Cuong Tran The

Design of wastewater treatment system for industrial wastewater containing Cyanide and Nickel

Helsinki Metropolia University of Applied Sciences

Bachelor of Engineering

Degree Programme of Environmental Engineering

Thesis

23/08/2018

Helsinki Metropolia

Author(s) Title Pages Date	Cuong Tran The Design of wastewater treatment system for industrial wastewater containing cyanide and nickel 51 pages + 2 appendix 23 August 2018
Degree	Bachelor of Engineering
Degree Programme	Environmental Engineering
Specialisation option	Water and Wastewater treatment technology
Company	ORGANO VIETNAM Co. Ltd.
Instructor(s)	Kaj Lindedahl, Principal Supervisor, Metropolia UAS Hiep Tran, Technical Manager, Organo Vietnam

Surface-mount technology (SMT) has been developed to produce printed circuit boards for electronic devices from as early as the 1960s. Since conductivity is highly valuable even in the smallest devices, various types of heavy and precious metals have been used to further increase the effectiveness of circuit boards. These metals include but are not limited to gold, nickel and copper. The plating process of Gold and Nickel at Kyocera Vietnam Co. Ltd.'s Manufacturing plant generates wastewater containing a high concentration of cyanide and nickel which needs to be treated properly.

The aim of this thesis was to study and design a treatment system for wastewater containing Cyanide and Nickel, based on the existing treatment system at Kyocera Vietnam Co. Ltd.'s manufacturing plant. Calculations of specifications of tanks, vessels, pits and treatment theories were made according to the confidential instructions provided by Organo Vietnam. Unfortunately, the positions of the tanks, vessels, pits, as well as the specifications of pumps, pipes could not be included, due to the requirements from Organo Vietnam's Technical Manager.

This new design can be used as a reference for future study as well as for providing theoretical guidelines for treating wastewater containing heavy metals.

Keywords	CN, Ni, coagulation, physiochemical treatment, flocculation, sedimentation, multimedia filtration, pH adjustments, sludge treatment

Table of Contents

Abbreviations

OV	Organo Vietnam Co. Ltd.
KVC	Kyocera Vietnam Co. Ltd.
ENIG	Electroless nickel immersion gold
SS400	SS400 structural steel (Japanese Material Standard)
SS316	Stainless steel – Grade 316
QCVN [12]	QCVN 40:2011/BTNMT – Vietnamese National Technical regulation on Industrial Wastewater
WW	Wastewater
LV	Linear Velocity
WWTS	Wastewater Treatment System
MMF	Multimedia Filtration
ACF	Activated Carbon Filtration
rpm	round-per-minute
SS	Suspended Solids
mmD	mm in Diameter
mmH	mm in Height
mmW	mm in Width
mmL	mm in Length
FP	Filter Press
P&ID	Process and Instrument Diagram

List of Figures and Tables

Figures

Tables

1. Introduction

1.1. Organo Vietnam and Kyocera Co. Ltd.'s manufacturing plant:

Organo Vietnam (OV) is the Vietnamese subsidiary of Organo Corporation, a Japanese pioneering water/wastewater treatment company since 1946. [1]

Kyocera Vietnam Co. Ltd. (KVC) is the Vietnamese branch of Kyocera Corporation, a Japanese multinational manufacturer, currently focusing on Information, Telecommunications equipment as well as Renewable resources. [2]

In Vietnam, KVC opens a manufacturing plant producing various surface-mount ceramic packages for their circuit boards.[3] The company employs a modern and efficient plating method, called **electroless nickel immersion gold (ENIG)** plating.

An example of ENIG plating in their ceramic package production is their low temperature co-fired ceramics (LTCC) package [4].

1.2. Electroless nickel immersion gold (ENIG) plating method

ENIG has been a famous and widely-used method in printing circuit boards, because it is cost-effective and does not require lead. [5]

ENIG first applies a Nickel layer of 3 – 6 µm, and then a Gold layer of 0.065 – 0.10 µm.[6] The Ni coating makes the surface board more receptive to soldering, brazing and welding. Ni coating also provides excellent corrosion protection.[7] The Gold plating, used after Ni coating, protects the components from corrosion, heat, wear and helps ensure reliable electrical connections. [8]

1.3. Overview of KVC wastewater from plating process

To perform Gold plating, an aqueous solution containing gold is needed. [9] Cyanide-based solution is preferred, as Cyanide is widely used to extract Gold from low-grade ore. Sodium Cyanide solution is used as follows:

$4Au(s) + 8NaCN(aq) + O_2(g) + 2H_2O(aq) \rightarrow 4Na[Au(CN)_2](aq) + 4NaOH(aq)$ [10]

The resulting wastewater from Gold plating contains a high amount of CN ions that must be removed as CN ions are extremely toxic to humans and animals.

Electroless Nickel plating "is a process using an auto-catalytic chemical reaction to deposit Nickel coating from an aqueous solution", most notably Nickel Phosphorus. [11] Henceforth, the wastewater from Nickel coating contains high level of Ni ions. As wastewater from KVC is discharged to the river of Bac Hung Hai, a Wastewater treatment system (WWTS) must be

developed to satisfy Column A of Vietnamese National Technical regulation on Industrial Wastewater (QCVN).

1.4. Chemical theory for treatment of CN and Ni wastewater (courtesy of OV presentation for WW discharge license at KVC)

In general, OV's proposed treatments for CN and Ni wastewater is physiochemical. The difference between them is the types of coagulant agents.

For CN wastewater, Copper Sulfate ($CuSO_4$) and a reducing agent (in this case, $NaHSO_3$) are used.

$$2CN^- + Cu^{2+} + \text{Reducing Agent} \rightarrow CuCN\downarrow$$

$$Fe(CN)_6^{3-} + 2Cu^{2+} + \text{Reducing Agent} \rightarrow Cu_2[Fe(CN)_6]\downarrow$$ [13]

The Reducing Agent helps to oxidize Cu^{2+} into Cu^+, then:

$$CN^- + Cu^+ \rightarrow CuCN\downarrow$$

The resulting treated water from CN treatment, while having a decreased concentration of CN, still contains Cu and Ni ions, which are heavy metals.

For wastewater containing ions of heavy metals, the accepted technique is to lower the pH of wastewater by injecting Sodium Hydroxide (NaOH). At optimal pH value, heavy metal ions react with hydroxide ions to form precipitates:

$$Ni^{2+} + 2OH^- \rightarrow Ni(OH)_2\downarrow$$

$$Fe^{3+} + 3OH^- \rightarrow Fe(OH)_3\downarrow$$

$$Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2\downarrow$$

For high-quality treatment, a chelate agent is also injected, which forms metal complex with Ni ions, helpful in the following flocculation and sedimentation step:

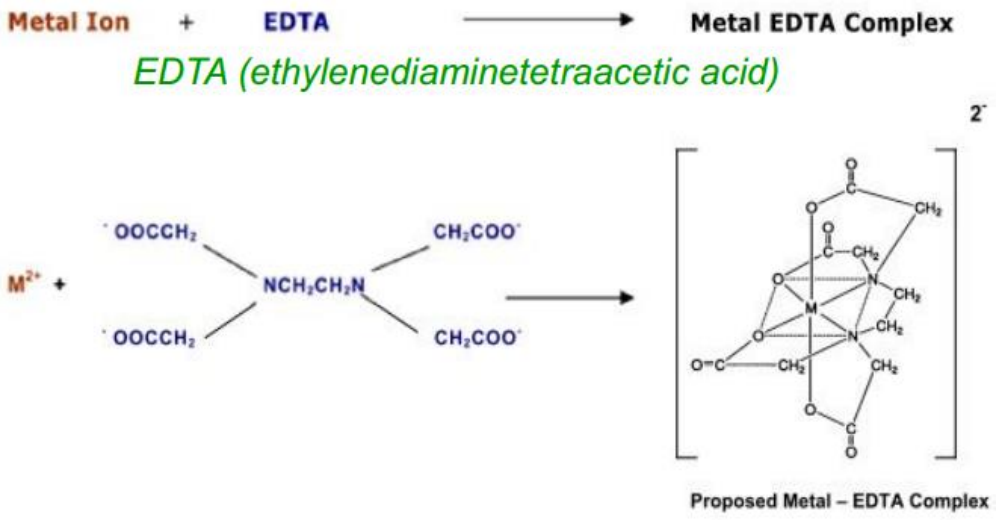


Figure 1: Chelation (Courtesy of OV training guide for engineers)

Afterwards, neutralization is needed to stabilize pH level before finally discharging to the environment.

1.5. Goal and scopes

Originally, the treatment plant in KVC cover both water and wastewater treatment. While WW from KVC factory produces CN wastewater, Ni wastewater, organic wastewater and low pH wastewater, the water treatment section delivers high-grade deionized water for factory use. Both sections are installed in combination with one another, as some chemicals, such as $NaHSO_3$ and NaOH are used in both sections.

The goal of this thesis was to redesign the wastewater treatment process into one that is suitable mainly for CN and Ni wastewater. The new design is believed to be suitable for future large-scale automated factories, which require little to no human presence. In case a factory as such would be commissioned, this design could serve as examples of pre-treatments for wastewater containing heavy metals before delivery to a centralized wastewater treatment plant.

The designing of a fully functional treatment plant contains a terrain overview as well as structural layout of the steel piping racks and positions of tanks and vessels, which proved to be too difficult and complicated for a Bachelor's thesis. Therefore, this study focused on the philosophy of the new treatment system as well as calculations of the specifications of the tanks, vessels and pits involved. Calculations for other equipment, such as specifications of pipes, pumps and valves were not included, due to confidentiality regulation from OV.

The above-mentioned treatment philosophy is based on OV's designed and currently installed wastewater treatment system at KVC manufacturing plant, which is responsible for discharging treated wastewater up to 800 m^3/d. The quality of treated wastewater is acceptable, as column A of QCVN in Table 1 shows:

Table 1: Values of the parameters of dischargeable industrial wastewater (QCVN)

No.	Parameter	Unit	Value	
			A	B
1	Temperature	^oC	**40**	40
2	Color	Pt/Co	**50**	150
3	**pH**	**-**	**6 to 9**	**5.5 to 9**
4	**BOD_5 (20^oC)**	**mg/L**	**30**	**50**
5	**COD**	**mg/L**	**75**	**150**

No.	Parameter	Unit	Value	
			A	B
6	**SS**	**mg/L**	**50**	**100**
7	Arsenic	mg/L	**0.05**	0.1
8	Mercury	mg/L	**0.005**	0.01
9	Lead	mg/L	**0.1**	0.5
10	Cadmium	mg/L	**0.05**	0.1
11	Chromium (VI)	mg/L	**0.05**	0.1
12	Chromium (III)	mg/L	**0.2**	1
13	**Copper**	**mg/L**	**2**	**2**
14	Zinc	mg/L	**3**	3
15	**Nickel**	**mg/L**	**0.2**	**0.5**
16	Manganese	mg/L	**0.5**	1
17	**Iron**	**mg/L**	**1**	**5**
18	**Total CN**	**mg/L**	**0.07**	**0.1**
19	Total Phenol	mg/L	**0.1**	0.5
20	Total mineral fats and oils	mg/L	**5**	10
21	Sulfide	mg/L	**0.2**	0.5
22	Fluoride	mg/L	**5**	10
23	Ammonium (as N)	mg/L	**5**	10
24	Total Nitrogen	mg/L	**20**	40
25	Total Phosphorus (as P)	mg/L	**4**	6
26	Chloride	mg/L	**500**	1000
27	Excess Chlorine	mg/L	**1**	2
28	Total organochlorine pesticide	mg/L	**0.05**	0.1
29	Total organophosphorus pesticide	mg/L	**0.3**	1
30	Total PCB	mg/L	**0.003**	0.01
31	Coliform	bacteria/100mL	**3000**	5000
32	Gross alpha activity	Bq/L	**0.1**	0.1
33	Gross beta activity	Bq/L	**1**	1

2. Reviews and Calculations of Capacities of Tanks, Vessels and Pits (courtesy of OV standard calculation sheet for engineers)

2.1. Treatment of CN wastewater

2.1.1. Overview

The simplified treatment process for CN wastewater is depicted by the following diagram:

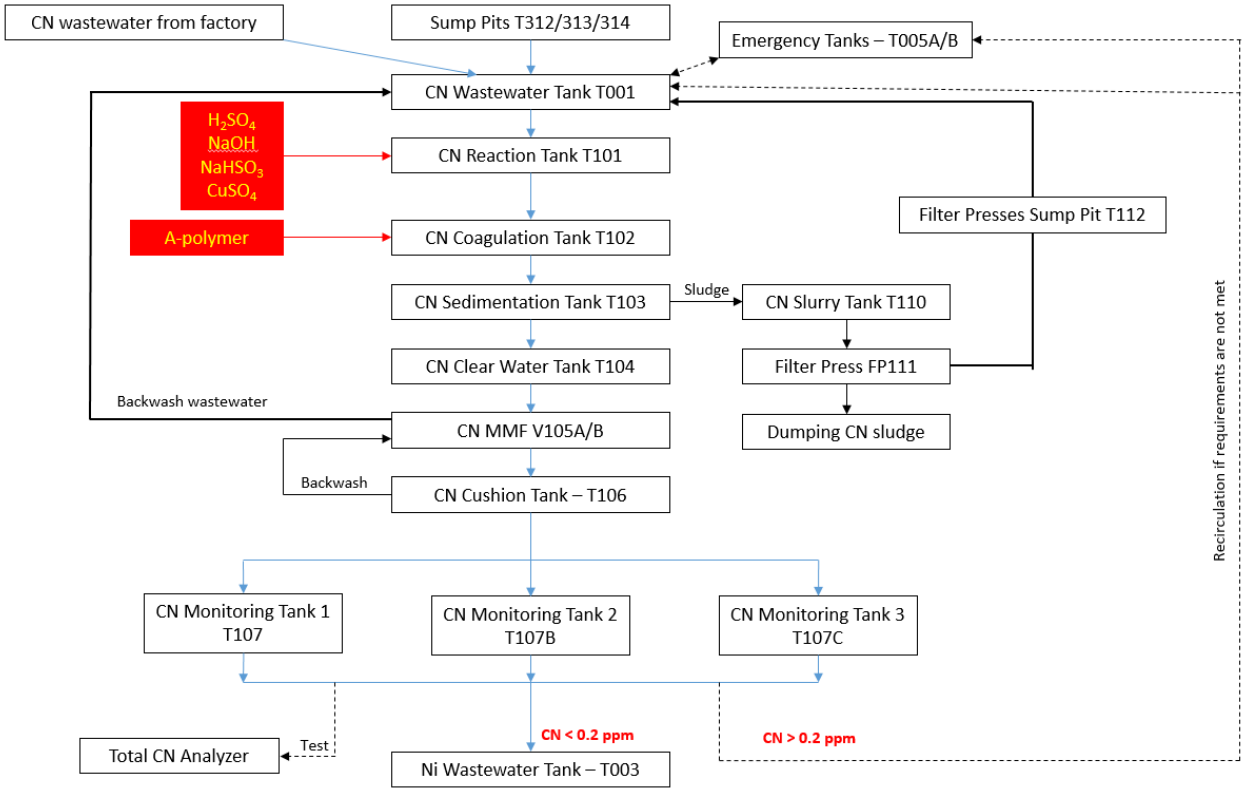


Figure 2: CN wastewater treatment process (courtesy of OV presentation for wastewater discharge license at KVC)

2.1.2. Coagulation, flocculation and sedimentation for CN wastewater:

The whole treatment system operates for 20 hours each day. The remaining 4 hours are used for backwash, rinsing and/or emergency.

As figure 2 above shows, CN wastewater from factory (226.0 m^3/d – 11.3 m^3/h), along with wastewater from sump pits T312/313/314 (Table 43) and other sources: overflow/emergency from T104 (Table 6), T106 (Table 9), T107A/B/C (Table 10), backwash wastewater from V105A/B (Table 8) are delivered to CN Wastewater Tank T001 (Table 2). This tank regulates flow rates and concentrations in wastewater stream using a submerged agitator before the wastewater is pumped to physical-chemical treatment.

Table 2: Specifications of CN Wastewater Tank T001

Design conditions					
Flow Rate	11.3	m^3/h			
Design Criteria					
Retention time	4	h			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**45.2**	m^3			
Tank Dimension					
- Depth	2000	mmH	2500	mmH	500mmH safety
- Width	5000	mmW	5000	mmW	
- Length	5000	mmL	5000	mmL	
	50	**m^3 (effective)**	**62.5**	**m^3 (gross)**	
Retention Time	**4.4**	h			
Material of Construction	Reinforced Concrete with Epoxy Paint				
Agitator					
Revolution	80	rpm			
Tank Volume	50.0	m^3			
Mixing power	0.01	kW/m^3			
	0.5	kW			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Selected Agitator Size	**0.5**	**kW**			
Type	Horizontal 4-Blade Impeller				
Material	SS316				

CN Reaction tank T101 (Table 3) is used to reduce the CN concentration, according to section 1.4. For successful reaction, fast mixing at 80 rpm is needed.

Table 3: Specifications of CN Reaction tank T101

Design conditions					
Flow Rate	11.85	m^3/h			
Design Criteria					
Retention time	25	mins			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**4.9**	m^3			
Tank Dimension					
- Depth	2350	mmH	2850	mmH	500mmH safety
- Width	1400	mmW	1400	mmW	
- Length	1500	mmL	1500	mmL	
	4.9	**m^3 (effective)**	**6.0**	**m^3 (gross)**	
Retention Time	**25.0**	mins			
Material of Construction	Reinforced Concrete with Epoxy Paint				
Agitator					
Revolution	80	rpm			
Tank Volume	4.9	m^3			
Mixing power	0.26	kW/m^3			
	1.3	kW			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Selected Agitator Size	**1.5**	**kW**			
Type	Vertical Pitched Paddle				
Material	SS316				

In CN Coagulation Tank T102 (Table 4), as flocs already form and trap impurities, slower mixing at 20 rpm is needed in order not to break them. A-Polymer is injected to help increase the size of flocs.

Table 4: Specifications of CN Coagulation Tank T102

Design conditions					
Flow Rate	11.85	m^3/h			
Design Criteria					
Retention time	20	mins			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**4.0**	m^3			
Tank Dimension					
- Depth	2500	mmH	3000	mmH	500mmH safety
- Width	1300	mmW	1300	mmW	
- Length	1300	mmL	1300	mmL	
	4.2	**m^3 (effective)**	**5.1**	**m^3 (gross)**	
Retention Time	**21.4**	mins			
Material of Construction	Reinforced Concrete with Epoxy Paint				
Agitator					
Revolution	20	rpm			
Tank Volume	4.2	m^3			
Mixing power	0.17	kW/m^3			
	0.7	kW			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Selected Agitator Size	**0.75**	**kW**			
Type	Vertical Pitched Paddle				
Material	SS316				

Sedimentation happens in CN Sedimentation Tank T103 (Table 5). The targeted retention time is **approximately 6 hours**. Heavy flocs are separated from wastewater by gravity. The scrapper rake at the bottom of T103 collect the flocs into sludge in a central hole located at the bottom of T103, which then is pumped to CN Slurry Tank T110 (Table 43, also see Figure 2 on p. 7 and Appendix 2).

Table 5: Specifications of CN Sedimentation Tank T103

Design Conditions					
Flow rate	11.85	m^3/h			
Design Criteria					
Settling Velocity	1.0	$m^3/ m^2/h$			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Settling Area	11.85	m^2			
Required Tank Diameter	3.9	mD			
Designed Tank Diameter	**4.0**	**mD**			
Tank Dimension					
- Diameter	4000	mmD			
- Height	4450	mmH	5250	mmH	500mmH safety
- Length	4000	mmL	4000	mmL	+ bottom slope
- Width	4000	mmW	4000	mmW	
	71.2	**m^3 (effective)**	**84.0**	**m^3 (gross)**	
Retention Time	**6.0**	h			
Material construction	Reinforced Concrete with Water Proof				
Sludge scrapper					
Flow rate	11.85	m^3/h			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Tank Dimension	4000	mmD			
Rake circumference speed	2.0	m/min			
Motor speed	1800	rpm			

Motor mechanical efficiency	0.97			
Rake arm diameter	3.8	m		
Reduction Gear Ratio	1/10417			
Selected Reducer	*1/10933*	*0.01 rpm*	*0.4 kW*	
Material	SS316			

In the meantime, clear water after settling and overflowing from T103 is stored in CN Clear Water Tank T104 (Table 6).

Table 6: Specifications of CN Clear Water Tank T104

Design condition					
Flow rate	11.85	m^3/h			
Design Criteria					
Retention time	1	h			
Capacity calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**11.85**	m^3			
Tank Dimension					
- Depth	3000	mmH	3500	mmH	500mmH safety
- Width	2000	mmW	2000	mmW	
- Length	2000	mmL	2000	mmL	
	12.0	**m^3 (effective)**	**14.0**	**m^3 (gross)**	
Retention Time	**1.0**	h			
Material of Construction	Reinforced Concrete with Epoxy Paint				

After sedimentation, the values of parameters such as CN, COD and BOD have been reduced, in accordance with the table below:

Table 7: Values of parameters after CN sedimentation

	CN wastewater		After CN sedimentation	
Open hs: 20 h/d				
DQ	226.0 m^3/d	11.3 m^3/h	237.1 m^3/d	11.9 m^3/h
COD	54.2 kg/d	240.0 mg/L	16.3 kg/d	68.6 mg/L
BOD	2.26 kg/d	10.00 mg/L	1.36 kg/d	5.72 mg/L
CN	16.72 kg/d	74.00 mg/L	0.05 kg/d	0.21 mg/L
Ni	1.36 kg/d	6.00 mg/L	0.07 kg/d	0.29 mg/L
Cu	1.36 kg/d	6.00 mg/L	1.36 kg/d	6.00 mg/L
Fe	0.11 kg/d	0.50 mg/L	0.06 kg/d	0.24 mg/L
pH	6 ~ 11		10.5	

2.1.3. CN Multimedia Filtration (MMF):

MMF vessels V105A/B further reduce the concentration of suspended solids in wastewater (Figure 3 and Table 8). The filtered water can be used to backwash the vessel. The backwash wastewater is redirected back to T001 (Table 2, also see Figure 2 on p. 7).

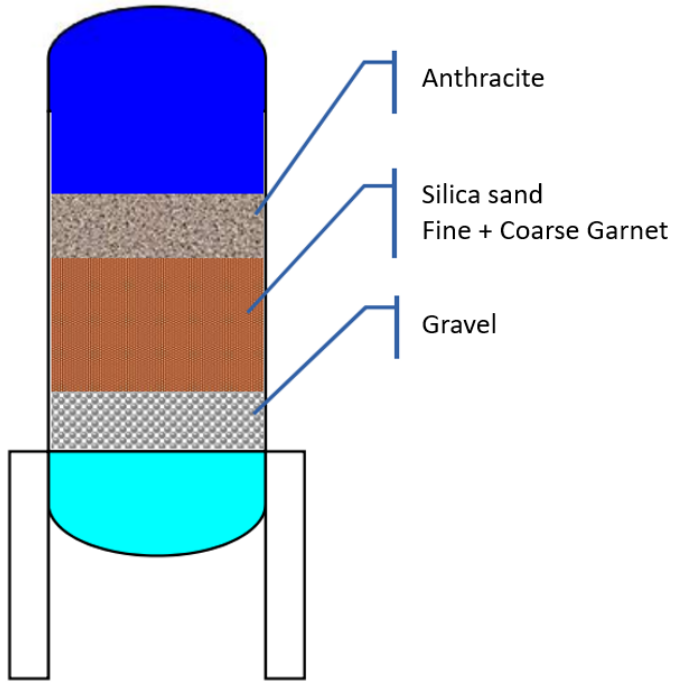


Figure 3: Overview of MMF vessel (courtesy of OV training guide for engineers)

Table 8: Specifications of CN MMF vessels V105A/B

Design Condition			
Flow rate	11.85	m^3/h	
Design Criteria			
Linear Velocity	6.5	$m^3/m^2/h$	
Vessel Calculation			
Quantity	2	(Two) for duty	
	2	**(Two) in total**	
Operated Pressure	0.35	Mpa	
Filter media, per vessel			
Gravel	200	mmH	
Coarse garnet	50	mmH	
Fine garnet	100	mmH	
Silica sand	350	mmH	
Anthacite	600	mmH	
Total	1300	mmH	
Effective filter	**1.2**	**mH**	
Volume	**1.14**	m^3	
Vessel height	**2200**	**mH**	900mmH safety
Required vessel diameter	0.98	mD	
Designed vessel diameter	**1.10**	**mD**	
MMF Backwash			
Backwash Linear Velocity	35.0	$m^3/ m^2/h$	
Backwash frequency	1	(One batch) per day	
	10	mins/batch	
Flow rate (per vessel)	**33.2**	**m^3/h**	
	11.1	**m^3/d, both vessels**	

CN Cushion Tank T106 (Table 9) is used to store and stabilize the filtered water, which then can be pumped to the CN monitoring process or to be used as backwash water for the MMF vessels (Table 8, also see Figure 2 on p. 7 and Appendix 2).

Table 9: Specifications of CN Cushion Tank T106

Design Condition					
Flow rate	11.1	m^3/d			
Design Criteria					
Retention time	1.5	Batch			
Tank calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank Capacity	16.62	m^3			
Tank Dimension					
- Height	1900	mmH	2400	mmH	500mmH safety
- Length	3000	mmL	3000	mmL	
- Width	3000	mmW	3000	mmW	
		m^3			
	17.1	**(effective)**	**21.6**	**m^3 (gross)**	
Rentention time	**0.5**	h			
Material of Construction	Reinforced Concrete with Epoxy Paint				

2.1.4. CN monitoring process

The monitoring process utilizes three monitoring tanks T107A/B/C (Table 10) with the following operation principle: Reception – Measurement – Discharge.

Firstly, the filtered wastewater is pumped from T106 (Table 9) to 1 of 3 tanks. Then, the level of CN concentration is tested with a device called Total CN Analyzer. Analysis result is received after 30 minutes. **If the level of CN is lower than 0.2 ppm**, wastewater will be pumped to Ni Wastewater Tank T003 (Table 12) for future treatment. If **the level of CN concentration is greater than 0.2 ppm**, wastewater will be pumped to emergency tanks T005A/B (Table 44) or back to T001 (Table 2, also see Figure 2 on p. 7 and Appendix 2).

Within this CN monitoring process, no two tanks are either receiving, measuring or discharging wastewater at the same time.

Table 10: Specifications of CN Monitoring Tanks T107A/B/C

Design Condition					
Flow rate	11.3	m3/h			
Design Criteria					
Retention time	1	h			
Tank calculation					
Quantity	3	(Three) for duty			
	3	**(Three) in total**			
Required tank capacity	**11.3**	**m3**			
Tank Dimension					
- Height	2900	mmH	3400	mmH	500mmH safety
- Length	2000	mmL	2000	mmL	
- Width	2000	mmW	2000	mmW	
	11.6	**m3 (effective)**	**13.6**	**m3 (gross)**	
Retention time	1.0	h			
Material of construction	Reinforced Concrete with Epoxy Paint				

Table 11: Values of parameters before and after CN treatment

	Before CN treatment		After CN treatment	
Open hrs: 20 h/d				
DQ	226.0 kg/d	11.3 mg/L	8.1 kg/d	36.0 mg/L
COD	54.2 kg/d	240.0 mg/L	1.4 kg/d	6.0 mg/L
BOD	2.26 kg/d	10.00 mg/L	0.02 kg/d	0.07 mg/L
T-CN	16.72 kg/d	74.00 mg/L	0.03 kg/d	0.12 mg/L
Ni	1.36 kg/d	6.00 mg/L	0.68 kg/d	3.00 mg/L
Cu	1.36 kg/d	6.00 mg/L	0.03 kg/d	0.13 mg/L
Fe	0.11 kg/d	0.50 mg/L	0.06 kg/d	0.24 mg/L
pH	6 ~ 11		10.5	

Table 11 above shows that the levels of BOD, COD and CN have been reduced to meet the requirements of Column A of QCVN. However, as CN treatment requires $CuSO_4$, concentration of Cu increases, while Ni has not been treated. Therefore, further treatment for heavy metals is required.

2.2. Treatment for Ni wastewater

2.2.1. Overview:

The simplified treatment process for Ni wastewater, and treated CN wastewater is depicted in the following diagram:

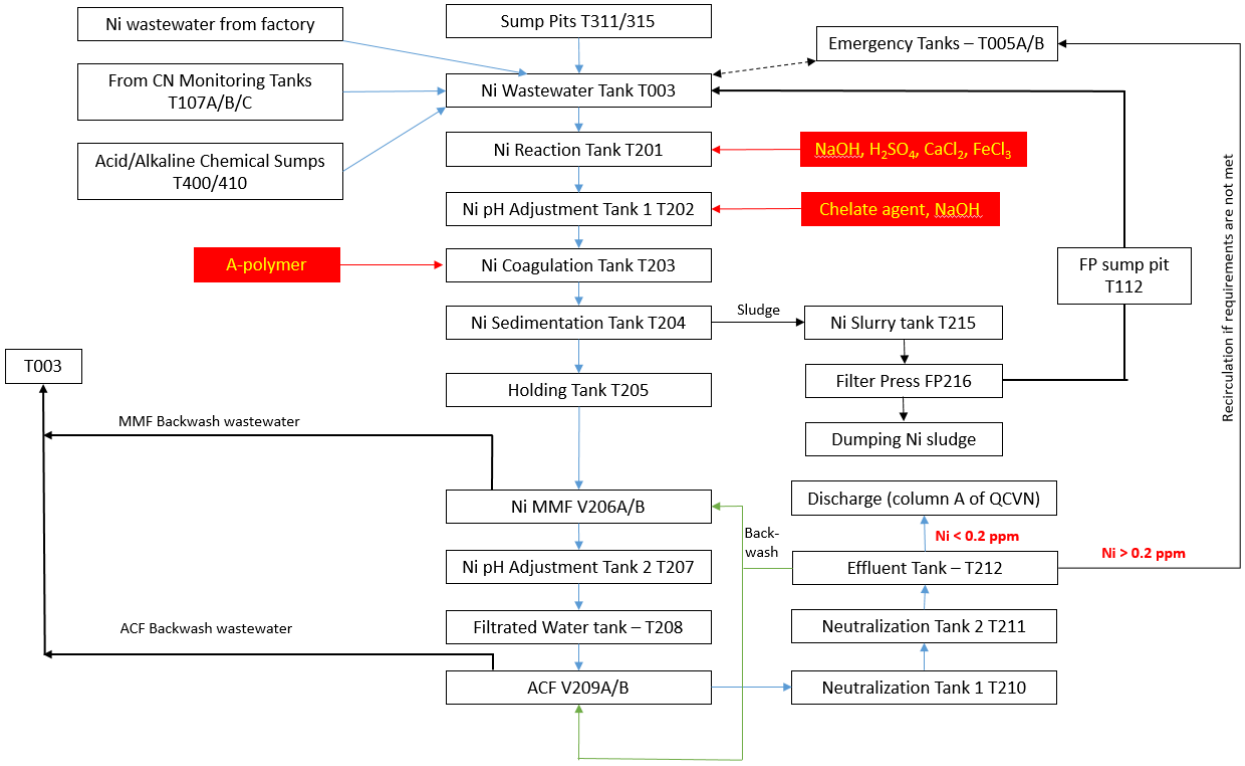


Figure 4: Ni wastewater treatment process (courtesy of OV presentation for WW discharge license at KVC).

2.2.2. Coagulation, flocculation and sedimentation for Ni wastewater:

As Figure 4 indicates, Ni wastewater from factory (74.0 m^3/d – 3.7 m^3/h), along with treated CN wastewater from T107/A/B/C (Table 10), Filter Presses Sump Pit T112 (Table 42), Sump Pits T311/315 (Table 43), Acid Chemical Sump T400 (Table 45) and Alkaline Chemical Sump T410 (Table 45) are pumped to Ni Wastewater Tank T003 (Table 12). Appendix 2 shows that similar to T001 (Table 2), a submerged agitator is needed to stabilize the flow rates and concentrations of the whole tank.

Table 12: Specifications of Ni Wastewater Tank T003

Design Condition					
Flow rate	16.2	m^3/h			
Design Criteria					
Retention time	6	h			
Tank calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required tank capacity	**97.2**	m^3			
Tank Dimension					
- Depth	4000	mmH	5000	mmH	1000mmH safety
- Length	5000	mmL	5000	mmL	
- Width	5000	mmW	5000	mmW	
	100	**m^3 (effective)**	**125**	**m^3 (gross)**	
Retention time	6.2	h			
Material of construction	Reinforced Concrete with Epoxy Paint				
Agitator					
Revolution	80	rpm			
Tank Volume	100.0	m^3			
Mixing power	0.01	kW/m^3			
	1.0	kW			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Selected Agitator Size	**1.0**	**kW**			
Type	Horizontal 4-Blade Impeller				
Material	SS316				

In Ni Reaction Tank T201 (Table 13), NaOH and H_2SO_4 are initially injected to decrease pH. Then $FeCl_3$ is injected as flocculant. At **pH 5.0**, $FeCl_3$ reacts with pollutants, creating micro flocs. $CaCl_2$ is injected as well and serves as a catalyst for the reactions and flocs formation.

Table 13: Specifications of Ni Reaction Tank T201

Design conditions					
Flow Rate	16.2	m^3/h			
Design Criteria					
Retention time	10	mins			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**2.7**	m^3			
Tank Dimension					
- Depth	1700	mmH	2200	mmH	500mmH safety
- Width	1100	mmW	1100	mmW	
- Length	1500	mmL	1500	mmL	
	2.8	**m^3 (effective)**	**3.6**	**m^3 (gross)**	
Retention Time	**10.4**	mins			
Material of Construction	Reinforced Concrete with Epoxy Paint				
Agitator					
Revolution	80	rpm			
Tank Volume	2.8	m^3			
Mixing power	0.4	kW/m^3			
	1.1	kW			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Selected Agitator Size	**1.5**	**kW**			
Type	Vertical Pitched Paddle				
Material	SS316				

After T201, wastewater overflows to Ni pH Adjustment Tank 1 T202 (Table 14). As the wastewater now contains high concentrations of Fe, Ca, Cu and Ni, NaOH is injected to precipitate the heavy metals. A chelate agent is also injected to specifically form a metal complex with Ni, as explained in section 1.4.

Table 14: Specifications of Ni pH Adjustment Tank 1 T202

Design conditions					
Flow Rate	16.2	m^3/h			
Design Criteria					
Retention time	10	mins			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**2.7**	m^3			
Tank Dimension					
- Depth	1700	mmH	2200	mmH	500mmH safety
- Width	1100	mmW	1100	mmW	
- Length	1500	mmL	1500	mmL	
	2.8	**m^3 (effective)**	**3.6**	**m^3 (gross)**	
Retention Time	**10.4**	mins			
Material of Construction	Reinforced Concrete with Epoxy Paint				
Agitator					
Revolution	80	rpm			
Tank Volume	2.8	m^3			
Mixing power	0.4	kW/m^3			
	1.1	kW			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Selected Agitator Size	**1.5**	**kW**			
Type	Vertical Pitched Paddle				
Material	SS316				

From T202, wastewater overflows to Ni Coagulation Tank T203 (Table 15), and then Ni Sedimentation Tank T204 (Table 16). Similar to CN treatment, A-Polymer is injected to form larger flocs. The flocs then settle in T204 due to gravity. The sludge scrapped from T204 is pumped to Ni Slurry Tank T215 (Table 39, also see Figure 4 on p. 17 and Appendix 2).

Table 15: Specifications of Ni Coagulation Tank T203

Design conditions					
Flow Rate	16.2	m^3/h			
Design Criteria					
Retention time	15	mins			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**4.1**	m^3			
Tank Dimension					
- Depth	2500	mmH	3000	mmH	500mmH safety
- Width	1200	mmW	1200	mmW	
- Length	1500	mmL	1500	mmL	
	4.5	**m^3 (effective)**	**5.4**	**m^3 (gross)**	
Retention Time	**16.7**	mins			
Material of Construction	Reinforced Concrete with Epoxy Paint				
Agitator					
Revolution	20	rpm			
Tank Volume	4.5	m^3			
Mixing power	0.1	kW/m^3			
	0.5	kW			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Selected Agitator Size	**0.75**	**kW**			
Type	Vertical Pitched Paddle				
Material	SS316				

Table 16: Specifications of Ni Sedimentation Tank T204

Design Conditions					
Flow rate	16.2	m^3/h			
Design Criteria					
Settling Velocity	1.0	$m^3/ m^2/h$			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Settling Area	16.2	m^2			
Required Tank Diameter	4.5	mD			
Designed Tank Diameter	**5.0**	**mD**			
Tank Dimension					
- Height	4450	mmH	5250	mmH	500mmH safety
- Diameter	4500	mmD			+ bottom slope
- Length	4500	mmL	4500	mmL	
- Width	4500	mmW	4500	mmW	
	90.1	**m^3 (effective)**	**106.3**	**m^3 (gross)**	
Retention Time	**5.6**	h			
Material construction	Reinforced Concrete with Water Proof				
Sludge scrapper					
Flow rate	16.2	m^3/h			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Tank Dimension	4500	mmD			
Rake circumference speed	1.5	m/min			
Motor speed	1800	rpm			
Motor mechanical efficiency	0.97				
Rake arm diameter	4.2	m			
Reduction Gear Ratio	1/15351				
Selected Reducer	*1/16211*	*0.01 rpm*		*0.75 kW*	
Material	SS316				

Holding Tank T205 (Table 17) is used to store the clear water after settling from T204 (Table 16), which also measures the quality of settled wastewater. Table 18 shows the wastewater parameters before and after Ni sedimentation.

Table 17: Specifications of Holding Tank T205

Design conditions					
Flow Rate	16.2	m^3/h			
Design Criteria					
Retention time	30	mins			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**8.1**	m^3			
Tank Dimension					
- Depth	1700	mmH	2200	mmH	500mmH safety
- Width	2500	mmW	2500	mmW	
- Length	2000	mmL	2000	mmL	
	8.5	**m^3 (effective)**	**11.0**	**m^3 (gross)**	
Retention Time	**31.5**	mins			
Material of Construction	Reinforced Concrete with Epoxy Paint				

Table 18: Values of parameters before and after Ni sedimentation

	Before Ni Sedimentation		After Ni Sedimentation	
Open hs: 20h/d				
DQ	325.0 m^3/d	16.2 m^3/h		
BOD	2.1 kg/d	6.4 mg/L	1.9 kg/d	5.8 mg/L
COD	8.88 kg/d	27.31 mg/L	7.10 kg/d	21.85 mg/L
T-CN	0.02 kg/d	0.05 mg/L	0.01 kg/d	0.02 mg/L
Ni	8.17 kg/d	25.13 mg/L	0.04 kg/d	0.13 mg/L
Cu	0.69 kg/d	2.11 mg/L	0.16 kg/d	0.50 mg/L
Fe	0.10 kg/d	0.31 mg/L	0.00 kg/d	0.01 mg/L
pH	~8.0		~10.0	

Table 18 indicates that after sedimentation, both Ni and Cu concentrations have been reduced.

2.2.3. Ni MMF, pH adjustment 2 and activated carbon filtration (ACF):

Two Ni MMF vessels V206A/B (Table 19) are installed to reduce residual suspended solids in Ni treatment, similarly to CN MMF V105A/B (Table 8).

Table 19: Specifications of Ni MMF Vessels V206A/B

Design Condition			
Flow rate	16.2	m^3/h	
Design Criteria			
Linear Velocity	7.5	$m^3/m^2/h$	
Vessel Calculation			
Quantity	2	(Two) for duty	
	2	**(Two) in total**	
Filter media, per vessel			
Gravel	200	mmH	
Coarse garnet	50	mmH	
Fine garnet	100	mmH	
Silica sand	350	mmH	
Anthracite	600	mmH	
Total	1300	mmH	
Effective filter	**1.2**	**mH**	
Volume	**1.36**	**m^3**	
Vessel height	**2300**	**mH**	1000mmH safety
Required vessel diameter	1.07	mD	
Designed vessel diameter	**1.20**	**mD**	
MMF Backwash			
Backwash Linear Velocity	35.0	$m^3/m^2/h$	
Backwash frequency	1	(One batch) per day	
	12	mins/batch	
Flowrate (per vessel)	**39.6**	**m^3/h**	
	15.8	**m^3/d, both vessels**	

After multimedia filtration, Ni wastewater is led to pH Adjustment Tank 2 T207 (Table 20). This second pH adjustment tank serves to adjust pH to **pH 5.5** for further treatment.

Table 20: Specifications of pH Adjustment Tank 2 T207

Design conditions					
Flow Rate	16.2	m^3/h			
Design Criteria					
Retention time	10	mins			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**2.7**	m^3			
Tank Dimension					
- Depth	1700	mmH	2200	mmH	500mmH safety
- Width	1100	mmW	1100	mmW	
- Length	1500	mmL	1500	mmL	
	2.8	**m^3 (effective)**	**3.6**	**m^3 (gross)**	
Retention Time	**10.4**	mins			
Material of Construction	Reinforced Concrete with Epoxy Paint				
Agitator					
Revolution	300	rpm			
Tank Volume	2.8	m^3			
Mixing power	0.4	kW/m^3			
	1.1	kW			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Selected Agitator Size	**1.5**	**kW**			
Type	Vertical Pitched Paddle				
Material	SS316				

After the second pH adjustment, filtered wastewater is temporarily stored in Filtrated Water Tank T208 (Table 21).

Table 21: Specifications of Filtrated Water Tank T208

Design conditions					
Flow Rate	16.2	m^3/h			
Design Criteria					
Retention time	40	mins			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**10.8**	m^3			
Tank Dimension					
- Depth	2000	mmH	2500	mmH	500mmH safety
- Width	2200	mmW	2200	mmW	
- Length	2500	mmL	2500	mmL	
	11.0	**m^3 (effective)**	**13.8**	**m^3 (gross)**	
Retention Time	**40.7**	mins			
Material of Construction	Reinforced Concrete with Epoxy Paint				

Two ACF vessels V209A/B (Table 22) serve to eliminate other dissolved pollutants that the previous units could not reduce (for example, residual chlorine). In addition, the activated carbon layer also reduces the COD concentration and remove odors and color. After ACF, the filtered water is transferred to Neutralization Tank 1 T210 (Table 23).

Table 22: Specifications of ACF Vessels V209A/B

Design Condition			
Flow rate	16.2	m^3/h	
Design Criteria			
Linear Velocity	12.0	$m^3/m^2/h$	
Vessel Calculation			
Quantity	2	(Two) for duty	
	2	**(Two) in total**	
Filter media, per vessel			
Effective filter Height	**1.2**	**mH**	
Volume	**0.94**	**m^3**	
Vessel height	**1.8**	**mH**	600mmH safety
Required vessel diameter	0.85	mD	
Designed vessel diameter	**1.00**	**mD**	
ACF Backwash			
Backwash Linear Velocity	35.0	$m^3/m^2/h$	
Backwash frequency	1	(One batch) per day	
	10	mins/batch	
Flowrate (per vessel)	**27.5**	**m^3/h**	
	9.2	**m^3/d, both vessels**	

For the backwash step of Ni MMF and ACF vessels, backwash water is pumped from Effluent Tank T212 (Table 25). The wastewater from backwashing and rinsing of vessels is circulated back to T003 for re-treatment (see Figure 4 on p. 17 and Appendix 2)

2.2.4. Final pH treatment and Discharge

For extra safety and satisfied quality treatment, two neutralization tanks, T210 (Table 23) and T211 (Table 24) are employed. The pH of wastewater is monitored and adjusted to acceptable level using an automatic pH sensor and acid/alkaline injection systems.

Table 23: Specifications of Neutralization Tank 1 T210

Design conditions					
Flow Rate	16.2	m^3/h			
Design Criteria					
Retention time	5	mins			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**1.4**	m^3			
Tank Dimension					
- Diameter	1200	mmD	1200	mmD	
- Height	1300	mmH	1800	mmH	500mmH safety
	1.5	**m^3 (effective)**	**2.0**	**m^3 (gross)**	
Retention Time	**5.4**	mins			
Material of Construction	Reinforced Concrete with Epoxy Paint				
Agitator					
Revolution	300	rpm			
Tank Volume	1.5	m^3			
Mixing power	0.4	kW/m^3			
	0.6	kW			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Selected Agitator Size	**0.75**	**kW**			
Type	Vertical Pitched Paddle				
Material	SS316				

Table 24: Specifications of Neutralization Tank 2 T211

Design conditions					
Flow Rate	16.2	m³/h			
Design Criteria					
Retention time	10	mins			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**2.7**	m³			
Tank Dimension					
- Depth	1300	mmH	1800	mmH	500mmH safety
- Width	1500	mmW	1500	mmW	
- Length	1500	mmL	1500	mmL	
	2.9	**m³ (effective)**	**4.1**	**m³ (gross)**	
Retention Time	**10.8**	mins			
Material of Construction	Reinforced Concrete with Epoxy Paint				
Agitator					
Revolution	300	rpm			
Tank Volume	2.9	m³			
Mixing power	0.4	kW/m³			
	1.2	kW			
Quantity	1	(One) for duty			
	1	**(One) in total**			
Selected Agitator Size	**1.5**	**kW**			
Type	Vertical Pitched Paddle				
Material	SS316				

Before discharging to the environment, the treated wastewater is stored in Effluent Tank T212 (Table 25). In case the desired quality is not achieved, the treated wastewater will be pumped to Emergency Tanks T005A/B (Table 44 and also see figure 4 on p. 17 and Appendix – P&ID). T212 also supplies backwash water for Ni MMF V206A/B (Table 19) and ACF V209A/B (Table 22 and Appendix 2).

Table 25: Specifications of Effluent Tank T212

Design conditions					
Flow Rate	16.2	m^3/h			
Design Criteria					
Retention time	10	mins			
Capacity Calculation					
Quantity	1	(One) for duty			
	1	**(One) in total**			
Required Tank capacity	**2.7**	m^3			
Tank Dimension					
- Depth	1300	mmH	1800	mmH	500mmH safety
- Width	1500	mmW	1500	mmW	
- Length	1500	mmL	1500	mmL	
	2.9	**m^3 (effective)**	**4.1**	**m^3 (gross)**	
Retention Time	**10.8**	mins			
Material of Construction	Reinforced Concrete with Epoxy Paint				
Discharge	**15**	**m^3/h**			

Comparing parameters' values after Ni treatment in Table 26 and those given in Column A of QCVN shown in Table 1, it can be concluded that the treatment for CN and Ni is successful.

Table 26: Values of parameters before Ni treatment and at Discharge

	Before Ni Treatment		Discharge	
Open hs: 20h/d				
DQ	324.98 m^3/d	16.25 m^3/h	300.00 m^3/d	15.00 m^3/h
BOD	2.10 kg/d	6.45 mg/L	1.89 kg/d	6.29 mg/L
COD	8.88 kg/d	27.31 mg/L	3.55 kg/d	11.83 mg/L
T-CN	0.02 kg/d	0.05 mg/L	0.00 kg/d	0.01 mg/L
Ni	8.17 kg/d	25.13 mg/L	0.02 kg/d	0.08 mg/L
Cu	0.69 kg/d	2.11 mg/L	0.16 kg/d	0.54 mg/L
Fe	0.10 kg/d	0.31 mg/L	0.00 kg/d	0.01 mg/L
pH	8	~9	9.50	

2.3. Chemical supply:

2.3.1. Acid and Alkaline

Due to OV's safety regulations, the supply of acid and alkaline chemicals differs from those of other chemicals. Storage tanks are needed to contain the delivered concentrated chemicals. The concentrated chemicals are then pumped to service tanks for dilution using potable water, before being pumped to the treatment system.

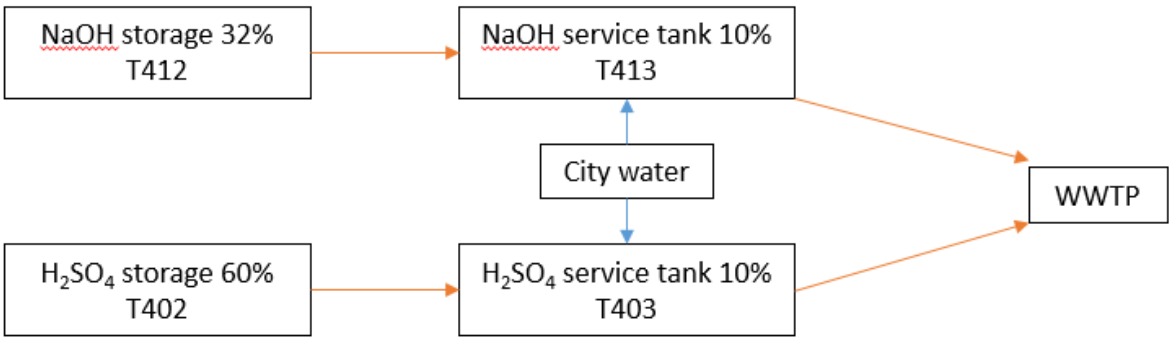


Figure 5: Acid and Alkaline chemical supply (courtesy of OV presentation for WW discharge license at KVC)

NaOH is supplied mainly to T202 (Table 14) to precipitate metals: Fe, Ca, Cu and Ni. Table 27 and Table 28 give the specifications of the storage tank and service tank for NaOH, respectively.

Table 27: Specifications of 32% NaOH Storage Tank T412

Design Conditions		
NaOH required for T202	120.5	kg/d
NaOH concentration	32	%
NaOH consumption	0.377	m³/d
Design Criteria		
Retention Time	7.0	d
Capacity Calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**2.6**	m³
Tank dimension		
- Diameter	1500	mmD
- Height	1750	mmH
	3.1	**m³**
Material of construction	FRP	

Table 28: Specifications of NaOH Service Tank T413

Design Conditions		
NaOH from T412	120.5	kg/d
NaOH concentration	10	%
NaOH consumption	1.205	m³/d
Design Criteria		
Retention Time	0.2	d
Capacity Calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**0.2**	m³

Tank dimension		
- Diameter	900	mmD
- Height	1000	mmH
	0.6	**m^3**
Material of construction	FRP	

H_2SO_4 is supplied to T101 (Table 3), T201 (Table 13) and T207 (Table 20) to decrease pH to 5.0 ~ 5.5. Specifications of storage tank and service tank for H_2SO_4 are listed in Table 29 and Table 30 respectively.

Table 29: Specifications of 60% H_2SO_4 Storage Tank T402

Design Conditions		
H_2SO_4 required for T101	11.1	kg/d
H_2SO_4 required for T201	5.2	kg/d
H_2SO_4 required for T207	1.6	kg/d
Total H_2SO_4 requirement	17.9	kg/d
H_2SO_4 concentration	60	%
H_2SO_4 consumption	0.030	m^3/d
Design Criteria		
Retention Time	30.0	d
Capacity Calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**0.9**	m^3
Tank dimension		
- Diameter	900	mmD
- Height	1500	mmH
	1.0	**m^3**
Material of construction	FRP	

Table 30: Specifications of H_2SO_4 Service Tank T403

Design Conditions		
H_2SO_4 from T402	17.9	kg/d
H_2SO_4 concentration	10	%
H_2SO_4 consumption	0.179	m^3/d
Design Criteria		
Retention Time	1.0	d
Capacity Calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**0.2**	m^3
Tank dimension		
- Diameter	900	mmD
- Height	1000	mmH
	0.6	**m^3**
Material of construction	FRP	
Agitator		
Revolution	300	rpm
Tank Volume	0.6	m^3
Mixing power	0.15	kW/m^3
	0.09	kW
Quantity	1	(One) for duty
	1	**(One) in total**
Selected Agitator Size	**0.1**	**kW**
Type	Vertical Pitched Paddle	
Material	SS316	

2.3.2. Other Chemicals

$CuSO_4$ and $NaHSO_3$ are delivered to the site in powder form, instead of concentrated solutions. Therefore, they need to be dissolved and mixed well with potable water before being pumped to the treatment system (Figure 6).

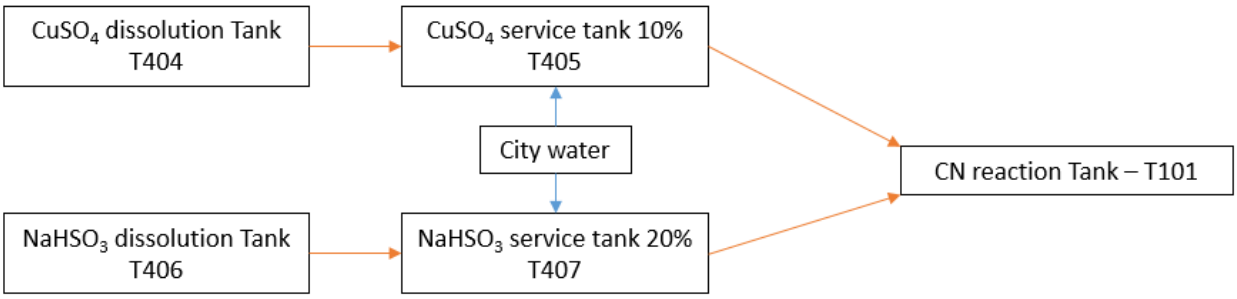


Figure 6: $CuSO_4$ and $NaHSO_3$ chemical supply (courtesy of OV presentation for WW discharge license at KVC).

$CuSO_4$ is supplied to T101 (Table 3) to react with CN in wastewater. Specifications of dissolution tank and service tank for $CuSO_4$ are given in Table 31

Table 31: Specifications of $CuSO_4$ Dissolution Tank T404 and $CuSO_4$ Service Tank T405

Design conditions		
$CuSO_4$ required for T101	133.8	kg/d
$CuSO_4$ concentration	15	%
$CuSO_4$ consumption	0.892	m^3/d
Design Criteria		
Retention Time	1.0	d
Capacity Calculation for $CuSO_4$ Dissolution Tank T404		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**0.9**	m^3
Tank dimension		
- Diameter	900	mmD
- Height	1500	mmH
	1.0	**m^3**
Material of construction	FRP	

Agitator for $CuSO_4$ Dissolution Tank T404		
Revolution	300	rpm
Tank Volume	1.0	m^3
Mixing power	0.2	kW/m^3
	0.2	kW
Quantity	1	(One) for duty
	1	**(One) in total**
Selected Agitator Size	**0.2**	**kW**
Type	Vertical Pitched Paddle	
Material	SS316	
Capacity calculation for CuSO4 service Tank - T405		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**1.2**	m^3
Tank dimension		
- Length	1000	mmL
- Width	1200	mmW
- Height	1000	mmH
	1.2	**m^3**
Material of construction	FRP	

$NaHSO_3$ is supplied to T101 (Table 3) to aid in the treatment of CN using $CuSO_4$. Specifications of dissolution tank and service tank for $NaHSO_3$ are given in Table 32.

Table 32: Specifications of $NaHSO_3$ Dissolution Tank T406 and $NaHSO_3$ Service Tank T407

Design conditions		
$NaHSO_3$ required for T101	334.5	kg/d
$NaHSO_3$ concentration	20	%
$NaHSO_3$ consumption	1.673	m^3/d
Design Criteria		
Retention Time	0.5	d

Capacity Calculation for $NaHSO_3$ dissolution Tank - T406		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**0.8**	m^3
Tank dimension		
- Diameter	900	mmD
- Height	1450	mmH
	0.9	**m^3**
Material of construction	FRP	
Agitator for NaHSO3 Dissolution Tank T406		
Revolution	300	rpm
Tank Volume	0.9	m^3
Mixing power	0.2	kW/m^3
	0.2	kW
Quantity	1	(One) for duty
	1	**(One) in total**
Selected Agitator Size	**0.2**	**kW**
Type	Vertical Pitched Paddle	
Material	SS316	
Capacity calculation for NaHSO3 service tank T407		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**1.0**	m^3
Tank dimension		
- Length	1000	mmL
- Width	1000	mmW
- Height	1000	mmH
	1.0	**m^3**
Material of construction	FRP	

$CaCl_2$ and $FeCl_3$ are used in concentrated solutions, therefore, dilution is not required. However, they are pumped to T201 only (Figure 7).

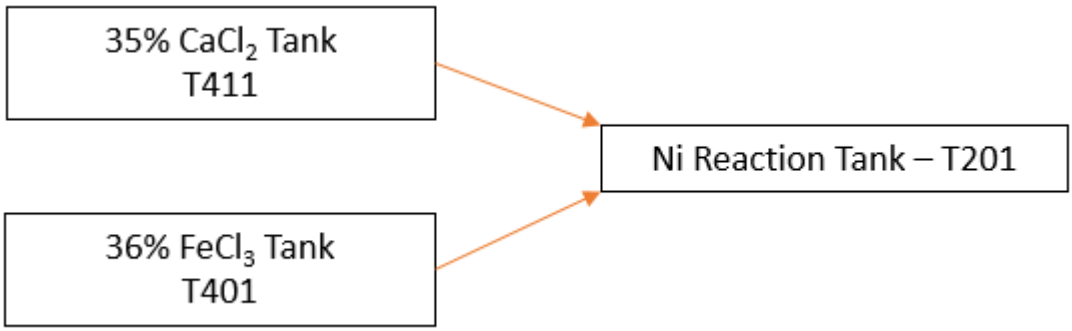


Figure 7: $CaCl_2$ and $FeCl_3$ chemical supply (courtesy of OV presentation for WW discharge license at KVC)

$CaCl_2$ is supplied to T201 (Table 13) to aid in flocs formation. Specifications of $CaCl_2$ storage tank are given in Table 33.

Table 33: Specifications of 35% $CaCl_2$ Storage Tank T411

Design conditions		
$CaCl_2$ required for T201	16.2	kg/d
$CaCl_2$ concentration	35	%
$CaCl_2$ consumption	0.046	m³/d
Design Criteria		
Retention Time	7.0	d
Capacity Calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**0.3**	m³
Tank dimension		
- Diameter	900	mmD
- Height	1000	mmH
	0.6	**m³**
Material of construction	FRP	

$FeCl_3$ is supplied to T201 (Table 13) as coagulant. Specifications of $FeCl_3$ storage tank are given in Table 34

Table 34: Specifications of $FeCl_3$ Storage Tank T401

Design Conditions		
$FeCl_3$ required for T201	152.3	kg/d
$FeCl_3$ concentration	36	%
$FeCl_3$ consumption	0.423	m^3/d
Design Criteria		
Retention Time	7.0	d
Capacity Calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**3.0**	m^3
Tank dimension		
- Diameter	1500	mmD
- Height	2000	mmH
	3.5	**m^3**
Material of construction	FRP	

Similar to $CuSO_4$ and $NaHSO_3$, A-polymer and chelate agent are delivered in powder. While the dissolution of A-polymer requires an agitator, the dissolution of chelate agent does not. Both tanks need potable water for the dissolution process, as Figure 8 demonstrates:

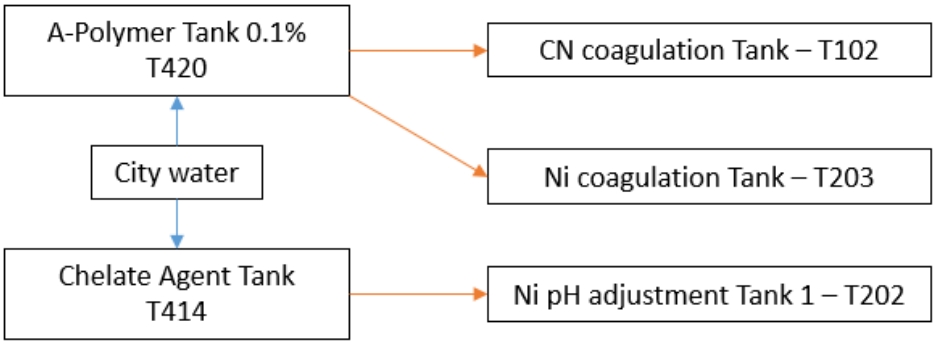


Figure 8: A-polymer and Chelate Agent chemical supply (courtesy of OV presentation for WW discharge license at KVC).

A-polymer is supplied to T102 (Table 4) and T203 (Table 15) as flocculant. Specifications of A-polymer tank are given in Table 35.

Table 35: Specifications of A-polymer Tank T420

Design conditions		
A-polymer required for T102	0.9	kg/d
A-polymer required for T203	1.3	kg/d
Total A-polymer required	2.2	kg/d
A-polymer concentration	0.1	%
A-polymer consumption	2.2	m^3/d
Design Criteria		
Retention Time	1.0	d
Capacity Calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**2.2**	m^3
Tank dimension		
- Diameter	1200	mmD
- Height	2200	mmH
	2.5	**m^3**
Material of construction	FRP	
Agitator		
Revolution	300	rpm
Tank Volume	2.5	m^3
Mixing power	0.15	kW/m^3
	0.4	kW
Selected Agitator Size	**0.4**	**kW**
Type	Vertical Pitched Paddle	
Material	SS316	

Chelate agent is supplied to T202 (Table 14) to specifically treat Ni in wastewater. Specifications of Chelate agent tank are listed in Table 36.

Table 36: Specifications of Chelate Agent Tank T414

Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank Capacity	**0.2**	m^3
- Diameter	500	mmD
- Height	1000	mmH
	0.2	**m^3**
Material of construction	FRP	

2.4. Sludge treatment and pits:

2.4.1. Sludge treatment

In CN Sedimentation Tank T103 (Table 5) and Ni Sedimentation Tank T204 (Table 16), the slurry is scrapped to a central hole at the bottom of the tanks. A specialized slurry transfer pump is used to deliver the slurry streams to their respective CN Slurry Tank T110 (Table 38) and Ni Slurry Tank T215 (Table 39).

The components of 2 slurry streams are given in Table 37 below:

Table 37: Components of two slurry streams from CN and Ni Sedimentation Tanks:

Flow rate	**5.3 m3/d**
CN slurry	1.5%
Dissolved solids	**79.0 kg/d**
CuCN	57.6 kg/d
$Cu(OH)_2$	19.1 kg/d
$Ni(OH)_2$	2.1 kg/d
$Fe(OH)_3$	0.2 kg/d
Organic	0.5 kg/d

Flow rate	**8.5 m3/d**
Ni slurry	1.5%
Dissolved solids	**127.1 kg/d**
$Cu(OH)_2$	1.1 kg/d
$Ni(OH)_2$	12.9 kg/d
$Fe(OH)_3$	100.6 kg/d
Organic	1.8 kg/d
$Ca(OH)_2$	10.8 kg/d

Table 38: Specifications of CN Slurry Tank T110

Design conditions		
Flow rate	5.3	m^3/d
Design Criteria		
Retention time	12.0	h
Capacity calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**2.7**	m^3
Tank dimension		
- Height	1000	mmH
- Length	1500	mmL
- Width	2000	mmW
	3.0	m^3
Material of construction	Reinforced Concrete with Water Proof	
Agitator		
Revolution	10.1	rpm
Tank Volume	3.0	m^3
Mixing power	0.05	kW/m^3
	0.2	kW
Quantity	1	(One) for duty
	1	**(One) in total**
Selected Agitator Size	**0.2**	**kW**
Type	Vertical Pitched Paddle	
Material	SS316	

Table 39: Specifications of Ni Slurry Tank T215

Design conditions		
Flow rate	8.5	m³/d
Design Criteria		
Retention time	12.0	h
Capacity calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**4.3**	m³
Tank dimension		
- Height	1500	mmH
- Length	1500	mmL
- Width	2000	mmW
	4.5	m³
Material of construction	Reinforced Concrete with Water Proof	
Agitator		
Revolution	10.1	rpm
Tank Volume	4.5	m³
Mixing power	0.08	kW/m³
	0.4	kW
Quantity	1	(One) for duty
	1	**(One) in total**
Selected Agitator Size	**0.4**	**kW**
Type	Vertical Pitched Paddle	
Material	SS316	

For each slurry tank, a filter press is used to dehydrate the sludge (Table 40 and Table 41). Water from the filter presses is collected into Filter Presses Sump Pit T112 (Table 42), to be pumped to T003 (Table 12 and Appendix P&ID) for treatment. Dehydrated sludge is packed for delivery for further treatment or use.

Table 40: Specifications of Filter Press FP111 and sludge dumping of CN slurry

Design Conditions		
CuCN	57.6	kg/d
$Cu(OH)_2$	19.1	kg/d
$Ni(OH)_2$	2.1	kg/d
$Fe(OH)_3$	0.2	kg/d
Organic	0.5	kg/d
Total Dissolved Solids	**79.5**	**kg/d**
Sludge concentration	75	%
Sludge load (for dumping)	**318.0**	**kg/d**
Wet sludge (for dumping)	238.5	kg/d
Design Criteria		
Loading	2.0	kg/m2
Open Batch	2	Batch/day
Capacity calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Area	79.5	m2/Batch
Required Volume	0.16	m^3/Batch
To FP sump pit - T112	**5.0**	**m^3/d**

Table 41: Specifications of Filter Press FP216 and sludge dumping of Ni slurry

Design Conditions		
$Ca(OH)_2$	10.8	kg/d
$Cu(OH)_2$	1.1	kg/d
$Ni(OH)_2$	12.9	kg/d
$Fe(OH)_3$	100.6	kg/d
Organic	1.8	kg/d
Total Dissolved Solids	**127.2**	**kg/d**
Sludge concentration	75	%
Sludge load (for dumping)	**508.8**	**kg/d**
Wet sludge (for dumping)	381.6	kg/d
Design Criteria		
Loading	2.0	kg/m^2
Open Batch	2	Batch/day
Capacity calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Area	127.2	m^2/Batch
Required Volume	0.25	m^3/Batch
To FP sump pit - T112	**8.0**	**m^3/d**

Table 42: Specifications of Filter Presses Sump Pit T112

Design condition		
From FP111	5.0	m^3/d
From FP216	8.0	m^3/d
Total	13.0	m^3/d
Design Criteria		
Retention time	20	h

Capacity calculation		
Quantity	1	(One) for duty
	1	**(One) in total**
Required Tank capacity	**13.0**	m^3
Tank dimension		
- Height	2000	mmH
- Length	2700	mmL
- Width	2700	mmW
	14.6	m^3

2.4.2. Sump pits, chemical pits and emergency tanks:

In the incident of leaking/overflowing from wastewater tanks, vessels, pipes and pumps, the leaked/overflowed wastewater is drained to five drain sumps No.1 to No.5. Drain sumps No. 2, 3 and 4 are used for CN treatment, while drain sumps No. 1 and No. 5 are used for Ni treatment (Appendix P&ID). Drainage wastewater is collected in five sump pits, T311/312/313/314/315 (Table 43). Similar to how the drain sumps are numbered, drainage water from T312, T313 and T314 is pumped to CN WW tank T001 (Table 2) while drainage water from T311 and T315 is pumped to Ni WW Tank T003 (Table 12).

Table 43: Specifications of Sump Pit T311/312/313/314/315

Quantity	5	(Five) for duty
	5	**(Five) in total**
Required pit volume	0.2	m^3
Tank dimension		
- Depth	800	mmH
- Length	500	mmL
- Width	500	mmW
	0.2	m^3

Two Emergency Tanks T005A/B (Table 44) are used to store emergency flow from factory and excess wastewater from T001 (Table 2) and T003 (Table 12). In addition, if CN and Ni treatment do not produce acceptable discharge quality according to Column A of QCVN, then wastewater from CN Monitoring Tanks T107A/B/C (Table 10) and Effluent Tank T212 (Table 25) will be

pumped to emergency tanks for further treatment and/or for waiting further decision from KVC management board (appendix – P&ID).

Table 44: Specifications of Emergency Tank T005A/B

Quantity	2	(Two) for duty
	2	**(Two) in total**
Required Tank Capacity	**100.0**	m^3
Tank Dimension		
- Height	4500	mmH
- Length	5000	mmL
- Width	5000	mmW
	112.5	m^3
Material of construction	Reinforced Concrete with Water Proof	

Acid Chemical Sump T400 and Alkaline Chemical Sump T410 (Table 45) are used to store wastewater from the acid and alkaline storage and service tanks. Wastewater from T400 and T410 is pumped to T003 (Table 12) for treatment (appendix – P&ID). T400 and T410 are identical in design

Table 45: Specifications of Acid Chemical Sump T400 and Alkaline Chemical Sump T410

Quantity	2	(One) for duty
	2	**(One) in total**
Required pit volume	1.0	m^3
Tank dimension		
- Depth	1000	mmH
- Length	1000	mmL
- Width	1000	mmW
	1.0	m^3

3. Discussions and Limitations

3.1. Discussions

In general, this thesis project is based on the physio-chemical treatment for wastewater, which has been developed and employed for several decades. However, coagulation – flocculation – sedimentation can reduce suspended solids to a certain level, but not necessarily eliminate colors, odors. Moreover, as the retention time for KVC Sedimentation Tanks is 6 hours, the wastewater can be contaminated with other substances from rain water. Therefore, following filter vessels (MMF and/or ACF) are required to eliminate residual suspended solids. The filter media must be monitored and replaced periodically.

The CN monitoring process at KVC is altogether modern and innovative. As three tanks are installed and no two tanks are either receiving, monitoring or discharging at the same time, the quality of CN treated WW can be assessed rather objectively.

3.2. Limitations

There are many limitations in this design, which can be classified into structural limitations and situational limitations.

Firstly, little is known about the terrain and structural layout of the area on which this treatment plant could be built. Therefore, it is impossible to deduct the suitable dimensions for the required tanks, pits and vessels. Many of the dimensions were calculated to fit the required volumes and were not following any specific principles of construction. Moreover, placements for tanks, vessels and pits were not included in this study. As such, pumping and piping specifications could not be designed and calculated properly, nor shown in the P&ID.

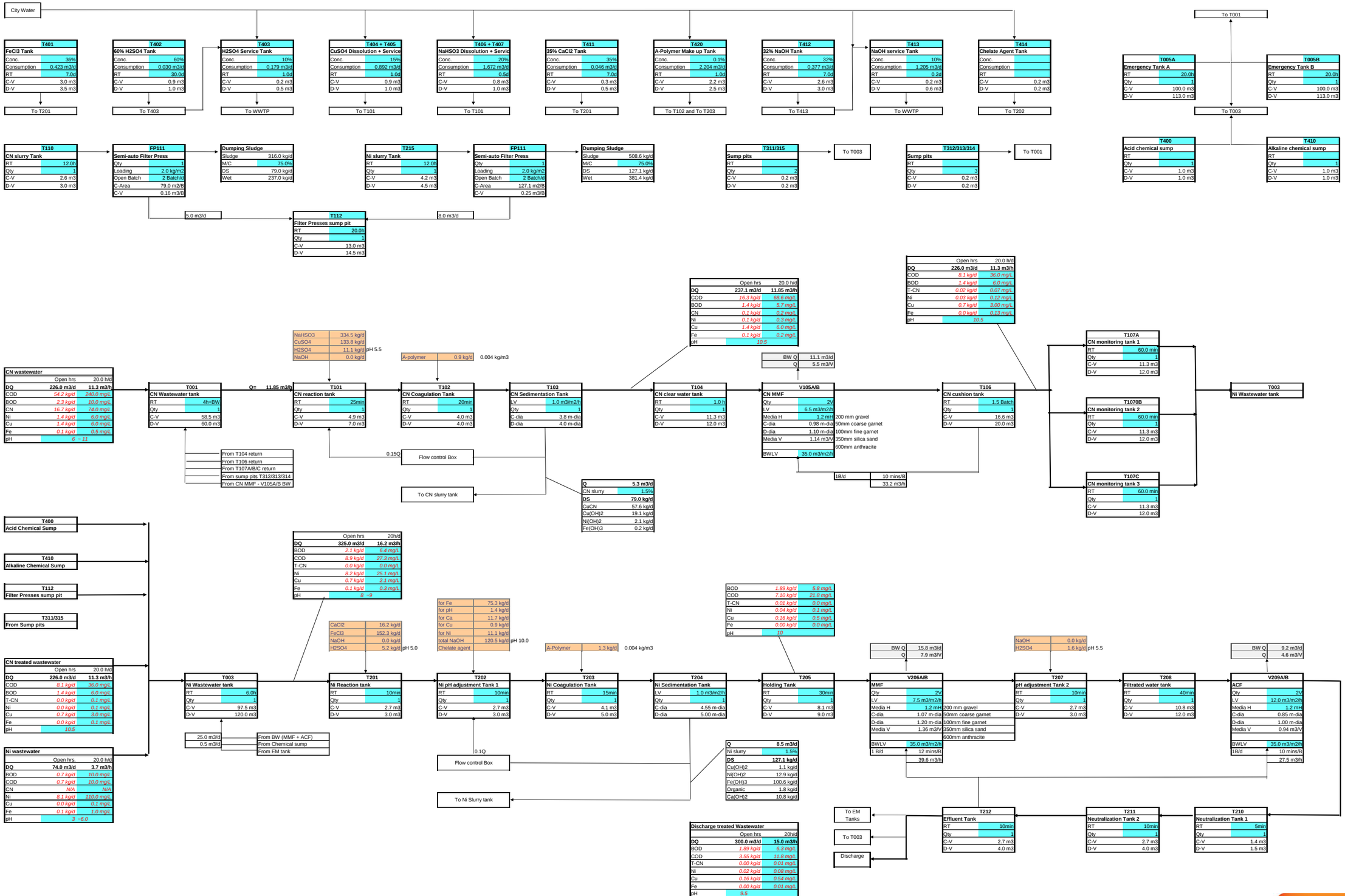
Secondly, situational limitations include but are not limited to WW components and chemical injections. The modified system in this study serves only to treat WW containing high SS and heavy metals. If the factory WW contains excessive organic materials, this treatment philosophy, and its equipment, may not be suitable. Furthermore, as the concentrations of WW components fluctuate, the loads and flow rates of treatment chemicals (acid, alkaline, etc.) have to be adjusted accordingly. This thesis project, however, introduced ONE variation of WW component only, without any equipment for precise chemical injections. In reality, at KVC manufacturing plant, there is a device called ‘pH cleaner’ to adjust pH to proper level at T101 (Table 3), T201 (Table 13) and T210 (Table 23).

List of references

1. ORGANO VIETNAM. History [Internet]. Hanoi (Vietnam): ORGANO (VIETNAM) Co. Ltd. [Cited 2018 Aug 12]. Available from: http://organovietnam.vn/en/ct/75-lich-su.html
2. KYOCERA. KYOCERA Group (Global) [Internet]. Japan: KYOCERA CORPORATION. [Cited 2018 Aug 12]. Available from: https://global.kyocera.com/company/location/region/global/asia.html
3. KYOCERA. KYOCERA holds Inauguration ceremony for new Manufacturing plant in Vietnam [Internet]. Japan: KYOCERA CORPORATION. 2014 Dec 17 [cited 2018 Aug 13]. Available from: https://global.kyocera.com/news/2014/1204_icmp.html
4. KYOCERA. LTCC packages [Internet]. Japan: KYOCERA CORPORATION. [Cited 2018 Aug 14]. Available from: https://global.kyocera.com/prdct/semicon/flow/ltcc_flow.html
5. EPECTEC. Printed Circuit board surface finishes – Advantages and Disadvantages [Internet]. New Bedford (USA): Epec Engineered Technologies. [Cited 2018 Aug 15]. Available from: http://www.epectec.com/articles/pcb-surface-finish-advantages-and-disadvantages.html
6. EUROCIRCUITS. Che Ni/Au or ENIG – Electroless Nickel Immersion Gold [Internet]. Hungary: Eurocircuits company. [Cited 2018 Aug 17]. Available from: https://www.eurocircuits.com/che-niau-or-enig-electro-less-nickel-immersion-gold/
7. Surface Treatment Experts. Electronics Electroplating [Internet]. Harrisburg (USA): Surface Treatment Experts. [Cited 2018 Aug 18]. Available from: https://www.sharrettsplating.com/industries/electronics-electroplating
8. Surface Treatment Experts. The use of Gold plating in Electronis & Electrical components [Internet]. Harrisburg (USA): Surface Treatment Experts. [Cited 2018 Aug 18]. Available from: https://www.sharrettsplating.com/blog/use-gold-plating-electronics-electrical-components/
9. Shor International. Cyanide-based gold plating solution instructions [Internet]. New York (USA): Shor International Corporation. [Cited 2018 Aug 20]. Available from: https://www.ishor.com/gold-plating-instructions
10. Multi Mix Systems. Technical Bulletin [Internet], Western Australia. Multi Mix Systems Pty Ltd.; 2009 [cited 2018 Aug 20]. Available from: https://web.archive.org/web/20091023235047/http://www.multimix.com.au/DOCUMENTS/Technical%20Bulletin1.PDF
11. Surface Technology. Electroless Nickel plating service [Internet]. Coventry (UK): Surface Technology. [Cited 2018 Aug 21]. Available from: http://www.surfacetechnology.co.uk/plating/electroless-nickel-plating/

12. Ministry of Natural Resources and Environment. QCVN 40:2011/BTNMT, National Technical regulation on Industrial wastewater [Internet], Vietnam; 2011 [cited 2018 Aug 15]. Available from: https://circabc.europa.eu/sd/a/97d7bd92-e92e-4b42-a2b3-6a1d8d00d81d/National%20Technical%20Regulation%20%20on%20Industrial%20Wastewater.pdf
13. Mudder TI, Botz MM, Smith A. Chemistry and Treatment of Cyanidation Wastes. Mining Journal books Ltd. [Internet]. [Cited 2018 Aug 25];1(1):327. Available from: http://dana6.free.fr/2%20SO2-Air%20cyanide%20oxydation.pdf

Appendix 1: Water-material Balance



Appendix 2: Process & Instrument Diagram

TANK/PIT EQUIPMENTS

- GARBAGE SCREENER
- WATER LEVEL SENSOR (FLOAT TYPE)
- WATER LEVEL SENSOR (ROD TYPE)
- WATER LEVEL SENSOR (FOR CHEMICAL TANKS)
- TANK MIXER (FOR TANK STABILIZATION)
- TANK MIXER (FOR CHEMICAL MIXING)
- pH INDICATOR
- AIR VENT (FOR CHEMICAL TANKS)

VALVE SYMBOLS

- BUTTERFLY VALVE (LEVER OPERATED)
- BUTTERFLY VALVE (GAUGE OPERATED)
- BUTTERFLY VALVE (AIR OPERATED)
- BALL VALVE
- BUTTERFLY VALVE (AIR OPERATED)
- CHECK VALVE
- BALL–CHECK VALVE
- DIAPHGRAM VALVE
- DIAPHGRAM VALVE (AIR OPERATED)
- AQUAMATIC DIAPHGRAM VALVE

VALVE SYMBOLS (CONT.)

- FLEX VALVE
- SOLENOID VALVE
- PETCOCK VALVE
- GATE VALVE
- RELIEF VALVE
- FLOW CHECKER (FOR CHEMICALS)
- STRAINER

OTHER EQUIPMENTS

- LINE REDUCER
- LINE INCREASER
- HORIZONTAL CENTRIFUGAL PUMP
- SUBMERSIBLE PUMP (FOR PITS)
- POSITIVE DISPLACEMENT PUMP (FOR CHEMICALS)
- FLOW INDICATOR (FOR WATER)
- FLOW INDICATOR (FOR CHEMICALS)
- PRESSURE INDICATOR
- PRESSURE INDICATOR WITH ALARM
- SAMPLING VALVE
- IN–LINE MIXER

PROCESS PIPING

- MAIN PROCESS FLOW PIPING
- SECONDARY FLOW PIPING

USER	CUONG TRAN THE		
TITLE	Waste Water Treatment Plant Flow Diagram 1/5 Symbols and Legends		
APP.		PURCHASER	
CHK.		SCALE NTS ● A3	UNIT mm
DSN.		WORKS No.	DRAWING No. / REV.
DWG.		FINAL THESIS	FT – 01
		Vietnam	

CN Waste Water		
Ope. Hrs		20h/d
DO	226.0m3/d	11.3m3/h
BOD	2.3kg/d	10mg/l
COD	54.2kg/d	240mg/l
SS	N/A	N/A
CN	16.7kg/d	74mg/l
NI	1.4kg/d	6mg/l
Cu	1.4kg/d	6mg/l
Fe	0.1kg/d	0.5mg/l
pH	6~11.0	

From T005 Emergency Tank
Dwg No.: FT – 03

From T112 FP Sump
Dwg No.: FT – 04

From T314 Sump
Dwg No.: FT – 05

From T312 Sump
Dwg No.: FT – 05

From CN MMF – V105A/B Backwash
Q = 11.1 m3/d

From T313 Sump
Dwg No.: FT – 05

CN Waste Water From Factory

LLA LAH LQA001

0.5kW, 4P SUS316 M001

T001
CN Waste Water Tank
L5000 x W5000 x H2500
RC/FRP 62m3

001-50 To T005A Emergency Dwg No.:

Drain Sump No.3

P001A/B
CN WW Feed Pump
SCS13
Centrifugal End Suction

Q=0~15m3/h FIQ001

001-43 001-44 001-45 001-42 To T005A Emergency 001-41 To T005B Emergency Dwg No.: FT – 03

Q=11.85m3/h

101-03 101-02 101-01 101-11 AV101-1 101-12 101-32 101-31 101-21 AV101-2

80rpm, 1.5kW SUS A101 pHC101

102-03 102-02 102-01

20rpm, 0.75kW INV SUS A102

1/10933, 0.01rpm, 0.4kW, INV FC W103 Cutter SUS

LLL LCA104

T101
CN Reaction Tank
L1500 x W1400 x H2850
RC/ FRP 6.0m3

T102
CN Coagulation Tank
L1300 x W1300 x H3000
RC/FRP 5.0m3

T103
CN Sedimentation Tank
W4500 x L4500 x H5250
RC/FRP

T104
CN Clear Water Tank
L2000 x W2000 x H3500
RC/FRP, 14m3

104-51 P104A 0~0.6Mpa 3/8 104-11 104-12 104-13 P104B 0~0.6Mpa 3/8 104-21 104-22 104-23 104-41 104-01

Drain Sump No.2

P104-A/B/C
CN MMF Feed Pump
FC
Centrifugal / End Suction
JIS10K FLG

0~8m3/h FIA105-1 105-01 105-02 105-03

AQ105A-01 AQ105A-02 SV 0.35MPa SA105A AQ105A-03 PI105A 0~0.6Mpa AV105A-04 AV105A-07 AQ105A-04 AV105A-03

V105A
CN MMF
D1100 x H2200
SS400/Tarepoxy

AQ105B-01 AQ105B-02 SV 0.35MPa SA105B AQ105B-03 PI105B 0~0.6Mpa AV105B-04 AV105B-07 AQ105B-04 AV105B-03

V105B
CN MMF
D1100 x H2200
SS400/Tarepoxy

From P405 CuSO4
To T413 Return NaOH
From P413 NaOH
To T403 Return H2SO4
From P403 H2SO4
From P407 NaHSO3
From P420-1 Polymer
Dwg No.: FT – 05

A-Mix/A A-Mix/B 103-07 103-06 103-05 103-01 AV103-01 AV103-02 P103 0~1.5Mpa 1/2" 103-04 103-03 103-02

To T110 CN Slurry Tank
Dwg No.: FT – 04

P103
CN Slurry Circulation Pump
FC
Self-priming
JIS10K FLG

To T112 FP Sump
Dwg No.: FT – 04

AQ108-00 108-03 CDA 108-02 IW Water 108-01

M108
Total CN Analyzer

HLL LCA106 106-41 106-42 106-43 P1062B 0~0.4Mpa P1062A 0~0.4Mpa 106-31 106-32 106-33 P1061B 0~0.4Mpa 106-20 106-21 106-22 P1061A 0~0.4Mpa 106-10 106-11 106-12 106-21

Drain Sump No.3

T106
CN Cushion Tank
L3000 x W3000 x H2400
RC/FRP, 21m3

P106-1-A/B	P106-2-A/B
CN Filtrated W Transfer Pump	CN Back Wash Pump
FC	FC
Centrifugal/End Suction	Centrifugal/End Suction
JIS10K FLG	JIS10K FLG

HLL LCA107A AQ107-01 AQ107-03 107-05 AQ107-04 AQ107-02 P107A 0~0.4Mpa 107-01 107-02 107-03 107-04

Drain Sump No.4

T107A
CN Monitoring Tank 1
L2000 x W2000 x H3400
RC/FRP, 14m3

P107A
CN Effulent Transfer Pump
FC
Centrifugal/End Suction
JIS10K FLG

HLL LCA107B AQ107-11 AQ107-13 107-15 AQ107-14 AQ107-12 P107B 0~0.4Mpa 107-11 107-12 107-13 107-14

Drain Sump No.4

T107B
CN Monitoring Tank 2
L2000 x W2000 x H3400
RC/FRP, 14m3

P107B
CN Effulent Transfer Pump
FC
Centrifugal/End Suction
JIS10K FLG

HLL LCA107C AQ107-21 AQ107-23 107-25 AQ107-27 AQ107-22 P107C 0~0.4Mpa 107-21 107-22 107-23 107-24

Drain Sump No.4

T107C
CN Monitoring Tank 3
L2000 x W2000 x H3400
RC/FRP, 14m3

P107C
CN Effulent Transfer Pump
FC
Centrifugal/End Suction
JIS10K FLG

CN treated wastewater		
Ope. Hrs		20h/d
DO	226m3/d	11.3m3/h
BOD	1.4kg/d	6.0mg/l
COD	8.1kg/d	36.0mg/l
T-CN	0.03kg/d	0.07mg/l
NI	0.03kg/d	0.12mg/l
Cu	0.7kg/d	3.0mg/l
Fe	0.01kg/d	0.13mg/l
pH	10.5	

AQ107-30 AQ107-31 To T003 NI WW Tank Dwg No.: FT – 03 AQ107-32 To T005A Emergency Dwg No.: FT – 03 AQ107-33 To T005B Emergency Dwg No.: FT – 03

USER	CUONG TRAN THE		
TITLE	Waste Water Treatment Plant Flow Diagram 2/5 CN Treatment		
APP.		PURCHASER	
CHK.		SCALE NTS @ A3	UNIT mm
DSN.		WORKS No.	DRAWING No. / REV.
DWG.		FINAL THESIS	FT – 02

Vietnam

Ni Process Waste Phase 1		
Ope. Hrs		20h/d
DO	74m3/d	3.7m3/h
BOD	0.7kg/d	10mg/l
COD	0.7kg/d	10mg/l
SS	N/A	N/A
Cu	0.01kg/d	0.1mg/l
Ni	8.1kg/d	110mg/l
Fe	0.1kg/d	1.0mg/l
CN	N/A	N/A
pH	3 ~ 6	

Ni Waste Water From Factory
From FP 216
V206A/B MMF BW Waste Water Q=15.8m3/d
V209A/B ACF BW Waste Water Q=9.2m3/d
From T005 Emergency Tank
From T107-A/B/C CN Monitoring Tanks
Dwg No.: FT – 02
From T214 Effluent Tank
Dwg No.: FT – 04
From T400 Acid Chemical Sump
From T410 Alkaline Chemical Sump Pump
Dwg No.: FT – 05
From T311 Sump
Dwg No.: FT – 05
From T315 Sump
Dwg No.: FT – 05

1.0kW, 4P SUS316 A003

LLLNLHH LCA003

T003
Ni Waste Water Tank
L5000 x W5000 x H4000
RC/FRP 125m3

003-02 To T005A Emergency Dwg No.: FT – 03

003-44 To T005A Emergency
003-45 To T005B Emergency
Dwg No.:

0~60m3/h FIQ003
003-41 003-43 003-42

INV PI003B 0~ 0.2Mpa P003A 003-20 003-21 003-22 003-01 003-10 003-11 003-12

Drain Sump No.5

P003-A/B/(C)
Ni WW Feed Pump
FC200
Centrifugal / End Suction
JIS10K FLG

From P411 CaCl2
From P401 FeCl3
From P403 H2SO4
To T413 Return NaOH
From P413 NaOH
From P414 Chelate Agent
From P420-2 A-Polymer
Dwg No.: FT – 05

201-03 201-13 201-01 201-02 201-12 201-11 AV201-1 AV201-2 201-21 201-22

80rpm, 1.5kW SUS A201 pHIC201

202-03 202-01 202-02 AV202 202-22

80rpm, 1.5kW SUS A202 pHIC202

203-03 203-01 203-02

20rpm, 0.75kW INV SUS A203

1/16211, 0.01 rpm,0.75kW, INV FC M204 Cutter SUS

T201
Ni Reaction Tank
L1500 x W1100 x H2200
RC/FRP 3.6m3

T202
Ni pH Adjustment Tank 1
L1500 x W1100 x H2200
RC/FRP 3.6m3

T203
Ni Coagulation Tank
L1500 x W1200 x H3000
FRP 5.4m3

T204
Ni Sedimentation Tank
L4500 x W4500 x H5250
RC/FRP

204-01

HJ LCA205

T205
Holding Tank
L2000 x W2500 x H2200
RC/FRP 11m3

205-42

PI005B 0~ 0.6Mpa PI005A 0~ 0.6Mpa 205-20 205-21 205-22 205-01 205-10 205-11 205-12 205-40

Drain Sump No.1

To V206A/B MMF Dwg No.: FT – 04

P205-A/B
Ni Filter Pump
FC
Centrifugal / End Suction
JIS10K FLG

0~5m3/h FIQ004 204-07 204-06 204-05

AV204-01 AV204-02

To T215 Ni Slurry Tank Dwg No.: FT – 04

PI004 0~ 1.5Mpa 204-04 204-03 204-02

Drain Sump No.1

P204-1
Ni Slurry Circulation Pump
FC250/NR
Self-priming
JIS10K FLG

005-14 005-13

Emergency Flow From Factory
From T214 Effluent Tank Dwg No.:
From T107-A/B/C CN Monitring Tank Dwg No.:
From T001 CN Waste Water Tank Dwg No.:
From T003 Ni Waste Water Tank Dwg No.:

LLLNLHH LCA005A

T005A
Emergency Tank A
L5000 x W5000 x H4500
RC/FRP 112m3

005-11

From T214 Effluent Tank Dwg No.:
From T107-A/B/C CN Monitring Tank Dwg No.:
From T001 CN Waste Water Tank Dwg No.:
From T003 Ni Waste Water Tank Dwg No.:

LLLNLHH LCA005B

T005B
Emergency Tank B
L5000 x W5000 x H4500
RC/FRP 112m3

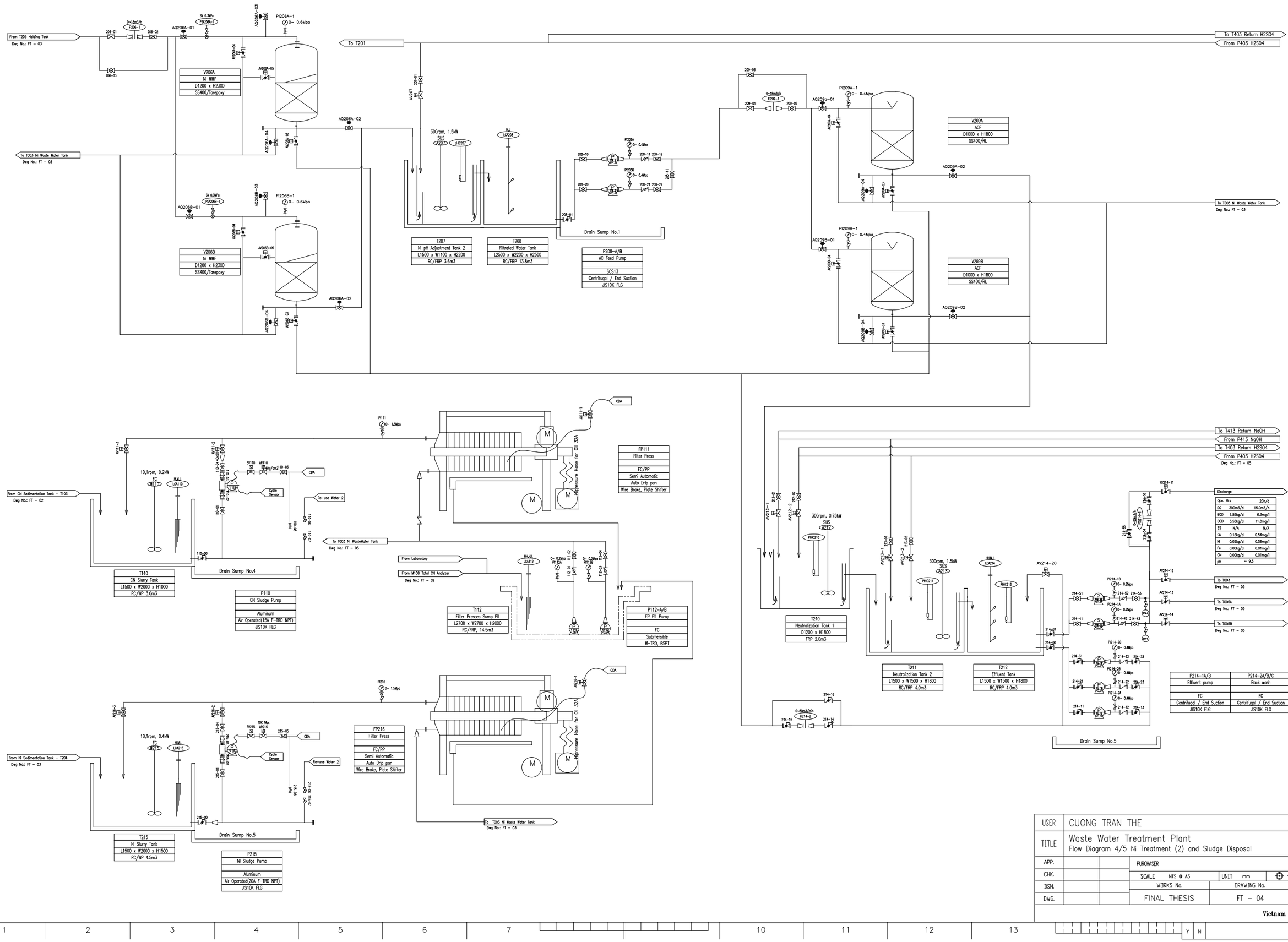
005-21 005-20 P005 005-01 To T001 CN Waste Water Tank Dwg No.: FT – 02 005-02 To T003 Ni WW Tank Dwg No.: FT – 03

Drain Sump No.2

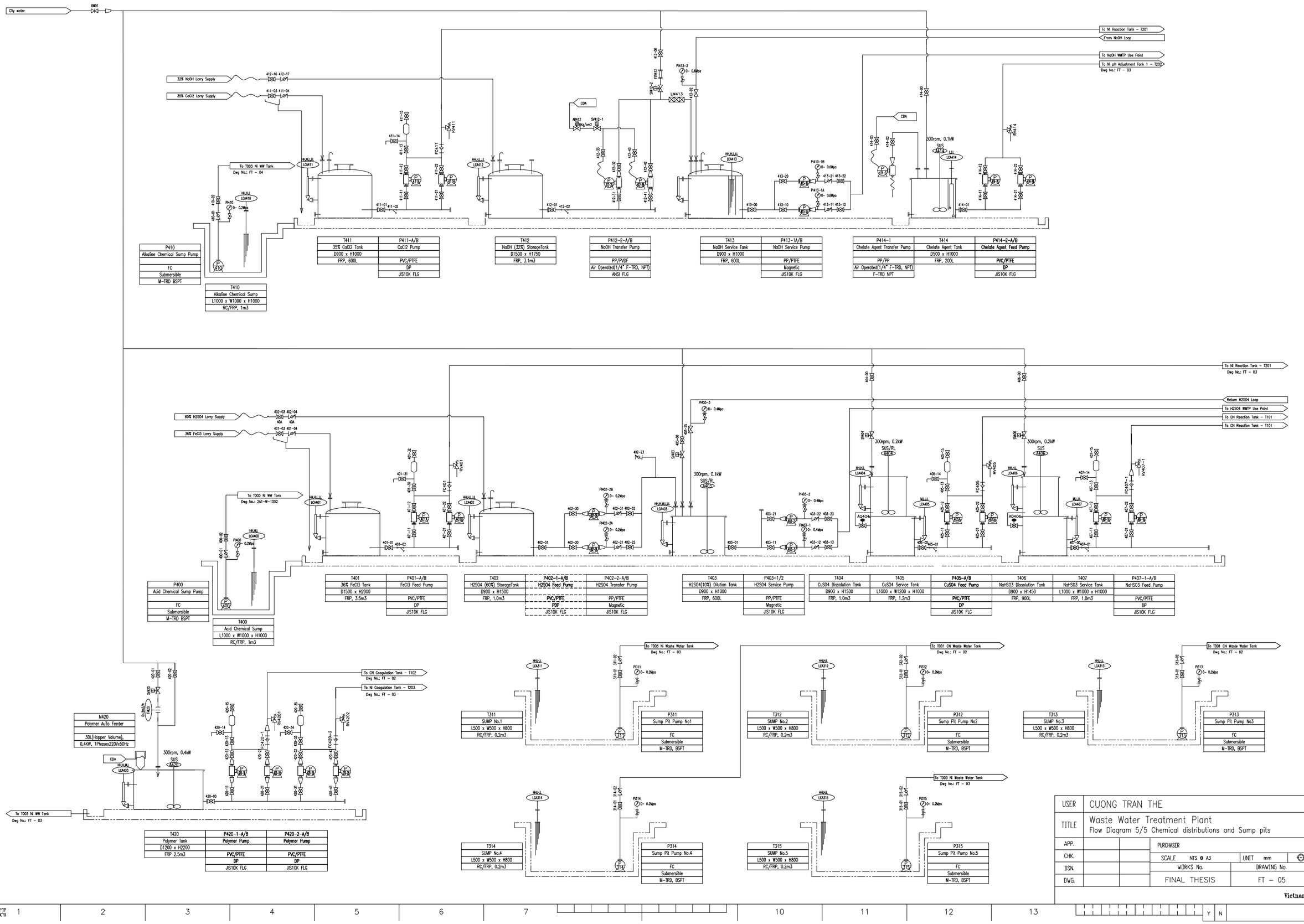
P005
Emergency Transfer Pump
FC250/NR
Centrifugal/End Suction
JIS10K FLG

USER	CUONG TRAN THE		
TITLE	Waste Water Treatment Plant Flow Diagram 3/5 Ni Treatment (1) and Emergency Tanks		
APP.		PURCHASER	
CHK.		SCALE NTS @ A3	UNIT mm
DSN.		WORKS No.	DRAWING No. REV.
DWG.		FINAL THESIS	FT – 03

Vietnam



USER	CUONG TRAN THE			
TITLE	Waste Water Treatment Plant Flow Diagram 4/5 Ni Treatment (2) and Sludge Disposal			
APP.			PURCHASER	
CHK.			SCALE NTS @ A3	UNIT mm
DSN.			WORKS No.	DRAWING No. / REV.
DWG.			FINAL THESIS	FT – 04
			Vietnam	



USER	CUONG TRAN THE
TITLE	Waste Water Treatment Plant Flow Diagram 5/5 Chemical distributions and Sump pits
APP.	
CHK.	
DSN.	
DWG.	
PURCHASER	
SCALE	NTS @ A3
UNIT	mm
WORKS No.	
DRAWING No.	FT – 05
REV.	
FINAL THESIS	

Vietnam