(3) Comment and evaluation of Case 1 and Case 2

(a) Technical comment

① Since the indirect cooling water for TEC reclamation system is used only once, the water temperature at the outlet is about 25°C, with no change in water quality.

② The plans for the effluent reuse (Cases 1 and 2) differ to a certain extent in water quantity, operation time, and operation days. But these problems can be technically solved to create an effective means of water conservation.

(b) Economic comment

The cost per recovered water in this water reuse plan is about 8 SIT/$m^3$ (Case 1), and about 31 SIT/$m^3$ (Case 2).

The costs are examined under the following conditions :

① Case 1 and 2 are economically feasible, because the present cost of water and effluent is about 200SIT/$m^3$.

② Since over 100SIT/$m^3$ is expected for future sewerage fees, both Case 1 and Case 2 have good returns.

③ The facility cost of Case 2 is only about 0.1% of annual sales. The company is thus advised to take these plans into consideration.

### 3.3.3 Pretreatment that Satisfy WWTP Discharge Standards, and Waste Water Treatment

This consists of the casting plant, the machining plant and the plating plant. The plating plant has two factories, the new factory and the old factory. Each is equipped with a waste water treatment plant. There is an efficient waste water treatment system fitted to the waste water type throughout the plant. There is no need to install a new pretreatment or waste water treatment factory.

In regard to the plating liquid treatment system, copper plating, nickel plating and chrome plating were designated as the basic processes, and the same agent was selected for the process. This led to a unified concept of a model plating plant waste water treatment system.

1) Design conditions

(1) Waste water discharge features

Waste water discharge is determined according to the following :

① No plating bath liquid replacement.
Bath liquid is generally replaced by preparing a storage tank for bath liquid replacement waste water; then adjusting the water treatment quantity to empty the tank by the next replacement; and finally mixing with the same rinsing treatment.

② Cyanide bath for copper plating liquid, and nickel plating liquid containing boron acid is used. Fluo boric acid bath is not applied.
In the event of fluo boric acid waste water, treat separately according to the previously mentioned method for fluo boric acid.

③ The batch system is used for the first stage of rinsing tank, and the multistage alternating current system for the latter stages.
The rinsing of the first stage is discharged to the waste water treatment plant. The rinsing of the latter stages is reused.

④ Sources of waste water are the rinsing of the first stage ; the rinsing of the multistage alternating current rinsing tank ; the reclamation waste water of the regeneration system; and the circulating waste water of the exhaust gas cleaning plant.

Table 3.3.8 shows discharge features of waste water for each process described above.

## Table 3.3.8 Discharge Features

| Waste water names | Waste water of each process | Discharge situation | Discharge destination |
|---|---|---|---|
| Acid alkaline rinsing | Acid rinsing, Alkaline cleaning rinsing, Chrome plating rinsing, Nickel plating rinsing, Other rinsings | Continuous | Reuse system |
| Cyan rinsing | Copper plating rinsing | Continuous | Reuse system |
| Cyan waste water | Copper plating first rinsing | Once a day | Waste water treatment plant |
| Chrome waste water | Chrome plating rinsing | Once a day | Waste water treatment plant |
| Acid alkaline waste water | Acid first rinsing, Alkaline cleaning first rinsing, Other first rinsings | Once a day | Waste water treatment plant |
| Nickel waste water | Nickel plating first rinsing | Once a day | Waste water treatment plant |

(2) Quality and quantity of waste water

Quality and the quantity of waste water are determined according to Table 3.3.9.

## Table 3.3.9 Quality and Quantity of Waste Water

| | H·OH Rinse | CN Rinse | CN W.W. | Cr W.W. | H·OH W.W. | Ni W.W. |
|---|---|---|---|---|---|---|
| pH | 3～4 | 9～10 | 11 | 2～3 | 3～4 | 4～5 |
| COD (mg/ℓ) | | | | | 150 | |
| B (mg/ℓ) | 0.3 | | | | | 50 |
| Cu (mg/ℓ) | | 15 | 450 | | 10 | |
| $Cr^{6+}$ (mg/ℓ) | 5 | | | 1,000 | | |
| Ni (mg/ℓ) | 5 | | | | | 1,000 |
| T-CN (mg/ℓ) | | 25 | 650 | | | |
| Zn (mg/ℓ) | | | | | 10 | |
| m³/day | 90 | 30 | 4 | 4 | 18 | 4 |

(3) Treatment quantity

The treatment quantity of the new plant is adopted.
Quantity of waste water treatment 30m$^3$/day
Quantity of reclamation process 120m$^3$/day

(4) Water quality of discharge, shown in Table 3.3.10.

(5) Operation time

The operation time of the new factory is as follows :
Waste water treatment 12h/day
Reuse 12h/day
Dehydration 8h/day

2) Reasons for system selection

(1) Waste water treatment

The construction and operating costs involved in the chemical treatment of plating waste water are comparatively low, and the quality of treated water is continuously obtainable; therefore this system was selected.
The treatment includes the oxidation decomposition of CN by NaClO, reduction of $Cr^{6+}$ by $NaHSO_3$, and the precipitation removal of heavy metals by pH control. A chelate resin plant is installed after chemical treatment to ensure the residure of heavy metal complex.
Waste water of the nickel plating liquid is separately treated to remove the boron, using boron absorption resin.

(2) Reuse

Rinsing treatment by ion exchange resin is easily performed, and the quality of treated water is continuously obtainable; therefore this system was selected.
Activated carbon absorber is used for the purpose of eliminating the organic matter in bath liquid. Ultraviolet sterilization is carried out on the treated water before pooling in the storage tank.

(3) Exhaust gas treatment

A scrubber is installed to treat the exhaust gas produced by each equipment.

## Table 3.3.10 Discharge Water Quality

| | Item | unit | River | Sewage |
|---|---|---|---|---|
| 1 | Temperature | °C | 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(b) |
| 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 | 6 | — |
| 7 | Biodegradation | — | — | (c) |
| 8 | B | mg/l | 1.0 | 10.0 |
| 9 | Al | mg/l | 3.0 | (c) |
| 10 | As | mg/l | 0.1 | 0.1 |
| 11 | Cu | mg/l | 0.5 | 0.5 |
| 12 | Ba | mg/l | — | — |
| 13 | Zn | mg/l | 2.0 | 2.0 |
| 14 | Cd | mg/l | 0.2 | 0.2 |
| | | kg/t | 0.3(d) | 0.3(d) |
| 15 | Co | mg/l | — | — |
| 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 | 3.0 | (c) |
| 23 | Hg | mg/l | 0.01 | 0.01 |
| 24 | $Cl_2$(Free chlorine) | mg/l | 0.5 | 0.5 |
| 25 | $Cl_2$(Total effective chlorine) | mg/l | 0.5 | 1.0 |
| 26 | $N\text{-}NH_3$ | mg/l | 80 | (e) |
| 27 | $N\text{-}NO_2$ | mg/l | — | — |
| 28 | $N\text{-}NO_3$ | mg/l | (f) | — |
| 29 | T-CN | mg/l | 0.5 | 10 |
| 30 | Free CN | mg/l | 0.2 | 0.2 |
| 31 | F | mg/l | 50 | 50 |
| 32 | $Cl^-$ | mg/l | (g) | — |
| 33 | T-P | mg/l | 2.0 | — |
| 34 | $SO_4$ | mg/l | (f) | 600(g) |
| 35 | S | mg/l | 1.0 | 1.0 |
| 36 | $SO_3$ | mg/l | 1.0 | 10 |
| 37 | TOC | mg/l | 30 | — |
| 38 | $COD_{Cr}$ | mg/l | 400 | — |
| 39 | $BOD_5$ | mg/l | 25 | — |
| 40 | Total grease | mg/l | 20 | 100 |
| 41 | THC | mg/l | 10(h) | 10(h) |
| 42 | Aromatic organic chlorine | mg/l | 0.1 | 1.0 |
| 43 | Absorbent organic chlorine | mg/l | 1.0(i) | 1.0(i) |
| 44 | Volatile organic chlorine | mg/l | 0.1 | 0.1 |
| 45 | Aqueous organic chlorine | mg/l | (k) | (l) |
| 46 | Phenol | mg/l | 0.1 | 10 |
| 47 | Surfactant | mg/l | 1.0 | — |

3) Outline of treatment system

(1) Waste water treatment plant

The waste water from each process is discharged to the appropriate storage tank, as shown in Table 3.3.8.

The waste water in No.1 cyan waste water storage tank is then pumped to the primary decomposition tank by the pump interlocked with the water level indicator. Then it flows down to reaction tank No.1 of the secondary decomposition tank, where free CN and copper cyan are decomposed.

Both primary and secondary decomposition tanks are equipped with a pH indicator and an ORP indicator. Interlocked with other instruments, they regulate the pH and ORP at the preset values by injecting NaOCl, $Ca(OH)_2$, and HCl. When decomposition in reaction tank No. 1 is complete, the waste water flows into the chrome reduction tank.

Primary decomposition : pH = over 10.5 ORP = over 300mV

$$NaCN + NaClO \rightarrow NaCNO + NaCl$$

Secondary decomposition : pH = 8.5 ORP = 600mV

$$2Na_2[Cu(CN)_3] + 2NaOH + 7NaClO + H_2O \rightarrow 2Cu(OH)_2 + 7NaCl + 6NaCNO$$

$$2NaCNO + 3NaClO + H_2O \rightarrow N_2 + 3NaCl + 2NaHCO_3$$

The chrome waste water discharged to the chrome waste water storage tank is then directed by the pump interlocking with water level indicator to No.1 chrome reduction tank, where $Cr^{6+}$ is reduced to $Cr^{3+}$.

The reduction tank is equipped with pH indicator and ORP indicator. Interlocked with other instruments, they can, by injecting $NaHSO_3$ and HCl, regulate pH and ORP in waste water at preset values. When the reduction reaction is complete, the waste water is directed to reaction tank No.3.

$$4H_2CrO_4 + 6NaHSO_3 + 3H_2SO_4 \rightarrow 2Cr_2(SO_4)_3 + 3Na_2SO_4 + 10H_2O$$

Acidic and alkaline waste water that has been discharged into the No. 1 acidic and alkaline waste water storage tank is fed into the No. 3 reaction tank by a storage pump that operates in connection with the level meter in the tank. In the No. 3 reaction tank, in which a pH meter is installed, a uniform amount of inorganic coagulant ($FeCl_3$) is injected and, in order to maintain the pH value of the waste water at the set level, $Ca(OH)_2$ is injected in line with the reading of the pH meter to carry out the first stage conditioning of the pH. The waste water is next fed into the No. 2 pH equalization tank, in which the pH is conditioned to its final value and heavy metal hydroxides are formed, and is then fed into the coagulation tank. Here, high polymer coagulant is added to form floc. The remaining waste water is fed into the next sedimentation tank, where the floc is separated by sedimentation. The supernatant is fed into the No. 1 pit and the sludge is taken to the sludge storage tank, where it is dewatered by centrifugal separator. The dewatered sludge cake is then taken to the landfill for final disposal and the filtrate is fed back to the acidic and alkaline waste water storage tank.

$$Me^{n+} + nOH^{-} \rightarrow Me(OH)_n$$

Waste water containing floc is directed to the next sedimentation tank in which the floc is precipitated. The supernatant is directed to pit No.1.

The waste water discharged to the nickel waste water storage tank is directed to reaction tank No.3, where the nickel is precipitated and coagulated as hydroxide nickel.

Reaction tank No.3 is a batch system. After $FeCl_3$ as a coagulant is added to the waste water, NaOH is included to adjust the pH to the preset value, thereby precipitating $Ni(OH)_2$.

When the polymer coagulant is added, floc is formed, which is left until it has precipitated. The supernatant fluid is directed to the neutralization tank.

HCl is added to neutralize the waste water to the pH of the preset value of the pH indicator installed in the neutralization tank.

Then the water is discharged to the next B absorbing resin plant to remove B, after which it is directed to the pit No.1. The B absorbing resin plant is regenereted by NaOH and HCl. The regenerated waste water is directed to pH control tank No.2 for pH control and evaporation by the drum dryer.

The treated water of all of the waste water is pumped from pit No.1 to the sand filter, the activated carbon absorber and the chelate resin unit. This is done to eliminate SS, organic matter and the heavy metal complex. It is then discharged via the water quality monitoring tank.

Regeneration of the chelate resin is carried out using NaOH and Hcl. The regenerated waste water is fed into the No. 2 acidic and alkaline waste water storage tank.

(2) Recycling system

The waste water in the acid alkaline rinsing storage tank is pumped to the sand filter, the strong cation exchange resin unit, the strong anion exchange resin unit and the activated carbon absorber. This is done to eliminate cation, anion and organic matter. The treated water is pooled in the storage tank and subsequently pumped for the plating process.

NaOH and HC l are used to regenerate the ion exchange resin. The regenerated waste water of the cation exchange resin is directed to No.2 acid alkaline waste water storage tank. The regenerated water of the anion exchange resin is sent to No.2 chrome waste water storage tank.

The cyan rinsing discharged to the cyan rinsing storage tank is pumped to the sand filter, the activated carbon absorber, strong cation exchange resin unit, the weak anion exchange resin unit and strong anion exchange resin unit. This is done to remove cation, anion and organic matter. The treated water is pumped for the plating process.

The regeneration of cation exchange resin is done by NaOH and HCl. The regenerated waste water of ion exchange resin is directed to No.2 acid alkaline waste water storage tank. The regenerated waste water of anion exchange resin is directed to No.2 cyan waste water storage tank.

(3) Exhaust gas treatment plant

The exhaust gas of each process is sent by an exhauster to the scrubber for treatment. The circulating water of the scrubber is alkaline absorption liquid to which NaOH is added by pH control. The absorption liquid is directed to No.2 cyan waste water storage tank.

4) Facility specifications

(1) Equipment list

Table 3.3.11 lists the equipment for the waste water treatment and reclamation systems

## Table 3.3.11 Equipment List (1/11)

| No. | Item | Q'ty | Material | Specification | Remarks |
|---|---|---|---|---|---|
| 1 | H・OH Rinse storage tank | 1 | RC | $5m^3$<br>1.2 mW ×2.0mL ×2.5mD | |
| | Level switch | 1 | | Float type | |
| | Transfer pump | 1+1 | SUS | 32A×80 ℓ/min×36m×1.5kw | |
| | Flow meter | 1 | | Area type | |
| | | | | | |
| 2 | SF Tower | 1 | SS+R/L | 500φ × 1,520H | |
| | | | | | |
| 3 | CIE Tower | 2 | SS+R/L | 500φ × 1,520H, 200 | |
| | | | | | |
| 4 | AIE Tower | 4 | SS+R/L | 500φ × 1,520H, 200 | |
| | | | | | |
| 5 | AC Tower | 1 | SS+R/L | 700φ × 1,520H | |
| | | | | | |
| 6 | H・OH Treated water tank | 1 | FRP | $10m^3$<br>2.2mφ×2.7mH | |
| | Level switch | 1 | | Float type | |
| | Transfer pump | 1+1 | SUS | 32A×80 ℓ/min×30m×0.75kw | |
| | Back wash pump | 1 | SUS | 32A×100 ℓ/min×26m×0.75kw | |
| | Flow meter | 2 | | Area type | |
| | Disinfector | 1 | | UV type $4m^3$/Hr | |
| | Filter | 1 | SUS | Cartridges type $4m^3$/Hr, 1μ | |
| | | | | | |
| 7 | CN Rinse storage tank | 1 | RC | $3m^3$<br>1.2 mW ×2.0mL ×2.0mD | |
| | Level switch | 1 | | Float type | |
| | Transfer pump | 1+1 | SUS | 32A×30 ℓ/min×55m×1.5kw | |

## Table 3.3.11 Equipment List (2/11)

| No. | Item | Q'ty | Material | Specification | Remarks |
|---|---|---|---|---|---|
| | Flow meter | 1 | | Area type | |
| | | | | | |
| 8 | SF Tower | 1 | SS+R/L | 400φ × 1,520H | |
| | | | | | |
| 9 | AC Tower | 1 | SS+R/L | 400φ × 1,520H | |
| | | | | | |
| 10 | CIE Tower | 2 | SS+R/L | 400φ × 1,520H, 125 | |
| | | | | | |
| 11 | AIE Tower | 4 | SS+R/L | 400φ × 1,520H, 125 | |
| | | | | | |
| 12 | CN Treated water tank | 1 | FRP | $5m^3$ | |
| | Level switch | 1 | | Float type | |
| | Transfer pump | 1+1 | SUS | 32A×30 ℓ/min×30m×0.75kw | |
| | Back wash pump | 1 | SUS | 32×80 ℓ/min×30m×0.75kw | |
| | Flow meter | 2 | | Area type | |
| | Disinfector | 1 | | UV type 1.5$m^3$/H | |
| | Filter | 1 | SUS | Cartridges type 1.5$m^3$/H, 1μ | |
| | | | | | |
| 13 | No1 CN Waste water storage tank | 1 | RC | $5m^3$ 1.2 mW ×2.0mL ×2.5mD with air diffuser | |
| | Level switch | 1 | | Float type | |
| | Transfer pump | 1+1 | SCS13 | 20A×20 ℓ/min×10m×0.4kw | |
| | Flow meter | 1 | | Area type | |
| | | | | | |
| 14 | No2 CN Waste water storage tank | 1 | RC | $3m^3$ 1.2 mW ×2.0mL ×2.0mD with air diffuser | |
| | Level switch | 1 | | Float type | |

## Table 3.3.11 Equipment List (3/11)

| No. | Item | Q'ty | Material | Specification | Remarks |
|---|---|---|---|---|---|
| | Transfer pump | 1 | SCS13 | 20A×20 ℓ/min×10m×0.4kw | |
| | Flow meter | 1 | | Area type | |
| | | | | | |
| 15 | Primary decomposition tank | 1 | FRP | 0.3m³<br>0.65 mW ×0.65mL ×0.93mH | |
| | Agitator | 1 | SS+R/L | 0.1kw Vertical propeller type | |
| | pH Meter | 1 | | Dip type, 0～14, 4～20mA | |
| | ORP Meter | 1 | | Dip type, -700～700mV, 4～20mA | |
| | | | | | |
| 16 | Secondary decomposition tank | 1 | FRP | 0.3m³<br>0.65 mW ×0.65mL ×0.93mH | |
| | Agitator | 1 | SS+R/L | 0.1kw Vertical propeller type | |
| | pH Meter | 1 | | Dip type, 0～14, 4～20mA | |
| | ORP Meter | 1 | | Dip type, -700～700mV, 4～20mV | |
| | | | | | |
| 17 | No.1 Reaction tank | 1 | FRP | 0.3m³<br>0.65 mW ×0.65mL ×0.93mH | |
| | Agitator | 1 | SS+R/L | 0.1kw Vertical propeller type | |
| | | | | | |
| 18 | No.1 Cr Waste water storage tank | 1 | RC | 5m³ 1.2 mW ×2mL ×2.5mD<br>with air diffuser | |
| | Level switch | 1 | | Float type | |
| | Transfer pump | 1+1 | PVC | 25A×45 ℓ/min×8.5m×0.75kw | |
| | Flow meter | 1 | | Area type | |
| | | | | | |
| 19 | No.2 Cr Waste water storage tank | 1 | RC | 3m³ 1.2 mW ×2mL ×2.0mD<br>with air diffuser | |
| | Level switch | 1 | | Float type | |

## Table 3.3.11 Equipment List (4/11)

| No. | Item | Q'ty | Material | Specification | Remarks |
|---|---|---|---|---|---|
| | Transfer pump | 1 | PVC | 25A×45ℓ/min×8.5m×0.75kw | |
| | Flow meter | 1 | | Area type | |
| | | | | | |
| 20 | Reduction tank | 1 | FRP | 0.3m³<br>0.65 mW ×0.65mL ×0.93mH | |
| | Agitator | 1 | SS+R/L | 0.1kw Vertical propeller type | |
| | pH Meter | 1 | | Dip type, 0～14, 4～20mA | |
| | ORP Meter | 1 | | Dip type, -700～700mV, 4～20mA | |
| | | | | | |
| 21 | No.1 H・OH Waste water storage tank | 1 | RC | 20m³ 2.8 mW ×3.8mL ×2.5mD<br>with air diffuser | |
| | Level switch | 1 | | Float type | |
| | Transfer pump | 1+1 | PVC | 25A×45ℓ/min×8.5m×0.75kw | |
| | Flow meter | 1 | | Area type | |
| | | | | | |
| 22 | No.2 H・OH Waste water storage tank | 1 | RC | 10m³ 1.6 mW ×3.3mL ×2.5mD<br>with air diffuser | |
| | Level switch | 1 | | Float type | |
| | Transfer pump | 1 | PVC | 25A×45ℓ/min×8.5m×0.75kw | |
| | Flow meter | 1 | | Area type | |
| | | | | | |
| 23 | No.2 Reaction tank | 1 | FRP | 0.5m³<br>0.73 mW ×0.73mL ×1.24mH | |
| | Agitator | 1 | SS+R/L | 0.2kw Vertical propeller type | |
| | pH Meter | 1 | | Dip type, 0～14, 4～20mA | |
| | | | | | |
| 24 | No.2 pH Control tank | 1 | FRP | 0.5m³<br>0.73 mW ×0.73mL ×1.24mH | |

## Table 3.3.11 Equipment List (5/11)

| No. | Item | Q'ty | Material | Specification | Remarks |
|---|---|---|---|---|---|
| | Agitator | 1 | SS+R/L | 0.2kw Vertical propeller type | |
| | pH Meter | 1 | | Dip type, 0~14, 4~20mA | |
| | | | | | |
| 25 | Coaguratuion tank | 1 | FRP | 0.3m³<br>0.65 mW ×0.65mL ×0.93mH | |
| | Agitator | 1 | SS+R/L | 0.1kw Vertical propeller type | |
| | | | | | |
| 26 | Sedimentation tank | 1 | SS | 2mφ ×3mH<br>Coan type | |
| | Auto valve | 1 | | Ball type | |
| | Discharge pump | 1 | FC+R/L | 25/20A×50ℓ/min×10m×0.75kw | |
| | | | | | |
| 27 | Ni Waste water storage tank | 1 | RC | 10m³<br>1.6 mW ×3.3mL ×2.5mD | |
| | Level switch | 1 | | Float type | |
| | Transfer pump | 1 | PVC | 25A×45ℓ/min×8.5m×0.75kw | |
| | | | | | |
| 28 | No.3 Reaction tank | 1 | FRP | 4m³<br>1.6mφ ×2.0mH | |
| | Agitator | 1 | SS+R/L | 1.5kw Vetical propeller type | |
| | Level switch | 1 | | Lead switch type | |
| | pH Meter | 1 | | Dip type, 0~14, 4~20mA | |
| | Transfer pump | 1 | PVC | 25/20A×50ℓ/min×10m×0.75kw | |
| | Auto valve | 2 | | Ball type | |
| | | | | | |
| 29 | No.1 Neutrarization Tank | 1 | RC | 5m³<br>1.2 mW ×2.0mL ×2.5mH | |
| | Agitator | 1 | SS+R/L | 2.2kw Vertical propeller type | |

## Table 3.3.11 Equipment List (6/11)

| No. | Item | Q'ty | Material | Specification | Remarks |
|---|---|---|---|---|---|
| | Level switch | 1 | | Lead switch type | |
| | pH Meter | 1 | | Dip type, 0～14, 4～20mA | |
| | Transfer pump | 1 | FC | 32A×40ℓ/min×24m×0.75kw | |
| | Filter | 1 | SUS | Cartridges type 2m³/Hr, 25μ | |
| | | | | | |
| 30 | B Ion absorber | 1 | SS+R/L | 500φ×1,520H | |
| | | | | | |
| 31 | No.1 Pit | 1 | FRP | 2m³ 1.3 mφ ×1.55mH<br>with air diffuser | |
| | Level switch | 1 | | Lead switch type | |
| | Transfer pump | 2 | PVC | 32A×70ℓ/min×35m×1.5kw | |
| | Flow meter | 1 | | Area type | |
| | | | | | |
| 32 | SF Tower | 1 | SS+R/L | 800φ×1,520H | |
| | | | | | |
| 33 | AC Tower | 1 | SS+R/L | 800φ×1,520H | |
| | | | | | |
| 34 | Me Chelate | 1 | SS+R/L | 700φ×1,520H | |
| | pH Control unit | 1 | | Inline type | |
| | | | | | |
| 35 | Final neutrarization tank | 1 | FRP | 0.75m³<br>0.9 mW ×0.9mL ×1.24mH | |
| | Agitator | 1 | SS+R/L | 0.4kw Vertical propeller type | |
| | pH Meter | 1 | | Dip type, 0～14, 4～20mA | |
| | | | | | |
| 36 | Monitoring tank | 1 | RC | 5m³<br>1.2 mW ×2.0mL ×2.5mH | |

## Table 3.3.11 Equipment List (7/11)

| No. | Item | Q'ty | Material | Specification | Remarks |
|---|---|---|---|---|---|
| | Level switch | 1 | | Float type | |
| | pH Meter | 1 | | Dip type, 0～14, 4～20mA | |
| | Transfer pump | 1+1 | FC | 32A×70 ℓ/min×16m×0.4kw | |
| | Back wash pump | 1 | FC | 50A×260 ℓ/min×26m×2.2kw | |
| | Auto valve | 2 | | Ball type | |
| | | | | | |
| 37 | Emergency tank | 1 | RC | 20m³<br>2.8 mW ×3.8mL ×2.5mH | |
| | Level switch | 1 | | Float type | |
| | | | | | |
| 38 | No.2 Pit | 1 | RC | 3m³ 1.2 mW ×2.0mL ×2.0mH<br>with air diffuser | |
| | Level switch | 1 | | Float type | |
| | Transfer pump | 1 | SUS | 25A×40 ℓ/min×13m×0.75kw | |
| | | | | | |
| 39 | No.2 pH Control tank | 1 | FRP | 1m³<br>0.9 mW ×0.9mL ×1.55mH | |
| | Agitator | 1 | SS+R/L | 0.4kw Vertical propeller type | |
| | pH Meter | 1 | | Dip type, 0～14, 4～20mA | |
| | Level switch | 1 | | Lead switch type | |
| | Feed pump | 1 | SUS | 25A×40 ℓ/min×7.5kw×0.2kw | |
| | | | | | |
| 40 | Drier | 1 | SUS | 2 m² Dram type 1.5kw | |
| | Exhaust blower | 1 | FRP | 20m³/min×80mmAq×0.75kw | |
| | | | | | |
| 41 | Slully tank | 1 | FRP | 3m³<br>1.4mφ ×2.0 mH | |
| | Agitator | 1 | SS+R/L | 0.75kw Vertical propeller type | |

## Table 3.3.11 Equipment List (8/11)

| No. | Item | Q'ty | Material | Specification | Remarks |
|---|---|---|---|---|---|
| | Slully feed pump | 1 | FC+R/L | 65A×400 ℓ/min×10m×1.5kw | |
| | Level switch | 1 | | Electrode type | |
| | | | | | |
| 42 | Dehydrator | 1 | SS | Semi automatic filterpress<br>16.2m², 5.2kw | |
| | | | | | |
| 43 | NaOH Tank | 1 | FRP | 2m³<br>1.3 mφ×1.55mH | |
| | Agitator | 1 | SUS | 0.4kw Vertical propeller type | |
| | Level switch | 1 | | Electrode type | |
| | Auto valve | 1 | | Ball type | |
| | AIE Feed pump | 2 | PVC | 25A×6 ℓ/min×3kg/cm²×0.2kw | |
| | Me Chelate feed pump | 1 | PVC | 25A×6 ℓ/min×3kg/cm²×0.2kw | |
| | B Adsirber feed pump | 1 | PVC | 25A×6 ℓ/min×3kg/cm²×0.2kw | |
| | Final Neutralization | 1 | PVC | 15A×0.05 ℓ/min×10kg/cm²×0.2kw | |
| | tank feed pump | | | | |
| | No.3 Reaction tank feed | 1 | PVC | 15A×1.7 ℓ/min×8kg/cm²×0.2kw | |
| | pump | | | | |
| | No.2 pH control tank | 1 | PVC | 15A×0.02 ℓ/min×10kg/cm²×0.2kw | |
| | feed pump | | | | |
| | Scrubber feed pump | 1 | PVC | 15A×0.5 ℓ/min×10kg/cm²×0.2kw | |
| | | | | | |
| 44 | 30% HCl Tank | 1 | FRP | 3m³<br>1.4 mφ×2.0mH | |
| | Level switch | 1 | | Float type | |
| | CIE Feed pump | 2 | PVC | 25A×6 ℓ/min×3kg/cm²×0.2kw | |
| | Me Chelate feed pump | 1 | PVC | 40A×9 ℓ/min×3kg/cm²×0.4kw | |

## Table 3.3.11 Equipment List (9/11)

| No. | Item | Q'ty | Material | Specification | Remarks |
|---|---|---|---|---|---|
| | B Adsorber feed pump | 1 | PVC | 25A×6ℓ/min×3kg/cm²×0.2kw | |
| | Transfer pump | 1 | PP | 40A×50ℓ/min×10m×0.4kw | |
| | | | | | |
| 45 | 10% HCl Tank | 1 | FRP | 0.5m³<br>0.73 mW ×0.73mL ×1.24mH | |
| | Agitator | 1 | SS+R/L | 0.1kw Vertical propeller type | |
| | Level switch | 1 | | Lead switch type | |
| | Auto valve | 1 | | Ball type | |
| | Primary decomposition | 1 | PVC | 15A×0.05ℓ/min×10kg/cm²×0.2kw | |
| | tank feed pump | | | | |
| | Secondary decomposition | 1 | PVC | 15A×0.85ℓ/min×10kg/cm²×0.2kw | |
| | tank feed pump | | | | |
| | Reduction feed pump | 1 | PVC | 15A×0.85ℓ/min×10kg/cm²×0.2kw | |
| | pH control unit feed | 1 | PVC | 15A×0.02ℓ/min×10kg/cm²×0.2kw | |
| | pump | | | | |
| | Final neutralization | 1 | PVC | 15A×0.05ℓ/min×10kg/cm²×0.2kw | |
| | tank feed pump | | | | |
| | Neutralization feed pump | 1 | PVC | 15A×0.05ℓ/min×10kg/cm²×0.2kw | |
| | | | | | |
| 46 | $Ca(OH)_2$ Tank | 1 | SS | 5m³<br>1.60 mW ×1.60mL ×2.46mH | |
| | Agitator | 1 | SUS | 1.5kw Vertical propeller type | |
| | Level switch | 1 | | Electrode type | |
| | Auto valve | 4 | | Ball type | |
| | Feed pump | 2 | FC | 40A×80ℓ/min×2m×0.4kw | |
| | | | | | |
| | | | | | |

## Table 3.3.11 Equipment List (10/11)

| No. | Item | Q'ty | Material | Specification | Remarks |
|---|---|---|---|---|---|
| 47 | $FeCl_3$ Tank | 1 | FRP | $3m^3$<br>1.4m$\phi$ ×2.0mH | |
| | Level switch | 1 | | Float type | |
| | No.2 Reaction tank feed pump | 1 | PVC | 15A×0.1ℓ/min×10kg/cm²×0.2kw | |
| | No.3 Reaction tank feed pump | 1 | PVC | 15A×0.1ℓ/min×10kg/cm²×0.2kw | |
| | | | | | |
| 48 | NaOCl Tank | 1 | FRP | $3m^3$<br>1.4 m$\phi$ ×2.0mH | |
| | Level switch | 1 | | Float type | |
| | Primaty decomposition tank feed pump | 1 | PVC | 15A×0.85ℓ/min×10kg/cm²×0.2kw | |
| | Secondary decomposition tank feed pump | 1 | PVC | 15A×0.85ℓ/min×10kg/cm²×0.2kw | |
| | | | | | |
| 49 | $NaHSO_3$ Tank | 1 | FRP | $3m^3$<br>1.4 m$\phi$ ×2.0mH | |
| | Level switch | 1 | | Float type | |
| | Feed pump | 1 | PVC | 15A×0.5ℓ/min×10kg/cm²×0.2kw | |
| | | | | | |
| 50 | Polymer Tank | 1 | FRP | $0.5m^3$<br>0.73 mW ×0.73mL ×1.24mH | |
| | Agitator | 1 | SUS | 0.4kw Vertical propeller type | |
| | Level switch | 1 | | Electrode type | |
| | Auto valve | 1 | | Ball type | |
| | Coagulation tank feed pump | 1 | PVC | 25A×2.8ℓ/min×5kg/cm²×0.2kw | |

## Table 3.3.11 Equipment List (11/11)

| No. | Item | Q'ty | Material | Specification | Remarks |
|---|---|---|---|---|---|
| | No.3 Reaction tank feed | 1 | PVC | 15A×1.7ℓ/min×8kg/cm²×0.2kw | |
| | pump | | | | |
| | Hopper | 1 | SS | 30L | |
| | | | | | |
| 51 | Blower | 1 | FC | 50A×0.95kg/cm²×3000mmAq×2.2kw | |
| | | | | | |
| 52 | Compressor | 1 | SS | 70ℓ/min×7kg/cm²×0.75kw | |
| | | | | | |
| 53 | Scrubber unit | 1 | PVC | 15m³/min 1.15kw | |
| | | | | | |
| 54 | Control panel | 1 | | Indoor self-standing enclosed type | |
| | | | | 4.8m ×0.6m ×2mH | |
| | | | | AC 400V ×50Hz | |
| | | | | Push button switch | |
| | | | | Alarm lamp | |
| | | | | pH indicator | |
| | | | | ORP indicator | |
| | | | | | |
| 55 | Pipe | | | | |
| | Raw waste water line | | VP | | |
| | Treated water line | | VP | | |
| | Chemical dosing line | | VP | | |
| | Air line | | SGP | | |
| | | | | | |
| 56 | Bilding | | steel frame & slate roof | 365m² X 7mH | |

(2) Design calculations

- H · OH rinsing storage tank
  Operation time of recycling system : 24h/day, by factory operating time : 24hr/day
  Retention time : over 1 hour
  $90m^3/day \div 24h/day \times 1h = 3.8m^3$

  Determined value $5m^3$

- Sand filter
  LV20 for average water treatment quantity
  $90m^3/day \div 24h/day \div 20m/h = 0.19m^2$

  Determined value 500 $\phi$

- Ion exchange tower (CIE)
  SV20 for average water treatment quantity
  $90m^3/day \div 24h/day \div 20m/h = 0.19m^2$

  Determined value 500 $\phi$

- Ion exchange tower (AIE)
  Same as CIE

  Determined value 500 $\phi$

- Activated carbon tower
  SV20 for average water treatment quantity
  $90m^3/day \div 24h/day \div 10m/h = 0.38m^2$

  Determined value 500 $\phi$

- Recycling water tank
  Retention in excess of 2 hours
  $90m^3/day \div 24h/day \times 2h = 7.5m^3$

  Determined value $10m^3$

- CN rinsing storage tank
  Retention in excess of 1 hour.
  $30m^3/day \div 24h/day \times 1h = 1.3m^3$

  Determined value $3m^3$

- Sand filter tower
  LV20 for average water treatment quantity.
  $30m^3/day \div 24h/day \div 20m/h = 0.06m^2$

  Determined value 400 $\phi$

- Activated carbon tower
  SV10 for average water treatment quantity.
  $30m^3/day \div 24h/day \div 10m/day = 0.13m^2$

  | Determined value 400 $\phi$ |

- Ion exchange tower (CIE)
  SV20 for average water treatment quantity
  $30m^3/day \div 24h/day \div 20m/day = 0.06m^2$

  | Determined value 400 $\phi$ |

- Ion exchange tower (AIE)
  Same as CIE

  | Determined value 400 $\phi$ x 2 |

- Recycling water tank
  Retention in excess of 2 hours for average water treatment quantity
  $30m^3/day \div 24h/day \times 2h = 2.5m^3$

  | Determined value $5m^3$ |

- CN regular waste water storage tank
  One batch capacity for reverse rinsing of CN rinsing sand filter tower, and 12 hour volume of daily discharge
  $4m^3/day \div 24h/day \times 12h + 0.5m^3 = 2.5m^3$

  | Determined value $5m^3$ |

- CN regenerated water storage tank
  One batch capacity for recovered water of CN rinsing AIE
  $1.5m^3/2days$

  | Determined value $3m^3$ |

- Primary decomposition tank
  Retention of over 20 min. for average water treatment quantity
  $5m^3/day \div 12h/day \div 60min/h \times 20min = 140l$

  | Determined value 300l |

- Secondary decomposition tank
  Same as primary decomposition tank.

  | Determined value 300 l |

- Retention tank
  Same as primary decomposition tank

  | Determined value 300 l |

- Cr-regular waste water storage tank
  One batch capacity of reverse rinsing of H・OH rinsing sand filter tower, and 12 hour volume of daily discharge.
  $4m^3/day \div 24h/day \times 12h + 1m^3 = 3m^3$

  Determined value $5m^3$

- Cr regenerated waste water storage tank
  One batch capacity of recovered water of H・OH rinsing AIE
  $1.4m^3/2$ days

  Determined value $3m^3$

- Reduction tank
  Retention in excess of 10 min. for average water treatment quantity
  $10m^3/day \div 12h/day \div 60min/day \times 10min = 140l$

  Determined value 300 l

- H•OH regular waste water storage tank
  One batch capacity of reverse rinsing of H・OH rinsing sand filter tower, and 12 hour volume of daily discharge.
  $18m^3/day \div 24h/day \times 12h + 4m^3 = 13m^3$

  Determined value 400 $\phi$

- H•OH regenerated waste water storage tank
  One batch capacity of recovered water of CIE and chelate recovered water
  $1m^3/2$ days + $0.65m^3/2$ days + $4.5m^3/25$ days = $6m^3$

  DDetermined value $10m^3$

- Reaction tank
  Retention of over 10 mins. for average water treatment quantity.
  $35m^3/day \div 12h/day \div 60min/day \times 10min = 500l$

  Determined value 500 l

- pH control tank
  Same as reaction tank

  Determined value 500 l

- Coagulation tank
  Retention in excess of l0 mins. for average water treatment quantity
  $35m^3/day \div 12h/day \times 60min/h \times 5min = 250$

  Determined value 300 l

- Sedimentation tank
  Sedimentation speed less than 1m/h.
  $35m^3/day \div 12h/day \div 1m/h = 2.9m^2$

  Determined value 3,000 l

- Relay pit

  Retention of over 30 min. for average water treatment quantity

  $40m^3/day \div 12h/day \div 60min/h \times 30min = 1.7m^3$

  | Determined value $2m^3$ |

- Sand filter tower

  LV7 for average water treatment quantity

  $40m^3/day \div 12h/day \div 7m/h = 0.5m^2$

  | Determined value 800mm $\phi$ |

- Activated carbon tower

  SV7 for average water treatment quantity.

  $40m^3/day \div 12h/day \div 7m/h = 0.5m^2$

  | Determined value 800mm $\phi$ |

- Metal chelate tower

  SV10 for average water treatment quantity.

  $40m^3/day \div 12h/day \div 10m/h = 0.3m^2$

  | Determined value 700mm $\phi$ |

- Final neutralization tank

  Retention of over 10 mins. for average water treatment quantity

  $40m^3/day \div 12h/day \div 60min/day \times 10min = 560 l$

  | Determined value 750mm $\phi$ |

- Monitoring tank

  Capacity of more than one batch of reverse rinsing of sand filter tower.

  | Determined value $5m^3$ |

- Emergency tank

  Capacity of half day volume.

  $40m^3 \div 2 = 20m^3$

  | Determined value $20m^3$ |

- Ni regular waste water storage tank

  Retention of more than one day quantity ($4m^3/day$).

  | Determined value $10m^3$ |

- Reaction tank

  Capacity of one day batch process ($4m^3/day$).

  | Determined value $4m^3$ |

- Neutralization tank
  Capacity of one day batch process ($4m^3$/day).

  | Determined value $5m^3$ |

- B absorption tower
  Daily quantity of B : $50g/m^3$ x $4m^3$/day = 200g/day
  One recovery per day with absorption amount of B absorption resin as 1g/l - R.
  200g ÷ 1g/l - R = 200l

  | Determined value 500mm $\phi$ |

- Recovery pit
  Retention of about 5 days for daily recovered water
  $0.5m^3$/day x 5days = $2.5m^3$

  | Determined value $3m^3$ |

- pH control tank
  Capacity of one day batch process ($0.5m^3$/day)

  | Determined value $1m^2$ |

- Dryer
  Processing amount per hour : $30kg/m^2 \cdot h$
  500kg/day ÷ 12h/day ÷ $30kg/m^2 \cdot h = 1.4m^2$

  | Determined value $2m^2$ |

- Sludge storage tank
  Daily sludge quantity

| | | |
|---|---|---|
| $CU(OH)_2$ : 2.43kg/day x 97.5/63.5 | = 3.73kg/day | |
| $Ni(OH)_2$ : 4.45kg/day x 92.7/58.7 | = 7.03kg/day | |
| $Cr(OH)_3$ : 4.45kg/day x 103/52 | = 8.81kg/day | |
| $Zn(OH)_2$ : 0.18kg/day x 99.4/65.4 | = 0.27kg/day | |
| $Fe(OH)_3$ : FeCl3 3.8kg/day x 106.9/162.4 | = 2.50kg/day | |
| Total | 22.34kg/day | as Dry |

  Capacity of one day with 2% slurry.
  22.34kg/day ÷ 0.02 x 1day = $1.1m^3$

  | Determined value $3m^2$ |

- Dehydrator
  One batch process per day. Moisture rate of dehydrated cake is 75%
  22.34kg/day ÷ 0.25 = 89.4kg/day (75% wet)
  Filtering capacity of dehydrator : regarding $1kg/m^2 \cdot$ batch.
  89.4kg/day ÷ $8kg/m^2 \cdot$batch ÷ 1batch/day = $11.2m^2$

  | Determined value $16.2m^2$ |

- Blower

  Over 15 l/m$^3$ min. for total tank capacity requiring agitation.

  $51m^3 \times 15\ l/m^3 \cdot min = 0.765m^3/min$

  Determined value $0.95m^3/min$

- Scrubber

  Capacity which can deduct $1m^3/min$ from each tank and agitation air volume x 3.

  $0.95m^3/min \times 3 + 1m^3/min \times 7 = 10m^3/min$

  Determined value $15m^3/min$

- Na OH tank

  Daily amount : 350kg/day (as 10%)

  Capacity of 5 day amount

  350kg/day x 5days = 1,750kg

  Determined value $2m^3$

- 30% HCl tank

  Amount of daily use : 135kg/ day (as 30%)

  Capacity which tank can receive from tank lorry.

  Determined value $3m^3$

- 10% HCl tank

  Amount of daily use : 170kg/day (as 10%)

  Determined value 500 l

- $Ca(OH)_2$ tank

  Amount of daily use: 800kg/day (as 5%)

  Capacity of 5 day use

  800kg/day x 5days = 4,000kg/day

  Determined value $5m^3$

- $FeCl_3$ tank

  Amount of daily use : 10kg/day (38%)

  Capacity which tank can receive from tank lorry.

  Determined value $3m^3$

- Na ClO tank

  Amount of daily use : 250kg/day (as 12%)

  Capacity which tank can receive from tank lorry.

  Determined value $3m^3$

- Na $HSO_3$ tank
  Amopunt of daily use : 45kg/day (as 34%)
  Capacity which tank can receive from tank lorry.

  | Determined value 3m$^3$ |

- High polymer tank
  Amount of daily use : 1,000kg/ day (as 0.1%)
  Retention of over 3hours for the amount per day
  1,000kg/day ÷ 12h/day x 3h = 250kg/day

  | Determined value 500 l |

(3) Flow sheet

Flow sheet of waste water treatment and recovery plant is shown in Fig.3.3.8.

(4) Material balance

Fig. 3.3.9 shows the material balance sheet.

(5) Layout

Fig.3.3.10 shows the layout of the waste water treatment and recovery plant.

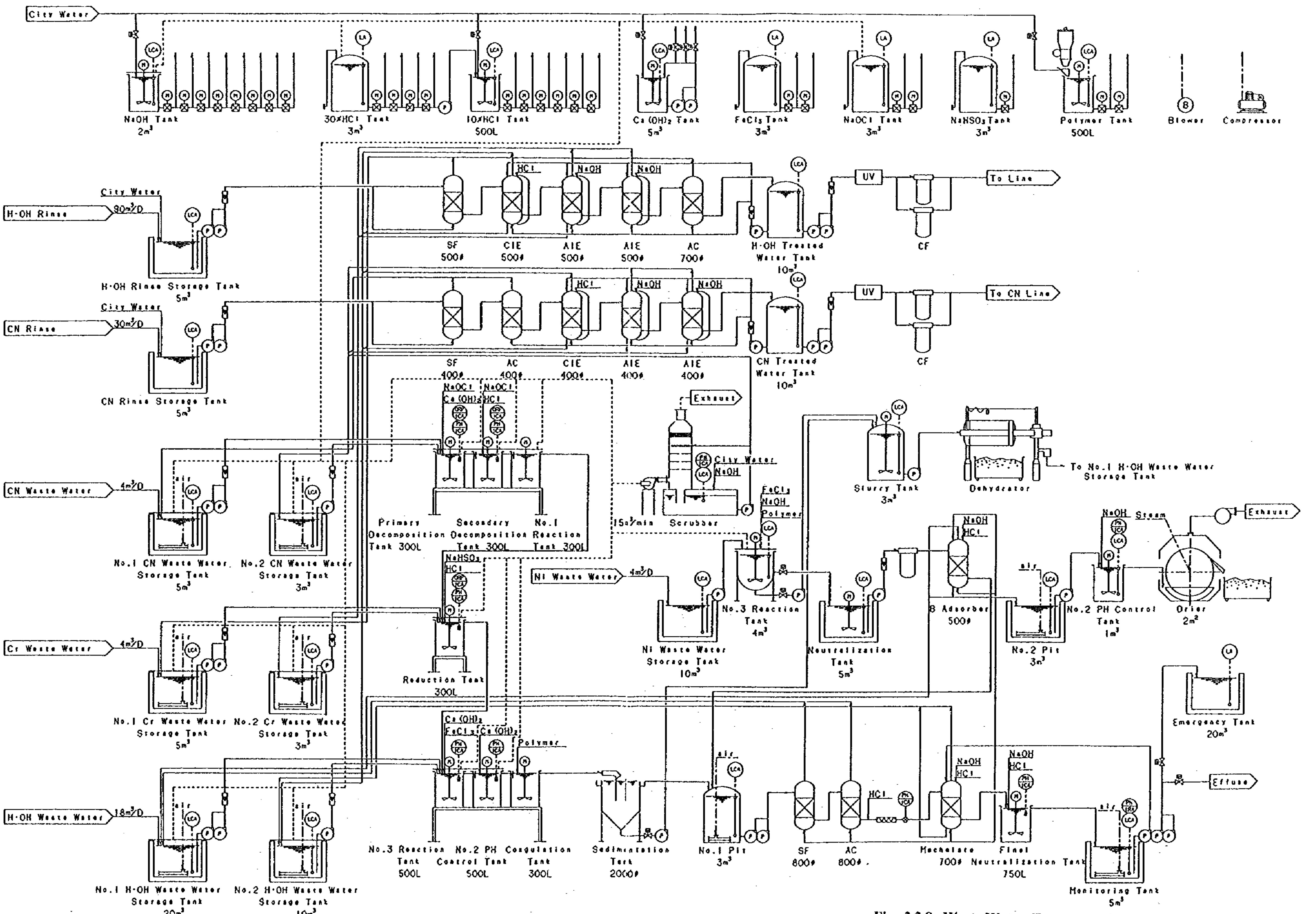



Fig. 3.3.8 Waste Water Treatment & Re-use Plant Flow Sheet

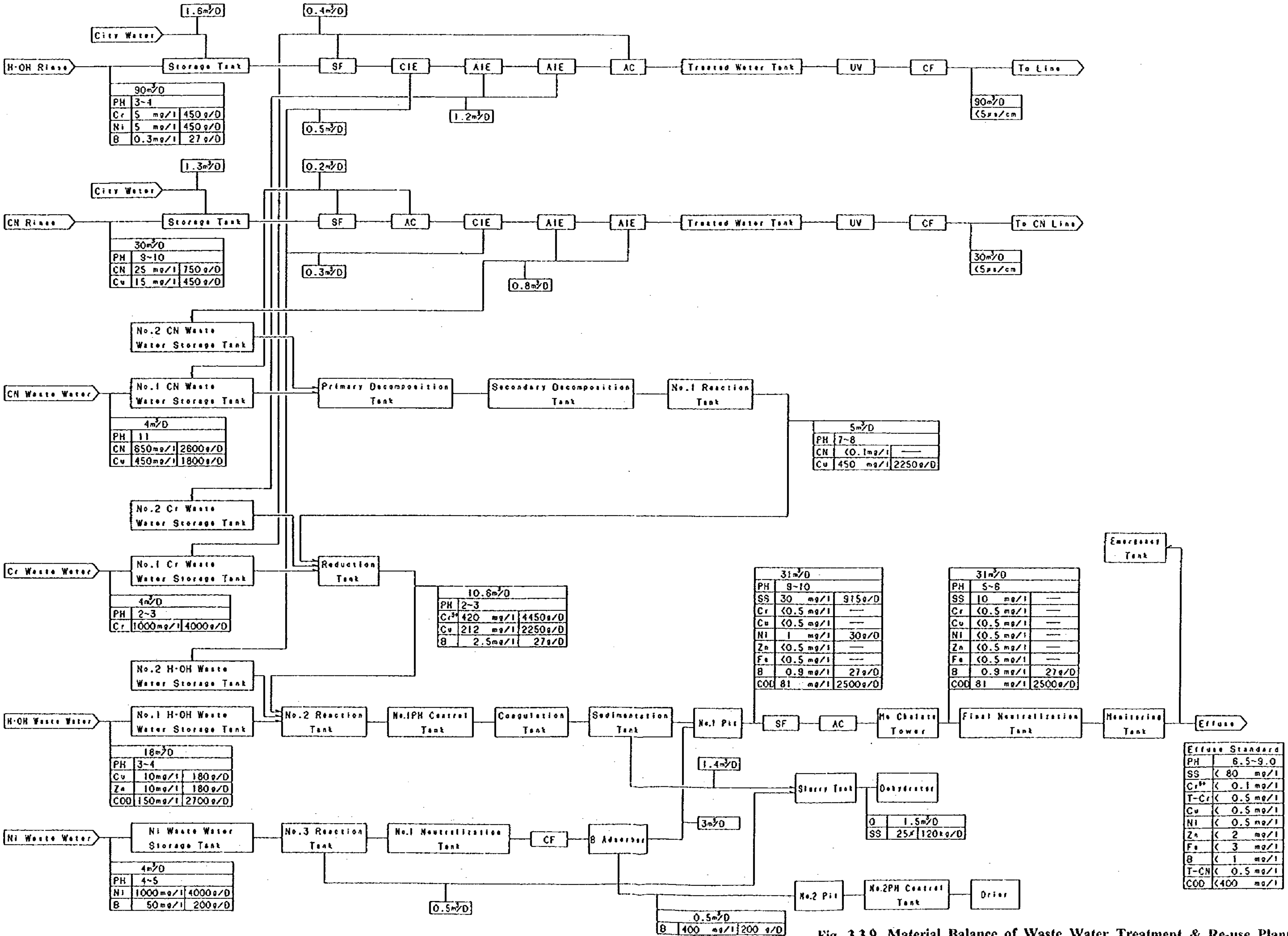
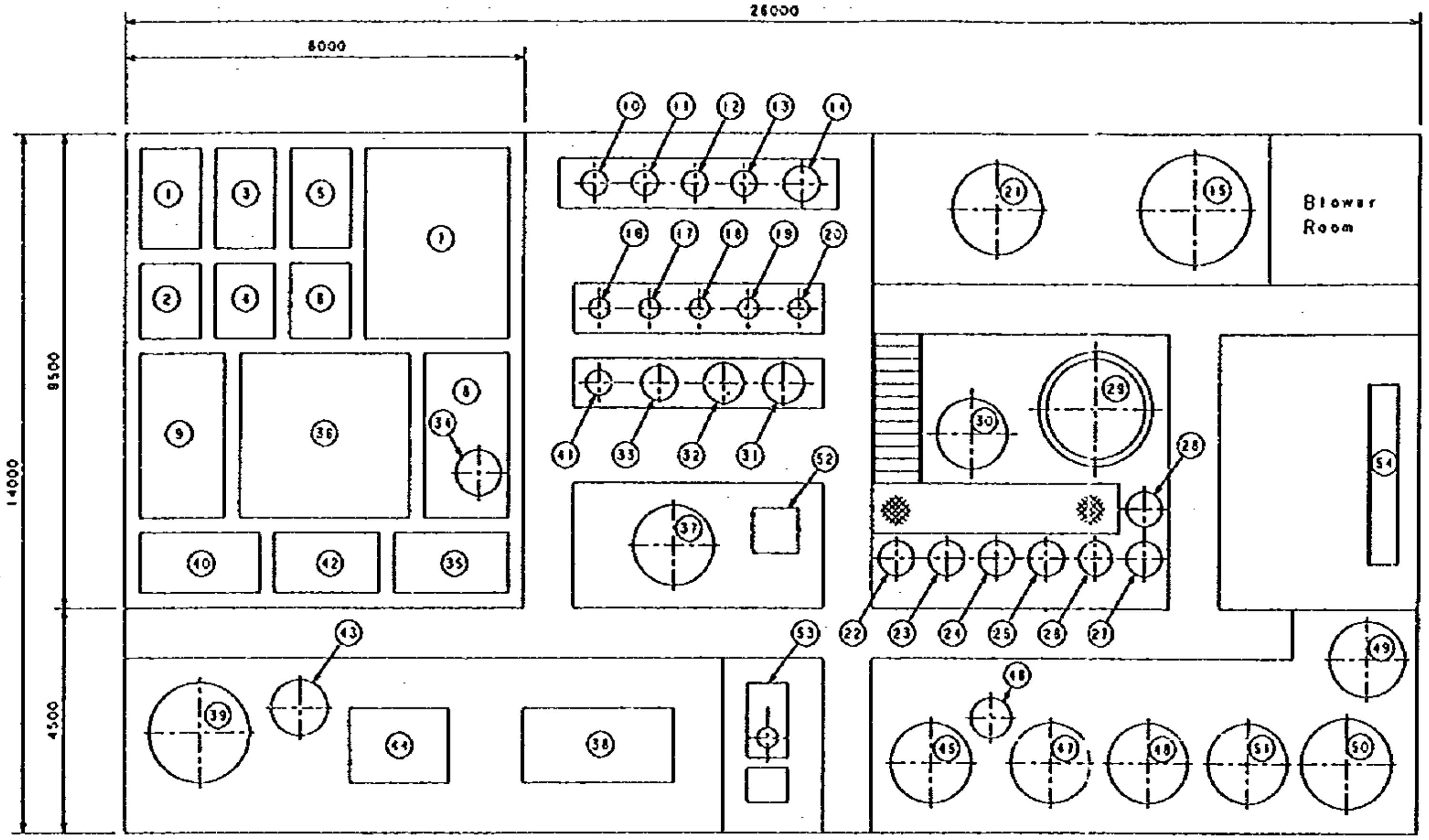



Fig. 3.3.9 Material Balance of Waste Water Treatment & Re-use Plant




| No. | Descriptions | Remarks | No. | Descriptions | Remarks | No. | Descriptions | Remarks | No. | Descriptions | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | H·OH Rinse Storage Tank | | 15 | H·OH Treated Water Tank | | 28 | Coagulation Tank | | 41 | Boron Adsorber | |
| 2 | CN Rinse Storage Tank | | 16 | Sand Filter | | 29 | Sedimentation Tank | | 42 | No.2 Pit | |
| 3 | No.1 CN Waste Water Storage Tank | | 17 | Activated Carbon Adsorber | | 30 | No.1 Pit | | 43 | No.2 PH Control Tank | |
| 4 | No.2 CN Waste Water Storage Tank | | 18 | Cation Exchanger | | 31 | Sand Filter | | 44 | Drier | |
| 5 | No.1 Cr Waste Water Storage Tank | | 19 | Anion Exchanger | | 32 | Activated Carbon Adsorber | | 45 | 30%HCl Tank | |
| 6 | No.2 Cr Waste Water Storage Tank | | 20 | Anion Exchanger | | 33 | Metal Chelate Tower | | 46 | 10%HCl Tank | |
| 7 | No.1 H·OH Waste Water Storage Tank | | 21 | CN Treated Water Tank | | 34 | Final Neutralization Tank | | 47 | $FeCl_3$ Tank | |
| 8 | No.2 H·OH Waste Water Storage Tank | | 22 | Primary Decomposition Tank | | 35 | Monitoring Tank | | 48 | $NaHSO_3$ Tank | |
| 9 | Ni Waste Water Storage Tank | | 23 | Secondary Decomposition Tank | | 36 | Emergency Tank | | 49 | NaOH Tank | |
| 10 | Sand Filter | | 24 | No.1 Reaction Tank | | 37 | Slurry Tank | | 50 | $Ca(OH)_2$ Tank | |
| 11 | Cation Exchanger | | 25 | Reduction Tank | | 38 | Dehydrator | | 51 | NaOCl Tank | |
| 12 | Anion Exchanger | | 26 | No.2 Reaction Tank | | 39 | No.3 Reaction Tank | | 52 | Polymer Tank | |
| 13 | Anion Exchanger | | 27 | No.1 PH Control Tank | | 40 | Neutralization Tank | | 53 | Scrubber | |
| 14 | Activated Carbon Adsorber | | | | | | | | 54 | Control Panel | |

Fig. 3.3.10 Waste Water Treatment & Re-use Plant Layout

5) Facility cost

The facility cost is 243,317,000 SIT.
Table 3.3.12 provides details of the facility cost.

**Table 3.3.12 Details of Facility Cost**

| Items | Contents | Prices (SIT) |
|---|---|---|
| Equipment | | |
| | Pump, Blower, Agitator, Speed reducer, Dehydrator, etc. | 57,558,000 |
| | Measuring instruments | 28,045,000 |
| | Other types of equipment (tank, tower, rake, etc.) | 39,363,000 |
| | Subtotal | (124,966,000) |
| Field work | | |
| | Machine installation, Piping | 23,100,000 |
| | Electric work | 32,250,000 |
| | Painting work | 375,000 |
| | Civil work | 18,750,000 |
| | Construction work | 29,375,000 |
| | Field management | 4,050,000 |
| | Trial operation | 1,463,000 |
| | Subtotal | 110,363,000 |
| Design | | 7,988,000 |
| | Total | 243,317,000 |

6) Operation cost

Operation cost is 23,185,000 SIT/year.
Table 3.3.13 provides details of the operation cost.

**Table 3.3.13 Details of Operation Cost**

| Items | | Contents | Prices (SIT/y) |
|---|---|---|---|
| Chemicals | HCl (30%) | 115kg/day x 22 SIT/kg x 256day/y | 647,680 |
| | NaOH | 35kg/day x 83.2 SIT/kg x 256day/y | 745,472 |
| | NaClO (12%) | 250kg/day x 54 SIT/kg x 256day/y | 3,456,000 |
| | $NaHSO_3$ (34%) | 45kg/day x 113.6 SIT/kg x 256day/y | 1,308,672 |
| | $FeCl_3$ (38%) | 10kg/day x 64 SIT/kg x 256day/y | 163,840 |
| | $Ca(OH)_2$ | 40kg/day x 40 SIT/kg x 256day/y | 409,600 |
| | Polymer | 1kg/day x 990 SIT/kg x 256day/y | 253,440 |
| | | Subtotal | (6,984,704) |
| Electricity | 359kWh x 15 SIT/kWh x 256day/y | | 1,378,560 |
| Sludge disposal | $0.0894m^3$/day x 49.683 SIT/$m^3$ x 256day/y | | 1,137,065 |
| Kerosene oil | 200l/day x 60 SIT/l x 90day/y | | 1,080,000 |
| Maintenance | 195,192,000 x 0.05 | | 9,759,600 |
| Labor cost | 1,422,300 SIT/y · man x 2man/y | | 2,844,600 |
| | | Total | 23,184,529 |

7) Economic comment

(1) Conditions

| | | | |
|---|---|---|---|
| ① | Repayment period | : | Facilities 15years. |
| | | | Buildings, Civil work 40 years. |
| ② | Interest | : | 10% / year |
| ③ | Repayment type | : | Equal repayment |
| ④ | WWTP discharge fee | : | 176.56 SIT/m$^3$ |
| ⑤ | Discharge to river | : | 0 SIT/m$^3$ |
| ⑥ | Amount of annual waste water treatment and water recovery | | |

150m$^3$/day x 256 day/year x = 38,400m$^3$/year

(2) Treatment cost of waste water and recovered water per 1m$^3$.

The treatment cost per 1m$^3$ is 1,291 SIT/m$^3$.
Table 3.3.14 provides details of the treatment cost per 1m$^3$.

**Table 3.3.14 Details of Treatment Cost per 1m$^3$**

| Items | | Contents | Prices |
|---|---|---|---|
| Repayment years | Equipment | 195,192,000 SIT÷15 years | ①13,012,800 SIT/year |
| | Buildings, Civil works | 48,125,000 SIT ÷40years | ② 1,203,125 SIT/year |
| Interest | 243,317,000 x 0.05 | | ③12,165,850 SIT/year |
| Operating costs | | | ④23,185,000 SIT/year |
| (① + ② + ③ + ④) ÷ 38,400 | | | 1,291 SIT/m$^3$ |

## 3.3.4 Pretreatment for Reduction of the Pollution Load

There is no need to install a pretreatment system for reducing the pollution load in this factory. Here, a general waste water treatment system for use in the plating plant shall be indicated.

1) General Waste Water Treatment System

Here, a general pretreatment system for dealing with the heavy metals, $Cr^{6+}$ and CN contained in plating waste water shall be described.

The flow sheet of a general plating waste water treatment system is shown in Fig. 3.3.11. The waste water treatment system was described earlier. That is to say that the discharged waste water shall be separated into waste water containing chromium, cyanic waste water and alkaline waste water, and the treatment processes shall consist of the reduction treatment of $Cr^{6+}$, the oxidization of CN and the coagulating sedimentation of heavy metals.

As the waste water volume of ARMAL d.o.o. is 30 $m^3/d$ and the annual operating days are 256 days, the equipment and running costs incurred in installing a general pretreatment system will be as indicated in Table 3.3.15.

**Table 3.3.15 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 |
|---|---|---|---|---|
| Pretreatment | 35,000,000 | 480 | 350 | 830 |

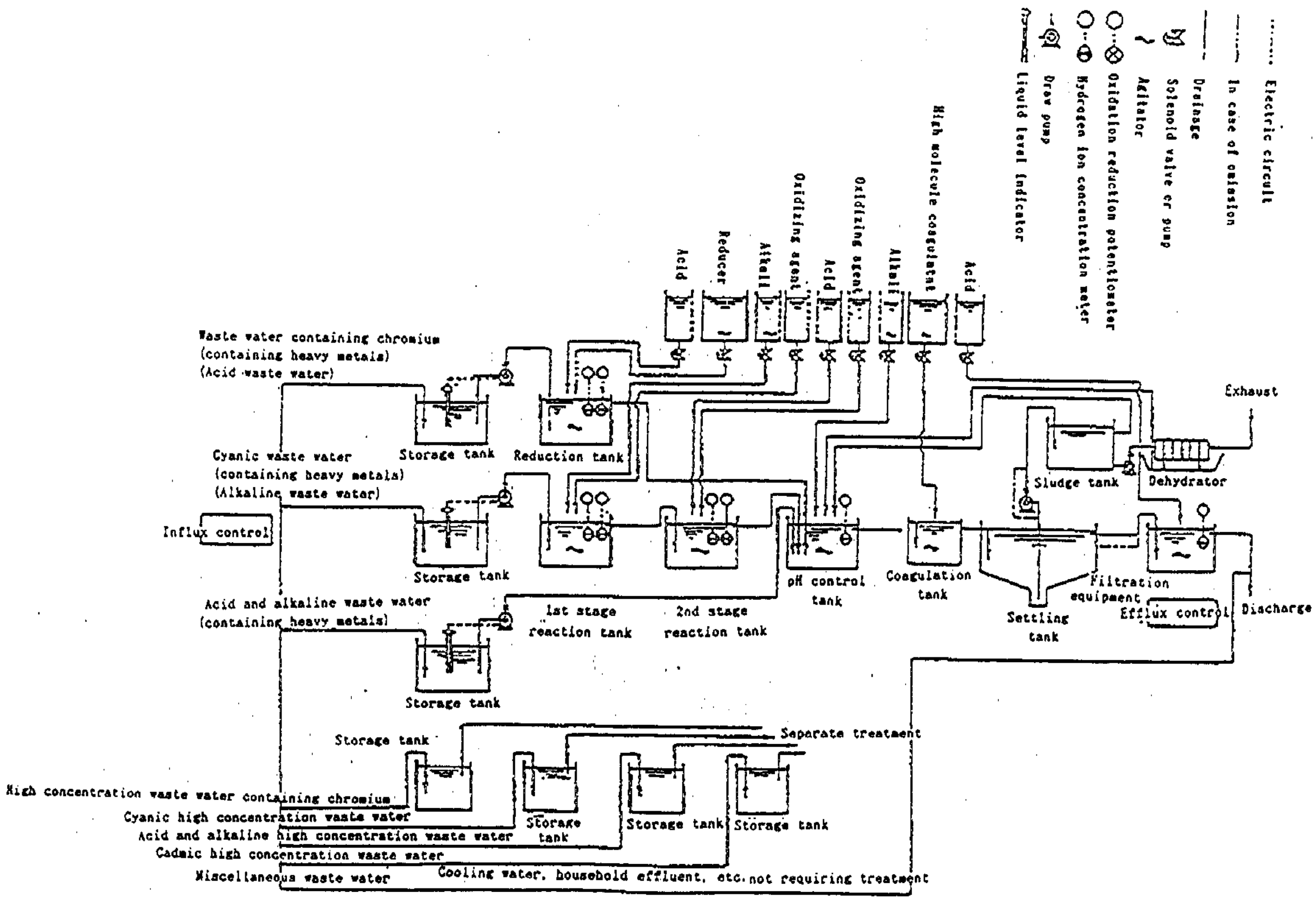
2) Current pollution load

It was not possible to carry out the follow-up survey of total waste water in the LIVARNA group due to measuring technology limitations. Therefore, materials provided by NIGRAD were used together with data obtained from the first survey to obtain the volumes of total waste water and estimate the quality and pollution loads of the waste water. The results of this are shown in Table 3.3.16.

**Table 3.3.16 Volume, Quality and Pollution Load of Waste Water**

| Kind of Waste Water | Quantity m³/d | pH | CODcr 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) |
|---|---|---|---|---|---|---|---|
| Total Waste Water (Livarna Group) | 1,193 | | 20 (23.9) | 8 (9.5) | – (–) | – (–) | – (–) |
| Total Waste Water (Armal d.o.o.) | 372 | | 20 (7.44) | 8 (2.98) | – (–) | – (–) | – (–) |

Fig. 3.3.11 Flow Sheet of a General Plating Waste Water Treatment System



## 3.4 M-4 STAJERSKA PIVOVARNA, d.d.

### 3.4.1 Factory Outline

(1) Outline

| | | |
|---|---|---|
| Capital | : | 130,000,000 SIT |
| Factory complex area | : | 40,000 $m^2$ |
| Employees | : | 170 |
| Products | : | Beer, soft drinks, juice |
| Annual production (hl) | : | 60,000 (beer), 50,000 (soft drinks), 80,000 (juice) |
| Operating conditions | : | 216 days/year, 8 hours/day |

(2) Quantity of consumed water classified by source and use

See Table 3.4.1.

(3) Flow diagrams of water supply and waste water discharge

See Fig. 3.4.1 and Fig. 3.4.2.

(4) Quality of make-up water and waste water

Se Table 3.4.2.

### 3.4.2 Water Conservation

1) Current condition of water usage and water conservation

(1) Features of water usage

① Two wells provide the only source of water. Water from the wells is supplied to the whole factory after first being temporarily stored in pressure tanks.

② Apart from the cooling water used in the ammonia refrigerator which is circulated through an evaporative condenser, the other water is discharged after being used only once.

③ The water usage is largely dominated by water for washing bottles (approximately 74% of the total) and water used as the raw material for the factory's products (approximately 21%). Only a small amount of water is used as cooling and domestic water.

## Table 3.4.1 Quantity of Consumed Water Classified by Source and Use

Factory Name M-4, STAJERSKA PIVOVARNA Industry; Food(Beer)

Unit; ㎥／day

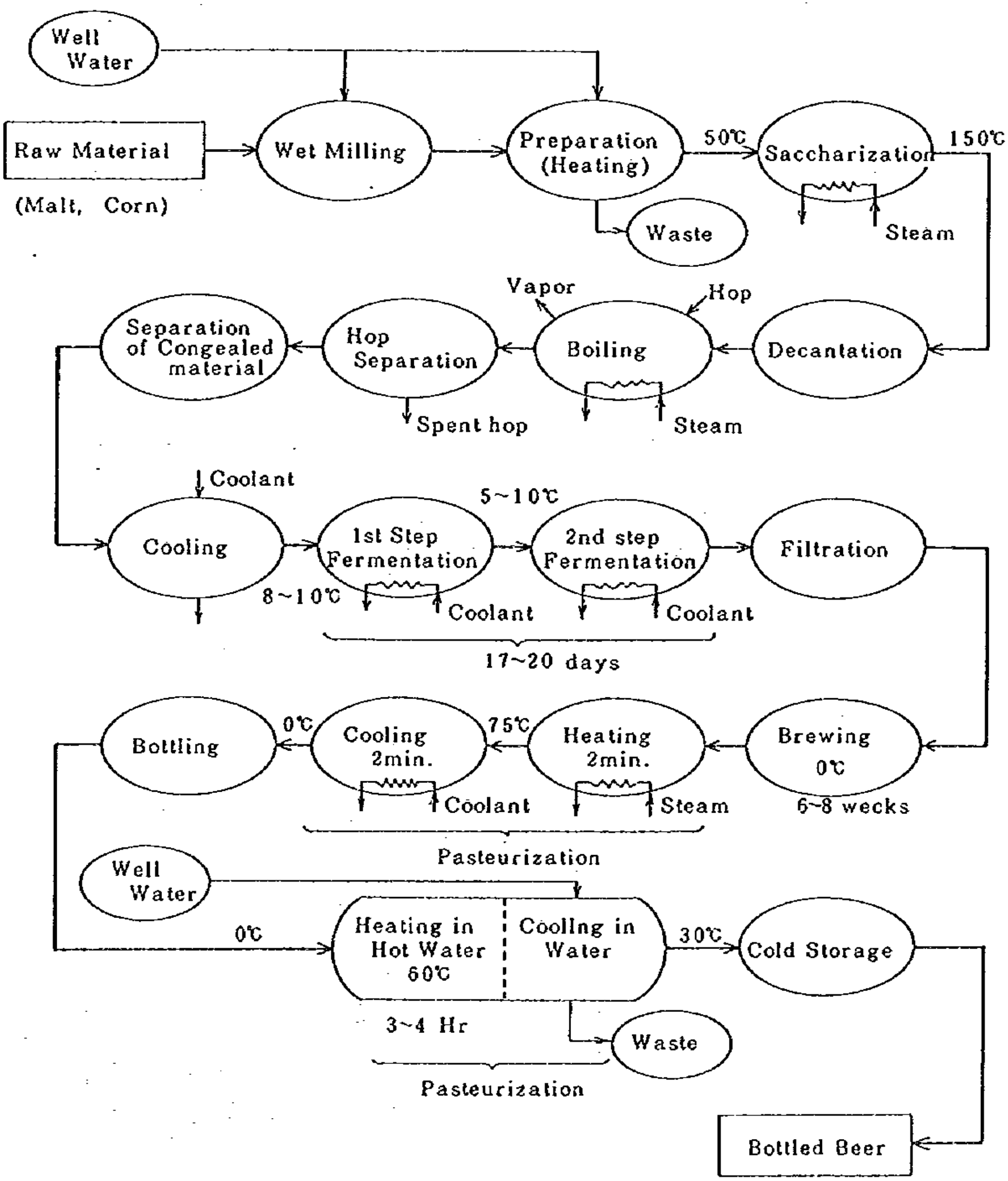
| Source / Use | Well Water | City Water | River Water | Sub-Total | Recoverd Water | Total |
|---|---|---|---|---|---|---|
| Boiler Feed | | | | | | |
| Raw Material | 88 | | | 88 | | 88 |
| Washing | 305 | | | 305 | | 305 |
| Cooling | 15 | | | 15 | | 15 |
| Air Conditioning | | | | | | |
| Miscellaneous | 3 | | | 3 | | 3 |
| Total | 411 | | | 411 | | 426 |
| | | | | Recoverd Water/Total | | % |

## Table 3.4.2 Quality of Make-up Water

| Water Source | | Well Water | City Water |
|---|---|---|---|
| Parameter | Unit | No. 1 | |
| Temperature | ℃ | 13 | |
| pH | | 7.5 | |
| COD | mg/l | | |
| BOD | mg/l | | |
| Iron | mg/l | <0.05 | |
| Manganese | mg/l | <0.05 | |
| Total Hardness | ° dH | 19.3 | |
| Alkalinity | mmo/l | 5.2 | |
| Chloride | mg/l | 22 | |
| Tortal Iron | mg/l | | |
| Evaporated Residue | mg/l | 490 | |
| Electric Conductivity | μS/cm | 680 | |

## Fig. 3.4.1 (1) Process Diagram of Production Line

(1) Beer

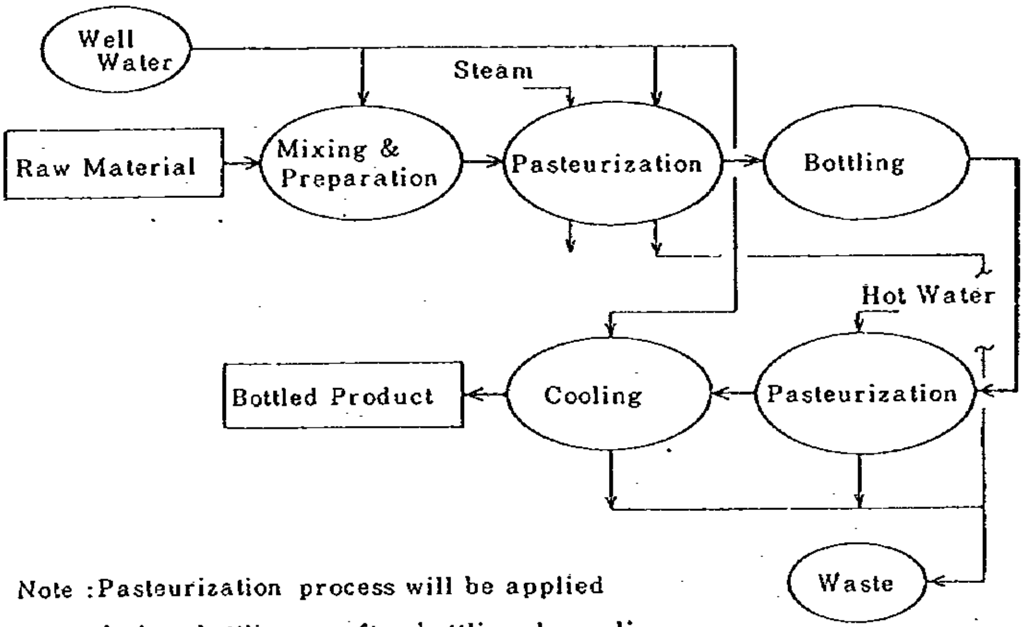



Note : a) Maribor City supplies steam for the brewery.

b) The coolant is 40% ethanol.

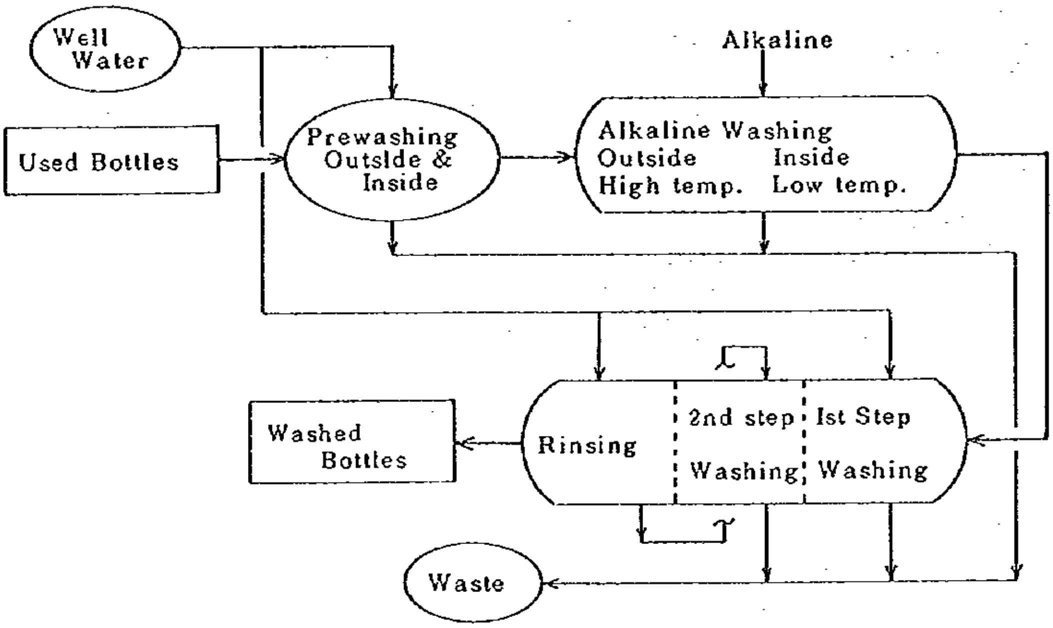
## Fig. 3.4.1 (2) Process Diagram of Production Line

(2) Juice and Soft Drinks

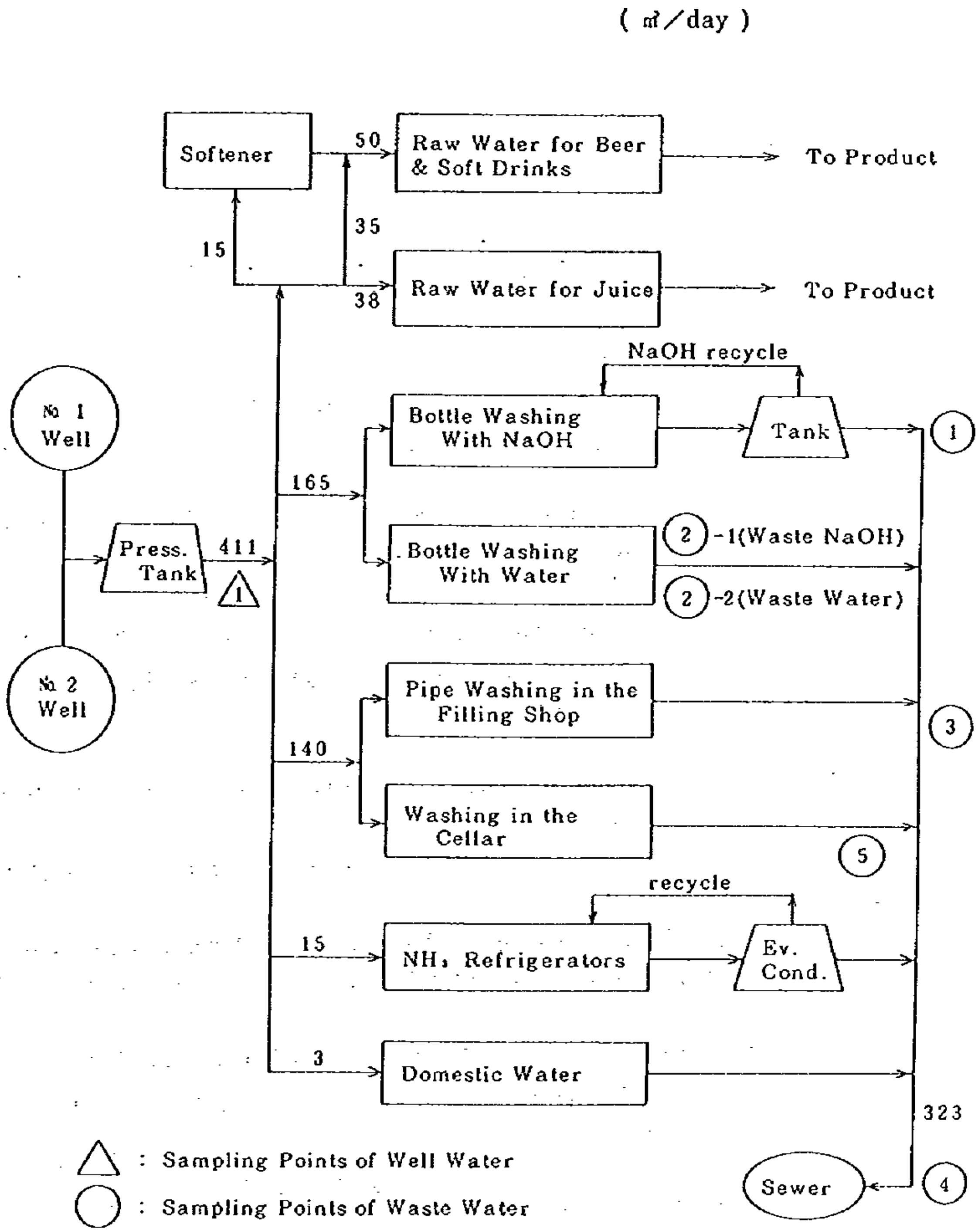



Note : Pasteurization process will be applied before bottling or after bottling depending on the product.

(3) Bottle Washing machine



## Fig. 3.4.2 Water Balance Diagram




Note : a) No flow meter for the well water is applied.
These flow rate are estimated value.
b) Ev. Cond. is Evaporated Condenser.

④ All waste water is discharged into the sewerage system.

⑤ Only the washing water is targeted for water conservation. However, as will be described later, large question marks exist with respect to the volumes of water usage shown here.

(2) Current condition of water conservation

① Flow meters are not installed in the wells and no records are kept on pump operating times.

② The volume of water usage shown on the questionnaire was calculated by multiplying the amount of beer production by the standard unit consumption of water in Germany and Austria and also taking production of soft drinks and juice and the number of bottles washed into account. As a result, the propriety of the value shown here has not been examined at all.

③ Because pressure tanks are in place, there is no wasteful emission of water from the wells.

④ There are two bottle washing machines in place, but it is considered that the washing method is not a water saving one in the fullest sense. This matter is discussed later.

⑤ It is estimated that the given volume of water usage is inaccurate for the following reasons.

- The operating rate of the well pumps at the time of the factory visit was fairly high.
- A fairly large amount of cooling water was being emitted from the evaporative condensers used for the ammonia refrigerator at the time of the factory visit.
- The BOD values (100-400 mg/l) measured at the final outlet were extremely low compared to similar values in the case of Japan (1,000-2,000 mg/l).

⑥ The volumes of waste water emission measured at the time of the factory visit were as follows.

- Approximately 455 $m^3$/day of waste water is emitted from the filling house, which houses the bottle washing machines.
- Approximately 268 $m^3$/day of waste water is emitted from the celler.

• Approximately 600 $m^3$/day of waste water is emitted at the final outlet. However, because this value should be the sum of waste water emitted from the above-mentioned filling house and celler together with waste cooling and domestic water, this figure contradicts with the above values.

⑦ If the above figures are followed, cooling water and domestic water should account for only an extremely small amount of waste water. However, fairly large emissions of such waste water were observed at the time of the factory visit.

⑧ The volume of water usage given on the questionnaire is 411 $m^3$/day. However, judging from the various standpoints, there is a strong possibility that the actual water usage is much greater than this value.

2) Planning of water conservation system

(1) Implementation of water usage control

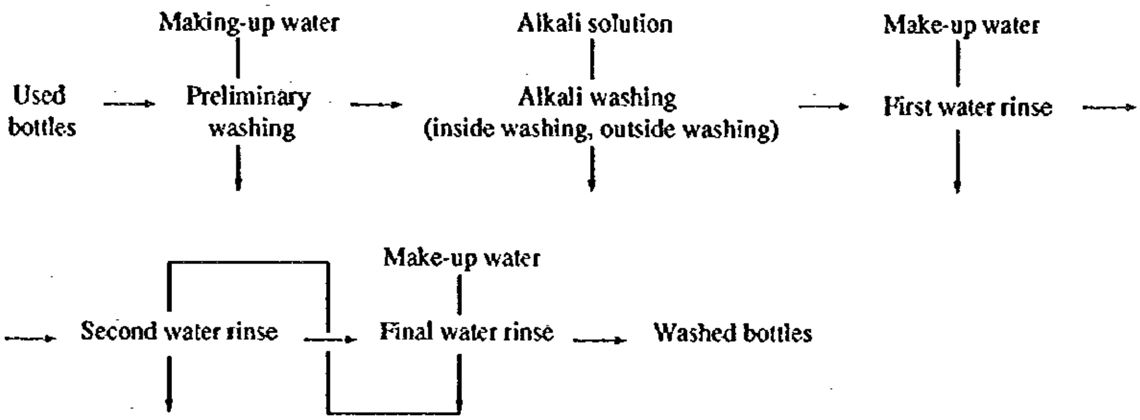
In the current situation, the amount of water pumped from the wells is not measured and there is practically no control of water usage at all. Flow meters must first be fitted in the wells and the control of water usage must be implemented throughout the whole factory. These are the basic conditions 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) Change of bottle washing machines to the water saving type

(a) Existing bottle washing machines

There are currently two bottle washing machines: one large double end type and one small single end type, but the washing system is the same in both. The washing system schematic is shown below.




Here, make-up water (new water) is used in the preliminary washing, first water rinse and final water rinse, while waste water from the final water rinse is reused in the second water rinse by means of a cascade system. In addition, the solution used in the alkali washing is circulated.

The volume of water used for washing by the bottle washing machines is unclear. However, if the aforementioned measurements are correct, it is estimated that 350 $m^3$/day of water is used when both machines are operating.

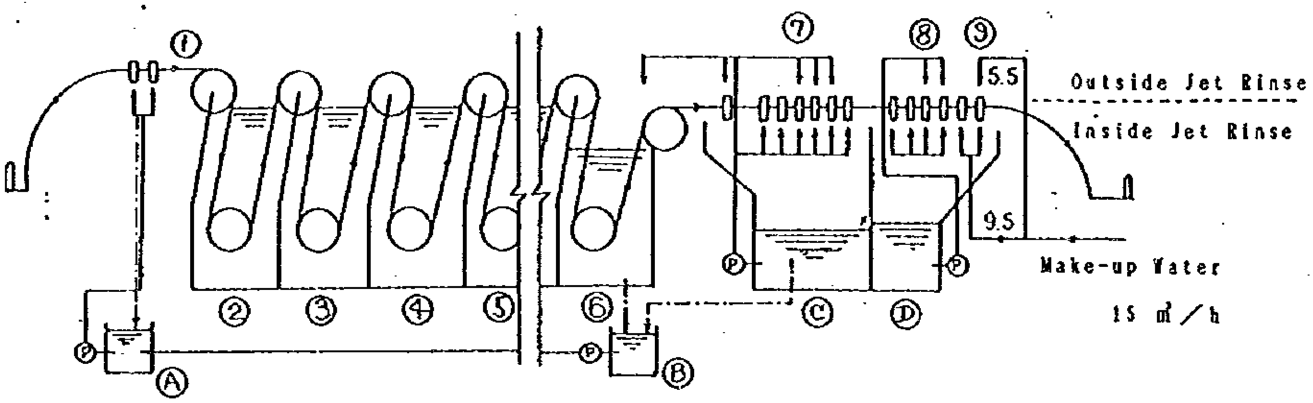
Regarding the number of bottles washed, assuming that production of beer is 28 kl/day and production of soft drinks is 60 kl/day (calculated from annual production volumes and operating days) and the size of the bottles is 0.5 liters (half of the soft drinks are put in 0.25 liter bottles), it works out that approximately 236,000 bottles are washed every day.

Based on this assumption, it works out that approximately 1.5 liters of water is used to wash one bottle. Compared to the amount of water used by recent bottle washing machines, this is a fairly high value.

(b) Outline of plan

The plan is to replace the existing bottle washing machines with the type that uses less water (water saving type). However, in view of the extremely high price (in excess of 10 million SIT) of bottle washing machines, it is thought that this cannot be carried out straight away. In the event where the existing machines are scrapped in the future, it would be desirable to replace them with water saving models. Fig. 3.4.3 shows an example of a water saving type bottle washing machine.

**Fig. 3.4.3 Example of a Water Saving Bottle Washing Machine (capacity: 36,000 bottles/hour)**




① Pre-washing, ② 1st detergent soak, ③ 2nd detergent soak, ④ 3rd detergent soak, ⑤ 4th detergent soak, ⑥ Final soak, ⑦ 1st water rinse, ⑧ 2nd water rinse, ⑨ Final water rinse, A) B) C) D) Recovery water tanks

The features of this machine in terms of water usage are as follows.

① Make-up water (new water) is only supplied for the final water rinse, and recovered water is used in all the other rinses.

② The flow of water starts from the final water rinse and passes through the second water rinse, the first water rinse, final soak tank and pre-washing. This is a counter current with respect to the flow direction of the bottles, and the washing process is known as multistage counter-current washing.

Based on the figures given in Fig. 3.4.3, approximately 0.4 liters of water is used to wash one bottle, representing a large improvement over the estimated amount of water used in the existing machines (approximately 1.5 liters per bottle). This is, however, an estimate for a large capacity machine, and it is reckoned that around 1.0 liter per bottle would be used in a smaller capacity machine. Having said that, there is no doubt that a large water saving could be achieved.

(c) Technical comment

A water saving bottle washing machine not only allows water to be saved on, it has a high washing effect and also makes the handling of peeled-off labels easy.

With the existing bottle washing machines, it is considered that much labor and water is used in the handling of peeled-off labels following the end of the washing. Thus, it is estimated that adoption of a water saving type bottle washing machine would lead to great savings both in water and labor.

(d) Economic comment

As it is difficult to obtain accurate values relating to the amount of water saved and the prices of water saving bottle washing machines, it is not easy to comment on the economic feasibility of this method. Examination is, however, made based on the following assumptions.

- Amount of water saved : 120 $m^3$/day (approx. 1/3 of water used by bottle washing machine)
- Future sewage charges and water costs : 217 SIT/$m^3$
- Annual operating days : 216 days

Based on these assumptions, it is estimated that the profit achieved as a result of water saving can be approximately 5,625,000 SIT per year. Because it is thought that the running costs of a new bottle washing machine would not be more than at present, it is imagined that such profits would be used to cover the depreciation costs of the machine. The depreciation conditions are assumed as follows.

- Depreciation method : Equal depreciation over 15 years
- Rate of interest : 10% per annum
- Equipment maintenance cost : 5% of equipment cost per year

Calculating the equipment cost of the machine equivalent to the profit gained (5,625,000 SIT/year) based on these assumptions, it works out to approximately 33,700,000 SIT.

If one also takes into account the above-mentioned savings that can be made in water usage and labor by introducing a water saving bottle washing machine, it is considered that an economic effect could be gained.

(3) Reclamation of waste water

Because this is a food factory, it is necessary to ensure that all water used is fit for drinking. Thus, the reclamation of waste water is totally inappropriate.

(4) Summing up of the water conservation plan

| No. | Contents of water conservation Plan | Amount of water saved $m^3$/day | Cost of recovered water SIT/$m^3$ |
|---|---|---|---|
| 1 | Changeover to water saving type bottle washing machine | 120 | * |

* If the equipment cost of the machine is approximately 34,000,000 SIT, the plan will be economically feasible.

| | | Now | After water conservation |
|---|---|---|---|
| Volume of water usage | $m^3$/day | 411 | 291 |
| Unit consumption of water | $m^3$/hl | 1.5 | 1.0 |
| Unit consumption of water in bottle washing | l/bottle | 1.5 | 1.0 |

Note: The volume of water use * Now is the value given on the questiomaire.
Volume of beer production : 60,000 hl/year, 280 hl/day
Water saving rate : 29.2%

## 3.4.3 Pretreatment that Satisfy WWTP Discharge Standards, and Waste Water Treatment

1) Manufacturing processes and sources of waste water generation

The major manufacturing processes are shown in Fig. 3.4.1.
The equipment of each manufacturing process is distributed among the five buildings described below. The celler and filling house are the main sources of waste water generation. The waste water generated in each process passes through separate pits before coming together at the factory exit and being discharged into the sewage system.

① Brewery house, celler

The brewery house contains equipment for the processes ranging from selection to the cooling of brew, while the celler contains equipment for the processes ranging from the No. 1 fermentation process to the pre-bottling sterilization. Waste water from the celler mainly comes from tank washing and floor washing. The exact frequency of waste water discharge is unclear, but it is discharged every few days.

② Filling house

The filling house is site of the bottling process after sterilization and it contains the equipment needed to make the products. The main sources of waste water here are the bottle washing machines, and waste water is also generated from CIP washing, the washing of tanks and pipes not belonging to the CPI, the washing of pumps and hoses and floor washing.

The bottle washing machines operate continuously over the three stages of water rinse, alkali soak (caustic soda) and water rinse again. Alkali water is used a number of times by recycling with only the supplementing of alkali performed.

There are five CIP systems in the whole factory and the washing takes place in the order of detergent washing, acid or alkali soak, and hot water rinse. Detergent and acid or alkali water is used a number of times by recycling and, because this is discharged upon checking the state of bacteria generation in it, it is not discharged every day but at set intervals. Because the detergent also acts as a disinfectant, it is thought that the waste water contains chlorine.

③ Soft drinks production house

Because bottling takes place in the filling house, the main sources of waste water generation here are the CPI and floor washing, however, quantities are small.

④ Engine house

Waste water is not generated here.

⑤ Domestic waste water

Domestic waste water is generated from the employees' toilets, and so on.

2) Water quality and volumes of waste water

① The amount of waste water discharged from the celler is 268 $m^3$/day, and the discharge conditions are as shown in Fig. 3.4.4. Regarding the time of discharge, approximately 50% of the total waste water is discharged in the daytime over roughly eight hours. The water quality is shown in Table 3.4.3.

② The amount of waste water discharged from the filling house is 455 $m^3$/day, and the discharge conditions are as shown in Fig. 3.4.5. Almost all this waste water is discharged in a period of roughly 10 hours starting from early morning. The water quality is shown in Table 3.4.4. A high pH value resulting from the alkali washing is a feature of the water quality.

Fig. 3.4.4

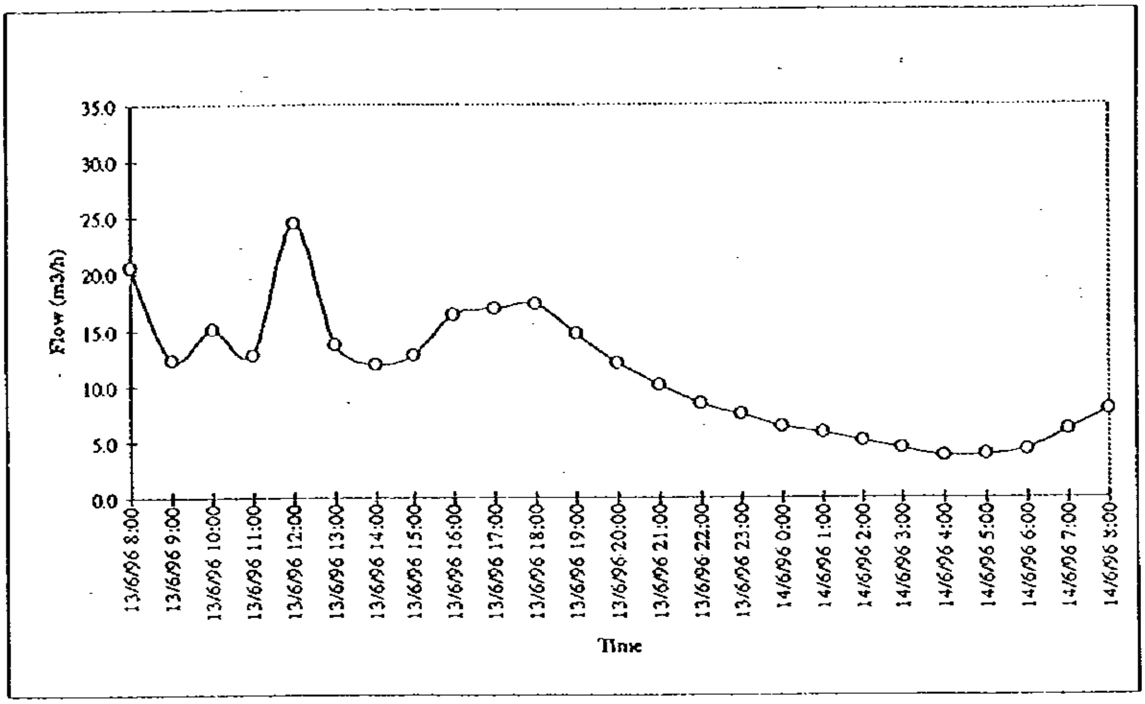
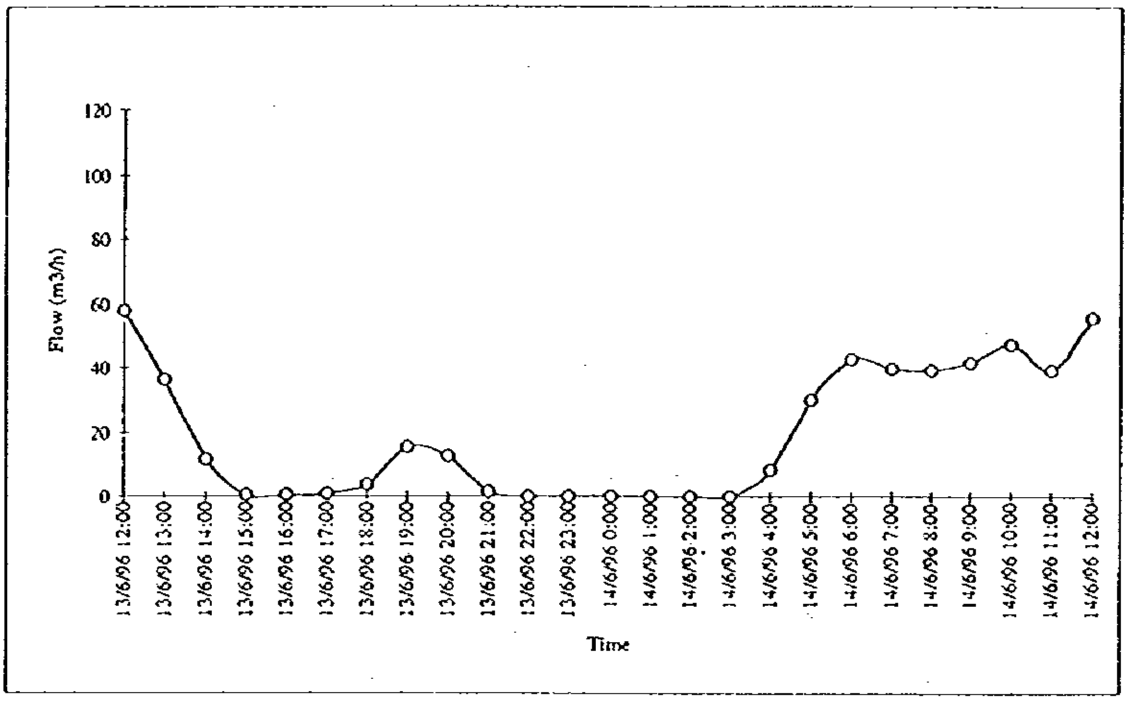



Table 3.4.3

| Parameter | expr.as | Unit | |
|---|---|---|---|
| pH | | | 7,6 |
| Suspended solids | | mg/l | 70 |
| Total nitrogen: | N | mg/l | 20,4 |
| - ammonium nitrogen | N | mg/l | 9,0 |
| - Kjeldahl nitrogen | N | mg/l | 13 |
| - nitrite nitrogen | N | mg/l | < 0,1 |
| - nitrate nitrogen | N | mg/l | 7,4 |
| Total phosphorus | P | mg/l | 13 |
| COD | $O_2$ | mg/l | 150 |
| $BOD_5$ | $O_2$ | mg/l | 30 |
| Anionic surfactants | DBS | mg/l | 1,2 |

## Fig. 3.4.5




## Table 3.4.6

| Parameter | expr.as | Unit | |
|---|---|---|---|
| pH | | | 10,8 |
| Suspended solids | | mg/l | 390 |
| Total nitrogen: | N | mg/l | 20 |
| - ammonium nitrogen | N | mg/l | 0,17 |
| - Kjeldahl nitrogen | N | mg/l | 9,0 |
| - nitrite nitrogen | N | mg/l | <0,1 |
| - nitrate nitrogen | N | mg/l | 11 |
| Total phosphorus | P | mg/l | 23 |
| COD | $O_2$ | mg/l | 540 |
| $BOD_5$ | $O_2$ | mg/l | 140 |
| Anionic surfactants | DBS | mg/l | 0,9 |

3) Pretreatment that satisfy WWTP discharge standards

Judging from the results of analysis, the quality of final waste water, as indicated in Table 3.4.5, is within standard values set for discharge into the WWTP. Thus, there is no need to install pre-treatment equipment.

4) Waste water treatment for river discharge

(1) Design conditions

**Table 3.4.5**

| | | Raw water quality (final wastewater) | Treated water quality standard for river discharge | WWTP discharge standards |
|---|---|---|---|---|
| Temp. | °C | 20 | under.30 | 40 |
| pH | | 6.1--8.7 | 6.5--9.0 | 6.5--9.5 |
| SS | mg/l | 76 | 80 | - |
| T-N | mg/l | 12 | - | - |
| $NH_4$-N | mg/l | 0.35 | 10 | - |
| Kjeldahl method-N | mg/l | 7.3 | - | - |
| $NO_2$-N | mg/l | 0.13 | 1.0 | 10 |
| $NO_3$-N | mg/l | 3.7 | - | - |
| T-P | mg/l | 6.0 | 2.0 | - |
| CODcr | mg/l | 890 | 120 | - |
| BOD | mg/l | 260 | 25 | - |

(a) Water quality : See Table 3.4.5.
(b) Treatment volume : 720 $m^3$/day
(c) Treatment time : 24 hours/day

(2) Basis for optimum system selection

(a) As waste water from a beer factory, the concentrations of both BOD and CODcr are low. This is because the volume of water used by the bottle washing machines is so great.

Thus, there would be no economic advantage to be gained through adopting an anaerobic biological treatment system. As a result, organic compounds are removed through a process of aerobic biological treatment and, by adopting a coagulation and sedimentation process, it is possible to remove phosphorous to below the environmental standard value. The CODcr/BOD ratio is slightly high, however, this poses no problem in terms of performing aerobic biological treatment.

(b) In the event where a water saving bottle washing machine is installed in the future, concentrations of washing waste water would become higher and it would be more advantageous to adopt an anaerobic biological treatment process in terms of running costs.

The following two treatment systems can be considered. If it is possible to screen thick waste water and treat it separately, System A would be more economically feasible than System B.

System A

(Thick waste water) → Screen → Equalization tank → Neutralization

→ Anaerobic treatment

(Thin waste water) → Screen → Equalization → Neutralization

→ Aerobic treatment → Sedimentation → Chemical clarification

→ Sterilization → (discharge)

System B

(Raw waste water)→Screen→Equalization tank→Neutralization
→Anaerobic treatment→Aerobic treatment→Sedimentation
→Chemical clarification →Sterilization→(discharge)

(c) Actual measurement found the total volume of final waste water to be 546 $m^3$/day. However, when one combines the individual amounts of waste water discharged by the celler (268 $m^3$/day) and filling house (455 $m^3$/day), the total comes to 723 $m^3$/day. The reason for this difference is unclear. However, a design value of 720 $m^2$ was adopted here.

(d) Regarding the capacity of the stabilization tank, although waste water is mostly discharged during the daytime hours, the design assumed 24 hour continuous waste water treatment and adopted a tank capacity equivalent to one day's total waste water in order to achieve maximum standardization of water quality and stable equipment operation.

(3) Other comment

(a) The level of T-P in the final waste water is 6.0 mg/l. It is estimated that this is generated from the detergent used in the washing of tanks and from waste yeast. Although lack of clarity regarding the amount of phosphorous coming from waste yeast makes it impossible to be conclusive, by changing over to the use of phosphorous-free detergent, there is a possibility that the coagulation and sedimentation system would become unnecessary. This is something that will need to be investigated in the detailed design phase.

(b) The level of $Cl_2$ in the final waste water is low at 0.05 mg/l and does not pose a problem. Generally speaking, if the level of $Cl_2$ exceeds 5 mg/l and aerobic biological treatment is continuously carried out, it is said that the activity level of activated sludge will fall.

Therefore, in the case where temporary disinfecting is carried out, if the level of $Cl_2$ calculated from the amount of disinfectant used exceeds the aforementioned value, it would be desirable to retain the generated waste water in the tank and treat it by mixing it a little at a time with the general waste water from the factory.

(4) Equipment specifications

Equipment list (see Table 3.4.6)

(5) Design calculations sheet

(a) Basic calculations

① Volume of waste water 720 $m^3$/day

② Water quality

| | | | |
|---|---|---|---|
| BOD | 260 mg/l | (720 $m^3$/day x 0.26 kg/$m^3$ | = 187.2 kg/day) |
| CODcr | 890 mg/l | (720 $m^3$/day x 0.69 kg/$m^3$ | = 640.8 kg/day) |
| SS | 76 mg/l | (720 $m^3$/day x 0.076 kg/$m^3$ | = 5.8 kg/day) |
| T-P | 6 mg/l | (720 $m^3$/day x 0.006 kg/$m^3$ | = 4.3 kg/day) |
| Temperature | 20°C | | |

③ Waste water inflow time : 24 hours/day

* The major proportion of the total waste water is discharged in a period of 12 hours per day.

④ Waste water treatment time : 24 hours day (dehydrator : 8 hours/day)

⑤ Treatment standards

| | |
|---|---|
| pH | 6.5-9.0 |
| BOD | 25 mg/l max. |
| CODcr | 120 mg/l max. |
| SS | 80 mg/l max. |
| T-P | 2 mg/l max. |
| Temperature | 30°C max. |

⑥ Hourly average treatment volume

720 $m^3$/day ÷ 24 hours/day = 30 $m^3$/hour

(b) Capacity calculations

① Raw water inflow pits

The actual raw water inflow time was set at 12 hours per day, and the peak hourly waste water discharge was set at 2.5 times the average hourly volume of waste water.

Peak hourly discharge

720 $m^3$/day ÷ 12 hours/day x 2.5 = 150 $m^3$/hour

The capacity was calculated by assuming the above peak hourly discharge and a retention time of 10 minutes.

150 $m^3$/day x 10/60 = 25 $m^3$

Finally decided value : 25 $m^3$

② Stabilization tank

Retention time : 1 day

720 $m^3$/day x 1 day = 720 $m^3$

Finally decided value : 720 $m^3$

③ Aeration tank

BOD capacity load : 0.5 kg-BOD/$m^3$/day

Capacity : 187.2 kg-BOD/day ÷ 0.5 kg-BOD/$m^3$/day= 347 $m^3$

Finally decided value : 400 $m^3$

MLSS load : 0.15 kg-BOD/kg-MLSS/day

MLSS concentration : 187.2 kg-BOD/$m^3$/day ÷ 0.15 kg-BOD/kg-MLSS/day ÷ 400 $m^3$ = 3.1 kg/$m^3$

3.1 kg/$m^3$ x 1,000 = 3,100 mg/l

④ No. 4 sedimentation tank

Surface area load : 12 $m^3/m^2$/day

Required surface area : 720 $m^3$/day + 12 $m^3/m^2$/day = 60 $m^2$

Finally decided value : 8 m x 8 m (64 $m^2$)

⑤ Reaction tank

Retention time : 10 minutes

Capacity : 720 $m^3$/day + 24 hours/day x 10/60 = 5 $m^3$

Finally decided value : 5 $m^3$

⑥ Coagulation tank

Retention time : 5 minutes

Capacity : 720 $m^3$/day + 24 hours/day x 5/60 = 2.5 $m^3$

Finally decided value: 3 $m^3$

⑦ No.7 sedimentation tank

Surface area load : 24 $m^3/m^2$/day

Required surface area : 720 $m^3$/day + 24 $m^3/m^2$/day = 30 $m^2$

Finally decided value : 5.5 m x 5.5 m (30.2 $m^2$)

⑧ Treated water tank

Retention time : 10 minutes

Capacity : 720 $m^3$/day x 24 hours/day x 10/60 = 5 $m^3$

Finally decided value: 5 $m^3$

⑨ Sludge storage tank

Calculation of the amount of sludge generated per day

- Excess sludge from biological treatment is assumed to be 30% of the total BOD volume

  187.2 kg/day x 0.3 = 56.2 kg/day (including SS content in raw water)

- Sludge from coagulation and sedimentation (whereas P is 4.3 kg/day, the amount of PAC added is 144 kg/day).

  4.3 kg/day x 122/31 = 16.9 kg (where all P forms $AlPO_4$ )
  144 kg/day x 0.153 = 22.0 kg/day (where all PAC forms Al $(OH)_3$ )

22.0 kg/day x 27/78 - 16.9 kg/day x 27/122 = 3.9 kg/day (amount of excess Al)

3.9 kg/day x 78/27 = 11.3 kg/day (amount of SS formed as $Al(OH)_3$ )

Total : 56.2 kg/day + 16.9 kg/day + 11.3 kg/day = 84.4 kg/day (Dry base)

Retention time : 1 day
Amount of incoming sludge : 8.4 $m^3$/day
Sludge concentration : 1%
Capacity : 8.4 $m^3$/day x 1 day = 8.4 $m^3$

Finally decided value : 10 $m^3$

⑩ Dehydrating equipment

- Sludge coagulation tanks
  Retention time : 5 minutes
  Capacity : 8.4 $m^3$/day ÷ 8 hours/day x 5/60 = 0.088 $m^3$

  Finally decided value : 0.1 $m^3$ x 2 tanks

- Dehydrator
  Amount of treated sludge : 84.4 kg/day as dry base
  Dehydrated sludge water content : 85%
  Treatment capacity : 84.4 kg/day + 8 hours/day = 10.6 kg/hour as dry base

  Finally decided value : Belt press type, 12 kg dry solid/hour

  Amount of dehydrated sludge : 84.4 kg/day + 0.15 = 563 kg/day

⑪ PAC tank
Retention time : 7 days minimum
Volume used : 144 kg/day (200 mg/l added)
Capacity : 144 kg/day + 1.2 kg/l x 7 days = 840 l

Finally decided value : 3 $m^3$

⑫ NaOH tank (10% concentration)
Retention time : 7 days minimum
Volume used : 20.3 kg/day as dry base (pH adjustment after PAC added)
20.3 kg/day + 0.1 = 203 l/day as 10%

Capacity : 203 l/day x 7 days = 1,421 l

| Finally decided value : 2 $m^3$ |
|---|

⑬ Polymer (A) tank (0.1% concentration)

Retention time : 2 days minimum

Volumes used :

For wastewater treatment : 1.44 kg/day as dry base (2 ppm added)

For dehydrator : 0.42 kg/day as dry base (0.5% of SS volume added)

Total : 1.86 kg/day as dry base 1.86 kg/day ÷ 0.001 = 1,860 l as 0.1%

Capacity : 1,860 l /day x 2 days = 3,720 l

| Finally decided value : 4 $m^3$ |
|---|

⑭ Polymer (K) tank (0.1% concentration)

Retention time : 2 days minimum

Volume used : 0.42 kg/day as dry base (0.5% of SS volume added)
0.42 kg/day ÷ 0.001 = 420 l as 0.1%

Capacity : 420 l /day x 2 days =840 l

| Finally decided value : 1 $m^3$ |
|---|

⑮ Agitation blower

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

| | | |
|---|---|---|
| Agitation tank : | Raw water inflow pit | 25 $m^3$ |
| | Stabilization tank | 720 $m^3$ |
| | Sludge storage tank | 10 $m^3$ |
| | Total : | 755 $m^3$ |

Aeration volume : 755 $m^3$ x 1 $m^3/m^3$/hour ÷ 60 = 12.6 $m^3$/min.

| Finally decided value : 12.9 $m^3$/min. x 0.45 kg/$cm^2$ x 18.5 kw |
|---|

⑯ Aeration blower

Oxygen for breaking down BOD : 187.2 kg/day x 1 kg-02/kg-BOD
= 187.2 kg/day

Oxygen for MLSS : 400 $m^3$ x 3.1 kg/$m^3$ x 0.12 kg-02/kg MLSS/day
= 148.8 kg/day

Volume of aeration air : (187.2 + 148.8) kg/day ÷ 32 x 22.4 ÷ 0.21 ÷ 0.1 ÷ 24 = 467 $m^3$/hour

Volume of air for air lift : 720 $m^3$/day ÷ 24 x 2 x 3 = 180 $m^3$/hour

Total aeration volume : (467 + 180) $m^3$/hour ÷ 60 = 10.8 $m^3$/min.

| Finally decided value : 12.9 $m^3$/min. x 0.45 kg/$cm^2$ x 18.5 kw |
|---|

(6) Flow sheet (see Fig. 3.4.6)

(7) Material balance sheet (see Fig. 3.4.7)

(8) Layout (see Fig. 3.4.8)

(9) Equipment costs

| | Thousand SIT |
|---|---|
| (a) Equipment | |
| ① Pumps, blowers, agitators, decelerator, dehydrator | 26,974,000 |
| ② Instrumentation | 1,575,000 |
| ③ Other equipment | 21,000,000 |
| (b) Site works | |
| ① Equipment installation, piping work | 11,725,000 |
| ② Electrical work | 8,225,000 |
| ③ Painting work | 188,000 |
| ④ Civil engineering work | 53,500,000 |
| ⑤ Building work | 56,250,000 |
| ⑥ Site supervision cost | 2,981,000 |
| ⑦ Trial run cost | 3,555,000 |
| (c) Design cost | 3,600,000 |
| Total | 189,573,000 |

(10) Running costs — SIT/Year

(a) Chemical costs

| | | | |
|---|---|---|---|
| ① PAC (11% $Al_2O_3$) | 144 kg/day x 74.7 SIT/kg x 216 days | = | 2,323,500 |
| ② NaOH (100%) | 20.3 kg/day x 83.2 SIT/kg x 216 days | = | 364,820 |
| ③ Polymer A (powder) | 1.83 kg/day x 990 SIT/kg x 216 days | = | 391,330 |
| ④ Polymer K (powder) | 0.39 kg/day x 2000 SIT/kg x 216 days | = | 168,480 |
| ⑤ NaCl0 (11-13%) | 180 kg/day x 54 SIT/kg x 216 days | = | 2,099,520 |
| Subtotal | | = | 5,347,650 SIT/year |

(b) Electricity charge

1,100 kwh/day x 15 SIT/kwh x 216 days = 3,564,000

(c) Sludge disposal cost

0.6 m³/day x 1423 SIT/m³ x 216 days = 184,420

(d) Water charge

18 m³/day x 100 SIT/m³ x 216 days = 388,800

(e) Kerosene charge

230 l/day x 60 SIT/l x 90 days = 1,242,000

(f) Maintenance cost

The cost of maintenance is assumed to be 5% of the equipment cost.
79,823,000 SIT x 0.05 = 3,391,000

(g) Personnel expenses

2 staff/year x 1,500,300 SIT = 3,000,600

Running costs total : 17,118,470 SIT/year
Running cost per 1 m³ of wastewater :

17,118,470/720 m³ x 216 days = 110 SIT/m³

(11) Economic feasibility assessment

(a) Conditions

| | | | | |
|---|---|---|---|---|
| ① | Depreciation period | : | Machinery | 15 years |
| | | | Buildings and civil engineering | 40 years |
| ② | Rate of interest | : | 10% per annum | |
| ③ | Depreciation method | : | Equal depreciation | |
| ④ | WWTP discharge rate | : | 176.56 SIT/m³ | |
| ⑤ | River discharge | : | 0 | |
| ⑥ | Annual treated waste water : | | | |

720 m³/day x 216 days/year = 155,520 m³/year

(b) Treatment cost per m³ of waste water

| Item | Contents | | Cost (SIT/m³) |
|---|---|---|---|
| Depreciation | Machinery | 79,823,000 SIT ÷ 15 years ÷ 155,520 m³/year | ① 34 |
| | Building, civil engineering | 109,750,000 SIT ÷ 40 years ÷ 155,520 m³/year | ② 18 |
| Interest | 189,573,000 SIT x 0.05 ÷ 155,520 m³/year | | ③ 61 |
| Running cost | | | ④ 110 |
| Total treatment cost ① + ② + ③ + ④ | | | 223 |

5) Conclusion

In the case of river discharge, because the discharge standards are so harsh (especially T-P: 2.0 mg/L), the equipment cost and running cost are both expensive.

As a result, it would be disadvantageous for this factory to independently install waste water treatment facilities at this point in time.

## Table 3.4.6 Equipment List

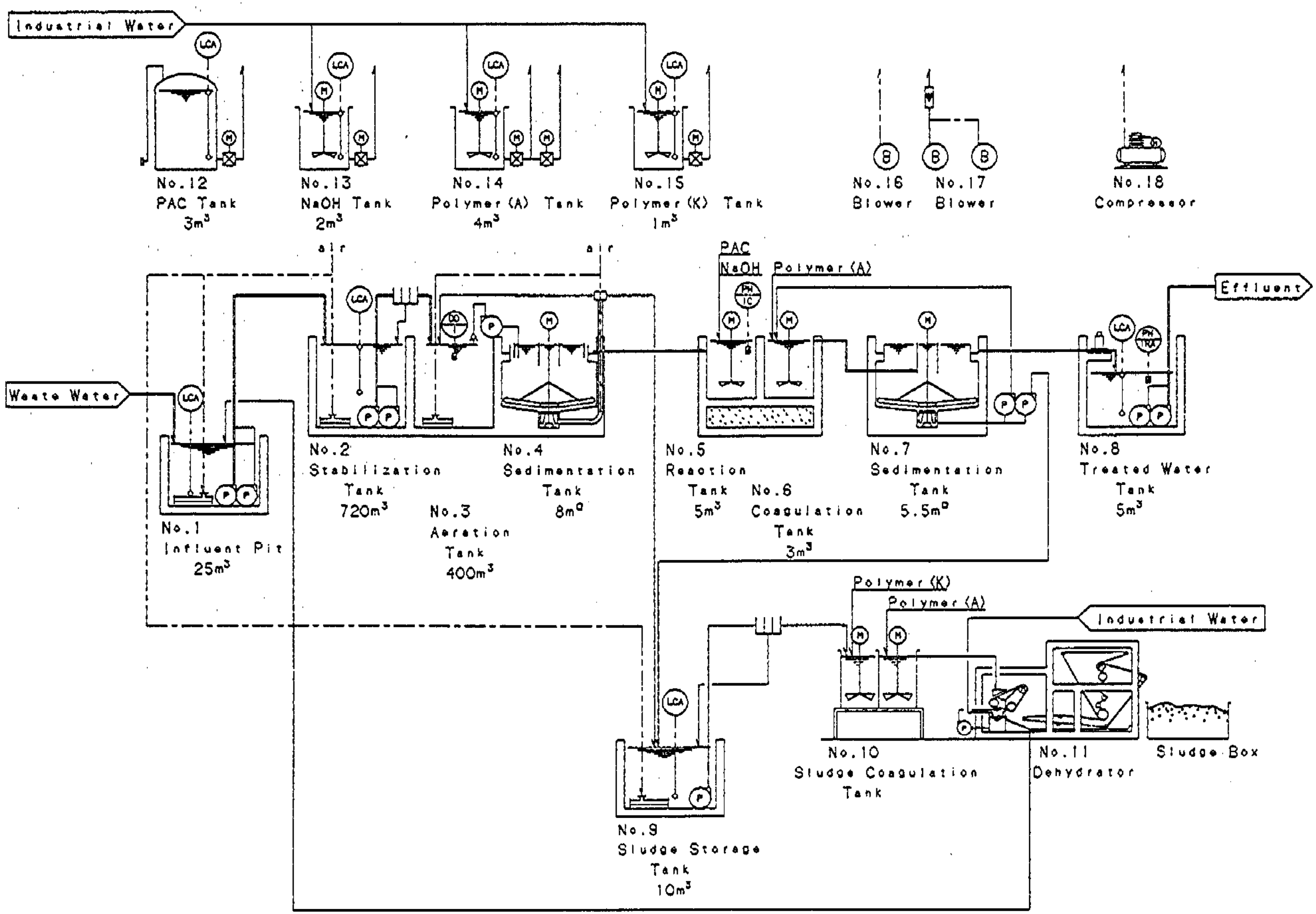
| No. | Item | Qty | Material | Specification | Remark |
|---|---|---|---|---|---|
| 1 | Influent pit | 1 | RC | Capacity 25 m³ | |
| | | | | 2m×4.5m×3mD with air diffuser | |
| | Pump | 1+1 | FC | 150A×2.5m³/min×8m×7.5kw | |
| | | | | Submersion type | |
| | Level switch | 1 | PVC | Float type | |
| | | | | | |
| 2 | Stabilization tank | 1 | RC | Capacity 720 m³ | |
| | | | | 6.7m×32m×3.5mD with air diffuser | |
| | Pumps | 1+1 | FC | 80A×0.6m³/min×10m×2.2kw | |
| | Level switch | 1 | PVC | Float type | |
| | Flow meter | 1 | SS | Box type | |
| | | | | | |
| 3 | Aeration tank | 1 | RC | Capacity 400 m³ | |
| | | | | 3.8m×15m×4mD×2 with air diffuser | |
| | DO meter | 1 | | Dip type 0~20mg/l , 4~20mA | |
| | | | | | |
| 4 | Sedimentation tank | 1 | RC | Surface area 64 m² | |
| | | | | 8m×8m×3mD | |
| | Sludge collector | 1 | SS | rake type 0.4 kw | |
| | Pump | 1 | FC | 65A×0.35m³/min×15m×2.2kw | |
| | | | | | |
| 5 | Reaction tank | 1 | RC+Anti- | Capacity 5 m³ | |
| | | | acid coating | 1.6m×1.6m×2mD | |
| | Agitator | 1 | SS+RL | Vertical type 2.2 kw | |
| | pH meter | 1 | | Dip type 0~14, 4~20mA | |
| | | | | | |
| 6 | Coagulation tank | 1 | RC | Capacity 3 m³ | |
| | | | | 1.6m×1m×2mD | |
| | Agitator | 1 | SUS | Vertical type 0.75 kw | |

| No. | Item | Qty | Material | Specification | Remark |
|---|---|---|---|---|---|
| 7 | Sedimentation tank | 1 | RC | Surface aera 30 m² | |
| | | | | 5.5m×5.5m×3mD | |
| | Sludge collector | 1 | SS | Rake type 0.2 kw | |
| | Recycle pump | 1 | FC | 40A×60 l/min×10m×0.75kw | |
| | Discharge pump | 1 | FC | 40A×60 l/min×10m×0.75kw | |
| | | | | | |
| 8 | Treated water tank | 1 | RC | Capacity 5 m³ | |
| | | | | 1.6m×2m×3mD | |
| | Level switch | 1 | PVC | Float type | |
| | pH meter | 1 | | Dip type · 10~14, 4~20mA | |
| | Pumps | 1+1 | FC | 80A×0.6m³/min×10m×0.75kw | |
| | | | | Submersion type | |
| | Disinfection box | 1 | PVC | Flow contact type | |
| | | | | | |
| 9 | Sludge storage tank | 1 | RC | Capacity 10 m³ | |
| | | | | 2m×2.6m×3.5mD with air diffuser | |
| | Pump | 1 | FC | 50A×60 l/min×10m×0.75kw | |
| | | | | Submersion type | |
| | Level switch | 1 | SUS | Electrode type | |
| | Flow meter | 1 | SS | Box type | |
| | | | | | |
| 10 | Sludge coagulation tanks | 2 | SS | Capacity 0.1 m³ | |
| | | | | 0.4m×0.4m×0.85mH | |
| | Agitators | 2 | SS | Portable type 0.1 kw | |
| | | | | | |
| 11 | Dehydrator | 1 | | Belt press type, 1.7 kw | |
| | | | | Filter wide 500 mm | |
| | | | | | |
| | | | | | |
| | | | | | |

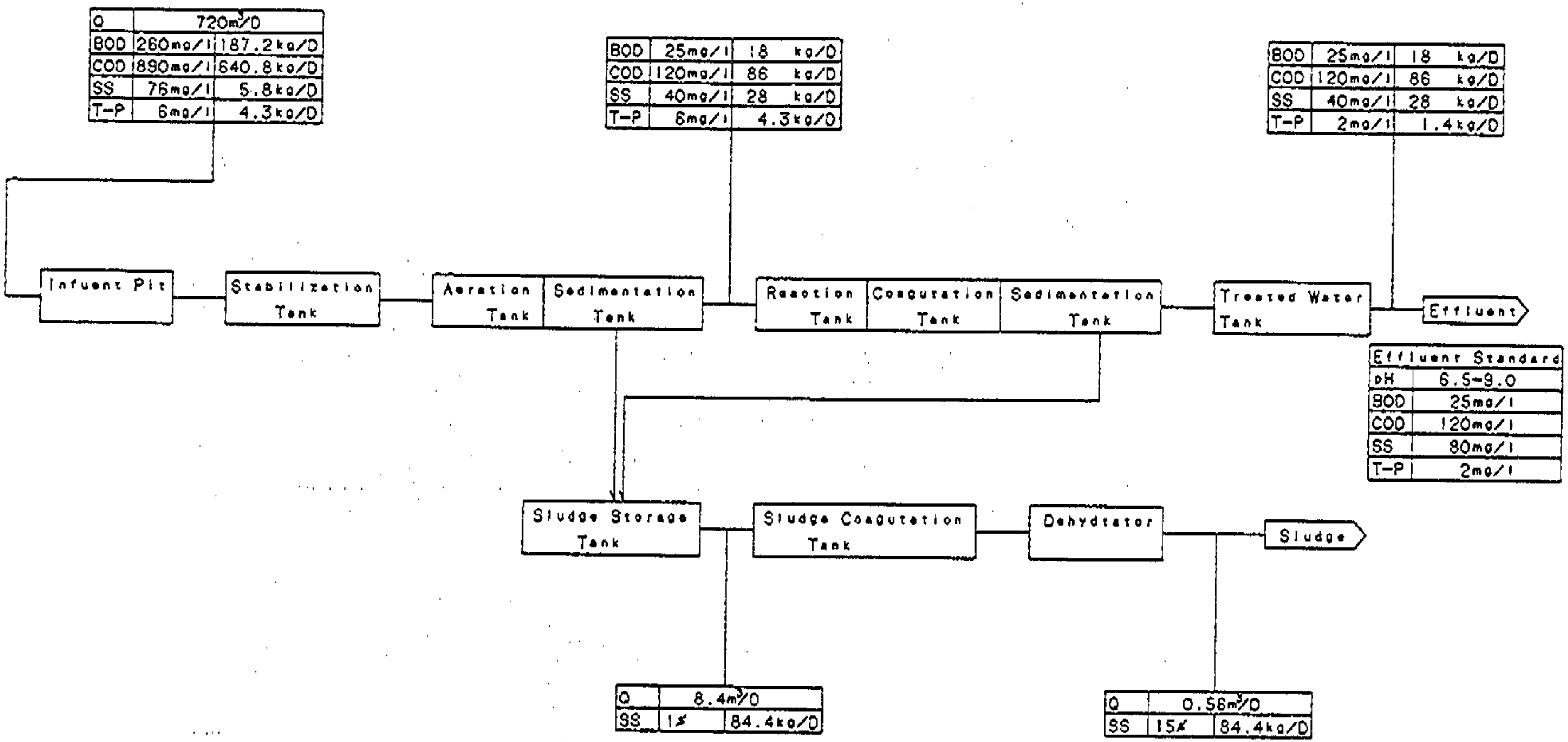
| No. | Item | Qty | Material | Specification | Remark |
|---|---|---|---|---|---|
| 1 2 | PAC tank | 1 | FRP | Capacity 3 m³ | |
| | | | | 1.4mφ ×2mH | |
| | Pump | 1 | PVC | 20A×0.5 l/min×10kg/cm² ×0.2kw | |
| | | | | Diaphram type | |
| | Level switch | 1 | PVC | Float type | |
| 1 3 | NaOH tank | 1 | SS | Capacity 2 m³ | |
| | | | | 1.2m×1.2m×1.85mH | |
| | Agitator | 1 | SUS | Veltical type 0.4 kw | |
| | Pump | 1 | PVC | 20A×1.7 l/min×8kg/cm² ×0.2kw | |
| | Level switch | 1 | SUS | Electrode type | |
| | | | | | |
| 1 4 | Polymer(A) tank | 1 | FRP | Capacity 4 m³ | |
| | | | | 1.42m×1.42m×2.46mH | |
| | Agitator | 1 | SUS | Vertical type 2.2 kw | |
| | Pump(For waste water) | 1 | PVC | 25A×2.8 l/min×5kg/cm² ×0.2kw | |
| | | | | Diaphram type | |
| | Pump(For Dehydrator) | 1 | PVC | 25A×6 l/min×3kg/cm² ×0.2kw | |
| | | | | Diaphram tyep | |
| | Level switch | 1 | SUS | Electrode type | |
| | | | | | |
| 1 5 | Polymer(K) tank | 1 | FRP | Capacity 1 m³ | |
| | | | | 0.91m×0.91m×1.55mH | |
| | Agitator | 1 | SUS | Vertical type 0.4 kw | |
| | Pump | 1 | PVC | 25A×6 l/min×3kg/cm² ×0.2kw | |
| | | | | Diaphram type | |
| | Level switch | 1 | SUS | Electrode type | |
| | | | | | |
| 1 6 | Mixing blower | 1 | FC | 150A×12.9m³/min×0.45kg/cm² | |
| | | | | ×18.5kw | |
| | | | | Roots type | |

| No. | Item | Qty | Material | Specification | Remark |
|---|---|---|---|---|---|
| 1 7 | Aeration blower | 1+1 | FC | 150A×12.9m³/min×0.45kg/cm² | |
| | | | | ×18.5kw | |
| | | | | Roots type | |
| | Flow meter | 1 | SS | Orifice type | |
| | | | | | |
| 1 8 | Compressor | 1 | FC | 36 l/min×9.9kg/cm² ×0.4kw | |
| | | | | | |
| 1 9 | Control panel | 1 | | Indoor Self-standing enclosed type | |
| | | | | 1.6m×0.6m×2mH | |
| | | | | AC 400V×50Hz | |
| | | | | Push button switches | |
| | | | | Alarm lamps | |
| | | | | pH indicators | |
| | | | | Do indicator | |
| | | | | | |
| 2 0 | Pipe | | | | |
| | Raw waste water line | | VP | | |
| | Treated water line | | VP | | |
| | Chemical dosing line | | VP | | |
| | Air line | | SGP | | |
| | | | | | |
| 2 1 | Building | 1 | Steel frame | 700m² x 7 mH | |
| | | | and slate | | |
| | | | roof/wall | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

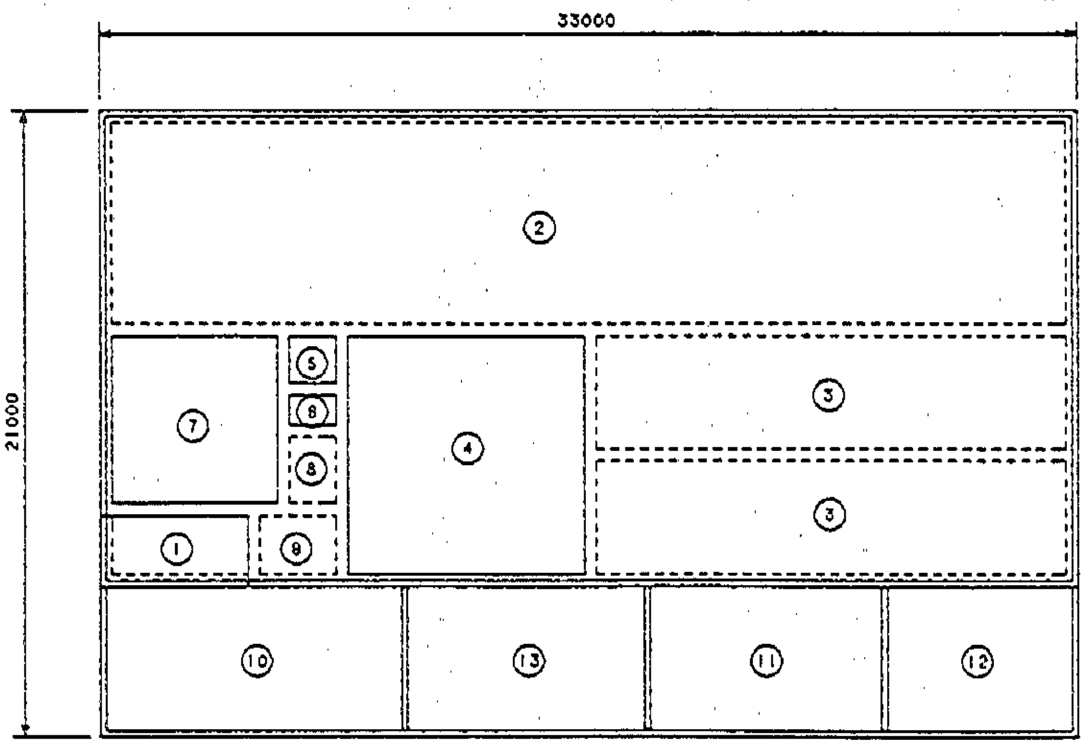
## Fig. 3.4.6 Flow Sheet



## Fig. 3.4.7 Material Balance Sheet



## Fig. 3.4.8 Layout




| No. | Description | Remarks |
|---|---|---|
| 1 | Influent Pit | |
| 2 | Stabilization Tank | |
| 3 | Aeration Tank | |
| 4 | Sedimentation Tank | |
| 5 | Reaction Tank | |
| 6 | Coagulation Tank | |
| 7 | Sedimentation Tank | |
| 8 | Treated Water Tank | |
| 9 | Sludge Storage Tank | |
| 10 | Dehydrator Room | |
| 11 | Chemical Tank Room | |
| 12 | Blower Room | |
| 13 | Control Room | |

### 3.4.4 Pretreatment for Reduction of the Pollution Load

1) Selection of pretreatment system

According to the results of total waste water analysis, approximately 60 % of total daily waste water, 90 % of BOD and COD were discharged during a 6 hour period from 6 a.m. to 12 p.m. (Table 3.4.7 Raw thick waste water)

The results indicate that to reduce pollution it is more economical to separately treat small amounts of highly polluted waste water than to treat the total waste water. For this reason both aerobic and anaerobic treatments of raw thick water are examined.

Aerobic total waste water treatment is also examined to compare with separate treatment.

Incidentally, the water volume measured in June 1996 has been adopted as the design water volume. As it is considered that the water volume is relatively high at this time of year, the mean annual water volume should be lower than this.

2) Outline of pretreatment

(1) Case-1 (Fig 3.4.9 (1))

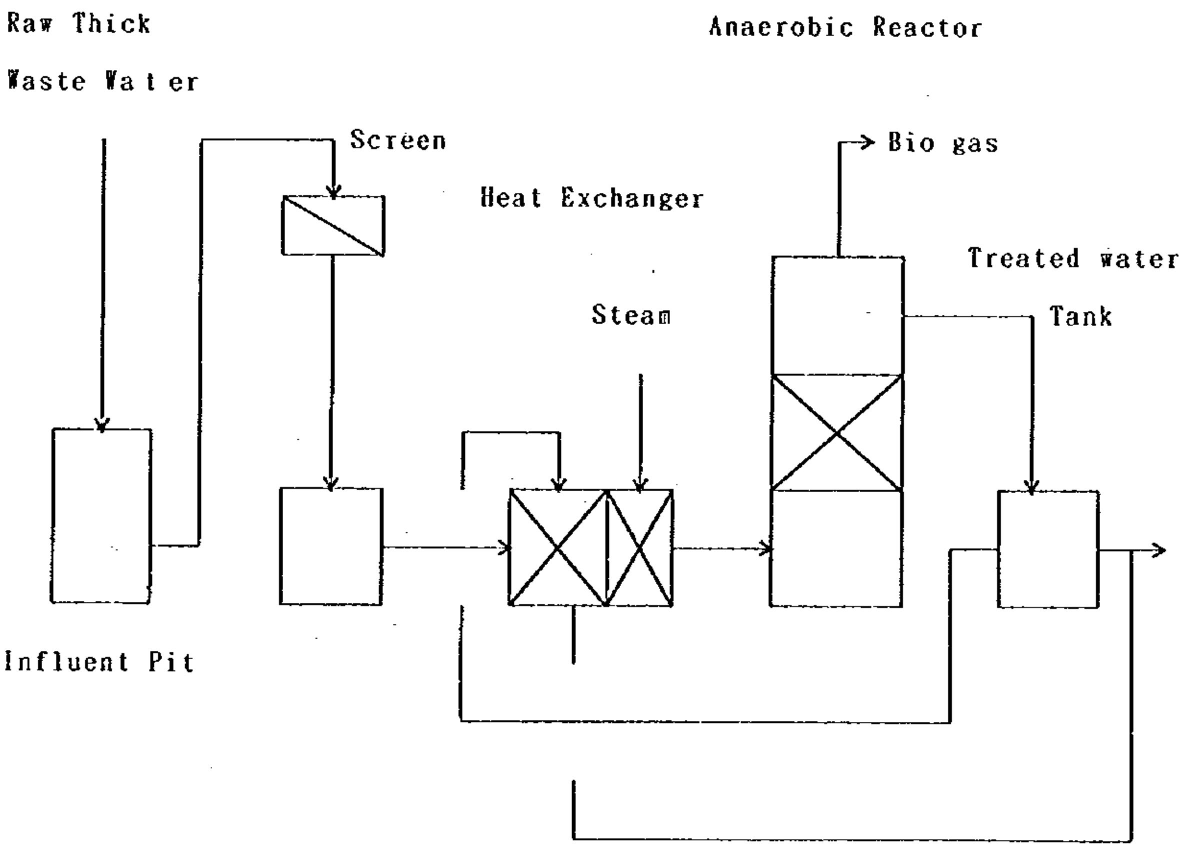
Raw waste water is heated to about 35°C by a heat exchanger after screening relatively large, grain-sized suspended substances. It is then treated by an anaerobic reactor. For this course a fixed bed system was selected over another typical anaerobic reactor UASB (Upflow Anaerobic Sludge Blanket Process).

No particular pH control is applied, since analysis results show that the pH of raw waste water is approximately neutral. Steam is used to supplement heat by liquid-liquid exchange; this minimizes the heating source for raw waste water.

Bio gas formed in the anaerobic reactor is also recovered as a heat source for the boiler.

## Fig. 3.4.9 (1) Flow Diagram of Pretreatment

Case－1




(2) Case 2 (Fig. 3.4.9 (2))

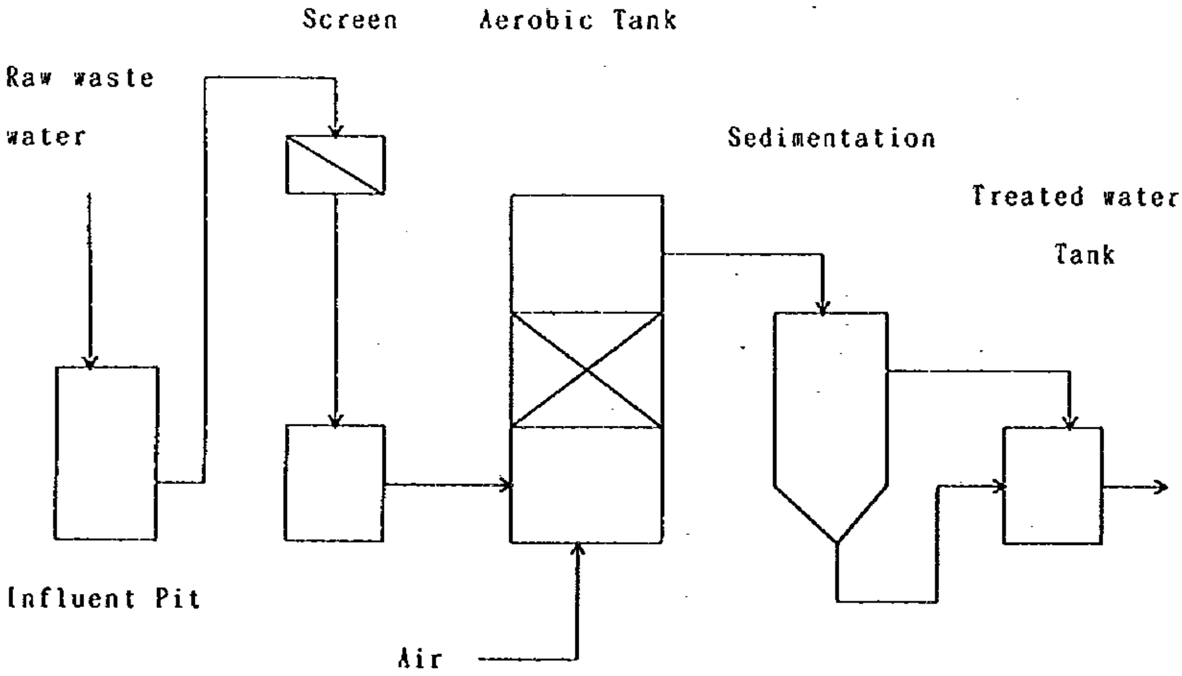
This is the same as Case 1, which treats raw thick waste water as raw waste water by the aerobic system.

There have been many technological developments for the aerobic system, such as the standard activated sludge, rotating disc system and bio-film filter. The bio-film filtering system was selected to compare with Case 1, because it is economical and suitable due to its high load and lack of bulking.

Because the amount of excess sludge generated in the bio-film filtering system is small, the sludge is gradually mixed with treated water and discharged to WWTP without the sludge treatment system, thereby reducing equipment costs.(The SS in waste water increases)

**Fig. 3.4.9 (2) Flow Diagram of Pretreatment**

Case－2 & Case－3




(3) Case 3 (Fig. 5.4.1(2))

This is the same as Case 2, which treats total waste water with a bio filtering system selected to compare with separate treatment of raw thick waste water.

3) Examination results

(1) Technical comment

Table 3.4.7 shows the waste and treated water quality and pollutant load

The COD removal rate of the anaerobic system is higher than that of the aerobic system. For this reason the rate is set a little higher for Case1 than for Cases 2 and 3.

SS is higher in value after aerobic treatment than in raw waste water, because the small amount of excess sludge produced by aerobic treatment may be discharged to WWTP along with treated water.

By the above it is concluded that the aerobic system is more advantageous for BOD reduction and the anaerobic system more advantageous for COD reduction. But since this depends upon the nature of the waste water, specific examinations hereafter should consider technical and economic aspects.

(2) Economic comment

Table 3.4.8 shows equipment and treatment costs of the treatment system.

Case 1 has the highest pretreatment costs due to the proportionately high heat source costs for heating raw waste water (When there is a high concentration of COD the aerobic system is often preferable).

Case 2 is the most economical because of the bio-film filter which reduces equipment costs (although increases electricity costs), and because there is no need for a heat source to heat raw waste water.

Case 3 is more expensive than Case 2 since it produces more waste water, and thereby raises equipment costs.

**Table 3.4.7 Waste and Treated Water Quality and Pollutant Load**

| Kind of waste water | Quantity m3/d | CODcr mg/L (kg/d) | BOD mg/L (kg/d) | PH | SS mg/L (kg/d) | T-N mg/L (kg/d) | T-P mg/L (kg/d) |
|---|---|---|---|---|---|---|---|
| *1 Raw thick waste water | 400 | 1400 (560) | 400 (160) | 7 | 100 (40) | 14.4 (5.8) | 8.3 (3.3) |
| *2 Treated thick waste water | | | | | | | |
| Case-1 | 400 | 300 (120) | 80 (32) | 7 | 100 (40) | 14.4 (5.8) | 8.3 (3.3) |
| Case-2 | 400 | 560 (224) | 80 (32) | 7 | 164 (66) | 10 (4) | 5 (2) |
| *3 Total waste water (Raw water) | 720 | 890 (641) | 260 (187) | Ave 7.4 | 76 (55) | 12 (8.6) | 6 (4.3) |
| CASE-1 | 720 | 249 (201) | 74 (59) | 7 | 76 (39) | 12 (6.2) | 6 (3.1) |
| CASE-2 | 720 | 424 (305) | 82 (59) | 7 | 113 (81) | 9.4 (6.8) | 4.2 (3) |
| CASE-3 | 720 | 400 (288) | 74 (53) | 7 | 114 (82) | 8 (5.8) | 3.6 (5) |
| *4 Discharge to River | 720 Design base | 120 (86) | 25 (18) | Ave 7.8 | 80 (58) | - | 2. (1.4) |

Notes Case 1: Raw thick waste water is pretreated by an aerobic system
Case 2: Raw thick waste water is pretreated by an aerobic system
Case 3: Total waste water is pretreated by aerobic system
*1: Water quality of concentrated liquid in total waste water
*2: Water quality of raw thick water treated in each case
*3: Quality of total waste water when treated raw thick waste water is mixed with other waste water
*4: Water quality in the case of river discharge

Table 3.4.8 Equipment and Treatment Costs of Treatment System

| | Equipment cost SIT | Depreciation & Interest SIT/m³ | Running Cost SIT/m³ | Total treatment cost SIT/m³ |
|---|---|---|---|---|
| CASE-1 | 39,300,000 | 36 | 81 | 117 |
| CASE-2 | 35,960,000 | 33 | 28 | 61 |
| CASE-3 | 43,500,000 | 40 | 31 | 71 |
| Discharge to River | 189,573,000 | 113 | 110 | 223 |

4) Conclusion

Costs are dramatically reduced because coagulation and sedimentation equipment for T-P treatment and chemicals are unnecessary, and because the lowered removal rate of BOD and COD reduces equipment costs.

## 3.5 M-5 VINAG VINARSTVO-SADJARSTVO

### 3.5.1 Factory Outline

1) Outline

This winery is located in the center of Maribor. Squeezed fruit juice that is carried in by tank lorry is brewed and matured in underground tanks, and the resulting wine is then bottled and shipped.

| | |
|---|---|
| Factory complex area | : |
| Employees | : 400 |
| Operating conditions | : 8 hours/day, 251 days/year |
| Products | : Wine (white, red) |
| Annual production | : 5,000 $m^3$ |

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

See Table 3.5.1. City water accounts for the factory's whole water usage.

3) Water supply and waste water discharge flow diagrams

See Fig. 3.5.1 and Fig. 3.5.2.

**Table 3.5.1 Quantity of Consumed Water Classified by Source and Use**

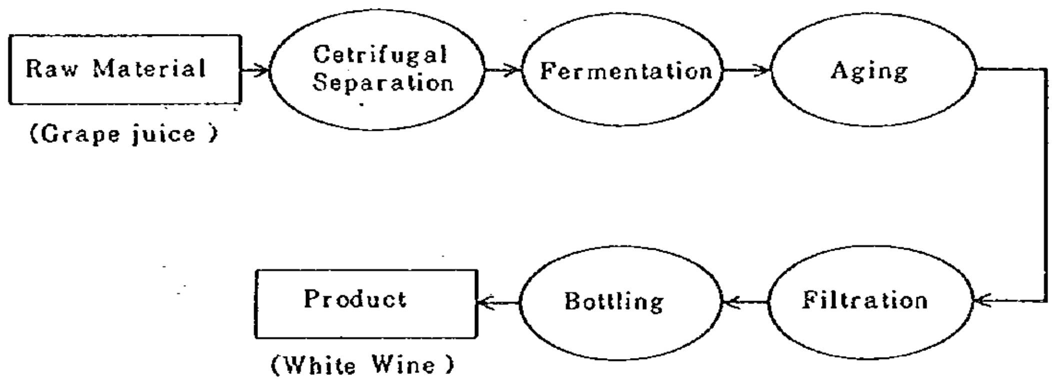
Unit: $m^3$/day

| Source / Use | Well Water | City Water | River Water | Sub-Total | Recoverd Water | Total |
|---|---|---|---|---|---|---|
| Boiler Feed | | (3) | | (3) | (10) | (13) |
| Raw Material | | | | | | |
| Washing | | 61 | | 61 | | 61 |
| Cooling | | (1) | | (1) | (30) | (31) |
| Air Conditioning | | | | | | |
| Miscellaneous | | 6 | | 6 | | 6 |
| Total | | 71 | | 71 | (40) | (111) |
| | | | | Recoverd Water/Total | | (36.0)% |

Note; A value in ( ) shows estimated one

**Fig. 3.5.1 (1) Process Diagram of Production Line**

(1) White Wine




(2) Red Wine

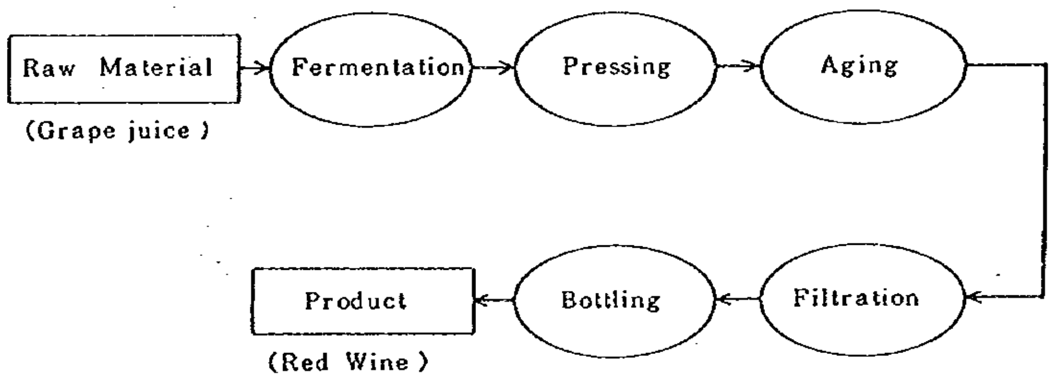


**Fig. 3.5.1 (2) Process Diagram of Production Line**

(3) Bottle washing

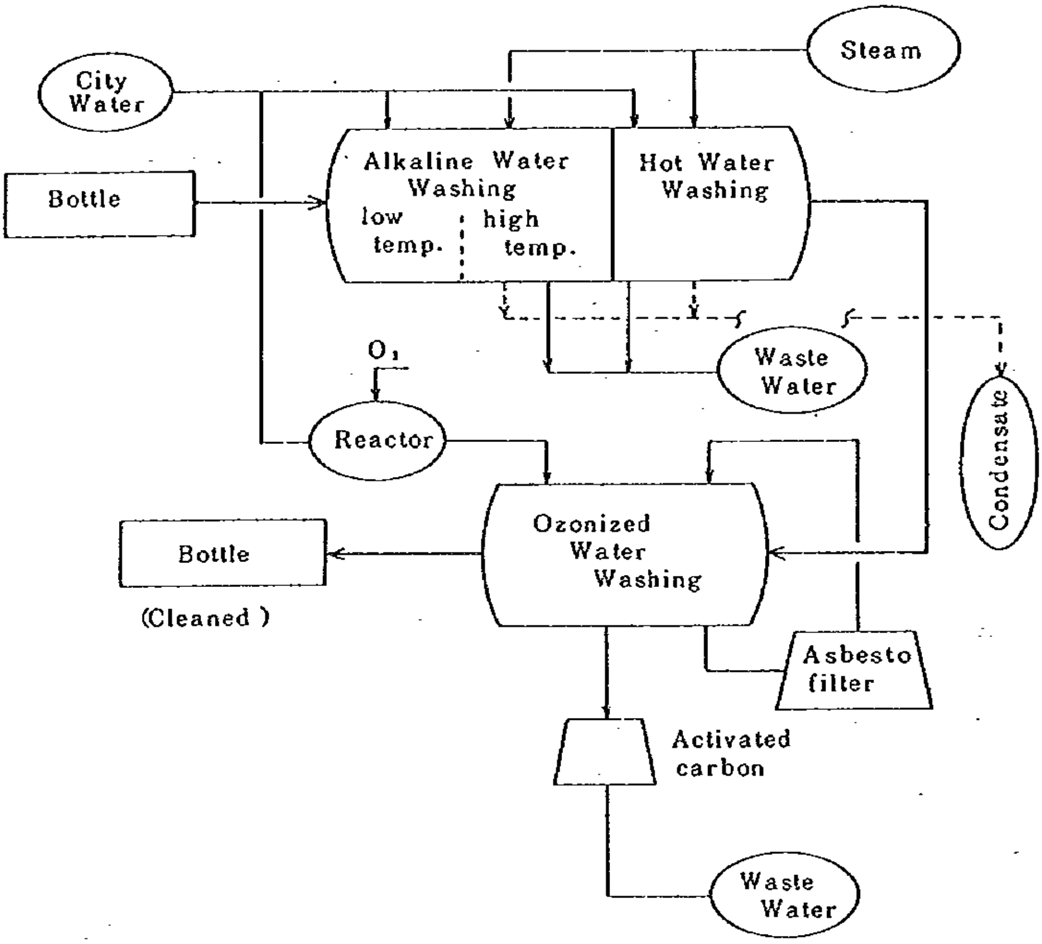
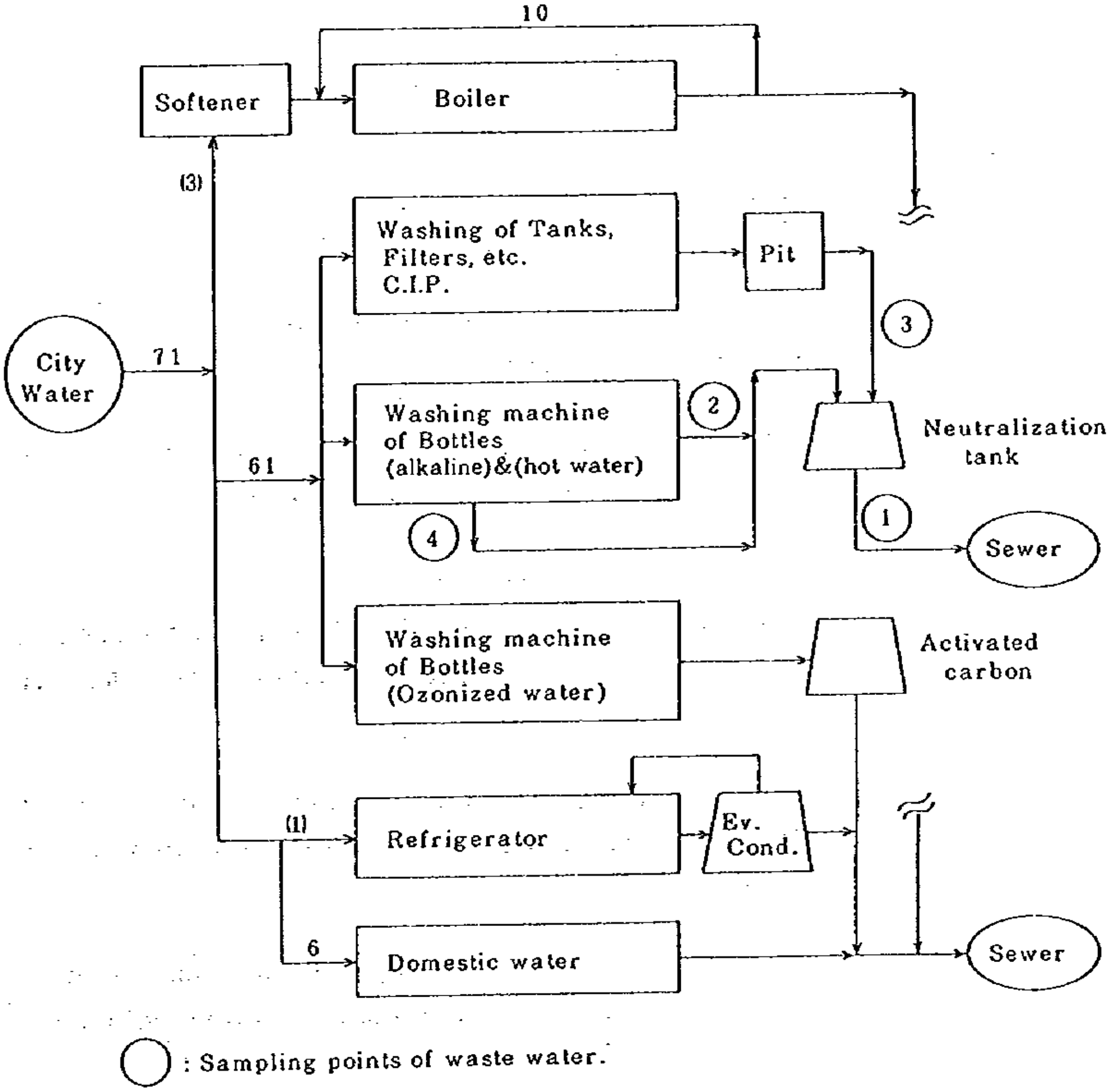


**Fig. 3.5.2 Water Balance Diagram ( m³/day )**




◯ : Sampling points of waste water.

Note : a) The figure in parenthesis is estimated value.

b) Ev. Cond. is Evaporated Condenser.

### 3.5.2 Water Conservation

1) Current condition of water usage and water conservation

(1) Features of water usage

① The city water supply is the sole water source, and flow meters are used to measure the volume of consumption.

② Almost all of the water (approximately 86%) is used for washing. The rest is used for miscellaneous purposes, boiler water and for the evaporative condenser used in the ammonia refrigerator.

③ The washing water is used in a bottle washing machine (1) and in the washing of filters and tanks, etc.

④ The recovery of boiler water is being conducted quite effectively (estimated rate of recovery is approximately 80%).

(2) Current condition of water conservation

① Partial water saving can be witnessed in the retrieval of boiler water, the adoption of a refrigerator evaporative condenser and the adoption of a CPI, etc.

② Water usage management is not sufficient. Many of the hoses used for floor and equipment washing do not have hand control valves attached to their ends.

③ Although the bottle washing machine (largest consumer of water) is the water saving type, the volume of water it uses is rather large at 1.5 liters per bottle.

④ With 40,000-50,000 bottles being washed per day (approximately 10,000 bottles per hour), even considering that the washing machine is a small model, the water consumed is too great.

2) Comment and assessment

(1) Technical comment

① The flow of bottles through the bottle washing machine and along the conveyor belt is not very smooth, and this is thought to be one reason for the poor washing efficiency.

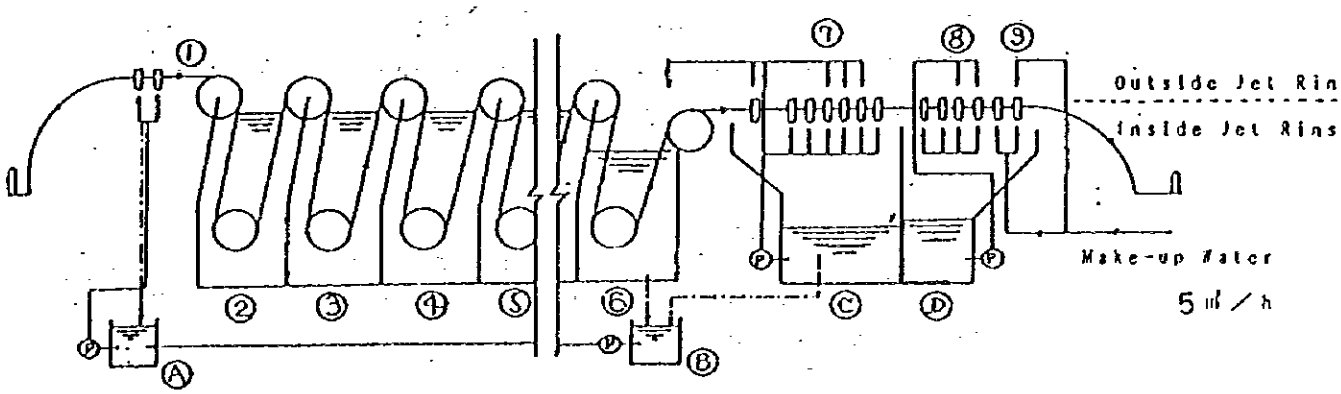
② It is estimated that approximately 20 $m^3$ of water a day could be saved on by renewing the bottle washing machine and conveyor belt. However, the investment required for this would be around 50,000,000 SIT, and it is clear that the resulting water conservation alone could not make this proposition economically feasible. Therefore, it is desirable that water saving equipment be installed when the proper time comes for investment into equipment improvement and renewal at the factory.

An example of a water saving bottle washing machine (capacity : 10,000 bottles/hour) is shown in Fig. 3.5.3.

③ The most important thing now with regard to water saving is to raise the awareness of managers and operators towards the issue.

④ Hand control valves should be attached to the ends of washing hoses. The investiment required for this would be around 10,000 SIT/piece.

**Fig. 3.5.3 Example of a Water Saving Bottle Washing Machine (capacity : 10,000 bottles/hour)**




① Pre-washing, ② 1st detergent soak, ③ 2nd detergent soak, ④ 3rd detergent soak, ⑤ 4th detergent soak, ⑥ Final soak, ⑦ 1st water rinse, ⑧ 2nd water rinse, ⑨ Final water rinse, A) B) C) D) Recovery water tanks

(2) Economic comment

① Because it is important for the present that water usage be reduced through higher awareness among managers and operators, it is impossible to make any economical comment.

### 3.5.3 Pretreatment that Satisfy WWTP Discharge Standards, and Waste Water Treatment

1) Manufacturing processes and sources of waste water generation

The major manufacturing processes are shown in Fig. 3.5.1.

(1) Sources of waste water generation

The main sources of waste water generation are the four areas described below. Of these, the bottle washing process accounts for approximately 80% of all the waste water generated. All the waste water is neutralized in neutralization tanks with NaOH and $H_2SO_4$ before being discharged into the sewerage system.

Volumes of water usage and waste water generation at the factory are shown in the Water Balance Diagram in Fig. 3.5.2.

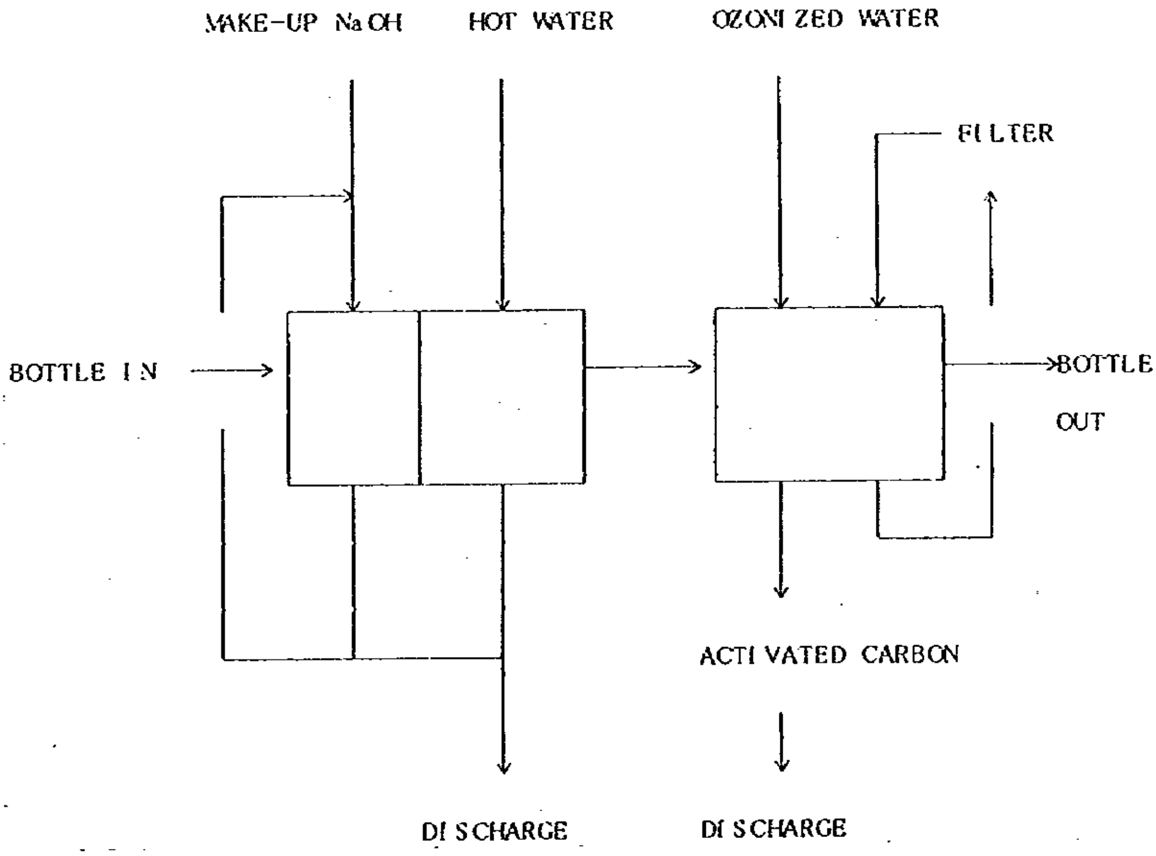
① Celler

CPI waste water and waste water from the washing of filters and tanks is generated here. After being temporarily stored in an underground pit, the waste water is sent by pump to a neutralization tank on ground level. The volume of waste water is small at between 5-10 $m^3$. However, the level of pollution is high. Accumulated SS is removed from the underground pit once per year. The results of the water quality analysis are shown in Table 3.5.2.

② Bottle washing process

The bottle washing process is a continuous one consisting of alkali washing, hot water rinsing and sterilization by ozone water.

The amount of caustic soda used is 120 kg (as 100%) per time, and this is fed after being diluted to 1.5%. Approximately 8 $m^3$ of alkaline waste water is generated around every two weeks. From the continuous hot water rinsing that takes place after the alkali washing, approximately 62 $m^3$/day of waste water is generated, and this is sent to the neutralization tank. Apart from having a high pH value resulting from the alkali washing, this waste water is not all that polluted. The results of the water quality analysis are shown in Table 3.5.2.




Waste water from the next stage of ozone water washing is recycled for further use through a filter and, depending on the degree of pollution, this waste water is treated with activated carbon and discharged once every one or two days. The amount discharged per time is approximately 3 $m^3$. The pollution level of this waste water is low and there is thought to be no problem in discharging it as it is into the river.

③ Alkaline waste water in the bottle washing process

Alkaline washing waste water in the bottle washing process is recycled for repeated use. However, when the pollution level reaches a certain point, it is discharged approximately once per 14 days. The amount discharged per time is low at around 8 $m^3$, but the degree of pollution is high. The results of the water quality analysis are shown in Table 3.5.2.

## Table 3.5.2

| Characterisation of samples | | ①-1 Outlet of neutralization | ①-2 Outlet of neutralization | ② Outlet of washing machine | ③ Outlet from the celler (underground water tank) | ④ Outlet of washing machine (alkaline waste) |
|---|---|---|---|---|---|---|
| Parameter | unit | | | | | |
| PH | | 7.4-7.6 | 7.5-7.8 | 10 | 5.5 | 13 |
| EL. conductivity | μS/cm | 1100 | 1100 | 1100 | 770 | |
| Total solid | mg/l | 1000 | 920 | 750 | 2300 | |
| Suspended solids | mg/l | 90 | 50 | 40 | 800 | 600 |
| Total phosphorus | mg/l | 14 | - | - | - | 125 |
| CODcr | mg/l | 760 | 750 | 160 | 7400 | 4200 |
| BOD | mg/l | 450 | 510 | - | - | 700 |
| Settable solids | ml/l | <0.1 | <0.1 | <0.1 | 8.0 | |
| Free chlorine $Cl_2$ | mg/l | <0.05 | <0.05 | - | - | |

④Domestic waste water

Approximately 8 $m^3$ of domestic waste water is generated from the employees' toilets, etc. every day.

2) Water quality and volume

(1) Water quality

Waste water from ②, ③ and ④ is discharged after under going neutralization in the neutralization tank. The water quality is indicated in Table 3.5.2. ①-1 shows the analysis values taken immediately after neutralization, and ①-2 shows the analysis values taken at the factory exit. Both sets of values can be considered to be more or less the same.

It is unclear whether the waste water described in ④. was discharged at the time of sample taking, but, if it was not discharged then, it is desirable to retain the waste water discharged once every 14 days (approximately 8 $m^3$) and treat it by mixing it with the general waste water a little at a time.

(2) Water volume

Observation was carried out at the neutralization tank outlet, however, it was not possible to obtain accurate data (measuring was difficult because the tank is located underground beneath the car park). Thus, in consideration of the fact that the observed level of city water usage is 76 $m^3$/d and the figure given in the hearing survey was 71 $m^3$/d, it is thought that the water volume lies in the range of 71-76 $m^3$/d.

3) Pretreatment system that satisfies WWTP discharge standards

Neutralization equipment is already in place and, as can be gathered from Table 3.5.3, the quality of the treated water (after neutralization) is within the WWTP discharge standards and no particular problem exists.
If waste water from the factory was to be first separated into acidic and alkaline waste water and stored separately before being discharged together, it may be possible to slightly reduce the amount of neutralizing agent currently used. There is room for future examination here.
Table 3.5.2

4) Waste water treatment for river discharge

As the ozone waste water from the bottle washing process can be released into the river as it is, conceptual design shall be performed for the other waste water.

(1) Design conditions

(a) Water quality : See Table 3.5.3.
(b) Treatment volume : 90 $m^3$/day
(c) Treatment time : 24 hours/day

**Table 3.5.3**

| | | Raw water quality (final wastewater) | Treated water quality standard for river discharge | WWTP discharge standards |
|---|---|---|---|---|
| Temp. | °C | 20 | under.30 | under 40 |
| pH | | 7.5-7.8 | 6.5--9.0 | 6.5--9.5 |
| SS | mg/l | 90 | 80 | - |
| T-P | mg/l | 14--20 | 2.0 | - |
| $NH_3$-N | mg/l | 1.0--3.5 | 10 | - |
| $NO_2$-N | mg/l | - | 1.0 | 10 |
| CODcr | mg/l | 750 | 120 | - |
| BOD | mg/l | 510 | 25 | - |
| Free chlorine $Cl_2$ | mg/l | 0.05 | - | - |

(2) Basis for optimum system selection

(a) Because the concentrations of both BOD and CODcr are low, there would be no economic advantage to be gained through adopting an anaerobic biological treatment system (adoption would of course be possible, but this is only worth it in cases where the water volume is great or the concentration is high). As a result, organic compounds are removed through a process of aerobic biological treatment and, by adopting a coagulation and sedimentation process, it is possible to remove phosphorous to below the environmental standard value.

Because the CODcr/BOD ratio is approximately 1.5, there is no problem in terms of performing aerobic biological treatment.

(b) In the event where a water saving bottle washing machine is installed in the future, because concentrations of washing waste water would become higher, it may become more advantageous to adopt an anaerobic biological treatment process in terms of running costs.

The following two treatment systems can be considered. If it is possible to screen thick waste water and treat it separately, System A is generally more economically feasible than System B.

System A

(Thick waste water) → Screen → Equalization tank → Neutralization

→ Anaerobic treatment

(Thin waste water) → Screen → Equalization tank → Neutralization

→ Aerobic treatment → Sedimentation → Chemical clarification

→ Sterilization → (discharge)

System B

(Raw waste water)→Screen→Equalization tank→Neutralization → Anaerobic treatment → Aerobic treatment → Sedimentation → Chemical clarification→Sterilization→(discharge)

(c) Regarding the capacity of the equalization tank, although waste water is mostly discharged during the daytime hours, the design assumed 24 hour continuous waste water treatment and adopted a tank capacity equivalent to one day's total waste water in order to achieve maximum standardization of water quality and stable equipment operation.

(3) Other comment

(a) The level of T-P in the final waste water is 14-20 mg/l. It is estimated that almost all of this is generated from the detergent used during the washing process. By changing over to the use of phosphorous-free detergent, there is a possibility that the coagulation and sedimentation system would become unnecessary. This is something that will need to be investigated in the detailed design phase.

(b) The level of $Cl_2$ in the final waste water is low at 0.05 mg/l and does not pose a problem. Generally speaking, if the level of $Cl_2$ exceeds 5 mg/l and aerobic biological treatment is continuously carried out, it is said that the activity level of activated sludge will fall.

Therefore, in the case where temporary disinfecting is carried out, if the level of $Cl_2$ calculated from the amount of disinfectant used exceeds the aforementioned value, it would be desirable to retain the generated waste water in the tank and treat it by mixing it a little at a time with the general waste water from the factory.

(4) Equipment specifications

Equipment List (see Table 3.5.5)

(5) Design calculations sheet

(a) Basic calculations

① Volume of waste water 90 $m^3$/day

② Water quality

| | | |
|---|---|---|
| BOD | 510 mg/l | (90 $m^3$/day x 0.51 kg/$m^3$ = 45.9 kg/day) |
| CODcr | 750 mg/l | (90 $m^3$/day x 0.75 kg/$m^3$ = 67.5 kg/day) |
| SS | 90 mg/l | (90 $m^3$/day x 0.09 kg/$m^3$ = 8.1 kg/day) |
| T-P | 17 mg/l | (90 $m^3$/day x 0.017 kg/$m^3$ = 1.5 kg/day) |
| Temperature | 20°C | |

③ Waste water inflow time : 12 hours/day

④ Waste water treatment time : 24 hours day (dehydrator : 8 hours/day)

⑤ Treatment standards

| | |
|---|---|
| pH | 6.5-9.0 |
| BOD | 25 mg/l max. |
| CODcr | 120 mg/l max. |
| SS | 80 mg/l max. |
| T-P | 2 mg/l max. |
| Temperature | 30 ℃ max. |

⑥ Hourly average treatment volume

90 $m^3$/day ÷ 24 hours/day = 3.8 $m^3$/hour

(b) Capacity calculations

① Raw water inflow pit

The actual raw water inflow time was set at 12 hours per day, and the peak hourly waste water discharge was set at 2.5 times the average hourly volume of waste water.

Peak hourly discharge
90 $m^3$/day ÷ 12 hours/day x 2.5 = 18.8 $m^3$/hour

The capacity was calculated by assuming the above peak hourly discharge and a retention time of 10 minutes.
$90\ m^3/day \times 10/60 = 3.1\ m^3$

Finally decided value : $4\ m^3$

② Equalization tank

Retention time : 1 day
$90\ m^3/day \times 1\ day = 90\ m^3$

Finally decided value : $90\ m^3$

③ Aeration tank

BOD capacity load : $0.5$ kg-BOD/$m^3$/day
Capacity : $45.9$ kg-BOD/$m^3$/day $\div$ $0.5$ kg-BOD/$m^3$/day $= 91.8\ m^3$

Finally decided value : $100\ m^3$

Finally decided value : $100\ m^3$

MLSS load : 0.15 kg-BOD/kg-MLSS/day
MLSS concentration : $45.9$ kg-BOD/$m^3$/day $\div$ $0.15$ kg-BOD/kg-MLSS/day $\div$ $100\ m^3 = 3.1\ kg/m^3$
$3.1\ kg/m^3 \times 1{,}000 = 3{,}100$ mg/l

④ No. 4 sedimentation tank

Surface area load : $12\ m^3/m^2/day$
Required surface area : $90\ m^3/day \div 12\ m^3/m^2/day = 7.5\ m^2$

Finally decided value : $3\ m \times 3\ m\ (9\ m^2)$

⑤ Reaction tank

Retention time : 10 minutes
Capacity : $90\ m^3/day \div 24\ hours/day \times 10/60 = 0.6\ m^3$

Finally decided value : $1\ m^3$

⑥ Coagulation tank

Retention time : 5 minutes
Capacity : $90\ m^3/day \div 24\ hours/day \times 5/60 = 0.3\ m^3$

Finally decided value : $1\ m^3$

⑦ No. 7 sedimentation tank

Surface area load : $24\ m^3/m^2/day$
Required surface area : $90\ m^3/day \div 24\ m^3/m^2/day = 3.75\ m^2$

Finally decided value : $3\ m \times 3\ m\ (9\ m^2)$

⑧ Treated water tank

Retention time : 10 minutes
Capacity : 90 $m^3$/day x 24 hours/day x 10/60 = 0.6 $m^3$

| Finally decided value : 1 $m^3$ |
|---|

⑨ Sludge storage tank

Calculation of the amount of sludge generated per day

• Excess sludge from biological treatment is assumed to be 30% of the total BOD volume

45.9 kg/day x 0.3 = 13.8 kg/day (including SS content in raw water)

• Sludge from coagulation and sedimentation (whereas P is 1.5 kg/day, the amount of PAC added is 45 kg/day).

1.5 kg/day x 122/31 = 5.9 kg (where all P forms $AlPO_4$ )
45 kg/day x 0.153 = 6.9 kg/day (where all PAC forms $Al(OH)_3$ )
6.9 kg/day x 27/78 - 5.9 kg/day x 27/122
= 1.1 kg/day (amount of excess Al)
1.1 kg/day x 78/27 = 3.2 kg/day (amount of SS formed as $Al(OH)_3$ )

Total :

13.8 kg/day + 5.9 kg/day + 3.2 kg/day =22.9 kg/day (Dry base)

Amount of incoming sludge : 2.3 $m^3$/day
Sludge concentration : 1%
Capacity : 3 days : 2.3 $m^3$/day x 3 day = 6.9 $m^3$

| Finally decided value : 8 $m^3$ |
|---|

⑩ Dehydrating equipment

• Sludge coagulation tanks

Retention time : 5 minutes
Capacity : 6.9 $m^3$/day + 8 hours/day x 5/60 = 0.072 $m^3$

| Finally decided value : 0.1 $m^3$ x 2 tanks |
|---|

• Dehydrator

Amount of treated sludge : 22.9 kg/day x 3 days
= 68.7 kg/ 3 days as dry solid
Dehydrated sludge water content : 85%
Treatment capacity : 68.7 kg/day + 8 hours = 8.6 kg/hour as dry solid

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

Amount of dehydrated sludge (3 days) :

68.7 kg/3 days ÷ 0.15 = 458 kg/3 days = 153 kg/day

⑪ PAC tank

Retention time : 7 days minimum
Volume used : 45 kg/day (500 mg/l added)
Capacity : 45 kg/day ÷ 1.2 kg/l x 7 days = 263 l
Capacity is made so that acceptance of lorry loads is possible.

Finally decided value : 3 $m^3$

⑫ NaOH tank (10% concentration)

Retention time : 7 days minimum
Volume used : 6.3 kg/day as dry solid (pH adjustment after PAC added)
6.3 kg/day ÷ 0.1 = 63 l/day as 10%
Capacity : 63 l/day x 7 days = 441 l

Finally decided value : 500 l

⑬ Polymer (A) tank (0.1% concentration)

Retention time : 3 days minimum
Volumes used :
For wastewater treatment : 0.18 kg/day as dry solid (2 ppm added)
For dehydrator : 0.35 kg/day as dry solid (0.5% of SS volume added)
Total : 0.18 kg/day x 3 + 0.35 kg/3 days = 0.89 kg/3 days as dry solid
0.89 kg/3 days ÷ 0.001 = 890 l as 0.1%

Finally decided value : 1 $m^3$

⑭ Polymer (K) tank (0.1% concentration)

Retention time : 3 days minimum
Volume used : 0.35 kg/3 day as dry solid (0.5% of SS volume added)
0.35 kg/3 days ÷ 0.001 = 350 l/3 days as 0.1%

Finally decided value : 500 l

⑮ Agitation blower

Aeration strength : 15 l/$m^3$/min.

| | | |
|---|---|---|
| Agitation tank : | Raw water inflow pit | 4 $m^3$ |
| | Stabilization tank | 90 $m^3$ |
| | Sludge storage tank | 8 $m^3$ |
| | Total : | 102 $m^3$ |

Aeration volume : 102 $m^3$ x 15 l/$m^3$/min. = 1.53 $m^3$/min.

Finally decided value : 1.54 $m^3$/min. x 0.45 kg/$cm^2$ x 3.7 kw

⑯ Aeration blower

Oxygen for breaking down BOD : 45.9 kg/day x 1 kg-02/kg-BOD

= 45.9 kg/day

Oxygen for MLSS : 100 $m^3$ x 3.1 kg/$m^3$ x 0.12 kg-02/kg MLSS/day

= 37.2 kg/day

Volume of aeration air :

(45.9 + 37.2) kg/day ÷ 32 x 22.4 ÷ 0.21 ÷ 0.1 ÷ 24 = 115.4 $m^3$/hour

Volume of air for air lift : 90 $m^3$/dayv ÷ 24 x 2 x 3 = 22.5 $m^3$/hour

Total aeration volume : (115.4 + 22.5) $m^3$/hour ÷ 60 = 2.3 $m^3$/min.

| Finally decided value : 2.6 $m^3$/min. x 0.45 kg/$cm^2$ x 5.5 kw |
|---|

(6) Flow sheet (see Fig. 3.5.4)

(7) Material balance sheet (see Fig. 3.5.5)

(8) Layout (see Fig. 3.5.6)

| (9) Equipment costs | SIT |
|---|---|
| (a) Equipment | |
| ① Pumps, blowers, agitator, decelerator, dehydrator | 14,276,000 |
| ② Instrumentation | 1,905,000 |
| ③ Other equipment | 11,788,000 |
| (b) Site works | |
| ① Equipment installation, piping work | 6,825,000 |
| ② Electrical work | 6,125,000 |
| ③ Painting work | 250,000 |
| ④ Civil engineering work | 19,625,000 |
| ⑤ Building work | 13,500,000 |
| ⑥ Site supervision cost | 2,194,000 |
| ⑦ Trial run cost | 1,238,000 |
| (c) Design cost | 3,488,000 |
| Total | 81,214,000 |

(10)Running costs SIT/Year

(a) Chemical costs

| | | |
|---|---|---|
| ① PAC (11% $Al_2O_3$) | 45 kg/day x 74.7 SIT/kg x 251 days | = 843,740 |
| ② NaOH (100%) | 6.3 kg/day x 83.2 SIT/kg x 251 days | = 131,560 |
| ③ Polymer A (powder) | 0.3 kg/day x 990 SIT/kg x 251 days | = 74,550 |
| ④ Polymer K (powder) | 0.12 kg/day x 2000 SIT/kg x 251 days | = 60,240 |
| ⑤ NaCl0 (11-13%) | 3.9 kg/day x 54 SIT/kg x 251 days | = 52,860 |
| Subtotal | | = 1,162,950 SIT/year |

(b) Electricity charge

259 kwh/day x 15 SIT/kwh x 251 days = 975,140

(c) Sludge disposal cost

0.17 $m^3$/day x 1423 SIT/$m^3$ x 251 days = 60,720

(d) Water charge

3.5 $m^3$/day x 100 SIT/$m^3$ x 251 days =875,850

(e) Kerosene charge

54 l/day x 60 SIT/l x 90 days = 291,600

(f) Maintenance cost

The cost of maintenance is assumed to be 5% of the equipment cost.
48,089,000 SIT x 0.05 = 2,404,000

(g) Personnel expenses

2 staff/year x 1,500,300 SIT = 3,000,600

<u>Running costs total : 7,982,860 SIT/year</u>

Running cost per 1 $m^3$ of wastewater :

7,982,860/90 $m^3$ x 251 days = 353 SIT/$m^3$

(11)Economic feasibility assessment

(a) Conditions

① Depreciation period : Machinery 15 years
Buildings and civil engineering 40 years

② Rate of interest : 10% per annum

③ Depreciation method : Equal depreciation
④ WWTP discharge rate : 176.56 SIT/$m^3$
⑤ River discharge : 0
⑥ Annual treated waste water : 90 $m^3$/day x 251 days/year
= 22,590 $m^3$/year

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

| Item | Contents | | Cost (SIT/$m^3$) |
|---|---|---|---|
| Depreciation | Machinery | 48,089,000 SIT + 15 years + 22,590 $m^3$/year | ① 142 |
| | Building, civil engineering | 33,125,000 SIT + 40 years + 22,590 $m^3$/year | ② 37 |
| Interest | 81,214,000 SIT x 0.05 + 22,590 $m^3$/year | | ③ 179 |
| Running cost | | | ④ 353 |
| Total Treatment cost ① + ② + ③ + ④ | | | 711 |

5) Conclusion

In the case of river discharge, because the discharge standards are so harsh (especially T-P: 2.0 mg/L), the equipment cost and running cost are both expensive. Moreover, because the treatment volume is so small and the annual operating days are few (216 days/year), the cost per unit treatment volume is high.

As a result, it would be highly disadvantageous for this factory to independently install waste water treatment facilities at this point in time.

## Table 3.5.5 Equipment List

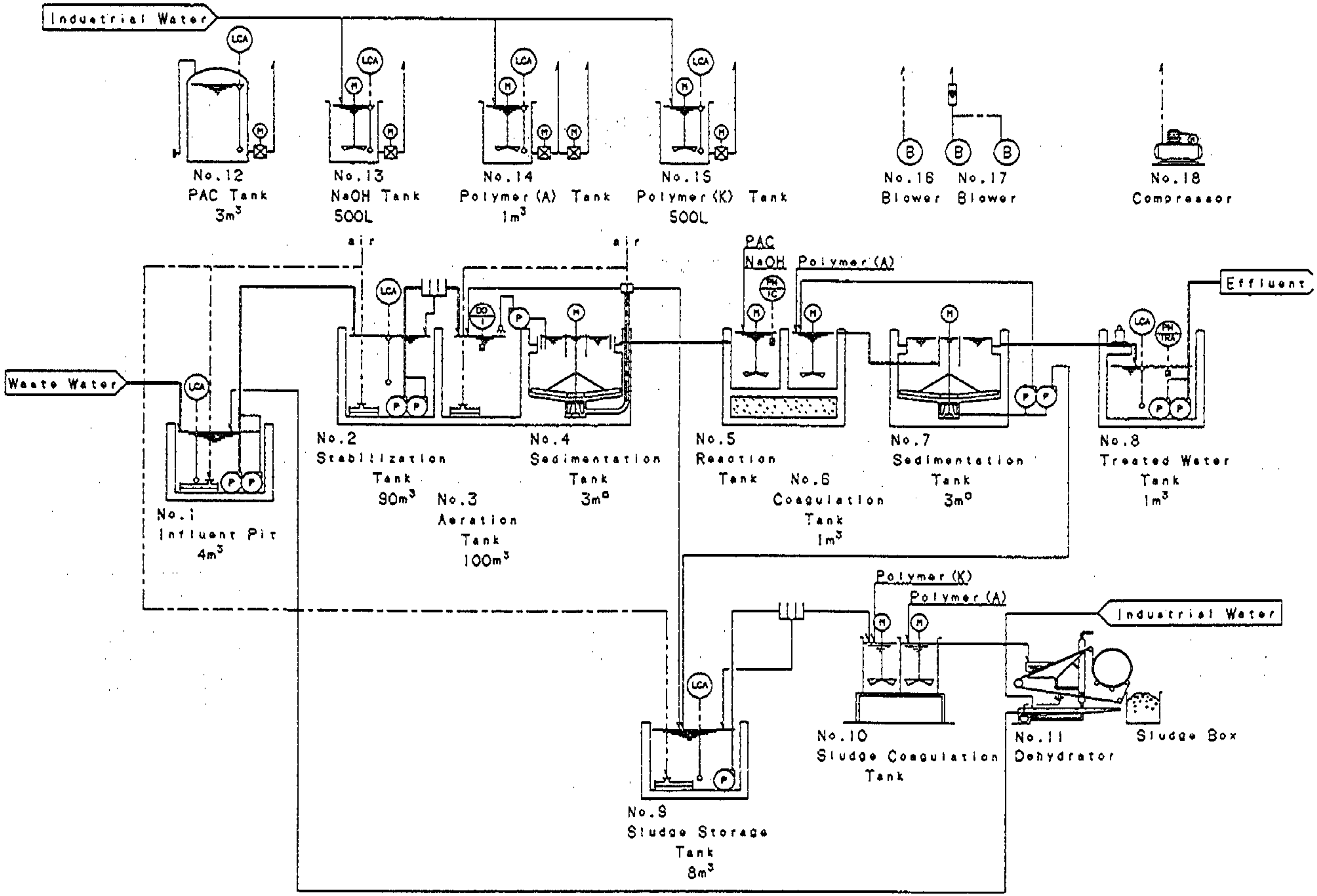
| No | Item | Q'ty | Material | Specification | Remark |
|---|---|---|---|---|---|
| 1 | Influent | 1 | RC | Capacity 4m³ | |
| | | | | 1.1m×2.2m×2mD | |
| | Pump | 1+1 | FC | 50A×350 l/min×13m×1.5kw | |
| | | | | Submersion type | |
| | Level switch | 1 | PVC | Float type | |
| | | | | | |
| 2 | Stabilization tank | 1 | RC | Capacity 90 m³ | |
| | | | | 5m×6m×3mD with air diffuser | |
| | Pump | 1+1 | FC | 50A×100 l/min×9m×0.4kw | |
| | Level switch | 1 | PVC | Float type | |
| | Flow meter | 1 | SS | Box type | |
| | | | | | |
| 3 | Aeration tank | 1 | RC | Capacity 100 m³ | |
| | | | | 4.1m×7.6m×3.3mD with air diffuser | |
| | DO meter | 1 | | Dip type, 0～20mg/l , 4～20mA | |
| | | | | | |
| 4 | No.1 Sedimentation tank | 1 | RC | Surface area 9 m² | |
| | | | | 3m×3m×3mD | |
| | Sludge collector | 1 | SS | rake type 0.2 kw | |
| | Pump | 1 | FC | 32A×100 l/min×20m×0.75kw | |
| | | | | | |
| 5 | Reaction tank | 1 | RC+Anti- | Capacity 1 m³ | |
| | | | acid | 0.8m×1m×1.5mD | |
| | Agitator | 1 | SS+RL | Vertical type 0.4 kw | |
| | pH meter | 1 | | Dip type, 0～14, 4～20mA | |
| | | | | | |
| 6 | Coagulation tank | 1 | RC | Capacity 1 m³ | |
| | | | | 0.8m×1m×1.5mD | |
| | Agitator | 1 | SUS | Vertical type 0.2 kw | |

| No. | Item | Q'ty | Material | Specification | Remark |
|---|---|---|---|---|---|
| 7 | Sedimentation tank | 1 | RC | Surface aera 9 m² | |
| | | | | 3m×3m×3mD | |
| | Sludge collector | 1 | SS | Rake type 0.2 kw | |
| | Recycle pump | 1 | FC | 25/20A×50 l/min×10m×0.75kw | |
| | Discharge pump | 1 | FC | 25/20A×50 l/min×10m×0.75kw | |
| | | | | | |
| 8 | Treated water tank | 1 | RC | Capacity 1 m³ | |
| | | | | 0.8m×1m×1.5mD | |
| | Level switch | 1 | PVC | Float type | |
| | pH meter | 1 | | Dip type, 0~14, 4~20mA | |
| | Pump | 1+1 | FC | 50A×100 l/min×11m×0.4kw | |
| | | | | Submersion type | |
| | Disinfection box | 1 | PVC | Flow contact type | |
| | | | | | |
| 9 | Sludge storage tank | 1 | RC | Capacity 8 m³ | |
| | | | | 1.1m×2.2m×3mD | |
| | Pump | 1 | FC | 50A×40 l/min×10m×0.4kw | |
| | | | | Submersion type | |
| | Level switch | 1 | SUS | Electrode type | |
| | Flow meter | 1 | SS | Box type | |
| | | | | | |
| 10 | Sludge coagulation tank | 2 | SS | Capacity 0.1 m³ | |
| | | | | 0.4m×0.4m×0.85mH | |
| | Agitator | 2 | SS | Portable type 0.1 kw | |
| | | | | | |
| 11 | Dehydrator | 1 | | Belt press type, 0.82 kw | |
| | | | | Filter wide 360 mm | |
| | | | | | |
| | | | | | |
| | | | | | |

| No. | Item | Q'ty | Material | Specification | Remark |
|---|---|---|---|---|---|
| 1 2 | PAC tank | 1 | FRP | Capacity 3 $m^3$ | |
| | | | | 1.4m$\phi$×2mH | |
| | Pump | 1 | PVC | 15A×0.25 l/min×10kg/$cm^2$×0.2kw | |
| | | | | Diaphram type | |
| | Level switch | 1 | PVC | Float type | |
| | | | | | |
| 1 3 | NaOH tank | 1 | FRP | Capacity 500 l | |
| | | | | 0.9m×0.8mH | |
| | Agitator | 1 | SUS | Veltical type 0.2 kw | |
| | Pump | 1 | PVC | 15A×0.25 l/min×8kg/$cm^2$×0.2kw | |
| | Level switch | 1 | SUS | Electrode type | |
| | | | | | |
| 1 4 | Polymer(A) tank | 1 | FRP | Capacity 1 $m^3$ | |
| | | | | 1m$\phi$×1.1mH | |
| | Agitator | 1 | SUS | Vertical type 0.4 kw | |
| | Pump(For Waste water) | 1 | PVC | 15A×0.5 l/min×10kg/$cm^2$×0.2kw | |
| | | | | Diaphram type | |
| | Pump(For Dehydrator) | 1 | PVC | 15A×1.7 l/min×8kg/$cm^2$×0.2kw | |
| | | | | Diaphram tyep | |
| | Level switch | 1 | SUS | Electrode type | |
| | | | | | |
| 1 5 | Polymer(K) tank | 1 | FRP | Capacity 500 | |
| | | | | 0.9m$\phi$×0.8mH | |
| | Agitator | 1 | SUS | Vertical type 0.2 kw | |
| | Pump | 1 | PVC | 15A×1.7 l/min×8kg/$cm^2$×0.2kw | |
| | | | | Diaphram type | |
| | Level switch | 1 | SUS | Electrode type | |
| | | | | | |
| 1 6 | Mixing blower | 1 | FC | 50A×1.54$m^3$/min×0.45kg/$cm^2$×3.7kw | |
| | | | | Roots type | |

| No. | Item | Q'ty | Material | Specification | Remark |
|---|---|---|---|---|---|
| 1 7 | Aeration blower | 2 | FC | 80A×2.6m³/min×0.45kg/cm²×5.5kw | |
| | | | | Roots type | |
| | Flow meter | 1 | SS | Orifice type | |
| | | | | | |
| 1 8 | Compressor | 1 | FC | 36 l/min×9.9kg/cm²×0.4kw | |
| | | | | | |
| 1 9 | Control panel | 1 | | Indoor self-standing enclosed type | |
| | | | | 1.6m×0.6m×2mH | |
| | | | | AC 400V×50Hz | |
| | | | | Push button switches | |
| | | | | Alarm lamps | |
| | | | | pH indicators | |
| | | | | Do indicator | |
| | | | | | |
| 2 0 | Pipe | | | | |
| | Raw waste water line | | VP | | |
| | Treated water line | | VP | | |
| | Chemical dosing line | | VP | | |
| | Air line | | SGP | | |
| | | | | | |
| 2 1 | Building | 1 | Steel frame | 180m² x 7mH | |
| | | | and slate | | |
| | | | roof/wall | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

## Fig. 3.5.4 Flow Sheet



# Fig. 3.5.5 Material Balance Sheet

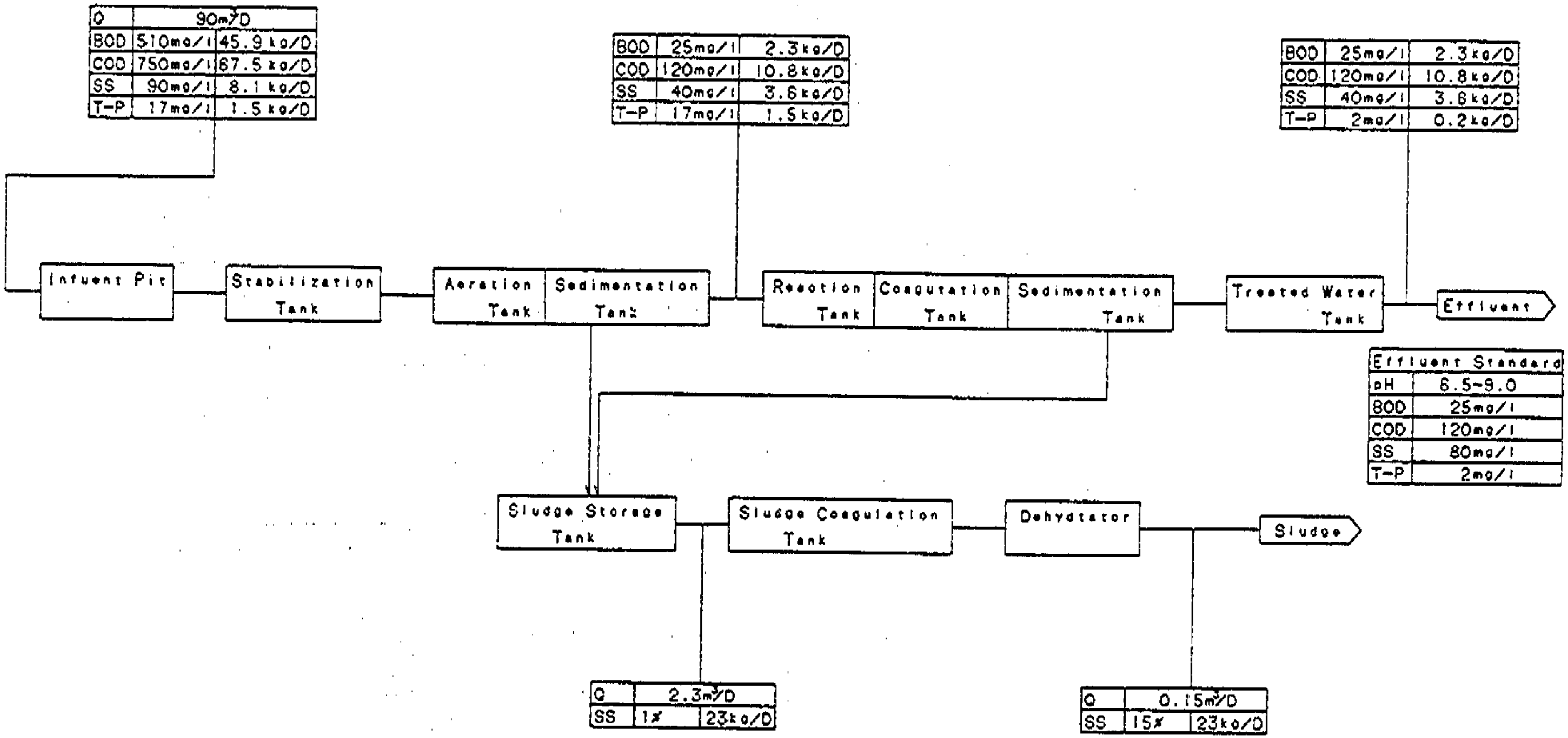
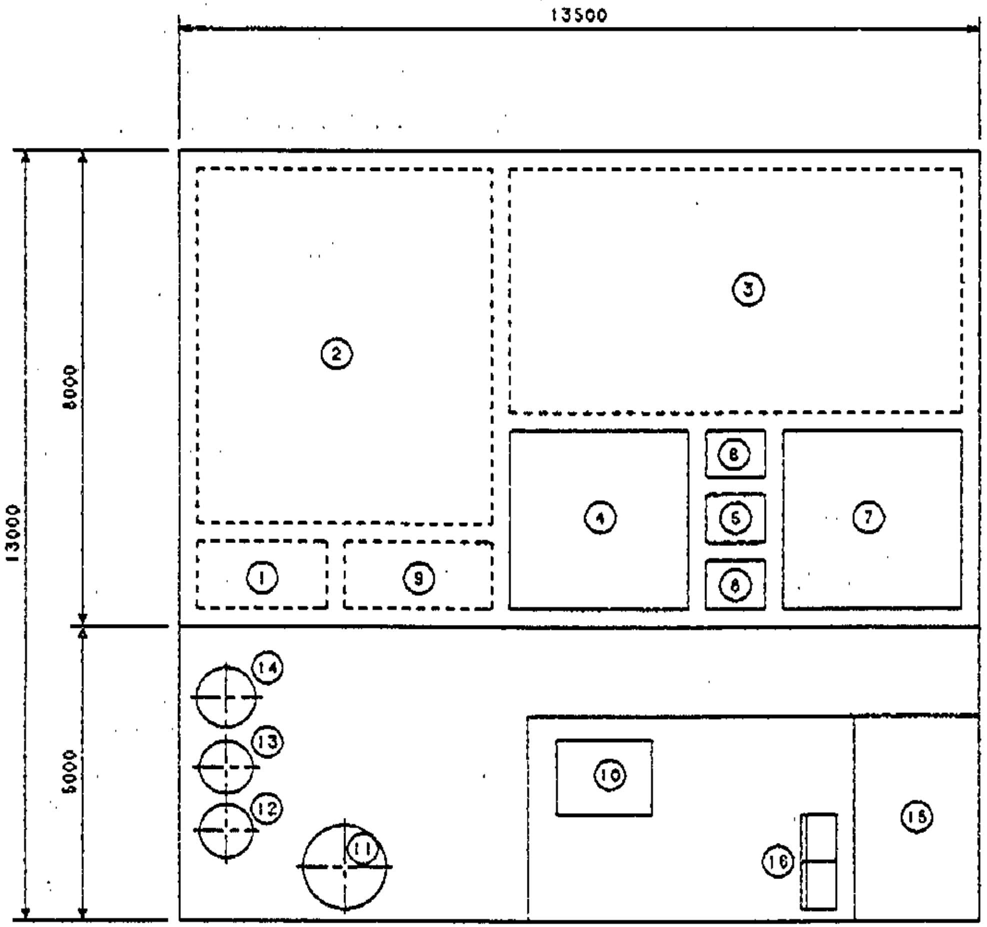


Fig. 3.5.6 Layout




| No | Descriptions | Remarks |
|---|---|---|
| 1 | Influent Pit | |
| 2 | Stabilization Tank | |
| 3 | Aeration Tank | |
| 4 | Sedimentation Tank | |
| 5 | Reaction Tank | |
| 6 | Coagulation Tank | |
| 7 | Sedimentation Tank | |
| 8 | Treated Water Tank | |
| 9 | Sludge Storage Tank | |
| 10 | Dehydrator | |
| 11 | PAC Tank | |
| 12 | NaOH Tank | |
| 13 | Polmer (K) Tank | |
| 14 | Polmer (A) Tank | |
| 15 | Blower Room | |
| 16 | Control Panel | |

### 3.5.4 Pretreatment for Reduction of the Pollution Load

1) Selection of pretreatment system

Since the Factory already applies neutralization treatment before discharge to WWTP, there appears to be no need for more pretreatment equipment installations. The examination was conducted for reference only.

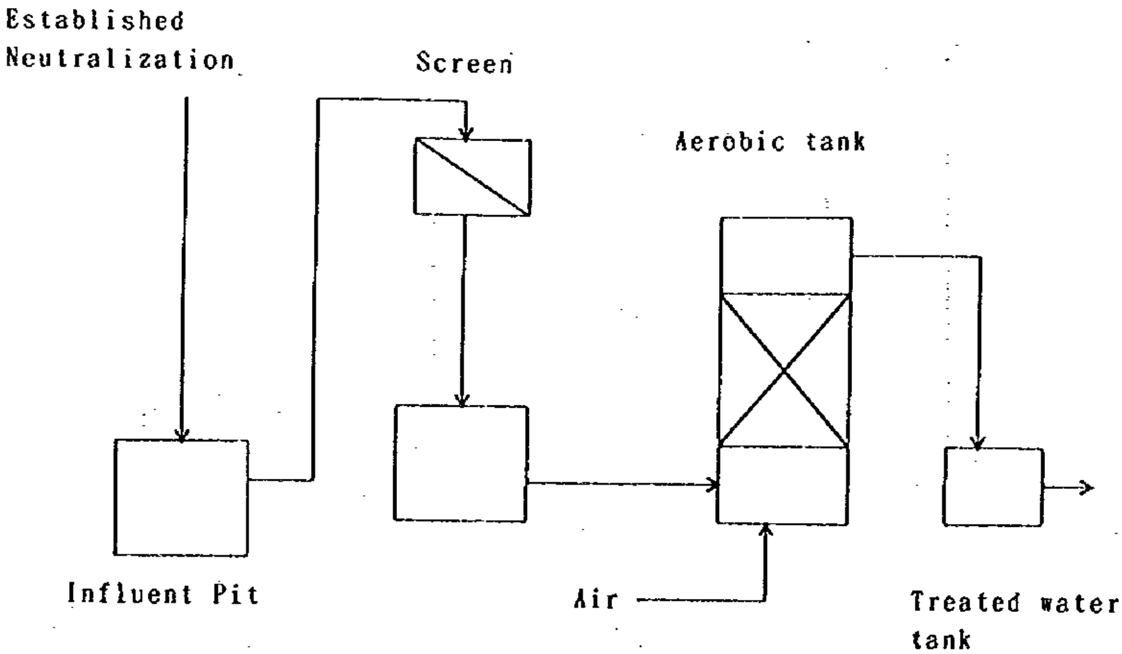
Aerobic and anaerobic are the two applicable pretreatment systems. The anaerobic treatment system is more expensive because it uses a heat source to heat raw waste water (20-35°C). The heat source is necessary due to the relatively low concentration of both BOD and COD and low production of bio gas.

For this reason the aerobic system has been selected. The waste water to be treated is neutralized total waste water. Moreover, regarding the design flow, this was found to be 71m³/d during the survay conducted in June 1996, however, in consideration of times when production will be higher, a figure of 90m³/d has been adopted.

2) Outline of pretreatment system (Fig. 3.5.7)

Raw waste water is treated by aerobic system after removal of relatively large, grain-sized suspended substances.

**Fig. 3.5.7 Flow Diagram of Pretreatment**



Of the array of aerobic systems, such as standard activated sludge, rotating disc method, and bio-film filter, the bio-film filter was selected as a pre-treatment system since it is economical, can apply a high load, and produces no bulking.

The amount of excess sludge produced in the bio-film filtering system is small and can be mixed with treated water without sludge treatment for WWTP discharge to minimize equipment costs (The SS in waste water increases).

3) Examination results

(1) Technical comment

Table 3.5.6 shows the quality of waste and treated water and pollutant load.

**Table 3.5.6 Quality of Waste and Treated Water and Pollutant Load**

| Kind of waste water | Quntity $m^3/d$ (kg/d) | CODcr mg/L (kg/d) | BOD mg/L (kg/d) | PH | SS mg/L (kg/d) | T-P mg/L (kg/d) |
|---|---|---|---|---|---|---|
| Total Raw waste water (After neu-tralization) | 90 | 750 (68) | 510 (46) | Ave 7.8 | 90 (8) | 17 (1.5) |
| Pretreated water (Discharge to WWTP) | 90 | 220 (20) | 100 (9) | 7 | 172 (15) | 10 (0.9) |
| Treated water (Discharge to River) | 90 | 120 (11) | 25 (2.3) | 7 | 80 (7) | 2 (0.2) |

The BOD and COD removal rate are set at 80% and 70 %. The value after T-P treatment is estimated. The value of SS after aerobic treatment is higher than in raw waste water, because the small amount of excess sludge produced by aerobic treatment is discharged as is to WWTP along with treated water.

(2) Economic comment

Table 3.5.7 shows the equipment and treatment costs of the treatment system, with added reference to the case of river discharge.

**Table 3.5.7 Equipment and Treatment Costs of Treatment System**

| | Equipment cost SIT | Depreciation & Interest SIT/m³ ① | Running cost SIT/m³ ② | Total Treatment cost SIT/m³①+② |
|---|---|---|---|---|
| Pretreatment | 24.630.000 | 112 | 114 | 226 |
| Discharge to River | 81.214.000 | 358 | 353 | 711 |

4) Conclusion

Costs are dramatically reduced, because coagulation and sedimentation equipment for T-P treatment and chemicals are unnecessary, and because the lowered removal rate of BOD and COD reduces equipment costs.

### 3.6 M - 6 KOSAKI TOVARNA MESNIH IZDELKOV

#### 3.6.1 Factory Profile

1) Outline

Kosaki is the only slaughter house in the Maribor district. It produces fresh meat almost daily, operating in the daytime only. Beef and pork production alternate according to a time schedule every day.
The factory is located near the Drava river, and separated from it by a road. Processed foods such as sausages are produced by a factory in a different location.

| | | |
|---|---|---|
| Factory area | : | 22,534m$^2$ |
| Number of employees | : | 100 |
| Working conditions | : | 5 hrs./day, 250 days/year |
| Products (livestock) | : | Beef cattle, Pork (pigs) |
| Annual production | : | 11,500 (head), 43,000 |
| Annual sales | : | |

2) Water consumption by source and use

Table 3.6.1 shows the source and uses of water consumption. City water is the sole source.

3) Water supply and flow diagram of waste water discharge.

Figures 3.6.2 and 3.6.3 outline the water supply and flow diagram of waste water discharge.

4) Quality of feed water and waste water

Table 3.6.2 shows the quality of feed water (city water).
Table 3.6.3 shows the quality of the rinsing water of the products, and Table 3.6.4 that of instruments and car wash effluent. The graphs indicate the hourly change in temperature, pH and amount of discharge.
Product rinsing, discharged at any time during operation, accounts for most waste water. Instrument washing, discharged after work is completed, is of small quantity. The pollution load of both types of waste water is quite large. The water quality at the outlet of the present oil separator has not been measured, but existing data suggests that it is sufficient for sewerage discharge. Car wash waste water also presents no problem regarding sewerage discharge.

Fig. 3.6.1 Factory Layout of KOSAKI

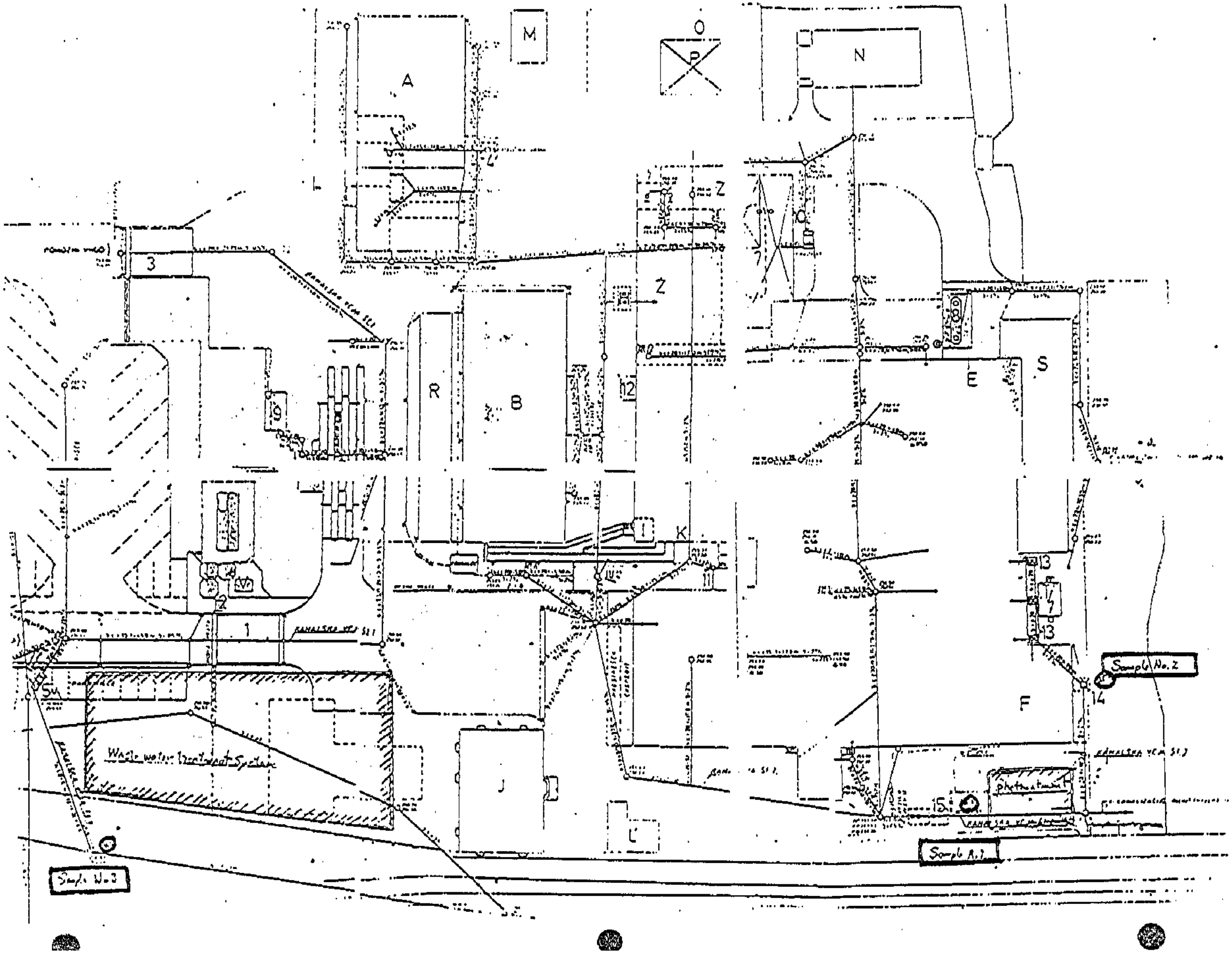


**Fig. 3.6.2 Process Diagram of Production Line**

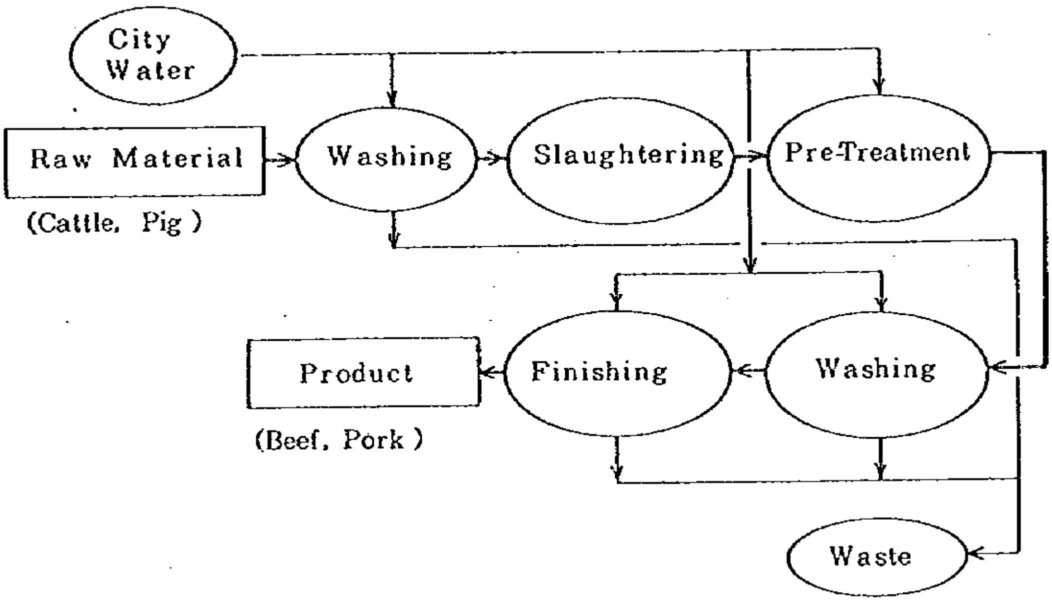



**Fig. 3.6.3 Water Balance Diagram** ( m³/day )

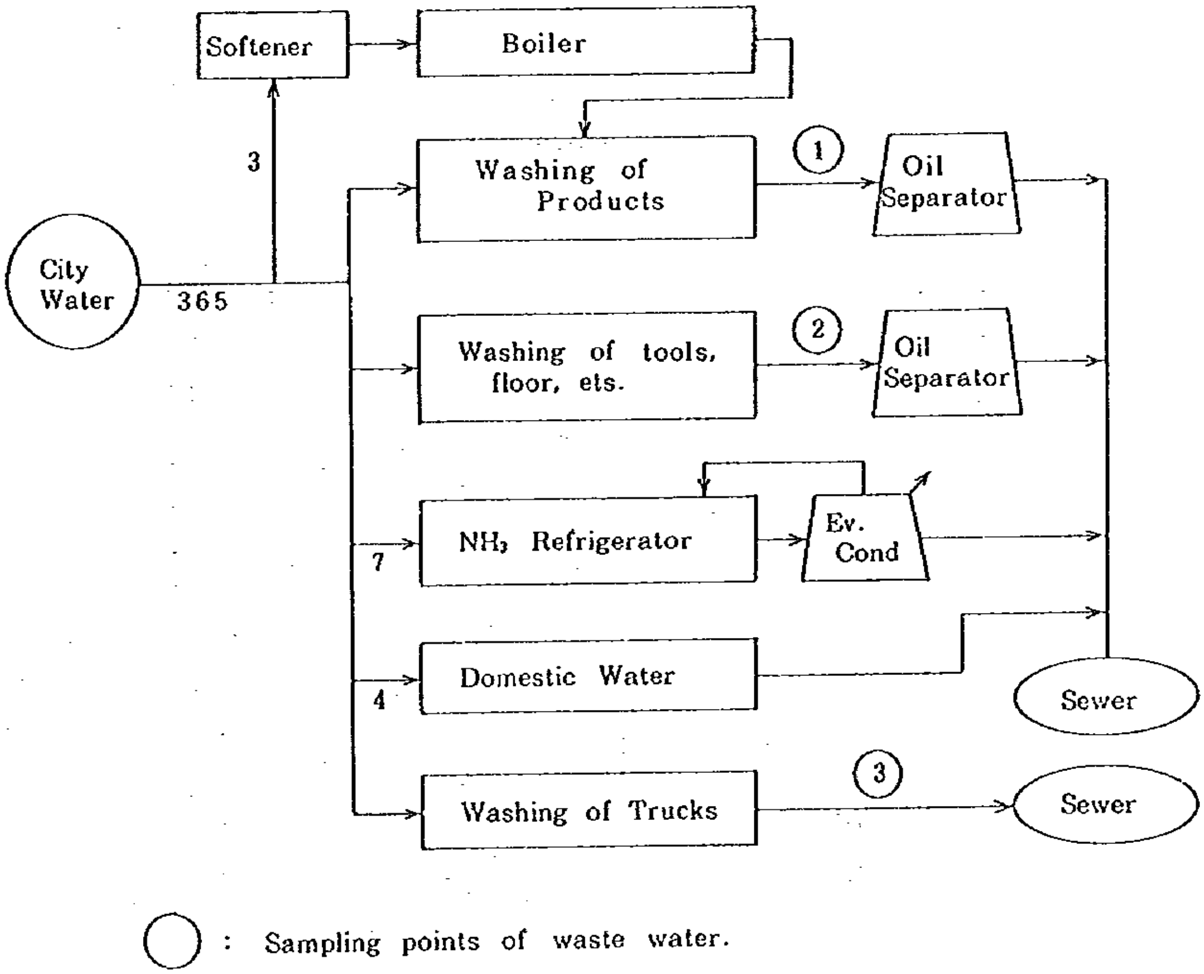


**Table 3.6.1 Quntity of Consumed Water Classified by Source and Use**

Industry: Food(Slaughter)

Unit: m³／day

| Source / Use | Well Water | City Water | River Water | Sub-Total | Recoverd Water | Total |
|---|---|---|---|---|---|---|
| Boiler Feed | | 3 | | 3 | | 3 |
| Raw Material | | | | | | |
| Washing | | 351 | | 351 | | 351 |
| Cooling | | 7 | | 7 | (60) | (67) |
| Air Conditioning | | | | | | |
| Miscellaneous | | 4 | | 4 | | 4 |
| Total | | 365 | | 365 | (60) | (425) |
| | | | | Recoverd Water/Total (14.1)% | | |

Note; A value in ( ) shows estimated one

**Table 3.6.2**

city water

| Characterization of the sample | | | City water |
|---|---|---|---|
| Lab. No. | | | 5721 |
| Parameter | expr.as | Unit | |
| Temperature | | ℃ | 20 |
| pH | | | 7,4 |
| Iron | Fe | mg/l | < 0,05 |
| Manganese | Mn | mg/l | < 0,05 |
| Total hardness | | °dH | 15,4 |
| Alkalinity | | mmol/l | 4,4 |
| Chloride | Cl | mg/l | 12 |
| Evaporated residue | | mg/l | 310 |
| Electric conductivity | | μS/cm | 460 |

## Table 3.6.3

No. 1, slaughtery water

| | | Lab. No. | 5867 | 5868 | 5869 | 5870 | 5871 | 5872 |
|---|---|---|---|---|---|---|---|---|
| Date of sampling | | | 12.06. | 12.06. | 12.06. | 12.06. | 12.06. | 12.-13.06. |
| Hour of sampling | | | 09-11 | 11-12 | 12-14 | 14-16 | 16-18 | 18-10 |
| Parameter | expr.as | Unit | | | | | | |
| pH | | | 6,8 | 6,3 | 6,1 | 6,7 | 6,9 | 7,2 |
| Suspended solids | | mg/l | 570 | 1000 | 2000 | 430 | 240 | 150 |
| Colour | | | | | | | | |
| α (436 nm) | | $m^{-1}$ | 48 | 82 | 36 | 16 | 27 | 6,8 |
| α (525 nm) | | $m^{-1}$ | 32 | 59 | 25 | 9,8 | 25 | 4,5 |
| α (620 nm) | | $m^{-1}$ | 23 | 41 | 22 | 7,2 | 25 | 3,7 |
| Total nitrogen | N | mg/l | 131 | 348 | 221 | 75 | 47 | 32 |
| - ammonium nitrogen: | N | mg/l | 72 | 150 | 180 | 47 | 35 | 19 |
| - Kjeldahl nitrogen | N | mg/l | 115 | 290 | 190 | 66 | 39 | 27 |
| - nitrite nitrogen | N | mg/l | < 0,1 | < 0,1 | < 0,1 | < 0,1 | < 0,1 | < 0,1 |
| - nitrate nitrogen | N | mg/l | 16 | 58 | 31 | 9,4 | 7,7 | 5,2 |
| Total phosphorus | P | mg/l | 7,8 | 42 | 5,8 | 30 | 26 | 13 |
| COD | $O_2$ | mg/l | 900 | 3100 | 3100 | 790 | 640 | 390 |
| $BOD_5$ | $O_2$ | mg/l | < 5 | 640 | < 5 | 150 | 180 | 100 |
| Total fat | | mg/l | 17 | 100 | 130 | 30 | 28 | 15 |
| Anionic surfactants | DBS | mg/l | 1,5 | 0,9 | 2,1 | 1,9 | 7,5 | 3,9 |

| Lab. No. | | | 6718 |
|---|---|---|---|
| Date of sampling | | | 03.07.1996 |
| Time of sampling | | | 09:00 |
| Type of the sampling | | | spot |
| Parameter | expr.as | Unit | |
| Settable solids | | ml/l | 0,1 |
| Free chlorine | $Cl_2$ | mg/l | < 0,05 |
| Total chlorine | $Cl_2$ | mg/l | < 0,05 |
| AOX | Cl | mg/l | 0,48 |

## Table 3.6.4

washing waste water

| | | Sample | 2 washing room | 3 car-washing |
|---|---|---|---|---|
| | | Lab. No. | 5873 | 5720 |
| Parameter | expr.as | Unit | | |
| Temperature | | °C | - | 13 |
| pH | | | 8,0 | 7,5 |
| Suspended solids | | mg/l | 290 | < 30 |
| Colour | | | | |
| α (436 nm) | | $m^{-1}$ | 42 | 0,1 |
| α (525 nm) | | $m^{-1}$ | 30 | < 0,1 |
| α (620 nm) | | $m^{-1}$ | 22 | < 0,1 |
| Total nitrogen | N | mg/l | 102 | 5,2 |
| - ammonium nitrogen: | N | mg/l | 68 | 0,4 |
| - Kjeldahl nitrogen | N | mg/l | 78 | 2,4 |
| - nitrite nitrogen | N | mg/l | 0,1 | < 0,1 |
| - nitrate nitrogen | N | mg/l | 24 | 2,8 |
| Total phosphorus | P | mg/l | 56 | 6,4 |
| COD | $O_2$ | mg/l | 1000 | < 15 |
| $BOD_5$ | $O_2$ | mg/l | 540 | < 5 |
| Total fat | | mg/l | 50 | < 5 |
| Anionic surfactants | DBS | mg/l | < 0,05 | < 0,05 |

**Fig. 3.6.4 Graphic Representation of Temperature Measurements of the Slaughtery Waste Water (10 min average values)**

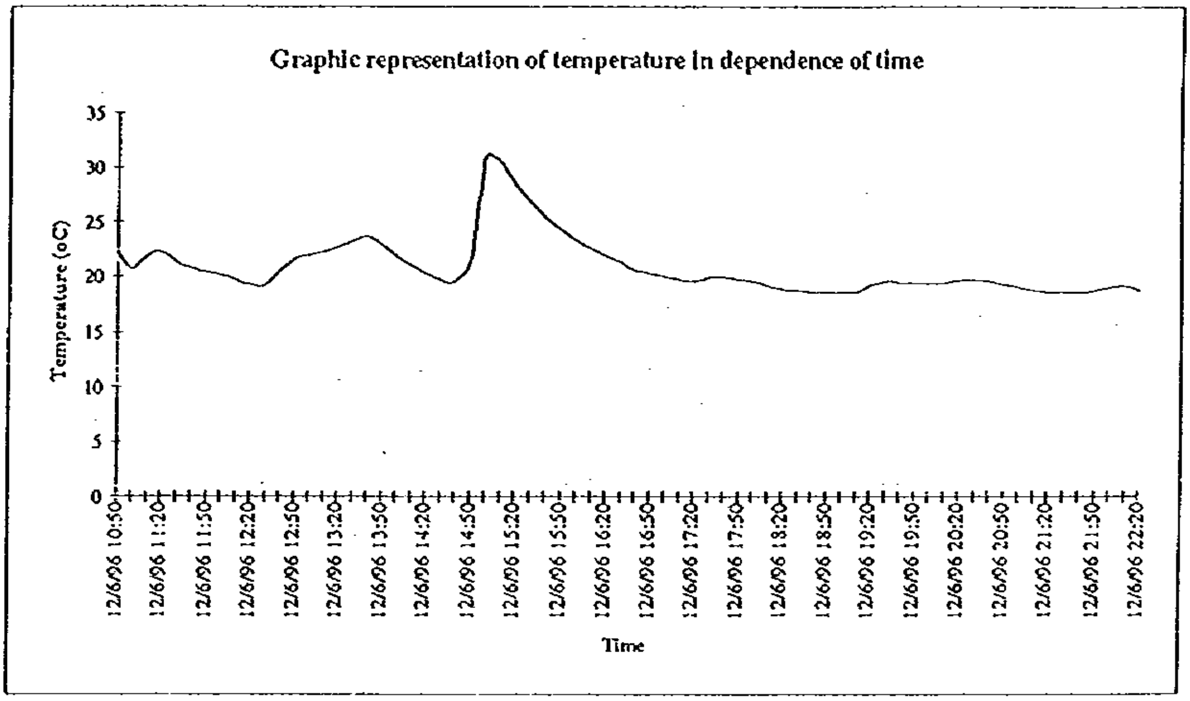



**Fig. 3.6.5 Graphic Representation of pH Measurements of the Slaughtery Waste Water (10 min average values)**

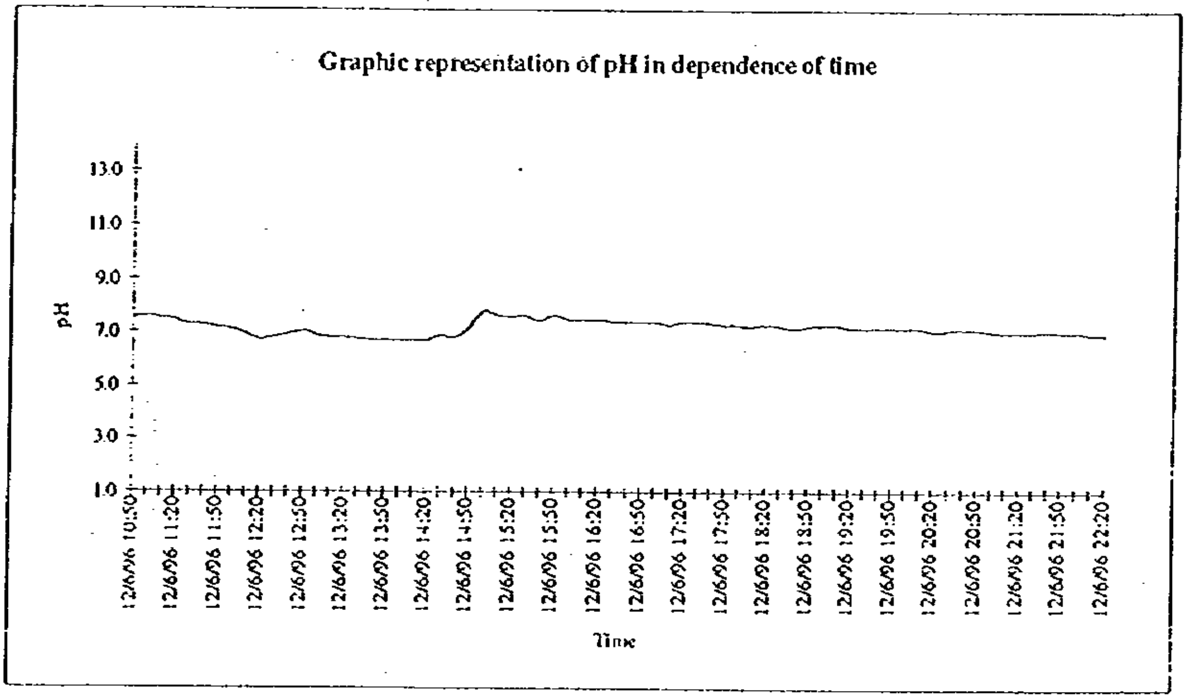


**Fig. 3.6.6 Graphic Representation of Flow Measurement of the Waste Water from Slaughtery in Kosaki (10 min average flow)**

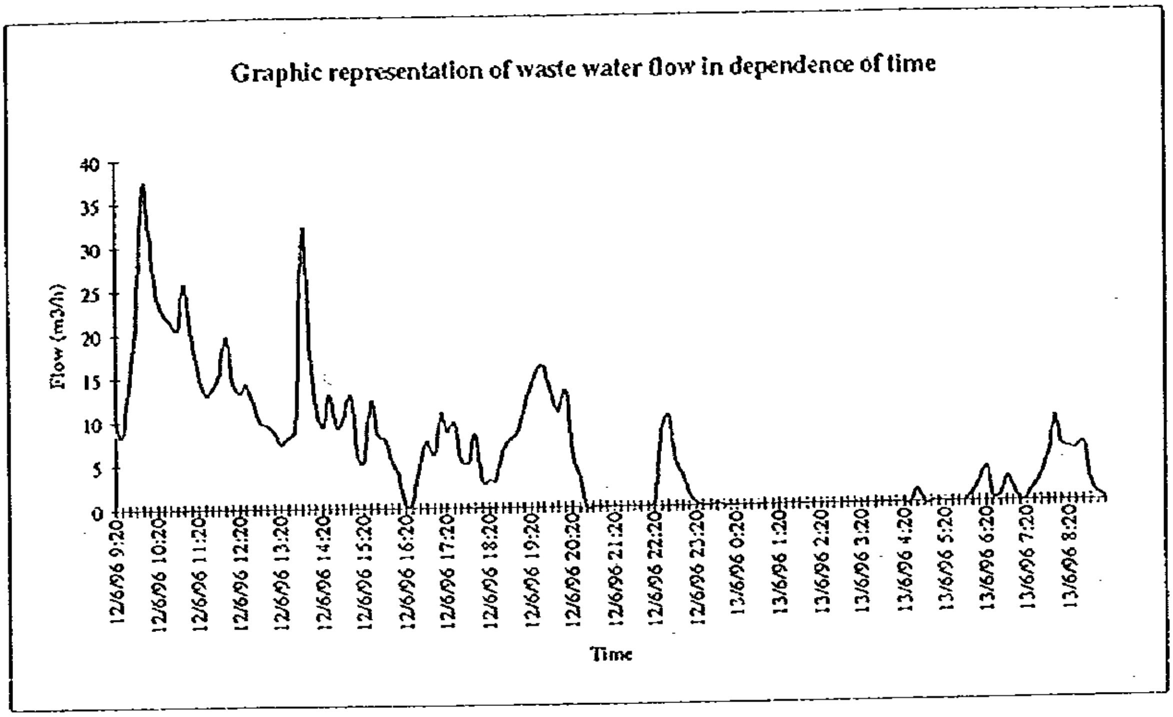
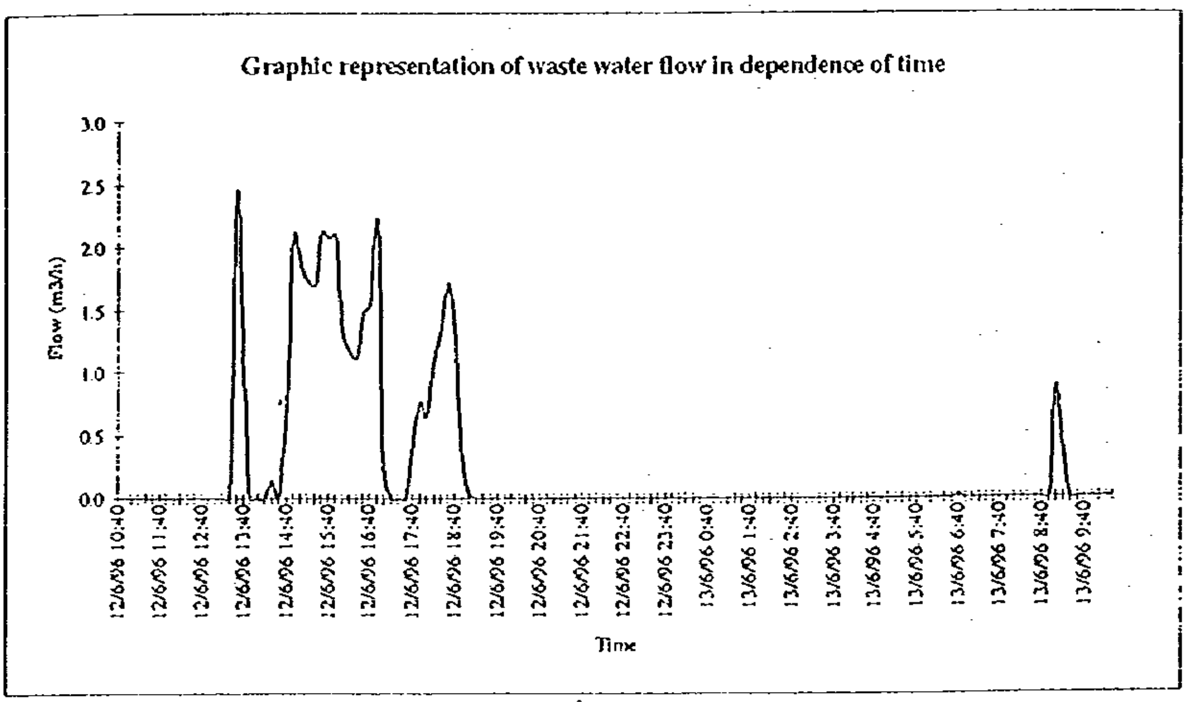



**Fig. 3.6.7 Graphic Representation of Flow Measurement of the Waste Water from Washing Room in Kosaki (10 min average flow)**



### 3.6.2 Water Conservation

1) Current conditions of water usage and conservation

(1) Features of water usage

① City water is the only source. Quantity is measured by a flowmeter.
② Most water (96%) is used for washing and product treatment. The remainder is for cooling, boiler and miscellaneous purposes.
③ Washing water and product treatment water is used for washing meat, floors and meat carving instruments.

(2) Present state of water conservation

① Cooling water of the ammonia refrigerators (3 units) is reduced by adopting evaporative condensers (3 units).
② Boiler feed is used to produce hot water by direct steam injection.
③ After bloodletting, products are washed as they pass through a hot water tank (1 unit).
④ The floor and carving tools are washed with water using a high pressure jet cleaner and hose with hand control valve. Some hoses are not equipped with hand control valves, however.

2) Technical evaluation of water conservation

(1) Technical comment

① Water for washing and product processing accounts for about 96% of water consumption; about twice that of Japan, on average. But since the two production systems differ, no simple conclusions may be drawn.
② Sanitary reclamation of washing water and product processing waste water is impossible. While it is possible to use recovered water for cooling or other purposes, it is not economically feasible, since the quantity is negligible.
③ Because cleaning and product processing are both manually operated, water consumption may be significantly reduced by encouraging workers to save water.

(2) Economic evaluation

① Nothing specific is noted here, except the importance of reducing water consumption by fostering awareness in the company of the need for water conservation.