capacity : 5m³	
				Shape : 2.7mLW×1.2mL×2.0mD	
				with air diffuser	
	Pump	1	FC	50φ×60ℓ/min×10m×0.75kw	
				Submersion type for slurry	
	Level Switch	1	SUS	Electrode type	
	Flow Meter	1		Box type	
6	Sludge Coagulation Tank	2	CS	Capacity : 0.1m³	
				Shape : 0.4m×0.4m×0.85mH	
	Agitator	2	SUS	Portable type 0.1kw	
7	Dehydrator	1		Belt Press type, 0.82kw	
				Filter wide 360m/m	
				Sludge box 1m³	
8	$Al_2(SO_4)_3$ Tank	1	FRP	Capacity : 500ℓ	
				Shape : 0.9mφ×1.6mH	
	No1 Reaction Tank				
	Feed Pump	1	PVC	15φ×0.25ℓ/min×10kg/cm²×0.2kW	
				Diaphram type	
	Agitator	1	SS+R/L	Vertical type 0.1kw	
	Level Switch	1	SUS	Electrode type	
9	NaOH Tank	1	FRP	Capacity : 2m³	

Table 3.2.14 Equipment List (3/4)

No.	Item	Q'ty	Material	Specification	Remark
				Shape : 1.3mϕ × 1.6mH	
	NaI Reaction Tank				
	Feed Pump	1	PVC	25ϕ × 6ℓ/min × 3kg/cm^2 × 0.2kw	
				Diaphram type	
	Neutralization				
	Feed Pump	1	PVC	15ϕ × 0.05ℓ/min × 10kg/cm^2 × 0.2kw	
				Diaphram type	
	Agitator	1	SUS	Vertical type 0.4kw	
	Level Switch	1	SUS	Electrode type	
10	Polymer(A) Tank	1	FRP	Capacity : 1.5m^3	
				Shape : 1.2 mϕ × 1.3mH	
	NaI Reaction Tank				
	Feed Pump	1	PVC	15ϕ × 0.25ℓ/min × 10kg/cm^2 × 0.2kw	
				Diaphram type	
	Sludge Coagulation				
	Tank Feed Pump	1	PVC	15ϕ × 0.25ℓ/min × 10kg/cm^2 × 0.2kw	
				Diaphram type	
	Agitator	1	SUS	Vertical type 0.75kw	
	Level Switch	1	SUS	Electrode type	
11	Blower				
	for Aeration	2		50ϕ × 1.84m^3/min × 4500mmAq × 3.7kW	
	Flow meter	1	CS	Area type	
	for Agitation	1		50ϕ × 1.28m^3/min × 4500mmAq × 3.7kW	

Table 3.2.14 Equipment List (4/4)

No.	Item	Q'ty	Material	Specification	Remark
1 2	Control Panel	1		Indoor self-standing enclosed type	
				Push button switch	
				Alarm lamp	
				pH indicator	
1 3	Pipe				
	Raw Waste Water Line		VP		
	Treated Water Line		VP		
	Chemical Dosing Line		VP		
	Air Line		SGP		
1 4	Bilding		Steel frame &	156 m² X 7H	
			slate roof		

d. Design calculations sheet

- Waste water receiving tank

The tank will receive 0.45 m^3/day of waste water from gluing machine washing and a maximum of 3.7m^3 of waste water from painting booth washing at any one time (irregular intervals).

$0.45m^3 + 3.7m^3 = 4.15m^3$

Finally decided value : 5m^3

- Reaction tank

Batchwise treatment shall be performed once per day. The volume of waste water is 1.32m^3 per day, and added chemicals will also be taken into account.

Finally decided value : 2m^3

- Regenerated waste water tank

One batch capacity (8m^3/day) for recovered waste water of softener.

$8m^3$/day x 1 day = 3m^3

Determined value : 10m^3

- Neutralization tank

Water retention in excess of 10 minutes for average water inflow (8m^3).

$8m^3$/day ÷ 24h/day ÷ 60min/h x 10min = 60 l

Equipping capacity of agitator and pH indicator

Determined value : 200 l

- Sludge tank

One day sludge quantity

Coagulated sludge ($Al_2(SO_4)_3 18H_2O$ (Quantity to be added : 42.6kg/day)

21.9kg/day x 0.456	=	10kg/day	(as $Al(OH)_3$)
1.32m^3/day x 5,150g/m^3	=	6.8kg/day	(as SS)
Total		16.8kg/day	(as Dry)
		840kg/day	(as 2%)

Water retention of more than 3 days with dehydrator operating as 8 hours/3days

$V = 0.84m^3$/day x 3days = 2.5m^3

Determined value : 3m^3

- $Al_2(SO_4)_3$ tank

Volume used : (102 kg/day as Al_2O_3 8% (27.3 kg/day as dry solid)
The tank shall hold a five day supply.
V = 102 kg/day + 1.2 (specific gravity) x 5 days = 425

Finally decided value : 500 ll

- NaOH tank

Volume used : 15.4 kg/day (as 100%) = 308 kg/day (as 5%)
The tank shall hold a five day supply.
V = 308 kg/day + 1 kg/l x 5 days = 1,540

Finally decided value : 2 m^3

- Polymer tank (A) (Concentration degree 0.1%)

Quantity to be used

For waste water	0.018kg/day as dry	(Adding 0.5% of SS quantity)
For dehydration	0.11kg/day as dry	(Adding 0.5% of SS quantity)
Total :	0.128kg/day as dry	

0.128kg/day + 0.1% = 128kg/day
Water retention of 5 days
V = 128kg/day + 1kg/1 x 5days = 640l

Determined value : $1m^3$

- Dehydrator

Sludge coagulation tank
Water retention of approximately 5 minutes :
V = $0.84m^3$/day + 8h/day x 5/60 = $0.00875m^3$

Determined value : 10 l x 2 (tanks)

- Dehydrator

Sludge processing quantity : 16.8kg/day as dry
Moisture rate of dried sludge : 85%
Processing capacity : 50.4kg/3days + 8h/3days = 2.1kg/h as Dry

Determined value : Belt press type for 3kg-Dry/h

Sludge volume : 50.4kg/3days + 0.15 = 336kg/3days = 112kg/day

• Blower for agitation

Aeration strength : 1 m^3/m^3/hour

Total tank volume : 62 m^3

Required air volume = 62 m^3 x 1 m^3/m^3/hour = 62 m^3/day = 1.0^3/min.

Finally decided value : 1.28 m^3/min. x 4,500 mmAq x 3.7 kW

(4) Equipment cost

The equipment cost is 23,955,000 SIT.

The equipment cost is indicated in Table 3.2.15.

Table 3.2.15 Equipment Cost

Equipment	Thousand SIT
Agitator	5,497,000
Instrumentation	813,000
Others (tanks)	3,250,000
Subtotal	9,560,000
Site works	
Equipment installation and piping	2,111,000
Electrical work	2,229,000
Painting work	81,000
Civil engineering work	3,575,000
Building work	4,225,000
Site supervision	877,000
Trial operation	68,000
Subtotal	13,166,000
Design cost	1,229,000
Total	23,955,000

(5) Operating cost

The operating cost is 2,108,000 SIT/year.

The operating cost is shown in Table 3.2.16.

Table 3.2.16 Operating Cost

Chemical Costs SIT/Year		
NaOH	15.4 kg/day x 83.2 SIT/kg x 239 d/y	= 306,226
$Al_2(SO_4)_3$	42.6 kg/day x 39.15 SIT/kg x 239 d/y	= 398,602
Polymer A (powder)	0.19 kg/day x 990 SIT/kg x 239 d/y	= 44,956
Subtotal		(749,784)
Electricity charge	58 kwh/day x 15 SIT/kwh x 239 days =	207,930
Sludge disposal	0.112 m^3/day x 1,423 SIT/m^3 x 239 days	= 38,091
Kerosene charge	12 l/day x 60 SIT/ l x 90 days	= 64,800
Maintenance	16,155,000 SIT x 0.05	= 807,750
Personnel expenses	1,200,000 SIT/y-person x 1 person x 0.2	= 240,000
Total		2,108,355

(6) Economic comment

a. Conditions

① Depreciation period : Equipment 15 years
Building, civil engineering 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
: 9.32 m^3/day x 239 days/year = 2,227.48 m^3/year

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

The treatment cost per 1 m^3 of waste water is 2,055 SIT/m^3.
The breakdown of this unit treatment cost is shown in Table 3.2.17.
Therefore, the cost of treating one cubic meter of all of the waste water is as follows.

(①+②+③+④) ÷ (304 m^3/day x 239 days/year) + 176.56 SIT/m^3 = 240 SIT/m^3

Table 3.2.17 Classification of the Treatment Cost per 1m^3 of Waste Water

Items	Contents		Cost (SIT/year)
Depreciation period	Equipment	16,155,000 SIT ÷ 15 years	① 1,077,000 SIT/year
	Buildings, Civil works	7,800,000 SIT ÷ 40years	② 195,000 SIT/year
Rate of interest	23,955,000 x 0.05		③ 1,197,750 SIT/year
Running cost			④ 2,108,000 SIT/year
(① + ② + ③ + ④) ÷ 2,227.48			2,055 SIT/m^3

3) Waste water treatment system

(1) Basis for system selection

The waste water that requires treatment is that from the washing of the painting booths and gluing machines and also the domestic waste water, and all these waste waters contain organic matter. The central unit process within an organic waste water treatment system is biological treatment. 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 intended for discharge.

The waste water from the washing of the painting booths and gluing machines is high concentration organic waste water, and it contains minute quantities of composite organic compounds. These compounds often obstruct the biological treatment process and do not biologically degrade easily, i.e. they are refractory organics. The waste water sampled was found to contain minute traces of toluene, xylene and surface active agent. However, it is possible to partially remove these chemical substances through coagulation treatment and further treat them by means of aerobic biological treatment by acclimatizations.

Thus, the planned system is one of pre-treatment consisting of coagulation and sedimentation, followed by aerobic biological treatment. The aerobic biological treatment shall be performed on a waste water mix with domestic waste water containing nitrogen and phosphorous and, in consideration of the nitrification of remaining nitrogen, the contact aeration method shall be adopted.

(2) Outline of waste water treatment system

① Washing waste water from painting booths and gluing machines

The same treatment as performed in the pre-treatment plant is carried out. However, supernatant will be discharged into a stabilization tank, and the sludge sediment will be sent to a sludge storage tank.

② Domestic waste water

After being passed through a screen to remove foreign material, the domestic waste water is stored in a waste water storage tank. A set amount of the waste water is then guided by storage pump into a stabilization tank, where it is mixed and equalized with the above-mentioned washing waste water. A set quantity of the mixed waste water is then fed by storage pump into a contact aeration tank, where organic material is treated and nitrification takes place. After that, the treated water is fed into a sedimentation tank, where sludge is separated by sedimentation. The supernatant is fed into No.2 reactor where the removal of phosphorous takes place. In this process, a set amount of $Al_2(SO_4)_3$ is added and, moreover, coagulation is made to occur through the addition of NaOH under control by a pH meter installed in the reaction tank. The coagulation process is completed with the addition of anionic high polymer coagulant to form floc. The treated water from the coagulation process is sent on No.2 sedimentation tank, where phosphorous is separated by sedimentation. The resulting supernatant is then fed into the monitoring tank, where it is mixed together with boiler blow water and compressor cooling water. This water mix flows by gravity into a water quality monitoring tank. After the pH value is automatically recorded and monitored in the monitoring tank, the 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.

③ Regenerated water from the softener

Regenerated waste water from the softener is discharged into the waste water receiving tank. From there, a set amount is fed by storage pump into the neutralization tank, where neutralization takes place through the addition of NaOH under control by the pH meter installed in the tank. The treated water is then sent to the stabilization tank.

④ Excess sludge

Excess sludge that has been separated in the sedimentation tank is sent to the sludge storage tank, where it joins the sludge separated from the painting booth and gluing machine washing waste water. A set amount of the sludge is fed into the dehydrator and, after coagulation has taken place through the addition of anionic high polymer coagulant and cationic high polymer coagulant, dehydration takes place. The resulting dehydrated cake is then taken to the landfill for final disposal.

⑤ Boiler blow water and compressor cooling water

This water is directly sent into the monitoring tank.

(3) Design conditions

a. Quality of waste water

The quality and volumes of waste water are shown in Table 3.2.13.

b. Volume of treated water

The volume of treated water is 304 m^3/day.

① Waste water that requires treatment

Washing waste water from gluing machines	:	0.45 m^3/day
Washing waste water from painting booths	:	0.87 m^3/day
Softener regenerated waste water	:	8 m^3/day
Domestic waste water	:	70 m^3/day

② Waste water that does not require treatment

Boiler blow water	:	180 m^3/day
Compressor cooling water	:	45 m^3/day

c. Waste water inflow time

12 hours/day

d. Operating time

24 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 3.2.13.
Table 3.2.12 Quality Standards of Waste Water

(3) Equipment specifications

a. Flow sheet

The waste water treatment plant flow sheet is shown in Fig. 3.2.11.

b. Layout

The waste water treatment plant layout is shown in Fig. 3.2.12.

c. Material balance

The material balance of the waste water treatment plant is shown in Fig. 3.2.13.

d. Equipment list

The waste water treatment plant equipment list is shown in Table 3.2.18.

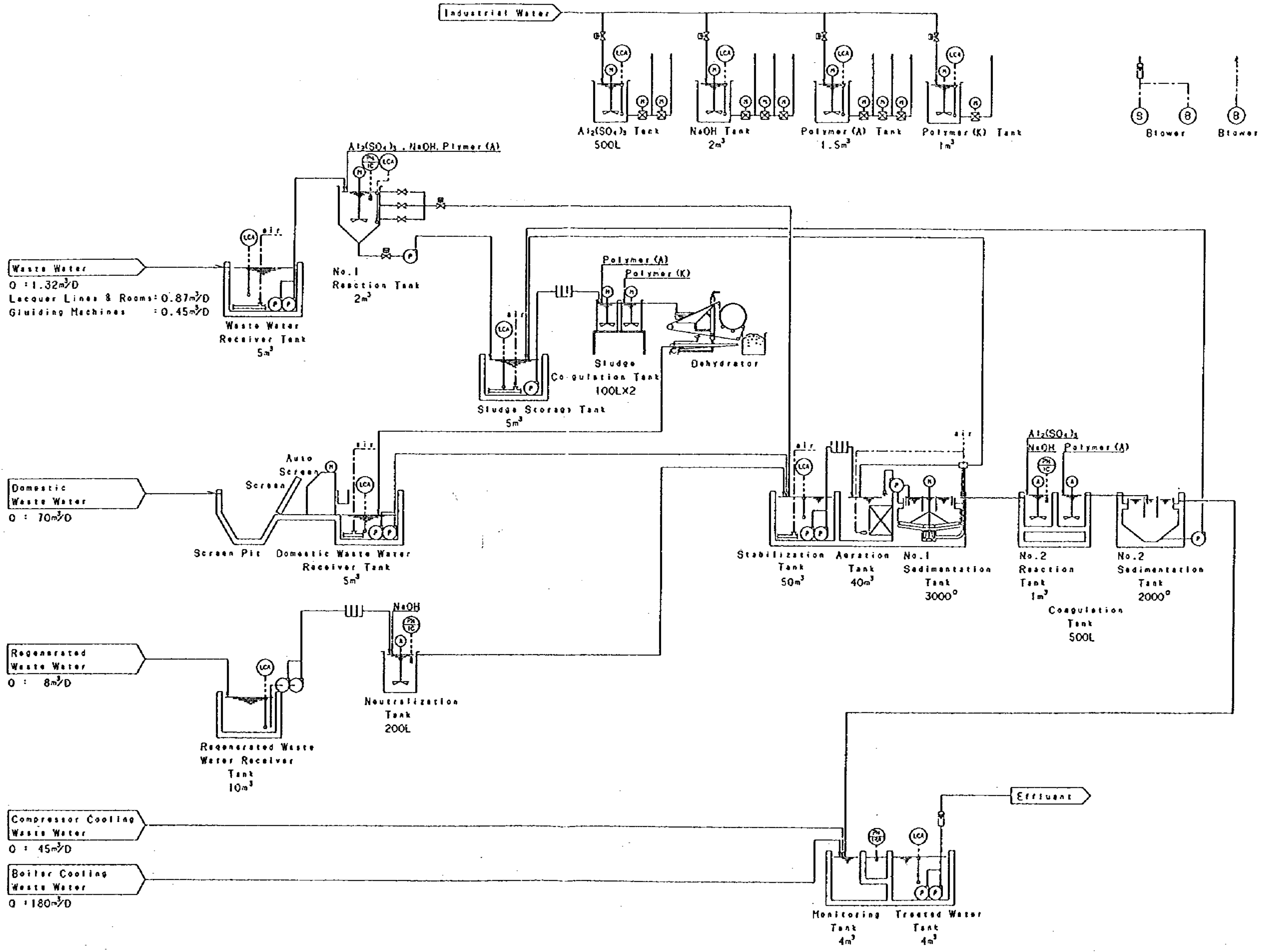
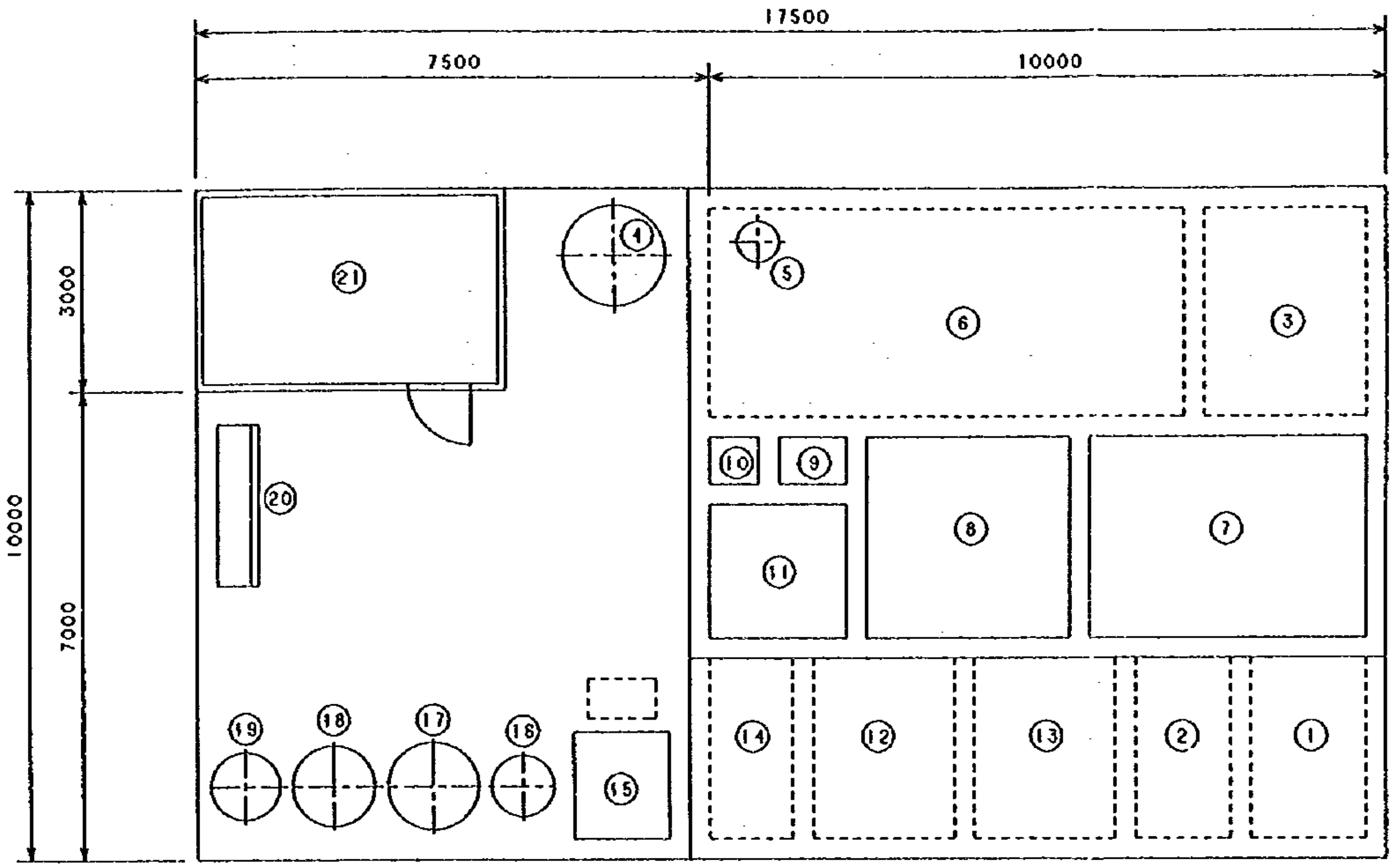
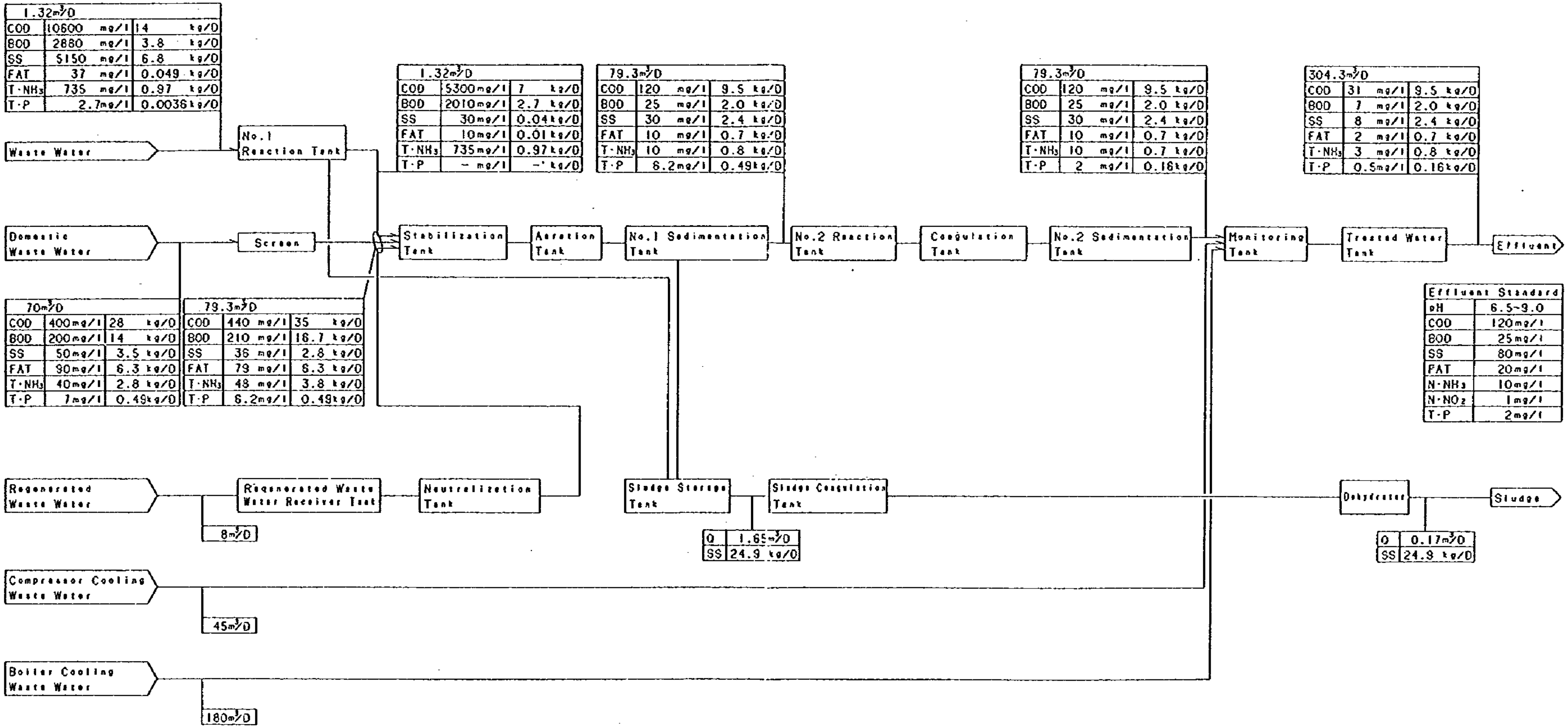


Fig. 3.2.11 Waste Water Treatment Plant Flow Sheet



No.	Description	Remarks
1	W.W.Receiver Tank	
2	D.W.W.Receiver Tank	
3	R.W.W.Receiver Tank	
4	No.1 Reaction Tank	
5	Neutralization Tank	
6	Stabilization Tank	
7	Aeration Tank	
8	No.1 Sedimentation Tank	
9	No.2 Reaction Tank	
10	Coagulation Tank	
11	No.2 Sedimentation Tank	
12	Monitoring Tank	
13	Treated Water Tank	
14	Sludge Storage Tank	
15	Dehydrator	
16	$Al_2(SO_4)_3$ Tank	
17	NaOH Tank	
18	Polymer Tank A	
19	Polymer Tank K	
20	Control Panel	
21	Blower Room	

Fig. 3.2.12 Waste Water Treatment Plant Layout



Waste Water (1.32m³/D)

COD	10600 mg/l	14 kg/D
BOD	2880 mg/l	3.8 kg/D
SS	5150 mg/l	6.8 kg/D
FAT	37 mg/l	0.049 kg/D
T·NH3	735 mg/l	0.97 kg/D
T·P	2.7mg/l	0.0036 kg/D

No.1 Reaction Tank outlet (1.32m³/D)

COD	5300mg/l	7 kg/D
BOD	2010mg/l	2.7 kg/D
SS	30mg/l	0.04 kg/D
FAT	10mg/l	0.01 kg/D
T·NH3	735mg/l	0.97 kg/D
T·P	- mg/l	- kg/D

No.1 Sedimentation Tank outlet (79.3m³/D)

COD	120 mg/l	9.5 kg/D
BOD	25 mg/l	2.0 kg/D
SS	30 mg/l	2.4 kg/D
FAT	10 mg/l	0.7 kg/D
T·NH3	10 mg/l	0.8 kg/D
T·P	6.2mg/l	0.49 kg/D

No.2 Sedimentation Tank outlet (79.3m³/D)

COD	120 mg/l	9.5 kg/D
BOD	25 mg/l	2.0 kg/D
SS	30 mg/l	2.4 kg/D
FAT	10 mg/l	0.7 kg/D
T·NH3	10 mg/l	0.7 kg/D
T·P	2 mg/l	0.16 kg/D

Effluent (304.3m³/D)

COD	31 mg/l	9.5 kg/D
BOD	7 mg/l	2.0 kg/D
SS	8 mg/l	2.4 kg/D
FAT	2 mg/l	0.7 kg/D
T·NH3	3 mg/l	0.8 kg/D
T·P	0.5mg/l	0.16 kg/D

Domestic Waste Water (70m³/D)

COD	400mg/l	28 kg/D
BOD	200mg/l	14 kg/D
SS	50mg/l	3.5 kg/D
FAT	90mg/l	6.3 kg/D
T·NH3	40mg/l	2.8 kg/D
T·P	7mg/l	0.49 kg/D

Stabilization Tank inlet (79.3m³/D)

COD	440 mg/l	35 kg/D
BOD	210 mg/l	16.7 kg/D
SS	36 mg/l	2.8 kg/D
FAT	79 mg/l	6.3 kg/D
T·NH3	48 mg/l	3.8 kg/D
T·P	6.2mg/l	0.49 kg/D

Effluent Standard	
pH	6.5~9.0
COD	120mg/l
BOD	25mg/l
SS	80mg/l
FAT	20mg/l
N·NH3	10mg/l
N·NO2	1mg/l
T·P	2mg/l

Fig. 3.2.13 Material Balance of Waste Water Treatment Plant

Table 3.2.18 Equipment List (1/7)

No.	Item	Q'ty	Material	Specification	Remark
1	Waste Water				
	Receiver Tank	1	RC	Capacity : $5m^3$	
				Shape : 2.7mW×1.8mL×2.0mD	
				with air diffuser	
	Pump	2	FC	50φ×120ℓ/min×8m×1.5kw	
				Submersion type	
	Level Switch	1	PVC	Float type	
2	NaI Reaction Tank	1	FRP	Capacity : $2m^3$	
				Shape : 1.5φm×1.8mH	
				Coan type	
	Pump	1	CS+R/L	40φ×100ℓ/min×8m×0.4kw	
				Centrifugal type for slurry	
	Agitator	1	CS+R/L	Vertical type 0.75kw	
	pH Meter	1		Dip type	
	Level Switch	1	PVC	Float type	
3	Screen Pit	1	RC		
	Bar Screen	1	SUS	Slit 20m/m	
	Auto Screen	1	SUS	Sit 1.5m/m×0.1	
4	Domestic Waste Water				
	Receiver Tank	1	RC	Capacity : $5m^3$	
				Shape : 2.7mW×1.4mL×2.0mD	
	Pump	2	FC	50φ×150ℓ/min×8m×0.75kw	

Table 3.2.18 Equipment List (2/7)

No.	Item	Q'ty	Material	Specification	Remark
				Submersion type	
	Level Switch	1	PVC	Float type	
5	Regenerated Waste Water	1	RC+FRP	Capacity : 10㎥	
	Tank			Shape : 3.1mW×2.4mL×3mD	
	Level Switch	1	PVC	Float type	
	Pump	2	PVC	25φ×20ℓ/min×8m×0.75kw	
6	Neutralization Tank	1	FRP	Capacity : 200ℓ	
	Agitator	1	SS+R/L	Portable type 0.1kW	
	pH Meter	1		Dip type, 0~14, 4~20mA	
7	Atabilization Tank	1	RC	Capacity : 50㎥	
				Shape : 3.1mW×7.0mL×3.5mD	
				with air diffuser	
	Pump	4	FC	40φ×100ℓ/min×8m×0.4kw	
				Submersion type	
	Level Switch	1	PVC	Float type	
	Flow Meter	1		Box type	
8	Aeration Tank	1	RC	Capacity : 40m^3	
				Shape : 3.0mW×4.1mL×3.5mD	
				with air diffuser	
				Contact media : 24m^3	

Table 3.2.18 Equipment List (3/7)

No.	Item	Q'ty	Material	Specification	Remark
9	No1 Sedimentation Tank	1	RC	Surface area : 9m²	
				Shape : 3.0m×3.0m×3mD	
				with air lift pump	
	Sludge Collector	1	CS	Rake type 0.4kW	
	Pump	1	FC	40φ×60ℓ/min×15m×1.5kw	
				Centrifugal type	
10	No2 Reaction Tank	1	RC+FRP	Capacity : 1m³	
				Shape : 0.7mW×1mL×2mD	
	Agitator	1	SS+R/L	Vertical type 0.4kw	
	pH Meter	1		Dip type, 0~14,4~20mA	
11	Coagulation tank	1	RC	Capacity : 500ℓ	
				Shape : 0.7mW×0.7mL×2mD	
	Agitator	1	SUS	Vertical type 0.1kw	
12	No2 Sedimentation Tank	1	RC	Surface area : 4m²	
				Shape : 2.0mW×2.0mL×3mD	
				Cone type	
	Sludge Collector	1	CS	Rake type 0.4kw	
	Pump	1	FC	40Aφ×50ℓ/min×10m×0.75kw	
13	Monitoring Tank	1	RC	Capacity : 4m³	
				Shape : 2.7mW×2.1mL×2mD	
	pH Meter	1		Dip type, 0~14, 4~20mA	

Table 3.2.18 Equipment List (4/7)

No.	Item	Q'ty	Material	Specification	Remark
14	Treated Water Tank	1	RC	Capacity : 4㎥	
				Shape : 2.7mW×2.1mL×2mD	
	Pump	2	FC	80φ×500ℓ/min×15m×2.2kw	
	Level Switch	1	PVC	Float type	
15	Sludge Storage Tank	1	RC	Capacity : $5m^3$	
				Shape : 2.7mLW×1.2mL×2.0mD	
				with air diffuser	
	Pump	1	FC	50φ×60ℓ/min×10m×0.75kw	
				Submersion type for slurry	
	Level Switch	1	SUS	Electrode type	
	Flow Meter	1		Box type	
16	Sludge Coagulation Tank	2	CS	Capacity : $0.1m^3$	
				Shape : 0.4m×0.4m×0.85mH	
	Agitator	2	SUS	Portable type 0.1kw	
17	Dehydrator	1		Belt Press type, 0.82kw	
				Filter wide 360m/m	
				Sludge box $1m^3$	
18	$Al_2(SO_4)_3$ Tank	1	FRP	Capacity : 500ℓ	
				Shape : 0.9mφ×1.6mH	
	NaI Reaction Tank				

Table 3.2.18 Equipment List (5/7)

No.	Item	Q'ty	Material	Specification	Remark
	Feed Pump	1	PVC	15ϕ×0.25ℓ/min×10kg/cm²×0.2kW	
				Diaphram type	
	No2 Reaction Tank				
	Feed Pump	1	PVC	15ϕ×0.1ℓ/min×10kg/cm²×0.2kW	
				Diaphram type	
	Agitator	1	SS+R/L	Vertical type 0.1kw	
	Level Switch	1	SUS	Electrode type	
19	NaOH Tank	1	FRP	Capacity : 2m³	
				Shape : 1.3mϕ×1.6mH	
	No1 Reaction Tank				
	Feed Pump	1	PVC	25ϕ×6ℓ/min×3kg/cm²×0.2kw	
				Diaphram type	
	Neutralization				
	Feed Pump	1	PVC	15ϕ×0.05ℓ/min×10kg/cm²×0.2kw	
				Diaphram type	
	No2 Reaction Tank				
	Feed Pump	1	PVC	15ϕ×0.5ℓ/min×10kg/cm²×0.2kw	
				Diaphram type	
	Agitator	1	SUS	Vertical type 0.4kw	
	Level Switch	1	SUS	Electrode type	
20	Polymer(A) Tank	1	FRP	Capacity : 1.5m³	
				Shape : 1.2 mϕ×1.3mH	
	No1 Reaction Tank				

Table 3.2.18 Equipment List (6/7)

No.	Item	Q'ty	Material	Specification	Remark
	Feed Pump	1	PVC	15ϕ×0.25ℓ/min×10kg/cm²×0.2kw	
				Diaphram type	
	Coagulation Tank				
	Feed Pump	1	PVC	15ϕ×0.5ℓ/min×10kg/cm²×0.2kw	
				Diaphram type	
	Sludge Coagulation				
	Tank Feed Pump	1	PVC	15ϕ×0.25ℓ/min×10kg/cm²×0.2kw	
				Diaphram type	
	Agitator	1	SUS	Vertical type 0.75kw	
	Level Switch	1	SUS	Electrode type	
21	Polymer(K) Tank	1	FRP	Capacity : 1m³	
				Shape : 1.2mϕ×1.3mH	
	Pump	1	PVC	15ϕ×0.25ℓ/min×10kg/cm²×0.2kW	
				Diaphram type	
	Agitator	1	SUS	Vertical type 0.4kW	
	Level Switch	1	SUS	Electrode type	
22	Blower				
	for Aeration	2		50ϕ×1.84m³/min×4500mmAq×3.7kW	
	Flow meter	1	CS	Area type	
	for Agitation	1		50ϕ×1.28m³/min×4500mmAq×3.7kW	
23	Control Panel			Indoor self-standing enclosed type	
				2.4m×0.6m×2mH	

Table 3.2.18 Equipment List (7/7)

No.	Item	Q'ty	Material	Specification	Remark
				Push button switch	
				Alarm lamp	
				pH indicator	
24	Pipe				
	Raw Waste Water Line		VP		
	Treated Water Line		VP		
	Chemical Dosing Line		VP		
	Air Line		SGP		
25	Bilding		Steel frame &	156 m² X 7H	
			slate roof		

e. Design calculations sheet

- Waste water receiving tank

The tank will receive 0.45 m^3/day of waste water from gluing machine washing and a maximum of 3.7 m^3 of waste water from painting booth washing at any one time (irregular intervals).

$0.45\ m^3 + 3.7\ m^3 = 4.15\ m^3$

Finally decided value : 5 m^3

- Domestic waste water receiving tank

Assuming an average inflow rate of 5.8 m^3/hour, a maximum inflow rate 2.5 times greater than this (14.5 m^3/hour) shall be assumed together with a retention time of 20 minutes.

$5.8\ m^3/hour \times 2.5 \times 0.33\ hour = 4.8\ m^3$

Finally decided value : 5 m^3

- Automatic screen

The maximum inflow rate is assumed as 14.5 m^3/hour.

Finally decided value : 15 m^3/hour

- Reaction tank 1

Batchwise treatment shall be performed once per day. The volume of waste water is 1.32 m^3 per day, and added chemicals will also be taken into account.

Finally decided value : 2 m^3

- Regenerated waste water tank

One batch capacity for regenerated waste water of softener (8m^3/day).

$8m^3/day \times 1\ day = 8m^3$

Determined value : 10m^3

- Neutralization tank

Water retention of more than 10 minutes for average water inflow (8m^3/day).

$8m^3/day \div 24h/day \div 60min/h \times 10min = 60\ l$

Equipping capacity of agitator and pH indicator

Finally decided value : 200 l

• Stabilization tank

In contract to a total inflow (washing waste water plus domestic waste water) of 6.6 m^3/hour (79.3 m^3/day), the outflow is 3.3 m^3/hour. Thus, the required capacity is as follows :

$V = (6.6 - 3.3)\ m^3/hour \times 12\ hours = 40\ m^3$

Finally decided value : 50 m^3

• Aeration tank

With BOD inflow of 16.7kg/day,

BOD capacity load = 0.4 - 0.5m^3/m^3/day

$V = 16.7kg/day \div 0.4 - 0.5m^3/m2/day = 33 - 42m^3$

Determined value : 40m^3

• Sedimentation tank 1

Water inflow : 3.3m^3/day

Water area load : Less than 0.5$m^3/m^2/h$

$A = 3.3m^3/h \div 0.5m^3/m^2/h = 6.6m^2$

Determined value : 3,000mm□

• Reaction tank 2

Water retention of more than 10 minutes for average water inflow 3.3m^3/h

$3.3m^3/h \div 60min/h \times 10min = 0.3m^3$

Determined value : 500 l

• Sedimentation tank 2

Water inflow : 3.3m^3/h

Water area load : Less than 1$m^3/m^2/h$

$A = 3.3m^3/h \div 1m^3/m^2/h = 3.3m^2$

Determined value : 2000mm□

• Monitoring tank

Water retention of over 10 minutes to mix microorganism treatment water 5.2m^3/h, compressor cooling water 3.8m^3/h (45m^3/day), and boiler cooling water 15m^3/h (180m^3/day).

$V = (3.3 + 3.8 + 15)m^3/h \times 5/60h = 3.7m^3$

Determined value : 4m^3

• Treated water tank

Water retention of 10 minutes; same as for monitoring tank

Determined value : $4m^3$

• Sludge storage tank

Volume of sludge generated per day

Coagulated sludge ($Al_2(SO_4)_3$ 18 H_2O Adding amount 42.6kg/day)

21.9 kg/day x 0.456 = 10 kg/day (as $Al(OH)_3$)

1.32 m^3/day x 5,150 g/m^3 = 6.8 kg/day (as SS)

Total 16.8 kg/day (as dry solid)

840 kg/day (as 2%)

Excess sludge

Assumed as 30% of total BOD.

16.7 kg/day x 0.3 = 5 kg/day (as dry solid)= 500 kg/day

Phosphorus-removed sludge ($Al_2(SO_4)_3$ Adding amount 5.4/day

p = 0.49/day)

5.4kg/day x 0.456kg/day

= 2.5kg/day(When entire quantity of $Al(SO_4)_3$ becomes $Al(OH)_3$)

0.49kg/day x 122/31 = 1.9kg/day (When p becomes $Al\,PO_4$)

2.5kg/day x 27/78 - 1.9kg/day x 27/122

= 0.4kg/day(Excessive quantity of Al)

0.4kg/day x 78/27 = 1.2kg/day (Quantity of SS as $Al\,(OH)_3$)

1.9kg/day + 1.2kg/day =3.1kg/day (as Dry)

=310kg/day (as Dry)

Total : 840 kg/day + 500 kg/day + 310kg/day = 1,650 kg/day

The dehydrator operating time is 8 hours/3 days and the tank shall hold three days of sludge minimum.

V = 1.34 m^3/day x 3 days = 4.95 m^3

Finally decided value : 5 m^3

• $Al_2(SO_4)_3$ tank

Volume used :

120 kg/day as Al_2O_3 8% (21.3 kg/day as dry solid)

The tank shall hold a 5 day supply.

V = 102 kg/day + 1.2 (specific gravity) x 7days = 473

Finally decided value : 500 l

• NaOH tank

Volume used :

19.2 kg/day (as 100%) = 384 kg/day (as 5%)

The tank shall hold a five day supply.

V = 381 kg/day + 1 kg/l x 5 days = 1,920

Finally decided value : 2 m^3

• Polymer tank (A) (0.1% concentration)

Volume used :

For waste water 0.018 kg/day as dry solid (0.5% of SS volume added)

For dehydration 0.11 kg/day as dry solid (0.5% of SS volume added)

For phosphorus removal 0.16kg/day as dry (Adding 2mg/l for water quantity).

Total : 0.29 kg/day as dry Dry

0.29 kg/day + 0.1% = 290 kg/day

The tank shall hold a five day supply.

V = 290 kg/day + 1 kg/l x 5 days = 1,450 l/day

Finally decided value : 1.5 m^3

• Polymer tank (K) (0.1% concentration)

Volume used : 0.11 kg/day as dry solid

0.11 kg/day + 0.1% = 110 kg/day

The tank shall hold a five day supply.

V = 110 kg/day + 1 kg/l x 5 days = 550 l

Finally decided value : 1 m^3

• Dehydrator

Sludge sedimentation tanks :

Retention shall be for roughly 5 minutes.

V = 4.95 m^3/day + 8 h/day x 5/60 = 0.052 m^3

Finally decided value : 100 l x 2 tanks

• Dehydrator

For sludge treatment : 74.7 kg/day as dry

Water content of dehydrated sludge : 85%

Treatment capacity : 74.7kg/3 days + 8h/3days = 9.3kg/h as Dry

Finally decided value : Belt press type, 10 kg/hour as dry solid

Volume of dehydrated sludge :

74.7kg/3days + 0.15 = 498 kg/3days = 166kg/day

- Aeration blower

For BOD :

BOD 16.7 kg/day + 0.12 kg O2 /kg-SS/day x 4 kg/m³ x 40 m³ = 35.9 kg/day

Assuming an oxygen solubility rate of 10% :

Required air volume = 35.9 kg/day x 1/0.1 + 0.277 m³/kg = 1,296 m³/day
= 0.9 m³/min.

For NH3 : 3.8 kg/day x 64/14 = 17.4 kg/day

Required air volume = 17.4 kg/day x 1/0.1 + 0.277 m³/kg = 628 m³/day

Assuming an air lift return volume of 200% :

Required air volume = 79.3 m³/day x 2 x 3 = 476 m³/day

Total required air volume = (1,296 m³/day + 628 m³/day + 476 m³/day) + 24 hours/day + 60 min./hour = 1.67 m³/min.

Finally decided value : 1.84 m³/min. x 4,500 mmAq x 3.7 kW

- Agitation blower

Aeration strength : 1 m³/m³/hour

Total tank volume : 62 m³

Required air volume = 62 m³ x 1 m³/m³/hour = 62 m³/day = 1.03/min.

Finally decided value : 1.28 m³/min. x 4,500 mmAq x 3.7 kW

(4) Equipment cost

The equipment cost is 92,779,000 SIT.

The equipment cost is indicated in Table 3.2.19.

Table 3.2.19 Equipment Cost

Item	Contents	Thousand SIT
Equipment	Pumps, blowers, agitators, decelerator, dehydrator	20,658,000
	Instrumentation	3,385,000
	Others (tanks)	11,738,000
	Subtotal	(35,781,000)
Site works	Equipment installation and piping	8,120,000
	Electrical work	8,575,000
	Painting work	313,000
	Civil engineering work	13,750,000
	Building work	16,250,000
	Site supervision	3,375,000
	Trial operation	1,890,000
	Subtotal	(52,273,000)
Design cost		4,725,000
	Total	92,779,000

(5) Operating cost

The operating cost is 7,699,000 SIT/year.
The operating cost is shown in Table 3.2.20.

Table 3.2.20 Operating Cost

Item	Contents	SIT/Year
Chemical costs		
NaOH	19.2 kg/day x 83.2 SIT/kg x 239 d/y	= 381,798
$Al_2(SO_4)_3$	53.1 kg/day x 39.15 SIT/kg x 239 d/y	= 496,849
Polymer A (powder)	0.29 kg/day x 990 SIT/kg x 239 d/y	= 82,814
Polymer K (powder)	0.11 kg/day x 2,000 SIT/kg x 239 d/y	= 52,580
Subtotal		= 999,834
Electricity charge	219 kwh/day x 15 SIT/kwh x 239 days =	785,115
Sludge disposal	0.166 m^3/day x 1,423 SIT/m^3 x 239 days	= 56,456
Kerosene charge	59 l/day x 60 SIT/l x 90 days	= 318,600
Maintenance Cost	62,779,000 SIT x 0.05	= 3,138,950
Personnel expenses	1,200,000 SIT/y person x 2 person/y	= 2,400,000
	Total	7,698,955

(6) Economic comment

a. Conditions

① Depreciation period : Equipment 15 years
Building, civil engineering 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
: 79m^3/day x 239 days/year = 18,88 m^3/year

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

The treatment cost per 1 m^3 of waste water is 915 SIT/m^3.
The breakdown of this unit treatment cost is shown in Table 3.2.21.
Therefore, the treatment cost per 1m^3 of all of the waste water is as follows :

(①+②+③+④) + (304 m^3/day x 239 days/year) = 238 SIT/m^3

Table 3.2.21 Classification of the treatment cost per $1m^3$ of waste water

Items		Contents	Cost (SIT/year)
Depreciation period	Equipment	62,779,000 SIT ÷ 15 years	① 4,185,267 SIT/year
	Buildings, Civil works	30,000,000 SIT ÷ 40years	② 750,000 SIT/year
Rate of interest	92,779,000 x 0.05		③ 4,638,950 SIT/year
Running cost			④ 7,699,000 SIT/year
(① + ② + ③ + ④) ÷ 18,881			3,902 SIT/m^3

3.2.4 Financial Analysis

1) Preconditions

(1) Project cases

Based on the technical comment described previously, financial analysis shall be carried out on the case of river discharge (Case 1) and the case of sewerage system discharge (Case 2).

(2) Waste water treatment capacity

Waste water treatment capacity: 72,656 m3/year
Operating days: 304 days/year

(3) Necessary funds

In addition to the plant construction cost estimated in the previous section, the funds required in each case 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 and half a year in Case 2.

Breakdown of required funds

(Unit: DEM, 1,000)

Item	Case 1	Case 2
Plant construction cost	1,084	280
Facilities and equipment	733	189
Civil engineering and building	351	91
Interest during construction	27	4
Total	1,111	284

(4) Fund raising

In the case of Marles, 50% of the required funds shall be raised as own capital, and the remaining 50% shall be obtained by means of a long-term loan. The rate of interest shall be 10%.

The preconditions including the above-mentioned items for each basic project case are indicated in Tables 3.2.22 and 3.2.25.

2) Financial analysis

The detailed breakdowns of waste water treatment cost based on the above-mentioned preconditions are shown in Tables 3.2.23 and 3.3.26, and the statements of cash income and disbursement are shown in Table 3.2.24 and 3.2.27.

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	0.25	0.14
Direct fixed cost	1.38	2.45
Treatment cost excluding depreciation and interest	(1.63)	2.59)
Depreciation and interest	1.20	0.31
Treatment cost including depreciation and interest (Total cost)	2.83	2.90

From the above table, it can be seen that the waste water treatment cost including depreciation and interest (total cost) in Case 2 (discharge into sewerage system) is slightly higher than in Case 1 (direct discharge into river), however, the difference between the two is negligible.

In Case 2, the sewage charge portion of the direct fixed cost accounts for 61% of the total cost, whereas in Case 1, the cost of depreciation, interest and repairs accounts for 60% of the total cost. This shows that the fixed cost incidental to the investment in Case 1 is equivalent to the sewage charge in Case 2.

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

Long-term debt service capacity

Item	Case 1	Case 2
(A) Cash, DEM 1,000	0.25	0.14
(B) Debt, DEM 1,000	1.38	2.45
(C) DSR, (A)/(B)		

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

The DSR in both cases is a little over 1.00, showing that there is 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	7.95% (1.42)	4.37% (1.07)
10% down	5.85% (1.21)	4.23% (1.06)
0% (basic case)	4.08% (1.05)	4.08% (1.05)
10% up	2.58% (0.97)	3.94% (1.03)
20% up	1.28% (0.80)	3.79% (1.02)
Case 2		
20% down	7.80% (1.42)	4.79% (1.12)
10% down	5.71% (1.21)	4.38% (1.08)
0% (basic case)	3.96% (1.04)	3.96% (1.04)
10% up	2.46% (0.91)	3.53% (1.01)
20% up	1.17% (0.80)	3.10% (0.97)

This shows that, in both cases, the plant construction cost is more sensitive to fluctuations than the chemicals 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 10% to 5%. The ability to repay the long-term debt (DSR) in 2010 in this case is shown below.

Long-term debt service capacity

Item	Case 1	Case 2
(A) Cash, DEM 1,000	87.19	22.26
(B) Debt, DEM 1,000	68.62	17.62
(C) DSR, (A)/(B)	1.27	1.26

(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, a healthy debt service ratio of more than 1.15 can be achieved in both cases and, moreover, that the effect of this in terms of the plant construction cost is the same as a 10% reduction.

As a result of the analyses described here, it was found that, of all the model factories, this is the only one where the waste water treatment cost will be the same regardless of discharge into the river or discharge into the sewerage system.

As with the other model factories, discharge into the sewerage system is just one alternative. On the other hand, the advantage of river discharge is that, if a fund surplus arises, the factory can make investments without concerning itself with operation of the WWTP, meaning that the factory will no longer have to pay the sewage charges it currently faces. Moreover, if low-interest funding can be obtained, the funding burden will be less than in the case of discharge into the sewerage system.

The decision on whether to discharge into the river or the sewerage system is one that should be made upon giving careful consideration to future trends in the economy.

Table 3.2.22 Project Profile and Assumptions for Financial Projection (1/3)

1 Project

Title	:	Wastewater Treatment Project
Factory	:	Marles Pohistvo d.o.o. (M-2)
Location	:	Maribor, Slovenia
Project Case	:	Base Case 1: Discharge to River
Annual Production	:	Furniture: 96,552 pieces/y
Maximum Operable Days	:	(365.25 - 126.25) x 100% = 239.00 DPY
Treatment Capacity (100%)	:	239.00 DPY x 304 m^3/d = 72,656 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*	1,084.00
- Equipment & Machinery	733.00
- Civil & Building	351.00
Interest during Construction	27.00
Fixed Capital Cost	1,111.00
Initial Working Capital	0.00
Total Capital Requirement	1,111.00

Financing Plan		DEM, '000
Equity	: 50.00 %	555.50
Long Term Loan	: 50.00 %	555.50
- Interest	: 10.00 %	
Short Term Loan	:	-
Total Project Financing Cost		1,111.00

* Including Sales Tax of 5%.

Table 3.2.22 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/m³)	Cost (DEM/m³)	Consumption ('000, Unit)	Cost DEM, '000
Chemicals			-	0.153	-	11.121
- $Al_2(SO_4)_3$	kg	0.436	0.17467	0.076	12.6910	5.533
- NaOH	kg	0.926	0.06316	0.058	4.5890	4.249
- A Polymer (powder)	kg	11.013	0.00095	0.010	0.0690	0.760
- K Polymer (powder)	kg	22.249	0.00036	0.008	0.0260	0.578
Utility Cost			-	0.100	-	7.263
- Electricity	kWH	0.059	0.72039	0.043	52.3410	3.088
- Sludge Disposal	m^3	15.830	0.00055	0.009	0.0400	0.633
- Fuel	Ltr.	0.667	0.07308	0.049	5.3100	3.542
Variable Cost	-	-	-	0.253	72.6560	18.384
Personnel	Man-Year	13,350		0.367	2.0000	26.700
Maintenance	Equipment & Machinery x 5.0%			0.504	-	36.650
Government Charge	m^3	0.053	1.0000	0.053	72.6560	3.851
Local Pollution Tax	m^3	0.453	1.0000	0.453	72.6560	32.913
Direct Fixed Cost	-	-	-	1.378	-	100.114
Cash Treatment Cost		-	-	1.631	72.6560	118.498

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/m³)	Price (DEM/m³)	Treatment ('000, Unit)	Sales DEM, '000
Treatment Fee	m^3	2.831	1.0000	2.831	72.6560	205.715

Table 3.2.22 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	10.00
- 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	2.83 - 2005	2.83 - 2010	2.83 - 2014
Treatment Cost including D&I			
- Base Case, DEM/m^3-year	3.21 - 2005	2.83 - 2010	2.53 - 2014
Sensitivity Analysis using FIRR	(-20%)	(0%)	(+20%)
- Investment Cost, %	7.95	4.08	1.28
- Chemical Cost, %	4.37	4.08	3.79
Sensitivity Analysis using DSR as of 2010	(-20%)	(0%)	(+20%)
- Investment Cost, times	1.42	1.05	0.80
- Chemical Cost, times	1.07	1.05	1.02
Debt Service Ratio (DSR), times-year			
- Base Case, @10% interest	0.78 - 2005	1.05 - 2010	1.43 - 2014
- Alt. Case, @5% interest	1.60 - 2005	1.27 - 2010	1.51 - 2014

Table 3.2.23 Wastewater Treatment Cost Statements

*** WASTEWATER TREATMENT PROJECT IN MARLES (M-2) ***
WASTEWATER TREATMENT COST STATEMENTS
: - CASE 1: DISCHARGE TO RIVER - (DEM. 1000)

YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
WASTEWATER TREATMENT (1000M3/Y)	0.0	72.66	72.66	72.66	72.66	72.66	72.66	72.66	72.66	72.66
CHEMICAL COST	0.0	11.12	11.12	11.12	11.12	11.12	11.12	11.12	11.12	11.12
AL2(SO4)3	0.0	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53
NAOH	0.0	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25
A POLYMER	0.0	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
K POLYMER	0.0	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
UTILITIES COST	0.0	7.26	7.26	7.26	7.26	7.26	7.26	7.26	7.26	7.26
ELECTRICITY	0.0	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09
SLUDGE DISPOSAL	0.0	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
FUEL	0.0	3.54	3.54	3.54	3.54	3.54	3.54	3.54	3.54	3.54
VARIABLE COST	0.0	18.39	18.39	18.39	18.39	18.39	18.39	18.39	18.39	18.39
EMPLOYMENT COST	0.0	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70
MAINTENANCE COST	0.0	36.65	36.65	36.65	36.65	36.65	36.65	36.65	36.65	36.65
GOVERNMENT CHARGE	0.0	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85
LOCAL POLLUTION TAX	0.0	32.91	32.91	32.91	32.91	32.91	32.91	32.91	32.91	32.91
DIRECT FIXED COST	0.0	100.11	100.11	100.11	100.11	100.11	100.11	100.11	100.11	100.11
CASH TREATMENT COST	0.0	118.50	118.50	118.50	118.50	118.50	118.50	118.50	118.50	118.50
EQUIPMENT & MACHINERY	0.0	48.87	48.87	48.87	48.87	48.87	48.87	48.87	48.87	48.87
CIVIL & BUILDING	0.0	8.77	8.77	8.77	8.77	8.77	8.77	8.77	8.77	8.77
INTEREST DRG. CONSTRUCTION	0.0	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
DEPRECIATION AND AMORTIZATION	0.0	59.44	59.44	59.44	59.44	59.44	59.44	59.44	59.44	59.44
TOTAL TREATMENT COST	0.0	177.94	177.94	177.94	177.94	177.94	177.94	177.94	177.94	177.94
UNIT TREATMENT COST	0.0	2.4491	2.4491	2.4491	2.4491	2.4491	2.4491	2.4491	2.4491	2.4491
INTEREST ON LONG TERM DEBT	0.0	55.55	49.99	44.44	38.88	33.33	27.77	22.22	16.66	11.11
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	233.49	227.94	222.38	216.83	211.27	205.72	200.16	194.61	189.05
UNIT TREATMENT COST	0.0	3.2137	3.1372	3.0601	2.9843	2.9078	2.8314	2.7549	2.6785	2.6020

YEAR	2014	2015	2016	2017	2018	2019
WASTEWATER TREATMENT (1000M3/Y)	72.66	72.66	72.66	72.66	72.66	72.66
CHEMICAL COST	11.12	11.12	11.12	11.12	11.12	11.12
AL2(SO4)3	5.53	5.53	5.53	5.53	5.53	5.53
NAOH	4.25	4.25	4.25	4.25	4.25	4.25
A POLYMER	0.76	0.76	0.76	0.76	0.76	0.76
K POLYMER	0.58	0.58	0.58	0.58	0.58	0.58
UTILITIES COST	7.26	7.26	7.26	7.26	7.26	7.26
ELECTRICITY	3.09	3.09	3.09	3.09	3.09	3.09
SLUDGE DISPOSAL	0.63	0.63	0.63	0.63	0.63	0.63
FUEL	3.54	3.54	3.54	3.54	3.54	3.54
VARIABLE COST	18.39	18.39	18.39	18.39	18.39	18.39
EMPLOYMENT COST	26.70	26.70	26.70	26.70	26.70	26.70
MAINTENANCE COST	36.65	36.65	36.65	36.65	36.65	36.65
GOVERNMENT CHARGE	3.85	3.85	3.85	3.85	3.85	3.85
LOCAL POLLUTION TAX	32.91	32.91	32.91	32.91	32.91	32.91
DIRECT FIXED COST	100.11	100.11	100.11	100.11	100.11	100.11
CASH TREATMENT COST	118.50	118.50	118.50	118.50	118.50	118.50
EQUIPMENT & MACHINERY	48.87	48.87	48.87	48.87	48.87	48.87
CIVIL & BUILDING	8.77	8.77	8.77	8.77	8.77	8.77
INTEREST DRG. CONSTRUCTION	1.80	1.80	1.80	1.80	1.80	1.80
DEPRECIATION AND AMORTIZATION	59.44	59.44	59.44	59.44	59.44	59.44
TOTAL TREATMENT COST	177.94	177.94	177.94	177.94	177.94	177.94
UNIT TREATMENT COST	2.4491	2.4491	2.4491	2.4491	2.4491	2.4491
INTEREST ON LONG TERM DEBT	5.55	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	183.50	177.94	177.94	177.94	177.94	177.94
UNIT TREATMENT COST	2.5256	2.4491	2.4491	2.4491	2.4491	2.4491

Table 3.2.24 Funds Flow Statements

*** WASTEWATER TREATMENT PROJECT IN NABLES (N-2) ***
FUNDS FLOW STATEMENTS
- CASE 1: DISCHARGE TO RIVER - (DEM. 1000)

YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
SOURCE OF FUNDS	1111.00	87.19	87.19	87.19	87.19	87.19	87.19	87.19	87.19	87.19
CASH GENERATED FROM OPERATION	0.0	87.19	87.19	87.19	87.19	87.19	87.19	87.19	87.19	87.19
PROFIT AFT. TAX, BFR INT.	0.0	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75
DEPRECIATION AND AMORTIZATION	0.0	59.44	59.44	59.44	59.44	59.44	59.44	59.44	59.44	59.44
FINANCIAL RESOURCES	1111.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SHARE CAPITAL	555.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LONG TERM LOAN	555.50	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	1111.00	111.10	105.54	99.99	94.43	88.88	83.32	77.77	72.21	66.66
FIXED CAPITAL EXPENDITURE	1111.00	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	1084.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INTEREST DURING CONSTRUCTION	27.00	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	111.10	105.54	99.99	94.43	88.88	83.32	77.77	72.21	66.66
REPAYMENT OF LONG TERM DEBT	0.0	55.55	55.55	55.55	55.55	55.55	55.55	55.55	55.55	55.55
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	55.55	49.99	44.44	38.88	33.33	27.77	22.22	16.66	11.11
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	-23.91	-18.36	-12.80	-7.25	-1.69	3.86	9.42	14.97	20.53
BEGINNING CASH BALANCE	0.0	0.0	-23.91	-42.27	-55.07	-62.32	-64.01	-60.14	-50.73	-35.75
ENDING CASH BALANCE	0.0	-23.91	-42.27	-55.07	-62.32	-64.01	-60.14	-50.73	-35.75	-15.22

YEAR	2014	2015	2016	2017	2018	2019
SOURCE OF FUNDS	87.19	87.19	87.19	87.19	87.19	87.19
CASH GENERATED FROM OPERATION	87.19	87.19	87.19	87.19	87.19	87.19
PROFIT AFT. TAX, BFR INT.	27.75	27.75	27.75	27.75	27.75	27.75
DEPRECIATION AND AMORTIZATION	59.44	59.44	59.44	59.44	59.44	59.44
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	61.10	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	61.10	0.0	0.0	0.0	0.0	0.0
REPAYMENT OF LONG TERM DEBT	55.55	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	5.55	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) -	26.09	87.19	87.19	87.19	87.19	87.19
BEGINNING CASH BALANCE	-15.22	10.86	98.05	185.24	272.42	359.61
ENDING CASH BALANCE	10.86	98.05	185.24	272.42	359.61	446.80

*** WASTEWATER TREATMENT PROJECT IN NABLES (N-2) ***
RETURN ON INVESTMENT (IN 1996 FIXED PRICE)
- CASE 1: DISCHARGE TO RIVER - (DEM. 1000)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
(1) GROSS CAPITAL EXPENDITURE	1084.00	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	87.19	87.19	87.19	87.19	87.19	87.19	87.19	87.19	87.19
OPERATING PROFIT	0.0	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75
DEPRECIATION & AMORTIZATION	0.0	59.44	59.44	59.44	59.44	59.44	59.44	59.44	59.44	59.44
(4) BFR-TAX NET IN-FLOW (2)-(1)	-1084.00	87.19	87.19	87.19	87.19	87.19	87.19	87.19	87.19	87.19

	2014	2015	2016	2017	2018	2019
(1) GROSS CAPITAL EXPENDITURE	0.0	0.0	0.0	0.0	0.0	-219.37
(2) GROSS CASH IN-FLOW	87.19	87.19	87.19	87.19	87.19	87.19
OPERATING PROFIT	27.75	27.75	27.75	27.75	27.75	27.75
DEPRECIATION & AMORTIZATION	59.44	59.44	59.44	59.44	59.44	59.44
(4) BFR-TAX NET IN-FLOW (2)-(1)	87.19	87.19	87.19	87.19	87.19	306.56

INTERNAL RATE OF RETURN

ON (4) BFR-TAX NET IN-FLOW (2)-(1) 4.08 PER CENT

Table 3.2.25 Project Profile and Assumptions for Financial Projection (1/3)

1 Project

Title	:	Wastewater Treatment Project
Factory	:	Marles Pohistvo d.o.o. (M-2)
Location	:	Maribor, Slovenia
Project Case	:	Base Case 2: Discharge to WWTP
Annual Production	:	Furniture: 96,552 pieces/y
Maximum Operable Days	:	(365.25 - 126.25) x 100% = 239.00 DPY
Treatment Capacity (100%)	:	239.00 DPY x 304 m^3/d = 72,656 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	:	July 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	:	0.5 Year from Start of Project Implementation

3 Financing Required and Financing Plan - 1996

Financing Required	DEM, '000
Land/Site Development	-
Plant Construction Cost*	280.00
- Equipment & Machinery	189.00
- Civil & Building	91.00
Interest during Construction	4.00
Fixed Capital Cost	284.00
Initial Working Capital	0.00
Total Capital Requirement	284.00

Financing Plan		DEM, '000
Equity	: 50.00 %	142.00
Long Term Loan	: 50.00 %	142.00
- Interest	: 10.00 %	
Short Term Loan	:	-
Total Project Financing Cost		284.00

* Including Sales Tax of 5%.

Table 3.2.25 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			-	0.115	-	8.343
- $Al_2(SO_4)_3$	kg	0.436	0.14013	0.061	10.1810	4.439
- NaOH	kg	0.926	0.05066	0.047	3.6810	3.409
- A Polymer (powder)	kg	11.013	0.00062	0.007	0.0450	0.496
Utility Cost			-	0.027	-	1.966
- Electricity	kWH	0.059	0.19079	0.011	13.8620	0.818
- Sludge Disposal	m^3	15.830	0.00037	0.006	0.0270	0.427
- Fuel	Ltr.	0.667	0.01486	0.010	1.0800	0.720
Variable Cost	-	-	-	0.142	72.6560	10.309
Personnel	Man-Year	13,350		0.037	0.2000	2.670
Maintenance	Equipment & Machinery x 5.0%			0.130	-	9.450
Government Charge	m^3	0.053	1.0000	0.053	72.6560	3.851
Local Pollution Tax	m^3	0.453	1.0000	0.453	72.6560	32.913
Sewage Charge	m^3	1.780	1.0000	1.780	72.6560	129.328
Direct Fixed Cost	-	-	-	2.453	-	178.212
Cash Treatment Cost		-	-	2.595	72.6560	188.520

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	2.901	1.0000	2.901	72.6560	210.775

Table 3.2.25 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	10.00
- 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	2.90 - 2005	2.90 - 2010	2.90 - 2014
Treatment Cost including D&I			
- Base Case, DEM/m^3-year	3.00 - 2005	2.90 - 2010	2.80 - 2014
Sensitivity Analysis using FIRR	(-20%)	(0%)	(+20%)
- Investment Cost, %	7.80	3.96	1.17
- Chemical Cost, %	4.79	3.96	3.10
Sensitivity Analysis using DSR as of 2010	(-20%)	(0%)	(+20%)
- Investment Cost, times	1.42	1.04	0.80
- Chemical Cost, times	1.12	1.04	0.97
Debt Service Ratio (DSR), times-year			
- Base Case, @10% interest	0.78 - 2005	1.04 - 2010	1.42 - 2014
- Alt. Case, @5% interest	1.05 - 2005	1.26 - 2010	1.50 - 2014

Table 3.2.26 Wastewater Treatment Cost Statements

*** WASTEWATER TREATMENT PROJECT IN MARLES (W-2) ***
WASTEWATER TREATMENT COST STATEMENTS
- CASE 2: DISCHARGE TO WWTP - (DEM. 1000)

YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
WASTEWATER TREATMENT (1000M3/Y)	0.0	72.66	72.66	72.66	72.66	72.66	72.66	72.66	72.66	72.66
CHEMICAL COST	0.0	8.34	8.34	8.34	8.34	8.34	8.34	8.34	8.34	8.34
AL2(SO4)3	0.0	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
NAOH	0.0	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41
A POLYMER	0.0	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
UTILITIES COST	0.0	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96
ELECTRICITY	0.0	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
SLUDGE DISPOSAL	0.0	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
FUEL	0.0	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
VARIABLE COST	0.0	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31
EMPLOYMENT COST	0.0	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67
MAINTENANCE COST	0.0	9.45	9.45	9.45	9.45	9.45	9.45	9.45	9.45	9.45
GOVERNMENT CHARGE	0.0	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85
LOCAL POLLUTION TAX	0.0	32.91	32.91	32.91	32.91	32.91	32.91	32.91	32.91	32.91
SEWAGE CHARGE	0.0	129.33	129.33	129.33	129.33	129.33	129.33	129.33	129.33	129.33
DIRECT FIXED COST	0.0	178.21	178.21	178.21	178.21	178.21	178.21	178.21	178.21	178.21
CASH TREATMENT COST	0.0	188.52	188.52	188.52	188.52	188.52	188.52	188.52	188.52	188.52
EQUIPMENT & MACHINERY	0.0	12.60	12.60	12.60	12.60	12.60	12.60	12.60	12.60	12.60
CIVIL & BUILDING	0.0	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27
INTEREST DRG. CONSTRUCTION	0.0	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
DEPRECIATION AND AMORTIZATION	0.0	15.14	15.14	15.14	15.14	15.14	15.14	15.14	15.14	15.14
TOTAL TREATMENT COST	0.0	203.66	203.66	203.66	203.66	203.66	203.66	203.66	203.66	203.66
UNIT TREATMENT COST	0.0	2.8031	2.8031	2.8031	2.8031	2.8031	2.8031	2.8031	2.8031	2.8031
INTEREST ON LONG TERM DEBT	0.0	14.20	12.78	11.36	9.94	8.52	7.10	5.68	4.26	2.84
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	217.86	216.44	215.02	213.60	212.18	210.76	209.34	207.92	206.50
UNIT TREATMENT COST	0.0	2.9985	2.9790	2.9594	2.9399	2.9203	2.9008	2.8813	2.8617	2.8422

YEAR	2014	2015	2016	2017	2018	2019
WASTEWATER TREATMENT (1000M3/Y)	72.66	72.66	72.66	72.66	72.66	72.66
CHEMICAL COST	8.34	8.34	8.34	8.34	8.34	8.34
AL2(SO4)3	4.44	4.44	4.44	4.44	4.44	4.44
NAOH	3.41	3.41	3.41	3.41	3.41	3.41
A POLYMER	0.50	0.50	0.50	0.50	0.50	0.50
UTILITIES COST	1.96	1.96	1.96	1.96	1.96	1.96
ELECTRICITY	0.82	0.82	0.82	0.82	0.82	0.82
SLUDGE DISPOSAL	0.43	0.43	0.43	0.43	0.43	0.43
FUEL	0.72	0.72	0.72	0.72	0.72	0.72
VARIABLE COST	10.31	10.31	10.31	10.31	10.31	10.31
EMPLOYMENT COST	2.67	2.67	2.67	2.67	2.67	2.67
MAINTENANCE COST	9.45	9.45	9.45	9.45	9.45	9.45
GOVERNMENT CHARGE	3.85	3.85	3.85	3.85	3.85	3.85
LOCAL POLLUTION TAX	32.91	32.91	32.91	32.91	32.91	32.91
SEWAGE CHARGE	129.33	129.33	129.33	129.33	129.33	129.33
DIRECT FIXED COST	178.21	178.21	178.21	178.21	178.21	178.21
CASH TREATMENT COST	188.52	188.52	188.52	188.52	188.52	188.52
EQUIPMENT & MACHINERY	12.60	12.60	12.60	12.60	12.60	12.60
CIVIL & BUILDING	2.27	2.27	2.27	2.27	2.27	2.27
INTEREST DRG. CONSTRUCTION	0.27	0.27	0.27	0.27	0.27	0.27
DEPRECIATION AND AMORTIZATION	15.14	15.14	15.14	15.14	15.14	15.14
TOTAL TREATMENT COST	203.66	203.66	203.66	203.66	203.66	203.66
UNIT TREATMENT COST	2.8031	2.8031	2.8031	2.8031	2.8031	2.8031
INTEREST ON LONG TERM DEBT	1.42	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	205.08	203.66	203.66	203.66	203.66	203.66
UNIT TREATMENT COST	2.8226	2.8031	2.8031	2.8031	2.8031	2.8031

Table 3.2.27 Funds Flow Statements

*** WASTEWATER TREATMENT PROJECT IN KARLES (K-2) ***
FUNDS FLOW STATEMENTS
- CASE 2: DISCHARGE TO WWTP - (DEN. 1000)

YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
SOURCE OF FUNDS	284.00	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26
CASH GENERATED FROM OPERATION	0.0	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26
PROFIT AFT. TAX. BFR INT.	0.0	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11
DEPRECIATION AND AMORTIZATION	0.0	15.14	15.14	15.14	15.14	15.14	15.14	15.14	15.14	15.14
FINANCIAL RESOURCES	284.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SHARE CAPITAL	142.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LONG TERM LOAN	142.00	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	284.00	28.40	26.98	25.56	24.14	22.72	21.30	19.88	18.46	17.04
FIXED CAPITAL EXPENDITURE	284.00	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	280.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INTEREST DURING CONSTRUCTION	4.00	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	28.40	26.98	25.56	24.14	22.72	21.30	19.88	18.46	17.04
REPAYMENT OF LONG TERM DEBT	0.0	14.20	14.20	14.20	14.20	14.20	14.20	14.20	14.20	14.20
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	14.20	12.78	11.36	9.94	8.52	7.10	5.68	4.26	2.84
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	-6.14	-4.72	-3.30	-1.88	-0.46	0.96	2.38	3.80	5.22
BEGINNING CASH BALANCE	0.0	0.0	-6.14	-10.87	-14.17	-16.05	-16.52	-15.56	-13.19	-9.39
ENDING CASH BALANCE	0.0	-6.14	-10.87	-14.17	-16.05	-16.52	-15.56	-13.19	-9.39	-4.17

YEAR	2014	2015	2016	2017	2018	2019
SOURCE OF FUNDS	22.26	22.26	22.26	22.26	22.26	22.26
CASH GENERATED FROM OPERATION	22.26	22.26	22.26	22.26	22.26	22.26
PROFIT AFT. TAX. BFR INT.	7.11	7.11	7.11	7.11	7.11	7.11
DEPRECIATION AND AMORTIZATION	15.14	15.14	15.14	15.14	15.14	15.14
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	15.62	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	15.62	0.0	0.0	0.0	0.0	0.0
REPAYMENT OF LONG TERM DEBT	14.20	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	1.42	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)	6.64	22.26	22.26	22.26	22.26	22.26
BEGINNING CASH BALANCE	-4.17	2.46	24.72	46.98	69.23	91.49
ENDING CASH BALANCE	2.46	24.72	46.98	69.23	91.49	113.75

*** WASTEWATER TREATMENT PROJECT IN KARLES (K-2) ***
RETURN ON INVESTMENT (IN 1996 FIXED PRICE)
- CASE 2: DISCHARGE TO WWTP - (DEN. 1000)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
(1) GROSS CAPITAL EXPENDITURE	280.00	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	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26
OPERATING PROFIT	0.0	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11
DEPRECIATION & AMORTIZATION	0.0	15.14	15.14	15.14	15.14	15.14	15.14	15.14	15.14	15.14
(4) BFR-TAX NET IN-FLOW (2)-(1)	-280.00	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26

	2014	2015	2016	2017	2018	2019
(1) GROSS CAPITAL EXPENDITURE	0.0	0.0	0.0	0.0	0.0	-56.00
(2) GROSS CASH IN-FLOW	22.26	22.26	22.26	22.26	22.26	22.26
OPERATING PROFIT	7.11	7.11	7.11	7.11	7.11	7.11
DEPRECIATION & AMORTIZATION	15.14	15.14	15.14	15.14	15.14	15.14
(4) BFR-TAX NET IN-FLOW (2)-(1)	22.26	22.26	22.26	22.26	22.26	78.26

INTERNAL RATE OF RETURN

ON (4) BFR-TAX NET IN-FLOW (2)-(1) 3.96 PER CENT

3.2.5 Pretreatment System 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

The waste water that requires pretreatment in a furniture manufacturing factory is that from the painting booths washing and the washing of gluing machines. Volumes of these kinds of waste water are very small, however, COD levels are high and the waste water contains harmful substances that will not biodegrade easily.

The pretreatment of waste water such as this generally involves coagulating treatment. The solids-liquid separation of the sludge that is generated by the coagulation can either be done by sedimentation or, in cases where the waste water has a high concentration of oil and fat, pressurized-air flotation. As the volume of waste water at this factory is extremely small, a batch system of coagulating sedimentation has been adopted. This system, as one that satisfies the WWTP discharge standards, is the same as that described in 3.2.3. This shall be assumed to be Case 1.

Organic matter will remain in the treated water from the above pretreatment system that satisfies the WWTP standards. Aerobic biological treatment is generally carried out to deal with this. Thus, the supernatant from the coagulation process shall be mixed with domestic waste water containing N and P and undergo further treatment by the contact aeration method. Furthermore, because regenerated water from the softener has a low pH value, the neutralization of this shall be conducted simultaneously. This shall be Case 2.

2) Outline of pretreatment systems

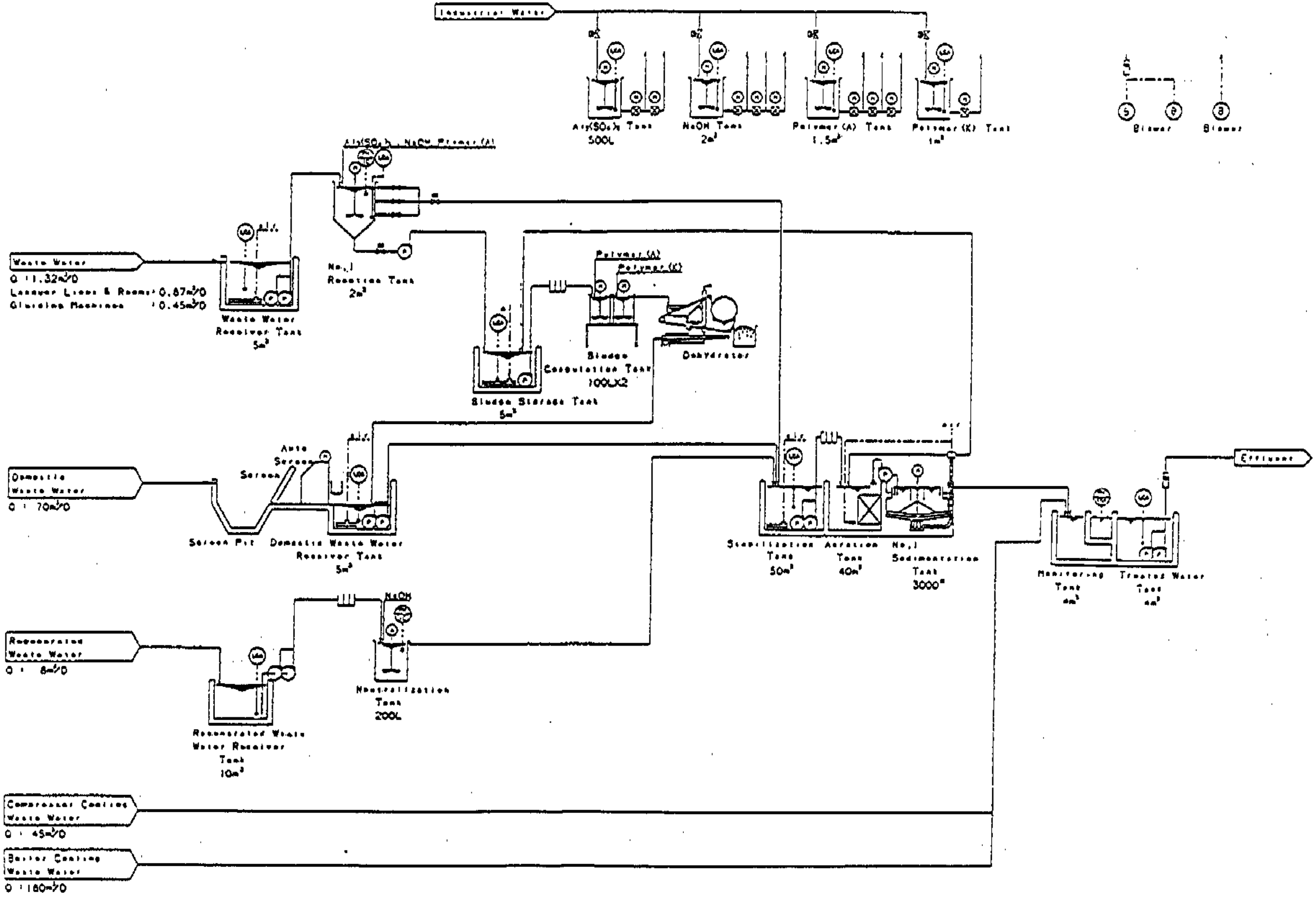
a. Case 1

The Case 1 pretreatment system is as described in 3.2.3.

b. Case 2

The flow sheet of the Case 2 pretreatment system is shown in Fig. 3.2.14. Treated water from the pretreatment system that satisfies the WWTP discharge standards is received with domestic waste water in an adjustment tank, where the two are equalized. Set amounts of this mixed waste water are fed by storage pump to the contact aeration tank, where the treatment of organic substances and ammonia nitration takes place. This treated water is then fed into the water quality monitoring tank with other waste water. In the monitoring tank, the pH value is automatically recorded and monitored before the treated water is finally discharged to the WWTP.

Fig. 3.2.14 Flow Sheet of the Case 2 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 3.2.28.

In the pretreatment system that satisfies the WWTP discharge standards, organic matter that could detrimentally affect the WWTP treatment is removed. In the subsequent pretreatment system, to which biological treatment is added in order to reduce the pollution load, the treatment of COD and BOD originating in residual organic matter takes place. However, because the removal of N and P is not sufficient here, this treated water cannot be discharged into the river.

Table 3.2.28 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)	T-N mg/ℓ (kg/d)	T-P mg/ℓ (kg/d)
Booth & Gluing	Raw Waste Water	1.32	7	10,600 (14.0)	2,880 (3.80)	5,150 (6.80)	735 (0.97)	2.7 (0.004)
	Case-1			5,300 (7.00)	2,010 (2.65)	30 (0.04)	735 (0.97)	2.0 (0.003)
	Case-2			120 (0.16)	25 (0.03)	30 (0.04)	10 (0.01)	6.2 (0.008)
Domestic	Raw Waste Water	70	7	400 (28.0)	200 (14.0)	50 (3.5)	40 (2.8)	7 (0.49)
	Case-2			120 (8.4)	25 (1.75)	30 (2.1)	10 (0.7)	6.2 (0.43)
Compressor	Raw Water	45		– ( )	– ( )	– ( )	– ( )	– ( )
Boiler	Raw Water	182		– ( )	– ( )	– ( )	– ( )	– ( )
Total Waste Water	Raw Waste Water	298	7	141 (42.0)	60 (17.8)	35 (10.3)	13 (3.8)	1.5 (0.46)
	Case-1			117 (35.0)	56 (16.7)	22 (6.7)	12 (3.7)	1.5 (0.43)
	Case-2			28 (8.51)	1 (0.30)	6 (1.82)	2 (0.61)	1.0 (0.30)
	Discharge to River			28 (8.51)	1 (0.30)	6 (1.82)	2 (0.61)	1.0 (0.30)

(2) Economic comment

The equipment and running costs of the treatment system are shown in Table 3.2.29.

Table 3.2.29 Equipment and Running Costs of the Treatment System

	Equipment Cost SIT	Depreciation & Interest SIT/m³ ①	Running Cost SIT/m³ ②	Total Treatment Cost SIT/m³ ①+②
Case-1	23,955,000	34	29	63
Case-2	44,000,000	96	78	174
Dicharge to Rever (Design Base)	92,779,000	132	106	238

4) Conclusion

If water is discharged to the WWTP, it will be necessary to add 176.56 SIT/m³ to the waste water treatment cost shown in Table 3.2.26. Thus, the least expensive method is discharge into the river.

However, the treated waste water in the case of river discharge only satisfies standards because it is diluted with boiler blow water and compressor cooling water. In the future, it is foreseen that, due to developments in manufacturing technology, changes in the times and demands from customers, etc., the facilities and raw materials used in production will change. Moreover, if water conservation advances further, the volumes of such diluting water from the boiler and compressors will fall. If such developments should occur in the future, it will become necessary to make improvements to the waste water treatment system for discharging into the river.

In view of the above, it is considered that discharging waste water to the WWTP upon first carrying out pretreatment by coagulation is the most advisable measure at the current time. If, however, WWTP discharge standards are reviewed or a charge system established according to pollution loads is adopted in future, it may become necessary to consider the next level of pretreatment, or, in the event of much harsher standards being laid down, the introduction of river discharge.

3.3 M-3 LIVARNA Maribor ARMAL

3.3.1 Factory Profile

1) Background

MARIBORSKA LIVARNA MARIBOR, p. o., originated as a Christian church bell producing company in 1952, and later expanded to include a variety of copper processed products.

Almost completely destroyed during World War II, the company nevertheless soon resumed production of welding rods for copper ware, faucets, showers, etc.

In 1974, following an amendment of the law (still in effect), it was partitioned into the following five companies :

① AKLIMAT (Producer of aluminum radiators)
② PREDELAVA BAKRA (Producer of copper alloys)
③ ARMAL (Producer of faucets, flush toilet mountings, and castings for heaters and air conditioners)
④ VZDRZEVANJE (Supplier of utilities and maintenance for group company)
⑤ MLM (Exporter and marketer of group company products)

The five companies operate in cooperation as the MARBORSKA LIVARNA MARIBOR group. Our survey, however, focused on the electro-plating factory of the ARMAL d.o.o., since its waste water is largely polluted.

The factory layout of MARIBORSKA LIVARNA MARIBOR, p.o. and ARMAL d.o.o. is shown in Fig. 3.3.1.

2) Water consumption by source and use

The volume of water usage and waste water by water source and purpose of use is shown in Table 3.3.1.

Fig. 3.3.1 Factory Layout

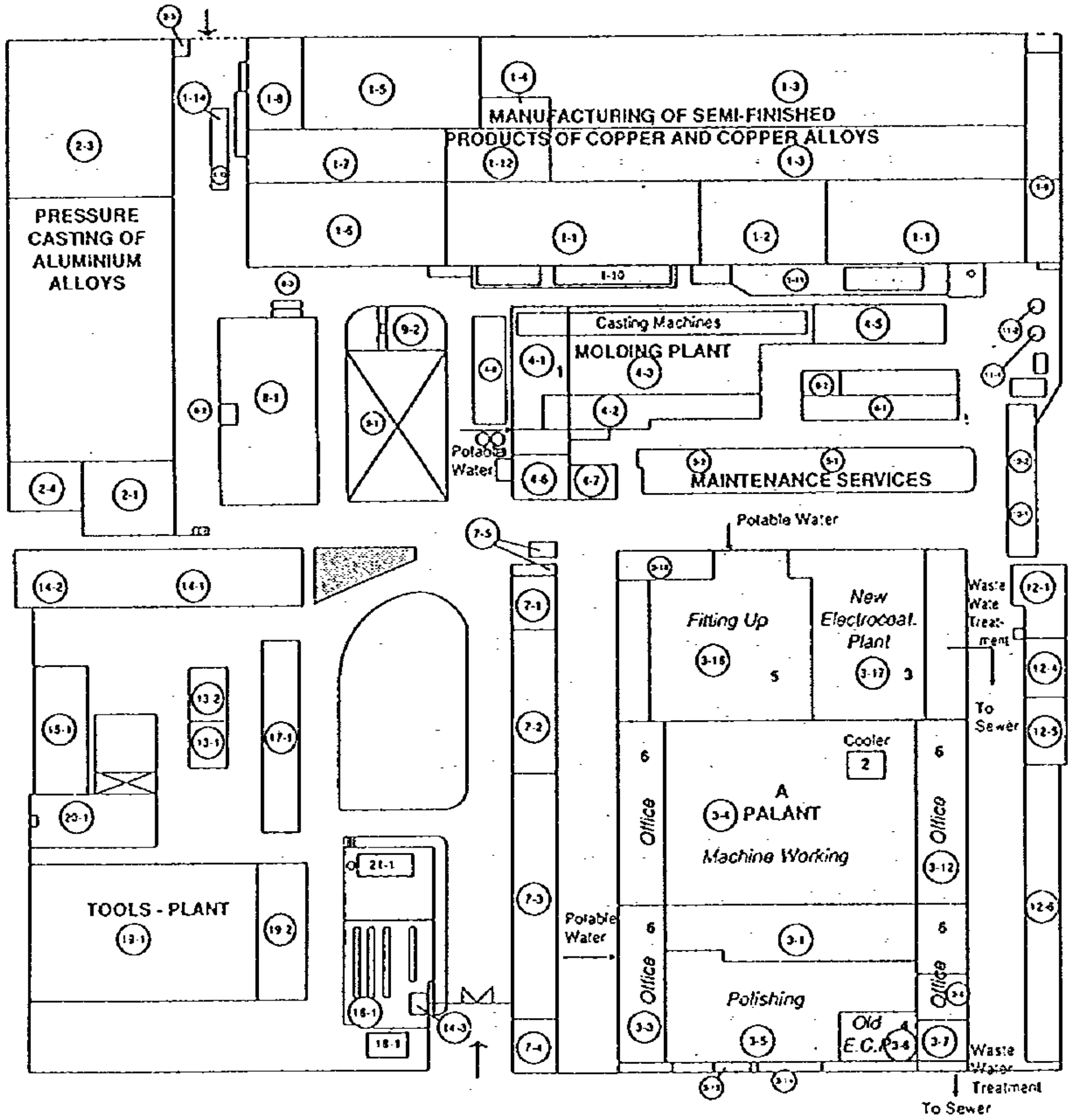


Table 3.3.1 Volume of Water Usage by Water Source and Purpose of Use

(m^3/day)

Use \ Source	Well Water	City Water	River Water	Sub-Total	Recovered Water	Total
Boiler Feed						
Raw Material						
Washing		130		130	120	250
Cooling		196		196		196
Air Conditioning						
Miscellaneous		46		46		46
Total		372		372	120	492
				Recovered Water/Total		24.4 %

3) Flow diagram of water supply and waste water discharge

The water balance of the factory is shown in Fig. 3.3.2.

(1) Water supply facilities

① Pretreatment plant

Some water supplied for the plating plant of the new factory is pure water pretreated by the pure water producing facility, which uses the ion exchange resin method with city water as a source.

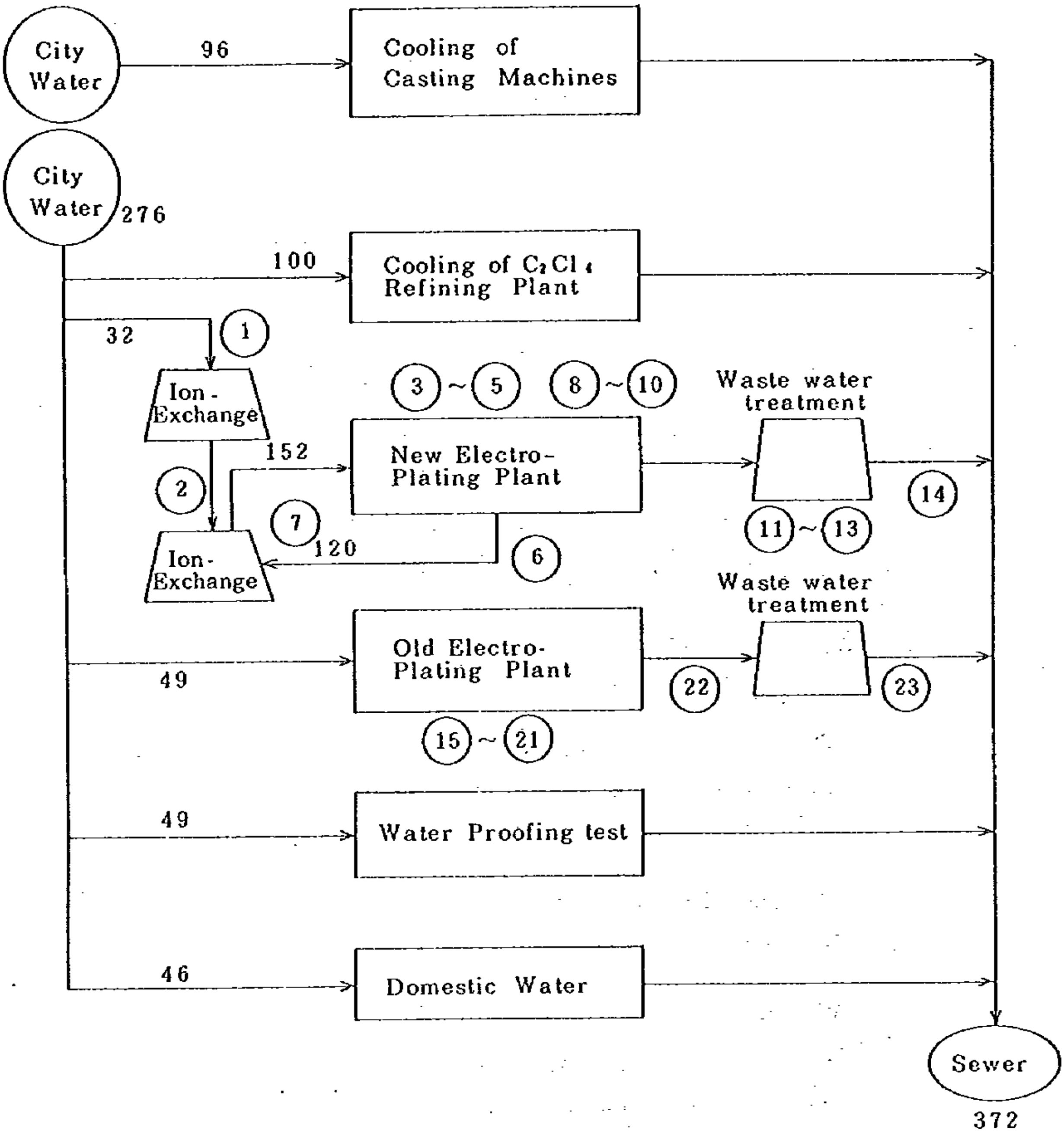
The pure water producing facility consists of the cation and anion exchange resin units.

② Water reuse plant

Water is reused at the plating facility of the new factory. With each rinsing process, the rinsing of the final step is reused. The reuse system consists of the filter, and the cation and anion exchange resin units.
The reused waste water comes from boron Fluoboric acid (HBF4) rinsing, copper plating rinsing, sulfuric acid rinsing, nickel plating rinsing and chrome plating rinsing.

These rinsings are first drained into the rinsing storage tank and then pumped into the reclamation plant.

Fig. 3.3.2 Water Balance of Factory



◯ : Sampling points of the process and waste water.

(2) Production process and source of waste water

A flow sheet of the production process is shown in the Fig. 3.3.3. The five steps are as follows :

a. Casting

Casting is produced by pouring melted copper-zinc alloy into a mold. Waste cooling water containing carbon powder is an outcome of this process.
Carbon powder is extracted from the waste water in the tank. Then the supernatant is drained.

b. Machining

Flashes of castings are shaved off, thread holes are cut, the surface is polished and the material is shaped. This process produces waste cutting oil, which is collected and disposed as industrial waste. There is no waste water discharge.

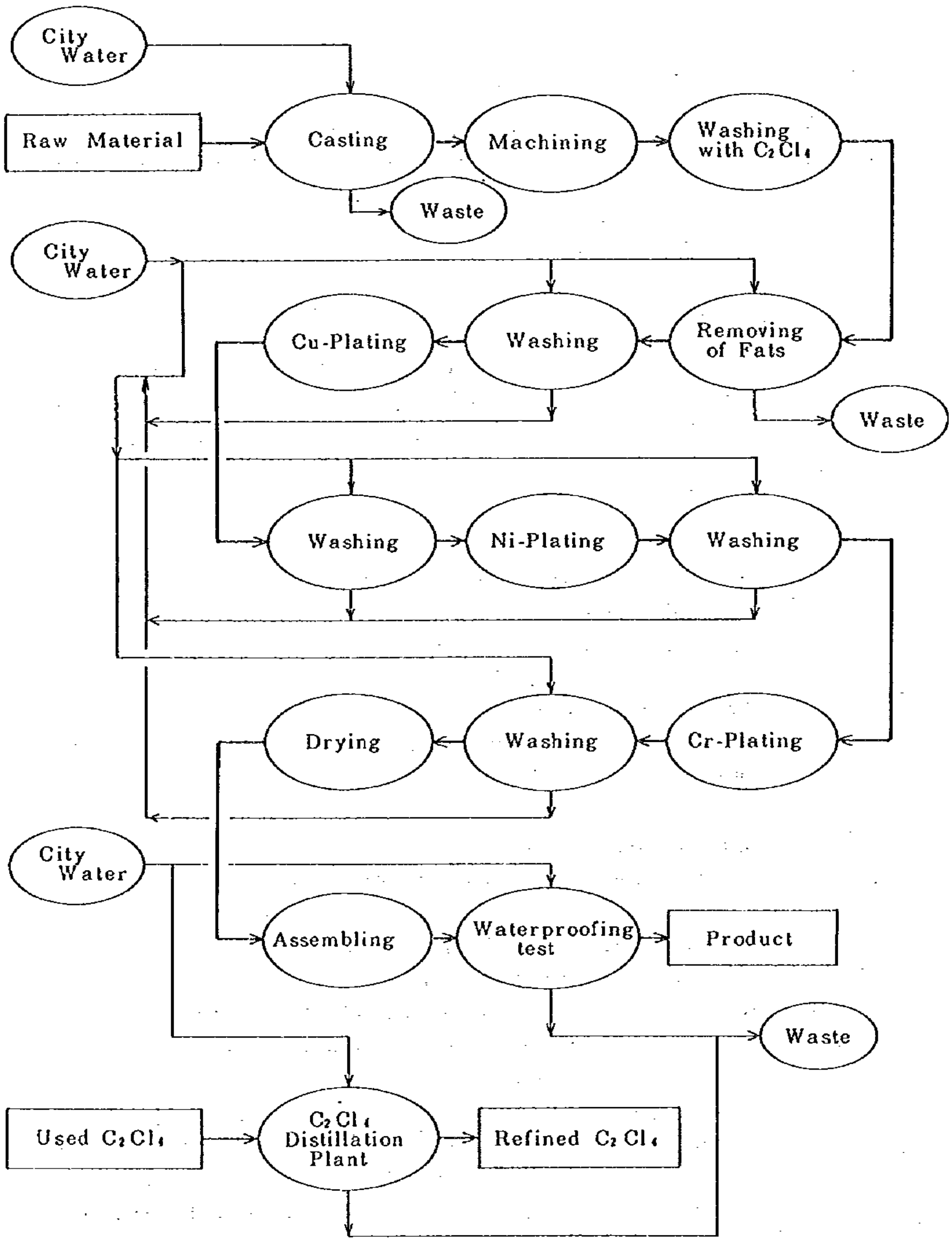
c. Electroplating

This plating process adds anticorrosion and heat resistance, and embellishments. Plating is done at both the old and new factories.
The basic steps for each factory are as follows :

Raw material → (Degreasing) → (Rinsing) → (Pickling) → (Rinsing) → (Copper plating) → (Rinsing) → (Nickel plating) → (Rinsing) → (Chrome plating) → (Rinsing) → (Drying) → Products.

Each step produces waste water. Since the plating bath is not renewed, no waste renewal water of the concentrated plating liquid is produced.
Plating is done manually at the old factory, and automatically by computer at the new factory. The plating facility at the new factory is efficiently structured, clean and well-managed.
The new factory has barrel plating and gold plating facilities. The gold plating facility has an ion exchange resin to reclaim gold from rinsing water.
There are two metal plating factories, so copper plating, nickel plating and chrome plating were designated as the basic plating processes for both factories and the agents currently used for both factories were selected for the processes. The examination is done as a unified factory of a typical model case with general characteristics.

Fig. 3.3.3 Flow Sheet of the Production Process



① Degreasing

Oil is removed from the casting surface by electro-cleaning, solvent cleaning by tetrachloroethylene (PCE) and alkaline cleaning. This process produces waste PCE, which is recycled after its impurities are extracted and separately disposed of.

② Rinsing of cleaning agent

Electro- and alkaline cleaning fluids on the material surface are washed off. This process produces rinsings of the diluted electro- and alkaline cleaning fluids.

③ Pickling and activation

This process removes the thin oxidation coating on the metal surface by placing the material in acid to ease the plating

④ Rinsing of acid

Sulfuric acid or HBF4 on the material surface is washed off. This step produces rinsing of diluted sulfuric acid or HBF4.

⑤ Copper plating

Copper plating is applied as a surface treatment plating with cyanided copper as a plating liquid.

Since the plating liquid is not replaced during this process, no waste water is produced.

⑥ Rinsing of copper plating liquid

The copper plating liquid on the material surface is washed off. This step produces diluted copper plating liquid as waste water.

⑦ Nickel plating

This process applies copper plating to nickel. Since plating liquid is not replaced, no waste water is produced.

⑧ Rinsing of nickel plating liquid

The nickel plating liquid on the surface is washed off. This process produces rinsing of diluted nickel plating liquid.

⑨ Chrome plating

This step applies chrome to the nickel plating. Since the plating liquid is not replaced, no waste water is produced.

An exhaust hood is attached over the chrome plating tank, which discharges by fan the gas and mist produced in the tank. The exhaust duct is connected to the exhaust gas collector to absorb the exhaust gas in the chrome plating liquid. Then the plating liquid is collected.

The ion exchange unit removes impurities from the degraded chrome plating liquid. The resin produces regeneration waste water which is discharged as waste water.

⑩ Rinsing of chrome plating liquid

The chrome plating liquid on the material surface is washed off. This step produces diluted chrome plating liquid as waste water.

⑪ Hot water washing (Drying)

In this final rinsing process, the material is submerged in hot water to heat it and make the surface moisture evaporate. No waste water is produced.

⑫ Other

An flaking tank for chrome plating is used to remove defective metal from defective plating materials. A water solution of NaOH is used as flaking liquid. After the flaking process, this solution is washed off.

d. Assembling

Component parts are assembled into products. No waste water is produced in this process, since no water is used.

e. Waterproof test

This process checks final products for water leakage. The waterproof test produces waste water which is not polluted.

(3) Waste water treatment plant

a. New factory

The waste water treatment plant combined with the plating facility provides for an effective means of dealing with waste water. The waste water treatment plant is installed in the first floor of the basement; one floor below the plating plant.

The flow sheet of the new factory's waste water treatment plant is shown in Fig. 3.3.4.

Waste water of the plating facility is separated into alkaline waste water and acidic waste water.

Alkaline waste water, the rinsings of the alkaline cleaning liquid and the copper plating liquid, is discharged into the waste water tank of CN/OH. Acidic waste water, the rinsings of HBF_4, H_2SO_4, nickel plating liquid and chrome plating liquid, is discharged into the waste water tank of H/Cr. The waste water pooled in each tank is pumped into another tank for oxidation, reduction, and pH control.

The pH of CN/OH waste water is controlled by adding HCl and NaOH; and oxidization decomposition of CN is accomplished by adding NaClO.

The pH of H/Cr waste water is controlled in the same manner, and reduction of Cr^{6+} is accomplished by adding $NaHSO_3$.

After oxidation or reduction treatment of the waste water, pH control is once again applied, resulting in hydroxide of the heavy metals.

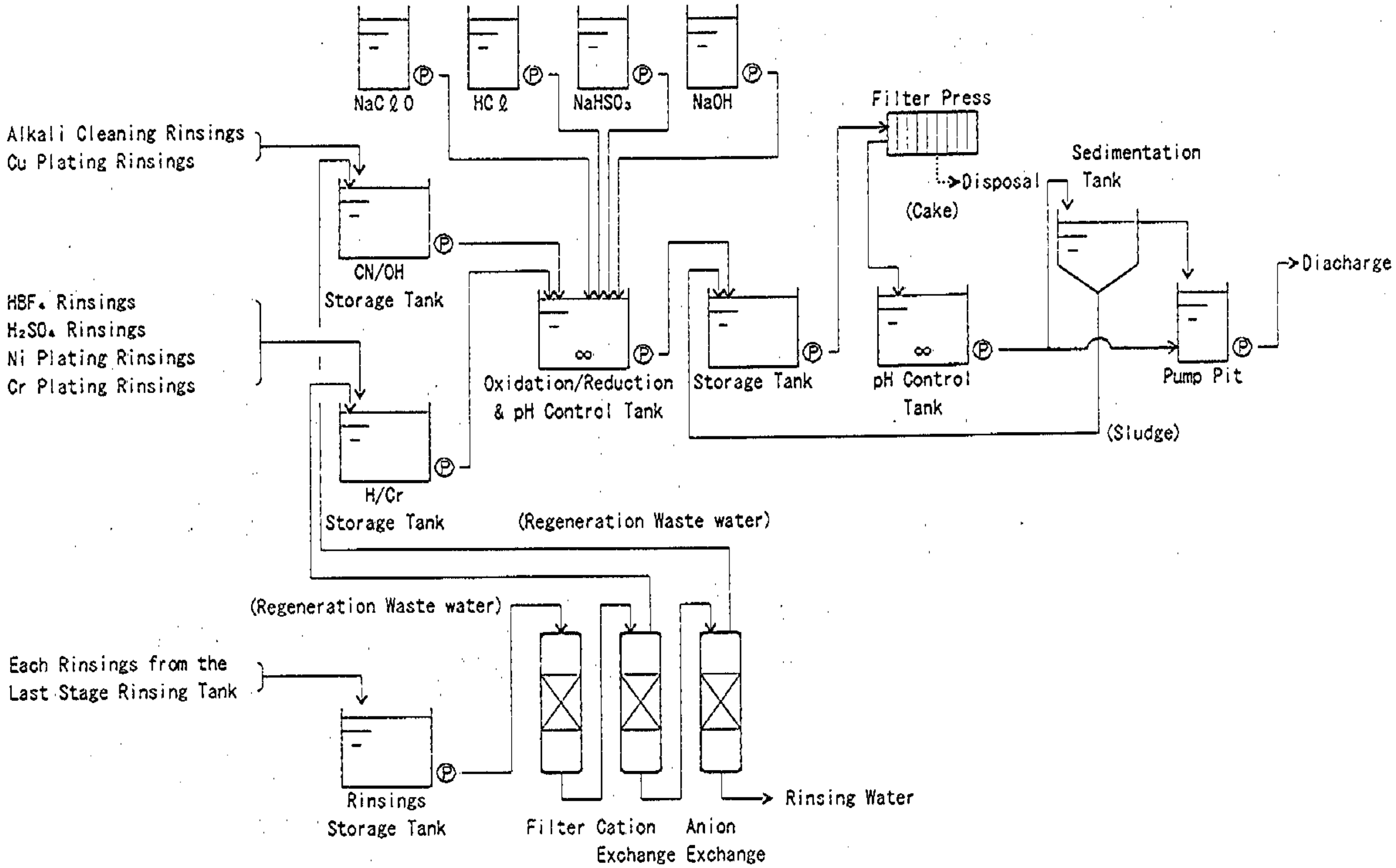
After this is completed, the waste water is pumped into another storage tank. A dehydrating agent is added, and the water is then pumped into a filter press to dehydrate the sludge produced.

The filtered water is pooled in the pH control tank, and the sludge cakes are sent to a waste disposal field.

The pH of the control tank is adjusted to the discharge standard. The pH adjusted water is pumped to a sedimentation tank, where the remaining fine SS is precipitated.

In most cases treated water is not sent to the sedimentation tank, but instead is directly pumped into the next pump pit and discharged.

Fig. 3.3.4 New Factory's Waste Water Treatment and Re-use Plant Flow Sheet



The chemical dosing, waste water, and reaction tanks are installed in a dike with ventilation facilities. This is sound management in that it ensures safety in working conditions.

The new factory's waste water treatment plant performs the copper and chrome plating rinsings of the old factory, in addition to the barrel and gold plating rinsings.

In the new factory, each final rinsing of the plating process is reclaimed by ion exchange resin. The regenerated waste water of this resin is treated by the same factory's waste water treatment plant.

b. The old factory

The old factory is responsible for plating touch-up and plating of materials not automatically plated.

This factory has alkaline cleaning and rinsing tanks; and HBF_4 and rinsing tanks. It also has a PCE tank, electro-rinsing tank and flaking tank not found in the new factory. They are manually operated.

The rinsing tank is continuously overflowing, but the copper plating rinsing and the chrome plating rinsing are pooled in each tank in the basement of the factory. As a result no waste water is discharged from them.

A cooling port which prevents the PCE from vaporization is installed in the upper wall of the PCE tank. Waste PCE is collected and its impurities removed by the factory's solvent reclamation facility.

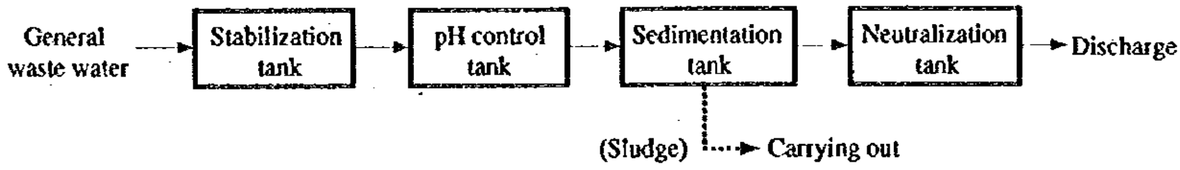
The impurities are appropriately disposed of as industrial waste, and thus no PCE is discharged.

Other rinsings are discharged as general waste water, apart from the copper plating rinsing which contains CN, and the chrome plating rinsing which contains Cr^{6+}. The waste water treatment plant of the old factory is evidently installed to remove heavy metals.

At present (June 1996) the waste water treatment plant is being renovated to improve treatment efficiency.

The flow sheet of the waste water treatment system is shown in Fig. 3.3.5.

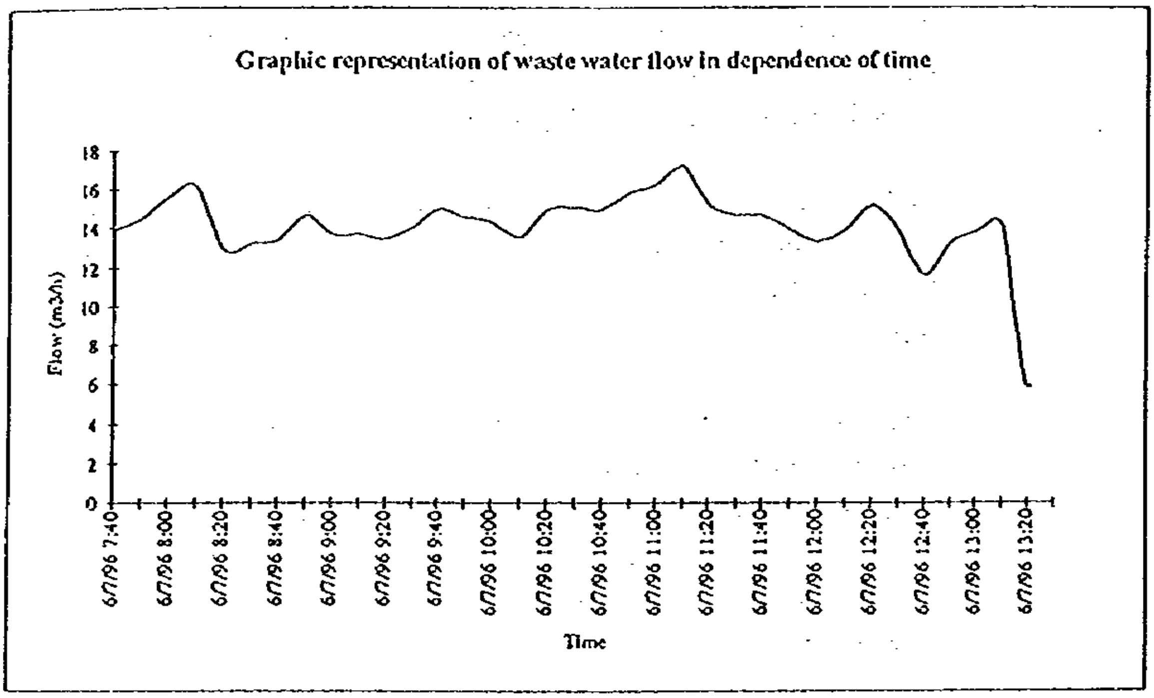
Fig. 3.3.5 Flow Sheet of Plating Waste Water Treatment System of Old Factory



Waste water is discharged at 7-10 m^3/h. The average is $49m^3/day$.

The waste water amount measured on the sampling date of June 7th is shown in Fig. 3.3.6. As indicated, waste water was discharged at an almost constant $15m^3/h$ during the day.

Fig. 3.3.6 Waste Water Discharge by Waste Water Treatment System of the Old Factory



(4) Waste water treatment and water management system

One engineer and two technicians are in charge of the waste water treatment and the water management at both old and new factories. The operation time of the waste water and water treatment plant is 12 hours.

(5) Other related conditions

The plating facility of the new factory is equipped with ventilation , for safety as well as resource recycling.

a. Organic solvent reclamation unit

At the old factory, organic solvent PCE is used for degreasing. Waste PCE is collected and reclaimed through the solvent reclamation unit.

b. Chrome plating evaporative enrichment unit

The exhaust hood over the chrome plating tank, connected to the evaporative enrichment unit, discharges exhaust gas.
Chrome plating liquid is used as an absorber, to collect scattered gas or mist for reuse.

c. Chrome plating liquid reclamation unit

Degradation of plating liquid is caused by the following factors : electro-oxidation of the plating liquid agent ; oxidation by air ; self-oxidation of the reducing agent ; transferring ; extraneous matter on plating material ; elution from material ; mixed reverse inflow from exhaust duct ; and elution from tank, pipe, and ancillary equipment.
The main cause of deterioration is the formation of Cr^{3+}, which is eliminated by the ion exchange resin facility. The chrome plating liquid is reclaimed for use.

(6) Evaluation of present system

The present system is adequate, for the following reasons :

① Waste water is classified for discharge.
② The unit operation to eliminate noxious materials is appropriately included in the waste water treatment plant.
③ Sufficient safety measures are taken.
④ The resource recovery facility is fully equipped.

The waste water treatment plant should be therefore properly operated and well managed in order to perform its ability.

The waste water treatment plant and the reclamation facility can be improved by the following suggestions for the treatment system.

① Treat HBF_4 rinsing separately.

HBF_4 cannot be treated by the addition of calcium ion alone. It must be separately treated.
HBF_4 is a stable complex ion. In water, however, it is hydrolyzed and its fluorine ion dissociated. It exists at the equilibrium state of the following (1)-(4) :

$$HBF_4+H_2O \Leftrightarrow HBF_3(OH)+HF \quad (1)$$
$$HBF_3(OH)+H_2O \Leftrightarrow HBF_2(OH)_2+HF \quad (2)$$
$$HBF_2(OH)+H_2O \Leftrightarrow HBF(OH)_3+HF \quad (3)$$
$$HBF(OH)+H_2O \Leftrightarrow H_3BO_3+HF \quad (4)$$

If calcium ion is added to HF and eliminated as CaF_2 , reaction proceeds to the right, and BF_4^- is decomposed. But the reaction of Formula (1) at ordinary temperatures is relatively slow. Aluminum salt is added as a catalyst to raise the temperature and accelerate reaction.

$$3HBF_4 + Al_2(SO_4)_3 + 6H_2O \rightarrow 2H_3AlF_6 + 2H_2SO_4 + 3H_3BO_3$$
$$2H_3AlF_6 + 6Ca(OH)_2 \rightarrow 6CaF_2 + Al(OH)_3 + 4H_2O$$

② Install a filtering unit before the final neutralization treatment (before discharge).

Examination of the treated water revealed SS (probably a heavy metal hydroxide), though less than is commonly detected. A filtering unit should be installed to eliminate SS.

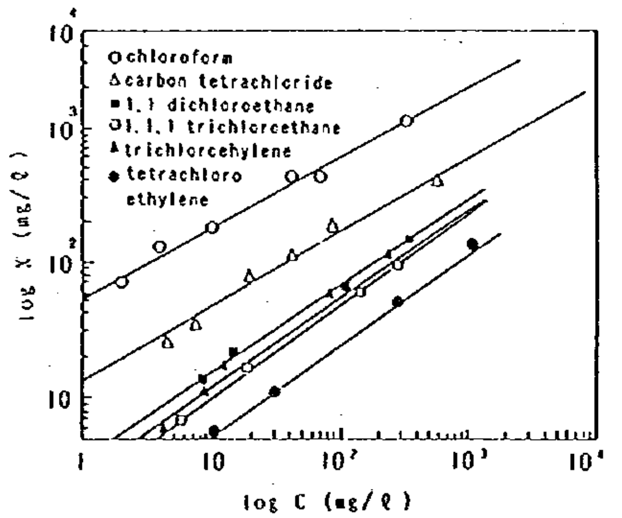
③ Install an activated carbon absorber after the filtering unit.

There is concern that organic solvent adhering to materials is transported out of the tank and mixed with waste water. The organic component of waste water could thereby exceed the effluent standard of TOC. The activated carbon absorber should be installed after the filtering process to prevent this occurrence.

The organic chlorine compound (which boils at a low temperature), dissolved in water, is absorbed by activated carbon.

The absorption isothermal lines of the organic chlorine compound (i.e., the relationship between strength in water and equilibrium absorption against strength), is shown in the Fig. 3.3.7.

Fig. 3.3.7 Absorption Isothermal Lines of Organic Chlorine Compound in Water, against Activated Carbon (25°C)



Source) Editing Committee on Pollution Prevention Technology and Legislation: Pollution Prevention Technology and Legislation (Water Quality Edition), Industrial Pollution Control Association of Ja[an (1993)

④ Install a chelate resin unit after the activated carbon absorber.

In certain cases, chelate agent is added to the alkaline cleaning agent. There is concern that material containing residue alkaline cleaning agent on the surface could leave the tank and mix with heavy metals in waste water to be discharged.

Since complex treatment is beyond the capacity of the present treatment system, a chelate resin unit should be installed after the activated carbon absorber.

⑤ Install an activated carbon absorber at the final stage of the plating rinsing of thewaste water reuse system.

During reuse treatment, various types of organic matter added to the plating liquid accumulate in the circulating water. An activated carbon absorber should be placed at the final step of the reuse system to prevent plating problems caused by this accumulation.

⑥ Install a reclamation system for each type of plating rinsing.

When nickel plating rinsing is mixed with the copper plating rinsing, cyan complex of nickel can form. This is very difficult to treat. A reuse system should be installed for each kind of waste water, in order to prevent both this problem and the plating problem mentioned in (e).

4) Quality of feed water and waste water

(1) Quality of feed water

The quality of feed water is shown in Table 3.3.2.

The sample numbers and sampling locations are as follows :

(No.1) City water as feed water

(No.2) City water treated by water demineralizer, a pretreatment facility.

Table 3.3.2 Quality of Feed Water

Items \ Name of Sample \ No.	1 City Water	2 Outlet of I.E. Plant
Fe (mg/ℓ)	< 0.05	< 0.05
Mg (mg/ℓ)	< 0.05	< 0.05
T-Hardness * (°dH)	15.6	< 0.5
M-Alkalinity (mmol/ℓ)	4.3	0.07
Cℓ (mg/ℓ)	12	< 1
TDS (mg/ℓ)	360	< 30

(NOTE) * : mmol/ℓ as CaCO

(2) Quality of waste water

Table 3.3.3 shows the quality of rinsing to be treated at the reuse plant and its treated water, and waste water treated by the waste water treatment plant and its treated water.

The sample numbers and the sampling locations are as follows :

(No.3-5)	Rinsings to be treated by new factory's reuse plant
(No.6)	Rinsing storage tank of new factory's reuse plant
(No.7)	Treated water of new factory's reuse plant
(No.8-10)	Rinsing of new factory's plating facility
(No.11)	CN/OH rinsing storage tank of new factory's waste water treatment plant
(No.12)	H/Cr rinsing storage tank of new factory's waste water treatment plant
(No.13)	Oxidation reduction and pH control tank of new factory's waste water treatment plant

(No.14) Discharge (composite sample) of new factory's waste water plant

(No.15-21) Plating bath and rinsing of old factory's plating facility

(No.22) General waste water (composite sample) of old factory's plating facility

(No.23) Discharge of old factory's waste water treatment plant

Table 3.3.3 Quality of Waste Water and Treated Water (1/5)

No.	3	4	5	6	7
Items \ Name of Sample	Rinsing (1.12)	Rinsing (1.13)	Rinsing (1.21)	Storage Tank (B 1)	Outlet of [E (A 1)
Temp. (℃)	25	20	23	–	–
pH (–)	6.0	4.5	8.1	7.8	5.4
SS (mg/ℓ)	–	–	–	–	–
B (mg/ℓ)	–	–	–	<0.05	0.4
Cu (mg/ℓ)	4.7	1.3	0.06	1.8	<0.05
Zn (mg/ℓ)	<0.05	<0.05	<0.05	<0.05	<0.05
T-Cr (mg/ℓ)	0.11	0.70	0.11	0.25	0.085
Cr^{6+} (mg/ℓ)	<0.05	0.38	<0.05	<0.05	<0.05
Ni (mg/ℓ)	<0.05	0.35	46	1.3	0.31
$N\text{-}NH_3$ (mg/ℓ)	–	–	–	–	–
T-CN (mg/ℓ)	14	8.0	0.04	4.6	7.0
T-F (mg/ℓ)	<0.01	<0.01	0.17	0.58	<0.01
T-P (mg/ℓ)	–	–	–	–	–
COD_{Cr} (mg/ℓ)	–	–	–	–	15
T-fat (mg/ℓ)	–	–	–	–	–
$CHCℓ_3$* (mg/ℓ)	–	–	–	–	–
$CH_2Cℓ_2$* (mg/ℓ)	–	–	–	–	–
$CCℓ_4$* (mg/ℓ)	–	–	–	–	–
$Cℓ_2CHCHCℓ_2$* (mg/ℓ)	–	–	–	–	–
$Cℓ_2CHCH_2Cℓ$* (mg/ℓ)	–	–	–	–	–
$CH_3CCℓ_3$* (mg/ℓ)	–	–	–	–	–
C_6H_6 (mg/ℓ)	–	–	–	–	–
C_7H_8 (mg/ℓ)	–	–	–	–	–
$C_6H_4(CH_3)_2$ (mg/ℓ)	–	–	–	–	–
Anionic surfactants (mg/ℓ)	–	–	–	–	–

(Note) * : Expression as Cℓ

Table 3.3.3 Quality of Waste Water and Treated Water (2/5)

Items \ No. / Name of Sample	8 Rinsing (1.7)	9 Rinsing (1.16)	10 Rinsing (1.22)	11 CN/OH Storage Tank (B 11)	12 H/Cr Storage Tank (B 12)
Temp. (℃)	16	22	23	—	—
pH (−)	8.2	<1	7.8	11.4	2.0
SS (mg/ℓ)	—	—	—	—	—
B (mg/ℓ)	—	—	—	—	—
Cu (mg/ℓ)	0.17	730	0.05	27	—
Zn (mg/ℓ)	<0.05	290	<0.05	1.3	—
T-Cr (mg/ℓ)	0.14	—	0.08	—	140
Cr^{6+} (mg/ℓ)	0.09	—	0.05	—	110
Ni (mg/ℓ)	0.07	320	560	—	—
$N-NH_3$ (mg/ℓ)	—	—	—	—	—
T-CN (mg/ℓ)	0.03	<0.01	400	44	0.26
T-F (mg/ℓ)	0.10	23	1.0	—	—
T-P (mg/ℓ)	—	—	—	—	—
COD_{cr} (mg/ℓ)	—	—	—	890-#	170
T-fat (mg/ℓ)	—	—	—	—	—
$CHCℓ_3$* (mg/ℓ)	—	—	—	—	—
$CH_2Cℓ_2$* (mg/ℓ)	—	—	—	—	—
$CCℓ_4$* (mg/ℓ)	—	—	—	—	—
$Cℓ_2CHCHCℓ_2$* (mg/ℓ)	—	—	—	—	—
$Cℓ_2CHCH_2Cℓ$* (mg/ℓ)	—	—	—	—	—
$CH_3CCℓ_3$* (mg/ℓ)	—	—	—	—	—
C_6H_6 (mg/ℓ)	—	—	—	—	—
C_7H_9 (mg/ℓ)	—	—	—	—	—
$C_6H_4(CH_3)_2$ (mg/ℓ)	—	—	—	—	—
Anionic surfactants (mg/ℓ)	—	—	—	—	—

(Note) * : Expression as Cℓ

Table 3.3.3 Quality of Waste Water and Treated Water (3/5)

Items \ No. / Name of Sample	13 ORP Reactor (B 13)	14 Effluent (B 17)
Temp. (℃)	--	—
pH (−)	7.2	9.1
SS (mg/ℓ)	—	50
B (mg/ℓ)	—	0.5
Cu (mg/ℓ)	—	1.4
Zn (mg/ℓ)	—	0.54
T-Cr (mg/ℓ)	1.1	0.20
Cr^{6+} (mg/ℓ)	<0.05	<0.05
Ni (mg/ℓ)	—	1.1
$N-NH_3$ (mg/ℓ)	—	0.45
T-CN (mg/ℓ)	<0.01	<0.01
T-F (mg/ℓ)	—	4.2
T-P (mg/ℓ)	—	0.94
COD_{Cr} (mg/ℓ)	490	20
T-fat (mg/ℓ)	—	<5
$CHCℓ_3$* (mg/ℓ)	—	<0.01
$CH_2Cℓ_2$* (mg/ℓ)	—	<0.01
$CCℓ_4$* (mg/ℓ)	—	<0.01
$Cℓ_2CHCHCℓ_2$* (mg/ℓ)	—	<0.01
$Cℓ_2CHCH_2Cℓ$* (mg/ℓ)	—	<0.01
$CH_3CCℓ_3$* (mg/ℓ)	—	<0.01
C_6H_6 (mg/ℓ)	—	<0.01
C_7H_8 (mg/ℓ)	—	<0.01
$C_6H_4(CH_3)_2$ (mg/ℓ)	—	<0.01
Anionic surfactants (mg/ℓ)	--	<0.05

(Note) * : Expression as Cℓ

Table 3.3.3 Quality of Waste Water and Treated Water (4/5)

No.	15	16	17	18	19
Items \ Name of Sample	Alkali De-ffatig Bath	Acid Bath	Cu Plating Bath	Rinsing of Cu Plating	Ni Plating Bath
Temp. (℃)	18	20	25	25	18
pH (−)	11.6	1.3	10.5	10.4	5.4
SS (mg/ℓ)	−	−	−	550	−
B (mg/ℓ)	−	−	−	1,300	−
Cu (mg/ℓ)	−	3.6	45,000	17,000	−
Zn (mg/ℓ)	4.3	72	710	130	−
T-Cr (mg/ℓ)	−	−	−	110	0.70
Cr^{6+} (mg/ℓ)	−	−	−	<0.05	−
Ni (mg/ℓ)	−	−	−	970	88,000
$N\text{-}NH_3$ (mg/ℓ)	−	−	−	18	−
T-CN (mg/ℓ)	30	−	−	3,400	−
T-F (mg/ℓ)	−	3,400	−	23	−
T-P (mg/ℓ)	−	−	−	1.1	−
COD_{cr} (mg/ℓ)	1,200	30	54,000	19,000	53,000
T-fat (mg/ℓ)	<5	−	−	<5	−
$CHCℓ_3$* (mg/ℓ)	−	−	−	−	−
$CH_2Cℓ_2$* (mg/ℓ)	−	−	−	−	−
$CCℓ_4$* (mg/ℓ)	−	−	−	−	−
$Cℓ_2CHCHCℓ_2$* (mg/ℓ)	−	−	−	−	−
$Cℓ_2CHCH_2Cℓ$* (mg/ℓ)	−	−	−	−	−
$CH_3CCℓ_3$* (mg/ℓ)	−	−	−	−	−
C_6H_6 (mg/ℓ)	−	−	−	−	−
C_7H_8 (mg/ℓ)	−	−	−	−	−
$C_6H_4(CH_3)_2$ (mg/ℓ)	−	−	−	−	−
Anionic surfactants (mg/ℓ)	2.6	−	−	3.1	−

(Note) * : Expression as Cℓ

Table 3.3.3 Quality of Waste Water and Treated Water (5/5)

No. Items \ Name of Sample	20 Cr Plating Bath	21 Rinsing of Cr Plating	22 Influent of W.W. Plant	23 Effluent of W.W. Plant
Temp. (℃)	25	25	18	20
pH (—)	1.0	3.0	7.4	8.9
SS (mg/ℓ)	—	210	<30	120
B (mg/ℓ)	—	3,000	0.1	0.08
Cu (mg/ℓ)	—	330	0.36	0.43
Zn (mg/ℓ)	—	260	0.17	0.21
T-Cr (mg/ℓ)	280,000	5,700	0.75	0.98
Cr^{6+} (mg/ℓ)	220,000	5,200	0.31	0.27
Ni (mg/ℓ)	—	300	0.72	0.85
$N\text{-}NH_3$ (mg/ℓ)	—	76	0.17	0.05
T-CN (mg/ℓ)	—	<0.01	0.24	0.13
T-F (mg/ℓ)	—	0.40	0.26	0.21
T-P (mg/ℓ)	—	43	1.6	0.7
COD_{Cr} (mg/ℓ)	—	—	<15	20
T-fat (mg/ℓ)	—	<5	<5	<5
$CHCℓ_3$* (mg/ℓ)	—	—	<0.01	<0.01
$CH_2Cℓ_2$* (mg/ℓ)	—	—	<0.01	<0.01
$CCℓ_4$* (mg/ℓ)	—	—	<0.01	<0.01
$Cℓ_2CHCHCℓ_2$* (mg/ℓ)	—	—	0.02	0.01
$Cℓ_2CHCH_2Cℓ$* (mg/ℓ)	—	—	0.13	0.10
$CH_3CCℓ_3$* (mg/ℓ)	—	—	<0.01	<0.01
C_6H_6 (mg/ℓ)	—	—	<0.01	<0.01
C_7H_8 (mg/ℓ)	—	—	<0.01	<0.01
$C_6H_4(CH_3)_2$ (mg/ℓ)	—	—	<0.01	<0.01
Anionic surfactants (mg/ℓ)	—	3.9	<0.05	<0.05

(Note) * : Expression as Cℓ

3.3.2 Water Conservation

1) Current condition of water usage and water conservation

(1) Water usage

① The water source is strictly city water supplied to the casting plant and the plant (A).

② Recovery water is used in the new plating plant at the rate of120 m^3/day.

③ 53% of the water is used for cooling water; 35% for washing and processing water; and the remainder miscellaneous.

④ About 50% of the cooling water is for direct cooling, and about 50% for indirect cooling. The cooling water is not recycled.

⑤ About 62% of the washing and processing water is used in the plating process, and about 38% for the waterproof test of final products.

(2) Water conservation

① Water conservation is practiced in the new plating plant and in the plating facility.

② Water controlling is inadequate in the old plating facility, where plating is manually performed.

③ The direct cooling water used in the casting plant is polluted and thus extremely difficult to recycle.

④ It is possible to recycle the indirect cooling water used for the TCE reclamation system, which at present is not recycled. The water temperature is rather high (city water temperature + 10°C approx.), but the water quality is good.

2) Planning of water conservation system

(1) To reuse indirect cooling water of TCE reclamation system for the waterproof test of final products. (case 1)

(a) Outline of plan

The indirect cooling water of TCE reclamation system is not at present recycled. The temperature of water at the outlet is about 25°C, with no change in water quality. This effluent is to be reused for waterproof test of final products in the assembly plant of the same building.

(b) Basic conditions

The basic conditions are shown in Table 3.3.4

Table 3.3.4 Basic Conditions

	Water quantity (m^3/d)	Operation time (h/d)	Water quantity (m^3/h)	Operation days quantity (d/y)	Water saving (m^3/d)
Present TCB reclamation system	100	16	6.25	229	
Present waterproof test facility	49	8	6.13	235	
Amount of reused water and time period	(49)	(8)	(6.25)	(229)	(48)

(c) Cost estimate

- Facility cost
  Pipes and piping work 1 set 750 (thousand SIT)
- Operation cost
  Same as current operating cost 0
- Required cost

Table 3.3.5 shows required costs

Table 3.3.5 Required Costs

Item		Annual cost (thousand SIT/y)	Cost per recovered water (SIT/m^3)	Remarks
Fixed cost	Facility depreciation	50.3	4.58	15year equal depreciation
	Interest	37.5	3.41	10%
	Sub-total	87.8	7.99	
Operation cost		0	0	
Total		87.8	7.99	

(2) To reuse indirect cooling water of TCE reclamation system as direct cooling water for casting plant. (case 2)

(a) Outline of plan

The indirect cooling water of the TCE reclamation system is used only once. The water temperature at the outlet is about 25°C, with no change in water quality.
This effluent will be reused as direct cooling water for the casting plant of a different building.

(b) Basic conditions

The basic conditions are shown in Table 3.3.6

Table 3.3.6 Basic Conditions

	Water quantity (m^3/d)	Operation time (h/d)	Water quantity (m^3/h)	Operation days (d/y)	Water saving quantity (m^3/d)
Present TCE reclamation system	100	16	6.25	229	
Present casting cooling water	96	21.6	4.44	202	
quantity of reusing water and the period	(71)	(16)	(4.44)	(202)	(71)

(c) Cost estimate

- Facility cost

Pipes and piping work	1 set	1,500 (thousand SIT)
Cooling water tank	1 (1.5 m^3)	200
Instrument/ controller	1 set	100
Pump (1 Spare)	2 (40ø, 1.5 kw)	360
Installation cost, etc.	1 set	140
Total		2,300

- Operation cost

Electricity 1.5 kw x 0.8 x 16 h/d x 15 SIT/kwh x 202 d/y
= 58.2 (thousand SIT/y)

Labor cost Concurrent work

- Required costs

The required costs are shown in Table 3.3.7

Table 3.3.7 Required Costs

Item		Annual cost (thousand SIT/y)	Cost per recovered water (SIT/m^3)	Remarks
Fixed cost	Facility depreciation	153.3		15year equal depreciation
	Interest	115.0		10%
	Facility maintenance cost	115.0		5% of facility cost/year
	Sub-total	383.3	26.73	
Operation cost		58.2	4.06	
Total		441.5	30.79	