

## ภาคผนวก 2.4-3

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### WATER TREATMENT CALCULATION DATA SHEET

**WATER TREATMENT CALCULATION DATA SHEET**

**FOR**

**ADVANCE ENERGY DEVELOPMENT COMPANY LIMITED**

**PROJECT**

**WATER TREATMENT SYSTEM**

**(CLARIFIER 120 M<sup>3</sup>/HR + DEMIN 12 M<sup>3</sup>/HR)**

**BY**

**HYDROZONE COMPANY LIMITED**

**RAW WATER TREATMENT CALCULATION SHEET**



## RAW WATER TREATMENT CALCULATION

### I: Raw water characteristic

Item	Description	River	
		Value	Unit
1	pH	7.7 to 9.0	-
2	Conductivity	$\leq 350$	$\mu\text{S}/\text{cm}$
3	Turbidity	$\leq 90.00$	NTU
4	Total Suspended Solids	$\leq 50.00$	mg/l
5	Total Dissolved Solid	$\leq 245.00$	mg/l
6	Total Hardness	$\leq 70.00$	mg/l as $\text{CaCO}_3$
7	Iron	$\leq 5.00$	mg/l as Fe
8	Total Alkalinity	$\leq 50.00$	mg/l as $\text{CaCO}_3$
11	Silica	$\leq 20.00$	mg/l as $\text{SiO}_2$

### II: Treated Water Quality Guarantee Values

Item	Description	Service Water	
		Value	Unit
1	Capacity	120.00	$\text{m}^3/\text{hr}$
2	pH	7 to 8	-
3	Turbidity	$\leq 5.0$	NTU
4	Suspended Solids	$\leq 5.0$	-

### III: Design input parameter

Item	Description	Value	Unit	Remark
1	Design flowrate	130.00	$\text{m}^3/\text{hr}$	Inlet Clarifier
2	Design flowrate	120.00	$\text{m}^3/\text{hr}$	Inlet Sand Filter
3	Clarifier Inlet pressure	$> 1.00$	bar	At inlet valve
4	Pre-Chlorine dose	5.00	mg/l	NaOCl 100%
5	Coagulant dose	10.00	mg/l	PAC 100%
6	Polymer dose	1.00	mg/l	Polymer
7	Liquid chemical tank capacity	1.00	days	



## RAW WATER TREATMENT CALCULATION

## IV: Calculation

## 1 Chlorine Dosing unit

## 1.1 Compute capacity of Pre-Chlorine dosing pumps

Density of NaOCl 10%	=	1.190	kg/l
Dose requirement	=	Dosage (ppm)*Design Flowrate (m3/hr)/1000	
	=	0.65	kg/hr
	=	6.50	kg/hr @ 10% Concentration
	=	5.46	L/hr
Choose dosing pump cap.	=	25.00	L/hr at pressure > 1.0 bar

## 1.2 Compute capacity of NaOCl 10% storage tank for 1 days capacity

Tank capacity	=	(Pre Chlorine (L/hr))*24(hr/day)	
	=	131.09	L/day
	=	131.09	L (for 1 days)
Choose tank capacity	=	2,000.00	L

## 2 Coagulation Dosing Unit (PAC)

## 2.1 Compute capacity of PAC 10% dosing pumps

Density of PAC 23%	=	1.200	kg/l
Dose requirement	=	Dosage (ppm)*Design Flowrate (m3/hr)/1000	
	=	1.30	kg/hr
	=	13.00	kg/hr @ 10% Concentration
	=	10.83	L/hr
Choose dosing pump cap.	=	50.00	L/hr at pressure > 1.0 bar

## 2.2 Compute capacity of PAC 10% storage tank for 1 days capacity

Tank capacity	=	Dose requirement (L/hr)*24(hr/day)	
	=	260.00	L/day
	=	260.00	L (for 1 days)
Choose tank capacity	=	2,000.00	L



## RAW WATER TREATMENT CALCULATION

### 3 Polymer Dosing Unit

#### 3.1 Compute capacity of polymer (Clarifier) dosing pump

Use Polymer concentration	=	0.10	%
Density of polymer 0.1%	=	0.998	kg/l
Polymer Requirement	=	Dosage (ppm)*Design Flowrate (m <sup>3</sup> /hr)/1000	
	=	0.13	kg/hr @ 100% Concentration
	=	130.00	kg/hr @ 0.1% Concentration
	=	130.26	L/hr @ 0.1% Concentration
Choose dosing pump cap.	=	315.00	L/hr at pressure > 1.0 bar

#### 3.2 Compute capacity of Polymer 0.1% storage tank for 4 hour capacity

Tank capacity	=	Dose requirement (L/hr)*24(hr/day)	
	=	521.04	L/day
Choose tank capacity	=	2,000.00	L

#### 3.3 Compute capacity of Polymer 0.1% preparation tank capacity

Tank capacity	=	Dose requirement (L/hr)*Preparation time 1(hr/day)	
	=	130.26	L/day
Choose tank capacity	=	1,000.00	L

### 4 Pulsator Clarifier

#### 4.1 Design input parameter

Item	Range	Chose
Sedimentation detention time, hr	> 1.0	1.3
Overflow rate, m <sup>3</sup> /m <sup>2</sup> .hr	4 to 6	4.5

#### 4.2 Compute diameter of tank (2 x 50%)

Clarifier separation area	=	Design flowrate (m <sup>3</sup> /hr)/ Upflow velocity(m <sup>3</sup> /m <sup>2</sup> .hr)	
Required separation area	=	28.89	m <sup>2</sup>
Choose Clarifier WxH	=	5x6	m.
Top Width	=	5.00	m.
Top Length	=	6.00	m.
Vacuum Chamber Width	=	2.00	m.
Vacuum Chamber Length	=	2.00	m.



### RAW WATER TREATMENT CALCULATION

Reactor height	=	6.00 m.
Compute volume of tank		
Total tank volumn	=	Volume of straight height
	=	189.00 m <sup>3</sup>
Check detension time		
Detention time	=	Volume of tank (m3)/ Clarifier Inlet flowrate(m3/hr)
	=	1.45 hr. OK
Compute separation area of tank		
A	=	Area of tank (m2) - Area of center cylineder (m2)
	=	30.00 m <sup>2</sup>
Check upflow velocity		
Upflow velocity	=	Clarifier Inlet flowrate (m3/hr) / Separation area (m2)
	=	4.33 m3/m2.hr OK

## 5 Sludge Quantity

### 5.1 Design input data

Item	Range	Chose
Clarifier Inlet flowrate, m3/hr		130.00
Suspended solid, mg/l		30.00
Total Iron, mg/l		5.00
PACl 10% dosage, mg/l		100.00
Polymer dosage, mg/l		1.00
Sludge Concentration from clarifier, %	0.5-1.0	0.50
Specific Gravity	1.00-1.2	1.10

### 5.2 Compute dry sludge

Assume, SS removal effcent	=	100.00%
PACl 10% precipitation	=	Al <sup>3+</sup> + 3OH <sup>-</sup> -----> Al(OH) <sub>3</sub> Al(OH) <sub>3</sub> precipitate is about 15.32% of PACl dosing
Polymer precipitation	=	Polymer precipitate is about 100% of Polymer dosing
Iron precipitation	=	Fe <sup>3+</sup> + 3OH <sup>-</sup> -----> Fe(OH) <sub>3</sub>
Suspended Solid Sludge	=	93.60 kg/day



### RAW WATER TREATMENT CALCULATION

PACl Sludge	=	47.80 kg/day
Polymer Sludge	=	3.12 kg/day
Iron Sludge	=	17.91 kg/day
<b>Total dry sludge</b>	=	<b>162.43 kg/day</b>
<b>Total sludge volume from clarifier</b>	=	<b>32.49 m<sup>3</sup>/day</b>
		<b>1.35 m<sup>3</sup>/hr</b>

#### 6 Polymer dosing Unit (Sludge Thickener)

##### 6.1 Design input data

Item	Range	Chose	unit
Polymer dosing rate for sludge	0.001-0.003	0.001	Kg./Kg of dry solid
Polymer powder storage time	-	1.00	day
Bulk Density of polymer 100%	-	0.70	kg./l
Density of polymer 0.1%	-	1.00	kg./l
Preparation time	120-150	60.00	min

##### 6.2 Compute polymer (Sludge Thickener) dosing pump

Use polymer concentration	=	0.10%
Polymer requirement	=	Total dry solid (kg/day) x polymer dosing rate for sludge
	=	0.16 kg/day @ 100% concentration
	=	162.43 kg/day @ 0.1% concentration
	=	162.43 L/day @ 0.1% concentration
Consider for Clarified sludge drain	=	4.00 times/hr
Drain time	=	1.00 minute/time
	=	101.52 L/hr.
<b>Choose, Polymer dosing rate</b>	=	<b>330.00 L/hr.</b>





## RAW WATER TREATMENT CALCULATION

### 7 Sludge Thickener Tank

#### 7.1 Design input data

Item	Range	Chose	unit
Solid loading rate	100 - 300	100.00	kg/ m <sup>2</sup> .day
Sludge Concentration from thickener, %	1.5 - 3.0	2.00	
Sludge Density from thickener, kg/L	-	1.05	

#### 7.2 Compute diameter of tank

Dry sludge feed thickener	=	162.43 kg/ day
Area (m <sup>2</sup> )	=	Dry sludge feed (Kg/day)
		Solid loading rate (kg/m <sup>2</sup> .day)
Area	=	1.62 m <sup>2</sup>
Diameter	=	1.44 m
Choose, Diameter	=	3.20 m

#### 7.3 Compute dimension of tank

Chose conical tank shape

Tank dimension

Top diameter	=	3.20 m
Bottom diameter	=	0.60 m
Straight height	=	1.50 m
Conical height	=	2.20 m
Total height	=	3.70 m

(Free board 0.3 m)

Check Volume of tank

V1	=	Volume of straight height
	=	9.65 m <sup>3</sup>
V2	=	Volume of conical height
	=	7.21 m <sup>3</sup>
Total tank volume	=	V1+V2
	=	16.86 m <sup>3</sup>

Check detention time

Detention time (hr)	=	Volume of tank (m <sup>3</sup> ) / Sludge drain from clarifier (m <sup>3</sup> /day)
	=	0.52 day
	=	12.46 hr



## RAW WATER TREATMENT CALCULATION

### 8 Filter Press Unit

#### 8.1 Design input data

Item	Range	Chose
Sludge Concentration from thickener, %	1.5 - 3.0	2.00
Sludge Density from filter press, kg/L	-	1.30
Sludge Density from thickener, kg/L	-	1.05
Sludge feeding time to filter press, hr	0.75 - 1.5	1.00
Filtration cycle time of filter press, hr	4 - 6	6.00
Solid content of sludge cake, %	-	25.00

#### 8.2 Compute operation cycle

$$\begin{aligned}
 \text{Operation cycle} &= \frac{24 \text{ hr/days}}{\text{Filtration cycle time of filter press, hr}} \\
 &= \frac{24}{4.00} \\
 \text{Choose, Operation cycle} &= \boxed{4.00} \text{ times/ day or batch/day}
 \end{aligned}$$

#### 8.3 Compute Filter press feed pump capacity

$$\begin{aligned}
 \text{Solid loading} &= 162.43 \text{ kg/day} \\
 &= \boxed{40.61} \text{ kg/batch} \\
 \text{Volume of sludge} &= \frac{\text{Solid loading (kg/day)}}{\text{Density (kg/L)}} \\
 &= \boxed{1,933.64} \text{ L/batch @ 2\% concentration} \\
 \text{Feed pump cap.} &= \frac{\text{Volume (L/batch)}}{\text{Feeding time (hr/batch)}} \\
 &= \frac{1,933.64}{1.00} \text{ L/hr} \\
 \text{Choose Feed pump cap.} &= \boxed{5.00} \text{ m}^3/\text{hr}
 \end{aligned}$$



## RAW WATER TREATMENT CALCULATION

### 8.4 Compute Filter press capacity

Sludge cake (Mass)	=	$\frac{\text{Solid loading (kg/day)}}{\text{Solid content in sludge after press}}$
	=	649.70 kg/day
Sludge cake volume	=	$\frac{\text{Sludge cake (Mass)}}{\text{Sludge Density from filter press, kg/L}}$
	=	499.77 L/day
Filter Press Capacity	=	$\frac{\text{Sludge cake volume (L/day)}}{\text{Filter press operating cycle (batch/ day)}}$
	=	124.94 L/batch
<b>Chose, Filter Press Capacity</b>	=	<b>230.00 L/batch</b>

## 9 Multimedia Filter Column

### 9.1 Design input

Item	Range	Chose	unit
Design flow rate (3x50%)	Per desgin	60.00	m <sup>3</sup> /hr
Filtration flow rate	10-20	15.00	m <sup>3</sup> /hr
Selected sand & gravel height	-	0.60	m
Anthracite height	-	0.40	m
Rinse flow rate	75-150	100.00	m <sup>3</sup> /hr
Backwash flow rate	150-200	200.00	m <sup>3</sup> /hr

### 9.2 Compute tank dimension

Require tank area	=	4.00 m <sup>2</sup>
Require tank diameter	=	2.26 m
<b>Choose tank diameter</b>	=	<b>2.30 m</b>
Actual tank area	=	4.15
Actual service flow rate	=	14.45
Media height	=	1.00
% Expansion	=	60.00



### RAW WATER TREATMENT CALCULATION

Bed expansion height	=	0.60
Total column height	=	1.60
<b>Choose column height</b>	=	<b>1.80 m</b>
Selected sand and gravel volume	=	2,491.59 Liters
Anthracite volume	=	1,661.06 Liters

#### 9.3 Compute backwash volume

Backwash time	=	15.00 min
Backwash volume	=	50.00 m <sup>3</sup> /tank
Expect Backwash cycle	=	1.00 time/tank/day
Ave. backwash flowrate	=	250.00 m <sup>3</sup> /day

#### 9.4 Compute rinsing volume

Rinse time	=	10.00 min
Rinse volume	=	16.67 m <sup>3</sup> /tank
Expect Backwash cycle	=	1.00 time/tank/day
Ave. backwash flowrate	=	83.33 m <sup>3</sup> /day
<b>Total Ave. BW flowrate and rinsing</b>	=	<b>13.89 m<sup>3</sup>/hr</b>

### 10 Treated water capacity (Net)

Inlet Clarifier capacity	=	130.00 m <sup>3</sup> /hr
Sludge volume average	=	1.35 m <sup>3</sup> /hr
Sand filter backwash volume average	=	13.89 m <sup>3</sup> /hr
Treated water capacity (Net)	=	114.76 m <sup>3</sup> /hr

### 11 Activated Filter Column

#### 11.1 Design input

Item	Range	Chose	unit
Design flow rate (2x100%)	Per desgin	23.00	m <sup>3</sup> /hr
Filtration flow rate	10-20	12.00	m <sup>3</sup> /hr
Activated Carbon height	-	0.70	m
Selected sand & gravel height	-	0.30	m
Rinse flow rate	50-100	23.00	m <sup>3</sup> /hr
Backwash flow rate	50-100	23.00	m <sup>3</sup> /hr



## RAW WATER TREATMENT CALCULATION

### 11.2 Compute tank dimension

Require tank area	=	1.92	m <sup>2</sup>
Require tank diameter	=	1.56	m
<b>Choose tank diameter</b>	=	<b>1.80</b>	<b>m</b>
Actual tank area	=	2.54	
Actual service flow rate	=	9.04	
Media height	=	1.00	
% Expansion	=	60.00	
Bed expansion height	=	0.60	
Total column height	=	1.60	
<b>Choose column height</b>	=	<b>1.80</b>	<b>m</b>
Activated Carbon volume	=	1,780.38	Liters
Selected sand & gravel volume	=	763.02	Liters

### 11.3 Compute backwash volume

Backwash time	=	15.00	min
Backwash volume	=	5.75	m <sup>3</sup> /tank
Expect Backwash cycle	=	1.00	time/tank/day
Ave. backwash flowrate	=	28.75	m <sup>3</sup> /day

### 11.4 Compute rinsing volume

Rinse time	=	10.00	min
Rinse volume	=	3.83	m <sup>3</sup> /tank
Expect Backwash cycle	=	1.00	time/tank/day
Ave. backwash flowrate	=	19.17	m <sup>3</sup> /day
<b>Total Ave. BW flowrate and rinsing</b>	=	<b>2.00</b>	<b>m<sup>3</sup>/hr</b>

**1st PASS RO CALCULATION SHEET**



## 1st PASS REVERSE OSMOSIS TREATMENT CALCULATION

### I: Raw water characteristic

Item	Description	River	
		Value	Unit
1	pH	7.7 to 9.0	-
2	Conductivity	$\leq 350$	$\mu\text{S}/\text{cm}$
3	Turbidity	$\leq 90.00$	NTU
4	Total Suspended Solids	$\leq 50.00$	mg/l
5	Total Dissolved Solid	$\leq 245.00$	mg/l
6	Total Hardness	$\leq 70.00$	mg/l as $\text{CaCO}_3$
7	Iron	$\leq 5.00$	mg/l as Fe
8	Total Alkalinity	$\leq 50.00$	mg/l as $\text{CaCO}_3$
11	Silica	$\leq 20.00$	mg/l as $\text{SiO}_2$

### II: Treated Water Quality Guarantee Values

Item	Description	Service Water	
		Value	Unit
1	Capacity	17.00	$\text{m}^3/\text{hr}$
2	pH	5.5 to 7	-
3	RO Permeate Conductivity	$\leq 20.0$	$\mu\text{S}/\text{cm}$
4	RO Reject Conductivity	$\leq 1,200.0$	$\mu\text{S}/\text{cm}$

### III: Design input parameter

Item	Description	Value	Unit	Remark
1	Design flowrate	22.70	$\text{m}^3/\text{hr}$	Inlet 1st Pass RO
2	RO Permeate flowrate	17.00	$\text{m}^3/\text{hr}$	RO Permeate
3	RO Reject flowrate	5.70	$\text{m}^3/\text{hr}$	RO Reject
4	Antiscale	5.00	mg/l	Antiscalant
5	Biocide	0.10	l/hr.	

**1st PASS REVERSE OSMOSIS TREATMENT CALCULATION****IV: Calculation****1 Anti-scale Dosing Unit****1.1 Compute capacity of Anti-scale dosing pumps**

Density of Tripol 8510	=	1.040	kg/l
Dose requirement	=	Dosage (ppm)*Design Flowrate (m <sup>3</sup> /hr)/1000	
	=	0.11	kg/hr
	=	0.57	kg/hr @ 20% Concentration
	=	0.55	L/hr
Choose dosing pump cap.	=	<b>1.90</b>	L/hr at pressure > 1.0 bar

**1.2 Compute capacity of Anti-scale storage tank for 1 days capacity**

Tank capacity	=	(Pre Chlorine (L/hr))*24(hr/day)	
	=	13.10	L/day
	=	13.10	L (for 1 days)
Choose tank capacity	=	<b>100.00</b>	L

**2 Biocide Dosing Unit****2.1 Compute capacity of Biocide dosing pumps**

Density of Biocide	=	1.450	kg/l
Dose requirement	=	Dosage (ppm)*Design Flowrate (m <sup>3</sup> /hr)/1000	
	=	2.27	l/day
	=	3.29	kg/day
	=	2.27	L/day
Choose dosing pump cap.	=	<b>3.80</b>	L/day at pressure > 1.0 bar

**2.2 Compute capacity of Biocide storage tank for 1 days capacity**

Tank capacity	=	2.27	L/day
Choose tank capacity	=	<b>100.00</b>	L



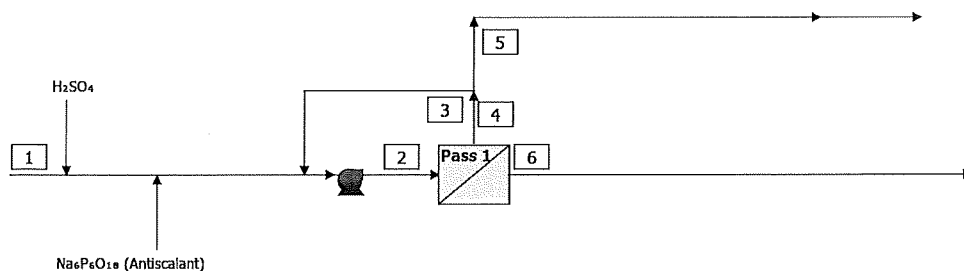
**1st PASS REVERSE OSMOSIS TREATMENT CALCULATION****3 1st Pass Reverse Osmosis****3.1 Membrane specification**

Membrane ECO-PRO400	Unit
Active area	37 m <sup>2</sup>
Feed spacer	34-LDP
Maximum Operating Temperature	45 °C
Maximum Operating Pressure	41 bar
Maximum Element Pressure Drop	1 bar
pH Range, Continuous Operation	2-11
pH Range, Short-Term Cleaning (30 min)	1-13
Maximum Feed SDI (SDI <sub>15</sub> )	5
Free Chlorine Tolerance	< 0.1 ppm

**3.2 Reverse Osmosis Calculation**

## RO Summary Report

### RO System Flow Diagram



#	Description	Flow (m <sup>3</sup> /h)	TDS (mg/L)	Pressure (psi)
1	Raw Feed to Pump	22.7	210.3	0.0
2	Net Feed to Pass 1	25.7	272.2	74.6
3	Concentrate Recycle from Pass 1 to Pass 1	3.00	795.0	50.0
4	Total Concentrate from Pass 1	8.66	794.9	50.0
5	Concentrate from Pass 1 after Recycle to Pass 1	5.66	794.9	50.0
6	Total Permeate from Pass 1	17.0	6.22	11.8

### RO System Overview

Total # of Trains	1	Online =	1	Standby =	0	RO Recovery	74.9 %
System Flow Rate	(m <sup>3</sup> /h)	Net Feed =	22.7	Net Product =	17.0		

Pass	Pass 1
Stream Name	Stream 1
Water Type	Surface Water (SDI < 5)
Number of Elements	20
Total Active Area	(m <sup>2</sup> ) 818
Feed Flow per Pass	(m <sup>3</sup> /h) 25.7
Feed TDS <sup>a</sup>	(mg/L) 272.2
Feed Pressure	(psi) 74.6
Flow Factor	0.85
Permeate Flow per Pass	(m <sup>3</sup> /h) 17.0
Pass Average flux	(LMH) 20.8
Permeate TDS <sup>a</sup>	(mg/L) 6.22
Pass Recovery	66.1 %
Average NDP	(psi) 44.1
Specific Energy	(kWh/m <sup>3</sup> ) 0.27
Temperature	(°C) 30.0
pH	6.0 (After Adjustment)
Chemical Dose	5.0 mg/L $Na_6P_6O_{18}$ (100%) 28.6 mg/L $H_2SO_4$ (98%)
RO System Recovery	75.0 %
Net RO System Recovery	75.0%

#### Footnotes:

<sup>a</sup>Total Dissolved Solids includes ions,  $SiO_2$  and  $B(OH)_3$ . It does not include  $NH_3$  and  $CO_2$



RO Flow Table (Stage Level) - Pass 1

Stage	Elements	#PV	#Els per PV PV	Feed				Concentrate			Permeate			
				Feed Flow	Recirc Flow	Feed Press	Boost Press	Conc Flow	Conc Press	Press Drop	Perm Flow	Avg Flux	Perm Press	Perm TDS
				(m³/h)	(m³/h)	(psi)	(psi)	(m³/h)	(psi)	(psi)	(m³/h)	(LMH)	(psi)	(mg/L)
1	ECO PRO 440	3	4	25.7	3.00	70.1	0.0	14.3	60.6	9.5	11.4	23.2	11.8	5.06
2	ECO PRO 440	2	4	14.3	0.00	57.7	0.0	8.66	50.0	7.7	5.60	17.1	11.8	8.62

RO Solute Concentrations - Pass 1

Concentrations (mg/L as ion)								
	Raw Feed	Adjusted Feed		Concentrate		Permeate		
		Initial	After Recycle	Stage1	Stage2	Stage1	Stage2	Total
NH <sub>4</sub> <sup>+</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K <sup>+</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na <sup>+</sup>	34.50	34.50	46.18	82.29	134.3	0.99	1.82	1.26
Mg <sup>+2</sup>	7.30	7.30	9.82	17.60	28.86	0.09	0.16	0.11
Ca <sup>+2</sup>	18.04	18.04	24.29	43.53	71.40	0.21	0.38	0.27
Sr <sup>+2</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba <sup>+2</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO <sub>3</sub> <sup>-2</sup>	0.05	0.00	0.00	0.01	0.04	0.00	0.00	0.00
HCO <sub>3</sub> <sup>-</sup>	61.12	25.78	34.28	60.65	98.40	1.87	2.61	2.10
NO <sub>3</sub> <sup>-</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cl <sup>-</sup>	70.62	70.62	94.83	169.6	277.5	1.31	2.43	1.68
F <sup>-</sup>	0.11	0.11	0.15	0.26	0.43	0.00	0.01	0.01
SO <sub>4</sub> <sup>-2</sup>	0.00	27.96	37.69	67.64	111.1	0.21	0.38	0.26
SiO <sub>2</sub>	18.58	18.59	24.93	44.55	72.79	0.37	0.84	0.52
Boron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO <sub>2</sub>	8.61	34.15	34.17	34.20	34.24	33.67	33.84	33.74
TDS*	210.3	202.9	272.2	486.1	794.9	5.06	8.62	6.22
pH	7.0	6.0	6.1	6.3	6.5	4.9	5.1	5.0

Footnotes:

\*Total Dissolved Solids includes ions, SiO<sub>2</sub> and B(OH)<sub>3</sub>. It does not include NH<sub>3</sub> and CO<sub>2</sub>

RO Design Warnings

Design Warning	Limit	Value	Pass	Stage	Element	Product
Element Recovery > Maximum Limit (%)	15.0	15.7	1	1	4	ECO PRO 440



### RO Flow Table (Element Level) - Pass 1

Stage	Element	Element Name	Recovery (%)	Feed Flow (m <sup>3</sup> /h)	Feed Press (psi)	Feed TDS (mg/L)	Conc Flow (m <sup>3</sup> /h)	Perm Flow (m <sup>3</sup> /h)	Perm Flux (LMH)	Perm TDS (mg/L)
1	1	ECO PRO 440	12.0	8.60	70.1	272.2	7.50	1.03	25.1	4.24
1	2	ECO PRO 440	12.9	7.50	66.9	308.8	6.60	0.97	23.7	4.71
1	3	ECO PRO 440	14.0	6.60	64.4	353.8	5.60	0.92	22.5	5.32
1	4	ECO PRO 440	15.7	5.60	62.2	410.9	4.80	0.88	21.6	6.12
2	1	ECO PRO 440	10.9	7.10	57.7	486.1	6.40	0.77	18.9	7.14
2	2	ECO PRO 440	11.3	6.40	55.2	544.4	5.60	0.72	17.6	8.07
2	3	ECO PRO 440	11.9	5.60	53.2	613.0	5.00	0.67	16.5	9.17
2	4	ECO PRO 440	12.7	5.00	51.4	694.9	4.30	0.63	15.5	10.51

#### Footnotes:

\*Total Dissolved Solids includes ions, SiO<sub>2</sub> and B(OH)<sub>3</sub>. It does not include NH<sub>3</sub> and CO<sub>2</sub>

### RO Solubility Warnings

None

### RO Chemical Adjustments

	Pass 1 Feed before pH Adjust	Pass 1 Feed After pH Decrease	RO 1 <sup>st</sup> Pass Conc
pH	7.0	6.0	6.5
Langelier Saturation Index	-1.4	-2.8	-1.1
Stiff & Davis Stability Index	-0.5	-1.8	-0.7
TDS* (mg/l)	210.3	202.9	794.9
Ionic Strength (molal)	0.00	0.00	0.02
HCO <sub>3</sub> <sup>-</sup> (mg/L)	61.12	25.78	98.40
CO <sub>2</sub> (mg/l)	8.61	34.15	34.24
CO <sub>3</sub> <sup>-2</sup> (mg/L)	0.05	0.00	0.04
CaSO <sub>4</sub> (% saturation)	0.0	0.1	1.7
BaSO <sub>4</sub> (% saturation)	0.0	0.0	0.0
SrSO <sub>4</sub> (% saturation)	0.0	0.0	0.0
CaF <sub>2</sub> (% saturation)	0.1	0.1	1.6
SiO <sub>2</sub> (% saturation)	13.7	12.2	50.9
Mg(OH) <sub>2</sub> (% saturation)	0.0	0.0	0.0

#### Footnotes:

\*Total Dissolved Solids includes ions, SiO<sub>2</sub> and B(OH)<sub>3</sub>. It does not include NH<sub>3</sub> and CO<sub>2</sub>

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2nd PASS RO CALCULATION SHEET



## 2nd PASS REVERSE OSMOSIS TREATMENT CALCULATION

## I: Raw water characteristic

Item	Description	River	
		Value	Unit
1	pH	5.5 to 7.0	-
2	Conductivity	$\leq 20.00$	$\mu\text{S}/\text{cm}$
3	Turbidity	$\leq 0.01$	NTU
4	Total Suspended Solids	$\leq 0.01$	mg/l
5	Total Dissolved Solid	$\leq 14.00$	mg/l
6	Total Hardness	$\leq 1.00$	mg/l as $\text{CaCO}_3$
7	Iron	$\leq 0.10$	mg/l as Fe

## II: Treated Water Quality Guarantee Values

Item	Description	Service Water	
		Value	Unit
1	Capacity	13.20	$\text{m}^3/\text{hr}$
2	pH	5.5 to 7	-
3	RO Permeate Conductivity	$\leq 5.0$	$\mu\text{S}/\text{cm}$
4	RO Reject Conductivity	$\leq 200.0$	$\mu\text{S}/\text{cm}$

## III: Design input parameter

Item	Description	Value	Unit	Remark
1	Design flowrate	17.00	$\text{m}^3/\text{hr}$	Inlet 1st Pass RO
2	RO Permeate flowrate	13.20	$\text{m}^3/\text{hr}$	RO Permeate
3	RO Reject flowrate	3.80	$\text{m}^3/\text{hr}$	RO Reject
4	NaOH dose	15.00	mg/l	NaOH 50%



## 2nd PASS REVERSE OSMOSIS TREATMENT CALCULATION

### IV: Calculation

#### 1 NaOH Dosing unit

##### 1.1 Compute capacity of NaOH dosing pumps

Density of NaOH 50%	=	1.180	kg/l
Dose requirement	=	Dosage (ppm)*Design Flowrate (m3/hr)/1000	
	=	0.26	kg/hr
	=	0.51	kg/hr @ 50% Concentration
	=	0.43	L/hr
Choose dosing pump cap.	=	1.90	L/hr at pressure > 1.0 bar

##### 1.2 Compute capacity of NaOH 50% storage tank for 1 days capacity

Tank capacity	=	(Pre Chlorine (L/hr))*24(hr/day)	
	=	10.37	L/day
	=	10.37	L (for 1 days)
Choose tank capacity	=	100.00	L

#### 2 2nd Pass Reverse Osmosis

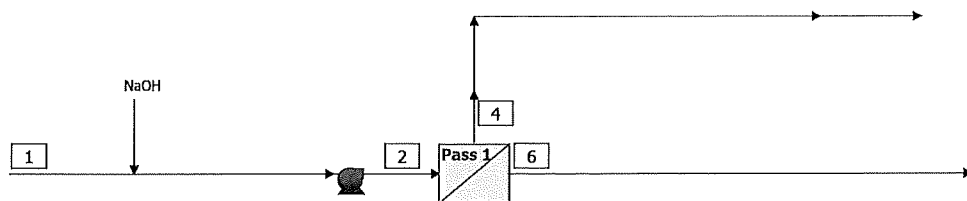
##### 2.1 Membrane specification

Membrane ECO-PRO400	Unit
Active area	37 m2
Feed spacer	34-LDP
Maximum Operating Temperature	45 °C
Maximum Operating Pressure	41 bar
Maximum Element Pressure Drop	1 bar
pH Range, Continuous Operation	2-11
pH Range, Short-Term Cleaning (30 min)	1-13
Maimum Feed SDI (SDI <sub>15</sub> )	5
Free Chlorine Tolerance	< 0.1 ppm

##### 4.2 Reverse Osmosis Calculation

## RO Summary Report

### RO System Flow Diagram



#	Description	Flow (m³/h)	TDS (mg/L)	Pressure (psi)
1	Raw Feed to Pump	16.8	6.44	0.0
2	Net Feed to Pass 1	16.8	9.91	91.1
4	Total Concentrate from Pass 1	3.60	40.61	64.4
6	Total Permeate from Pass 1	13.2	1.50	30.0

### RO System Overview

Total # of Trains	1	Online =	1	Standby =	0	RO Recovery	78.6 %
System Flow Rate	(m³/h)	Net Feed =	16.8	Net Product =	13.2		

Pass	Pass 1
Stream Name	Stream 1
Water Type	RO/NF Permeate (SDI < 1)
Number of Elements	15
Total Active Area (m²)	613
Feed Flow per Pass (m³/h)	16.8
Feed TDS <sup>a</sup> (mg/L)	9.91
Feed Pressure (psi)	91.1
Flow Factor	0.85
Permeate Flow per Pass (m³/h)	13.2
Pass Average flux (LMH)	21.5
Permeate TDS <sup>a</sup> (mg/L)	1.50
Pass Recovery	78.6 %
Average NDP (psi)	45.6
Specific Energy (kWh/m³)	0.28
Temperature (°C)	30.0
pH	7.8 (After Adjustment)
Chemical Dose	1.7 mg/L NaOH (50%)
RO System Recovery	78.5 %
Net RO System Recovery	78.6%

#### Footnotes:

<sup>a</sup>Total Dissolved Solids includes ions, SiO<sub>2</sub> and B(OH)<sub>3</sub>. It does not include NH<sub>3</sub> and CO<sub>2</sub>



RO Flow Table (Stage Level) - Pass 1

Stage	Elements	#PV	#Els per PV PV	Feed				Concentrate			Permeate			
				Feed Flow	Recirc Flow	Feed Press	Boost Press	Conc Flow	Conc Press	Press Drop	Perm Flow	Avg Flux	Perm Press	Perm TDS
				(m³/h)	(m³/h)	(psi)	(psi)	(m³/h)	(psi)	(psi)	(m³/h)	(LMH)	(psi)	(mg/L)
1	ECO PRO 440	2	5	16.8	0.00	86.6	0.0	7.27	76.2	10.4	9.53	23.3	30.0	1.15
2	ECO PRO 440	1	5	7.27	0.00	73.3	0.0	3.60	64.4	8.9	3.67	17.9	30.0	2.41

RO Solute Concentrations - Pass 1

Concentrations (mg/L as ion)							
	Raw Feed	pH Adjusted Feed	Concentrate		Permeate		
			Stage1	Stage2	Stage1	Stage2	Total
NH <sub>4</sub> <sup>+</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K <sup>+</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na <sup>+</sup>	0.92	1.89	4.01	7.51	0.28	0.58	0.36
Mg <sup>+2</sup>	0.24	0.24	0.54	1.06	0.01	0.03	0.02
Ca <sup>+2</sup>	0.40	0.40	0.90	1.76	0.02	0.05	0.03
Sr <sup>+2</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba <sup>+2</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO <sub>3</sub> <sup>-2</sup>	0.00	0.02	0.07	0.21	0.00	0.00	0.00
HCO <sub>3</sub> <sup>-</sup>	2.59	5.04	10.60	19.68	0.75	1.56	0.98
NO <sub>3</sub> <sup>-</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cl <sup>-</sup>	1.34	1.34	3.02	5.93	0.07	0.15	0.09
F <sup>-</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO <sub>4</sub> <sup>-2</sup>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SiO <sub>2</sub>	0.95	0.95	2.17	4.33	0.02	0.04	0.02
Boron	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO <sub>2</sub>	1.91	0.12	0.14	0.17	0.13	0.16	0.13
TDS*	6.44	9.91	21.37	40.61	1.15	2.41	1.50
pH	6.3	7.8	8.1	8.2	7.0	7.2	7.1

Footnotes:

\*Total Dissolved Solids includes ions, SiO<sub>2</sub> and B(OH)<sub>3</sub>. It does not include NH<sub>3</sub> and CO<sub>2</sub>

## RO Design Warnings

None



RO Flow Table (Element Level) - Pass 1

Stage	Element	Element Name	Recovery (%)	Feed Flow (m³/h)	Feed Press (psi)	Feed TDS (mg/L)	Conc Flow (m³/h)	Perm Flow (m³/h)	Perm Flux (LMH)	Perm TDS (mg/L)
1	1	ECO PRO 440	12.2	8.40	86.6	9.91	7.40	1.03	25.1	0.84
1	2	ECO PRO 440	13.2	7.40	83.6	11.17	6.40	0.98	23.9	0.97
1	3	ECO PRO 440	14.7	6.40	81.0	12.72	5.50	0.94	23.0	1.13
1	4	ECO PRO 440	16.8	5.50	79.0	14.72	4.50	0.92	22.4	1.32
1	5	ECO PRO 440	20.0	4.50	77.4	17.42	3.60	0.91	22.2	1.56
2	1	ECO PRO 440	11.0	7.30	73.3	21.37	6.50	0.80	19.6	1.83
2	2	ECO PRO 440	11.7	6.50	70.8	23.78	5.70	0.76	18.5	2.10
2	3	ECO PRO 440	12.7	5.70	68.7	26.65	5.00	0.72	17.7	2.40
2	4	ECO PRO 440	14.0	5.00	67.0	30.16	4.30	0.70	17.1	2.73
2	5	ECO PRO 440	16.0	4.30	65.5	34.63	3.60	0.69	16.8	3.12

Footnotes:

\*Total Dissolved Solids includes ions, SiO<sub>2</sub> and B(OH)<sub>3</sub>. It does not include NH<sub>3</sub> and CO<sub>2</sub>

RO Solubility Warnings

None

RO Chemical Adjustments

	Pass 1 Feed before pH Adjust	Pass 1 Feed After pH Increase	RO 1 <sup>st</sup> Pass Conc
pH	6.3	7.8	8.2
Langelier Saturation Index	-5.0	-3.2	-1.6
Stiff & Davis Stability Index	-2.7	-1.1	0.0
TDS* (mg/l)	6.44	9.91	40.61
Ionic Strength (molal)	0.00	0.00	0.00
HCO <sub>3</sub> <sup>-</sup> (mg/L)	2.59	5.04	19.68
CO <sub>2</sub> (mg/l)	1.91	0.12	0.17
CO <sub>3</sub> <sup>-2</sup> (mg/L)	0.00	0.02	0.21
CaSO <sub>4</sub> (% saturation)	0.0	0.0	0.0
BaSO <sub>4</sub> (% saturation)	0.0	0.0	0.0
SrSO <sub>4</sub> (% saturation)	0.0	0.0	0.0
CaF <sub>2</sub> (% saturation)	0.0	0.0	0.0
SiO <sub>2</sub> (% saturation)	0.7	0.7	2.6
Mg(OH) <sub>2</sub> (% saturation)	0.0	0.0	0.0

Footnotes:

\*Total Dissolved Solids includes ions, SiO<sub>2</sub> and B(OH)<sub>3</sub>. It does not include NH<sub>3</sub> and CO<sub>2</sub>

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**EDI PASS RO CALCULATION SHEET**



## DI WATER TREATMENT CALCULATION

### I: Raw water characteristic

Item	Description	River	
		Value	Unit
1	pH	5.5 to 7.0	-
2	Conductivity	$\leq 5.00$	$\mu\text{S}/\text{cm}$
3	Turbidity	$\leq 0.01$	NTU
4	Total Suspended Solids	$\leq 0.01$	mg/l
5	Total Dissolved Solid	$\leq 3.50$	mg/l
6	Total Hardness	$\leq 0.01$	mg/l as $\text{CaCO}_3$
7	Iron	$\leq 0.01$	mg/l as Fe

### II: Treated Water Quality Guarantee Values

Item	Description	Service Water	
		Value	Unit
1	Capacity	12.00	$\text{m}^3/\text{hr}$
2	pH	6.5 to 7.5	-
3	DI Product Conductivity	$\leq 0.2$	$\mu\text{S}/\text{cm}$
4	Silica	$\leq 0.02$	mg/l
5	Total Dissolved Solids	$\leq 1.00$	mg/l
6	Total Iron	$\leq 0.01$	mg/l
5	TOC	$\leq 0.3$	mg/l
6	DI Reject Conductivity	$\leq 25.00$	$\mu\text{S}/\text{cm}$

### III: Design input parameter

Item	Description	Value	Unit	Remark
1	Design flowrate	13.20	$\text{m}^3/\text{hr}$	Inlet EDI module
2	DI Product flowrate	12.00	$\text{m}^3/\text{hr}$	EDI Product
3	DI Reject flowrate	1.20	$\text{m}^3/\text{hr}$	EDI Reject



## DI WATER TREATMENT CALCULATION

## IV: Calculation

## 1 DI Water Treatment

## 1.1 EDI specification

EDI Module VNX55EP-2	Unit
Recovery	90-95%
Minimum flow	5.7 m <sup>3</sup> /hr
Nominal flow	12.5 m <sup>3</sup> /hr
Maximum flow	18.7 m <sup>3</sup> /hr
Product Resistivity	> 18 MΩ.cm
Silica (SiO <sub>2</sub> ) Removal	≥ 95%

## 1.2 EDI Calculation

# IONPURE®

## CEDI Performance Projection

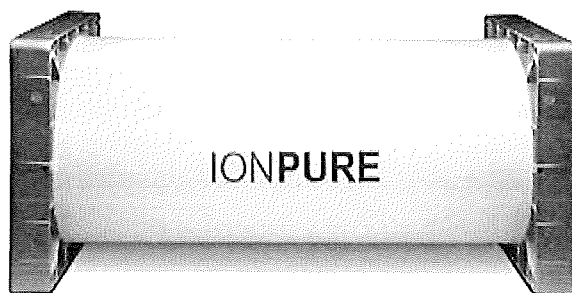
File Name:AED 15 Mw

### System Summary

Product Flow Rate	12 m <sup>3</sup> /h
Module Type	VNX55EP-2
Number of Modules	1
Flow Per Module	12 m <sup>3</sup> /h
Conductivity @ 25°C	2.03 µS/cm
Feed water conductivity equivalent, including CO <sub>2</sub>	2.16 µS/cm
Total Exchangeable Anions (TEA)	0.9 ppm as CaCO <sub>3</sub>
System Recovery	90 %
Product Resistivity	18 MΩ-cm
Salt Rejection	99.5 %
Pressure Drop	1.45 bar

### Water Analysis

Species	Inlet (ppm as ion)	Outlet (ppb as ion)	Concentrate (ppm as ion)
NH <sub>4</sub>			
K			
Na	0.1	0.5	1
Mg	0.1	0.5	1
Ca	0.1	0.5	1
Sr			
Ba			
Fe			
Cu			
Al			
Mn			
CO <sub>3</sub>			
HCO <sub>3</sub>			
NO <sub>3</sub>			
Cl	0.5	2.5	5
F			
SO <sub>4</sub>			
B			
SiO <sub>2</sub>	0.05	<5	0.5
CO <sub>2</sub>	0.01		0.1
pH	6.5	NA	
Calc pH	4.3	NA	
Temp °C	30		



Total Feed	Total Reject	Total Product
13.2 m <sup>3</sup> /h	1.2 m <sup>3</sup> /h	12 m <sup>3</sup> /h
2.03 μS/cm		18 MΩ-cm
2.16 μS/cm FCE		
0.05ppm as ion SiO <sub>2</sub>		
0.01 ppm as CO <sub>2</sub>		
30 (deg.C)		

This projection is an estimate of performance and not a guarantee. The outputs from this program are a guide only and are not a guarantee of performance, pressure drop, voltage or current. Performance may vary when operating above module nominal flow rate and/or high ionic challenge applications, or at the extremes of the permitted feed water temperature. Please consult IONPURE sales and technical support for verification of data.

#### Estimated Power Requirements

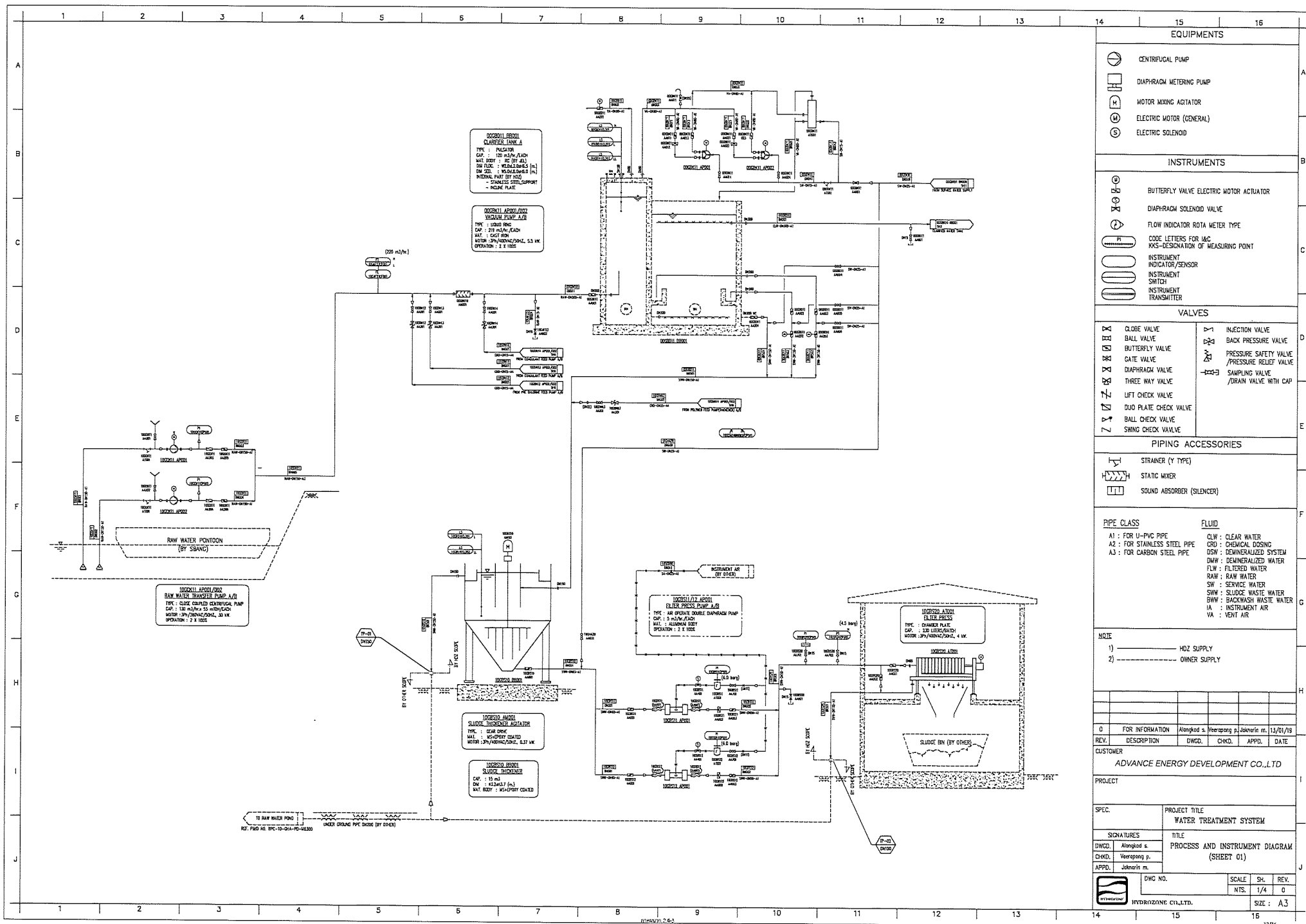
AC POWER CONSUMPTION	0.01 kW/module
Total AC Power Consumption	0.77 kWh/day (24/7 operation)
DC Power Consumption	0kWh/kgal
DC Power Consumption	0kWh/m <sup>3</sup>
Voltage	50V
Start-up Current	2A


\* Assumes 85% efficiency of AC to DC power controller

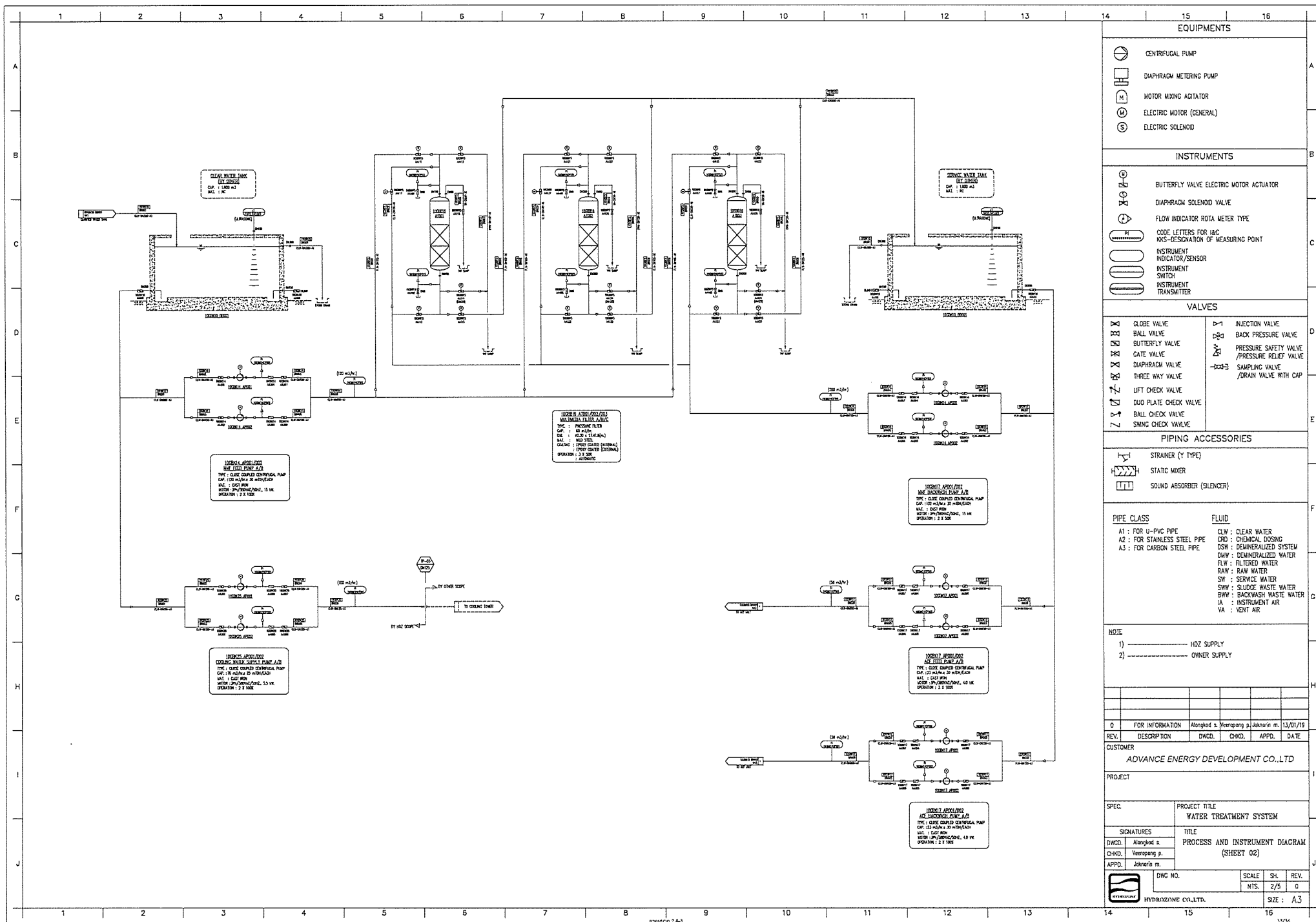
IONPURE recommends the use of the DC3 power supply IP-DC3PH600V-M1 (W2T827150) with IONPURE CEDI modules.

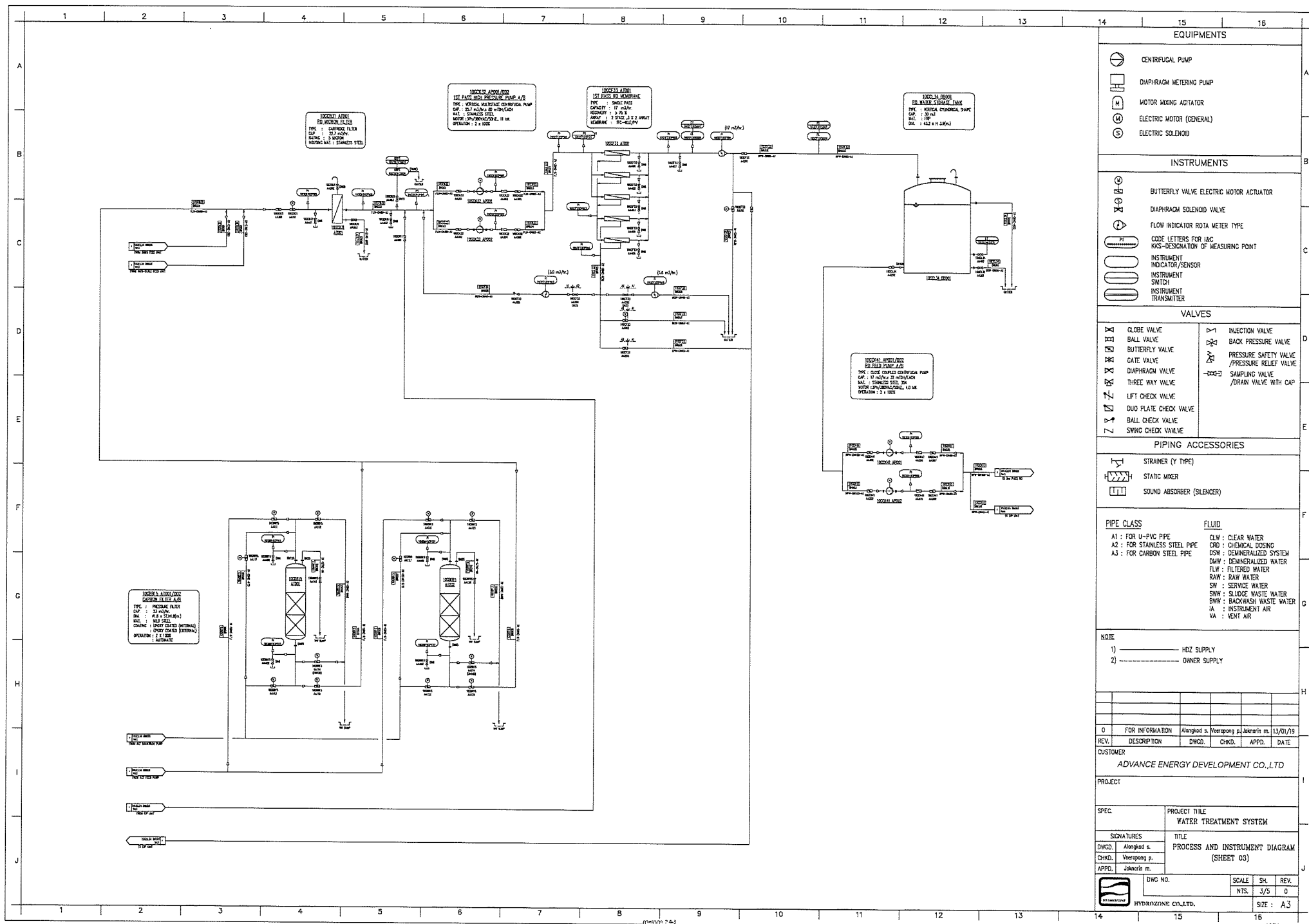
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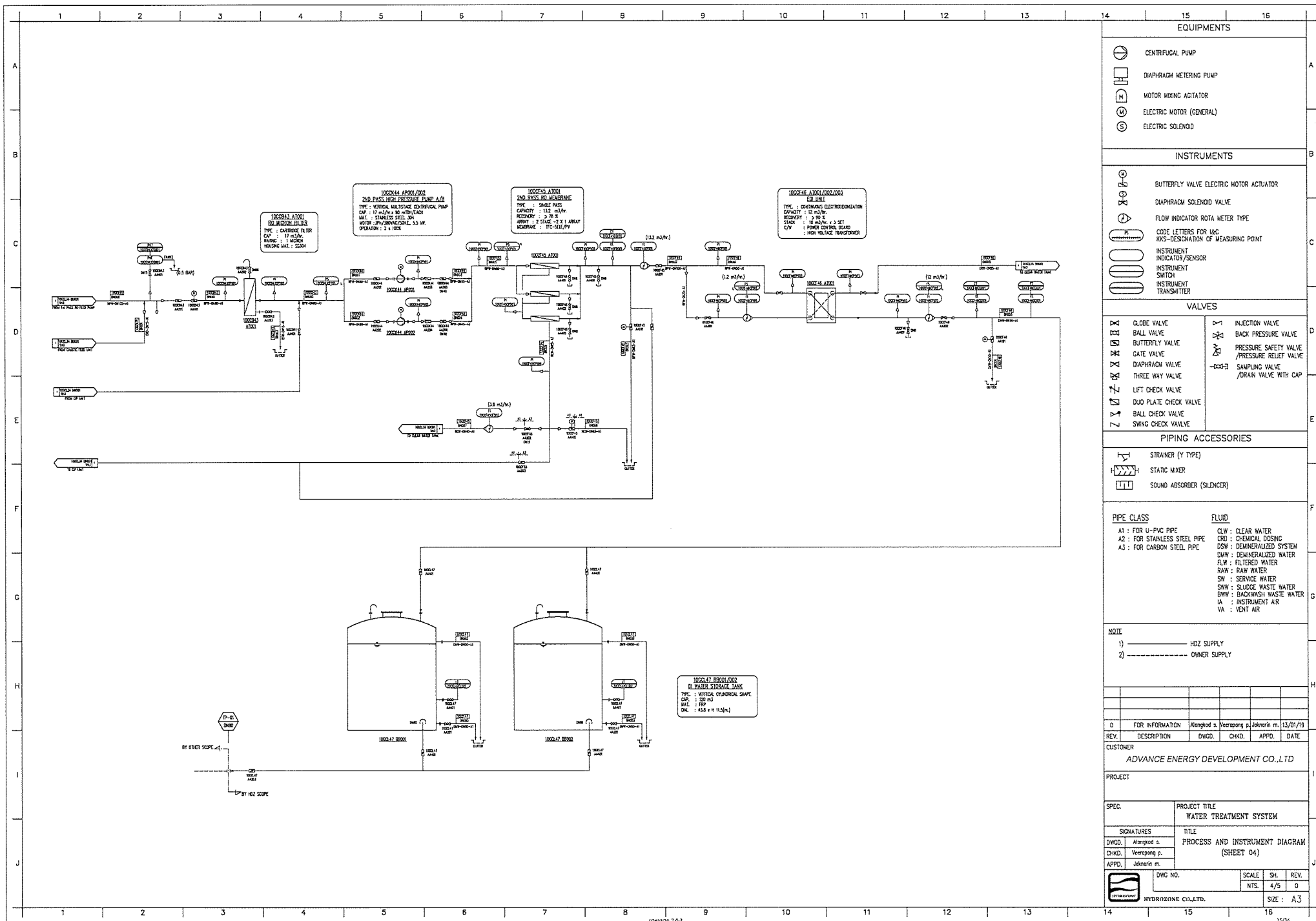


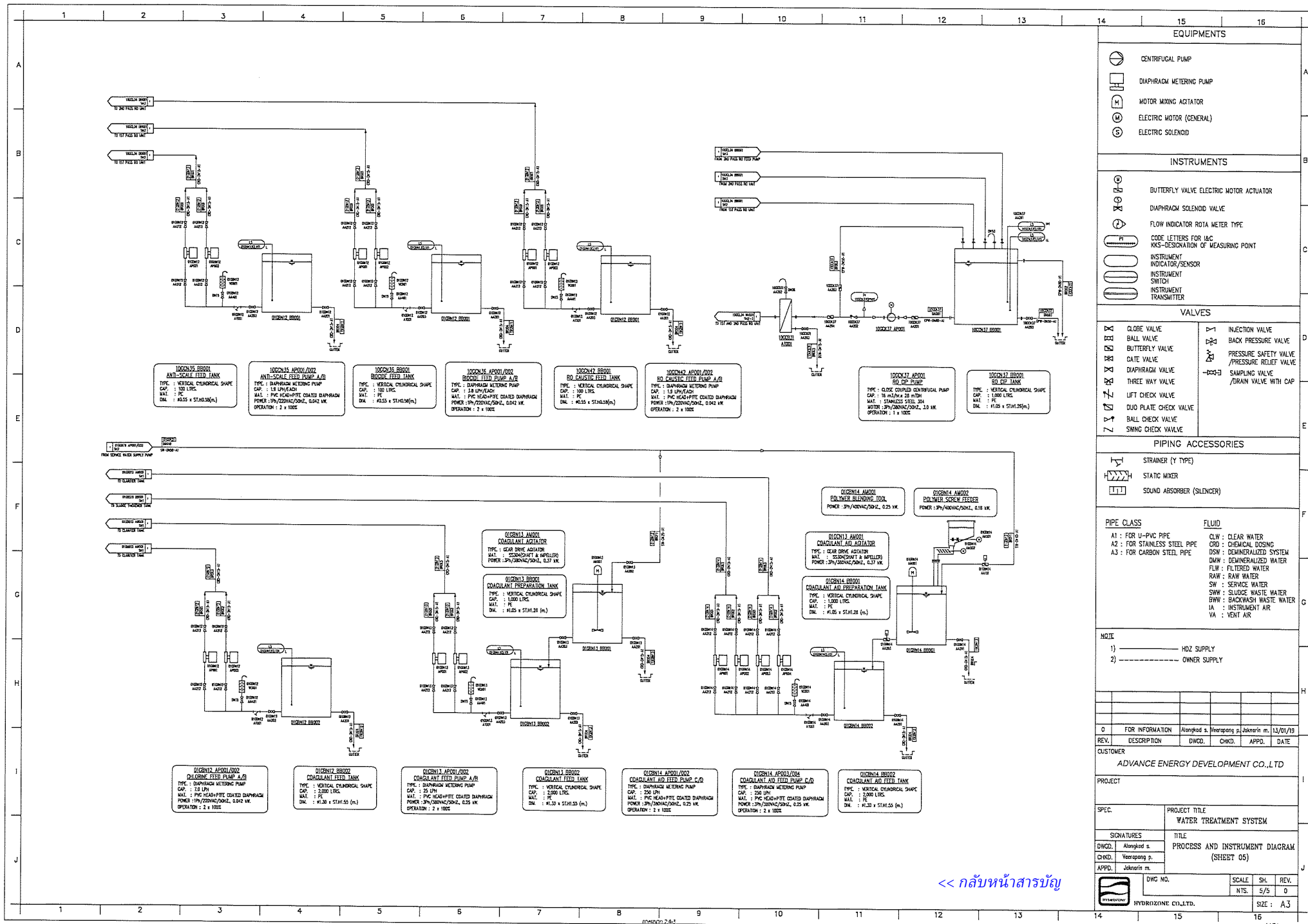


	DWG NO.	SCALE	SH.	REV.
		NTS.	1/4	0
HYDROZONE CO., LTD.		SIZE : A3		









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