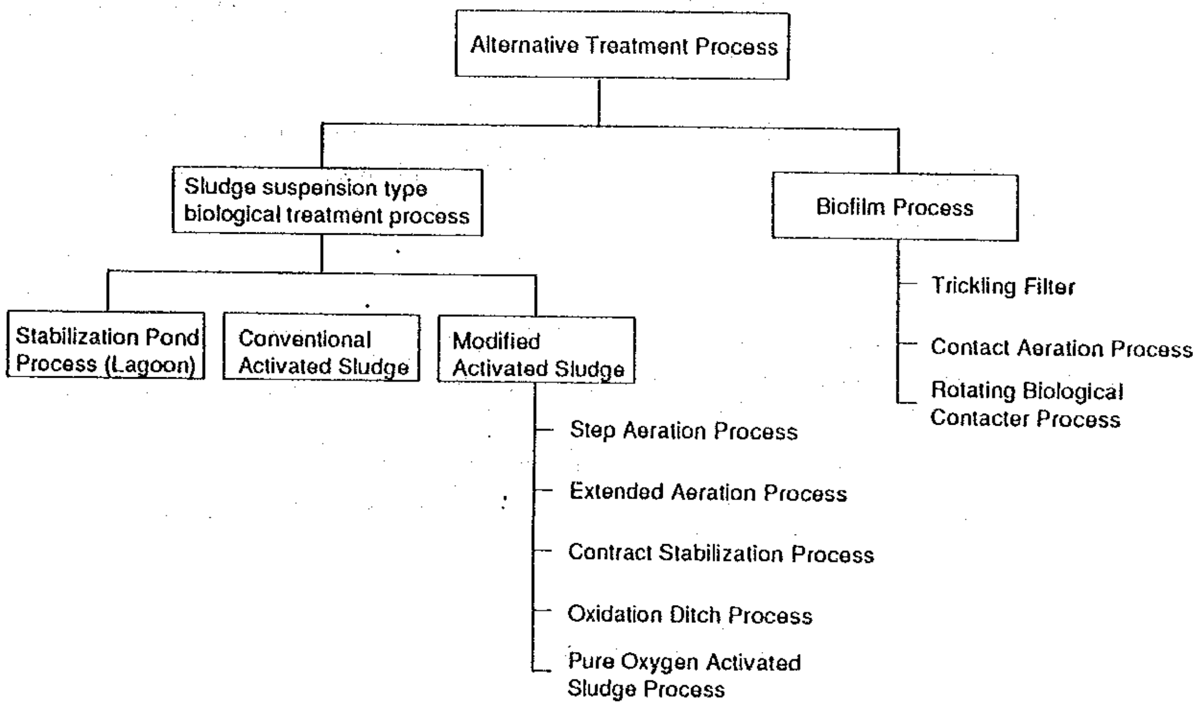
[Appendix 3.8-2] Comparative Study of Facilities

[Appendix 3.8-2-1] Selection of Biological Treatment Process

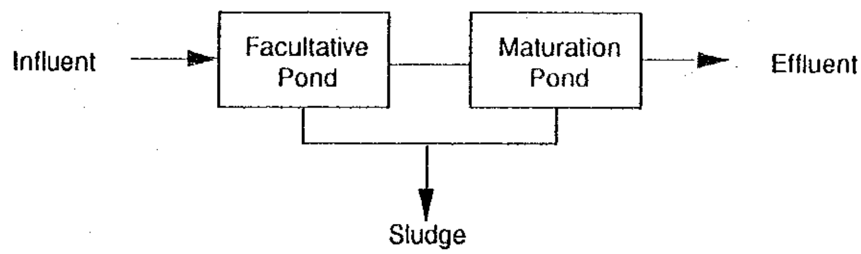
a) Feature of Treatment Process

Alternative treatment processes can be summarized as follows.



i. Lagoon

In hot climate countries the stabilization lagoon is commonly applied taking advantages of high temperature as well as the attraction of low cost and simple operational needs. However, this process requires quite a wide land space which is not available in the vicinity of the Project Area.

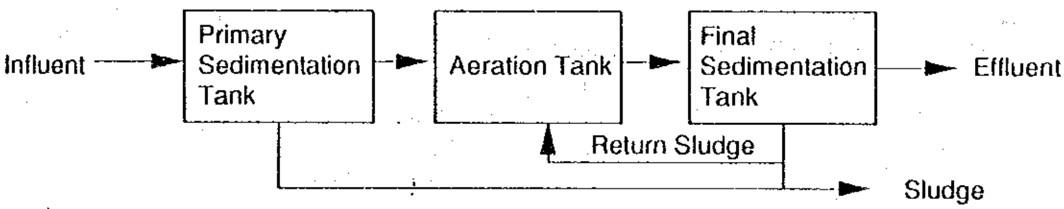


Flow Sheet of Stabilization Pond Process

ii. Conventional Activated Sludge Process (CASP)

The conventional activated sludge process has a long history of experienced and proved to be appropriate for wastewater plants with capacities similar to the one considered here. However, the requirement of rather high level technique for operation and maintenance which is a vital factor that makes the process inappropriate in the lack of experienced and trained necessary manpower. In case of industrial wastewater plants, a considerable high engineering technique is essentially needed and unavoidable.

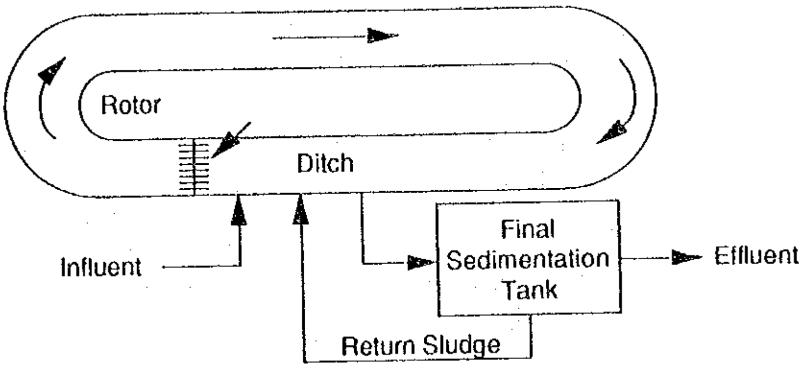
The CASP is more compactly installed than other alternatives. Thus the CASP will be suitably allocated in the available limited space proposed on the Project Area.



Flow Sheet of CASP

iii. Oxidation Ditch Process

The oxidation ditch process has originally been developed for applying to small size plants. The oxidation ditch is a long continuous channel usually oval in plan and 1.0 - 3.0 m in depth. The wastewater in the ditch is aerated by one or more brush or rotors placed across the channel. Theoretically if the number of ditches is increased the capacity of the plant become larger in proportion. In Japan, the maximum capacity of a single ditch is about 5,000 m^3/day.



Flow Sheet of Oxidation Ditch Process

iv. Other Alternatives

Other remaining alternatives seem to be infeasible for the considered treatment plant, since some are suitable only for small size plants and others are too costly. The trickling filter is likely to cause a higher level of odor released from the biofilters. On top of that the microbial film in biofilters becomes a breeding ground of various flies and midges, which can cause severe nuisance especially in hot climates.

b) Comparative Study of Biological Treatment Processes

i. A General Comparison Between Alternatives

Alternative treatment processes are compared on the basis of capital costs, operation and maintenance costs, and required areas. The results of these comparisons are as follows.

- Cost Comparison

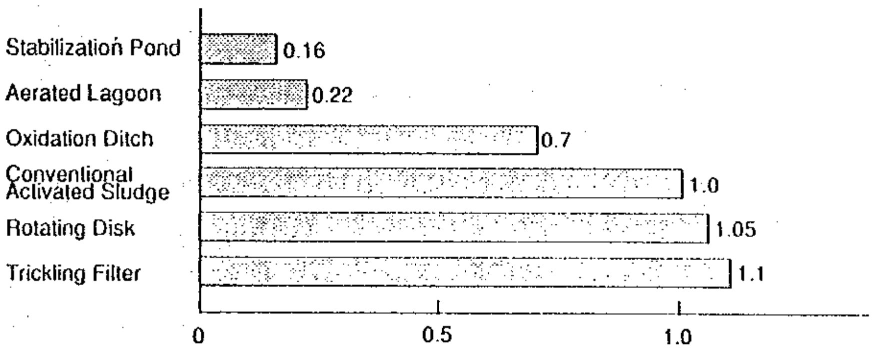


Figure 1 Normalized Capital Costs of Alternative Processes

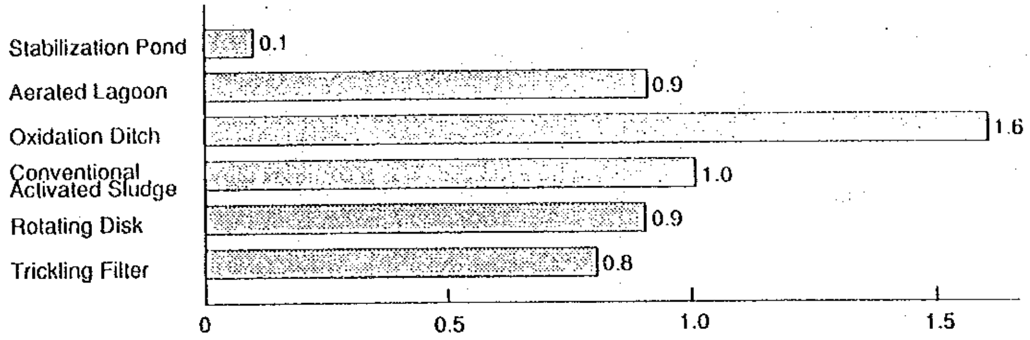


Figure 2 Normalized O & M Costs of Alternative Processes

- Comparison of Required Area

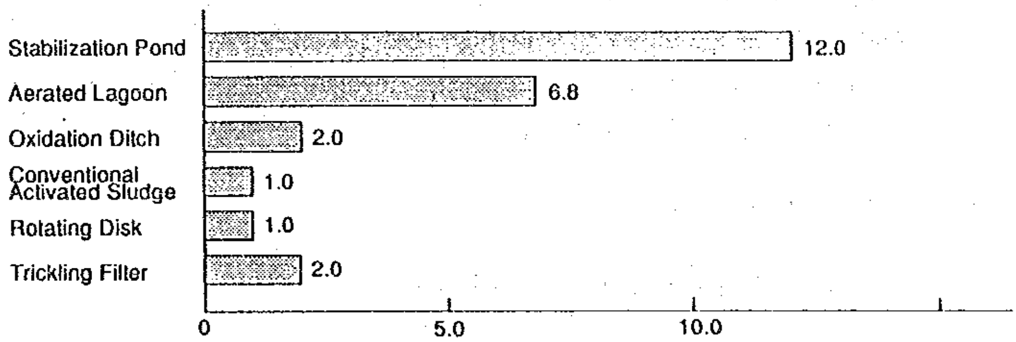


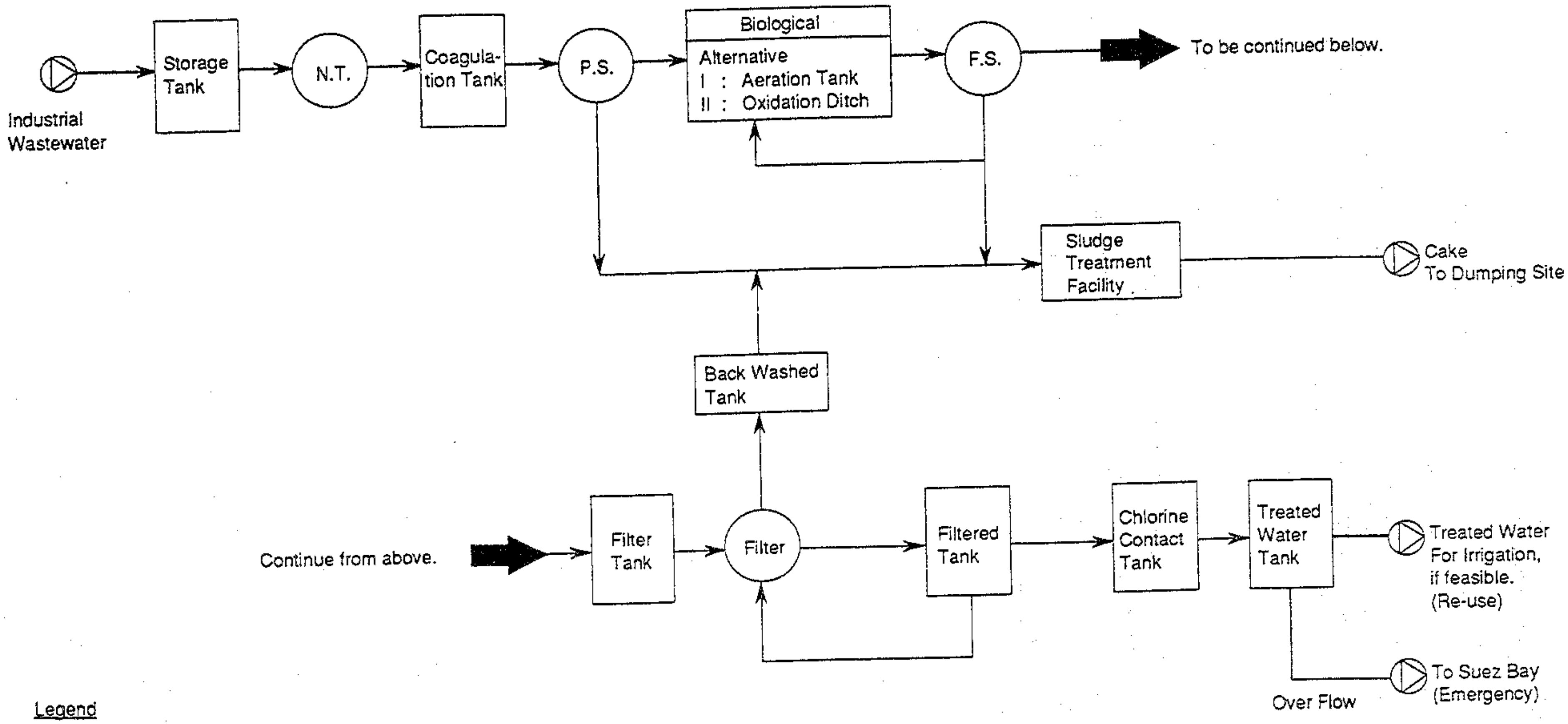
Figure 3 Normalized Area Required for Alternative Processes

ii. Conventional Activated Sludge Process (CASP) Versus Oxidation Ditch Process

Through comparative studies and discussions previously mentioned, the conventional activated sludge process and the oxidation ditch process are considered to be the most suitable for this area. More detailed comparison between these processes is shown in Table 1 and Figure 4 . The comparison shows that the conventional activated sludge process (CASP) is most feasible. However, it has to be mentioned that in case of the CASP, the preparation for operation and maintenance of the plant should include a training program for the concerned manpowers.

Table 1 Conventional Activated Sludge Versus Oxidation Ditch

Item		CAS	OD
BOD removal efficiency (%)		80 - 95	80 - 90
Plant Capacity		Economically beneficial for large scale (>20,000 m^3/d) plant rather than small	Practices for small scale plant (<20,000 m^3/d) are many, for large scale few
Cost	Capital	100 %	70 %
	O & M (30 years)	100 %	160 %
Area for treatment plant site		350 m * 150 m = 5.25 ha	400 m * 270 m = 10.8 ha
Additional Works to secure land		-	Relocation of the existing water pipe or the oil pipe
Overall appraisal		◎	×



Legend

N.T. : Neutralization Tank
P.S. : Primary Sedimentation Tank
F.S. : Final Sedimentation Tank

Figure 4 Flow Diagram of Industrial Wastewater Treatment Plant

c) Conclusion

As the result of comparative study of the above several treatment processes, conventional activated sludge process was selected from view points of economy, required area, and well experienced with similar capacities wastewater treatment plants.

[Appendix 3.8-2-2] Selection of Aeration Method

Method of aeration shall be decided after studies about its cost saving, energy-saving and easiness of maintenance.

C-1

Method of Aeration	Features	Cost-saving	Energy-saving	Maintenance
Circulation aeration by blower, (Air-Blowing Type)	• This method is popular for standard activated sludge system. • This is applicable for rectangular tank of 5 m depth. • Big bubble diffusers and fine bubble diffusers can be used.	Lower price	Low consumption of energy	Low cost maintenance
Total area aeration by blower (Nozzle-jet Type)	• Recently this system has been developed in combination with Ultra fine bubble diffusers in view of energy saving. • This system is very effective on O_2 dispersion and O_2 transfer in the tank and of energy saving type, but this requires an additional facilities to prevent clogging.	Initial cost is rather high	Lowest consumption of energy	Prevention of clogging is required
Mechanical surface aeration	• This system is to aerate surface of water mechanically. It is said that this is of energy saving type, but it is constrained by depth of water, structure of pond, numbers of pond, numbers of machines, adjustment of air supply, environmental conditions (generation of noise scattering of water, corrosion of machine, water temp. and ambient temp.) life of machine and maintenance.	Short life span of machine due to corrosion	Average	• Low maintenance cost • Turbulent flow break flocs

* Conclusion : Circulation aeration system shall be chosen for the Suez waste water treatment plant judging from the tables of C-1 and C-2 and fine bubble type shall be chosen for diffusers.

C-2 Compression Table on Aerators

(1) Table for various aerators

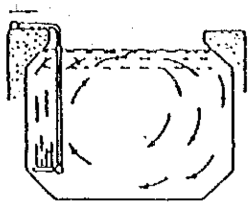
Aerator	Features of Equipment	Merit	Demerit	Application
Big bubble type	• Bubbles generated are big	• Low Cost • No cloggings • Low maintenance cost • Easy maintenance • Blower can be installed far away from the aerators (Less pressure loss)	• Low efficiency of O_2 transfer (High cost of power) • Turbulent flow breaks flocs	• Small scale treatment plant (for labour saving)
Fine bubble type	• Bubbles generated are small	• High efficiency of O_2 transfer (Low cost of power) • Easy maintenance	• Air cleaner may be needed to prevent cloggings on the aerators • Turbulent flow breaks flocs	• Large scale treatment plant
Ultrafine bubble type	• Bubbles generated are smaller than that of fine bubble type	• Efficiency of O_2 transfer is much better • No restriction on the shape of tank • Good for flocculation	• Air cleaner may be needed to prevent clogging • Initial cost is a little high	• Treatment plant to reduce energy cost • Better treatment • Treatment plant that requires high nitrification
Vertical shaft agitator type	• There are two types of float type and fixed type • There are turbine type and propeller type	• Low cost • High efficiency of O_2 transfer • Effective mixing	• Maintenance is not easy, if numbers of unit are many • Insufficient nitrification • Not suited for cold area • Turbulent flow breaks flocs • Distribution of DO in the tank is not even	• Treat plant that does not require nitrification • Treatment plant located in hot area • Aerating lagoon
Horizontal shaft drive type	• Waves caused by rotation of aerator transfer O2 (only for shallow tanks) • There are two types of puddle type and rotor type	• High efficiency of O_2 transfer • Low price • Low maintenance cost	• Limitation of tank shape • Not suited for cold area • Insufficient in nitrification • Turbulent flow breaks flocs	• Oxidation ditch
Combination type	• Air is injected from spurjaring and simultaneously agitated by turbine propellers equipped in the water	• Good mixing • Efficiency of O_2 transfer is ordinary • Supply of air is largely adjustable	• Reducer and air compressor are required • High price • High maintenance cost • Turbulent flow breaks flocs	• Treatment plant that requires wide range of air supply • Nitrification tank

(2) Comparison Table of O_2 Transfer in Water

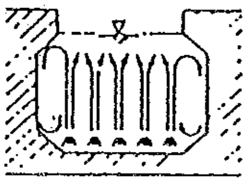
Aerator		O_2 dissolving efficiency in water (%)	Power efficiency when O_2 transferred in water (kgO_2/kwh)	Required Energy (kwh/kgO_2)
BUBBLING TYPE	Big bubble type			
	Static aerator	10 - 16	1.4 - 1.9	0.51 - 0.71
	Big bubble double type	10 - 13	1.4 - 1.9	0.62 - 0.71
	Big bubble single type	8 - 10	1.2 - 1.5	0.60 - 0.71
	Fine bubble type			
	Circling type	15 - 26	1.9 - 3.3	0.31 - 0.55
(C	Ultra fine bubbling type total aeration type	20 - 32	3.0 - 4.6	0.22 - 0.33
MECHANICAL AERATION	Low speed surface aeration type		1.5 - 2.2	0.46 - 0.66
	High speed surface aeration type		1.2 - 1.8	0.55 - 1.82
COMBINATION TYPE	Turbine spurjar	14 - 18	1.2 - 1.8	0.55 - 0.82
	Jet aerator	15 - 26	1.6 - 2.3	0.44 - 0.62

* In case of mixed liquid in the aeration tank, it will be doubled.

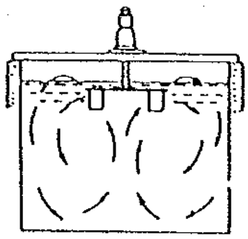
Figuré. Aeration Method



Circulation Aeration by Blower (Air-Blowing Type)

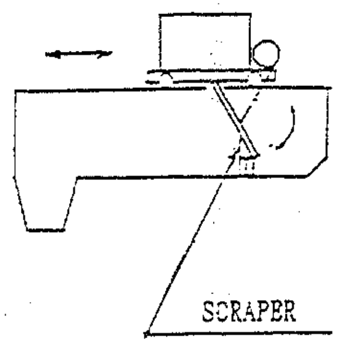
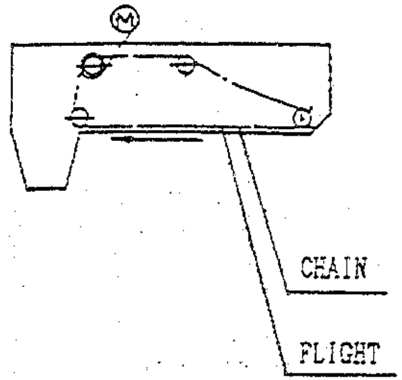


Total Area Aeration by Blower (Nozzle-Jet Type)



Mechanical Surface Aeration

[Appendix 3.8-2-3] Comparison Table for Sludge Collector (1)

TYPE / ITEM	TRAVELING MODE TYPE	LINK-BELT TYPE
SKETCH	 	
MECHANISM	The sludge scraper is hanged on traveling equipment which is provided with rope winding drum for "up" and "down" of scraper. This sludge collector would traveling forward as scraper moves "down" and as scraper "up" for sludge collecting. The scraper would be above the water level when sludge collector is not functioning.	The sludge scraper attached endless chain as bout three (3) meters pitch. This sludge collector is moving in direction of arrow described in the above sketch for sludge collecting.
RECORD OF PERFORMANCE	Slightly Less	Lot

Comparison Table for Sludge Collector (2)

TYPE / ITEM	TRAVELING MODE TYPE	LINK-BELT TYPE
MAINTENANCE	Complicated. Traveling Equipment, Limit Switch etc. require inspection.	Easy Machine Mechanism is simple.
OPERATION METHOD	Intermittent movement, many limit switches. Operation is complicated	Continuous running. Operation is easy.
PERFORMANCE	Slightly no-good performance compare with Link-Belt Type.	Good
MOTOR POWER	Primary Settling Tank : 12.0 kW (3.0 kW/2 tanks) Final Settling Tank : 12.0 kW (3.0 kW/2 tanks)	Primary Settling Tank : 6.0 kW (1.5 kW/2 tanks) Final Settling Tank : 8.8 kW (2.2 kW/2 tanks)
INITIAL COST	180 %	100 %
RUNNING COST	250 %	100 %
SAFETY	Not good Mechanism is complicated and many limiting switches are required. Due to loading of sludge, possibility for wheels of traveling equipment to slip out.	Good Mechanism is simple.

Comparison Table for Sludge Collector (3)

TYPE / ITEM	TRAVELING MODE TYPE	LINK-BELT TYPE
TROUBLE PERCENTAGE	High Many limit switches. Slipping out of wheels of traveling equipment.	Low Mechanism is simple.
EVALUATION	(1) Mechanism is complicate, motor power is big and intermittent operation. (2) Many limiting switches are necessary and maintenance work require a lot of time. (3) Normally, if Link-Belt Type can not be installed, select this type. (4) Possibility for scraper to slip out	(1) This sludge collector can adjust moving speed of scraper so that sludge flotation be prevented. (2) Return scraper can introduce floating scum to scum trough. (3) Lower height of scraper minimizes interference with flow of wastewater..
RESULT	×	○

[Appendix 3.8-2-4] Comparative Study of Industrial Relay Pumping Systems

The maximum excavation depth for setting sewer pipes is limited to 5 m, taking into consideration local practices and experience. As a result it became necessary to inset two relay pumping stations into the sewer network. One is in the Ataqa I.E. Coastal Area which will be developed by coastal reclamation, therefore, the planned elevation is lower than the remaining areas, and flat. Another one is beside the Suez-Ain Sukhuna road which runs through the east rim of Ataqa I.E. East and is, due to topographic conditions, the route of the intercepting sewer for Ataqa I.E. East.

The road is relatively flat and the required excavation depth for the intercepting sewer becomes about 5 m at a point 1.9 km from the northern boundary of the Project Area. The site is about one km away from the coastal area's pumping station, which means it is infeasible to combine the two pumping stations into one.

If the shortest course from each pumping station to the sewers to reach the wastewater treatment plant by gravity is selected, the force main's distance from these two pumping stations is roughly 850 m and 450 m respectively.

There are alternatives, however, by which the two force mains can be combined together or the force main from the coastal area's pumping station can be connected to the nearest sewer flowing down to another pumping station. This is to minimize related costs. A comparative study of the alternatives stated above has been carried out and is summarized below.

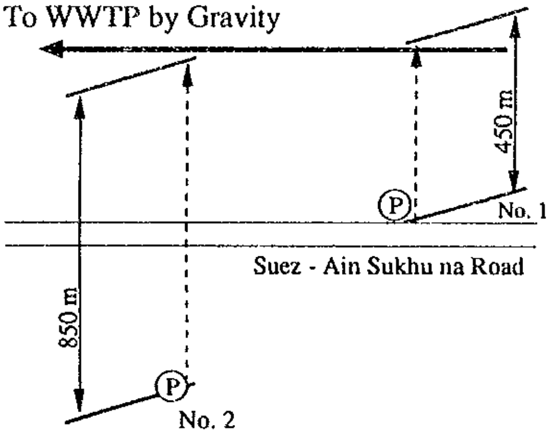
Table 8.2.5 Comparative Study of Alternatives

(Unit: Million LE)

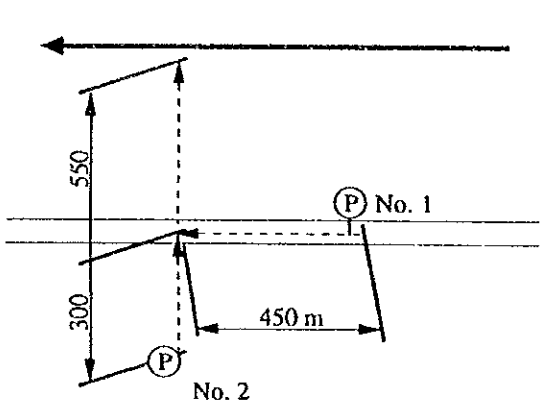
Content			Case-1	Case-2	Case-3	Remarks
Cost	Construction	Pumping station	21.0	21.0	25.0	
		Force main	1.0	1.3	0.9	
		Subtotal	22.0	22.3	25.9	
	Operation		0.3	0.3	0.4	
	Total		22.3	22.6	26.3	
Appraisal			orthodox, simple and least trouble	combined force man is undesirable	too costly than others	

It is concluded form the study mentioned above that Case-1 should be adopted.

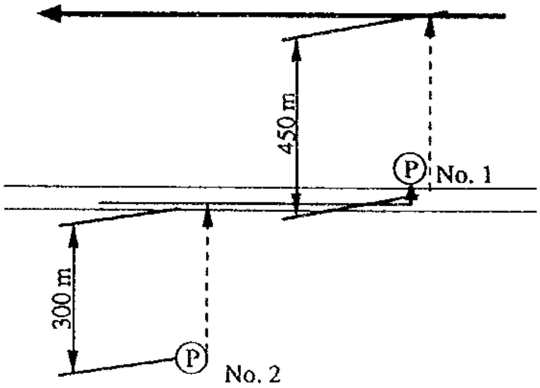
CASE - 1



CASE - 2



CASE - 3



Legend

◄——	: Gravity Sewer
◄- - - -	: Force Main
(P)	: Relay Pumping Station
No. 1	: No. 1 Relay Pumping Station
No. 2	: No. 2 Relay Pumping Station

Figure - 8.2.1 Alternatives to be Compared

[Appendix 3.8-2-5]

COMPARISON TABLE OF MAIN PUMPS FOR SEWER RELAY PUMPING STATION

ITEM / TYPE	(1) Horizontal shaft type pump	(2) Vertical shaft type pump	(3) Submersible pump
1. Installation method	Pump & motor are installed on the floor.	In case of single floor, pump casing is installed underwater and the motor is installed on the floor.	Pump & motor are installed underwater.
2. Installation space	Large	Smaller than (1)	Small
3. Suction Capability	Cavitation is apt to break out because the impeller is located above water level.	Cavitation is seldom to break out because the impeller is located underwater.	Same as (2).
4. Priming	Required.	Not required.	Not required.
5. Motor start method	Slightly complicated.	Comparatively easy.	Comparatively easy.
6. Inner inspection	Easiest because pump is installed on the floor.	It is necessary for inspection to lift up pump and motor.	Same as (2). But it is comparatively easy to inspect by the installation & removal device. The pump unit can be raised to ground level for maintenance and inspection by chain and can be simply replaced by lowering with the chain. The pump discharge and syphon are jointed automatically.

7. Ceiling height	Lowest	Higher than (3)	Low
8. Durability against corrosion	Major portions are located above water level and seldom corrode.	Major portions are located under water and are apt to corrode.	The pump unit is located under water and is apt to corrode.
9. Safety measure	The measure of (3) is not required.	Same as (1).	Counter measure for an electric shock is required.
10. Maintenance	Replacing the bearings and inspecting the parts of gland.	Same as (1).	Replacing the mechanical seal. Exchange the oil and the bearing checking the insulation resistance (once a month).
11. Equipment cost	(3) < (1) < (2)	Most expensive	Cheapest

Appendix 3.8-3

[Appendix 3.8-3] Caluculations

[Appendix 3.8-3-1] Capacity of the Equipment of Wastewater Treatment Plant

CONTENTS

1. Basic Design Condition

1.1 Wastewater Characteristics

(1) Wastewater Quantities

Average Daily = 46,500 m^3/d (D ave Q)
Maximum Daily = 55,800 m^3/d (D max Q)
Peak Houry = 3,875 m^3/hr (H max Q)

(Notes)
Maximum Daily = Average Daily x 1.2
Peak Houry = Average Daily x 2.0 x 1/24

(2) Wastewater Qualities

PH (IN) = 6 to 10
BOD (IN) = 330 mg/l
COD (IN) = 280 mg/l
SS (IN) = 380 mg/l

(3) Treated Wastewataer Qualities

PH (OUT) = 7 (6 to 9)
BOD (OUT) = less than 20 mg/l
SS (OUT) = less than 30 mg/l (50 mg/l : Criteria)
OIL (Mineral) = less than 5 mg/l
OIL (Animal and Vegetable) = less than 30 mg/l
Coliforms = less than 3,000 MPN/100 ml

1.2 Quantity and Quality of Industrial Wastewater from Each Industries

Industry	Quantity (Avg. Daily)	Quality						
		PH	BOD		COD*		SS	
	m³/day	-	mg/l	kg/day	mg/l	kg/day	mg/l	kg/day
1. Ataqa I.E. and Adabiya I.F.Z								
1) Food	2,400	6 to 10	400	960	310	744	340	816
2) Wood Products	2,400	6 to 10	100	240	280	672	120	288
3) Plastic	1,890	6 to 10	390	738	340	643	90	171
4) Paper Products	2,140	6 to 10	400	856	200	428	390	835
5) Spinning & Waving	5,310	6 to 10	400	2,124	260	1,381	230	1,222
6) Electrical	4,370	6 to 10	240	1,049	170	743	500	2,185
7) Mechanical & Metal ind.	1,630	6 to 10	280	457	280	457	300	489
8) Building Materials	5,060	6 to 10	270	1,367	50	253	500	2,530
9) Chemicals & Pharmaceutio	3,000	6 to 10	400	1,200	400	1,200	500	1,500
10) Others	6,420	6 to 10	400	2,568	480	3,082	500	3,210
Sub-Total	34,620	6 to 10	334	11,559	278	9,603	383	13,246
2. Ataqa I.E. Expansion Area	10,280	6 to 10	334	3,434	278	2,858	383	3,938
3. Ataqa Port	1,400	6 to 10	200	280	180	252	250	350
4. Commercial & Public Use	200	6 to 10	200	40	180	36	250	50
Total	46,500	6 to 10	330	15,313	280	12,749	380	17,584

1.3 System of the Treatment

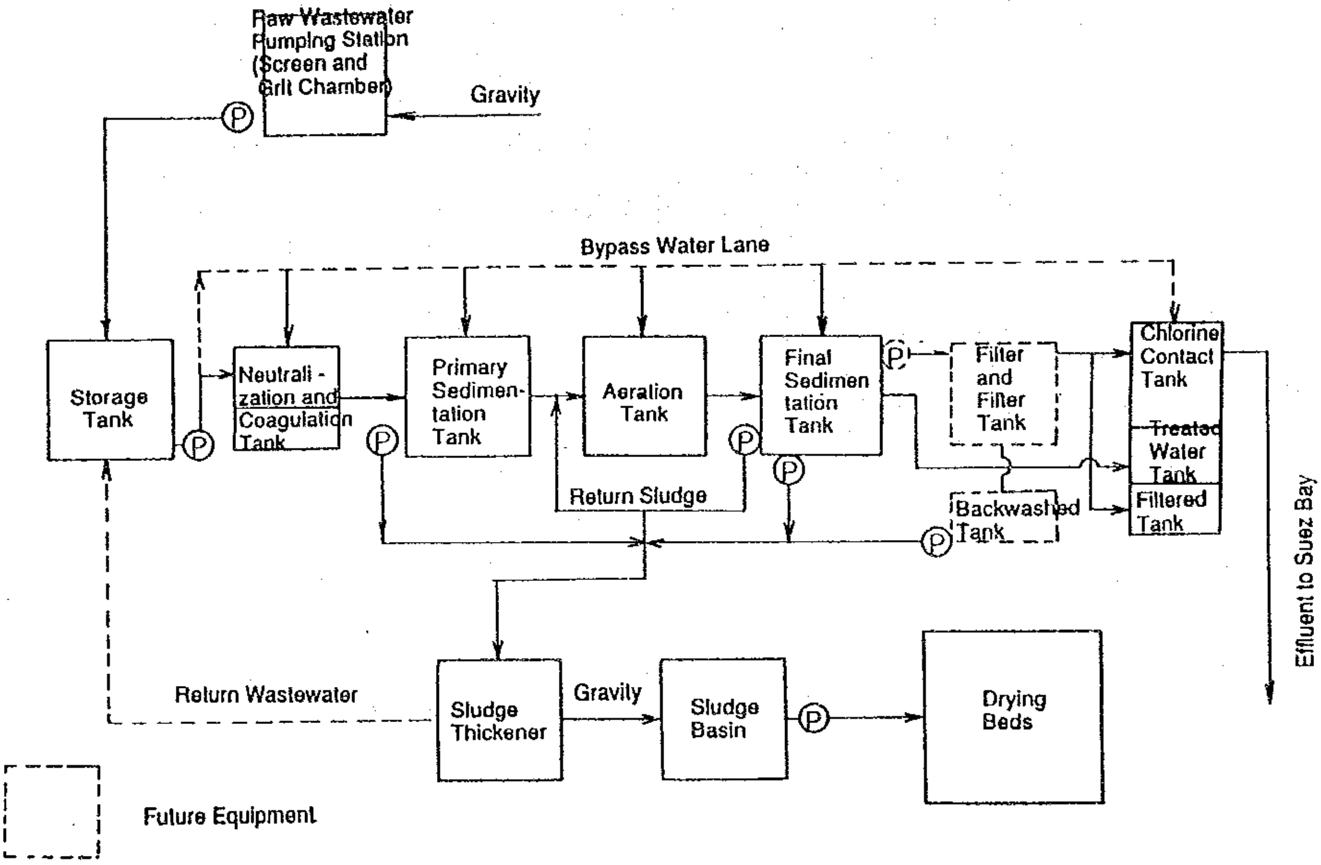
Coaguration Sedimentation and Standard Activated Sludge Method.

1.4 Remove Ratio

	Qualities (mg/l)		Removal (%)			Note
	Waste-water	Treated Waste-water	P.S.T.	A.T. and F.S.T	Synthe-sis	
B.O.D	330	20	30.0	91.4	94.0	
SS	380	30	40.0	86.8	92.2	

* P.S.T. = Primary Sedimentation Tank
A.T. = Aearation Tank
F.S.T. = Final Sedimentation Tank

2. Flow Sheet of Wastewater Treatment Processes



Flow Sheet (Industrial Wastewater Treatment Processes)

3. Design Criteria

3.1 Sewer System

Design Flow : Peak Hourly Flow (H max Q)
Q max /Q ave : 2.0
Values of "N" : VC : 0.012 (Vitrified Clay Pipe)
RC : 0.013 (Reinforced Concrete Pipe)
Minimum Diameter : f 175 mm
Minimum Cover : 1.0 m
Minimum Velocity : 0.6m/S

3.2 Wastewater Treatment Processes

(1) Primary Sedimentation Tank

Over Flow Rate = less than 35 m^3/m^2 day at D max Q
Retention Time = 2,0 - 4.0 hour at D max Q

(2) Aeration Tank

BOD - SS Load = 0.2 - 0.5 kg/kg . ss. day at D mas Q
MLSS = 1,000 - 3,000 mg/l
Aeration Time = more than 6.0 hour (based on design flow)

(3) Final Sedimentation Tank

Over Flow Rate = less than 25 m^3/m^2. day at D max Q
Retention Time = 1.8 - 3.0 hour at D max Q

(4) Filter : Future Equipment

Line Velocity = less than 230m/day at D max Q
Bed Depth = 0.6 - 1.0 m
Kind of Media = Anthrasite and Sand

(5) Chlorination Equipment

Chlorine Contact Time = 30 minite at D ave Q
Dosage = 6.0 mg/l at Tertiary Filtration Effluent

(6) Sludge Thickener

Solid Loading = 25 - 29 kg/m^2.day
Hydraulic Loding = 16 - 32 m^3/m^2.day

(7) Sludge Drying Beds

Retention Time = 5.0 to 7.0 days
Width = 6.0 to 8.0 m
Length = 30.0 to 45.0 m

(8) Stand-by of pumps

40% of Actual Load

4. Number of Treatment Equipment Line

Four (4) Line
Therefore, wastewater per line that have to treatment (Q) is as follow.

D ave Q (Average Daily) = 46,500 x 1/4 = 11, 625 m^3/day
D max Q (maximum Daily) = 55,800 x 1/4 = 13,950 m^3/day
H max Q (Peak Houry) = 3,875 x 24 x 1/4 = 23,250 m^3/day

5. Calculation of Basic Capacity of the Equipment

5.1 Main Equipment

(1) Screen (Fine)

H max Q = 3,875m3/hour
Minimam Flow Velocity : 0.6m/sec
Need Screen Sectional Area :
3,875/(0.6 x 60 x 60) = 1.80 m2
Screen Max Water Level = 1.2 m
Screen Bar Thickness = 5mm (Bar Quantity= 2,000mm/20mm=100pcs)
Screen Wide = 2,000 mm (100 pcs x 5 mm = 500 mm)
Make Good Use of Wide :
2,000 - 500 = 1,500 mm
1.2 m^h x 1.5 m^w = 1.80 m^2 -------- O.K.
Specification :
Type : Manual Bar Screen
Wide and Pich : 2,000mm(Wide), 20mm(Pich), 5mm(Thickness)
Setting Angle : 60°

(2) Grit Chamber

H max Q = 93,000 m^3/day
Over Flow Rate : less than 1,800 m^3 / m^2 . day at H max Q
Surface Area :
SA = 93,000 / 1,800 = 52.0 m^2
Mesurement :
3.6 m^W x 15.0 m^L x 1 pcs
Over Flow Rate (Actual) :
OFR = 93,000 / (3.6 x 15.0 x 1) = 1,722 m^3 / m^2 . day -------- O.K.

(3) Storage Tank

D max Q = 55,800 m^3/day

Retention Time : RT = 6.0 hour

Capacity :

V_1 = 55,800 x 6/24 = 13,950 m^3

V_2 = 3,488 m^3/each x 4 pcs

Depth : H = 3.5 m

Surface Area :

SA = 3,488/3.5 = 997 m^2/each

Measurement :

10.0 m^W x 50.0 m^L x 3.5 m^H x 8 set

Capacity (Actual) :

V_1 = 10.0 x 50.0 x 3.5 = 1,750 m^3/each ----- OK

V_2 = 1,750 x 8 = 14,000 m^3 ----- OK

Retention Time (Actual) :

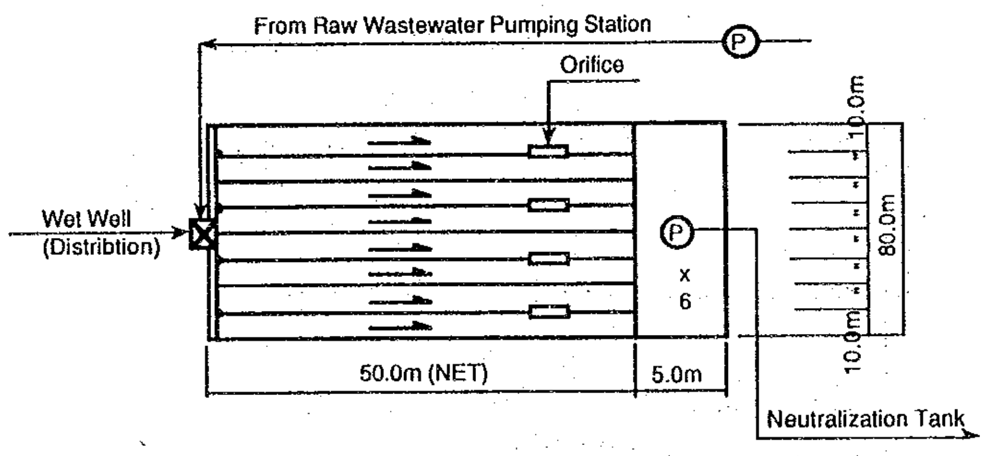
RT = 14,000/55,800 x 24 = 6.02 hour ----- OK

Peripheral Equipment :

Raw Pump :

q = 13,950/(24 x 60) = 9.69 m^3/min. each

10.0 m^3/min x 6(2) PCS



(4) Neutralization Tank

D max Q = 55,800 m^3/day

Retention Time : RT = 20 min

Capacity :

V_1 = 55,800 x 20/(24 x 60) = 775 m^3
V_2 = 194 m^3/each x 4 pcs

Depth : H = 4.0 m

Surface Area :

SA = 194/4.0 = 49 m^2/each

Measurement :

7.0 m^W x 4.0 m^H x 4 pcs

Capacity (Actual) :

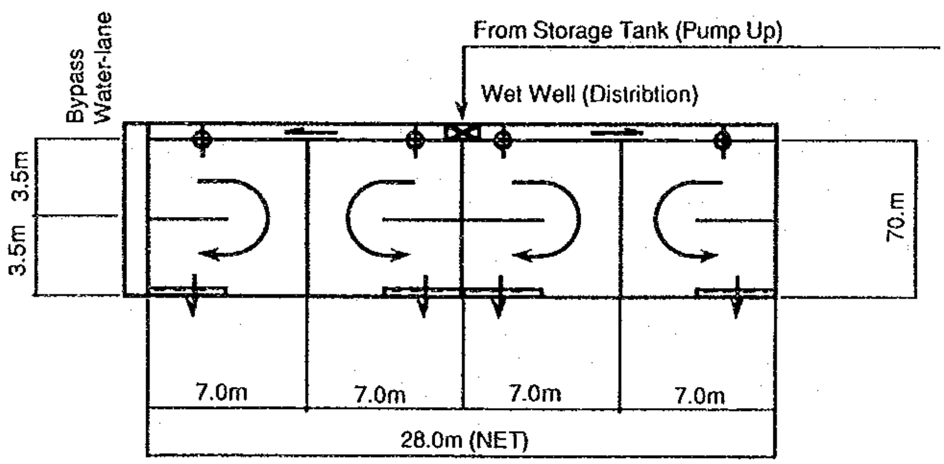
V_1 = 7.0^2 x 4.0 = 196 m^3/each ----- OK
V_2 = 196 x 4 = 784 m^3 ----- OK

Retention Time (Actual) :

RT = 784/55,800 x 24 x 60 = 20.2 min ----- OK

Air Quantity for Mixing

q = $(7.0)^2$ x 1.0 m^3/m^2.hr x 1/60
= 0.82 m^3/min.each ------ 1.0 m^3/min.each
1.0 m^3/min x 6(2) PCS



(5) Coagulation Tank

D max Q = 55,800 m^{3}/day

Retention Time : RT = 20 min

Capacity :

V_1 = 55,800 x 20/(24 x 60) = 775 m^3

V_2 = 194 m^3/each x 4 pcs

Depth : H = 4.0 m

Surface Area :

SA = 194/4.0 = 49 m^2/each

Measurement :

7.0 m^W x 4.0 m^H x 4 pcs

Capacity (Actual) :

$V_1 = 7.0^2$ x 4.0 = 196 m^3/each ----- OK

V_2 = 196 x 4 = 784 m^3 ----- OK

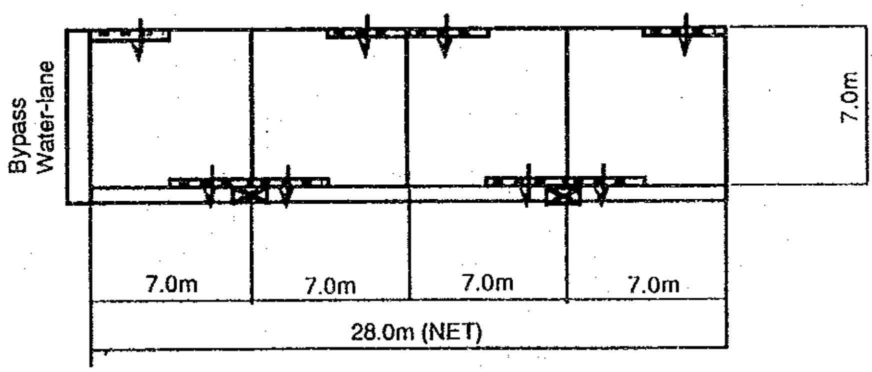
Retention Time (Actual) :

RT = 784/55,800 x 24 x 60 = 20.2 min ----- OK

Mixer :

Type : Double Paddle x 4 pcs

Material : Stenless Steel



(6) Primary Sedimentation Tank

D max Q = 55,800 m^3/day, H max Q = 93,000 m^3/day

Over Flow Rate :

OFR_1 = less than 35 m^3/m^2 day at D max Q

Retention Time :

RT = 2.0 - 4.0 hour at D max Q

Surface Area :

SA_1 = 55,800/35 = 1,595 m^2 = 399 m^2/each

Capacity :

V = 55,800 x 2.0/24 = 4,650 m^3 = 1,163 m^3/each

Depth :

H = 1,163/399 = 2.91 3.0 m

Measurement :

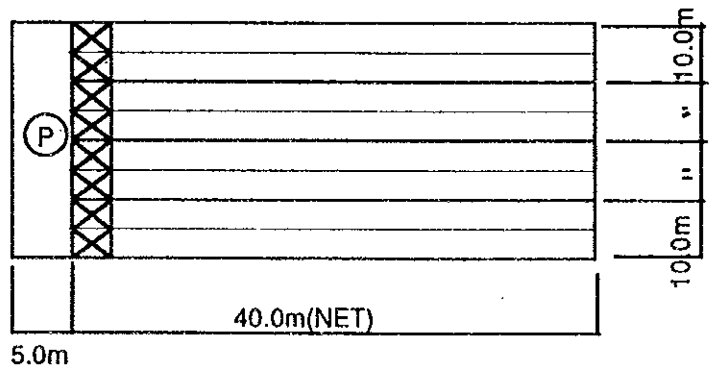
10.0 m^W x 40.0 m^L x 3.0 m^H x 4 pcs

Over Flow Rate (Actual) :

OFR_1 = 55,800/(10.0 x 40.0 x 4) = 34.9 m^3/m^2 day
----- OK

Retention Time (Actual) :

RT = (10.0 x 40.0 x 3.0 x 4) / 55,800 x 24 = 2.06 hr
----- OK



Sludge Generation :

Sludge Generation Ratio : as 40.0 %

SS Concentrate of Sludge : as 2.0^{wt} %

Removal SS = $55,800 \times 380 \times 0.40 \times 10^{-3}$
= 8,481.6 kg - ss/day
= 2,120.4 kg - ss/day. each x 4 line

Sludge Volume :
SV = $8,481.6/0.02 \times 10^{-3}$
= 424.08 m^3/day
= 106.02 m3/day.each x 4 line

Peripheral Equipment :

Rake : Chain Flight Double Rink Type
(5.0 $m^w \times 2^{set}$) x 4 line

Scum Skimer : 4 pcs

Sludge Pump :
q = 424.08/(12 x 60) x 1/4 = 0.147 m^3/min.each
0.20 m^3/min x 6(2) pcs

(7) Aeration Tank

D max Q = 55,800 m^3/day

BOD - SS Load = 0.2 - 0.5 kg/kg.ss.day at D max Q

MLSS = 1,000 - 3,000 mg/l

Aeration Time = more than 6.0 hour

Influent Quality :

BOD (IN) = 55,800 x 330 x (1 - 0.30) x 10^{-3}
= 12,889.8 kg - BOD/day

BOD (mg/l) = 12,889.8/55,800 x 10^3
= 231 mg/l

SS (IN) = 55,800 x 380 x (1 - 0.40) x 10^{-3}
= 12,722.4 kg - ss/day

SS (mg/l) = 12,722.4/55,800 x 10^3
= 228 mg/l

Capacity :

V_1 = 55,800 x 6.0/24 = 13,950 m^3
V_2 = 12,889.8/(0.30 c 2,000) x 10^{-3} = 21,482 m^3
= 21,483 m^3
= 5,371 m^3/each x 4 pcs

Depth : H = 5.0 m

Measurement :

15.0 m^W x 72.0 m^L x 5.0 m^H x 4 pcs

Surface Area (Actual) :

SA = 15.0 x 72.0 x 4
= 4,320 m^2
= 1,080 m^2/each x 4 pcs

Capacity (Actural) :

V = 15.0 x 72.0 x 5.0 x 4
= 21,600 m^3
= 5,400 m^3/each x 4 pcs

BOD - SS Load (Actual) :

L (BOD - SS) = 12,889.8/(21,600 x 2,000/10^3)
= 0.298 kg - BOD/kg - ss. day ----- OK

Aeration Time (Actual) :

Ta = 21,600/(55,800/24) = 9.29 hour ----- OK

BOD Volume Load (Actual)

L (BOD.V) = 12,889.8/21,600 = 0.579 kg/m^3.day
----- OK (= 0.600 kg/m^3.day)

Return Sludge Volume :

Return Sludge Rate :

Rr = (MLSS - SS[IN])/(Cr - MLSS) x 10^2
Cr : Return Sludge Generation Ratio
(= 8,000 mg/l)

Therefore

Rr = (2,000 - 228)/(8,000 - 2,000) x 10^2
= 29.53 % (Maximum = 100 %)

RSV = D max Q x Rr/10^2
= 55,800 x 29.53/10^2
= 16,477.74 m^3/day
= 11.44 m^3/min

Aeration Time of Influent Sludge (Actral) :

SA = V(AT) x MLSS/10^3/SS(IN)
= 21,600 x 2,000/10^3/12,722.4
= 3.40 day ----- OK (2.0 < SA < 4.0 day)

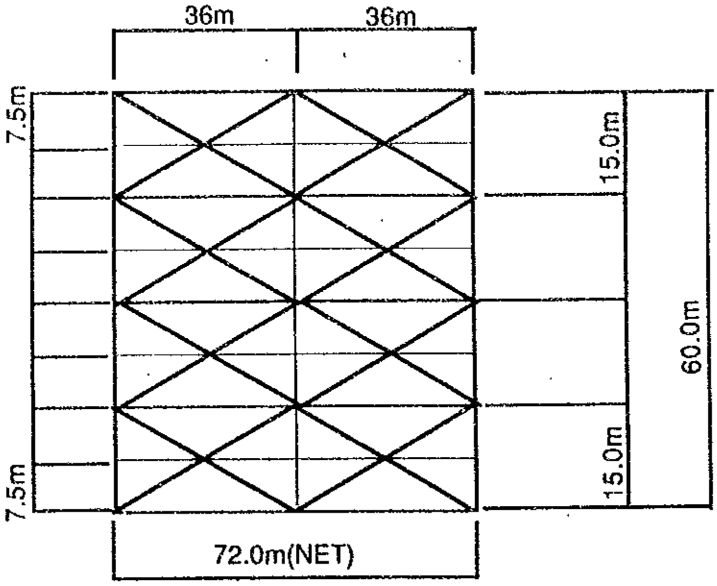
Sludge Retention Time (Actual) :

SRT = [V(A.T) x MLSS + V(F.S.T) x MLSS]
/ (Qw x Cr + D max Q x SSo)

Where

* V(A.T) = Aeration Tank Capacity = 21,600 m^3
* V(F.S.T.) = Final Sedimentation Tank Capacity
= 6,975 m^3
* Qw = Sludge Volume at Final Sedimentation Tank
= 1,380.38 m^3/day
* Cr = Return Sludge Generation Ratio
= 8,000 mg/l
* SSo = Treated Wastewater Qualities
= 30 mg/l

SRT = (21,600 x 2,000 + 6,975 x 2,000) /
(1,380.38 x 8,000 + 55,800 x 30)
= 4.50 day



Aeration :

Need Oxigen = D max Q x BOD(IN) x (1 - R(P)) x R(F) x 10^{-3} x 35 m^3/kg - BOD

Where,

* R(p) : Removal at Primary Sedimentation Tank = 30.0 %

* R(f) : Removal at Aeration Tank + Final Sedimentation Tank = 91.4 %

O(w) = 55,800 x 330 x (1 - 0.30) x 0.914 x 10-3 x 35
= 412,345 m3/day
= 286.35 m3/min

Blower :

q = 286.35/4 = 71.59 m3/min.each

(8) Final Sedimentation Tank

D max Q = 55,800 m^3/day

Over Flow Rate = less than 25 (20) m^3/m^2 day at D max Q
Retention Time = 1.8 - 3.0 hour at D max Q

Surface Area :
SA = 55,800/20 = 2,790 m^2 = 698 m^2/each

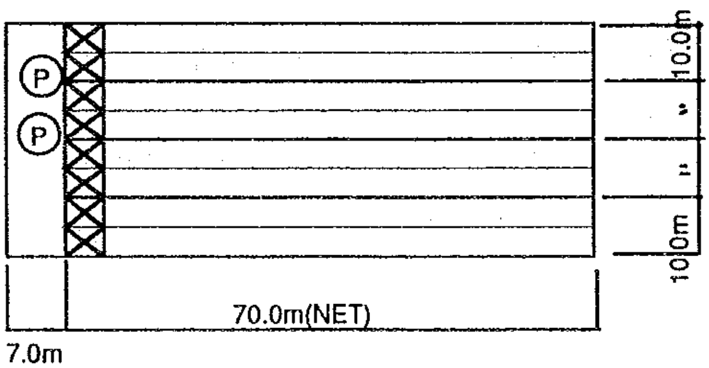
Capacity :
V = 55,800 x 3.0/24 = 6,975 m^3 = 1,744 m^3/each

Depth :
H = 1,744/698 = 2.50 m

Measurement :
5.0 m^W x 70.0 m^L x 2.5 m^H x 8 set (4 pcs)

Over Flow Rate (Actual) :
OFR = 55,800/(10.0 x 70.0 x 4) = 19.9 m^3/m^2.day
----- OK

Retention Time (Actual) :
RT = (10.0 x 70.0 x 2.5 x 4) / 55,800 x 24 = 3.01 hour
----- OK



Return Sludge to Aeration Tank

Maximum Return Sludge Ratio = 100 %
q = 55,800 x 100 = 55,800 m^3/day
= 13,950 m^3/day. each x 4 pcs
= 9.69 m^3/min. each x 4 pcs

Sludge Generation :

Sludge Generation Ratio :
as 40.0 % (Primary Sedimentation Tank)
as 86.8 % (Aearation Tank + Final Sedimentation Tank)

SS Consentrate of Sludge : as 0.8^{wt} %
Removal SS = 55,800 x 380 x (1 - 0.40) x 0.868 x 10^{-3}
= 11,043.0 kg - SS/day
= 2,761 kg - SS/day. each x 4 line

Sludge Volume :
SV = 11,043.0/0.008 x 10^{-3}
= 1380.38 m^3/day
= 345.10 m^3/day. each x 4 line

Peripheral Equipment :

Rake : Chain Flight Double Rink Type,
($5.0\ m^W \times 2\ ^{set}$) x 4 line

Sum Skimer : 4 set

Return Sludge Pump : 4.90 m^3/min x 6(2) pcs

Sludge Pump :
q = 345.10/(12 x 60) x 1/4 = 0.120 m^3/min. each
Therefore
0.50 m3/min x 6 (2) pcs

(9) Chlorine Contact Tank

D ave Q = 46,500 m^3/day

Chlorine Contact Time = 30 minite at D ave Q

Capacity :

$V = 46,500 \times 30 / (24 \times 60) = 967\ m^3$

$V = 967.0\ m^3 = 121\ m^3$/each x 8 pcs

Measure :

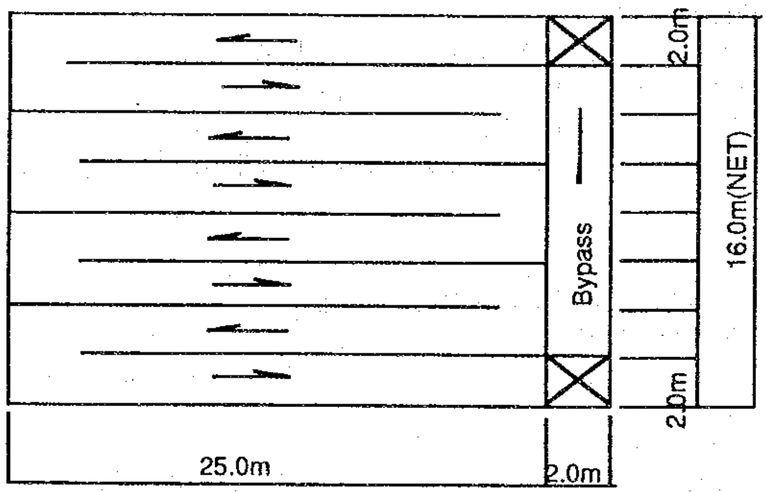
$2.0\ m^W \times 25.0\ m^L \times 2.5\ m^H \times 8$ pcs

Capacity :

$V = 2.0 \times 25.0 \times 2.5 \times 8 = 1,000\ m^3$

Chlorine Contact Time :

CT = 1,000/46,000 x 24 x 60 = 31.0 minute ----- OK



(10) Treated Water Tank

D max Q = 55,800 m^3/day

Retention Time :
RT = 5 minute at D max Q

Capacity :
V = 55,800 x 5/(24 x 60)
= 193.8 --- 200 m^3
V = 100 m^3/each x 2 set

Measurement :
5.0 m^W x 8.0 m^L x 2.5 m^H x 2 set

Retention Time (Actual) :
RT = [(5.0 x 8.0 x 2.5 x 2) / 55,800] x 24 x 60
= 5.2 minute ----- OK

(11) Filtened Tank

Surface Washing :
Surface Washing Velocity = 0.3 m^3/m^2. min
Sruface Washing Time = 5.0 minute
Surface Washing :
q_1 = 0.3 x 36 m^2/each x 5.0 = 54 m^3/day . set

Back Washing :
LV = 0.7 m^3/m^2.min
Back Washing Time = 10.0 minute
Back Washing :
q2 = 0.7 x 36 m^2/each x 10.0 = 252 m^3/day.set

Total Washing Water :
q = (q_1 + q_2) x 8 set = (54 + 252) x 8 = 2,448 m^3/day

Capacity :
V = q1 + q2 = 54 + 252 = 306 m^3

Measurement :
8.0 m^W x 16.0 m^L x 2.5 m^H x 1 set

(12) Filter Tank (Future Equipment)

Influent Flow : D max Q

D max Q = 55,800 - 1,380,38 = 54,419.6 m^3/day

Influent Quality :

ΔS = 55,800 x 380 x 10^{-3} x (1 - 0.922)

= 1,653.9 kg-ss/day

SS = 1,653.9/54,419.6 x 10^3 = 30.4 mg/l

Retention Time :

RT = 10.0 minute at D max Q

Capacity :

V = 54,419.6 x 10.0/(24 x 60)

= 378 m^3

= 95 m^3/each x 4 pcs

Measurement :

4.0 m^W x 10.0 m^L x 2.5 m^H x 4 pcs

Capacity (Actual) :

V = 4.0 x 10.0 x 2.5 x 4 = 400 m^3

Retention Time (Actual) :

RT = (400/54,419.6) x 24 x 60 = 10.6 minute

----- OK

Filter Pump :

q = 54,419.6/(24 x 60) x 1.05

= 39.7 m^3/minute

= 10.0 m^3/minute, each x 6(2) pcs

(13) Filter (Future Equipment)

Live Velocity :

LV = 200 m/day (Max : 300 m/day)

Filterd Area :

S = 54,419.6 x 1.05/200

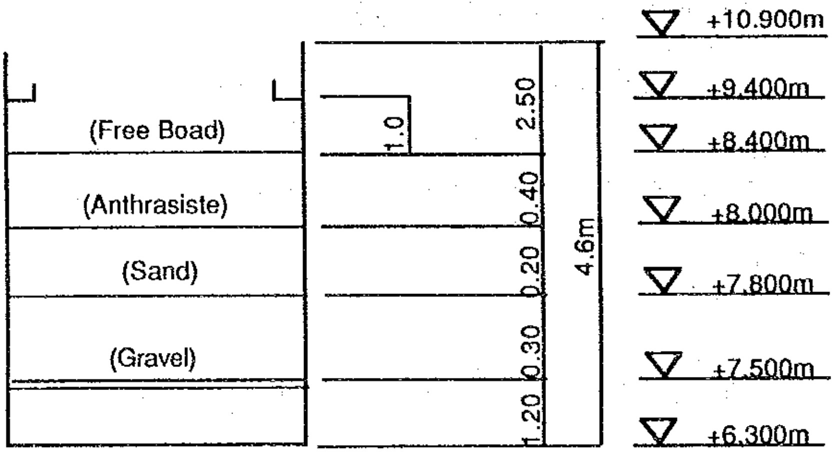
= 286 m^2

= 36 m^2/each x 8 set

Measurement and Number :

6.0 m^W x 6.0 m^L x 4.6 m^H x 8 set

Filter Unit : (m)



Time of Back Washing : 1 time/day

Anthrasite Volume :

$$AV = \frac{1,653.9 \text{ kg - ss/day}}{15 \text{ kg - ss/m3. Anthrasite}} \times 1/8 = 13.8 \text{ m}^3$$

Depth of Anthrasite :

13.8/36 = 0.4 m

Depth of Sand :

0.4 x 0.60 = 0.24 0.2 m (less than 60%)

* Depth (Anthrasite + Sand) = 0.6 - 1.0 m

Q'ty of Washing Water :

(a) Surface washing

Surface Washing Velocity = 0.3 $m^3/m^2 \cdot$ minute

Surface Washing Time = 5.0 minute

q_1 = 0.3 x 36 m^2/each x 5.0 = 54 m^3/day. set

(b) Back Washing

LV = 0.7 m^3/m^2. minute

Back Washing Time = 10.0 minute

q_2 = 0.7 x 36 m^2 / each x 10.0

= 252 m^3/day.set

(c) Total Washing Water

$q = (q_1 + q_2) \times q^{set}$

$= (54 + 252) \times 8$

$= 2{,}448\ m^3/day$

Wastewater Quality of Back Washing Water :

SS : Suspended Solid

$$SS = \frac{54{,}419 \times (30.4 - 10.0) + 2{,}448 \times 10.0}{2{,}448} = 463.5\ mg/l$$

(14) Backmashed Tank (Future Equipment)

Capacity :

$V = q^1 + q^2 = 54 + 252 - 306\ m^3$

Measurement :

$8.0\ m^W \times 16.0\ m^L \times 2.5\ m^H \times 1^{set}$ $(V = 320\ m^3)$

Transfer Pump

$q = (306\ m^3/cycle) / (2.0\ hr/cycle \times 60)$

$= 2.55 \quad 3.0\ m^3/minute$

$3.0\ m^3/minute \times 2(1)$ pcs

Air Quantity for Mixing :

$q = (8.0 \times 16.0) \times 1.0\ m^3/m^2\ hr \times 1/60$

$= 2.2\ m^3 / minute$

5.2 Sludge Treatment Facility

(1) Influent Flow and Quality

Sources of Sludge Generation	Quantity	SS	
	(m^3/day)	(mg/l)	(kg/day)
Primary Sedimentation Tank	424.08	20,000	8,481.6
Final Sedimentation Tank	1,380.38	8,000	11,043.0
Backwashed Water of Filter	(2,720.00)	(942.6)	(2,564.0)
Separate Water and Washed Water	-	-	-
Total	4,524.46	4,882	22,088.6

(2) Sludge Thickener

Solid Loading = 25 - 59 kg/m^2. day
Hydraulic Loading = 16 - 32 m^3/m^2. day

Surface Area :
SA = 22,088.6/40 = 553 m^2

Measurement :

$$D = \frac{553 \times 1/2}{p/4} = 18.8 \quad 19.0 \text{ m} \varnothing$$

19.0 m Ø x 3.0 m^H x 2 pcs

Surface Area :
SA = (p x 19.0^2) / 4
= 283.5 m^2/each x 2 pcs
= 567 m^2

Capacity :
V = 567 x 3.0 = 1,701 m^3

Solid Loading (Actual) :
SL = 22,088.6/567 = 39.0 kg/m^2. day ----- OK

Hydraulic Loading (Actual) :
HL = 4,524.46/567 = 8 0 m^3/m^2. day ----- OK

Retention Time (Actual) :

RT = 1,701.4,524.46 x 24 = 9.0 hour

Concentration Sludge Volume :

Sludge Water Rate = 98.0 %

CSV = 22,088.6/(1 - 0.98) x 10^{-3}

= 1,104.43 m^3/day

= 0.77 m^3/min

Effluent Separate Water :

ESW = 4,524.46 - 1,104.43

= 3,420.03 m^3/day

Peripheval Equipment :

Rake : 2 set

Scum Box : 2set

(3) Sludge Basin

Concentration Sludge Volume = 1,104.43 m^3/day
= 0.77 m^3/min

Retention Time : RT = more than 12.0 hour

Capacity :
V = 1,104.43 x 12/24
= 552.2 m^3
= 280 m^3/each x 2 pcs

Measurement :
10.0 m^{ll} x 3.0 m^H x 2 pcs

Capacity (Actual) :
V = 10.0^2 x 3.0 x 2 = 600 m^3 ----- OK

Retention Time (Actual) :
RT = 600/1,104.43 x 24 = 13.0 hour ----- OK

Peripheral Equipment :
Diffuser :
Aeration q = 600 x 1.0 m^3/m^3· hour x 1/60
= 10.00 m^3/min
= 5.0 m^3/min. each x 2 pcs

Sludge Feed Pump :
q = 1,104.43 m^3/day x 1/(12.0 hour/day x 60) x 1/4 pcs
= 0.38 m^3/min 0.40 m^3/min
Therefore
0.40 m^3/min x 6(2) pcs

(4) Sludge Drying Beds

Sludge Volume :

SV = 1,104.43 m^3/day (Sludge Water Rate = 98.0 %)

Retention Time : RT = 5.0 to 7.0 days

Width = 6.0 to 8.0 m
Length = 30.0 to 45.0 m
Sludge Depth = 10.0 cm
Depth of the Sand = 15.0 to 30.0 cm
* Sand Size = 0.3 to 1.2 mm
Depth of the Gravel = at least 8.0 cm
= 20.0 - 30.0 cm
* Gravel Size = 3.0 - 6.0 mm

Suface Area :

SA = SV x RT/SD

Where SV : Sludge Volume (= 1,104.43 m^3/day)
RT : Retention Time (=7.0 day)
SD : Sludge Depth (= 0.10 m)

SA = 1,104.43 x 5.0/0.10
= 55,222 m^2

Measurement :

8.0 m^W x 45.0 m^L x 160 pcs

Suface Area (Actual) :

SA = 8.0 x 45.0 x 160 = 57,600 m^2

Retention Time (Actual) :

RT = 57,600 x 0.10/1,104.43 = 5.22 day ----- OK

5.3 Bypass Pipe

(1) Setting of Bypass Discharge

Setting is made so as to entirely bypass the influent higher than H max Q. Since there is an allowance of H = 6,500 - 1,220 (4,720) = 5,280 m (1,780 m) between HWL of the Bay of Suez and the ultimate level (Chlorine Flocculation Basin Weir Height) of the treatment facilities, there is no danger about back water, and if the effluent pipes are installed higher than back water level (+ 1,220 m) the effluent (treated water and bypass water) is always discharged into the Bay of Suez by gravity with no presence of standing water inside of the effluent pipe.

(2) Setting of Bypass Weir Height

Type of Weir : Lateral overflow weir (bypass weir)

GH = + 7.500 m

Water Level of Suez Bay :

HWL = + 0.763 m
LWL = - 0.737 m

Treated Water Discharge Pipe Loss Head :

Pipe Form : ϕ 1.350 mm x 1.2 o/oo x 1.000 m^L (H.P.)
Loss Head : Δ H (D ave Q) = 0.113 m
Δ H (D max Q) = 0.162 m
Δ H (H max Q) = 0.450 m
Δ H (RH max Q) =

Back Water Level :

D ave WL = + 0.763 + 0.113 + α = + 0.880 m (+ 4.380 m)
D max WL = + 0.763 + 0.162 + α = + 0.930 m (+ 4.430 m)
H max WL = + 0.763 + 0.450 + α = + 1.220 m (+ 4.720 m)
RH max WL =

Chlorine Contact Tank :

Outflow Wier Level = + 6.500 m

Bypass Pipe :

ϕ 1.350 mm x 1.2 o/oo (H. P.)
V full = 1.292 m/sec
Q full = 1.8489 m^3/sec

Water Level of Influent Pipe :

D ave Q/Q full = 0.538 / 1.8489 = 0.291 → 29.1
D max Q/Q full = 0.646 / 1.8489 = 0.349 → 34.9
H max Q/Q full = 1.076 / 1.8489 = 0.582 → 58.2

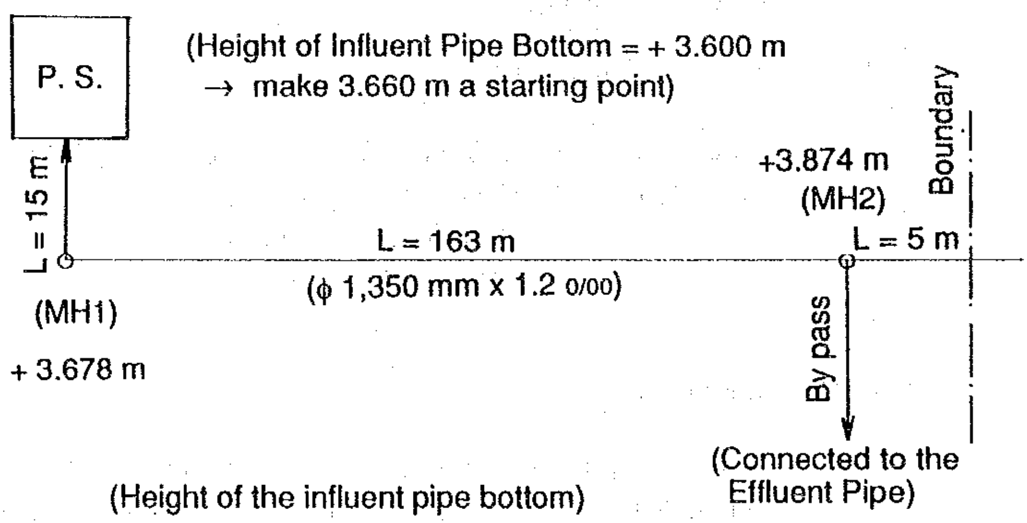
Hydraulic characteristic curve (Manning's Formula)

d / D (D ave Q) = 0.37
d / D (D max Q) = 0.41
d / D (H max Q) = 0.55

According by the water depth of the influent pipe are ;

d (D ave Q) = 1.350 x 0.37 = 0.500 m
d (D max Q) = 1.350 x 0.41 = 0.554 m
d (H max Q) = 1.350 x 0.55 = 0.743 m

Profil of Influent Pipe :



(Height of the influent pipe bottom)

$$(MH1) = +3.660 + 1.2 \times 15 \times 10^{-3} = +3.678 \text{ m}$$
$$(MH2) = +3.660 + 1.2 \times (15 + 163) \times 10^{-3} = +3.874 \text{ m}$$

Bypass Weir Height (Lateral Overflow Weir) :

Bypass Wier Level = + 3.874 + 0.743 + α = + 4.620 m

Installed at (MH2) Manhle.

Appendix 3.8-3

[Appendix 3.8-3] Caluculations

[Appendix 3.8-3-2] Capacity of the Machinery of Wastewater Treatment Plant

1. Basic Design Condition

1－1. Waste Water Characteristics

(1) Waste Water Quantities

Average [Daily] ＝46,500m³ /d (Q/d …ave)

Maximum [Daily] ＝55,800m³ /d (Q/d …max)

Peak [Hourly] ＝ 3,875m³ /h (Q/h …max)

(Note)

Maximum [Daily] ＝Average Daily ×1.2

Peak [Hourly] ＝Average Daily ×2.0 ×1/24

(2) Waste Water Quantity

pH (in) ＝6 to 10

BOD (in) ＝330 mg/l

COD (in) ＝280 mg/l

SS (in) ＝380 mg/l

(3) Treated Waste Water Quantity

pH (out)＝6 to 8

BOD (out)＝Less than 20 mg/l

SS (out)＝Less than 30 mg/l (50mg/l ; Criteria)

Oil (Mineral) ＝Less than 5mg/l

Oil(Animal and Vegetable) ＝Less than30mg/l

Coliforms ＝Less than 3,000MPN/100ml

1－2. Quantity and quality of industrial waste water from each industry

(See table-1)

1－3. System of the treatment

Coaguration Sedimentation and Standard Activated Sludge Method

Industry	Quantity (Avg. Daily)	Quality							
		PH	BOD		COD*		SS		
	m³/day	-	mg/l	kg/day	mg/l	kg/day	mg/l	kg/day
1. Ataqa I.E. and Adabiya I.F.Z								
1) Food	2,400	6 to 10	400	960	310	744	340	816
2) Wood Products	2,400	6 to 10	100	240	280	672	120	288
3) Plastic	1,890	6 to 10	390	738	340	643	90	171
4) Paper Products	2,140	6 to 10	400	856	200	428	390	835
5) Spinning & Waving	5,310	6 to 10	400	2,124	260	1,381	230	1,222
6) Electrical	4,370	6 to 10	240	1,049	170	743	500	2,185
7) Mechanical & Metal ind.	1,630	6 to 10	280	457	280	457	300	489
8) Building Materials	5,060	6 to 10	270	1,367	50	253	500	2,530
9) Chemicals & Pharmaceutio	3,000	6 to 10	400	1,200	400	1,200	500	1,500
10) Others	6,420	6 to 10	400	2,568	480	3,082	500	3,210
Sub-Total	34,620	6 to 10	334	11,559	278	9,603	383	13,246
2. Ataqa I.E. Expansion Area	10,280	6 to 10	334	3,434	278	2,858	383	3,938
3. Ataqa Port	1,400	6 to 10	200	280	180	252	250	350
4. Commercial & Public Use	200	6 to 10	200	40	180	36	250	50
Total	46,500	6 to 10	330	15,313	280	12,749	380	17,584

1－4. Removal Rate

	Qualities(mg/l)		removal(%)			Note
	Waste Water	Treated Waste Water	P.S.T.	A.T and F.S.T.	Synthesis	
BOD	330ppm	20ppm	30.0	91.4	94.0	
SS	380ppm	30ppm	40.0	86.8	92.2	

(Note) P.S.T.=Primary Sedimentation Tank
A.T. =Aeration Tank
F.S.T.=Final Sedimentation Tank

3, Design Criteria

3－1. Sewer System

Design Flow ; Hourly peak flow(maxQ/hr)
Qmax/Qave ; 2.0
Values of 「N」 ; VC＝0.012(Vitrified clay pipe)
RC＝0.013(Reinforced concrete pipe)
Minimum Diameter ; 175mmΦ
Minimum Cover ; 1.0m
Minimum Velocity ; 0.6m/sec

3－2. Waste Water treatment process

(1)Primary Sedimentation tank
Over flow rate=Less than 35m^3 /m^2 .day at DmaxQ
Retention time=2.0～4.0 hour at DmaxQ

(2)Aeration Tank
BOD － SS Load＝0.2 ～0.5kg/kg.ss.day at DmaxQ
MLSS ＝1,000 ～3,000mg/l
Aeration Time ＝more than 6.0 hour (based on design flow)

(3)Final Sedimentation Tank
Over Flow Rate＝Less than 25 m^3 /m^2 .day at Dmax
Retention time＝1.8 ～3.0 hour at DmaxQ

(4)Filter…………Future Equipment
Line Velocity ＝Less than 230m/day at Dmax
Bed Depth ＝0.6 ～1.0 m
Kind of Media ＝Anthracite and Sand

(5)Chlorination Equipment
Chlorine Contact Time ＝30 minutes at DaveQ
Dosage ＝6.0mg at Tertiary Filtration Effluent

(6)Sludge Thickner
Solid Loading =25～59kg/m² .day
Hydraulic Loading =16～32m3/m² .day

(7)Sludge Drying Beds
Retention Time=5.0 to 7.0 days
Wide =6.0 t0 8.0m
Length =30.0 t0 45.0

(8)Stand-by units of Pumps
40% of Actual Load

4. Number of treatment equipment line
Four(4) Line
Therefore ,Wastewater per line to be treated (Q) is as follow;
DaveQ (Average-Daily) =46,500m³ /d×1/4 =11,625m³ /day
DmaxQ (Maximum-Daily) =55,800m³ /d×1/4 =13,950m³ /day
HmaxQ (Peak -Hourly) = 3,875m³ /h×24×1/4 =23,250m³ /day

5. Calculation of basic capacity of the equipment

5－1.Main equipment
(1)Raw waste water pumping station……scope of civil work
Influent Quantity;46,500m³ /d(aveQ),55,800m³ /d(maxQ),3,875m³ /h(Peak Hour)
Pit Capacity ;10 ～15min(Peak hour) 3,875m³ /h÷60=64.59m³ /min
64.59m³ /minx10 ～15min=645.9 ～968.9m³ ⟶ 950m³
Pump station Dimention;(9.0mWx23.0mLx4.8mH)=993.6m³
a)Influent pipe B.O.P.;+3,600(GL-3,900) dia.1,300mm Φ
b)Pump outlet pipe;velocity=2.0m/sec Φ=146√64.6/2 =830mm ⟶1000mm Φ
c)Pump quantity ;6pcs(2pcs spare) 64.6/4=16.15m³ /min(each)
d)Pump outlet size;velocity=3.0m/sec Φ=146√16.15/3 =339mm ⟶400mm Φ
e)Pump head v(1000)=64.6m³ /(60 x 3.14/4 xD²) =1.37m/sec
v(400) =16.15m³ /(60 x 3.14/4 xD²)=2.14m/sec
Influent pump head;Actual head(H1)=(▽+9,120)+(▽-1,700)=10.82m
piping loss head(HL1)(400)=f1xL/Dx v² /2g

f1(400)=0.02+0.0005/D=0.0213　f2(1000)=0.02+0.0005/D=0.0205

H2(400) =0.0213x10.2m/0.4x(2.140) ² /19.6=0.127m

H3(1000)=0.0205x250.0m/1.0x(1.37) ² /19.6=0.491m

Elbow loss head H4(400) =1pcsx0.2x(2.14)² /19.6 =0.047m

H5(1000)=5pcsx0.2x(1.37) ² /19.6 =0.096m

Checkvalve loss H6(400)=1pcx1.8x(2.14)² /19.6 =0.421m

Tee loss H7(1000) =1pc x1.2 x(1.37)² /19.6 =0.115m

Total head H =H1+~+H7=10.82+0.127+0.491+0.047+0.096+0.421+0.115=12.117m

=13.0m

f)Power of moter PS=0.163 x (γ x Q x H)/ η)x α

PS	; Power of motor	kw
γ	;Gravity of gravity inlet water	1.0
Q	;Flow volume	16.15m³ /min
H	;Total head	13.0m
η	;Efficiency of pump	72 %
α	;Safety ratio	1.2

PS = 0.163 x (1.0 x 16.15 x 13.0)/0.75 x1.2= 54.8kw → 55.0kw

①[Sewerage Pump for raw waste water pumping station specification]

……(Facility NO.M-5)

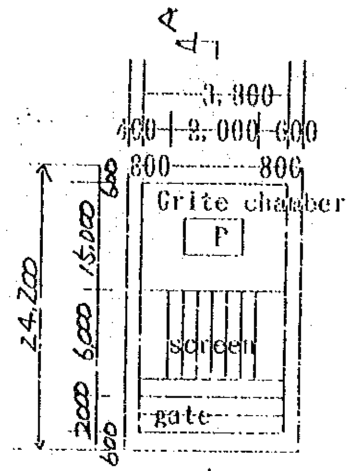
Type	;Submersible Waste Water Pump
Specification	;400Φx16.15m3/minx13.0mx55kw (380Vx50HZ)
Quantity	;6pcs(spare 2 pcs)
Accessory	;Cable20m/1 PCS,Chain;6m/1pcs(Stainless Steel), Guide pipe 1set/1pcs(Stainless Steel),Automatic connection 1Set/1pcs

②Chain hoist ; Hoist 2.8tonx6m hoist(2.4+0.2kw) 1 Set …(Facility NO.M-7)

Accessory ; Heip plain trtolley;2.8tonx6.0m 1 Set

(2)Screen

Influent Quantity	= 3,375m³ /h(Peak houry)
Minimum flow velocity	= 0.6m/sec
Required Screen Section Area	= 3,375m³ /h÷(0.6m/sx60x60) = 1.8m²
Screen Max Water Level	= 1.12m
Screen Bar Thickenes s	= 5mm (Bar Quantity 2,000mm ÷ 30mm=67pcs)
Screen Wide	= 2,000mm　67pc s x5mm=335mm
Effective Width	= 2,000mm-335mm=1,665mm　1.12mhx1.665mw=1.86m ²



③[Screen Specification]…(Facility NO.M-2)

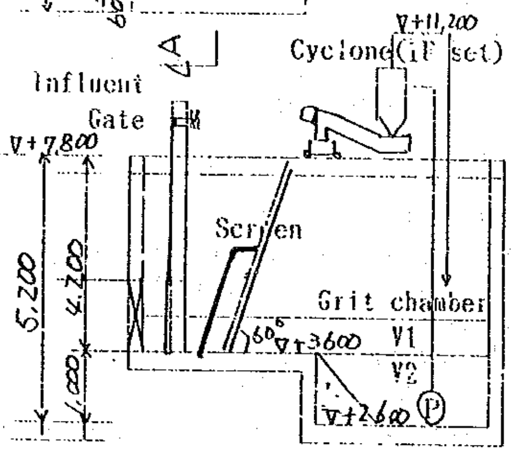
Type ; Manual operation type
Capacity ; 3,875m3/hour
Width ; Width 2,000mmx4,200mmH
Pitch and bar; 30mm, Bar Thickness=5mm
Water top level ; 1,000mm
Setting Angle ; 60 °
Material ; Stainless steel
Quantity ; 1 pc
Accessories ; Hand rake tool 1 unit

(3)Grit chamber(Hopper type)

Design Capacity; 60sec (at Hourly peak)
=3,875m3/h ÷(60sec/minx60min/h)
x60sec=64.6m3

Dimension; 3.8mWx15.0mLx1.0mH(hopper type)

Capacity
(V)={(3.8x15.0)X1.0}+0.5/6{(3.8x15.0)
+(15.0+10.0)(3.8+2.9)+(2.9x10.0)}
=78.1m3 > 64.6m³ OK



A-A Section

(4)Sand pump

a)Sand pump capacity q=0.5m3/min

b)Pump outlet size

Velocity=3.0m/sec
Φ=146√0.5/3=59.6mm ⟶ 80mm

c)Pump head

v(80)=0.5m3/(60x3.14/4xD²)
=1.656m/sec

Acutual pump head(H1)= (∇+11.200)-(∇+2.600)=8.6m

Pipe loss head (H2)80mm=f1xL/Dxv² /2g f1=0.02+0.0005/D=0.0263
H2(80) =0.0263 x30/0.08x(1.656)² /19.6=1.380m

Elbow loss head H3(80) =8pcs x0.2x (1.656)² /19.6 =0.224m

Cyclone loss head H4 =0.7kg/cm² =7.000m

Total head =H1 + H2 + H3=8.6+1.38+0.224+7.0=17.204m ⟶ 18m

d)Power of motor (PS)=0.163x(γ xQxH)/ η x1.2=0.163x(1.1x0.5x18)/0.50 x1.2
=3.88kw ——→ 5.5kw

④[Sand Pump] ……………………………………(Facility NO.M-3)

Type ;Submersible Sand Pump
Specification;80mmx0.5m3/minx18mx5.5kw (380V 50HZ)
Quantity ;2pcs(1 pcs Stand-By ……Werehouse)
Accessory ;Cable 20m/1pcs,Chain20m/1pcs(Stainless steel)

⑤ [Cyclone] ……………………………………(Facility NO.M-8)

Type ;Vertical Cyclone Type Capacity;40m ^{3} /hr
Specification;approx. 230mmdia.x1270mmh
Material ;Frame (Aluminum+Inside Rubber Lined) or equivalent.
Quantity ;1 pc

⑥[Grit washer] ……………………………………(Facility NO.M-4)

Type ;Screw conveyor type …with air bubbling nozzle 2pc
Specification;approx. 200 Φx5.0mLx1.5kw (380V 50HZ)
Quantity ;1 pc
Accessory ;Sand Container 0.3m ^{3} (0.7x0.8x0.6h stainless steel) 1pc

⑦[Inlet Gate]……………………………………(Facility NO.M-1)

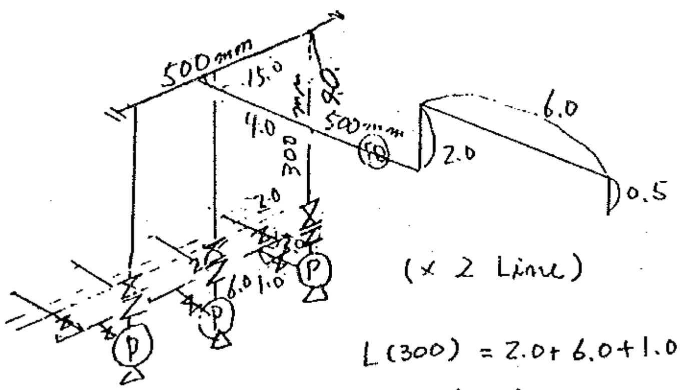
Type ;Power operated type
Dimension ;1,400x1,400 x 4.2mH x 1.5 kw(380V 50HZ)
Quantity ;1 pc

⑧[Chain hoist] ……………………………………(Facility NO.M-7)

Type ;Power operated type
Specification;2.8TON x 6m (380Vx2.4kw+0.2kw 50HZ)
Quantity ;1 pc

(4)Storage Tank

DmaxQ ＝55,800m3/day
Retention Time; RT=6.0 hour
Capacity ; V1=55,800m3/d x6/24 =13,950m3
V2=13,950m3 ÷4 line=3,488m3
Capacity(Actual)V1=10.0x50.0x3.5=1,750m3 /each 1 Line=2 tank
V2=1750m3 x 8tank=14,000m3 ＞13,950m3 OK
Retention time;(Actual)
RT=14,000m3÷(55,800m3/24hr) =6.02hour ＞6.0hr OK



(× 2 Line)

L(300) = 2.0+ 6.0+1.0+ 4.0 = 13.0m
L(500) = 15.0+ 4.0+ 2.0+ 0.5 = 27.5m

Raw Water Pump

a)Capacity ;55,800m3/d ÷4 line =13,950m3/d……1 line
13,950m3/d ÷24 hour=581.25m3/h=9.69m3/min 10.0m3/min

b)Pump outlet size;velocity=2.0 ～ 3.0m/sec
$\Phi 1=146\sqrt{10.0/2.0\sim 3.0}$=267mm ～ 326mm 300mm
pipe line(1 line 2pump);$\Phi 2=146\sqrt{20.0/2\sim 3}$=377mm ～ 462mm 500mm

c)Acutual pump Head ;(H1) =11.0m-5.0m=6.0m
Piping loss head(HL1)=f1xL/Dxv^2 /2g f1(300)=0.02+0.0005/D=0.0217
f1(500)=0.02+0.0005/D=0.021
v1(300)=10m3/(60x3.14/4 xD^2)=2.36 v2(500)=20m3/(60x3.14/4 xD^2)=1.70
HL1(300)=0.0217 x13/0.3 x $(2.36)^2$ /19.6=0.268m
HL1(500)=0.027 x27.5/0.5x$(1.70)^2$ /19.6=0.219m
Inlet loss head(HL2)=f x v^2 /2g=1pcx1.0x$(2.36)^2$ /19.8=0.282m f=1.0
Tee loss head(HL3)=f x v^2 /2g=2pcx1.2x$(2.36)^2$ /19.8=0.564m f=1.2
Check valve loss(HL4)=fx v^2 /2g=1pcx1.8x$(2.36)^2$ /19.8=0.507m f=1.8
Elbow loss head (HL5)=fx v^2 /2g=3pcx0.3x$(1.70)^2$ /19.8=0.132m f=0.3
Total head(H) =6.0+0.268+0.219+0.282+0.564+0.507+0.132=7.972m → 9.0m

d)Power of motor=0.163x(γ xQxH)/η x1.2
=0.163x(1.0x10x9)/0.65x1.2=27.1kw → 30.0kw

① [Specification of Raw water pump]…………(Facility NO.W-12)
Type ;Horizontal Sewage Pump (Slurry pump)
Specification ;300mmx10.0m3/minx9.0mx30kw (380v,50hz.6pole)
V-belt drive , Mechanical seal type
Quantity ; 6 pcs (2 pcs spare)

②[Inlet gate for storage tank] ……………(Facility NO.W-9)
Type ;Movable weir type
Specification ;1,000mmWx300ST
Quantity ;2 pcs

③[Mixing blower for storage tank]…………(Facility NO.W-50)
Mixing Air ;0.5m^3 /m^3 .hr
3,500m^3 x2 linex0.5m^3 /m^3 .hrx1/60=58.4m^3 /min
Specification ;Type;Roots Blower 250mmx59m^3 /minx 0.4kg/cm^2 x55kw
Quantity ;3 pcs (1 pc spare)

④[Separated gate for storage tank] …………(Facility NO.W-10)
Type ;Sluice gate type

Specification ;500mm x 500mm

Quantity ;4 pcs

⑤[Diffuser for storage tank] ······························(Facility NO.M-11)

Type ;Per-forated pipe

Quantity ;20set/1 tank (Total 160 pcs)

⑥[Floor drain pump for storage tank pump room] ······(Facility NO.M-13)

Type ;Submersible pump

Specification ;50mmx0.1m3/minx10mx0.75kw

Quantity ;2pcs (1pc spare)

⑦[Air flow meter for storage tank] ·····················(Facility NO.FI-1)

Type ;Oriffice type

Specification ;200mm Conection (600 ～2,800Nm ³ /H)

Quantity ;8 pcs

(5). Neutralization tank

DmaxQ =55,800m3/day

Retention Time;RT=20min

Capacity ;V1=55,800m3/d x20min/(24x60)=775m3

V2=775m3 ÷4 line=194m3

Capacity(Actual)V1=7.0x7.0x4.0=196m3/each ＞194m3 OK

V2=196m3x4=784m3 ＞775m3 OK

Retention time;(Actual)RT=784/(55,800 ÷24÷60)=20.2min ＞20min OK

Required air for Mixing

;q=7.0x7.0x1.0m3/m3.hrx1/60=0.82m3/min···1.0 m3/min···each

mixing air to be supplied from aeration blower

①[Distributor gate for neutralization tank]······(Facility NO.M-14)

Type ;Movable weir type

Specification ;1,000mmWx300ST FC20

Quantity ;2 pcs

②[Inlet gate for neutrarization tank]·············(Facility NO.M-15)

Type ;Sluice gate type

Specification ;500mm x500mm

Quantity ;4 pcs

③[Diffuser for neutrarization tank] ·············(Facility NO.M-16)

Type ;Disc Type

Quantity ;8 pcs/1 line(Total 32pcs)

④[pH Meter]………Scope of machinary section …(Facility NO,PH-1)

Type ;Soaking or type (Indicator and Control)

Quantity ;4 pcs

Accessory ;pH-holder 1pcs/1pcs,others 1set/1pcs

⑤[Buffer plate for neutrarization tank]…………(Facility NO,M-71)

Type ;Plate type

Specification ;1000mmx600mmx3000mmh

Material ;Stainless steel

Quantity ;4 pcs

⑥[Air flow meter for neutralization tank]………(Facility NO,F I -2)

Type ;Oriffice type (Flange sandwich type)

Specification ;50mm conection (Flow rate; 35～175Nm ³ /H)

Quantity ;4 pc

(6)Coagulation tank

DmaxQ =55,800m3/day

Retention time;RT=20min

Capacity ;V1=55,800m3/dx20min÷(24x60)=775m3

V2=775m3 ÷4=194m3/each

Capacity(Actual);V1=7.0x7.0x4.0=196m3/each ……>194m3 OK

V2=194x4pc=784m3…………………>775m3 OK

Retention time;(Actual)

RT=784/(55,800÷24÷60)=20.2min >20min OK

①[Mixer for coagulation tank]…………………………(Facility NO,M-17)

Type ;Double paddle type

Specification;Mixing capacity (194m3),Rotating speed(12rpm)x11kw

Material ;Stainless steel

Quantity ;4 pcs

②[Buffer plate for coagulant tank] ………………(Facility NO,M-72)

Type ;Plate type

Specification;1000mmx600mmx3000mmh

Material ;Stainless steel

Quantity ;4pcs

(7)Caustic Soda Feeding System

Caustic Soda to be used ;45% solid

(pH 4.0 ——> PH 7.0)

NaOH = g=(10^{-4} - 10^{-7})kg-ionx40/1x55,800m3/dx10

=4.0x10^{-3}x55,800m3/dx10 =2,232kg/d

NaOH Feed=2,232kg/dx100/45x1/1.49=3,329L/d (Solution Gravity=1.49

Storage period ;More than 7days/1tank

=3.33m3/dx7day=23.31m3/1 tank

①[Caustic Soda tank] ·························(Facility NO,M-46)

Capacity ; 30m3

Material ;Mild Steel

Dimension ;Approx 3,000mmΦ x 5,000mmH

Quantity ;1 pc

Accessory ;Level gauge 1/1 unit

②[Caustic Soda Feeding Pump] ·············(Facility NO,M-47)

Dosing volume ;3.33m3/day÷4 Line÷1,440=0.58L/min

Type ;Uniaxial screw pump

Specification ,20mmΦ x～ 1000cc/minx0.4kw (380Vx50HZ)

Quantity ;6 pcs(2 pcs spare)

Accessory ;Pressure gauge 6pc/6pcs.

③[Caustic Soda solution tank unit] ················(Facility No.M-70)

Capacity ; 4.2m3 (for 45%Solid ——> 45% Liquid)

Material ; Mild Steel

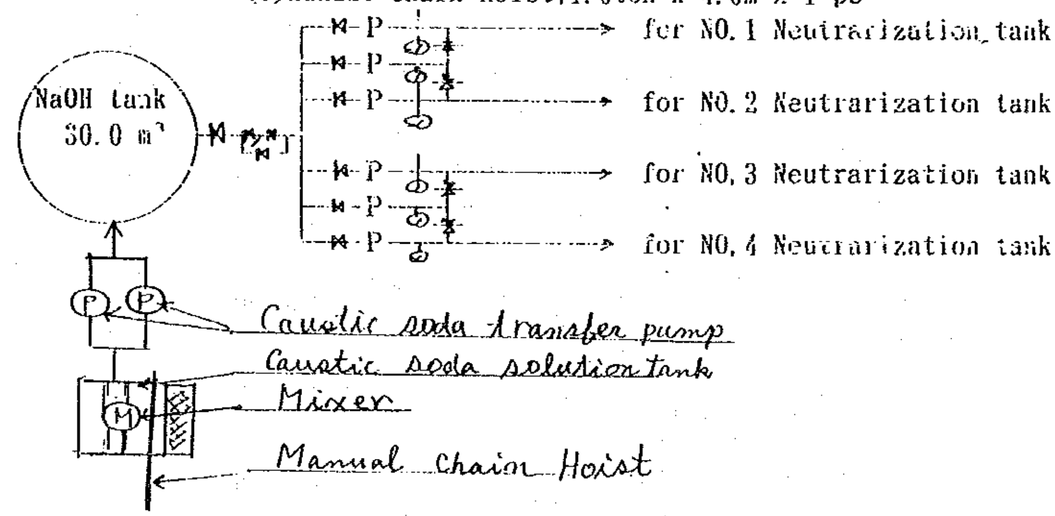
Dimension ;Approx2.0mW x 2.0mL x 1.7mH(used depth approx 1.2mH)

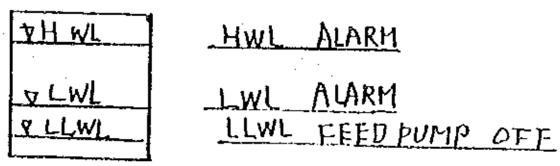
Quantity ; 1 pc

Accessory ;(A)Mixer ;2.2kw x 380V x 50HZ x 1 pc

(B)NaOH transfer pump; 50mmx40mmx0.2m3/minx10mx1.5kwx2pcs

(C)Manual Chain Hoist;1.0ton x 4.0m x 1 pc





(8)Aluminium Sulfate Feeding system

Aluminium Sulfate to be used;8% Liquid (as Al_2O_3)(Gravity-1.08)

Dosing Rate ,max.100ppm (as Al_2O_3)

Required Volume ;55,800m3/dx100ppmx10^{-3}=5,580kg/d

Dosing Volume ;5,580m3/dx100/8x1/1.08=64,584L/d

Dosing Volume line ;64,584L/d÷4 Line÷1,440=11.22L/min

①Aluminium Sulfate tank……Scope of Civil works

Storage period ;More than 7day
=64,584L/dx7dayx10^{-3}=452m3

Material ;RC (Inside…Rubber lined or FRP lined)

Dimension ;8.0mWx8.0mLx4.0mh 2pcs

Tank Inside ;FRP or Rubber Lined ……Scope of civil works

Capacity ;8.0mx8.0mx4.0mhx2pcs=512m3 >452m3 OK

②[Aluminium Sulfate Feeding pump]……………………(Facility NO.M-48)

Dosing volume ;11.22L/min…1 line

Type ;Diaphragm pump

Specification ;40mmx ~20L/minx0.75kw (380Vx50HZ)

Quantity ;6 pcs(2 pcs spare)

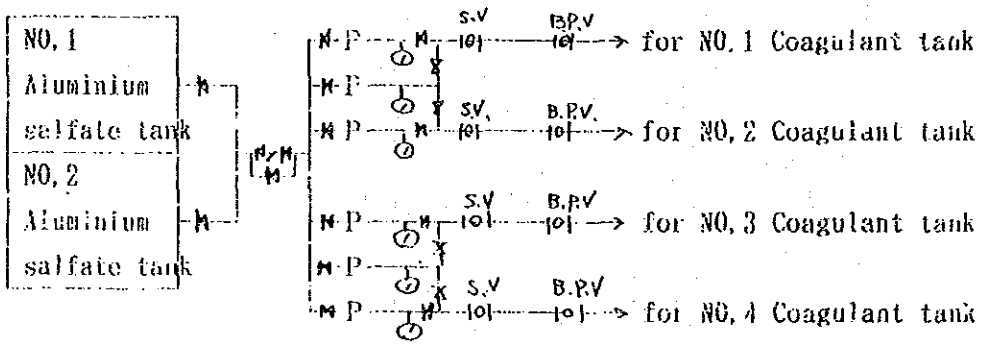
Accessory ;Pressure gauge 6pcs/6pcs, Safety valve 4pcs/6pcs,
Back pressure valve 4pcs/6pcs,

③[Floor drain pump for Dosing pump Room] ……………(Facility NO.M-49)

Type ;Submersible pump

Specification ;50mmx0.1m3/minx10mx0.75kw (380v 50HZ)

Quantity ;2pcs(1pc spare)



(9)Primary Sedimentation tank

DmaxQ =55,800m3/d, HmaxQ =93,000m3/d=3,875m3/d

Over Flow Rate ;QFR1=Less than 35m3/m2.day at Dmax

Retention time ;RT =2.0～4.0 hour at DmaxQ

Surface Area ;SA1 =55,800m3/35=1,595m2
1,595m2/4=399m2 (each)

Capacity ;V =55,800x2.0/24=4,650m3=1,163m3(each)

Depth ;H =1,163/399=2.91m ——> 3.0m

Dimension ;10.0mWx40.0mLx3.0mHx4pcs

Over flow rate(Actual);OFR1=55,800/(10.0x40.0x4)=34.9m3/m2.day OK

Retention time(Actual);RT=(10.0x40.0x3.0x4)/55,800x24=2.06hr OK

Sludge Generation ;

Sludge Generation ratio; as 40%

SS Concentrate of Sludge; as 2.0wt %

Removal SS =55,800m3/dx380ppmx10 ^{3}x0.4=8,481.6kg-ss/day
=8,481.6kg-ss/d÷4 line =2,120.4kg-ss/day(each)

Sludge volume(SV) =8,481.6/0.02x10 ^{3} =424.08m3/day
=424.08m3/day÷4 line=106.02m3/day(each)

1) Sludge Characteristics
Concentrate ; 5.0%(Max)
Gravity ; 1.05%

2) Rake Capacity(Q) =60 x v x h x ℓ
Q =Sludge rake capacity ········ m^{3} /hr
v =rake speed ······················0.3 ～0.6m/min
h =flighth height ················0.18m
ℓ =flight width ···················3.70m
Q =60 x0.6 x 0.18 x 3.7 =24.0m^{3} /hr

3) Tension of chain
a)part of Rake Weight(W1)=2 x w1 +(w2+w3)/P
W1=part of rake weight···········kg/m
w1=chain weight ············11.27kg/m(Stainless)
w2=flight weight ············37.0 kg/1pc

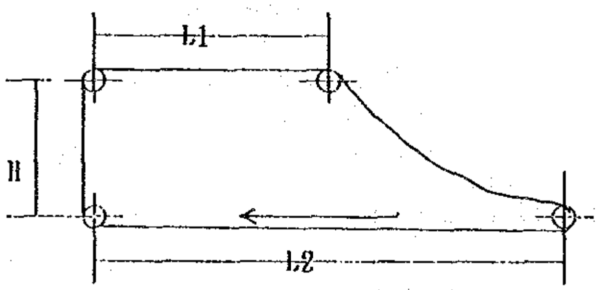
w3=attachment weight ……………6.38 kg/1pc
P =flight pitch ……………about3.0m

(W1)=2 x 11.27 +(37+6.38)/3.0=37kg/m

b)Carried sludge weight(W2),=(1,000 x Q x r)/(60 x v)
w2= carried sludge weight ……kg/m
Q = Raked sludge volume ………24.0 m³ /hr
r = sludge gravity ……………1.05
v = raking speed ………………0.6m/min
(W2)=(1,000 x 24.0 x 1.05)/(60 x 0.6)=700 kg/m……700kg/m

c)Primary tension of chain(P1)= 200 kg (2 line)

d)Tension of friction(Raked sludge and bottom of Tank)
P2= W2 x L2 x μ2
P2=Tension of friction(sludge and bottom of tank)
……………………… kg
w2=Raked sludge weight……………………670kg/m
L2=length of horizontal shaft center…36m
μ2=friction coefficiency(sludge to bottom…0.05



P2=670 x 36 x 0.05 = 1,206 kg

e)Tension of friction(rail and flight shoe)

$P3=W1 \times L \times \mu 1$

P3	=Tension of friction(rail and flight shoe)	kg
W1	=flight weight	37kg/pc
L	=2 x 12	72m
$\mu 2$	=friction of rail and flight shoe	0.3

$P3=37 \times 72 \times 0.3= 800kg$

f)Tension of lift up

$P4=W1 \times H$

P4	=Tension of lift up	kg
W1	=flight weight	37kg/pc
H	=length of vertical shaft center	3.0m

$P4=37 \times 3.0 =111$ kg

g)Friction loss of pillow block

$P5=(P1+P2+P3+P4) \times 0.1$

$P5=(200 + 1,207 + 800 +111)\times 0.1 =232$ kg

h)Tension of chain

$P =P1 + P2 + P3 + P4 + P5$

$P =200 + 1,206 + 800 + 111 + 232 =2,549$ kg

i)Power of motor(Drive unit)

$PS=(n \times P \times v)/(6,120 \times \eta) \times \alpha$

PS	=Power of motor	kw
n	=Sedimentation tank quantity of drive	2
P	=Tension of chain	2,549kg
v	=rake speed	0.6m/min
η	=Total efficiency	0.7
α	=Safety ratio	2

$PS=\{(2 \times 2,549 \times 0.6)/(6,120 \times 0.7)\} \times 2=1.43$ kw

Power of motor ………1.5kw

4)Chain strength calculation

a)from tension of chain

chain 2 line   tention of one side (P)≒70%

S =Po /(0.7 x P)

S =Safety ratio of chain

Po=Average breaking strength of chain   19,000kg

P =Tension of chain   2,549kg

S =19,000/(0.7 x 2,549) =10.7

b)Tension of chain from motor torque

①Tension of chain from motor output

T =(6,120 x PS x η x fo)/v

PS =Output of motor   1.5 kw

η =Total efficiency   0.7

fo =Coefficiency (one side chain for total load)   0.7

v =Rake speed   0.6m/min

T =(6,120x1.5x0.7x0.7)/0.6=7,497kg

②Safety ratio of chain

S =Po/T

Po=Average breaking strength of chain   19,000kg

T =Tension of chain   7,497kg

S =19,000/7,497=2.53

5)Calculation Strength of drive shaft

Mt =97,370 x PS/r x η

Mt =π/16x d^3 x τ

$d = \sqrt[3]{Mt \times 16/(\pi \times \tau)}$

$= \sqrt[3]{97,370 \times (16 \times Ps \times \eta)/(\pi \times \tau \times r)}$

$= 116 \times \sqrt[3]{(Ps\ \eta)/(\pi \times \tau \times r)}$

Mt	;twist moment of drive shaft	kg-cm
Ps	;power of drive motor	1.5kw
η	;drive efficiency	0.78
τ	;twist stress allowed	860 kg/cm²
r	;rotation of drive shaft	0.358rpm

r = v /(P x Z)

v ;raking speed 0.6m/min

P ;pitch of drive sprocket 0.1524m

Z ;teeth of drive sprocket 11

r =0.6/(0.1524x11)=0.358rpm

d =116x $\sqrt[3]{(1.5\times0.78)/(\pi\times860\times0.358)}$ =12.4cm

plus key ditch depth······ 124mm+10mm=134mm

Drive shaft diameter ··········· 140mmΦ

①[Specification of rake for P.s.T.]················(Facility NO.M-19)

Type	;Chain flight double link type
Tank dimention	;Width 5,000mm xLength 40,000mm xdepth 3,000mm
Length of rake	;approx 36,000mm
Rake speed	;approx 0.6m/min
Flight pitch	;approx 3,000mm
Drive unit	;cycro-reduction motor 1.5kw
Material	;Chain(stainless steel or plastic),Flight(Plastic) Rail(15kg/m) Bolt/nut(Stainless steel)
Quantity	;(5.0mWx2set) x4 line

Accessories

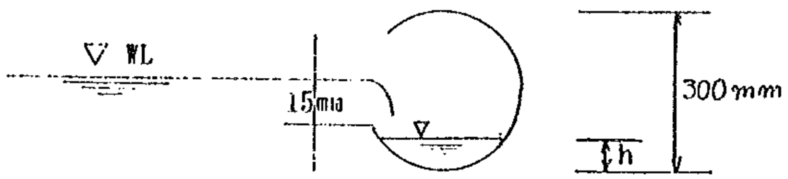
A	Drive unit	1.5kw	4pcs
B	;Grease up nozzle	(4pcs x 2) x 8line	64pcs
C	;Weir	(14mx4pcs)	4line

6)Scum skimmer for P.S.T. ··································· (Facility NO.M-20)

Type and diameter ;Pipe skimmer 300mmΦ x 0.4kw (380v 50HZ)

Volume of scum and water ;

Quantity ;8 pcs



$Q = k \times B \times H^{3/2}$

k ;effluent coeficiency 119

B ;width of slit approx 4.0m

H ;over flow water depth 0.015m

$Q = 119 \times 4.0 \times 0.015^{3/2} = 0.874\ m^3/min$

water depth of inside pipe immer h

$h = ho/\sqrt{3}$

ho; water depth of the upper stream max0.15m

$h = 0.15/\sqrt{3} = 0.087m$

max effluent volume of pipe skimmer

$Qo = \sqrt{g \times D^2 \times h^3}$

Qo; max effluent volume m3/sec

g ; accelation of gravity $9.8m/sec^2$

D ; diameter of pipe skimmer 0.3m

h ; effluent water depth 0.087m

$Qo = \sqrt{9.8 \times (0.3)^2 \times (0.087)^3} = 0.024\ m3/sec$

=1.45 m3/min > 0.874m3/min ok

②[Specification of pipe skimmer] ····················(Facility NO,M-20)

Type ;pipe skimmer

Pipe diameter; 300mmΦ

Length ; 5,000mm

motor ; 0.4 kw (380Vx50hz)

Quantity ; 8 pcs

7).Sludge pump for primary sedimentation tank

a) Sludge volume;Q=424.08m3/d

Pump capacity;q=(424.08m3)d/(12x60)x1/4pcs=0.147m3/min(each pump)

=approx0.2m3/min(each pump)

b)Pump diameter;$D1 = 146\sqrt{Q/v}$ v=1.5 ~2.5m/sec

$=146\sqrt{0.2/(1.5\sim2.5)}$ =42mm ~54mm ⟶ 80mm

c)Sludge pipe diameter ;sludge total volume=0.2m3/minx 4 pcs=0.8 m3/min

$D2 = 146\sqrt{0.8/(1.5\sim2.5)}$ = 82mm ~107mm → 150mm d)Pump head (Primary sedimentation tank ←→ Sludge Thickener)

Actual head(H1) =(▽+12.0m)-(▽+2.5m(max))=9.5m

Pipe length L(150)=15m+80m+65m+45m+2m+3m=220m ……

L(80) =2m+2m+2m+3m+ =9 m

Loss head

Inlet mouth loss $H2(80)=f \times v^2/2g$ f=1.0

$v(80)=0.2m3/(60 \times 3.14/4 \times D^2)=0.663m/sec$

$v(150)=0.8m3/(60 \times 3.14/4 \times D^2)=0.755m/sec$

$=1.0 \times (0.663)^2/19.6=0.023m$

Piping loss $H3(80)=f1 \times L/D \times v^2/2g$

$f1(80)=0.02+0.0005/D=0.0263$

$f1(150)=0.02+0.0005/D=0.0234$

$=0.0263 \times 10/0.08 \times (0.663)^2/19.6=0.074m$

$H4(150)=0.0234 \times 220/0.15 \times (0.755)^2/19.6=0.999m$

Tee loss $H5(80)=f \times v^2/2g$ f=1.2

$=1.2 \times (0.663)^2/19.6 \times 2pc=0.054m$

$H6(150)=1.2 \times (0.755)^3/19.6 \times 2pcs=0.070m$

Elbow loss $H = f \times v^2/2g$ f=0.2

$H7(80)=0.2 \times (0.663)^2/19.6 \times 1pc=0.005m$

$H8(150)=0.2 \times (0.775)^2/19.6 \times 5pcs=0.031m$

Gate valve loss $H9(80)=f \times v^2/2g$ f=0.168

$=0.168 \times (0.663)^2/19.6 \times 5pcs=0.089m$

$H10(150)=f \times v^2/2g$ f=0.145

$=0.145 \times (0.775)^2/19.6 \times 6pcs=0.028m$

Check valve loss $H11(80)=f \times v^2/2g$ f=1.8

$=1.8 \times (0.663)^2/19.6 \times 1pc=0.041m$

Total head=H1+H2+H3+H4+H5+H6+H7+H8+H9+H10

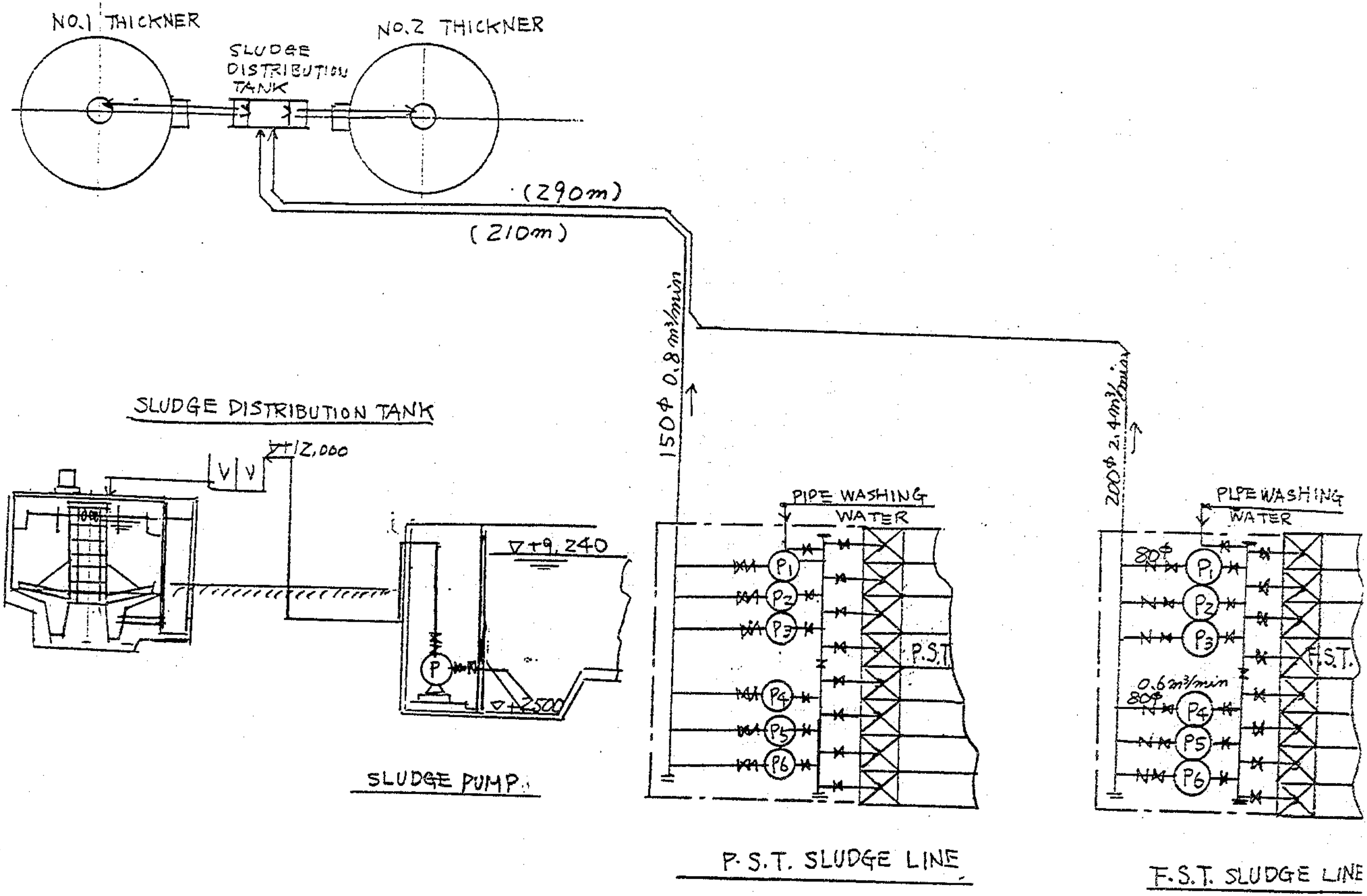
=9.5+0.024+0.074+0.999+0.054+0.07+0.005+0.031+0.089+0.028

+0.041

=10.915m

Safety ratio of sludge ; 50%(98% Sludge)

= 10.915mx1.5 =16.37m ——> 17.0m


NO.1 THICKNER
NO.2 THICKNER
SLUDGE DISTRIBUTION TANK
(290m)
(210m)
150φ 0.8m³/min
200φ 2.4m³/min
SLUDGE DISTRIBUTION TANK
▽+12,000
V V
▽+9,240
▽+2,500
P
SLUDGE PUMP
PIPE WASHING WATER
P.S.T
P1
P2
P3
P4
P5
P6
P.S.T. SLUDGE LINE
PIPE WASHING WATER
80φ
0.6m³/min
F.S.T.
F.S.T. SLUDGE LINE

e)Power of motor

PS =0.163 x (γ x Q x H)/η) α

PS	; Power of motor	kw
γ	; Gravity of sludge	1.05
Q	; Flow volume	0.2m3/min
H	; Total head	17.0m
η	; Efficiency of pump	30%
α	; Safety ratio	1.2

PS =0.163 x (1.05 x0.2 x 17.0)/0.30)x1.2 = 2.33 kw > 3.7kw Ok

③[Specification of sludge pump for P.S.T.] ·······(Facility NO.M-21)

Type ;Horizontal sludge pump

Specification;80x80mmx0.2m3/minx15mx3.7kw (380Vx50HZ)

Quantity ;6 pcs(2 pcs spare)

④[Sludge distribution tank]·····························(Facility NO.M-43)

Type ;Weir type Dimension;1,600Wx3000Lx1000H(Stainless steel)

Quantity ;1 pc

8)Scum transfer pump for P.S.T·······(To raw waste water pumping station)

a) Scum transfer volume; 0.874m³ /min ——> 0.88m3/min

b) Pump diameter ;D1=146 $\sqrt{Q/v}$=146 $\sqrt{0.88/(1.5 \sim 3.0)}$

=79～112mm ——> 100mm

v(100) =0.88m3/(60x3.14/4x D^2)=1.869m/sec

c) Pump head

Actual head (H1) =(∇+9.200)-(∇+6.240)= 2.96m

Pipe length = 5.5+3.0+35.0+110.0+60.0+21.0+5.5=240m ——> 250m

Loss head

Piping loss H2(100)=f1 x L/D x v^2 /2g f1(100)=0.02+0.0005/D=0.025

=0.025 x 250/0.1 x (1.869) ^{2} /19.6=11.139m

Elbow loss H3(100)= f x v^2 /2g f=0.2

= 0.2x (1.869)^2 /19.6 x 9pcs =0.321m

Check valve lossH4(100)= f x v^2 /2g f=1.8

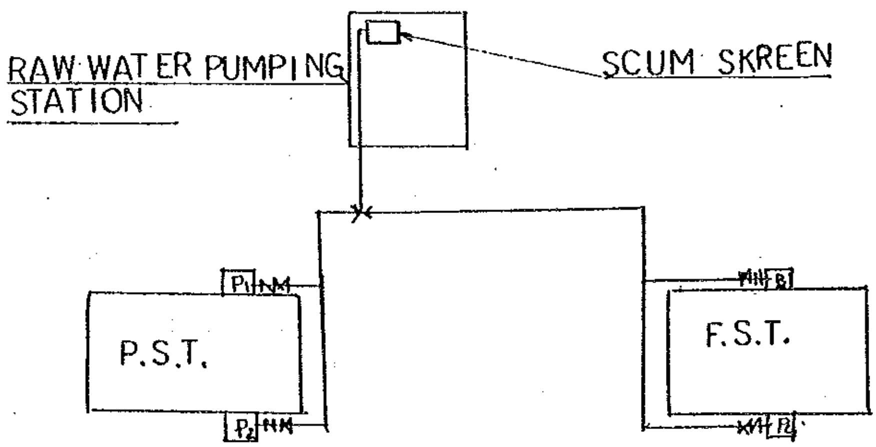
=1.8 x (1.869)^2 /19.6 x 1pc =0.321m

Gate valve loss H5(100)= f x v^2 /2g f=0.164

=0.164x (1.869)^2 /19.6 x 1pc=0.030m

Total head H = H1 + H2 + H3 + H4 + H5

=2.96+11.139+0.321+0.321+0.03=14.771m ——> 16m



NOTE: (P_1,P_2,P_3,P_4) EACH PUMP WILL BE OPERATED SIMULTANEOUSLY.

d)Power of motor PS =0.163 x (γ x Q x H)/ η x1.2

PS ;Power of motor kw

γ ;Gravity of scum 1.0

Q ;Flow volume 0.88m3/min……0.9m3/min

H ;Total head 16.0m

η ;Efficiency of pump 60 %

α ;Safety ratio 1.2

PS =0.163 x (1.0x0.9x16.0)/(0.60)x1.2 =4.695kw ——> 5.5kw

Scum pit ………Scope of civil works

Scum pit capacity;Retention time10min x 1 pc= 0.88m³ /min x 10min = 8.8m

Scum pit dimention; 1.2mW x3.0mL x 2.5mh

Scum pit volume :=1.2 x 3.0 x 2.5h = 9.0m3 > 8.8m3 OK

④[Inlet gate for P.S.T.] ……………………………………(Facility NO.M-18)

Type ;Sluice gate

Specification;400W x400H

Quantity ; 8 pcs

⑤[Scum transfer pump for P.S.T.] ……………………………(Facility NO.M-22)

Flow route ;Scum pump pit ——> (to raw waste water pumping station)

Type ;Submersible pump

Specification;100mm x 0.9m3/min x 16m x 5.5kw

Quantity ;4 pcs(2pcs spare … warehouse)

Accessories ;Cable 10m/1pc,Chain 6m/1pc(Stainles steel),Guide pipe 1set/1pc,(Stainless steel),Automatic connection 1set/1pc

⑥[Floor drain pump for P.S.T. pump room] …………………(Facility NO.M-23)

Flow route ;floor pump pit ——> Primary sedimentation tank

Type ;Submersible pump

Specification:50mmx0.1m3/minx10mx0.75kw

Quantity ;2 pcs(1pc spare)

⑦[Scum screen] ………………………………………………(Facility NO.M-6)

Type ;Wedge-wire screen

Specification;1200Wx1,200H Pitch 2.0mm 60m3/hr stainless steel

Quantity ;1pc

Accessory ;Scum container 350mmx600mmx400mmh 2pcs/1pc (stainless steel net)

(9)Aeration tank

Dmax =55,800m3/day

BOD-SS Load =0.2 ～0.5kg/kg.SS.day

MLSS =1,000 ～3,000mg/L

Aeration time=more than 6.0 hour

Influent Quantity

BOD(in) =55,800m3/dayx330ppm(1-0.30)x10³ =12,889.8kg-BOD/day

BOD(PPM)=12,889.8/55,800x10 ³=231mg/L

SS(in) =55,800m3/dayx380ppmx(1-0.4)x10 ³=12,722.4kg-SS/day

SS(ppm) =12,722.4/55,800x10³ =228mg/L

Capacity(V1)=55,800x6.0/24=13,950m3

(V2)=12,889.8/(0.30x2,000)x10 ³ =21,482m3

=21,482m3 ÷4 Line =5,371m3(each)

Depth (H) =5.0m

Dimension =15.0mw x 72.0mL x 5.0mh x 4 pcs

Surface Area=(Actual)

(SA)=15.0 x 72.0 x 4 line =4,320m2

=4,320m2÷4 line=1,080m2(each)

Capacity(Actual)

(V) =15.0 x 72.0 x 5.0 x 4 line =21,600m3

=21,600m3 ÷ 4 line =5,400m3(each)

BOD-SS Load(Actual)

L(BOD-SS)=12,889.8/(21,600 x 2,000/10³)=0.298kg-BOD/kg-SS.day

OK

Aeration time(Actual)

Ta =21,600/(55,800/24)=9.29 hour OK

BOD Volume Load(Actual)

L(BOD.V) =12,889.8/21,600 0.597/m3z.day OK

Return Sludge Volume ;

Return Sludge Rate;Rr=(MLSS-SS(in)/Cr-MLSS)x10 ²

Cr=Return sludge generation ratio(=8,000mg/L)

RR=(2,000-228)/(8,000-2,000)x 10² =29.53%

(Max 50%)

RSV = DmaxQ x Rr/10² =55,800x29.53/10² =16,477.74m3/day

=11.44m3/min

Aeration time of influent sludge(Actual);

SA =V(AT) x MLSS/10^3 /SS(in)

= 21,600 x 2,000/10^3 /12,722.4=3.40day OK

(2.0 < SA < 4.0day)

Sludge retention time(Actual)

SRT =(V(A.T.) x MLSS+V(F.S.T.)xMLSS)/(Qw x Cr +DmaxQ xSSo)

V(A.T.) ;Aeration tank capacity=21,600m3

V(F.S.T.);Final sedimentation tank capacity =6,975m3

Qw ;Slude volume at Final sedimentation tank=1,380.38m3/d

Cr ;Return sludge generation raitio =8,000mg/L

SSo ;Treated waste water Quantity =30mg/L

SRT =(21,600 x 2,000+6,975 x 2,000)/(1,380.8 x 8,000 +55,800x30)

=4.50day

Aeration;

Required Oxigen =DmaxQ x BOD(in) x (1-R(P)) x R(F) 10 ^{3} x 35m3/kg-BOD

R(P);Removal rate at Primary sedimentation tank =30.0%

R(F);Removal rate at Aeration tank +Final sedimentation tank=91.4%

Required Oxigen =55,800 x 330 x (1-0.30) x 0.914 x 10 ^{3} x 35

=412,345m3/day = 286.35m3/min

a)Required air

Blower ;q1=(286.35m3/min + 4.0m3/min) ÷ 8pcs =36.3m3/min

4.0m3/min ;Neutralization tank mixing air

b)Aeration system

Type ;Circulation aeration by blower

(This method is popular for standard activated sludge system.)

c)Bubbling type

Type ;Fine bubble type

(This type is effective on O_2 dispertion and O_2 transfer in the tank, and of energy saving type.)

d) Capacity and quantity of air diffuser

(1) Air capacity of 1 line .... g = Q/N

Q ; Required air in total =286.35m3/min

N ; Line quantity =8

g = 286.35/8 = approx 35.8 m3/min

(2) Nos. of diffuser/line

n = (1000 x q)/q1

q , Diffuser capacity / line =35.8m3/min

q1; Maximum capacity of a diffuser =200 ℓ /min

N = (1,000 x 35.8m3)/200 =179 pcs ——> 180pcs/1 line

(3) Air capacity of a diffuser

q2 = (1,000 x q)/n

q ; Air capacity of 1 line =35.8m3/min

n ; Diffuser quantity per 1 line =180pcs

q2 = (1,000 x 35.8)/180 =198.9 ℓ /min.pc

e) Measurement of air capacity and control

Measurement method of air capacity ——> 1 line 1 flowmeter

Control method of air capacity ——> 1 line 1 control valve (manual operation)

Air capacity control of blower ——> Controlled by numbers of unit operating (manual operation)

① [Air diffuser for aeration tank] .... (Facility NO. M-28)

Type ; Fine bubble diffuser (cylindrical diffuser)
Air capacity; approx 200 ℓ /min.pc x2
Material ; ABS Plastic
Dimension ; 70 Φ x1,130mm connection ; 25mm PT thread
Pressure loss; approx100mmAq
Quantity ; Hanger pipe (stainless steel) 90set/1 line x 8 line=720set (with double diffuser/1set)

② [Return sludge inlet gate] .... (Facility NO. M-24)

Type ; Movable weir type
Specification; 500W x 300ST
Material ; FC20
Quantity ; 8 pcs

③[Inlet gate for Aeration tank] ···················(Facility NO.M-25)

Type ;Movable weir type

Specificatipn;1,000Wx300ST Material;FC20

Quantity ;8 pcs

④[Step gate for aeration tank] ······················(Facility No.M-26)

Type ;Movable type

Specification;400Wx300ST Material;FC20

Quantity ;24 pcs

⑤[Floor drain pump for A.T.piping space] ········(Facility NO.M-27)

Type ;Submersible pump

Specification;50mm x 0.1m³ /min x 10m x 0.75kw

Quantity ;2pcs(1 pc spare)

f)Defoaming equipment

(1)Defoaming method

Water to be used ;Treated water(By spray pump)

(2)Selection of defoaming nozzle

Selection of nozzle to be done considering easy maintenance

(3)Quantity and capacity of nozzle

Nozzle capacity ; 10 ℓ /min.1pc

Pitch of setting nozzle ; approx 1.5m

Quantity of 1 line;

n1=L/P

L ; Length of 1 line 72m/ line

P ; Setting pitch of nozzle 1.5m

n1= 72/1.5 =48 pcs/1 line

⑥[Spray nozzle specification]·······················(Facility NO.M-73)

Type ; cock type

Capacity ; 10ℓ /min.pc

Size ; PT3/4

Nozzle pressure; 1.0kg/cm2

Setting pitch ; approx 1.5m

Quantity ;(48 pc/1 line) x 8 line = 384 pcs g)Decision of aeration tank inlet movable weir

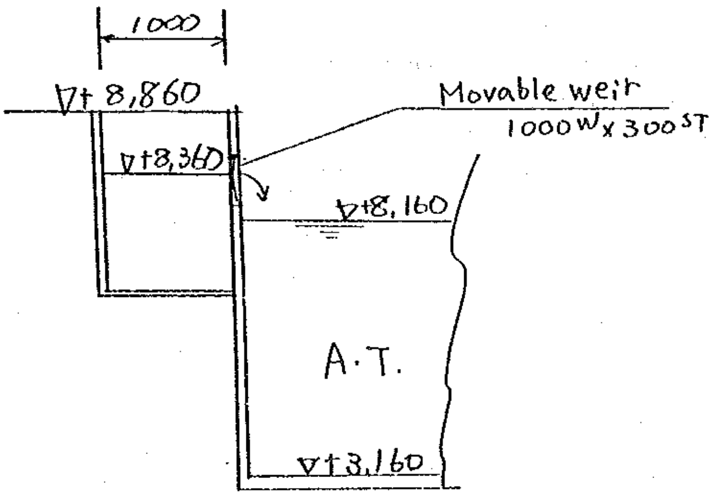
(1)Decision of weir width

Type ;Four-sided weir
Over flow maximum water level;approx 200mm
Nos.of line ;4 line
Flow volume of 1 movable weir
Q1(Inlet volume)= DmaxQ/4=55,800/4=13,950m3/day=0.1615m3/sec(1 line)
$B = Q1/(1.84 x H^{3/2})$ ———> H=0.2m
$= 0.1615/(1.84 x 0.2^{3/2})$
=0.981m ———> Weir width= 1,000mm

(2) Over flow water depth of design flow volume
$H = \{(Q/(1.84 x B)\}^{2/3} = \{(0.1615)/(1.84 x 1.0)\}^{2/3} = 0.198m$

(3)Aeration tank control method
Control of each aeration tank (in-flow volume, air capacity, return sludge volume) is made manually.
In-flow movable weir is operated manually

Aeration tank in-flow movable weir
Type ,movable weir made of cast iron
Dimension;width 1,000mm x 300mmST
Stroke ;approx300mm
Quantity ; 8 pcs



(10) Aeration blower equipment

a)Air capacity of blower

1 unit blower capacity(see 24page);36.3m^3/min ---> 37.0m^3/min

b)Diameter of blower

D=146 $\sqrt{Q/V}$

D ; Diameter of blower mm

Q ; Air capacity 37.0m^3/min

V ; Wind velocity 20～30m/sec

D=146 $\sqrt{37/(20\sim30)}$ =162～198.6mm ------> 200mm

c)Pressure of blower

H=hd-hs

H ;Pressure of blower mmaq

hd;Outlet pressure of blower mmaq

hs;Inlet pressure of blower mmaq

(1)Outlet pressure of blower(hd)

1)Friction loss of outlet pipe(See page 32)

hd1= 230 mmaq

2)Loss of diffuser

hd2= 100 mmaq

3)Loss of air flow meter

hd3=50mmaqx1pcs=50mmaq

4)Water pressure

hd4=(water level of aeration tank)-(Setting level of diffuser)

=8,160-3,660=4,500mmaq

5)Clogging of diffusers

hd5=50mmaq/year x10 year=500mmaq

Total outlet pressure

hd=hd1+hd2+hd3+hd4+hd5

=230+100+50+4,500+500=5,380mmaq

(2)Inlet pressure of blower(hs)

1)Friction loss of inlet pipe

hs1= -65mmaq (See page 31)

2)Dry filter loss

Hs2= -20 ~ -30 mmaq

Total inlet pressure

hs=hs1+hs2

=(-65)+(-20～-30)=(-85 ～95mmaq) ——> 95mmaq

(3)Required pressure(H)

H=5,380-(-95)=5,475 mmaq ——> 5,500mmaq

d)Friction loss of piping

1)Methord of calculation

Temperature ;at 20℃

Humidity ;at 65%

Atmospheric pressure ;1,322mmaq

2)Calcuration

(1)Friction of straight pipe

$\triangle h = \lambda \times L/D \times v^2/2g \times \gamma$ (mmaq)

λ ;Coefficiency of friction

L ;Pipe length m

D ;Pipe diameter 0.2 m

v ;Velocity of wind m/sec

g ;Accelation of gravity 9.8m/sec ^{2}

γ ;Gravity of air 1.198kg/m3

λ ; Coefficiency of roughness = ε /D and Reynolds(Re)

——> Moody curve

Reynolds (Re)=(v x D)/ ν

ε ; 0.15mm(Galvanized pipe)

ν ; coefficiency 1.5 x10.^{5} m2/sec

(2)Friction loss of elbow tee valve and other

$\Delta h = f \times (V^2)/2g \times \gamma$ (mmaq)

f ;coefficiency of friction

v ;velocity m/sec

g ;accelation of gravity 9.8 m/sec²

γ ;gravity of air 1.198kg/m³

(3)Calculation of air gravity

(3)-1 Air gravity of standard condition

$\gamma = \gamma_0 \times (273)/(273+t) \times (h - 0.378 \times \phi \times F)/h_0$ (kg/m³)

γ_0 ;Air gravity (0℃, 760mmAq) 1.293kg/m³

t ;Temperature (standard condition) 20℃

φ ;Rerative atomosphere(standard condition) 0.65

F ;Saturated vapor pressure(standard condition) 238.3mmaq

h_0 ;Rerative pressure(standard condition) 10332mmaq

h ;Atmospheric pressure 10322mmaq

$\gamma = 1.293 \times (273)/(273+20) \times (10322 - 0.378 \times 0.65 \times 238.3)/10332$

$= 1.198$ kg/m³

(3)-2 Air gravity of inlet side (γs)

$\gamma s = \gamma \times hs/h \times T/Ts$ (kg/m³)

γ ;Gravity of air(standard condition)

h ;Rerative pressure(standard condition) 10332mmaq

T ;Rerative temperecture(standard condition) 293°K

hs ;Rerative pressure of inlet side 10132mmaq

Ts ;Rerative temperature of inlet side 293° K

$\gamma s = 1.198 \times 10132/10332 \times 293/293$

$= 1.175$ kg/ m³

(3)-3 Air gravity of outlet side (γd)

$\gamma d = \gamma \times hd/h \times T/td$ (kg/m³)

$Td = Ts + Ts/\eta\theta \, \{(hd/hs)^{(1.4-1)/1.4} - 1\}$

γ ;Air gravity(standard condition) 1.198kg/m³

h ;Rerative pressure(standard condition) 10332mmaq

T ;Rerative atomosphere(standard condition) 293° K

hd ;Rerative pressure of outlet side(10332+5500) 15832mmaq

Td ;Rerative temperature of outlet side ° K hs ;Rerative pressure of inlet side 10132mmaq

Ts ;Rerative temperature of inlet side 293° K

$\eta 0$;Adiabatic efficiency temperature 0.7

Td =293 + 293/0.7 x {(15832/10132) $^{(1.4-1)/1.4}$ -1}

=350 ° K

γd=1.198 x 15832/10332 x 293/350

=1.537 kg/m^3

(4) Revision of air capacity and air gravity

G = γ x Q = γs x Qs = γd x Qd

Q ; Air capacity m3/min

Qs ; Air capacity of inlet side m3/min

Qd ; Air capacity of outlet side m3/min

Qs = γ / γs x Q

Qd = γ / γd x Q

Friction loss of straight pipe

Δh=k1 x (v ^{2})/2g x γ

=k2 x Q^2 x γ (k1, k2 ;constant)

Δhs1=k2 x Q^2 x γ

=k2(γ / γs x Q) ^{2} x γs^1

=(k2 x Q ^{2} x γ) x γ / γs

=Ks x Δh (Ks= γ / γs ;value of revise)

result Δhs1=Kd x Δh (Kd= γ / γd ;value of revise)

(5) Decision of friction loss inlet side and outlet side

(5)-1 Friction loss of inlet side (Δhs1)

See calculation table·········P/37 Δh=63.6mmaq

Δhs1=Ks x Δh

=1.198/1.175 x 63.6

=approx 65mmaq

(5)-2 Friction loss of outlet side (Δhd1)

See calculation table·········P/37 Δh=295.1mmaq

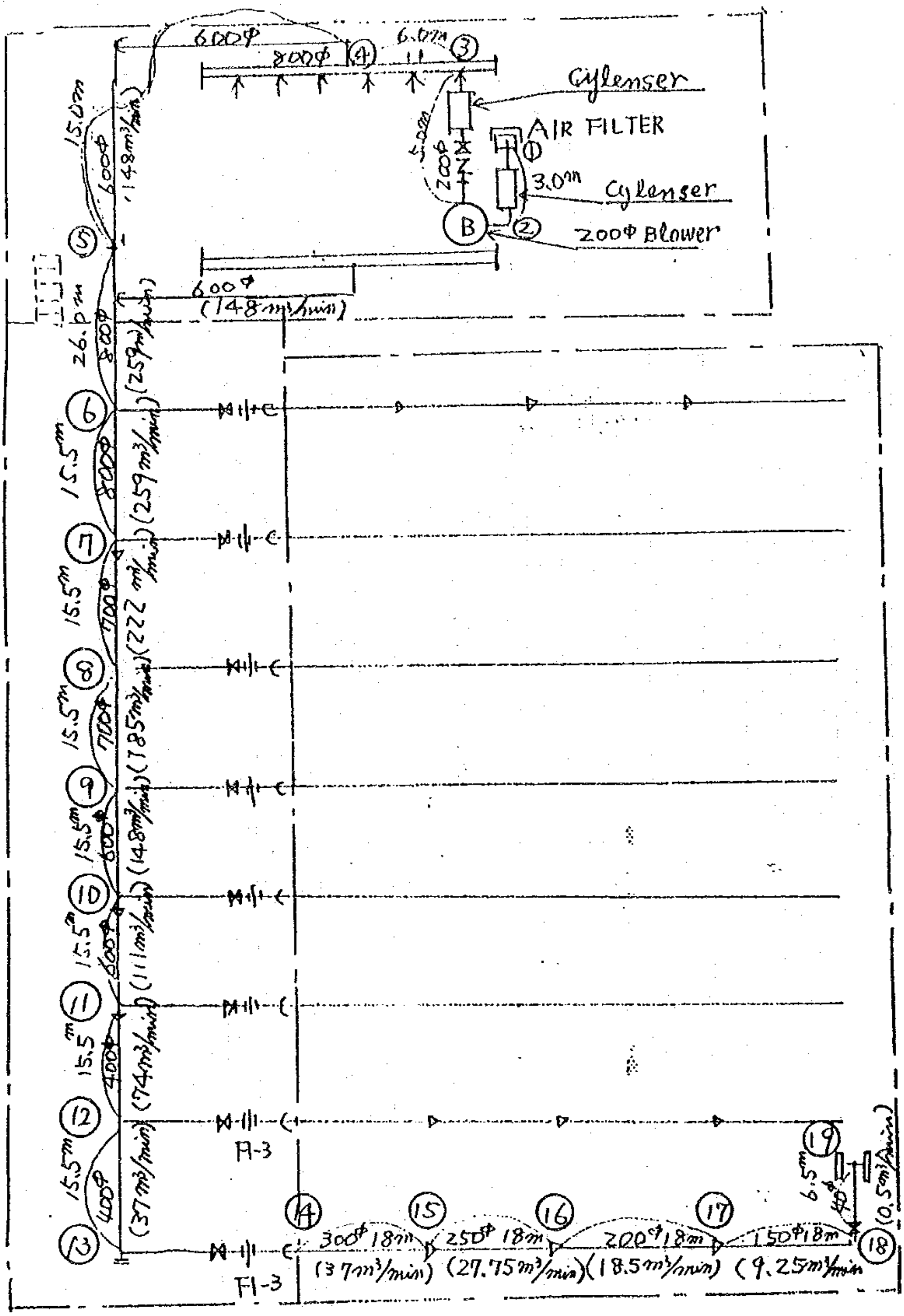
$\triangle hd1 = Kd \times \triangle h$
$= 1.198/1.537 \times 295.1$
$\fallingdotseq 230mmaq$

⑥[Aeration blower specification] ……………(Facility NO.M-52)

Type ;Roots blower
Specification;200A x 37.0m³ /min x 5500mmaq x 55.0kw
Quantity ;12unit (stand-by 4unit)
Accessory ; per one unit
Inlet silencer 1pc.Outlet silencer 1pc
Safety valve 1pc, Pressure guage 1pc
V-belt 1set Belt cover 1pc
Flexible joint 1pc. Anchor bolt 1set
Base 1pc Unti-Swing rubber 1set

⑦[AirFlow meter] ……………………………………(Facility NO.FI-3)
Type ;Orifice type
Size ;300A (1,600 ~7800Nm³ /hr) One scale 200Nm ³ /hr
Flange sandwich type
Quantity ;8pcs
Accessory ;cock piece and handle 1pc/1pc

⑧[Chain hoist for blower house]………………(Facility NO.M-54]
Type ;Power operated type
Specification ;2.0 T x 4.0m x hoisting 1.5kw + travelling 0.4kw
Quantity ;2 set



AIR LINE FOR AERATION BLOWER

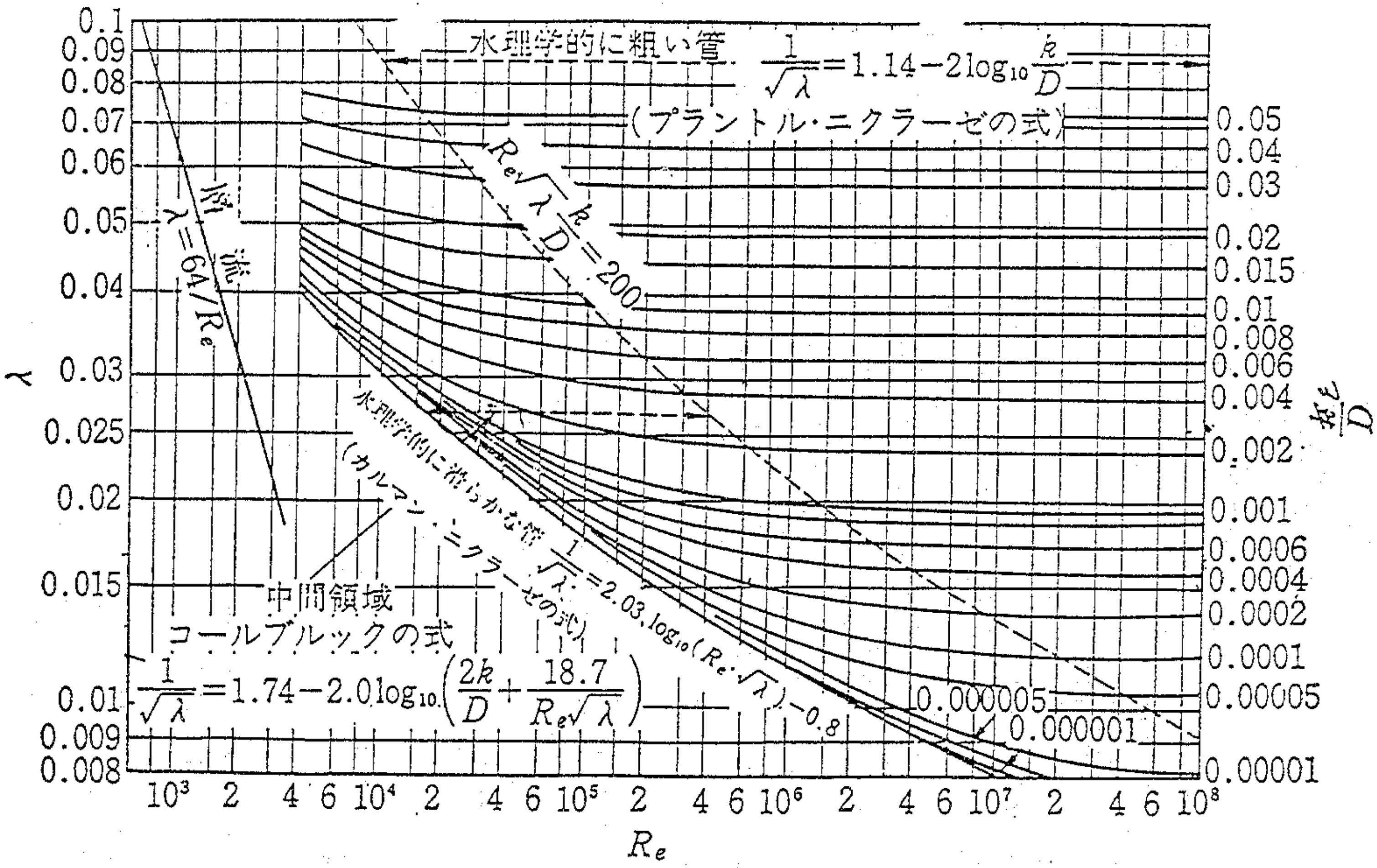


図 3.42 ムーディの図 (MOODY CURVE)

ε

e) Culculation table of air piping(friction loss)

Name	Dia Dmm	Length(m) pcs	capacity Qm3/min	velocity vm/sec	calculation	coeff-icency	Loss head mmaq
①～②					γ =1.198	λ	
Straight pipe	200	3.0	37.0	19.6	λ xL/Dxv² /2gx γ	0.015	5.3
Inlet mouth	200	1	37.0	19.6	fxv² /2gx γ	0.62	14.5
90° elbow	200	1	37.0	19.6	〃	0.36	8.5
Silencer	200	1	37.0	19.6	〃	1.5	35.3
(Total)							(63.6)
②～③							
Straight pipe	200	5.0	37.0	19.6	λ xL/Dxv² /2gx γ	0.015	8.8
Check valve	200	1	37.0	19.6	fxv² /2gx γ	2.0	47.0
Gate valve	200	1	37.0	19.6	〃	0.1	2.4
90° elbow	200	1	37.0	19.6	〃	0.36	8.5
Silencer	200	1	37.0	19.6	〃	1.5	35.3
Tee	800	1	37.0	4.9	〃	1.23	1.8
(Total)							(103.8)
③～④							
Straight pipe	800	6.0	148.0	4.9	λ xL/Dxv² /2gx γ	0.014	0.2
Tee	800	1	148.0	4.9	fxv² /2gx γ	1.23	1.8
(Total)							(2.0)
④～⑤							
Straight pipe	800	30.0	148.0	4.9	λ xL/Dxv² /2gx γ	0.014	0.8
90° elbow	800	2	148.0	4.9	fxv² /2gx γ	0.36	1.1
(Total)							(1.9)
⑤～⑥							
Straight pipe	800	26.0	296.0	9.9	λ xL/Dxv² /2gx γ	0.013	2.9
90° elbow	800	2	296.0	9.9	fxv² /2gx γ	0.36	4.3
(Total)							(7.2)

Name	Dia. Dmm	Length(m) pcs	capacity Qm ³ /min	velocity vm/sec	caluculation	coeff-icency	Loss head mmaq
⑥～⑦							
Straight pipe	800	15.5	259.0	8.6	$\lambda xL/Dxv^2/2gx\gamma$	0.013	1.2
(Total)							(1.2)
⑦～⑧							
Straight pipe	700	15.5	222.0	9.6	$\lambda xL/Dxv^2/2gx\gamma$	0.014	1.8
Down reducer	700	1	222.0	9.6	$fxv^2/2gx\gamma$	0.06	0.4
(Total)							(2.2)
⑧～⑨							
Straight pipe	700	15.5	185.0	8.0	$\lambda xL/Dxv^2/2gx\gamma$	0.014	1.3
(Total)							(1.3)
⑨～⑩							
Straight pipe	600	15.5	148.0	8.7	$\lambda xL/Dxv^2/2gx\gamma$	0.014	1.8
Down reducer	600	1	148.0	8.7	$fxv^2/2gx\gamma$	0.06	0.3
(Total)							(2.1)
⑩～①							
Straight pipe	500	15.5	111.0	9.6	$\lambda xL/Dxv^2/2gx\gamma$	0.014	2.5
(Total)							(2.5)
①～②							
Straight pipe	400	15.5	74.0	9.8	$\lambda xL/Dxv^2/2gx\gamma$	0.012	2.8
(Total)							(2.8)
②～③							
Straight pipe	400	15.5	37.0	4.9	$\lambda xL/Dxv^3/2gx\gamma$	0.012	0.7
(Total)							(0.7)
③～④							
Straight pipe	300	7.0	37.0	8.8	$\lambda xL/Dxv^2/2gx\gamma$	0.017	1.9
Tee	300	1	37.0	8.8	$fxv^2/2gx\gamma$	1.23	5.9
90° elbow	300	2	37.0	8.8	〃	0.36	0.4
B.F valve	300	1	37.0	8.8	〃		50.0
(Total)							(58.2)

Name	Dia. Dmm	Length(m) pcs	capacity Qm³ /min	velocity vm/sec	caluculation	coeff-icency	Loss head mmaq
④～⑤							
Straight pipe	300	18.0	37.0	8.8	λ xL/Dxv² /2gx γ	0.017	4.9
(Total)							(4.9)
⑤～⑥							
Straight pipe	250	18.0	27.8	9.5	λ xL/Dxv² 2gx γ	0.018	7.2
Down reducer	250	1	27.8	9.5	fxv² /2gx γ	0.06	0.4
(Total)							(7.6)
⑥～⑦							
Straight pipe	200	18.0	18.5	9.9	λ xL/Dxv² /2gx γ	0.018	9.7
Down reducer	200	1	18.5	9.9	fxv² /2gx γ	0.06	0.4
(Total)							(10.1)
⑦～⑧							
Straight pipe	150	18.0	9.3	8.8	λ xL/Dxv² 2gx γ	0.019	10.8
Down reducer	150	1	9.3	8.8	fxv² /2gx γ	0.06	0.3
(Total)							(11.1)
⑧～⑨							
Straight pipe	40	6.5	0.4	5.3	λ xL/Dxv² /2gx γ	0.028	7.8
Tee	40	2	0.4	5.3	fxv² /2gx γ	1.23	2.1
Grove valve	40	1	0.4	5.3	〃		50.0
90° elbow	40	1	0.4	5.3	〃	0.36	0.6
(Total)							(60.5)
Friction loss of inlet side (Total)							(63.6mmaq)
Friction loss of outlet side(Total)							(295.1mmaq)

e)Calculation of motor power(Blower)

(1)Average of available pressure (h)

$h = hs \times K/(K-1) \times \{(hd/hs)^{(K-1)/K} - 1\}$

hs	;Rerative pressure(inlet side)	(10332-200)	=10132mmaq
hd	;Rerative pressure(outlet side)	(10332+5480	=15812mmaq
K	;Coefficiency		=1.4

$h = 10132 \times 1.4/(1.4-1) \times \{(15812/10132)^{(1.4-1)/1.4} - 1\}$

=4809 mmaq

(2)Adiabatic air power of blower (P1)

$P1 = \{h \times (Q \times h0/hs)\}/6{,}120$

h	;Average of available pressure	=	4809mmaq
Q	;Suction air capacity	=	37.0 m^3 /min
hs	;Rerative pressure(inlet side)	=	10132mmaq
h0	;Atmospheric pressure	=	10332mmaq

$P1 = \{4809 \times (37 \times 10332/10132)\}/6{,}120$

=29.65 KW

(3) Motor power of blower (Ps)

$Ps = P1/\eta \times Ts/T \times d$

P1	;Adiabatic air power of blower	=	29.65KW
η	;Total adiabatic efficiency	=	0.63
Ts	;Rerative temperature of inlet side	(273+35.4)=	308.4 °K
T	;Minimum temperature	(273+10.4)=	283.4 °K
α	;Safety ratio	=	1.05

$Ps = 29.65/0.63 \times 308.4/283.4 \times 1.05$

=53.8 KW ——> 55.0kw

(10) Final sedimentation tank

DmaxQ =55,800m3/d
Over flow rate= less than 25(20)m3/m2.m2.day at DmaxQ
Retantion time=1.8 ~3.0 hour at DmaxQ
Capacity (v)=55,800x3.0/24=6,975m3 6,975m3 ÷ 4 line=1,744m3(each)
Depth (H)=2.5m
Dimension = 10.0mW x 70.0mL x 2.5mh x 4 pcs

[Return Sludge, to Aeration tank]
Maximum Return Sludge Ratio =50%
q =55,800 x 0.5 =27,900m3/day=6,975m3/day.each x 4 pcs
=290.7m3/hr(=4.85m3/min) x 4 pcs

[Sludge Generation]
Sludge Generation Ratio;
as 40.0% (Primary Sedimentation Tank)
as 86.8% (Aeration Tank + Final Sedimentation Tank)
SS Concentrate of Sludge; as 0.8 wt%
Removal SS =55,800 x 380 x (1-0.4) x 0.868 x 10 $^{-3}$
=11,043kg-SS/day 11,043÷4 line=2,761kg-SS/day.each
= 2,761kg-SS/day.each x 4 line

[Sludge Volume]
SV =11,043/0.008 x 10 $^{-3}$
=1,380.38m3/day
= 345.10m3/day.each x 4 line

[Auxiliary equipment]
①Rake ;Chain flight double link type…(5mwx2set)x4line
②Scum skimmer ;300mm Pipe skimmer …8set
③Return sludge pump;4.9m3/min …6pcs(2pcs)
④Sludge pump ;q=345.1/(12x60)x1/4=0.12m3/min, each
=0.2m3/min …6pcs(2pcs)

(10)-1. Sludge characteristics

Concentrate ;max 3.0%

Gravity : 1.02

(10)-2. Rake capacity(Q) =60 x V x h x ℓ

Q ;Sludge rake capacity ……………………m^3 /hr

V ;Raking speed ……………………0.3m/min

h ;Flight height ……………………0.18m

ℓ ;Filter width ……………………3.5m

Q =60 x 0.3 x 0.18 x 3.5=11.34m^3 /hr

(10)-3. Tension of chain

a). weight of rake parts(W1)=2 x w1 x (w2+w3)/P…… kg/m

w1 ;chain weight ……… 11.27kg/m(Stainless)

w2 ;flight weight ……… 37.0 kg/1pc

w3 ;attachment weight ……… 6.38kg/1pc

P ;flight pitch ……… about3.0m

W1 =2 x 11.27 + (37+6.36)/3.0=37.0kg/m

b). Carried sludge weight (W2)=(1,000 x Q x γ) /(60 x V)

w2 ;carried sludge weight ………kg/m

Q ;sludge volume …………………… 11.34m3/hr

γ ;Sludge gravity…………………… 1.02

V ;raking speed …………………… 0.3m/min

W2 =(1,000 x 11.3 x 1.02)/(60 x 0.3)=641kg/m

c). Primary tension of chain (P1)=200kg (2 line)

d). Tension of friction(Raking sludge and bottom tank)

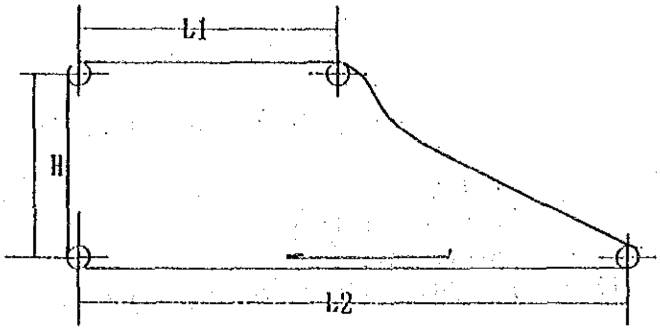
P2 =W2 x L2 x μ2

P2 ;Tension of friction(sludge and bottom of tank)
……………kg

W2 ;Raked sludge weight ……………………641kg

L2 ;Length of horizontal shaft center …65m

μ2;Friction coefficiency(Sludge to bottom) …0.05



P2=641 x 65 x 0.05 =2,084 kg

e). Tension of friction(rail to flight shoe)

P3=W1 x L x μ1

P3 ;Tension of friction(rail to flight shoe) ···kg

W1 ;Flight weight ··········37.0kg/pc

L ;2 x L2 ······ 135m

μ2 ;Friction coefficiency(rail to shoe)·········· 0.3

P3=37.0 x 135 x 0.3 =1,499kg

f). Tension of lift up

P4=W1 x H

P4 ;Tension of lift up ·················kg

W1 ;Flight weight ·················37.0kg/1pc

H ;Length of vertical a shaft center·············2.5m

P4=37.0 x 2.5 =92.5 kg

g). Friction loss of pillow block

P5=(P1+P2+P3+P4) x 0.1

=(200 + 2,084 + 1,499 + 92.5) x 0.1=388 kg

h). Tension of chain

P =P1 + P2 + P3 + P5

=200 + 2,084 + 1,499 + 92.5 + 388=4,263.5kg i). Power of motor(Drive unit)

$PS = (n \times P \times V)/(6,120 \times \eta) \times \alpha$

PS ;Power of motor ………KW

n ;Sedimentation tank quantity of drive ……2

P ;Tension of chain ……4,263.5kg

V ;raking speed ………0.3m/min

η ;Total efficiency ………0.7

α ;Safety ratio ………2

$PS = (2 \times 4,263.5 \times 0.3)/(6,120 \times 0.7) \times 2 = 1.195kw$

Power of motor ——> 2.2KW

(10)-4. Chain strength calculation

a). From tension of chain

chain 2 line Tension of one side(P)=70%

$S = P_0 / (0.7 \times P)$

S ;Safety ratio of chain

P_0 ;Average breaking stregth of chain 25,000 kg

P ;Tension of chain 4,263.5kg

$S = 25,000/(0.7 \times 4,263.5) = 8.37$

b) Tension of chain from motor torque

①Tension of chain from motor output

$T = (6,120 \times PS \times \eta \times fo)/v$

PS ;Output of motor ……………………………………2.2kw

η ;Total efficiency ……………………………………0.7

fo ;Coefficiency(against total load for one side chain) …0.7

v ;Raking speed ……………………………………0.3m/min

$T = (6,120 \times 2.2 \times 0.7 \times 0.7)/0.3 = 22,992kg$

②Safety ratio of chain

S =Po/T

Po ;Average breaking stregth of chain ………………25,000kg

T ;Tension of chain …………………22,992kg

$S = 25,000/22,992 = 1.087$

(10)-5. Strength of drive shaft calculation

$Mt = 97,370 \times Ps/r \times \eta$

$Mt = \pi/16 \times d^3 \times \tau$

$d = \sqrt[3]{97,300 \times (16 \times Ps \times \eta)/(\pi \times \tau \times r)}$

Mt ;Twist moment of drive shaft ……………………………kg-cm

Ps ;Power of drive motor ……………………………2.2kw

η ;Drive efficiency ……………………………0.78

τ ;Twist stress allowed ……………………………860kg/cm

r ;Rotation of drive shaft ……………………………0.179rpm

r = v/(p x z)

v ;Raking speed ……………………………0.6m/min

P ;Pitch of drive sprocket ……………………………0.1524m

z ;Teeth of drive sprocket ……………………………11

r = 0.3/(0.1524 x 11) =0.179rpm

$d = 116 \times \sqrt[3]{(2.2 \times 0.78)/(\pi \times 860 \times 0.179)} = 17.69cm$

plus key ditch depth…………177mm+10mm=187mm

Drive shaft diameter………………190mm Φ

①[Specification of rake for final sedimentation tank]…(Facility NO.M-30)

Type ;Chain flight double link type

Tank dimension;Width5,000mm x Length70,000mm x Depth2,500mm

Length of rake;approx 65,000mm

Raking speed ;approx 0.6m/min

Flight pitch ;approx 3,000mm

Drive unit ;Cycro-reduction motor 2.2kw

Material ;Chain(stenless steel or plastic), Flight(Plastic)
Rail(15kg/m), Bolt/Nut(Stainless steel)

Quantity ;(5.0mW x 2set) x 4 line

Accessories ;

A ;Drive unit 2.2kw 4 pcs

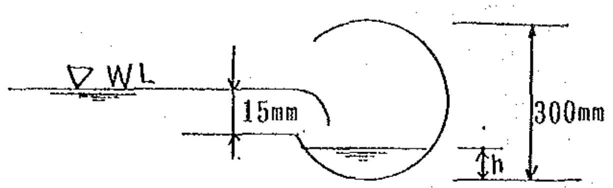
B ;Grease up nozzle (4 pcsx 2 x 8 line)64pcs

C ;Weir (24m x 2) 4 pcs

(10)-6. Scum skimmer

Type and diameter ;Pipe skimmer 300mm

Scum effluent volume;



$Q = k \times B \times H^{3/2}$

k ;effluent coefficiency ……………119

B ;width of slit ……………approx4.0m

H ;over flow water depth………………0.015m

$Q = 119 \times 4.0 \times 0.015^{3/2} = 0.874$ m3/min

Water depth of inside pipe skimmer……………h

$h = ho / \sqrt{3}$

ho ;water depth of the upper stream max0.15m

$h = 0.15/\sqrt{3} = 0.087$m

max effuluent volume of pipe skimmer

$Qo = \sqrt{g \times D^2 \times h^3}$

Qo;max effuluent volume ………………m3/sec

g ;accelation of gravity………………9.8m/sec²

D ;diameter of gravity…………………0.3m

h ;effluent water depth ………………0.087m

$Qo = \sqrt{9.8 \times (0.3)^2 \times (0.087)^3} = 0.024$ m3/sec

$= 1.45$ m3/min > 0.874m3/min OK

②[Specification of scum skimmer for F.S.T.]………Facility NO.M-31)

Type	;Pipe skimmer
Pipe diameter	;300mm Φ
Length	;5,000mm(Slit width 4,000mm)
Motor	;0.4kw
Quantity	;8pcs

(10)-7. Sludge pump for final sedimentation tank

a)Sludge volume ;Q=1,380.38m3/day‥‥‥‥Actual pump 4pcs

Pump capacity=q=(1,380.38m3/d)/(12 x 60)x 1/4=0.479m3/min(each)

=approx0.6m3/min(each)

b)Pump diameter;D1=146 $\sqrt{Q/v}$　　v=1.5 ～2.5m/sec

=146 $\sqrt{0.6/(1.5\sim2.5)}$= 71.5～ 92.3mm ⟶ 80mm

c)Sludge Piping diameter;Sludge total volume=0.6m3/min x 4pcs=2.4m3/min

D2=146 $\sqrt{2.4/(1.5\sim2.5)}$ =143 ～184.7mm ⟶ 200mm

d)Pump head (Final sedimentation tank ⟶ Sludge Thickener

Acutual head(H1) =▽+9.5m-▽+1.0m=8.5m

Pipe length L(200)=290m ‥‥‥‥‥

L(80) =2m+2m+2m+4m=10m

Pipe loss head

Inlet mouth loss	H2(80)=f x v^2 /2g　　f=1.0	
	v(80) =0.6m3/(60x3.14/4x D^2)=1.990m/sec	
	v(200)=2.4m3/(60x3.14/4x D^2)=1.274m/sec	
	H2(80) =1.0x$(1.990)^2$ /19.6=0.202m	
Piping loss	H =f1 x L/D x v^2 /2g	
	f1(80) =0.02+0.0005/D=0.0263	
	f1(200)=0.02+0.0005/D=0.0225	
	H3(80) =0.0263 x 10/0.08 x $(1.990)^2$ /19.6=0.665m	
	H4(200) =0.0225 x 290/0.2 x $(1.274)^2$ /19.6=2.702m	
Tee loss	H =f x v^2 /2g　f=1.2	
	H5(80) =1.2 x $(1.990)^2$ /19.6 x 2pcs	=0.485m
	H6(200) =1.2 x $(1.274)^2$ /19.6 x 2pcs	=0.199m
Elbow loss	H =f x v^2 /2g　f=0.2	
	H6(80) =0.2 x $(1.990)^2$ /19.6 x 1pc	=0.041m
	H7(200) =0.2 x $(1.274)^2$ /19.6 x 8pc	=0.133m
Gate valve loss	H =f x v^2 /2g　f(80)=0.164 f(200)=0.103	
	H8(80) =0.164 x $(1.990)^2$ /19.6 x 5pcs	=0.170m
	H9(200) =0.103 x $(1.274)^2$ /19.6 x 6pcs	=0.052m
Check valve loss	H =f x v^2 /2g　f(80)=1.8	
	H10(80) =1.8 x $(1.990)^2$ /19.6 x 1pc	=0.364m

Total head=H1 ～H10 =8.500+0.202+0.665+2.702+0.485+0.199+0.041+0.133+0.170+0.070+0.364=13.513m ⇒ 17m e)Power of motor (PS)

PS =0.163 x (γ x Q x H)/ η x α

γ ;Gravity of sludge……………………1.02

Q ;Flow volume ……………………0.6m3/min

H ;Total head ……………………17.0m

η ;Efficiency of pump …………………40%

α ;Safety ratio …………………1.2

PS =0.163 x (1.02 x 0.6 x 17) / 0.4 x 1.2 =5.09kw ⟶ 5.5kw

③[Specification of sludge pump for F.S.T.] …………(Facility NO.M-33)

Type ;Horizontal sludge pump

Specification;80x80x0.6m3/minx17mx5.5kw

Quantity ;6pcs(2pcs spare)

(10)-8.Sludge return pump

a)Sludge return volume ;Q=290.7m3/hrx4pcs(=4.85m3/minx4pcs)

Sludge capacity ;Q=4.9m3/minx4pcs

b)Pump diameter ;D1=146$\sqrt{Q/v}$ v=1.5～2.0m/sec

=146$\sqrt{4.9/1.5 \sim 2.0}$ =228.6～263.9mm ⟶ 250mm

c)Piping diameter ;D2=146$\sqrt{Q/v}$ v=1.0～2.0m/sec

=146$\sqrt{4.0/1.0 \sim 2.0}$ =228.6～323.2mm ⟶ 300mm

d)Pump head (Final sedimentation tank ⟶ Aeration tank)

Actual head (H1) =(+10.50)-(+ 7.80)=2.70m

Inlet mouth loss H2(250)=f x v ^{2} /2g f=1.0

v(250)=4.9m3/(60x3.14/4xD^2)=1.665m/sec

v(300)=4.9m3/(60x3.14/4xD^2)=1.156m/sec

H2(250)=1.0x(1.665) ^{2} /19.6 =0.142m

Piping loss H =f x L/D x v ^{2} /2g

f(250)=0.02+0.0005/D=0.0220

f(300)=0.02+0.0005/D=0.0217

L(250)= 30m H3(250) =0.0220x(30/0.25)x(1.665)^2 /19.6 =0.374m

L(300)=120m H4(300) =0.0217x(120/0.3)x(1.156)^2 /19.6 =0.592m

Tee loss H =f x v ^{2} /2g f=1.2

H5(250)=1.2 x (1.665) ^{2} /19.6 x 4pcs =0.679m

H6(300)=1.2 x (1.156) ^{2} /19.6 x 2pcs =0.164m

Elbow loss H =f x v^2 /2g f=0.2

H7(250)=0.2 x $(1.665)^2$ /19.6 x 1pc =0.029m

H8(300)=0.2 x $(1.156)^2$ /19.6 x 7pcs =0.096m

Gate valve loss H =f x v^2 /2g f(250)=0.047

H9(250)=0.047 x $(1.665)^2$ /19.6 x1pc =0.007m

Check valve loss H =f x v^2 /2g f=1.8

H10(250)=1.8 x $(1.665)^2$ /19.6 x 1pc =0.255m

Total head (H)=H1+～H10=2.7+0.142+0.374+0.592+0.679+0.164+0.029
+0.096+0.007+0.255
=5.038m ——>8.0m

e).Power of motor (PS)

PS =0.163 x (γ x Q x H)/ η x α

γ ;Gravity of sludge ……………………1.02
Q ;Flow volume ……………………0.6m3/min
H ;Total head ……………………8.0m
η ;Efficiency of pump……………………45%
α ;Safety ratio ……………………1.2

PS =0.163 x (1.02 x 4.9 x 8.0)/0.45 x 1.2=17.4kw ——> 18.5kw

④[Specification of sludge return pump for F.S.T.]……(Facility NO.M-32)

Type ;Horizontal sludge pump
Specification;250 x 250 x 0.49m3/min x 8.0m x 18.5kw
Quantity ; 6pcs(2pcs spare)

(10)-9.Scum transfer pump for final sedimentation tank

a)Scum transfer volume;0.847m3/min ——> 0.88m3/min

b)Pump diameter ;$D1=146\sqrt{Q/v}=146\sqrt{0.88/(1.5 \sim 3.0)}$
=79 ～112mm ——> 100mm
v(100)=0.88m3/(60 x 3.14/4 xD^2)=1.869m/sec

c)Pump head

Acutual head (H1) =(▽+9.2)-(▽+5.5)=3.7m
Pipe length =250m
Loss head
Piping loss H2(100)=f x L/D x v^2 /2g f=0.025

=0.025x250/0.1x(1.869) ^{2} /19.6 =11.139m

elbow loss H3(100)=f x v ^{2} /2g ， f=0.2

=0.2x(1.869) ^{2} /19.6x 6pcs =0.214m

check valve loss H4(100)=f x v ^{2} /2g f=1.8

=1.8x(1.869) ^{2} /19.6 x 1pc =0.321m

gate valve loss H5(100)=f x v ^{2} /2g f=0.164

=0.164x(1.889) ^{2} /19.6 x 1pc =0.030m

Total head=H1+ ～+ H5=3.7+11.139+0.214+0.321+0.030=15.404m ⟶ 16m

d)Power Of motor (PS) =0.163 x (γ xQ x H)/ η x 1.2

γ ;Gravity of scum 1.0

Q ;Flow volume 0.88m^3 /mi …0.9m^3 /min

H ;Total head 16.0m

η ;Efficiency of pump 60%

α ;Safety ratio 1.2

PS = 0.163 x (1.0 x 0.9 x 16.0)/(0.60) x 1.2 = 4.694kw ⟶ 5.5kw

⑤[Specification of scum transfer pump for F.S.T.] ……(Facility NO.M-34)

Type ;Submersible pump

Specification;100 x 0.9m3/min x 16m x 5.5kw

Quantity ;4PCS (2pcs spare……ware house)

Accessory ;Cable 10m,Chain 6m/1pc(Stainless steeL),
Guide pipe 1set/1pc(Stainless steel),
Automatic connection 1set/1pc

⑥[Floor drain pump for F.S.T.pump room]……………………(Facility NO.M-35)

Type ;Submersible pump

Specification;50mm x 0.1m^3 /min x 10m x 0.75kw

Quantity ;2pcs(1pc spare)

(ii).Chlorine Contact tank

Flow rate; DaveQ=46,500m3/day HmaxQ=93,000m3/day

Chlorine contact time=15min at HmaxQ

=30min at DaveaQ

Capacity

V1 =93,000m3/day x 15/(24 x 60) =967m3

V2 =46,500m3/day x 30/(24 x 60) =967m3

V =967.0m3 =121m3 x 8pcs

Dimension ;2.0w x 25.0mL x 2.5mh x 8pcs

Capacity ;V=2.0 x 25.0m x 2.5mh x 8=1,000m3

Chlorine dosing ratio :6mg/ℓ at DmaxQ(DmaxQ=55,800m3/day)

Q = 55,800m3/day x 6mg/ ℓ x 10⁻³= 334.8 kg/day

334.8 kg/day÷24hr =13.95kg/hr at 2pcs

1pc dosing capacity=13.95kg/2 pcs=7.0kg/hr(each)

①[Specification of chlorinator]…………………(Facility NO.M-56)

Capacity ;10.0kg/hr

Quantity ; 3pcs (1pc…stand-by)

Accessory ;Flow indicator and pressure gauge

②[Specification of Chlorine container] ………(Facility NO.M-55)

Capacity ;1ton

Chlorine gas Storage=more than 30days

=334.8kg/d x 30 days =10,044 kg

=10,044 k÷1,000kg =10.05pcs ---> 12pcs

Quantity ;12 pcs

Accessory ;Auxiliary valve,Flexible connector,Tank manifold,

Pressure indicator alarm.

③[Specification of Booster pump] ……………… (Facility NO.M-57)

Specification;65mm x 0.3m3/min x 40m x 5.5kw

Quantity ;3pcs (1pc…standby)

Accessory ;Pressure gauge 2pcs/1pc

④[Specification of injector] …………………… (Facility NO.M-75)

Specification;40mm

Quantity ;3pcs(1pc …standby)

Accessory ;Pressure gauge 1pc/1pc

⑤[Specification of contorol panel for chlorination]…(Facility NO.M-79)

Type ;Stand type

Quantity ;1pc

⑥[Specification of chain hoist for chlorination house] …(Facility NO.M-58)

Type ;Power operated type

Specification;2.0 Ton x 4.0mh x (380v 1.5kw+0.4kw)

Quantity ;1pc

⑦[Specification of chlorine gas neutralization unit] …(Facility NO.M-59)

Type ;Packed column gas-liquid contact(2 column system)

Specification; 500 kg/hr

Chamical ;15% NaOH solution (Gravity=1.165)

⑦-1. NaOH 15% storage tank;16m3 x 1 tank

⑦-2. NaOH dissolve tank;1.0 m3 steel tank(with mixer;3Φx380Vx0.75kwx1 pc)

NaOH required=16m3 x 15/100 x 1.165 =2.796 ton

NaOH dissolve tank=1.0 m3(45% liquid)=1.0 x 45/100 x 1.48 =0.666 ton

Dissolve times= 2.796/0.666 =4.2 ---> approx 5 times

⑦-3. NaOH circulation pump;900 l/min x 15 m x 5.5 kw x 2 pcs(1 pc spare)

⑦-4. Exhaust fan ;45 m3/min x 250 mmaq x 3.7 kw x 2pcs(1pc spare)

⑦-5. Chlorine gas leak detector;Type;Diffusion type diaphragm electrode

Range:0~3 ppm Power source;1 Φ x 100V

Quantity,1 set (with sensor 3 points)

2 points(Chlorine cylinder room),1 point (chlorine dosing room)

⑧[Specification of drain pump for chroline house]……(Facility NO.M-80)

Type ;Submersible pump(Chemical pump)

Specification;50mm x 0.1 m3/min x 10m x 0.75 kw x 2 pcs(1 pc spare)

Quantity ;2 pcs(1 pc spare)

(12)Filtered tank RC

DmaxQ=55,800m3/day

Retention time;8 min at DmaxQ

Capacity(V)=55,800m3/d x 8/1,440=310.0m3 ------> 350m3

Dimension ;8.0m x 8.85m x 2.5mh x 2pc

Volume ;8.0 x 8.85 x 2.5 x 2 =354m3

①[Specification of inlet gate for filter tank] ……(Facility NO.M-37)

Type ;Sluice gate

Specification ;Manual operation ,, 1.000x1000
Quantity ;2 pcs

(13)Spray pump (For deforming aeration tank and sludge pipe washing etc.)

a)Required flow capacity: for 2 line Aeration tank (at one spray pump)
Q =48pcs x 2line x 10ℓ /min.1pc =960 ℓ /min ——> 1.0m3/min

b) Pump diameter :D1=146√ Q/v =146√ 1.0/(1.5~3.0)
=84.3 ~119.2mm ——> 100mm
v(100)=1.0/(60 x 3.14/4 x D1²)=2.123m/sec

Main pipe dia. ;D2=146√ Q/v=146 √ 4.0/(1.0~2.0)=206~292mm ⇒ 250mm
v(250)=4.0/(60 x 3.14/4 x D2²)=1.359m/sec

c)Pump head

Acutual head (H1) =(▽+9.20m)- (▽ +4.32m) =4.88m
(Sludge line washing water supply for sludge feeding inlet side)

Required pressure for spray nozzle Ho = 1.0kg/cm² =10.0m

Straight pipe loss; H=f x L/D x v² /2g
f(250)=0.02 +0.0005/D=0.022
f(125)=0.02 +0.0005/D=0.024
f(100)=0.02 +0.0005/D=0.025
v(125)=1.0/(60 x 3.14/4 x D²)=1.359m/sec
v(100)=0.5/(60 x 3.14/4 x D²)=1.062m/sec

pipe length L(250)=9+3+8+85+20+82+70+20+30+40+4=371m ——> 380m
L(125)=3.0+30 = 33m ——> 40m
L(100)=20 = 20m ——> 20m
L(100)=5 = 5m ——> 5m

H2(250)=0.022 x 380/0.25 x (1.359)² /19.6 =3.151m
H3(125)=0.024 x 33/0.125 x (1.359)² /19.6 =0.597m
H4(100)=0.025 x 20/0.1 x (1.062)² /19.6 =0.288m
H5(100)=0.025 x 5/0.1 x (2.123)² /19.6 =0.289m

elbow loss H = f x v² /2g f=0.2
H6(250)=0.2 x (1.359) ² /19.6 x 8pcs =0.151m

tee loss H = f x v² /2g f=1.2
H7(250)=1.2 x (1.359) ² /19.6 x 4pcs =0.453m

Gate valve loss H = f x v² /2g f(100)=0.164 f(250)=0.047
H8(250)=0.047 x (1.359) ² /19.6 x 1pcs =0.005m
H9(125)=0.164 x (1.062)² /19.6 x 1pc =0.010m

H10(100)=0.164x $(2.123)^2$ /19.6 x 1pc =0.038m

Check valve loss $H = f \times v^2 / 2g$ f(100)=1.8

H11(100)=1.8 x $(1.062)^2$ /19.6 x 1pc =0.104m

Total head=Ho+ ~ +H10=10.0+3.151+0.597+0.288+0.289+0.151+0.453+0.005 +0.010+0.038+0.104 = 15.086m ——> 20m

d)Power Of motor (PS)=0.163 x (γ x Q x H)/η x 1.2

γ ; Gravity of treated water ········1.0

Q ; Flow volume ·······················1.0m3/min

H ; Total head ····················· 20.0m

η ; Efficiency of pump············ 60%

α ; Safety ratio···················· 1.2

(PS)=0.163 x (1.0 x 1.0 x 20.0)/0.60x 1.2 =6.52kw ——> 7.5kw

①[Spray pump specification]························(Facility NO.M-36)

Type ;Submersible pump

Specification;100mm x 1.0m3/min x 20.0m x 7.5kw

Quantity ;6pcs(2pcs stand-by)

Accessory ;Cable 10m/1pc,Chain 6m/1pc(stainless steel),
Guide pipe 1set/1pc.(stainless steel),

②[pump hunger] ·······································(Facility NO.M-76)

Type ;Mild steel Pump hunger

Quantity ;1set/6pcs

Accessory ; 0.5ton manual operation chain hoist 1pc

(14).Treated water tank RC

DmaxQ=55,800m3/day

Retention time ;5min at DmaxQ

Capacity ;V=55,800m3/day x 5/(24 x 60)=193.7m3 ——> 200m3

Dimension ;8.85m x 5.0m x 2.5mh x 2pcs

Capacity ;V=8.85 x 5.0 x 2.5x 2pcs=221.25m3

①[Specification of inlet gate for treated water tank]···(Facility NO.M-37)

Type ;Sluice gate

Specification ;Manual operation 1,000x1,000

Quantity ;1 pcs

②[Specification of Inlet gate for chlorine tank ··········(Facility NO.M-42)

Type ;Sluice gate
Specification ;Manual operation '' 1,000x1,000
Quantity ;3 pc

(15).Sludge thickener

Influent flow and quality

Sources of sludge Generation	Quantity (m3/day)	SS (mg/ℓ)	(kg-DS/day)
Primary sedimentation tank	424.08	20,000	8,481.6
Final sedimentation tank	1,380.38	8,000	11,043.0
Back-washed water of filter	(2,720.00)	(942.6)	(2,564.0)
Separated water and washed water			
Total	4,524.46	4,882	22,088.6

Solid loading ;25~59kg/m ^{2} .day
Hydraulic loading;16~32m ^{3} /m ^{2} .day
Surface area (SA);22,088.6/40=553m^2

Dimension ;
D = √(553 x 1/2)/(3.14/4) =18.3m ---> 19.0m Φ
=19.0mΦ x 3.0mh x 2 pcs
Surface area; SA={3.14 x (19.0) ^{2} } /4 = 283.5m ^{2} (each)
283.5m ^{2} x 2pcs =567 m ^{2}
Capacity ; V =567m ^{2} x 3.0mh =1,701 m^3
Solid loading; SL=22,088.6/567 = 39.0kg/m ^{2}.day………OK
Hydraulic loading; HL=4,524.6/567 =8.0m ^{3} /m^2 .day………OK
Retention time ;
RT=(1,701/4,524.46) x 24 = 9.0 hour
Concentrated sludge volume;(Sludge water rate=98%)
CSV= 22,088.6/(1-0.98) x 10 $^{-3}$ =1,104.43 m^3 /day= 0.77m ^{3} /min
Sludge drawing out method; Gravity
Effluent water;
ESW=(4,524.46m^3 /day)-(1,104.43m^3 /day)=3,420.03m ^{3} /day

Auxiliary equipment;

Rake ; 2 set

Scum box; 2set

a). Power of thickener drive unit

Sludge volume at one hour;(Sludge water rate=98%)

Q(98%) =1,104.43m^3 /day= 46.02m^3 /hour

One rotation time;t=(D x π)/(v x 60) v=2m/min

t=(19.0 x 3.14)/(2.0 x 60) = 0.497hour

Sludge volume at t(=0.497 hour)hour

Qt=Q(98%) x t =(46.02m^3 /hour) x 0.497 hour = 22.87m^3 /t hour (one rotation)

Drive unit

Reducing ratio :1/44,500

Torque allowed ;600kg-m

Rotation ;1,500rpm /44.500=0.0337rpm

Speed ;19.0 x 3.14 x 0.0337rpm =2.01m/min

a)Power of Rake (P1)

$P1 = Po/\eta 1$

Po;theoretical rake power (kw)

η1;Efficiency of rake

$$\eta 1 = \frac{f \cot \alpha - 1}{\Phi \sin(\beta+\gamma)\{\cot \beta + (\sin(\beta+\gamma))/(\cot(\beta+\gamma)) + 1/\Phi\}}$$

f ;Friction coefficiency of sludge……………0.55

α ;Taper angle of bottom ……………2.5 °

β ;Brade angle against rake arm ……………45°

γ ;Friction angle of sludge against plate ……25°

$$\Phi = \sqrt{f^2 \times \cot^2 \alpha - \sin^2(\beta+\gamma)} - \cos(\beta+\gamma)$$

$$\Phi = \sqrt{(0.55)^2 \times \cot^2 2.5° - \sin^2(45° + 25°)} - \cos(45° + 25°)$$

=12.22

$$\eta 1 = \frac{0.55 \times \cot 2.5^\circ - 1}{12.22 \times \sin(45^\circ + 25^\circ)\{\cot 45^\circ (\sin(45^\circ + 25^\circ))/(\cot(45+25)+1/12.22)\}}$$

=0.637

$Po=1/6,120 \times Q \times (f \times \cos\alpha - \sin\alpha) \times (2D1^3 + D2^3 - 3D1^2 \times D2)/6(D1^2 - D2^2)$

Q ;Influent Sludge volume (drysolid)=0.77m3/minx0.02=0.0154kg/min-DS
D1;Thickener diameter =19.0mΦ
D2;Rake hopper diameter ≒ 3.0mΦ

$Po=0.0154/6,120 \times (0.55 \times \cos 2.5^\circ - \sin 2.5^\circ)$
$\times \{(2 \times 19.0^3 + 3.0^3 - 3 \times 19.0^2 \times 3.0^2)/6\{(19.0^2 - 3.0^2)\}$

$Po=0.00241 \times 10^3$ kw

$P1=po/\eta 1=0.00241/0.637=0.00379$ kw

b)Power of friction loss ;(P2)

$P2 = N/974 \times (W \times d \times \mu)/2$

N ;Rake rotation speed ……………………0.0337 rpm
W ;Machine Weight(part of rotation)………8,500 kg
d ;Diameter of drive bearing ………………1.20 m
μ ;Friction efficiency of bearing…………0.1

P2 =0.0337/974 x (8,500 x 1.2 x 0.1)/2=0.0177 kw

c) Power of solution loss (P3)

$P3 = 1.000/102 \times (C \times \rho \times A \times v^3)/2g$

ρ ;Gravity of sludge ……………………1.05
C ;Coefficiency of rake arm…………………4
A ;Resistance area of rake arm ……………3.0m2
v ;Circumference speed ……………2.01 m/min ≒0.0335m/sec
g ;Acceration of gravity …………………9.8m/sec²

$P3 = 1,000/102 \times (4 \times 1.05 \times 3.0 \times 0.0335^3)/19.6 = 0.000237kw$

d)Power of motor (PS)

$PS = (P1 + P2 + P3)/\eta o \times \alpha$

$\eta 0$;Total efficiency ……………0.4

α ;Safety ratio ……………3

$PS = (0.00379 + 0.0177 + .000237)/0.4 \times 3.0$

$= 0.163$ kw < 1.5 kw OK

①[Specification of sludge thickener] …………………(Facility NO.M-38)

Type ;*Center post drive type*

Specifiocation; 19.0mΦ x 3.0mH x 2.0m/min x 1.5kw

Quantity ; 2 pcs

Accessory ;Bridge(SS41), Center post(SS41), Drive unit, Rake, Center post,

(15)-2. Pipe line for effuluent separated water (to Raw water pump station)

Volume of effuluent separated water;Q=3,420.03m ^{3} /day

Effuluent time ;12 hour

3,420.03m ^{3} /12hr=285m^3 /hr=4.75m ^{3} /min

Effuluent pipe dia.;$D=146\sqrt{Q/v}$ v=0.6m/sec

$D=146\sqrt{4.75/0.6} = 410.8mm \longrightarrow 450mm$

(15)-3. Pipe line for sludge drain line (to Sludge basin)

Volume of sludge drain;0.77m ^{3} /min (One thickener)

Pipe dia. $D1=146\sqrt{Q/v}$ v=0.6m/sec

$=146\sqrt{0.77/0.6} = 165.4mm \longrightarrow$ 250mm

$D2=146\sqrt{1.54/0.6} = 233.9mm \longrightarrow$ 350mm

②[Specificatipn of sludge drain valve for Sludge thickener

…(Facility NO.M-40)

Type ;Reverse action Diaphragm valve(with actuator)

Dia. ;250mm

Material ;Diaphragm(Rubber)

Quantity ;2 pcs

Accessory ;3-way solenoid valve 1pc/1pc,

ON-OFF Limit switch 1 set/1pc

(15)-4. Required air capacity of actuator for sludge drain valve

$Q = V(P + Pa)/ Pa$

Q ;Required air capacity (Nℓ)
V ;Capacity of air cylinder for actuator (ℓ) 22.6 ℓ
P ;Operation pressure (kg/cm^2 .G) 4.0kg/cm^2 .G
Pa;Atmospheric pressure (1.0 kg/cm^2 .abs)

Q =22.6(4+1)/1 x 2 pcs = 226ℓ

Acutuator action =1 action/min ⟶ 250 ℓ /min

③[Specification of compressor for sludge drain valve]…(Facility NO.M-69)
Type ;Pressure ON-OFF type
Specification;250ℓ /min x 9.5 kg/cm^2 x 2.2kw
Quanyity ; 2 pcs(1pc spare)
Accessory ;Air filter 1set/2pcs, Regulator 1set/2pcs

④[Specification of floor drain pump for thickener valve room
……(Facility NO.M-39)
Type ;Submersible pump
Specification;50mm x 0.1m^3 /min x 10m x 0.75kw
Quantity ;2pcs(1pc spare)

(16). Sludge basin
Concentrated sludge volume =1,104.43m3/day=0.77m3/min
Retention time RT= more than 12.0 hour
Capacity (V)=1,104.43 x 12/24 =552.2 m3 ⟶ 560m3
=280m3 x 2 pcs = 560m3
Dimension ; 10.0m x 10.0m x 3.0mh x 2pcs
Capacity ;V=10.0 x 10.0 x 3.0mh x 2 pcs =600m3 >560m3 OK
Retention time ;RT=600/(1,104.43) x 24 =13.0 hour

Auxiliary equipment;

(1) Sludge basin Mixing blower

a)Required air capacity (q)=600m3 x 1.0m3/m3.hour x 1/60 =10.0m3/min
=10.0m3/min(each) x 2 pcs (1 pc stand-by)

b)Diameter of blower

D =146√Q/V   V=20 ~30m/sec
=146√10.0/(20 ~30)=84.3mm~103.3mm ———>125mm

c)Pressure of blower H=(water depth)3000mm+(loss)500mm=3500mma

⑤[Specification of sludge basin mixing blower] ···(Facility NO.M-51)

Type ;Roots blower
Specification; 125mm x 10.0m3/min x 3500mmaq x 11.0 kw
Quantity ;2pcs (1pc stand-by)

⑥[Specification of diffuser for sludge basin]···(Facility NO.M-41)

Type ;Disc type
Specification;200 ℓ /min/pc
Quantity ;50 pcs

⑦[Air flow meter for sludge basine]·················(Facility NO.FI-4]

Type ;Orifice type
Specification; 125mm x 250~1,250 Nm³ /H
Quantity , 1 pc

(2)Sludge feeding pump (to sludge bed)

a)Capacity ; (q)= 1,104.43m3/day x 1/(8.0hour x 60) x 1/4 pcs
=0.58m3/min ———> 0.6m3/min

b)Pump diameter;D)=146 √Q/v=146 √0.6/(1.5~3.0)
=50.6mm~92.3mm ———> 80mm
V(80)=0.6/(60 x 3.14/4 x D²)=1.987 m/sec

c)Pump head

Actual head (H1)=▽152.0m - ▽+4.2 = 47.8m
Straight pipe lossH=fx L/D x v ² /2g
f(80) =0.02 + 0.0005/D =0.0263

$f(250)=0.02 + 0.0005/D = 0.0220$

pipe length L(80)=6.5m L(250)=1,050m

$v(80) = 0.6/(60 \times 3.14/4 \times D^2) = 1.987$ m/sec

$v(250) = 2.4/(60 \times 3.14/4 \times D^2) = 0.816$ m/sec

$H2(80) = 0.0263 \times 6.5/0.08\ (1.987)^2/19.6 = 0.431$ m

$H3(250) = 0.0220 \times 1,050/0.25 \times (0.816)^2/19.6 = 3.139$ m

Elbow loss $H = f \times v^2/2g$ $f=0.2$

$H4(80) = 0.2 \times (1.987)^2/19.6 \times 3pcs = 0.121$ m

$H5(250) = 0.2 \times (0.816)^2/19.6 \times 7pcs = 0.048$ m

Tee loss $H = f \times v^2/2g$ $f=1.2$

$H6(250) = 1.2 \times (0.816)^2/19.6 \times 1pc = 0.041$ m

Gate valve loss $H(80) = f \times v^2/2g$ $f(80)=0.164$ $f(250)=0.047$

$H7(80) = 0.164 \times (1.987)^2/19.6 \times 2\ pcs = 0.066$ m

$H8(250) = 0.047 \times (0.816)^2/19.6 \times 1\ pc = 0.002$ m

Check valve loss $H = f \times v^2/2g$ $f=1.8$

$H9(80) = 1.8 \times (1.987)^2/19.6 \times 1pc = 0.363$ m

Total head =H1 ～H9=47.8+0.431+3.139+0.121+0.048+0.041+0.066+0.002
+0.363 =52.011m ⟶ 53.0m

d)Power of motor (PS)

$PS = 0.163 \times (\gamma \times Q \times H)/\eta \times 1.2$

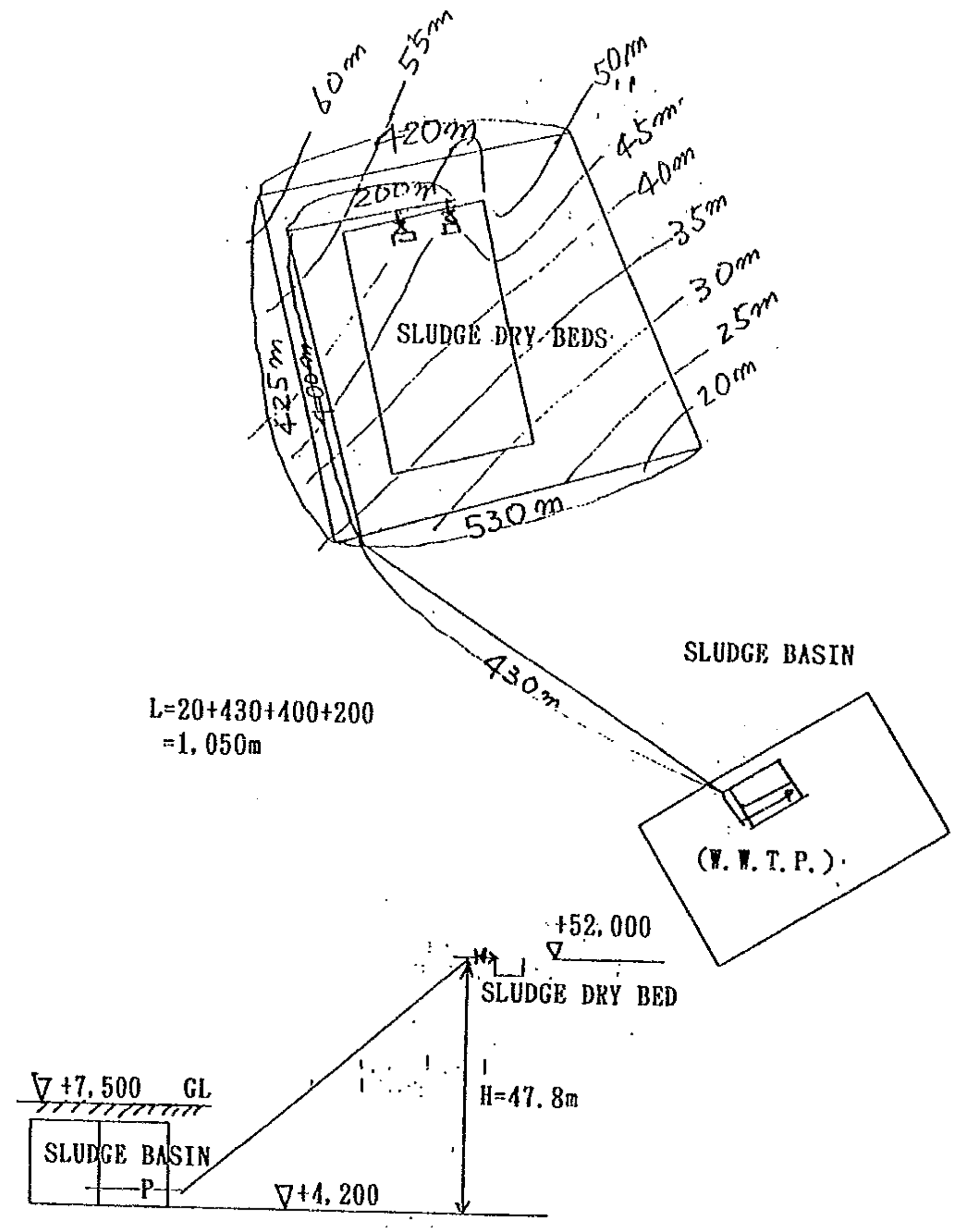
$= 0.163 \times (1.05 \times 0.6 \times 53.0)/0.38 \times 1.2 = 17.19kw$ ⟶ 18.5kw

⑧[Sludge feeding pump for sludge basin](to sludge bed)
…(Facility NO.M-44)

Type ;Horizontal sludge pump
Specification;80mmx 0.6m3/min x 53.0m x 18.5kw
Quantity ;6pcs(2pcs standby)

⑨[Specification of floor drain pump for sludge feeding house]
……(Facility NO.M-45)

Type ;Submersible pump
Specification;50mm x 0.1 m^3 /min x 10m x 0.75kw
Quantity ; 2 pcs(1pc spare)



60m
55m
50m
45m
40m
35m
30m
25m
20m
120m
200m
425m
400m
530m
SLUDGE DRY BEDS
430m
SLUDGE BASIN
L=20+430+400+200
=1,050m
(W.W.T.P.)
+52,000
SLUDGE DRY BED
H=47.8m
▽+7,500 GL
SLUDGE BASIN
P
▽+4,200

CALCULATION OF MOTOR OUTPUT FOR RELAY PUMPS (No.1 P/S)

The motor output for No.1 Relay Pumps shall be calculated as follows.

(1) Relay Pump Specification

The specification of Relay Pumps shall be as follows.

Pump capacity	: 6.9	cu.m/min
Pump total head	: 18	m

(2) Pump Shaft Horse Power (L)

For the above pumps, the shaft horse power shall be calculated as follows.

$$L = \frac{0.163 \times Q \times H \times r}{E_{ff}} = \frac{0.163 \times 6.9 \times 18 \times 1.0}{0.65} = 31.2 \text{ kw}$$

where Q : Capacity cu.m/min

H : Total head m

r : Weight per unit volume of water kgf/l

E_{ff} : Pump efficiency

(3) Output Required for Motor (L_m)

$L_m = L \times (1+A) = 31.2 \times (1+0.2) = \underline{37.5}\text{kw}$

where A : margine

According to the above calculation the output required for motor shall be 45 kw.

CALCULATION OF MOTOR OUTPUT FOR RELAY PUMPS (No.2 P/S)

The motor output for No.2 Relay Pumps shall be calculated as follows.

(1) Relay Pump Specification

The specification of Relay Pumps shall be as follows.

Pump capacity : 4.56 cu.m/min

Pump total head : 25 m

(2) Pump Shaft Horse Power (L)

For the above pumps, the shaft horse power shall be calculated as follows.

$$L = \frac{0.163 \times Q \times H \times r}{E_{ff}} = \frac{0.163 \times 4.56 \times 25 \times 1.0}{0.64} = 29.1 \text{ kw}$$

where Q : Capacity cu.m/min

H : Total head m

r : Weight per unit volume of water kgf/l

E_{ff} : Pump efficiency

(3) Output Required for Motor (L_m)

$L_m = L \times (1+A) = 29.1 \times (1+0.2) = \underline{35.0}$ kw

where A : margine

According to the above calculation the output required for motor shall be 37 kw.

CALCULATION OF MOTOR OUTPUT FOR RELAY PUMPS (No.3 P/S)

The motor output for No.3 Relay Pumps shall be calculated as follows.

(1) Relay Pump Specification

The specification of Relay Pumps shall be as follows.

Pump capacity : 3.69 cu.m/min

Pump total head : 39 m

(2) Pump Shaft Horse Power (L)

For the above pumps, the shaft horse power shall be calculated as follows.

$$L = \frac{0.163 x Q x H x r}{E_{ff}} = \frac{0.163 x 3.69 x 39 x 1.0}{0.64} = 36.7 \text{ kw}$$

where Q : Capacity cu.m/min

H : Total head m

r : Weight per unit volume of water kgf/l

E_{ff} : Pump efficiency

(3) Output Required for Motor (L_m)

Lm= Lx(1+A) = 36.7 x(1+0.2) = 44.1kw

where A : margine

According to the above calculation the output required for motor shall be 45 kw.