5. Tertiary Factories

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5. Tertiary Factories

5.1 A-1 TVT-Tovarna vozil in toplotne tehnike-Boris Kidric-TIRNA VOZILA

5.1.1 Factory Outline

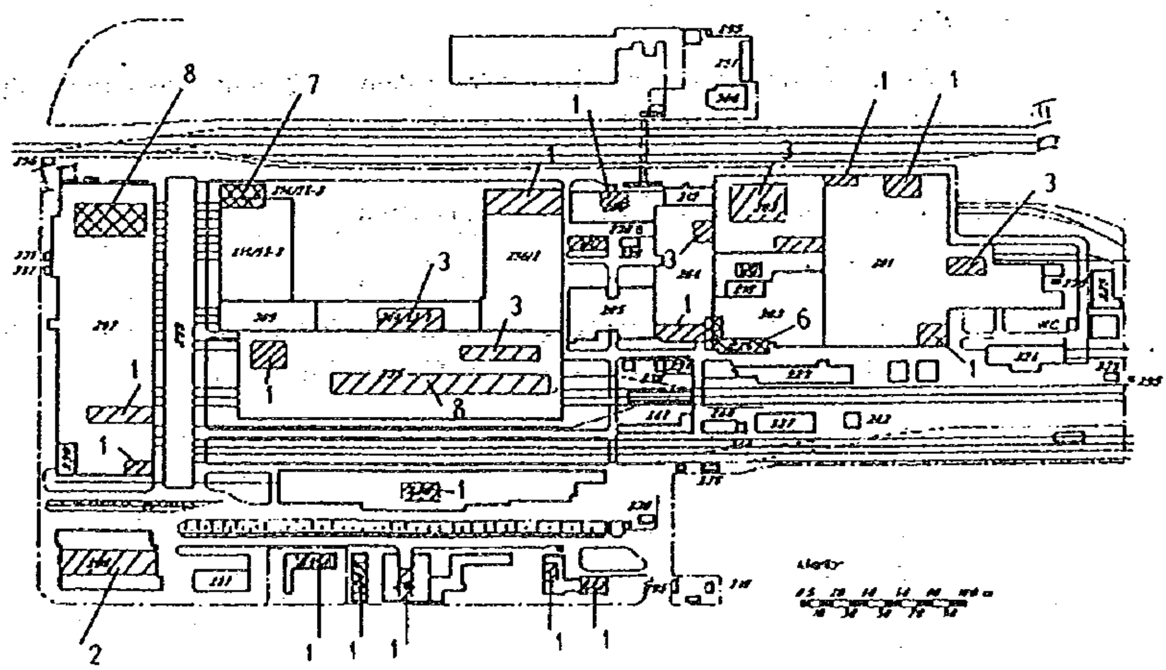
1) Outline

TVT was established in 1863 as a factory for manufacturing and repairing railway rolling stock (steam engines and passenger cars). The company has now split up into 30 establishments and the survey target factory of Druzba za proizcodnjo in remont tirnih vozil d.o.o. mainly carries out the manufacture and repair of rolling stock, although its manufacturing activities have almost come to a halt.

Main work at the factory consists of dismantling and repainting rolling stock cars and repairing or renewing their component parts. Waste water is generated in the car washing and painting pre-washing processes, however, the car washing water is re-use for repeated use and no water is used in the painting process itself. As a result, there is no generation of waste water.

The layout of the factory is illustrated in Fig. 5.1.1.

Fig. 5.1.1 Factory Layout



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

The quantities of water consumed according to water source and purpose of use in the TVT group are shown in Table 5.1.1.

Table 5.1.1 Volume of Water Usage by Water Source and Purpose of Use

(m^3/day)

Source / Use	Well Water	City Water	River Water	Sub-Total	Recovered Water	Total
Boiler Feed			100.5	100.5		100.5
Raw Material						
Washing		77	2.5	79.5	624	703.5
Cooling		4		4	925	929
Air Conditioning						
Miscellaneous		436		436		436
Total		517	103	620	1,549	2,169
				Recovered Water/Total		71.4 %

3) Water supply and waste water discharge flow diagrams

The main manufacturing processes and water balance of TVT group and painting process are shown in Fig. 5.1.2.

(1) Water usage

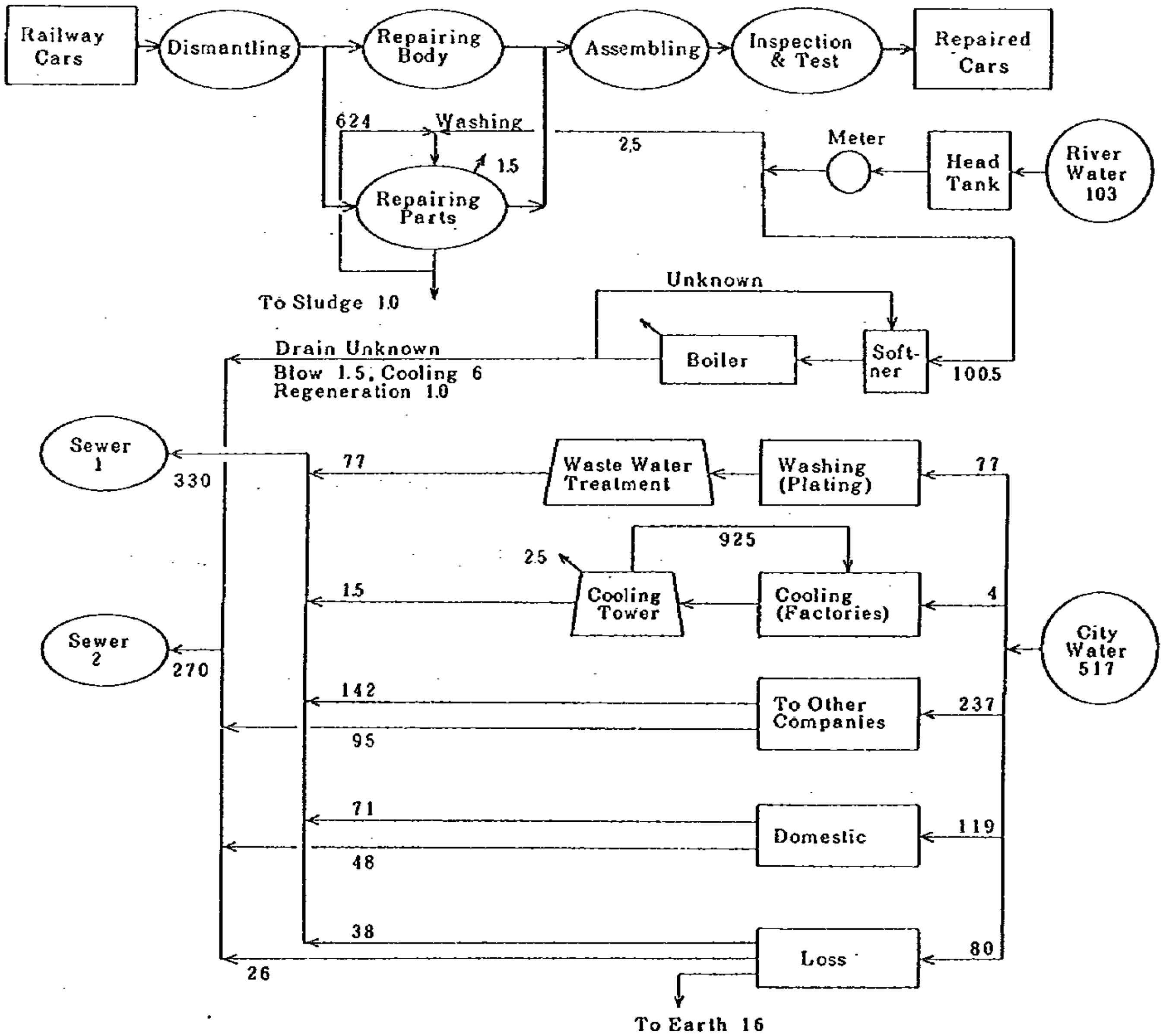
620 m^3 of water is consumed on average daily. 517 m^3/d comes from city water and the remaining 103 m^3/d comes from river water.

(2) Processes and sources of waste water generation

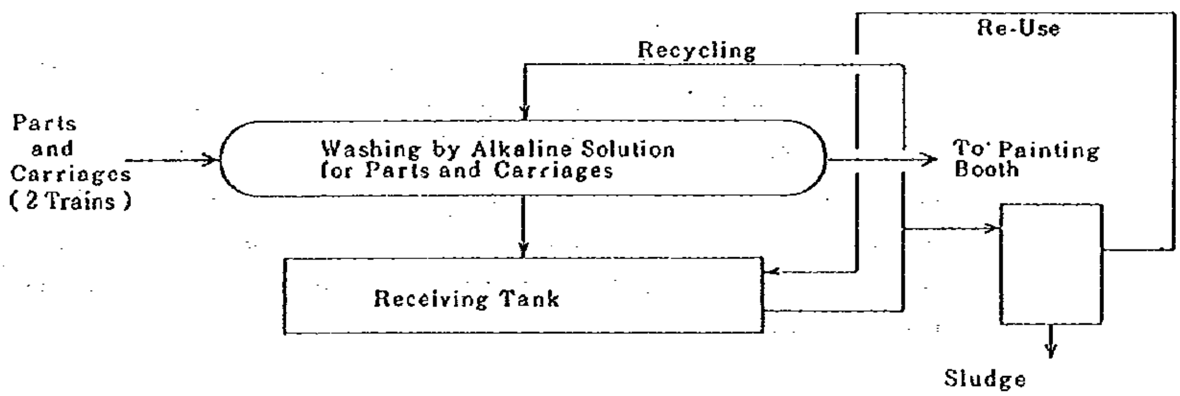
① Acceptance

This is the process of accepting cars from outside for repair. As no water is used in this process, there is no generation of waste water.

Fig. 5.1.2 Process Flow Chart, Water Balance and Painting Process Diagram (m³/day)



Detail of the Pre-Washing Prcess of the Painting Booth



② Dismantling and washing

In this process, cars are broken down into their component parts and car bottoms are washed. An indirectly heated NaOH solution of pH = 10 is recycled for re-use as the washing water here. Solids that have accumulated in the recycled water are removed by sedimentation three times per year, and readjustment of the pH value is also carried out to allow the water to be recycled for continued use. Thus, no waste water is generated in this process.

③ Parts repair and renewal

In this process, deteriorated parts are either repaired or renewed. As no water is used in this process, there is no generation of waste water.

④ Car repair and renewal

In this process, areas of peeling or blistered paint on car surfaces are repainted. The cars are washed prior to the painting and, because the control of the water is the same as described in ②, above, no waste water is generated in this process.

Moreover, as no water is used in the painting part of this process, there is no generation of waste water here, either.

⑤ Assembly

In this process, the repaired or renewed component parts are assembled back into the cars. As no water is used in this process, there is no generation of waste water.

⑥ Inspection

In this process, the repaired cars undergo internal inspection. As no water is used in this process, there is no generation of waste water.

(3) Waste water treatment system

Because all water is circulated for re-use use, which means that no waste water is generated, there is no need to install a waste water treatment system. Regarding the recycled water used for washing, accumulated solids are periodically removed from the water by sedimentation. A coagulation and pressurized-air floatation treatment plant has been installed to deal with the supernatant produced after the separation by sedimentation, however, this is not currently in use.

The branch factory has an MIPI that carries out metal plating and this factory does have a waste water treatment plant. This factory carries out copper plating, nickel plating and chrome plating, and the waste water treatment system consists of the oxide decomposition of cyanic waste water, the Cr^{6+} reduction of waste water containing chrome and the neutralization of heavy metals.

It is considered that this waste water treatment plant could be operated more efficiently by carrying out the following improvements.

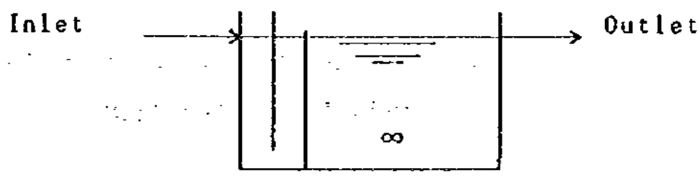
① Short passes could be prevented by placing a shielding plate at the waste water inlet of the reaction tank, as shown in Fig. 5.1.3.

② The outflow of SS including heavy metal hydroxides could be prevented by installing a sand filter after the separation by sedimentation process.

③ In the pH adjustment process, the separation of heavy metals could be carried out with more certainty by setting the pH control value on the alkali side. Moreover, by adding anionic high polymer coagulant to water following the pH adjustment, it would be possible to perform appropriate solids-liquid separation in the sedimentation tank.

④ Cyanide treatment is currently being conducted without any problems, however, in order to respond to variations in cyanide concentration more accurately, it would be desirable to install control equipment on the two reaction tanks.

Fig. 5.1.3 Cross Section of Reaction Tank



4) Waste water

Industrial waste water from the processes and domestic waste water from the 530 strong work force of the factories in the TVT group is discharged into the sewerage system from two outlets.

The quality of treated waste water from the MIPI plating process, for which materials were provided, the quality of water at waste water outlets RJ I and RJ II, and the quality of water sampled at RJ II are shown in Table 5.1.3.

The sampling numbers and sampling points are as follows:

(No. 1): treated waste water from plating process
(No. 2): waste water outlet RJ I
(No. 3): waste water outlet RJ II
(No. 4): sample from waste water outlet RJ II (composite sample)

It was impossible to measure the water-flow at waste water outlet RJ II, where sampling was carried out.

5.1.2 Water Conservation

1) Features of water usage

① The water sources are the public water supply and river water, and water volumes are measured. Moreover, the volumes of water used in main consumption areas are estimated to a certain extent. However, because only the overall volume of water usage over the whole group is measured, the amounts of water used by each of the 30 individual plants and factories are unclear.

② River water is mainly used as boiler water, while water from the public water supply is used for all other purposes including domestic water. The small scale plants, etc. within the group use approximately 46% of the public water supply and approximately 38% of the combined water supply.

③ The water loss, including percolation underground, amounts to approximately 15% of the public water supply.

④ The main areas of water consumption are in the pre-washing process before the painting of cars and parts, boiler water, washing in the plating process, cooling water in compressors and domestic water. In addition, there is a separate water supply and water loss for the small-scale plants.

Table 5.1.3 Quality of Individual Waste Water Types and Total Waste Water

No.	1	2	3	4
Items \ Name of Sample	Metal Plating	Effluent RJ I	Effluent RJ II	Effluent RJ II
Temp. (℃)	15	15	17	—
pH (−)	8.3	8.4	8.3	8.1
COD_{Cr} (mg/ℓ)	12	74	16	16
COD_{Mn} (mg/ℓ)	—	—	—	10
BOD (mg/ℓ)	3	31	6	<5
SS (mg/ℓ)	28	29	34	55
Oil / Fat (mg/ℓ)	<5	<5	<5	<5
T-P (mg/ℓ)	—	—	—	2.4
T-N (mg/ℓ)	—	—	—	6.3
CN (mg/ℓ)	<0.01	<0.01	<0.01	—
Cu (mg/ℓ)	0.92	0.71	<0.05	—
Cd (mg/ℓ)	<0.05	<0.05	<0.05	—
Fe (mg/ℓ)	2.4	2.1	0.24	—
Zn (mg/ℓ)	0.21	0.15	0.08	—
T-Cr (mg/ℓ)	1.25	0.54	<0.01	—
Cr^{6+} (mg/ℓ)	0.04	<0.01	<0.01	—
Ni (mg/ℓ)	3.1	1.6	<0.1	—
Surfactants (mg/ℓ)	—	—	—	<0.05
AOX* (mg/ℓ)	80.6	51	7.5	—

(Note) * : Expression as Cℓ

2) Current condition of water conservation

① Water used in the washing of cars and parts prior to painting, and cooling water used in the compressors is recycled for total repeated use. Moreover, as the painting process is the dry type, no water is used.

② The counter-current washing system is used in the plating processes, meaning that water conservation is practiced to a certain degree.

③ The condition of water usage at small-scale plants of high water consumption is unclear.

3) Technical comment

① Grasping of water usage conditions at the small-scale plants

It is extremely difficult to accurately gauge the volumes of water used by plant and purpose of use at the 30 or so small-scale plants. However, because the water consumed by these plants does account for such a large proportion of the total water usage, it is vital to have an understanding of this water usage from the viewpoint of water conservation.

It is assumed that water in these small-scale plants is mainly put to use in large water tank (100 m^3) leakage tests and the washing of parts. Recycling for repeated use would be easy to achieve in the former case.

② Reduction of public water supply loss

The water loss accounts for as much as 15% of the overall public water supply. As the factory complex is broad and piping deteriorated, there is a strong possibility that the loss originates from the piping.

There is no accurate way to prevent leakage in technical terms, but a lot of patience is required. It is necessary to reduce the loss over the long term by partially closing pipes and searching for leaks when plants are not operating, or transferring underground piping to above ground as much as possible when piping renewal times come around, and so on.

③ Potential water saving

Through carrying out the above measures, it would be easy to save around 100 m^3/d of the current small-scale plant water usage of 237 m^3/d and water loss of 80 m^3/d.

4) Economic comment

The above-mentioned conservation methods require man hours in the survey and examination stages, however, because equipment and running costs would be low, such methods would be economically feasible if implemented over time.

5) Problem points

TVT controls water supply and waste water discharge over the whole factory complex, including the small-scale plants. However, because the water supply and waste water discharge costs are borne by each of the plants, there would be little profit for TVT even if water saving measures were to be implemented. Thus, in order to promote the conservation of water usage, it would be necessary for TVT to take the lead in forming a joint project team composed of members from all related plants and for the project team to survey, examine and promote the conservation.

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

Looking at the main manufacturing facilities that discharge waste water in the TVT group, as it can be seen that the plating facilities are fitted with a waste water treatment plant and no waste water is generated from washing facilities due to water recycling; there is no need to install pretreatment or waste water treatment plants.

The current quality, quality and pollution loads of discharged water from the TVT group are shown in Table 5.1.2.

Table 5.1.2 Volumes, Quality and Pollution Loads of Waste Water and Treated Water

Kind of Waste Water	Case	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)
Effluent RJ I	Raw Water	103	8.4	74 (7.62)	31 (3.19)	29 (2.99)	( )	( )
Effluent RJ II	Raw Water	517	8.4	16 (8.27)	6 (3.10)	34 (17.6)	6.5 (3.36)	2.4 (1.24)
Total Waste Water (Discharge to Rever)		620	8.4	25.6 (15.9)	10.1 (6.29)	33.2 (20.6)	( )	( )

5.2 A-2 ELEKTROKOVINA-SVETILA

5.2.1 Factory Outline

1) Outline

The forerunner of this company, ELEKTROKOVINA, was established in 1948 and at its peak possessed a work force of 3,500. With the onset of organizational division and privatization following independence of the country, the company was split up into three medium-size factories and approximately 300 small enterprises. The total work force now numbers approximately 300.

This company forms one of three group factories, the other two being ELKO ELEKTROKOVINA MARIBORR (A-4) and ELEKTROKOVINA TEHNIKA, which provides maintenance services to group factories. The current owner of the company is the German firm SIEMENS.

The factory's main products are indoor, outdoor and industrial lighting fixtures and its annual production is 2,700,000 units, approximately 70% of which are exported mainly to neighboring countries. The factory now has approximately 260 employees; it once possessed 1,000 employees prior to independence but this figure dropped as a result of the restructuring typified by closure of the parts plant following establishment of the maintenance group.

Capital	:	1,000,000,000 SIT
Factory complex area	:	
Employees	:	266
Operating hours	:	8 hours/day
Products	:	lighting fixtures
Annual production	:	764,913 units

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

The quantities of water consumed according to water source and purpose of use are shown in Table 5.2.1.

3) Water supply and waste water discharge flow diagrams

The main manufacturing processes, waste water discharge flow and water balance are shown in Fig. 5.2.1.

Fig. 5.2.1 Process Diagram and Water Balance Diagram (m³/day)

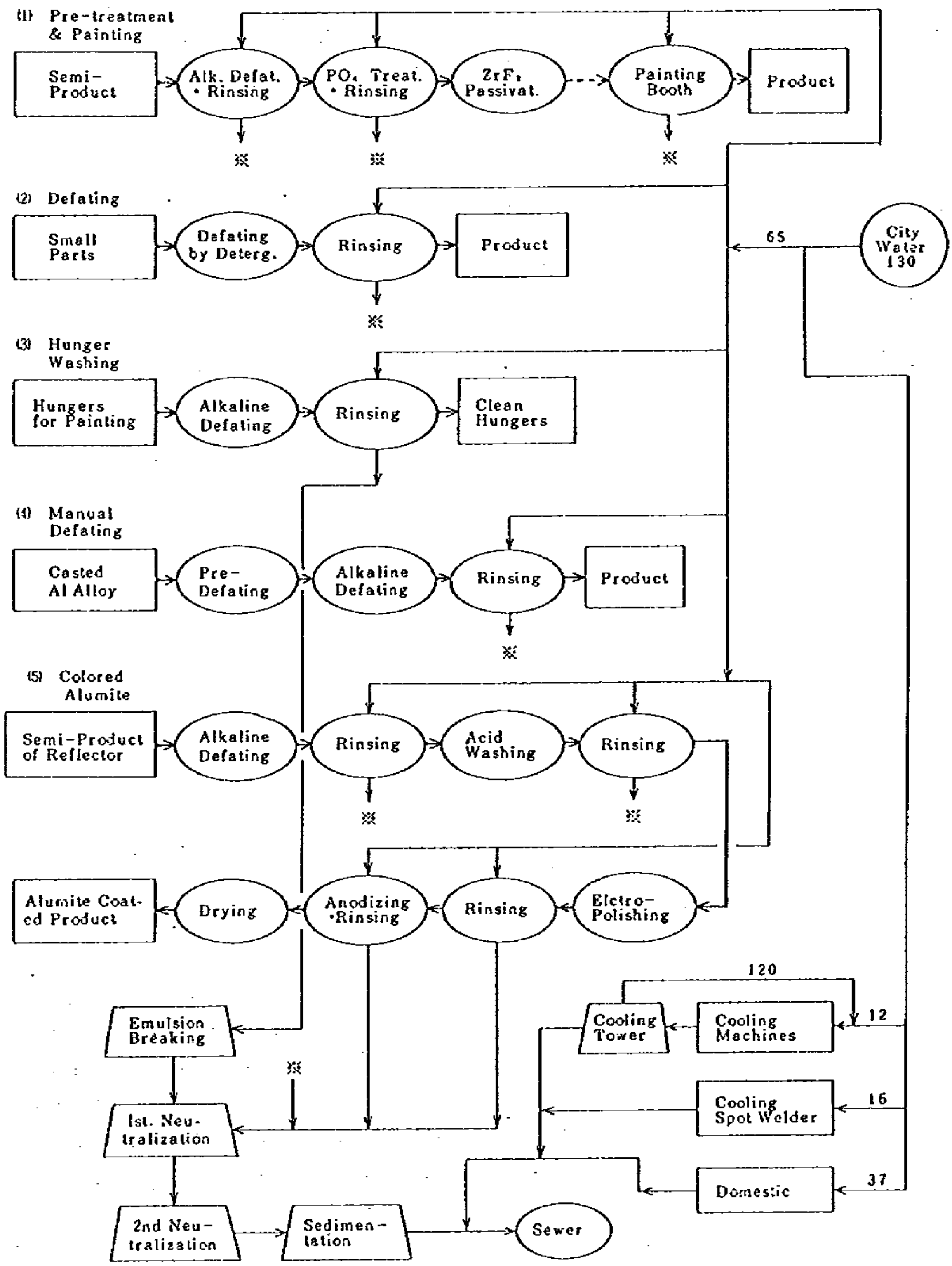


Table 5.2.1 Quantity of Consumed Water Classified by Source and Use

Unit: m³/day

Source / Use	Well Water	City Water	River Water	Sub-Total	Recoverd Water	Total
Boiler Feed						
Raw Material						
Washing		65		65		65
Cooling		28		28	120	148
Air Conditioning						
Miscellaneous		37		37		37
Total		130		130	120	250
				Recoverd Water/Total		48 %

Note: A value in ( ) shows estimated one

4) Quality of make-up water and waste water

City water accounts for all the make-up water. The quality of waste water is shown in Table 5.2.2.

5.2.2 Water Conservation

1) Features of water usage

Most of the water supply is used in pretreatment for coating and alumite processing, and minor quantities are used as cooling tower make-up water and spot welder cooling water. The overall usage is approximately 93 m³/day.

All of the water used by the factory comes from the public water supply, and the supply system that was used from the time of the former ELEKTROKOVINA is currently used by approximately 30 companies in the group. Water is taken from the public water supply in three points each installed with water meters, and ELEKTROKOVINA TEHNIKA is currently in charge of these intake points. Because the individual factories receiving the water supply do not have water meters, the water usage of each factory is estimated each month by taking the total of the readings of the above-mentioned three water meters and multiplying by the share ratios of each factory that are determined according to factory scale. The share ratio of the target factory is set at 36.33%, and the above-mentioned water usage quantity of 93 m³/day is estimated based on this.

Table 5.2.2 Quality of Each Type of Waste Water and Total Waste Water

Items \ Name of Sample \ No.	1 Storage Tank	2 Effluent from WWTP
pH (–)	8.2	8.6
COD_{cr} (mg/ℓ)	16	70
COD_{Mn} (mg/ℓ)	10	19
BOD (mg/ℓ)	3	< 5
SS (mg/ℓ)	< 5	< 30
Oil / Fat (mg/ℓ)	< 5	< 5
T-P (mg/ℓ)	29	11
T-N (mg/ℓ)	20.6	18.3
Surfactants (mg/ℓ)	< 0.05	< 0.05
LKCH* (mg/ℓ)	< 0.01	< 0.01
BTX* (mg/ℓ)	0.25	< 0.05
AOX* (mg/ℓ)	0.10	0.09

(Note) * : Expression as Cℓ

2) Current condition of water conservation

① Water conservation is already practiced through the recycling of cooling water for hydraulic molding machines by means of a water tower. The recycled water volume is 120 m³/day and 12 m³/d of make-up water is also used.

② Cooling water for spot welders is only used once, however, the operating rate of the welders is low and water usage minor so this does not pose a problem.

3) Technical comment

The installation of a water meter for the factory is a fundamental condition for water saving. In fact, it is preferable to control water usage by installing flow meters for each area of water use (manufacturing process washing water, cooling tower make-up water, domestic water, miscellaneous water, etc.). It is considered that room does exist for further water saving, for example, the cooling tower make-up water, etc.

5.2.3 Pretreatment and Waste Water Treatment

1) Current conditions

The factory possesses a waste water treatment system for treating washing water from the manufacturing processes, etc. that was constructed around 20 years ago, and this is still in good working order today. The basic processes of the waste water treatment system are oil separation, neutralization, and chemical precipitation.

In addition to the statutory measurements carried out twice annually, the quality of treated water is tested for pH, Fe, Cu, Ni and Zn twice per week by the factory.

2) Pretreatment and waste water treatment

As the factory is already treating its waste water to within existing discharge standards, there is no need to install additional facilities.

5.3 A-3 PRIMAT-Tovarna kovinske opreme

5.3.1 Factory Outline

1) Outline

TKO PRIMAT MARIBOR uses steel plate as a raw material to manufacture various types of safe boxes and steel furniture. The company has three plants in Slovenia, and the one located in Maribor is the OBRAT MELJE Factory.

The main processes consist of the machine processing of steel plate, painting and assembly, and the main source of waste water is the painting process.

The layout of the factory is illustrated in Fig. 5.3.1.

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

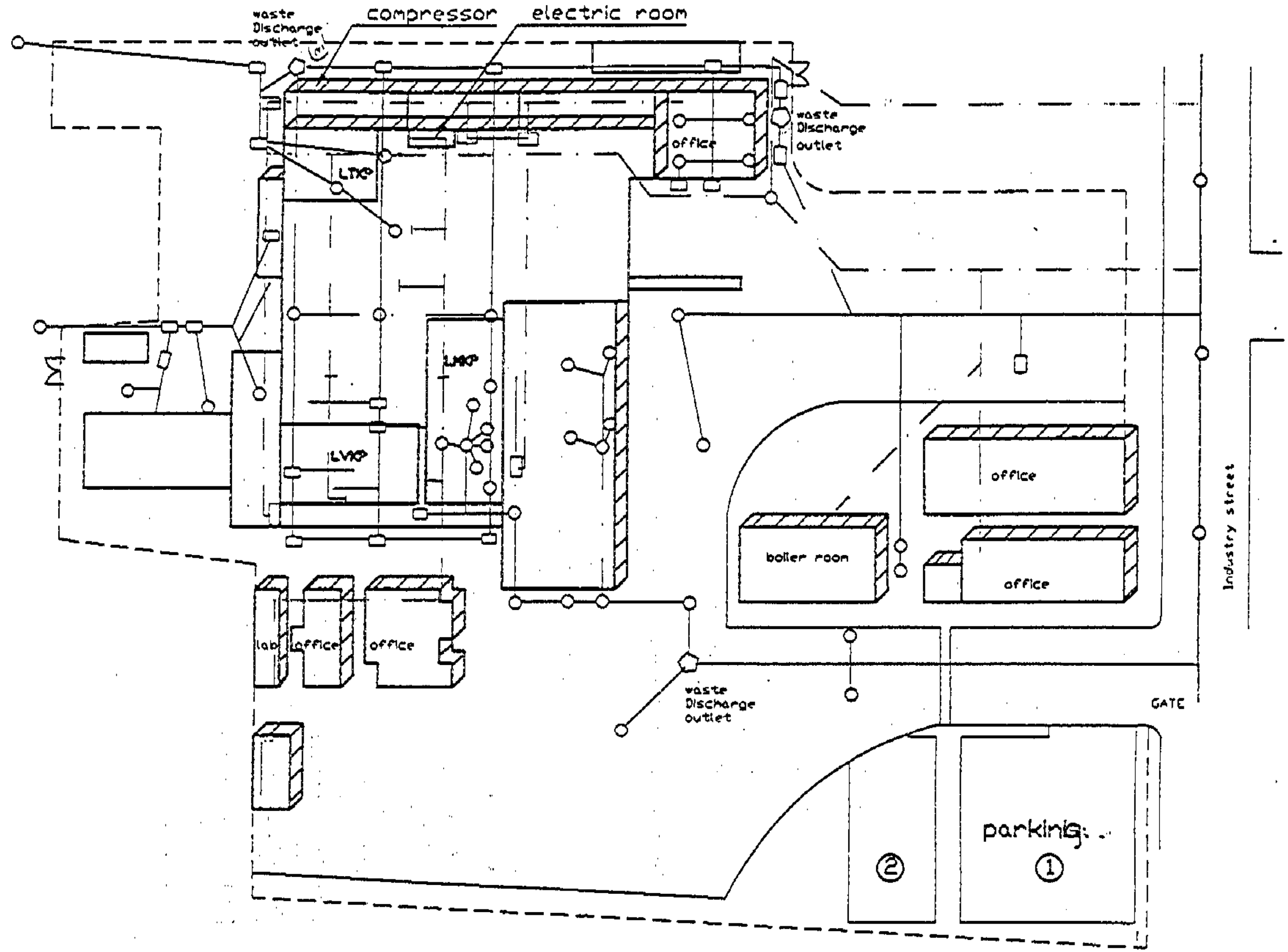
The quantities of water consumed according to water source and purpose of use are shown in Table 5.3.1.

Table 5.3.1 Volume of Water Usage by Water Source and Purpose of Use

(m^3/day)

Source / Use	Well Water	City Water	River Water	Sub-Total	Recovered Water	Total
Boiler Feed		2				
Raw Material						
Washing		6				
Cooling		90				
Air Conditioning						
Miscellaneous		11				
Total		109				
				Recovered Water/Total		%

Fig. 5.3.1 Factory Layout



3) Water supply and waste water discharge flow diagrams

The main manufacturing processes and water balance are shown in Fig. 5.3.2.

(1) Water supply facilities

City water accounts for the whole water supply of the factory. City water used in the boiler undergoes treatment in a softener first.

(2) Processes and sources of waste water generation

① Cutting

In this process, the raw steel plate is cut. As no water is used in this process, there is no generation of waste water.

② Forming

In this process, parts are made by applying pressure to the cut steel plate to bend and form it in the manner desired. As no water is used in this process, there is no generation of waste water.

③ Machine processing

In this process, the formed parts are shaped into their final form through the removal of burrs, opening of screw holes and polishing of surfaces, etc. Here, waste cutting oil is generated.

Because the waste cutting oil is retrieved and consigned for disposal externally as industrial waste, there is no generation of waste water.

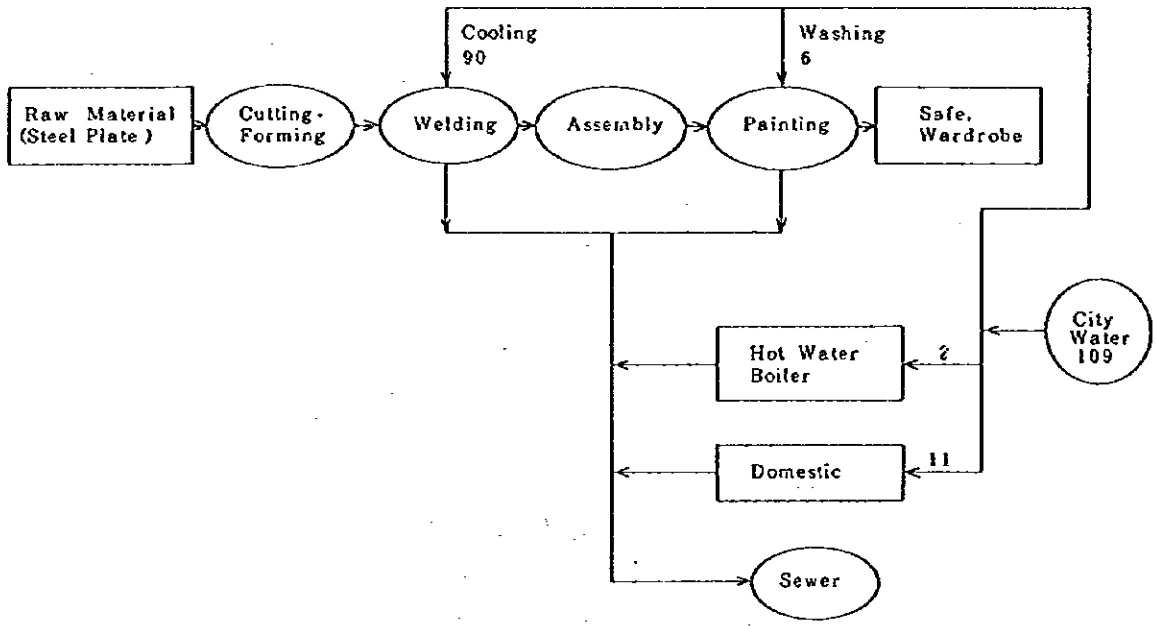
④ Welding

In this process, the formed parts are welded together to make new parts. Nine spot welding machines and five pincer welding machines are used. Here, waste water is generated from the cooling water used for the welding machines.

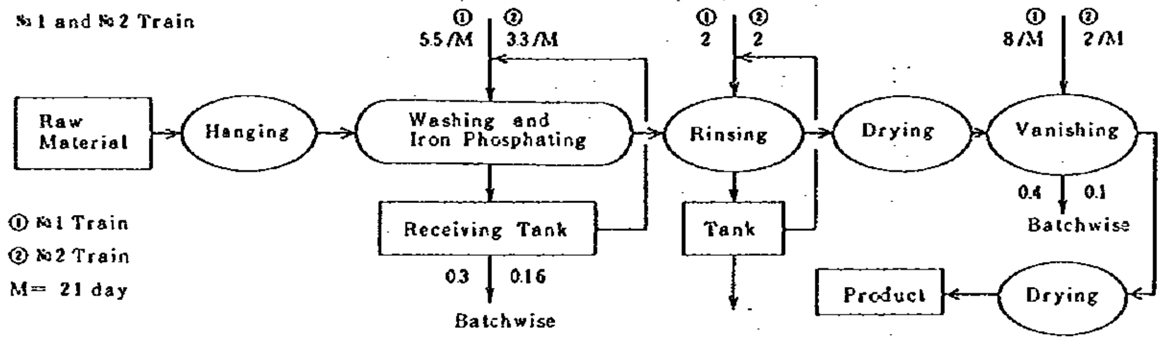
⑤ Painting pretreatment

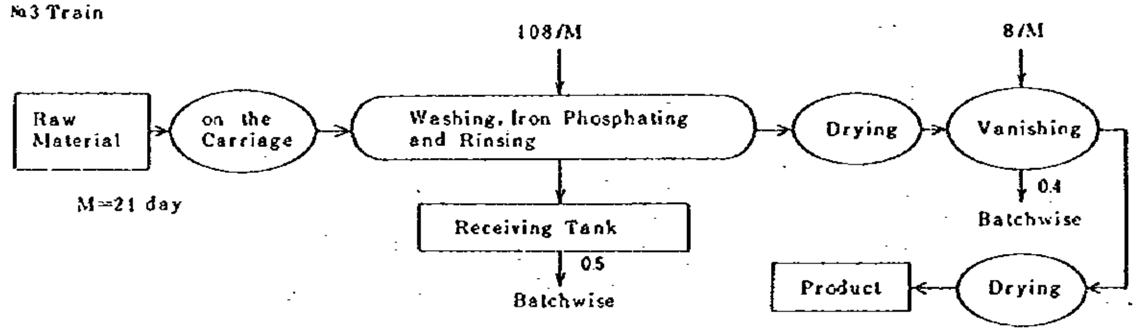
The main production processes are integrated with the painting process. There are three production lines in this integrated process: the LVKP line used for making relatively large parts, the LMKP line used for small parts, and the LTKP line used for safe boxes. Parts except for safe boxes are put in a hanging state in the painting pretreatment and painting processes, however, the contents of the manufacturing processes are the same for all part types.

Fig. 5.3.2 Manuacturing Process and Water Balance (㎥/day)



Detal of the Painting Process





This process involves degreasing and surface treatment using phosphoric acid (iron phosphating).

A mixed liquid, consisting of mainly surface active agent and phosphoric acid and possessing a pH value of 4-5 and a temperature of 30-50°C, is sprayed onto the surface of the parts in order to remove any grease that has attached to the surface of the raw steel plate and phosphate treat the surface of the raw steel. The mixed liquid is stored and recycled for re-use, and it is renewed once per month. As a result, waste water is generated every time the composite liquid is replaced.

In the following washing process, any mixed liquid remaining on the parts surfaces is washed away. Because the washing water is only used once before discharge, there is continuous generation of washing waste water during line operation.

In the LTKP line used for making safe boxes, however, because the pretreatment and washing processes are not separated, the composite liquid and washing waste water are stored together, and waste water is only generated once every two or three weeks when the storage tank becomes full.

⑥ Painting

In this process, parts surfaces are painted. Because the parts have curves and complex planes, gun spray painting is carried out two times, once for each part side. Much of the paint flies off into the surrounding area without adhering to the parts and this results in not only the vaporization of the paint but also the generation of paint mist and paint dust. There are two rinsing booths used to adjust these conditions. Waste water from the booths has a pH value of 10-11 and it is discharged once per month.

The factory has plans to change over to the use of powder paint and investigation into this will start from 1997. If powder paint is used, water will cease to be used and waste water will no longer be generated.

⑦ Assembly

In this process, the component parts are assembled into products. As no water is used in this process, there is no generation of waste water.

(3) Waste water treatment plant

There is no waste water treatment plant. However, mixed liquid waste water and rinsing booth waste water undergo neutralization before being discharged.

4) Make-up water and waste water

(1) Make-up water

The average monthly volume of make-up water is 146 m^3 (97-204 m^3/month), and the quality of the make-up water is shown in Table 5.3.2.

Table 5.3.2 Quality of Make-up Water

Items \ Name of Sample	City Water
T-Hardness* (°dH)	15～15.2
Electro Conductivity (μS/cm)	< 0.05

(2) Waste water

a. Discharge characteristics of waste water

One month is assumed to be 21 days.

① Waste water from painting pretreatment (4.74 m^3/d) and the painting Process (0.86 m^3/d)

LVKP line (53.5 m^3/21 days)

Mixed waste water : 5.5 m^3/21 days

Washing waste water: 40 m^3/21 days

Booth washing waste water: 8 m^3/21 days

LMKP line (45.3 m^3/21 days)

Mixed waste water : 5.3 m^3/21 days

Washing waste water: 40 m^3/21 days

Booth washing waste water: 2 m^3/21 days

LTKP line (14.8 m^3/21 days)

Mixed waste water + washing waste water : 5.4 m^3/2-3 weeks (10.8 m^3/month)

Booth washing waste water: 8 m^3/2 months

② Welding machine cooling water (90 m^3/d)

Spot welding machine cooling water: 84 m^3/d

Pincer welding machine cooling water: 6 m^3/d

③ Domestic waste water

Domestic waste water is generated by the work force of 220 employees.

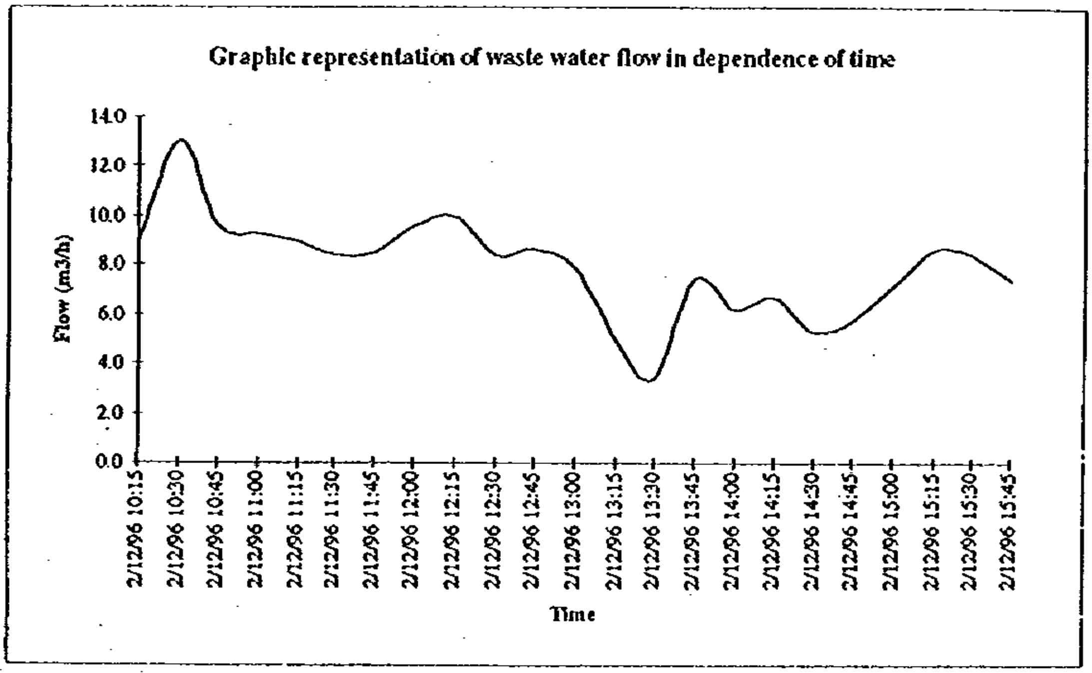
④ Other waste water

A softener is used for the boiler make-up water, however, regeneration only takes place about once per year and the amount of waste water regenerated on each occasion is 10 m^3.

b. Total waste water discharge flow

There are three waste water discharge outlets, of which two are used for discharge at normal times. The results of measuring the flow of manufacturing process waste water, which was sampled in the survey, are shown in Fig. 5.3.3.

Fig. 5.3.3 Results of Total Waste Water Flow Measurement



c. Quality of waste water

The quality of waste water from each process and the quality of total waste water are shown in Table 5.3.3. The sampling numbers and sampling points are as follows:

(No. 1-2) : mixed waste water from LMKP line
(No. 3) : washing waste water from LMKP line
(No. 4-5) : booth washing waste water from LMKP line
(No. 6) : total waste water (composite sample)

Table 5.3.3 Quality of Individual Waste Water Types and Total Waste Water

No.	1	2	3	4	5	6
Items \ Name of Sample	Washing & Phosphating (LMKP)	Washing & Phosphating (LMKP)	Rinsing	Varnishing (LMKP) cabinel+2	Varnishing (LTKP)	Effluent
Temp. (℃)	37	–	–	–	–	11~13
pH (–)	5.7	5.9	7.5	10	8.5	7.7
COD_{Cr} (mg/ℓ)	380	650	25	20,000	4,000	36
COD_{Mn} (mg/ℓ)	200	290	18	6,700	1,300	26
BOD (mg/ℓ)	230	200	10	3,500	600	30
SS (mg/ℓ)	180	200	<30	150	750	<30
Oil / Fat (mg/ℓ)	70	42	8	40	18	16
T-P (mg/ℓ)	1,500	2,100	37	200	42	4.4
T-N (mg/ℓ)	16	20	10.4	39.3	70	15.8
Cu (mg/ℓ)	–	–	–	0.017	–	0.009
Cd (mg/ℓ)	–	–	–	0.001	–	<0.001
Pb (mg/ℓ)	–	–	–	1.3	–	0.021
Fe (mg/ℓ)	23	–	0.67	0.55	–	0.25
T-Cr (mg/ℓ)	–	–	–	9.7	–	<0.005
Cr^{6+} (mg/ℓ)	–	–	–	7.0	<0.05	0.06
Zn (mg/ℓ)	–	–	–	0.43	–	0.23
Surfactants (mg/ℓ)	0.84	2.5	–	1.9	3.3	<0.05
BTX* (mg/ℓ)	–	–	<0.05	0.38	–	<0.05
AOX* (mg/ℓ)	–	–	–	0.15	<0.02	0.03
Pb (mg/ℓ)	–	–	–	1.3	–	<0.01
Pb (mg/ℓ)	–	–	–	1.3	–	–
Pb (mg/ℓ)	–	–	–	1.3	–	–
LKCH* (mg/ℓ)	–	–	–	0.03	–	–

(Note) * : Expression as Cℓ

5.3.2 Water Conservation

1) Features of water usage

① Being an establishment that processes raw metal to make safe boxes and other metal products, this factory is a typical non-water-using plant. The amount of water consumption is small at 109 m^3/d.

② The public water supply is the sole water source. 80% of the water supply is used as cooling water for the spot welding machines, and the remainder is used as domestic water and so on.

2) Current condition of water conservation

As city water is the only water source, water volumes are measured, however, recycling is not carried out at all.

3) Technical comment

① Recycling of cooling water for spot welding machines

In view of the fact that the 14 welding machines are concentrated into one area and the cooling water does not have to be very cold, it would be relatively simply to carry out water recycling.

A cooling tower would be used to recycle the water, however, because the tips of spot welding machines are very narrow, there is a risk that airborne dust might infiltrate the recycled water and block the tips if a normal open-type cooling tower were used.

In order to avoid this problem, it is desirable to use a closed-type cooling tower. In this type of cooling tower, the recycled water is indirectly cooled in pipes without coming into direct contact with the air. As a result, the cooling water is not contaminated, however, the cooling effect is slightly inferior compared with that obtained in an open-type cooling tower. Having said that, such a drawback would not prove too much of a problem in this case.

② Potential water saving

It is normally the case to expect a water saving of more than 90% when introducing a cooling tower, however, in consideration of the fact that the cooling capacity of the closed-type cooling tower may be insufficient in the summer, it is considered that approximately 70% of the existing cooling water can be saved. Thus, a water saving of approximately 60 m^3/day is considered possible.

4) Economic comment

As a closed-type cooling tower would be used, the equipment and running costs would be higher than compared to the case of an open-type cooling tower. However, comparing this with the existing cost of approximately 200 SIT/m^3 incurred by the water supply and waste water, this proposal is still thought to be amply feasible in economic terms.

5.3.3 Pretreatment for Reduction of the Pollution Load

1) Current condition of waste water

TKO PRIMAT MARIBOR has plans to change over to the use of powder paint, and investigation into this will commence in 1997. Consequently, waste water will cease to be generated in the painting processes in future.

It is also planned to carry out remodeling of the painting pretreatment facilities, however, adding waste water treatment functions to the manufacturing facilities would only hinder the manufacturing process. Thus, it is desirable to place the waste water pretreatment plant at the end of the manufacturing process as an independent system.

a. Waste water that requires treatment

① Painting pretreatment waste water (4.74 m^3/d)
LVKP line
Mixed waste water: 5.5 m^3/21 days
Washing waste water: 40 m^3/21 days
LMKP line
Mixed waste water: 5.3 m^3/21 days
Washing waste water: 40 m^3/21 days
LTKP line
Mixed waste water + washing waste water: 5.4 m^3/2-3 weeks (10.8 m^3/21 days)

② Painting booth washing waste water (0.67 m^3/d)
LVKP line
Booth washing waste water: 8 m^3/21 days
LMKP line
Booth washing waste water: 2 m^3/21 days

LTKP line

Booth washing waste water: 8 m^3/2 months (0.19 m^3/d)

b. Waste water that does not requires treatment

① Welding machine cooling water (90 m^3/d)

Spot welding machine cooling water: 84 m^3/d

Pincer welding machine cooling water: 6 m^3/d

② Domestic waste water

Domestic waste water from the work force of 220 is discharged at all times for eight hours per day.

③ Softener regenerated waste water

HCl is not used in the regenerant. The amount of regenerated waste water is 10 m^3 per regeneration per year.

2) Discharge standards

The quality standards of discharged water are shown in Table 5.3.4.

3) Selection of pretreatment system

In addition to neutralizing the waste water pH, it is necessary to partially remove the heavy metals and organic substances contained in the waste water from the painting booths washing. Because coagulating sedimentation is the most widely diffused method of pretreating waste water from painting and is cheap, it shall be selected as the pretreatment method for this case.

4) Outline of the pretreatment system

(1) Case 1

In this case, heavy metals, organic substances and phosphorous are partially removed from painting pretreatment waste water and painting booth washing waste water.

Table 5.3.4 Discharged Water Quality Standards

	Item	unit	River	Sewage
1	Temperature	℃	30	40
2	pH	–	6.5--9.0	6.5--9.5
3	SS	mg/l	80	(a)
4	SV^{30}	m/	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	A	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-NH3	mg/l	80	(e)
27	N-NO_2	mg/l	-	–
28	N-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 oil and fat	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	Evaporative organic chlorine	mg/l	0.1	0.1
45	Aqueous organic chlorine	mg/l	(k)	(l)
46	Phenol	mg/l	0.1	10
47	Surfactant	mg/l	1.0	–

Note) (a)-(1): does not apply to this factory

Waste water from the painting pretreatment and the painting booths washing is discharged into a waste water receiving tank, where it is equalized, and it is then fed into a reaction tank by storage pump. Here, a set amount of $Al_2(SO_4)^3$ is added and, moreover, NaOH is added under control by a pH meter installed in the tank in order to neutralize the water. Next, anionic high polymer coagulant is added to form flock, and this completes the coagulation process. Following that, the flock is left to separate by sedimentation. After more anionic high polymer coagulant has been added to the sludge sediment, the sludge is dehydrated in a dehydrator, and the resulting dehydrated cake is then carried out to the landfill for final disposal.

(2) Case 2

In consideration of the future use of powder paint, this case deals only with the treatment of waste water from the painting pretreatment process (the treatment of painting booth washing waste water is omitted). The actual system of waste water treatment, however, is the same as that described in Case 1.

5) Design conditions

(1) Quality of waste water

The quality levels of general waste water items are laid down in Table 5.3.5.

Table 5.3.5 Quality of General Waste Water Items

Items \ Name of Waste Water \ No.	1 Washing & Phosphating	2 Varnishing
pH (−)	5.8	9
COD_{cr} (mg/ℓ)	245	14,000
BOD (mg/ℓ)	225	2,050
SS (mg/ℓ)	190	450
T-P (mg/ℓ)	1,800	120
T-N (mg/ℓ)	18	55

(2) Volume of treated water

a. Case 1

The volume of treated water is 5.6 m^3/d (painting pretreatment waste water 4.74 m^3/d + painting booth washing waste water 0.86 m^3/d).

b. Case 2 and 3

The volume of treated water is 4.74 m^3/d (painting pretreatment waste water).

(3) Waste water inflow time

8 hours/day

(4) Operating time

8 hours/day

(5) Quality of treated water

The quality of treated water is shown in Table 5.3.5.

a. Case 1: heavy metals and phosphorous are removed and the pollution load is reduced.
b. Case 2: pH is neutralized and the pollution load is reduced.

6) Flow sheet

The treatment flow of waste water is the same in Case 1 and Case 2. The flow sheet of the pretreatment system is indicated in Fig. 5.3.4.

7) Results of examination

(1) Technical comment

The quality, volumes and pollution loads of the waste water and treated water are shown in Table 5.3.5. Under the present painting system, as there is a danger that the quality of total waste water may go over BTX standards, it is necessary to adopt a system of coagulating sedimentation. In the future case of a painting system that uses powder paint, because no waste water would be generated from the painting booths washing, carrying out coagulating sedimentation would have little effect in terms of reducing the pollution load but would lead to a major reduction in the P level.

Fig. 5.3.4 Pretreatment System Flow Sheet

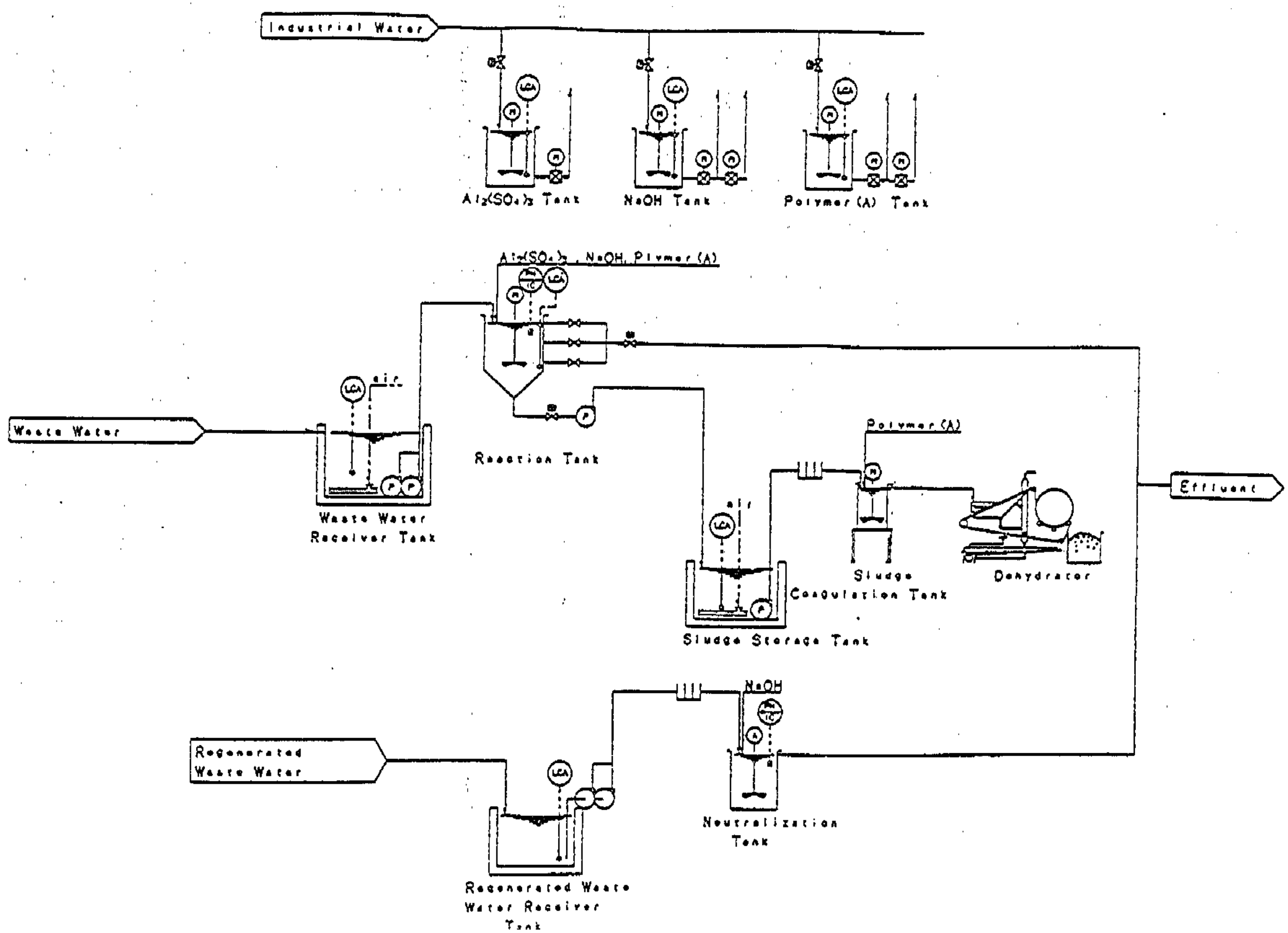


Table 5.3.5 Volumes, Quality and Pollution Loads of Waste Water and Treated Water

Kind of Waste Water	Case	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)
Pre-Treatment of Varnishing	Raw Waste Water	4.74	5.8	245 (1.16)	225 (1.07)	190 (0.9)	18 (0.09)	1,800 (8.53)
	Case-1	4.74	7	1,880 (8.91)	404 (1.91)	30 (0.14)	25 (0.12)	2 (0.09)
	Case-2	4.74	7	196 (0.93)	180 (0.85)	30 (0.14)	18 (0.09)	2 (0.01)
Varnishing	Raw Waste Water	0.86	9	14,000 (12.0)	2,050 (1.76)	450 (0.39)	55 (0.05)	120 (0.10)
	Case-1	0.86	7	1,880 (1.62)	404 (0.35)	30 (0.03)	25 (0.02)	2 (0.02)
Domestic	Raw Water	11		400 (4.4)	200 (2.2)	50 (0.55)	40 (0.44)	7 (0.08)
Total Waste Water	Raw Waste Water	109	7.7	161 (17.6)	46 (5.03)	17 (1.84)	5.3 (0.58)	80 (8.71)
	Case-1	109	7	137 (14.9)	41 (4.46)	7 (0.72)	5.3 (0.58)	2 (0.19)
	Case-2	108	7	49 (5.33)	28 (3.05)	6 (0.69)	4.9 (0.53)	1 (0.09)

(2) Economic comment

The equipment and running costs that would be incurred by the treatment plants are shown in Table 5.3.6.

Table 5.3.6 Equipment and Running Costs of the Treatment System

	Equipment Cost SIT	Depreciation & Interest SIT/m³ ①	Running Cost SIT/m³ ②	Total Treatment Cost SIT/m³ ①·②
Case-1, Case-2	10,000,000	53	11	64

8) Conclusion

Under the present painting system, as there is a danger that the quality of total waste water may go over BTX standards, it is necessary to adopt a system of coagulating sedimentation.

In the case where the painting system is changed to one using powder paint in the future, measures for dealing with pH and P in the painting pretreatment waste water are sufficient.

5.4 A-4 ELEKTROKOVINA Elektromotorji

5.4.1 Factory Outline

1) Outline

The forerunner of this company, ELEKTROKOVINA, was established in 1948 and at its peak possessed a work force of 3,500. With the onset of organizational division and privatization following national independence, the company was split up into approximately 30 small companies and factories. The total work force now numbers approximately 600.

The factory's main products are small pumps and motors of up to 15 Kw in capacity for use in industry, works, buildings and the home. The factory produces 10,000 pumps and 47,000 motors annually, and approximately 60% of its products are exported mainly to the United Kingdom and Germany. This factory is the largest manufacturer of pumps and motors in Slovenia.

Capital	:	882,795,000 SIT
Factory complex area	:	49,412 m^2
Employees	:	252
Operating hours	:	8 hours/day
Products	:	pumps, motors
Annual production	:	57,000 units

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

The quantities of water consumed according to water source and purpose of use are shown in Table 5.4.1.

3) Water supply and waste water discharge flow diagrams

The main manufacturing processes, waste water discharge flow and water balance are shown in Fig. 5.4.1.

4) Quality of make-up water and waste water

City water accounts for all the make-up water. The quality of waste water is shown in Table 5.4.2.

Fig. 5.4.1 Process Diagram and Water Balance Diagram (m³/day)

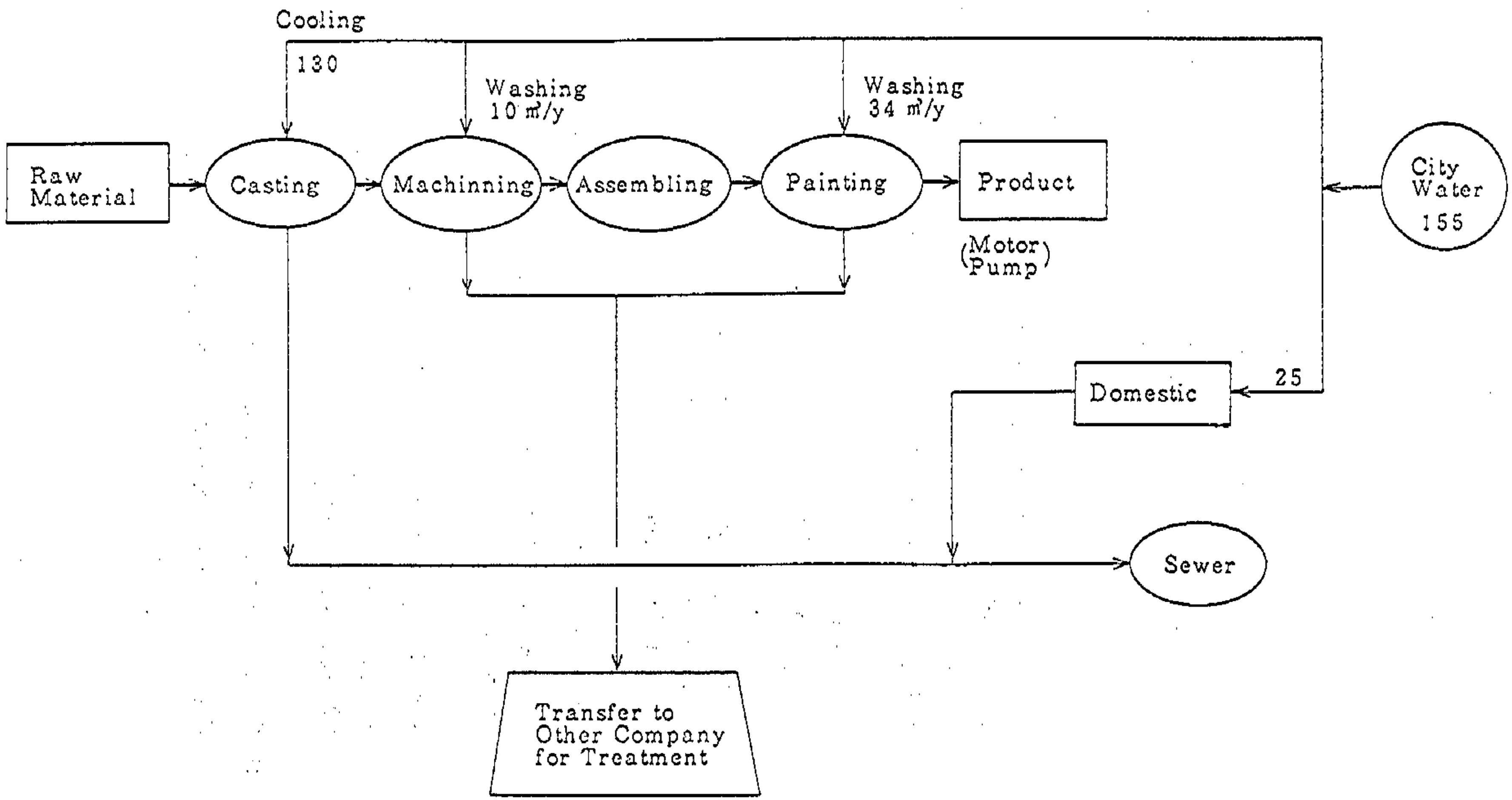


Table 5.4.1 Quantity of Consumed Water Classified by Source and Use

Unit: m^3/day

Source / Use	Well Water	City Water	River Water	Sub-Total	Recoverd Water	Total
Boiler Feed						
Raw Material						
Washing		A bit				
Cooling		130				
Air Conditioning						
Miscellaneous		25				
Total		155				
				Recoverd Water/Total		%

Note; A value in ( ) shows estimated one

Table 5.4.2 Quality of Each Type of Waste Water and Total Waste Water

Items \ Name of Sample \ No.	1	2	3
	Varnishing & defating	Varnishing mixture 2samples	Effluent
pH (−)	9.8	7.9	8.0
COD_{Cr} (mg/ℓ)	3300	3400	47
COD_{Mn} (mg/ℓ)	1050	2800	15
BOD (mg/ℓ)	1000	2500	< 5
SS (mg/ℓ)	95	660	18
Oil / Fat (mg/ℓ)	460	190	16
T−P (mg/ℓ)	700	200	2.1
T−N (mg/ℓ)	16.8	63	32
Cu (mg/ℓ)	−	0.38	< 0.005
Cd (mg/ℓ)	−	< 0.001	< 0.001
Pb (mg/ℓ)	−	11	< 0.004
Fe (mg/ℓ)	12	12	0.16
T−Cr (mg/ℓ)	−	17	< 0.005
Cr^{6+} (mg/ℓ)	−	< 0.05	< 0.05
Surfactants (mg/ℓ)	1.0	2.0	0.45
LKCH* (mg/ℓ)	−	< 0.01	< 0.01
BTX* (mg/ℓ)	−	2.8	< 0.05
AOX* (mg/ℓ)	−	0.23	0.097

(Note) * : Expression as Cℓ

5.4.2 Water Conservation

1) Features of water use

Most of the water supply is used for cooling water in the casting process, and the total usage is 130 m^3/day.

All of the water used by the factory comes from the public water supply, and the supply system that was used from the time of the former ELEKTROKOVINA is currently used by all the companies in the group. Water is taken from the public water supply at three points each installed with water meters, and ELEKTROKOVINA TEHNIKA is currently in charge of these intake points. ELEKTROKOVINA TEHNIKA collects charges from each of the companies based on their respective water usage volumes and pays the money to the city authorities. Because the individual factories receiving the water supply do not have water meters, the water usage of each factory is estimated each month by multiplying the overall water supply by the share ratios of each factory that are determined according to factory scale. The share ratio of ELKO ELEKTROKOVINA MARIBOR is set at 37%.

2) Current condition of water conservation

① The factory possesses an idle cooling tower that was installed to circulate water for cooling purposes at the time when the factory used to produce its own aluminum alloy ingots for casting and large quantities of cooling water were required.

② Cooling water for the factory's nine casting machines is only used once, and it appears that water quantities are not adjusted at the outlets by means of water temperature control.

3) Technical comment

① Installation of a water meter at the factory entrance

The installation of a water meter for the factory is a fundamental condition for water saving. In fact, it is preferable to control daily volumes of water usage by installing a water meter on the branch pipe for water to the casting machines.

② Recycling of cooing water for the casting machines

It is possible to circulate cooling water for repeated use by means of a cooling tower, and it is thought that the existing cooling tower that lies idle can be effectively used for this purpose. This cooling tower has a capacity of 100 m^3/day, which is more than enough.

③ Potential water saving

It is normally the case to expect a water saving of more than 90% when introducing a cooling tower, however, in consideration of the high temperatures recorded in Maribor in the summer, it is considered that approximately 80% of the existing cooling water (130 m^3/day) can be saved. Thus, a water saving of approximately 100 m^3/day is considered possible.

4) Economic comment

The cost of introducing the recycled use of cooling water by means of a cooling tower is estimated to be around 30-40 SIT/m^3 following examination of the model factories and secondary beneficiary factories. Thus, comparing this with the existing cost of 200 SIT/m^3 for water supply and waste water, this proposal is thought to be highly feasible in economic terms.

5.4.3 Pretreatment and Waste Water Treatment

Waste water from washing in the machine processing process and the painting booths amounts to 10 m^3 and 34 m^3 per year respectively. The factory consigns the treatment of its waste water to the neighboring ELEKTROKOVINA SVETILKE and there are no problems with this.

5.5 A-5 HENKEL ZLATOROG

5.5.1 Factory Outline

1) Outline

This company was formed by Zlatorog, a company possessing a 110 year history and numerous group firms all over Eastern Europe, and the Austrian company Henkel on June 1, 1991, and it was the first foreign joint enterprise to be formed in Slovenia following its independence. It boasted the 29th largest turnover in Slovenia in the first half of 1996. Henkel is a major manufacturer of domestic chemicals (washing powder, cosmetics, etc.) and it is the fifth largest cosmetics maker in the world. Its products are manufactured all over the world but this factory produces washing powders, shampoo, tooth paste and cosmetics using the brand names of both companies, and its products are exported to 18 countries. The production of cosmetic soap was transferred to Poland in 1996, however, the factory plans to start production of hair dye from in 1997.

Capital	:	8,317,517,000 SIT
Factory complex area	:	28,200 m^2
Employees	:	575
Operating hours	:	16 hours/day (two shifts), 249 days/year
Products	:	powder detergents, cosmetics
Annual production	:	16,000 t, 6,640 t
Annual turnover	:	130,000,000 DM (1995)

The factory pays particular attention to the quality of its products and improvement of the factory environment, and it has already acquired ISO-9001. Volumes of water usage by water source and purpose of use are monitored and the factory conducts regular analysis of its waste water every week. Effective controls can be seen in all areas.

The manufacturing process is outlined below.

(Washing powder)→Receiving of raw materials→Batch weighing→Continuous slurry→Continuous powder drying→Intermediate product silo→Continuous mixing of perfumes, etc.→Automatic packaging→Warehouse shipping

Water used in the processes is basically closed off and almost all the water is vaporized in the drying process. Minor amounts of excess water are during changeovers, etc., but these can be reduced to zero in the future.

Various kinds of cosmetics are produced using a total of 30 batch mixers (of differing models) and automatic injection machines for putting the products into their respective containers. Because the product changes by batch, the machinery needs to be washed during every changeover.

Incidentally, a temporary holding tank for use in emergencies is installed underground beneath the incoming truck platform.

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

The quantities of water consumed according to water source and purpose of use are shown in Tables 5.5.1, 5.5.2 and 5.5.3.

Water used by the factory comes from the city water supply and the Drava river. The volume used from each source is almost equal and is recorded every month.

3) Water supply and waste water discharge flow diagrams

The main manufacturing processes, waste water discharge flow and water balance are shown in Figs 5.5.1 and 5.5.2.

Moreover, Fig. 5.5.3 and Fig. 5.5.4 show the factory layout and route of waste water discharge.

4) Quality of waste water

The quality of waste water is analyzed weekly by the company, and the average values of data taken between August and November 1996 are shown in Table 5.5.4. Samples taken from three main points were analyzed during the factory survey and the results of this are given in Tables 5.5.5.

Table 5.5.1 Quantity of Consumed Water Classified by Source and Use

Source / Use	City Water m³/day	River Water m³/day	Sub Total m³/day	Recovered m³/day	Total m³/day
Boiler Feed		44	44	unknown	44
Raw Material				32	32
Washing	134		134		134
Cooling	117	268	385	unknown	385
Domestic	88				88
Total	339	312	651	32	683

Table 5.5.2 Monthly Water Consumption

(1997 Estimated)

Items / Month	Total Quantity of Make-up Water (m³/day)	Well Water (m³/day)	Potable Water (m³/day)*	Other (m³/day)	Monthly Operating Day (day)
Jan	570		259	311	21
Feb	543		247	296	20
Mar	842		383	459	20
Apr	935		425	510	22
May	1003		455	548	20
Jun	882		400	482	20
Jul	775		351	424	23
Aug	675		306	369	20
Sept	801		363	438	22
Oct	803		364	439	22
Nov	465		209	256	20
Dec	658		296	362	21
Avr**	747		339	408	21

Table 5.5.3 Quantity of Consumed Water Classified by Source and Use

Place	Use	No.	Process or Equipment	Water Quantity in Operating Day (m^3/d) cl. to source 1) 2) WW	3) PW	4) OW	5) RW	Total	Op Hr (h/d)	Op Dy (d/y)
TPD	Washing Cooling	101	Washing Powder Production		20	8	32	60	16	251
	Washing, Meteor Water	102	Raw Material Transfuse Platform		2			2	16	251
TPK 1	Washing Cooling	103	Cosmetics Production		182			182	16	251
TPK 2	Washing Cooling	104	Cosmetics Production		45			45	16	251
TPE	Cooling	105	Plastic Container Production			120		120	24	251
Compressor Station	Cooling	106	Compressor		1500 m³/y 4	140		144	16	251
Boiler House	Boiler Feed, Other	107	Boiler			~~108~~ 44		~~108~~ 44	16	251
TIV-AM	Washing	108	Automechanic Garage		10			10	8	251
	Washing	109	Labs, Canteen, Laundry, Other		54			54	8; 16	251
Office		110	Sanitary Water		22			22	10	251
			Total		339	~~376~~ 312	32	~~747~~ 683		

Note:
1) Please fill in annual average quantity of operating day.
Please fill in additionally peak quantity in ( ) if seasonal change is high.
2) WW = Well Water; 3) PW = Potable Water; 4) OW = Riverbed and/or surface Water;
5) RW = Recycling Water; 6) CW = Cooling Water

Fig. 5.5.1 Process Diagram of Production Lines

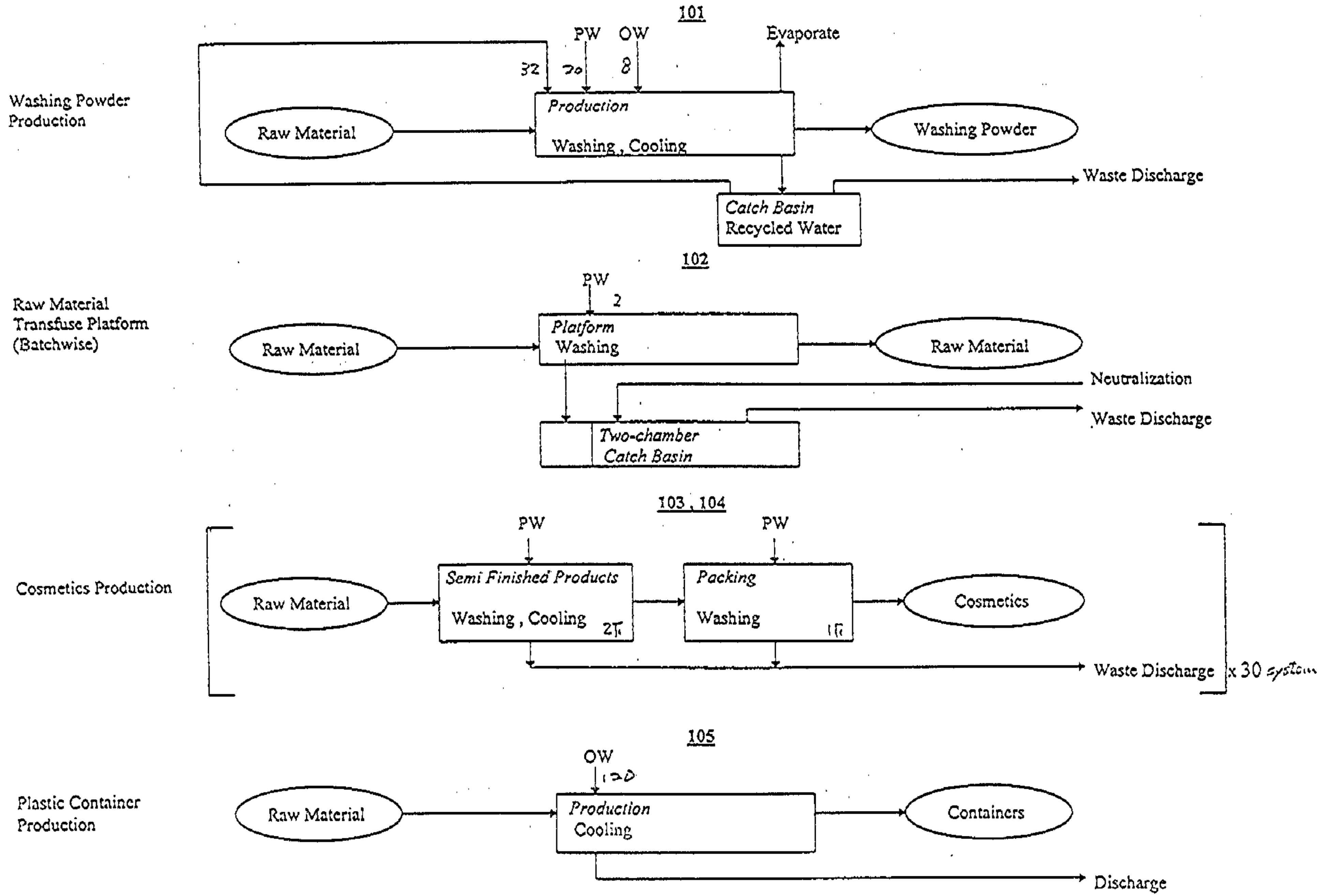
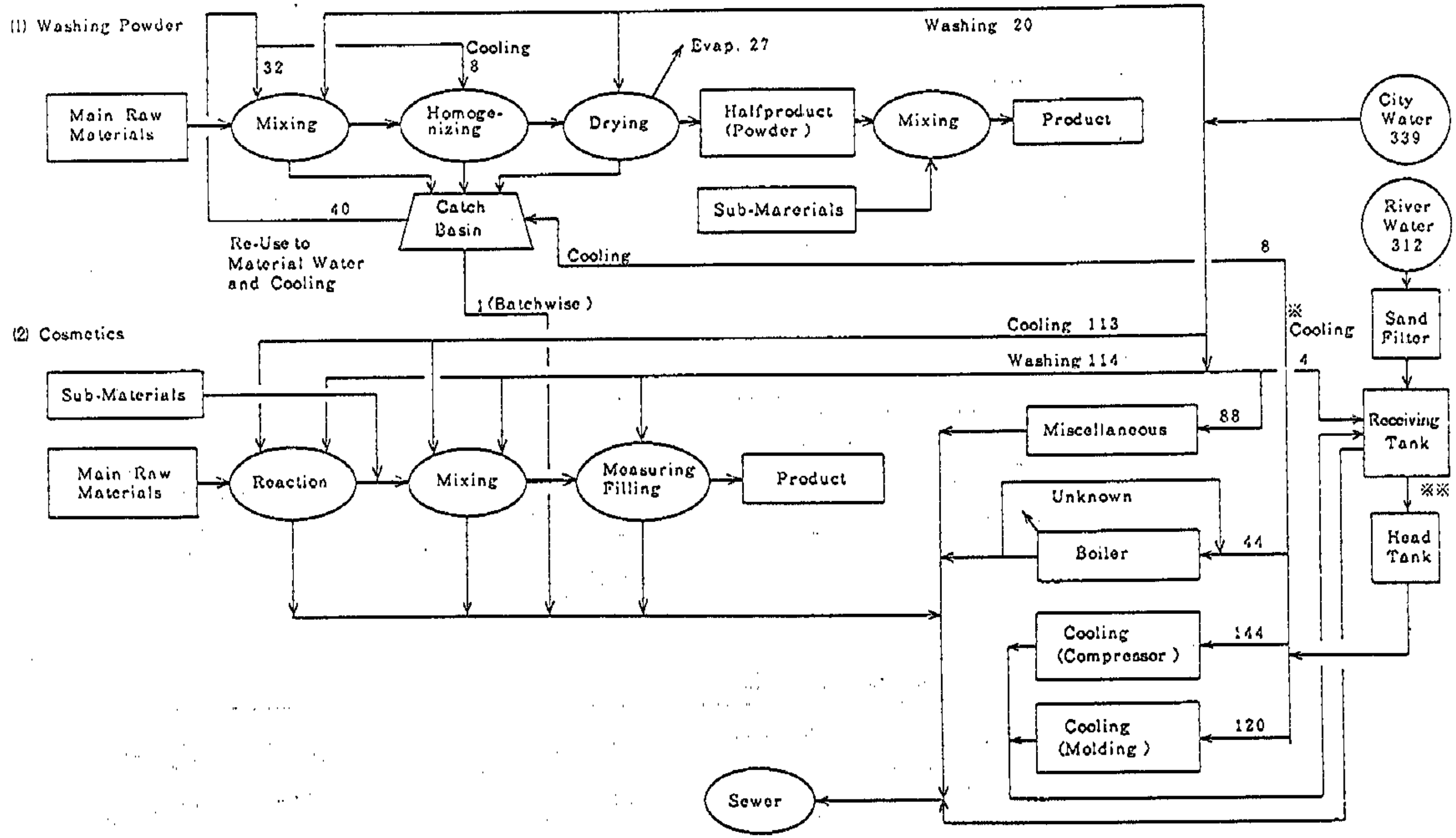


Fig. 5.5.2 Process Diagram and Water Balance Diagram



※ Used in Summer. Ca 1,000m³/y

※※ Temperature of Receiving Tank is held under 25℃

Table 5.5.4

Average results of analysis of waste water Henkel-Zlatorog that runs in the canalisation

Analysed according to the Handbook regulating the control of waste water Henkel-Zlatorog.

Period: VIII. - XI. 1996.

Sampling on sample-points - outlet no..... is carried out manually; spot samples; during the forenoon working shift; weekly or every two weeks

Parameter	T °C	pH	COD_5 mgO_2/l	BOD_5 mgO_2/l	Suspended solids mg/l	Sediment. substanc. ml/l	Petrolether soluble mg/l	P mg/l	Al mg/l
Limit value for outlet in canalization	40	6,5-9,5				10	Fats, Mineral oils 100		
Sample-point No.									
1									
2									
3a	21	8,6	810	(230)	397	1,2		5,7	round 3
4a	22	7,6	820	(360)	251	1	44	4,6	
5	21	7,2	2530		456	turbidity line is in the range of 1			
7	18	7,1	240		96	< 0,1	5		

Note:
Waste water sample-points according to Figure C of the Questionnaire:

Sample-point No. 1 - the cessation of soap production - there is not waste water
Sample-point No. 2 - the cessation of soap production - there is not waste water

Table 5.5.5 Quality of Waste Water

Characterization of the sample			1 Catch Basin in TPD factory	2 Effluent 4a	3 Effluent 5
Type of the sample			spot	flow - prop.	time - prop.
Date of sampling			11.12.1996	09.12.1996	09.12.1996
Time of sampling			12:00	8:30 - 18:00	8:30 - 18:00
Parameter	expr.as	Unit			
pH			9.7	9.8	6.7
Suspended solids		mg/l	460	130	310
Colour:					
α (436 nm)		m^{-1}	37	26	82
α (525 nm)		m^{-1}	27	20	79
α (620 nm)		m^{-1}	20	17	80
Total nitrogen:	N	mg/l	11.2	18.1	24
- ammonium nitrogen	N	mg/l	< 0.05	0.34	0.59
- Kjeldahl nitrogen	N	mg/l	3.2	12	17
- nitrite nitrogen	N	mg/l	1.0	0.10	< 0.01
- nitrate nitrogen	N	mg/l	7.0	6.0	7.0
Total phosphorus	P	mg/l	0.7	0.6	6.3
COD_{Cr}	O_2	mg/l	910	660	2400
COD_{Mn}	O_2	mg/l	360	240	810
BOD_5	O_2	mg/l	180	300	1400
Total fat		mg/l	-	-	900
Surfactants		mg/l	150	390	270

Fig. 5.5.3 Factory Layout and Sewage Pipe Location #1

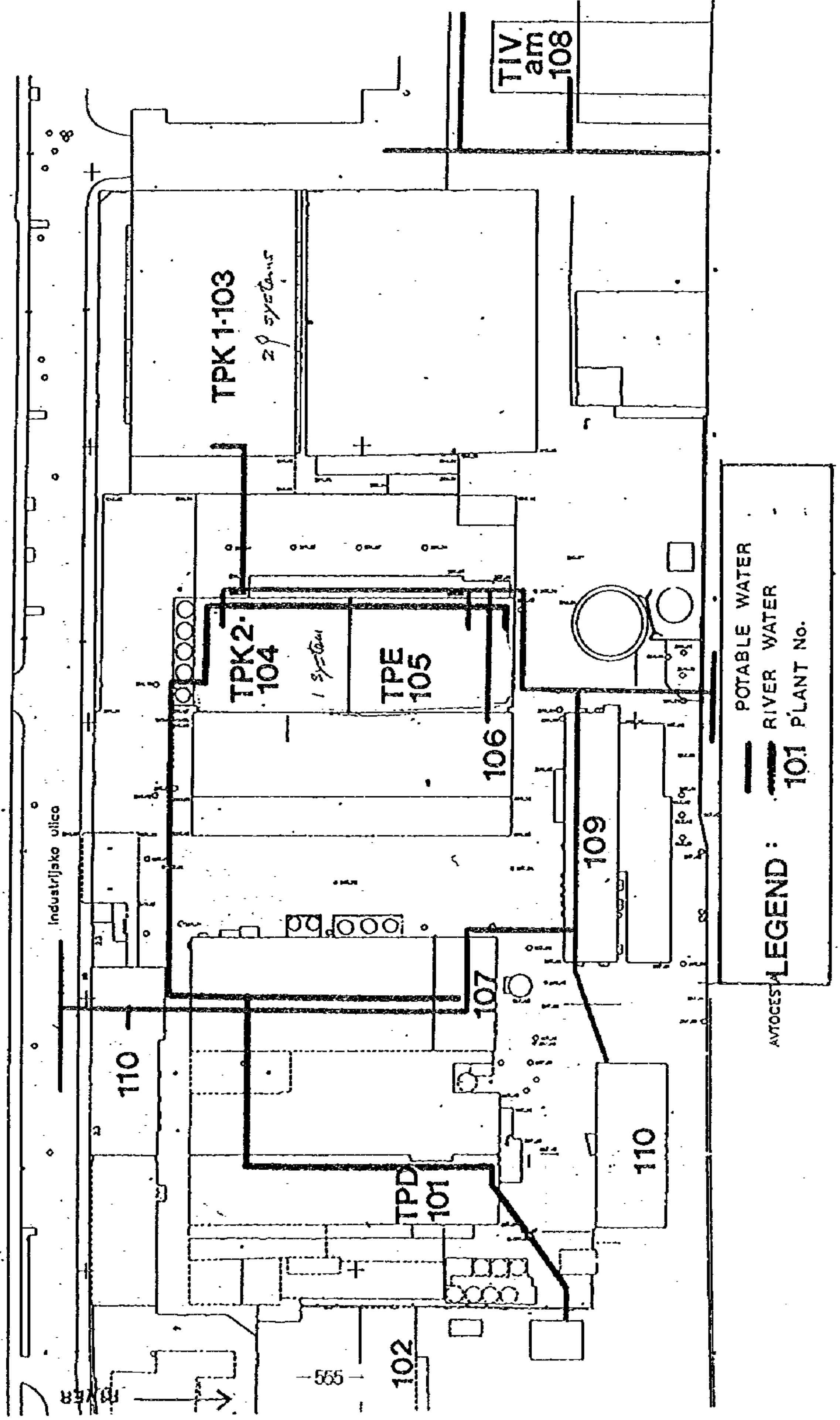


Fig. 5.5.4 Factory Layout and Sewage Pipe Location #2

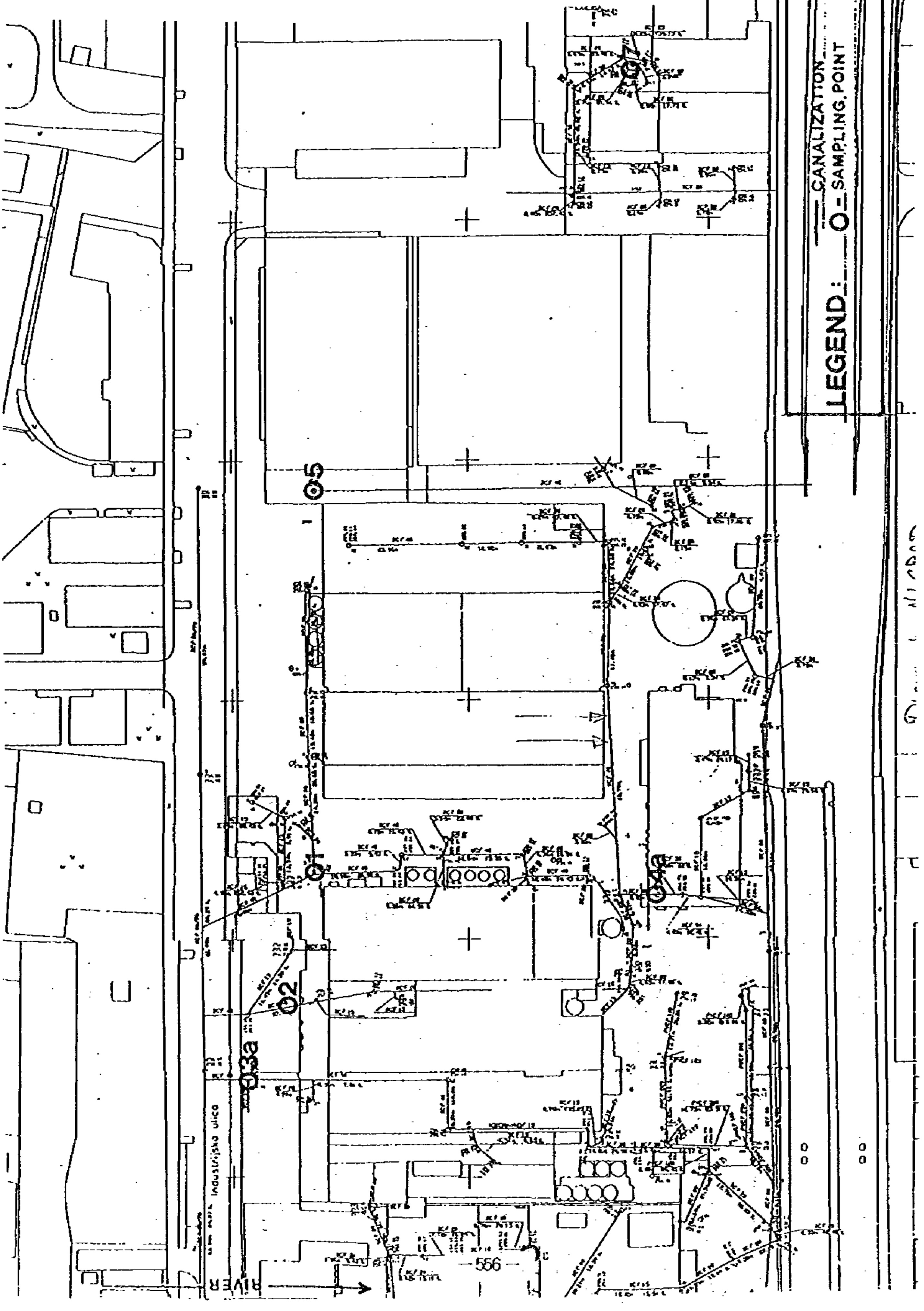
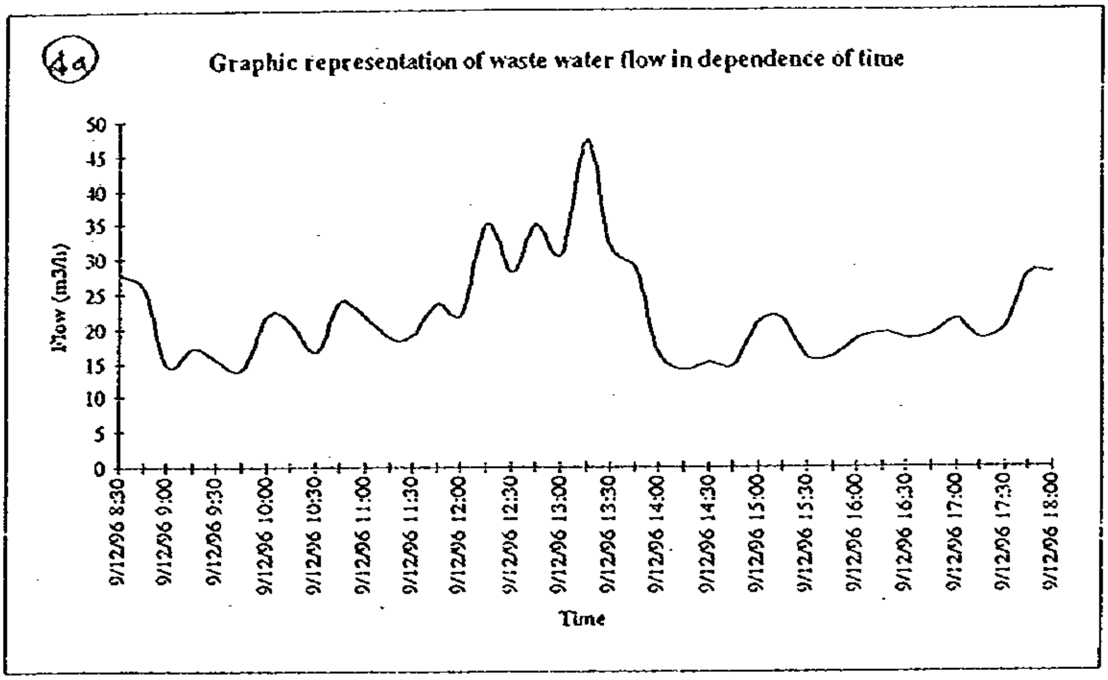
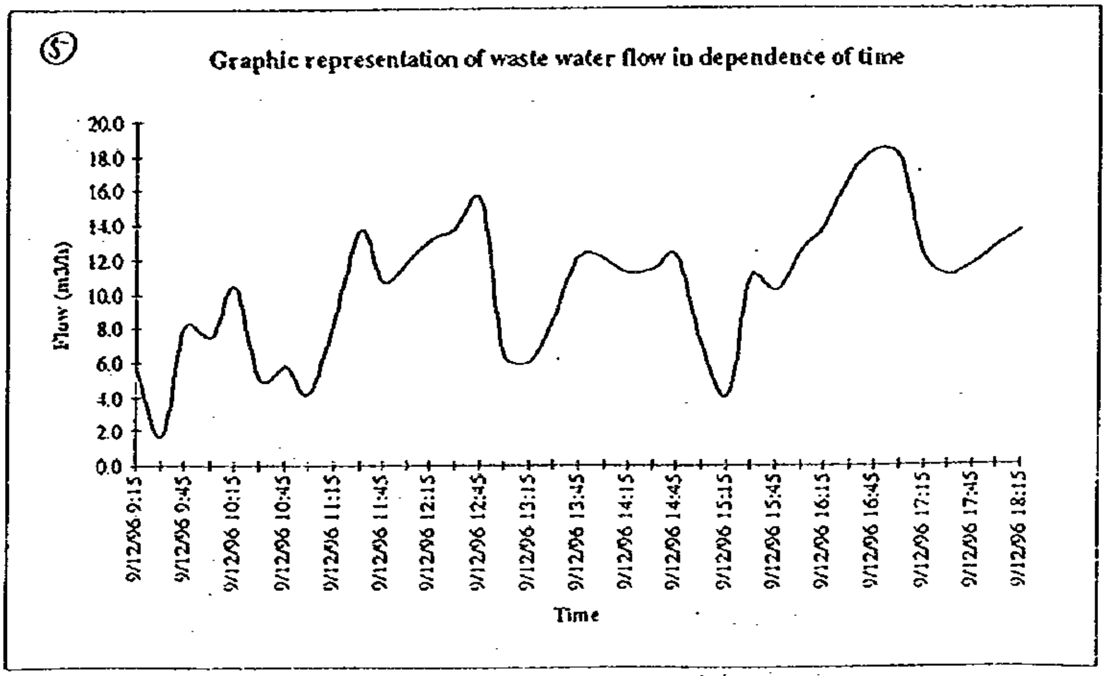


Fig.5.5.5 Waste Water Flow of 4a and 5





5.5.2 Water Conservation

1) Features of water use

① Although this factory is classified as a chemicals plant, its manufacturing processes mainly involve physical chemical operations and there are hardly any reactive processes.

② The water sources are city water and river water. City water is used in the manufacturing processes and for domestic purposes, and river water is used in boilers and as cooling water for pneumatic compressors, etc.

③ Approximately 55% of the water used in the manufacturing processes (247 m^3/day) is used for washing, and the remainder is used for cooling purposes in reactive and mixing operations.

④ River water is supplied via an overhead water tank following sand filtration.

2) Current condition of water conservation

① No water meter is installed for the river water. The volume of river water used is estimated based on the measured operating time of the intake pump.

② The washing powder manufacturing process is almost totally a closed system. Here, all the make-up water that is used mainly for machine washing and also cooling is recovered and used in the solution of raw materials. Most of this water is vaporized during the drying of the raw products and some remains in the final products. Therefore, almost no waste water is discharged out of the system.

③ All of the cooling water used in the manufacturing processes and pneumatic compressors, etc. is recovered in recycling tanks and circulated for repeated use. However, because there is no cooling tower or other cooling equipment, it is thought that the recycling rate is low (less than 50%).

Recycling of the cooling water from the manufacturing process is difficult due to the number of areas of use. Regarding the latter case (cooling water in compressors and injection molding machines), because these facilities are located in one area, total recycling is easy.

3) Technical comment

① Installation of water meter for river water

The estimation of water usage volumes is carried out, however, because the use and discharge of river water costs a lot (more than 100 SIT/m^3), it is necessary to carry out more effective water control by installing a water meter.

② Total recycling of cooling water for compressors and injection molding machines

In view of the fact that the said machinery is concentrated in one area and the cooling water does not need to be very cold, it would be easy to carry out the total recycling of water by means of a cooling tower.

③ Potential water saving

It is normally the case to expect a water saving of more than 90% when introducing a cooling tower, however, in consideration of the high temperatures recorded in Maribor in the summer, it is considered that approximately 80% of the existing cooling water can be saved. Thus, a water saving of approximately 220 m^3/day is considered possible.

4) Economic comment

The cost of introducing the recycled use of cooling water by means of a cooling tower is estimated to be around 30-40 SIT/m^3 following examination of the model factories and secondary beneficiary factories. Thus, comparing this with the existing cost of more than 100 SIT/m^3 for water supply and waste water, this proposal is thought to be highly feasible in economic terms.

5.5.3 Pretreatment

1) Current conditions

① There are seven sewage discharge outlets, of which two are not currently used. Apart from an oil-water separator installed underneath the incoming truck platform, there are no other pretreatment facilities of note.

② Waste water from the manufacturing processes contains weak traces of product substances. The COD level is very high, however, because there no discharge standards for COD, this does not pose a problem at the current time. The products are composed of easily biodegradable (so-called "soft") substances which could be treated at the central treatment plan in future.

③ Foam is apt to appear in waste water from the manufacturing processes due to the influence of surface active agent, however, this is becomes barely recognizable by dilution, when the water reaches the downstream sewage pump station.

④ Regarding waste water generated in the production of hair dye planned for 1997, quality analysis was carried out on a model waste water sample.

Table 5.5.6 Result of Phenton Method Test

		Sample	Fenton Method	
Wastewater from Hair-dye Plant		Simulated sample	$FeSO_4$ 100 ppm	H_2O_2 200
Parameter				
pH		10.2	2.2	
SS	mg/L	4,700		
Color		intensive violet	brown-yellow	
α(436nm)	m^{-1}	82	82	
α(525nm)		79	79	
α(620nm)		83	83	
t - N	mg/L	436		
t - P	mg/L	7.5		
COD_{Cr}	mg/L	15,700	17,000	
COD_{Mn}	mg/L	2,500		
BOD_5	mg/L	2,000		
t - Fat	mg/L			
Surfactants	mg/L	210		

2) Examination of pretreatment method for reducation of the pollution load

Examination shall be carried out to investigate methods to deal with the future case where sewerage charges are set based on BOD, COD and other load values.

Recycling	Completely closed process
Separation and removal	Thickening and separation
	Coagulation and separation
Decomposition	Chemical decomposition
	Ozone treatment
	Anaerobic biological treatment

① Regarding the washing powders, the manufacturing process can be completely closed off through making only a slight devising. In specific terms, make-up water is currently added to the recycling tanks from the city water supply, however, by lowering the make-up surface control level, it would be possible to accept around 1-2 m^3 of water that currently overflows during changeovers and other extraordinary times.

② Thickening and separation would be difficult in the case of cosmetics because of the large volumes of waste water generated (180 m^3/d) , however, this would be an effective method in the case of hair dye (scheduled for production soon) because the volume of waste water generated would only be 1 m^3/d. Moreover, thickening and separation would be an effective means of dealing with the oil and fat content of the waste water.

The recycle of thickened waste water in hair dye is considered to be difficult due to the nature of hair dye products, which differs from powder detergents, and the subtle effects on function and color. Generally, thickened waste water is evaporated to dryness and the resulting solid waste is either incinerated or disposed of. If there is sufficient calorific value, the thickened liquid could be mixed with boiler fuel and combusted.

③ In the case of the cosmetics and hair dye manufacturing processes, the coagulation of waste water is difficult. Various conditions were tested in jar tests, however, no floc at all was formed in reaction to inorganic coagulant.

④ Oxidization decomposition by the Phenton method does cause a remarkable change in the apparent water color, however, there are no reductions in the measured values of absorbancy and COD. Moreover, because this method is expensive and only adds to the overall pollution, and so on, it is not appropriate for this case.

⑤ Degradation by ozone treatment would also seem to be difficult judging from the Phenton method test results.

⑥ Anaerobic biological treatment is a method worth considering in the case of cosmetics waste water treatment. If treatment results were favorable, it is thought that this method could also be applied to waste water from hair dye production.

3) Outline of the pretreatment system

Case 1: anaerobic biological treatment of cosmetics waste water (4a, 5)
In 4a, waste water from areas other than the cosmetics plant is included, but the waste water from 5 shall be treated together.

The aim is to reduce the extremely high levels of COD, BOD and oil and fat.

As the pH value of the raw water is practically neutral and there are no coarse suspended solids, the raw water is directly without filteration heated to 35°C and treated in an anaerobic reactor. The selected reactor type is the fixed bed system.

In order to save on the heat source for heating, heat exchange is carried out between treated water and waste water and the remaining heat is supplemented by steam. Bio-gas generated in the reactor can be recycled as a heat source for the boiler.

Fig. 5.5.6 Flow Diagram of Anaerobic Treatment

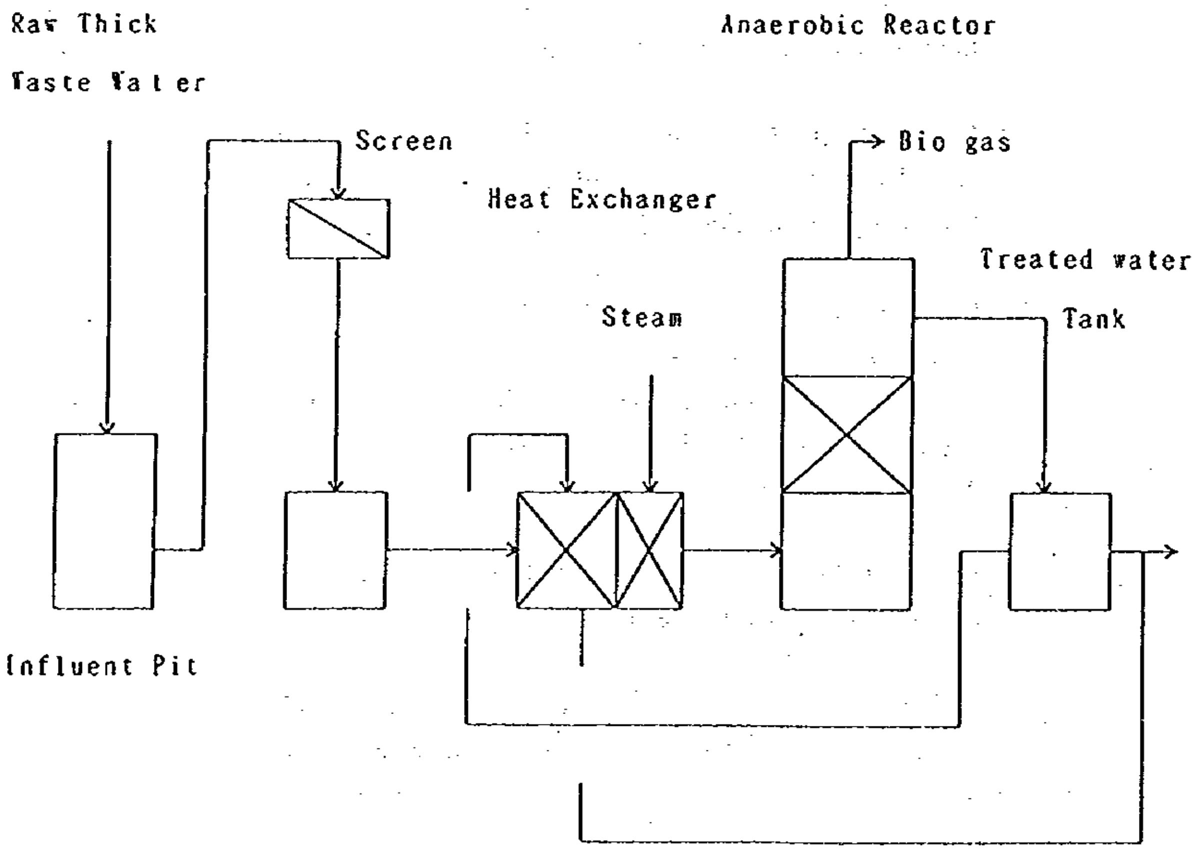


Table 5.5.7 Quality and Pollution Loads of Waste Water and Treated Water

Kind of wastewater	Quantity m³/d	CODcr mg/L (kg/d)	BOD mg/L (kg/d)	pH ( )	SS mg/L (l/m)	t-Fat mg/L (kg/d)	t-P mg/L (kg/d)
Wastewater outlet 4a	200	660 (132)	300 (60)	9.8	130 (26)		0.6
outlet 5	100	2,400 (240)	1,400 (140)	6.7	310 (31)	900 (90)	6.3
*1 Total (4a + 5)	300	1,240 (372)	670 (200)	9	190 (57)	300 (90)	2.5
*2 Case-1 Anaerobic treated	300	370 (110)	200 (60)	8	190 (57)	< 100	< 2

(Notes) * 1: quality of cosmetics waste water

* 2: Case 1: case where cosmetics waste water undergoes pretreatment (anaerobic biological treatment)

Table 5.5.8 Equipment and Running Costs of the Pretreatment 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

The total treatment cost of 117 SIT/m³ shown in Table 5.5.8 is for a treatment volume of 300 m³. When converted to the cost for a total waste water volume of 700 m³, this will be 50 SIT/m³.

5.6 A-6 SWATY Tovarna umetnih brusov

5.6.1 Factory Outline

1) Outline

This company is a specialist maker of revolving grindstones and is a leading manufacturer within Slovenia. It makes 40,000 product types and 80% of its production is done on order. 80% of its products are exported to Europe and America and its annual turnover is relatively steady at 25,000,000 DM (approximately 2,000,000,000 yen).

Capital	:	2,124,000 SIT
Factory complex area	:	39,779 m^2
Employees	:	451
Operating hours	:	8 hours/day (two shifts sometimes), 260 days/year
Products	:	revolving grindstones (diamond, ceramic, reinforced resin, resin)
Annual production	:	44,000 carat, 667 t, 1,072 t, 465 t
Annual turnover	:	25,000,000 DM

The manufacturing processes are separate for diamond, ceramic and resin products, however, the following manufacturing method is basically the same in each case.

Receiving of raw material→Weighing and mixing→Press molding→Baking→ Finish shaping→Warehouse shipping

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

The volumes of water consumption are shown in Tables 5.6.1 and 5.6.2 and Fig. 5.6.1.

All of the water used by the factory comes from city water. There are four water receiving pipelines and the volume of water usage is recorded and controlled every month. The annual volume of water usage was 38,905 t in 1995 and 38,185 t in 1994.

The volumes of water usage by purpose of use are not accurately monitored, but it is likely that most of the 150 t of water used daily is used as cooling water. Domestic waste water for the work force of 400 is probably around 40 t per day. Steam is only used to make up moisture during the grindstone drying process, and the hot water boiler for heating purposes circulates water and so does not require a large amount. Also, only a very small amount of water is used in the dextrin (adhesive) mixing process. Water used to wash the mixers of grindstone raw materials is measured and analyzed twice annually by an external study agency. Data from 1995 indicate that the daily water consumption is around 3 m^3. The site survey found the daily water consumption to be in the region of 5 m^3.

Table 5.6.1 Quantity of Consumed Water Classified by Source and Use

Source / Use	Well Water m^3/day	City Water m^3/day	River Water m^3/day
Boiler Feed		1	
Washing		3	
Cooling		120	
Domestic		25	
Total		149	

3) Flow diagrams of water supply and waste water discharge

See Fig. 5.6.2. Also, Fig. 5.6.3 shows the factory layout and waste water discharge routes.

4) Quality of make-up water and waste water

As city water is used as make-up water, it is not necessary to discuss the quality. With respect to waste water, there are six sewage discharge outlets but only one main outlet for factory waste water. Samples were taken and analyzed from this outlet and from mixer washing water. Most of the waste water is cooling water and there are no problems in terms of quality except for the mixer washing water. The volume of mixer washing water is around 5 m^3 and in terms of quality it satisfies discharge standards. The results of the analysis are shown in Table 5.6.3 and Table 5.6.*.

Table 5.6.2 Water Consumption

	Titova c60	Titova c62	Primorska	Jadranska	month total	year total
1994. 1	109	66	1	2,003	2,179	
. 2	130	87	2	3,042	3,261	
. 3	172	75	2	2,460	2,709	
. 4	135	88	2	2,354	2,579	
. 5	187	92	1	3,484	3,764	
. 6	153	90	2	3,436	3,681	
. 7	359	116	2	3,404	3,881	
. 8	102	91	2	3,306	3,501	
. 9	132	58	2	3,344	3,536	
. 10	127	53	2	3,327	3,509	
. 11	33	119	0	2,467	2,619	
. 12	21	56	1	2,899	2,977	38,196
1995. 1	8	56	2	2,987	3,053	
. 2	52	97	2	2,631	2,782	
. 3	103	90	1	3,269	3,463	
. 4	105	85	1	2,989	3,180	
. 5	50	95	1	2,041	2,187	
. 6	127	99	2	2,857	3,085	
. 7	157	148	2	3,396	3,703	
. 8	140	116	1	3,034	3,291	
. 9	59	98	1	3,186	3,344	
. 10	131	135	1	3,976	4,243	
. 11	59	89	1	3,196	3,345	
. 12	52	117	1	3,059	3,229	38,905
1996. 1	57	94	1	3,575	3,727	
. 2	89	96	1	3,447	3,633	
. 3	599	274	1	3,438	4,312	
. 4	120	122	1	3,047	3,290	
. 5	106	180	1	4,622	4,909	
. 6	130	167	1	3,726	4,024	*23,895
. 7	254	278	1	4,415	4,948	
. 8						
. 9						

Fig. 5.6.1 Water Consumption

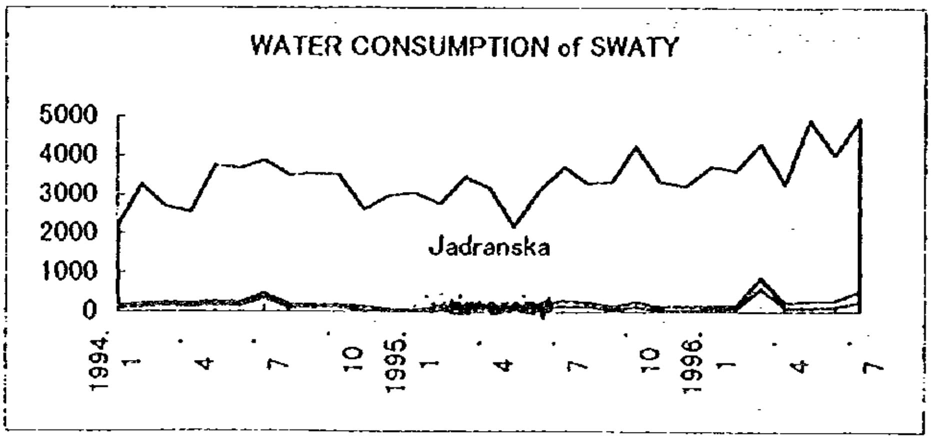
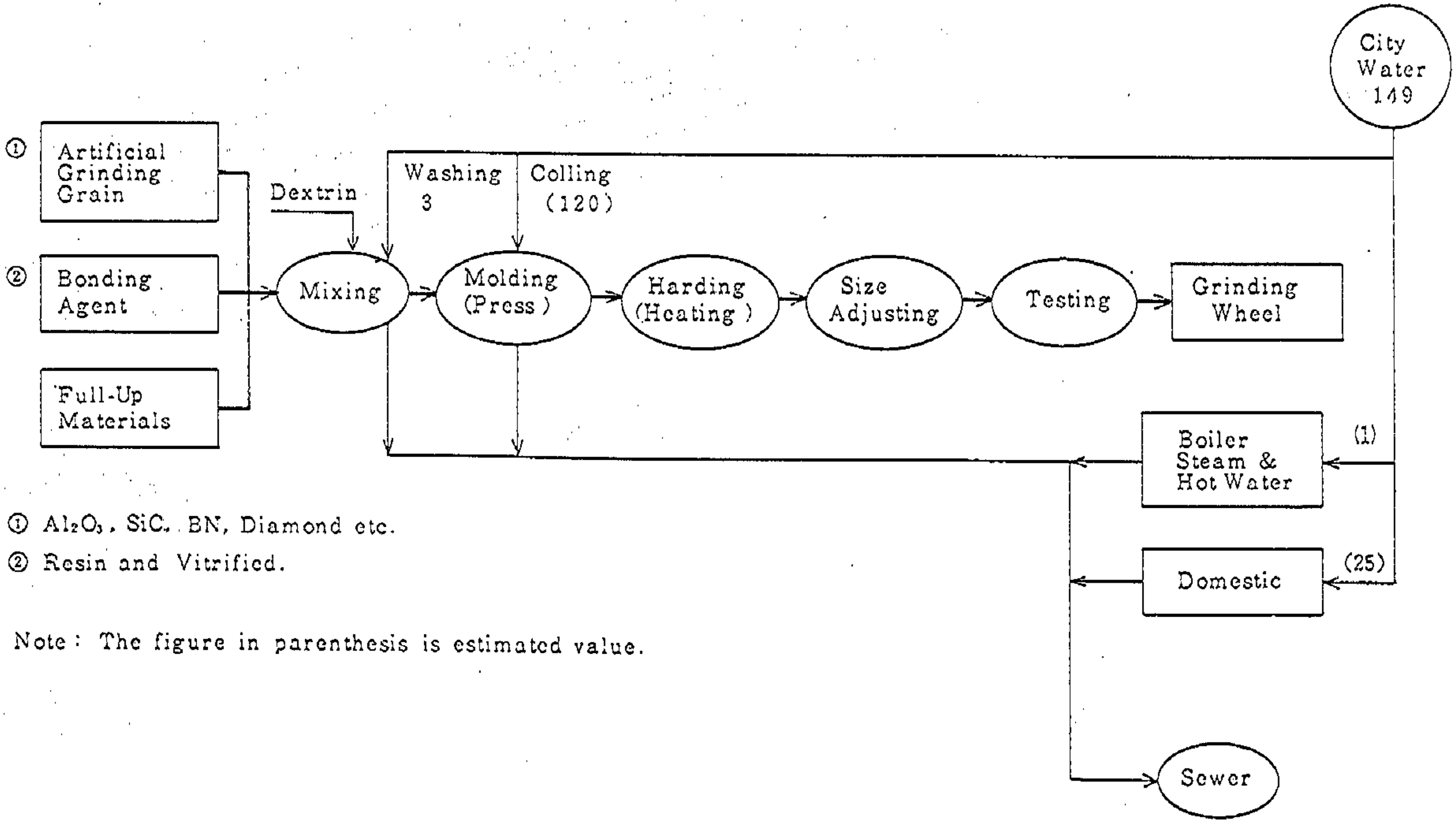


Fig. 5.6.2 Process Diagram and Water Balance Diagram (m^3 /day)



① Al_2O_3, SiC, BN, Diamond etc.

② Resin and Vitrified.

Note: The figure in parenthesis is estimated value.

Fig. 5.6.3 Factory Layout and Sewage Pipe Location

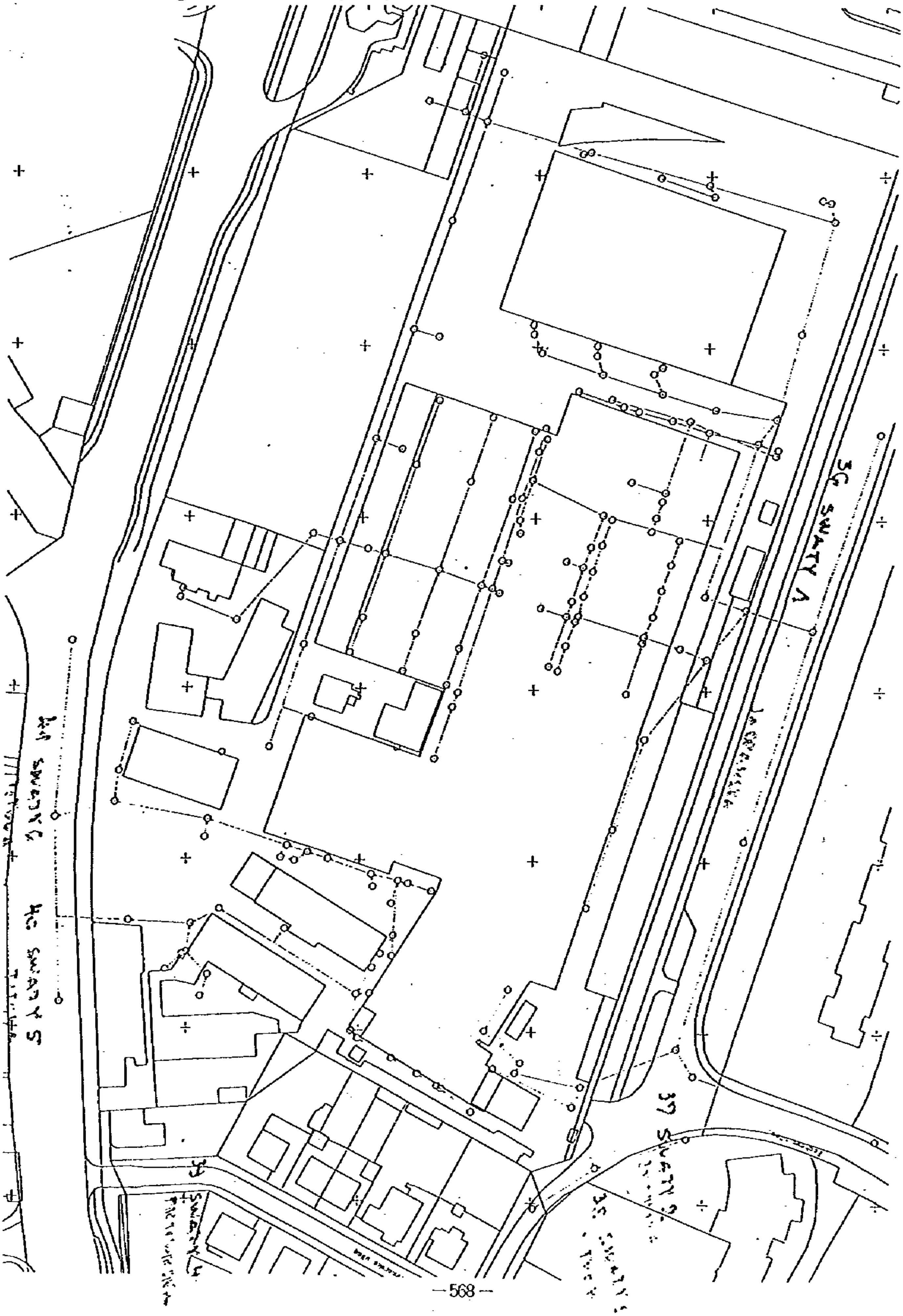


Table 5.6.3 Quality of Waste Water

Characterization of the sample			Final outlet from the factory	Washing water of mixers
Type of the sample			time - prop	flow - prop.
Date of sampling			03.12.1996	03.12.1996
Time of sampling			6:00 - 15:00	6:00 - 14:15
Lab. No.			12362	12361
Parameter	expr. as	Unit		
pH			8.7	9.5
Suspended solids		mg/l	47	830
Total nitrogen:	N	mg/l	10.5	-
- ammonium nitrogen	N	mg/l	2.4	-
- Kjeldahl nitrogen	N	mg/l	2.5	-
- nitrite nitrogen	N	mg/l	0.5	-
- nitrate nitrogen	N	mg/l	7.5	-
Total phosphorus	P	mg/l	0.8	-
COD_{Cr}	O_2	mg/l	130	300
COD_{Mn}	O_2	mg/l	32	100
BOD_5	O_2	mg/l	50	60
Total fat		mg/l	7	40
Phenol		mg/l	0.05	3.6

Fig. 5.6.4 Flow of Main Process Waste Water

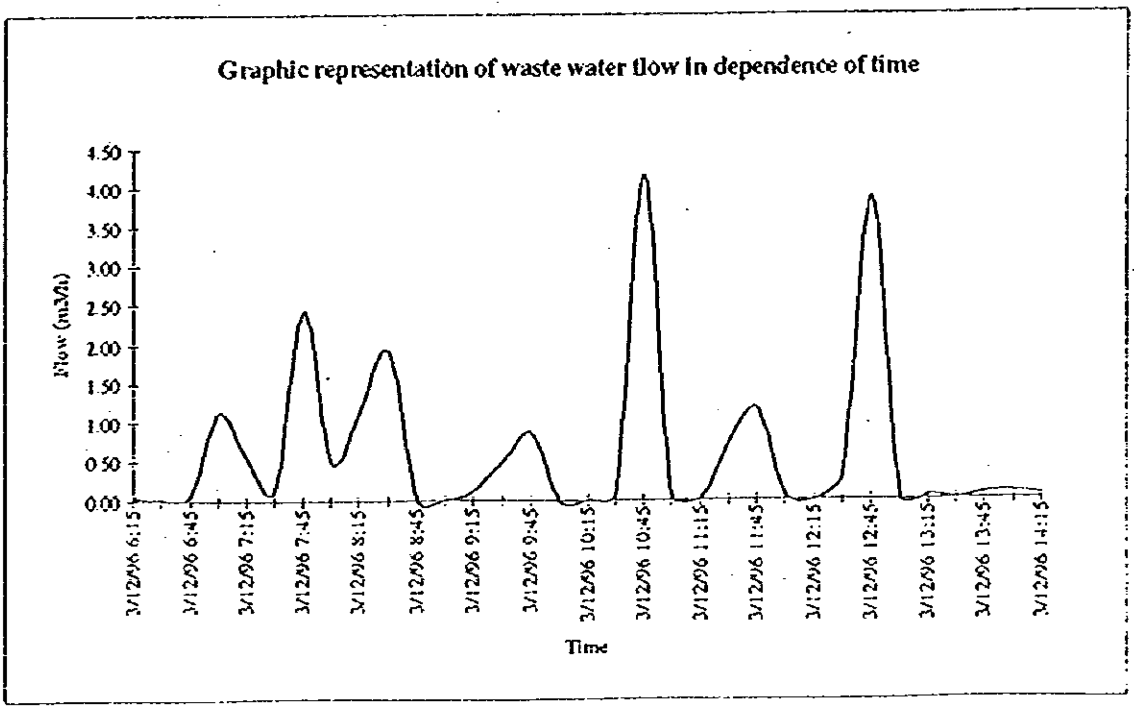


Table 5.6.4 Quality of Wastewater

(Dec. 1995)

Parameter	Izražen kot	Enota	Metoda	Vzorec 1 Lab.št. 8378	Mejne vrednosti za iztok v kanalizacijo
Splošni parametri					
Opis				motna z usedlino, vonj	
pH-vrednost			DIN 38404-C5	7,7	6,5-9,0
Elektroprevodnost		µS/cm	DIN 38404-C8	590	-
Raztopljene snovi		mg/l	DIN 38409-H1-2	450	-
Raztopljene anorganske snovi		mg/l	DIN 38409-H1-3	300	-
Neraztopljene snovi		mg/l	DIN 38409-H2-2	1600	-
Usedljive snovi		ml/l	DIN 38409-H9	10	-
Organski parametri					
KPK	O_2	mg/l	DIN 38409-H41	140	-
BPK_5	O_2	mg/l	DIN 38409-H51	50	-
Ekstrakt (maščobe, olja)		mg/l	DIN 38409-H17	9	-
Fenolni indeks	fenol	mg/l	DIN 38409-H16-2	0,035	2,0
Formaldehid		mg/l	-	0,5	5,0
Skupni ogljikovodiki		mg/l	DIN 38409-H18 mod	1,6	20
Biološki parametri					
Test strupenosti - Offhaus		%	DEV L 2 mod	< 10%	neg.

5.6.2 Water Conservation

1) Features of water usage

① Although the factory is classified as a chemicals plant, there are hardly any reactive operations and the production processes consist of physical chemical operations such as mixing, compression and heating, etc. As a result, the waste water characteristics are similar to those of a machine factory and the volume of water usage is small (149 m^3/day).

② The public water supply is the only water source. It is estimated that more than 80% of water is used as cooling water for the press machines, and the remainder is used as domestic water and for other miscellaneous purposes.

2) Current condition of water conservation

As the public water supply is the only water source, the volume of usage is measured. Recycling of water is not carried out at all.

3) Technical comment

① Recycled use of cooling water for press machines

In view of the fact that the six large presses at the factory are concentrated in one area and the cooling water does not need to be very cold, it would be easy to carry out the total recycling of water by means of a cooling tower. However, because there are numerous other small presses, it would be difficult to circulate water for use in all the machinery.

② Potential water saving

It is normally the case to expect a water saving of more than 90% when introducing a cooling tower, however, in consideration of the high temperatures recorded in Maribor in the summer and the fact that it would be difficult to recycle water for use in all the machinery, it is considered that approximately 60% of the existing cooling water (approximately 120 m^3/day) can be saved. Thus, a water saving of approximately 70 m^3/day is considered possible.

4) Economic comment

The cost of introducing the recycled use of cooling water by means of a cooling tower is estimated to be around 30-40 SIT/m^3 following examination of the model factories and secondary beneficiary factories. Thus, comparing this with the existing cost of 200 SIT/m^3 or more for water supply and waste water, this proposal is thought to be highly feasible in economic terms.

5.6.3 Pretreatment

① Most of the waste water is cooling water and there are no problems in terms of quality except for the mixer washing water. The volume of mixer washing water is around 5 m^3 and in terms of quality it satisfies discharge standards. Because this waste water is diluted to around a fiftieth of its original concentration within the overall waste water, there is no need to carry out pretreatment.

② Organic waste gases are generated in the manufacture of resin grindstones and there are no particular measures to deal with this at the present time. If such gases come to be regulated in the future, they could either be rendered innocuous through using after burners or water washing with scrubbers could be tried. In the case where water washing is applied, it would be necessary to deal with organic waste water.

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