



**ECS OMSM**  
**(Operation, Maintenance & Safety**  
**Manual)**

**Rev. 0.6, dated April 30, 2019**

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**ECS OMSM (Operation, Maintenance & Safety Manual)** describes and provides detailed information on operation, maintenance and troubleshooting of Techcross Ballast Water Management System, Electro-Clean™ System (hereinafter called ECS).

The successful and safe operation of ECS is dependent upon proper handling, installation, operation and maintenance.

Failure to follow the instructions may cause unexpected accidents and severe damage to crew, ECS and other property in the vessel.

TECHCROSS shall not be responsible for any injuries or damage resulting from neglecting the directions described in the manual or any improper installation, use or maintenance.

Please read full manual carefully before operation.

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## Revision Status

REV.	Date	Page	Summary of revised content
00	17/12/12	-	Established
0.1	18/04/21	76	5.3.3.4 Alarm Check Flow Chart
		77	5.3.3.5 Fault Check Flow Chart
		136	7.2 Trouble shooting for ECS Major Alarm <ul style="list-style-type: none"> <li>• TSU Alarm/Fault</li> </ul>
0.2	18/8/27	103, 104, 105	6.4 Regular maintenance Procedure <ul style="list-style-type: none"> <li>• Adding procedures for PRU</li> </ul>
0.3	18/09/04	15	Revising the Concentration of Target TRO Adding the Hold Time
		16	3.3.1 Ballasting Procedure
		18	Adding the table for 'Division of ECS'
		64, 65, 82	Clarifying Mixing Ballasting Operation is optional
		65	Revising the flow rate for Mixing solution
		66, 82, 83, 92	HMI Screen for Mixing solution
		76	5.3.3.4 Alarm Check Flow Chart
		77	5.3.3.5 Fault Check Flow Chart
		139	7.2 Trouble shooting for ECS Major Alarm <ul style="list-style-type: none"> <li>• Alarm/Fault point for Mixing Solution</li> </ul>
		146	7.3 Main Problems and Measures <ul style="list-style-type: none"> <li>• Adding solutions for alarm messages</li> </ul>
		164	Revising the Operation range of FMU for Mixing Solution
0.4	19/01/03	15	3.2.1 Specifications of ECS <ul style="list-style-type: none"> <li>• Adding operational limitation</li> </ul>
		66, 79, 83	HMI Screen for hold time
0.5	19/03/04	15	3.2.1 Specifications of ECS <ul style="list-style-type: none"> <li>• Changing Operation performance and Hold time</li> </ul>
		65	Preparation for mixing ballasting operation <ul style="list-style-type: none"> <li>• Amount of sea water for mixing ballasting operation</li> </ul>
		66, 79, 83, 92	HMI Screen for operational limitation
		116, 117, 118, 119	6.6.1 CLX(TRO Sensor) <ul style="list-style-type: none"> <li>• Revising the calibration guide for CLX</li> </ul>
0.6	19/04/26	15	3.2.1 Specifications of ECS <ul style="list-style-type: none"> <li>• Revising the operational limitation</li> </ul>
		79, 92	HMI Screen for operational limitation

# 1. WARNING

Only qualified personnel should operate and maintain ECS after becoming thoroughly familiar with proper operation, all warnings, safety notices, maintenance requirements and troubleshooting.





- DO NOT operate if Inlet /Outlet valves of ECU are CLOSED. It can cause severe damage to the equipment and crews.

Make sure that Inlet & Outlet valves of the ballast pump are OPEN before operation of ECS.

- DO NOT open the cover of the equipment or maintain the equipment when power is ON in an explosive and flammable environment.

Failure to heed warning and danger labels may result in equipment damage and possible personal injury.

## WARNING & DANGER LABELS

	<p>HAZARDOUS VOLTAGE (WARNING) Contact may cause electric shock or burn. <b>Turn off</b> and <b>lock out</b> system power before servicing.</p>
	<p><b>Do Not Open</b> the door and cover. <b>Turn off</b> and <b>lock out</b> power before servicing.</p>
	<p>HAZARDOUS VOLTAGE (DANGER) Contact may cause electric shock or burn. <b>Turn off</b> and <b>lockout</b> power before servicing.</p>
	<p>Attached :</p> <ol style="list-style-type: none"> <li>1. Near emergency stop Button.</li> <li>2. Near RCM selection switch.</li> </ol>

<p><b>NOTICE</b> This CPC (Control PC) &amp; HMI to be used only for ECS (BWMS) operation</p>	<p>Attached above CPC (Control PC) @ CCR</p>
<p><b>WARNING</b> Do not close this valve during ECS operation</p>	<p>Attached manual In/Outlet valves for ECS</p>

**2. ABBREVIATION**

	<b>Abbr</b>	<b>Full Name</b>
A	ANU	Auto Neutralization Unit
	APU	Air Pump Unit
C	CPC	Control PC
	CLX	Chlorine Monitor
	CSU	Conductivity Sensor Unit
E	ECM	Electro-Chamber Module
	ECU	Electro-Chamber Unit
	EM	Electrode Module
	EPJ	ECU Power Junction box
	ESJ	ECU Signal Junction box
F	FMU	Flow Meter Unit
	FTS	Fresh water Temperature Sensor
	FTU	Fresh water Tank Unit
G	GDS	Gas Detection Sensor
H	HMI	Human Machine Interface
	HEU	Heat Exchanger Unit

	<b>Abbr</b>	<b>Full Name</b>
P	PDE	Power Distributor Equipment
	PI	Pressure Indicator
	PS	Pressure Switch
	PLC	Programmable Logic Controller
	PRU	Power Rectifier Unit
	PSU	Practical Salinity Unit
R	RTU	Remote Terminal Unit
	RCM	Rectifier Control and Monitoring
T	TRO	Total Residual Oxidant
	TRC	Treatment Rated Capacity
	TSU	TRO Sensor Unit
	TI	Temperature Indicator
	TS	Temperature Switch

## **3. ECS OVERVIEW**

### **3.1 Introduction of ECS**

#### **3.1.1 General Information**

The purpose of a ballast water treatment system is to preserve the marine environment by preventing harmful sea organisms from migrating through ship's ballast water. Techcross Inc. has developed and manufactured ECS, a Ballast Water Treatment System, and its goal is to sterilize marine bio species that pose potential threats to oceanic ecosystem elsewhere.

#### **3.1.2. Principles of disinfection**

There are four disinfection mechanisms in the electrolysis process of ECS: Hypochlorous acid, Radicals, ORP (oxidation reduction potential), and Residual chlorine. Hypochlorous acid, Radicals, and ORP (oxidation reduction potential) sterilize harmful organisms contained in the ballast water and Residual chlorine prevents harmful organisms from regenerating in the ballast tanks.

#### **3.1.3 Safety**

ECS is developed and designed to ensure that the operation is conducted in a safe and efficient manner, and to familiarize the users with the basic procedures that affect their own safety and the safety of their fellow users. However, the users should read the manual thoroughly and be educated to be able to maintain overall control of software and hardware safety before starting to operate ECS.

#### **3.1.4 Environment friendly**

ECS employs electrolysis method for active substance to disinfect micro-organisms in the ballast water. The levels of active substances produced during the electrolysis of seawater are below the standards for dangerous substances (United States standards). ECS adopts automatic neutralization system which is ANU to neutralize the treated water in the ballast tanks, resulting in lowering the TRO value below 0.1mg/L before discharging in order not to interrupt marine environment.

## 3.2 SYSTEM SPECIFICATIONS

### 3.2.1 Specifications of ECS

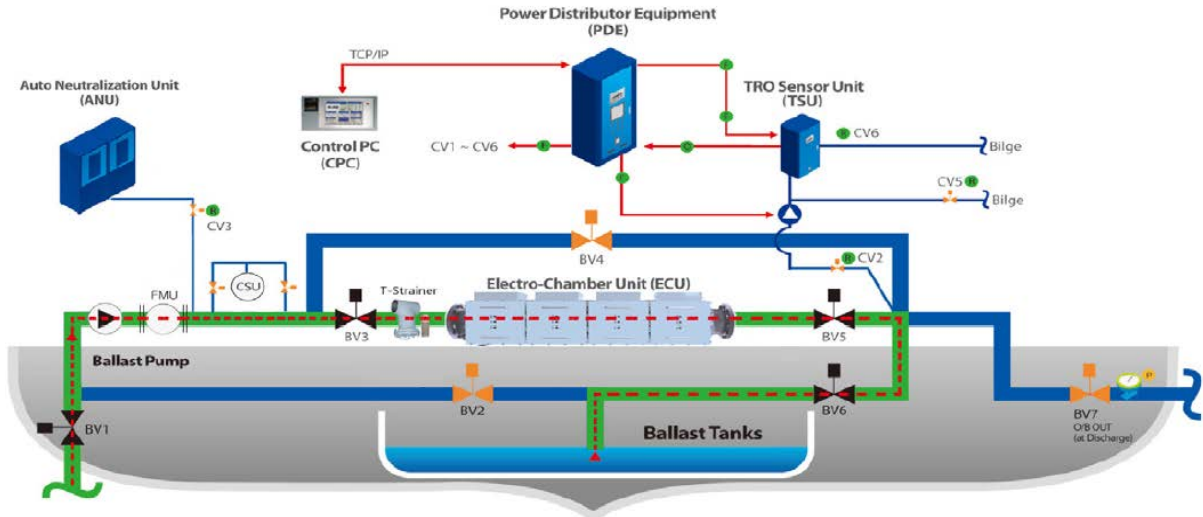
Division	Specifications
Name	ECS (Electro-Clean™ System)
Biological Efficacy	Compliance with D-2 performance standard regulated by IMO Compliance with USCG 33 CFR Part 151.1511,2030
Operation Performance	Less than TRO 10 mg/L(At the inside of EM, average 6~10 mg/L) - Target TRO: Fresh water <sup>1)</sup> and Brackish water <sup>2)</sup> - 7.5 mg/L Marine water <sup>3)</sup> - 7.8mg/L
Neutralization Performance	Less than TRO 0.1 mg/L: after neutralization before discharging
Neutralization Method	Automatic input of Neutralization solution
Neutralizing Agent	Sodium Thiosulfate (Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ) (Density: 45 ~ 55% (wt %))
Hold Time	48hrs (Fresh water <sup>1)</sup> ) N/A (Brackish water <sup>2)</sup> and Marine water <sup>3)</sup> )
Operation method	Automatic (Remote / Local) operation by CPC
Operation S/W	HMI (Human Machine Interface)
System Flow capacity	Min. 150m <sup>3</sup> /h ~ Max. 12,000m <sup>3</sup> /h
Operational limitation of salinity	Not applicable
Electrolyte feed salinity	1.5 PSU
Working pressure - ECU	Max. 5 bar
Working pressure - ANU	Max. 10 bar
Working pressure – Compressed air (Only Dry Air)	Max. 7 bar - APU
Pressure drop	ECU – Max. 0.2 bar (Based on from inlet to outlet of the ECU)
Fresh water working pressure for ANU	Max. 10 bar
Treated water temperature of ECU (Electrolyte feed temperature)	0°C ~ 36°C
Cooling water temperature of PRU	Max 36°C
Ambient air temperature	0°C ~ 45°C
Power consumption -Based on water Temp : 15°C -Excepted F.W pump	1PSU – 9kW ( per 100m <sup>3</sup> /h) 3PSU – 7.5kW ( per 100m <sup>3</sup> /h) 8PSU – 5kW ( per 100m <sup>3</sup> /h) 30PSU – 3.4kW ( per 100m <sup>3</sup> /h)
Current to PRU	Max. 1100A
Power	440VAC +/-10% - 60Hz
Operating area	Non-hazardous/hazardous [hazardous (zone1), Ex type should be used.]

1) Fresh water: <1PSU, 2) Brackish water: 1-28PSU, 3) Marine water: >28PSU

### 3.3 OPERATION PROCESS

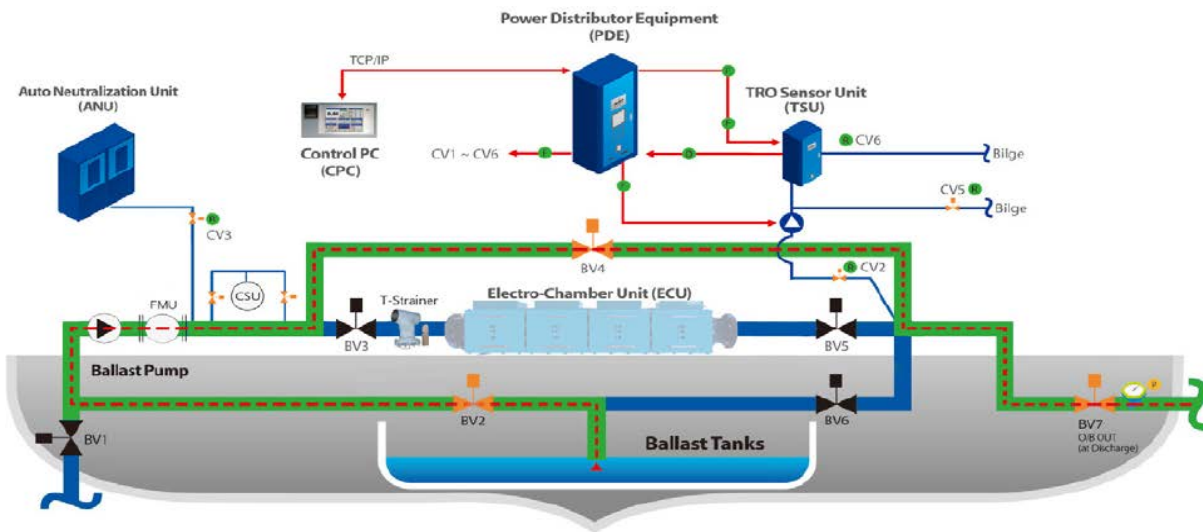
#### 3.3.1 Ballasting Procedure

The ballast water flows into the ship's ballast pipelines through ballast pumps or other pumps via sea chests and/or ballast tanks including aft peak tank and fore peak tank. The intake or internal circulating seawater is disinfected by ECS, and the disinfected water remains in the ballast tanks until it is discharged. The ECS system, controlled by CPC, carries out the disinfection procedure.



#### 3.3.2 Deballasting Procedure

The neutralizer shall be injected with maximum rate at the initial stage of deballasting. And then the amount of neutralizer shall be controlled in order that the TRO concentration may be less than 0.1mg/L.



\* Above image can be different from actual system

## 3.4 INSTALLATION AREA OF ECS

ITEM		On-deck / Pump room (Hazardous Area)	Accommodation / Engine Room (Non-Hazardous Area)
<b>Ballast water Treatment Equipments</b>	Electro Chamber Unit (ECU)	O (Ex)	O
	Auto Neutralization Unit (ANU)		O
	T-Strainer	O	O
	Fresh water Tank Unit (FTU)	O (Ex)	O
	Air Pump Unit (APU)	O (Ex)	O
	Heat Exchanger Unit (HEU) *If Central cooling cannot be used	O	O
	Drain Tank Unit (DTU) * If necessary	O (Ex)	O
<b>Control and Monitoring Equipments</b>	Power Distribution Equipment (PDE)	-	O
	Control PC (CPC)	-	O
	TRO Sensor Unit (TSU)	O (Ex)	O
	Flow Meter Unit (FMU)	O (Ex)	O
	Fresh water Temperature Sensor (FTS)	O (Ex)	O
	Ex-Sea water Temperature Sensor (Ex-STS) * If Non-Ex proof type CSU cannot be used.	O (Ex)	
	Conductivity Sensor Unit (CSU)	O (Ex)	O
	Gas Detection Sensor (GDS)	O (Ex)	O
	Sea Water Pump (SWP)	O (Ex)	O

### 3.5 ECS COMPONENTS



- ① ECU (Electro Chamber Unit)
- ② TSU (TRO Sensor Unit)
- ③ PDE (Power Distributor Equipment)
- ④ ANU (Auto Neutralization Unit)
- ⑤ CPC (Control PC)
- ⑥ T-strainer
- ⑦ FMU (Flow Meter Unit)
- ⑧ CSU (Conductivity Sensor Unit)
- ⑨ FTS (Freshwater Temperature Sensor)

\* Above image can be different from actual system

#### Division of ECS

No.	Division	List	
1	Equipment	ECU	Electro Chamber Unit
2		PRU	Power Rectifier Unit
3		EM	Electrode Module
4		EPJ	ECU Power Junction box
5		ESJ	ECU Signal Junction box
6		CPC	Control PC
7		TSU	TRO Sensor Unit
8		ANU	Auto Neutralization Unit
9		PDE	Power Distributor Equipment
10	Sensor	FMU	Flow Meter Unit
11		FTS	Fresh water Temperature Sensor
12		CSU	Conductivity Sensor unit
13		GDS	Gas Detection Sensor
14		TS	Temperature Switch
15		PS	Pressure Switch
16	Option	APU	Air Pump Unit
17		FTU	Fresh water Tank Unit
18		HEU	Heat Exchange Unit
19		T-Strainer	

3.5.1 All scaled system of ECS

3.5.1.1 Equipment scheme by scale up/down ECS-B1.1 (Ballast pump 1 line)

No.	TRC (m <sup>3</sup> /h)	Model	ECU1.1						PDE					ANU		TSU	FMU	CSU	FTS	CPC	T-STRAINER							
			150B 1.1	300B 1.1	450B 1.1	600B 1.1	1000B 1.1	24A 1.1K	12A 1.1	A4 1.1	5T 1.1	10T 1.1																
1	150	ECS-150B 1.1X1set	1																									
2	300	ECS-300B 1.1X1set		1																								
3	450	ECS-450B 1.1X1set			1																							
4	600	ECS-600B 1.1X1set				1																						
5	750	ECS-750B 1.1X1set					1																					
6	900	ECS-900B 1.1X1set						1																				
7	1,000	ECS-1000B 1.1X1set							1																			
8	1,050	ECS-1050B 1.1X1set								1																		
9	1,200	ECS-1200B 1.1X1set									2																	
10	1,300	ECS-1300B 1.1X1set											1															
11	1,350	ECS-1350B 1.1X1set													3													
12	1,450	ECS-1450B 1.1X1set														1												
13	1,600	ECS-1600B 1.1X1set															1											
14	1,800	ECS-1800B 1.1X1set																3										
15	2,000	ECS-2000B 1.1X1set																	2									
16	2,300	ECS-2300B 1.1X1set																		2								
17	2,400	ECS-2400B 1.1X1set																			4							
18	2,450	ECS-2450B 1.1X1set																				1						
19	2,600	ECS-2600B 1.1X1set																				1						
20	3,000	ECS-3000B 1.1X1set																					3					
21	3,000	ECS-3000B 1.1X1set																					5					
22	3,300	ECS-3300B 1.1X1set																					5					
23	3,300	ECS-3300B 1.1X1set																					5					
24	3,450	ECS-3450B 1.1X1set																					3					
25	3,450	ECS-3450B 1.1X1set																					3					
26	3,600	ECS-3600B 1.1X1set																					3					
27	3,600	ECS-3600B 1.1X1set																					6					
28	4,000	ECS-4000B 1.1X1set																					4					
29	4,300	ECS-4300B 1.1X1set																					4					
30	4,450	ECS-4450B 1.1X1set																					4					
31	4,600	ECS-4600B 1.1X1set																					4					
32	5,000	ECS-5000B 1.1X1set																					5					
33	5,300	ECS-5300B 1.1X1set																					5					
34	5,450	ECS-5450B 1.1X1set																					5					
35	5,600	ECS-5600B 1.1X1set																					5					
36	6,000	ECS-6000B 1.1X1set																					6					
37	6,000	ECS-6000B 1.1X1set																					10					

3.5.1.2 Equipment scheme by scale up/down ECS-B1.1 (Ballast pump 2 lines)

No.	TRC (m <sup>3</sup> /h)	Model	ECU						PDE				ANU		TSU 1,1	FMU	CSU 1,1	FTS 1,1	CPC	T-STRAINER			
			150B 1,1	300B 1,1	450B 1,1	600B 1,1	1000B 1,1	24A 1,1K	12A 1,1	A4 1,1	5T 1,1	10T 1,1											
1	300	ECS-150B 1.1X2set	2																				
2	600	ECS-300B 1.1X2set		2																			
3	900	ECS-450B 1.1X2set			2																		
4	1,200	ECS-600B 1.1X2set				2																	
5	1,800	ECS-750B 1.1X2set					2																
6	1,800	ECS-900B 1.1X2set						2															
7	2,000	ECS-1000B 1.1X2set							2														
8	2,100	ECS-1050B 1.1X2set								2													
9	2,400	ECS-1200B 1.1X2set									4												
10	2,600	ECS-1300B 1.1X2set											2										
11	2,700	ECS-1350B 1.1X2set												2									
12	2,900	ECS-1450B 1.1X2set													2								
13	3,200	ECS-1600B 1.1X2set														2							
14	3,600	ECS-1800B 1.1X2set															2						
15	4,000	ECS-2000B 1.1X2set																2					
16	4,600	ECS-2300B 1.1X2set																	2				
17	4,800	ECS-2400B 1.1X2set																		2			
18	4,900	ECS-2450B 1.1X2set																			2		
19	5,200	ECS-2600B 1.1X2set																				2	
20	6,000	ECS-3000B 1.1X2set																				2	
21	6,000	ECS-3000B 1.1X2set																				2	
22	6,600	ECS-3300B 1.1X2set																				2	
23	6,600	ECS-3300B 1.1X2set																				2	
24	6,900	ECS-3450B 1.1X2set																				2	
25	6,900	ECS-3450B 1.1X2set																				2	
26	7,200	ECS-3600B 1.1X2set																				2	
27	7,200	ECS-3600B 1.1X2set																				2	
28	8,000	ECS-4000B 1.1X2set																				2	
29	8,600	ECS-4300B 1.1X2set																				2	
30	8,900	ECS-4450B 1.1X2set																				2	
31	9,200	ECS-4600B 1.1X2set																				2	
32	10,000	ECS-5000B 1.1X2set																				2	
33	10,600	ECS-5300B 1.1X2set																				2	
34	10,900	ECS-5300B 1.1X2set																				2	
35	11,200	ECS-5300B 1.1X2set																				2	
36	12,000	ECS-6000B 1.1X2set																				2	
37	12,000	ECS-6000B 1.1X2set																				2	

3.5.1.3 Equipment scheme by scale up/down Ex-ECS-B1.1 (Ballast pump 1 line)

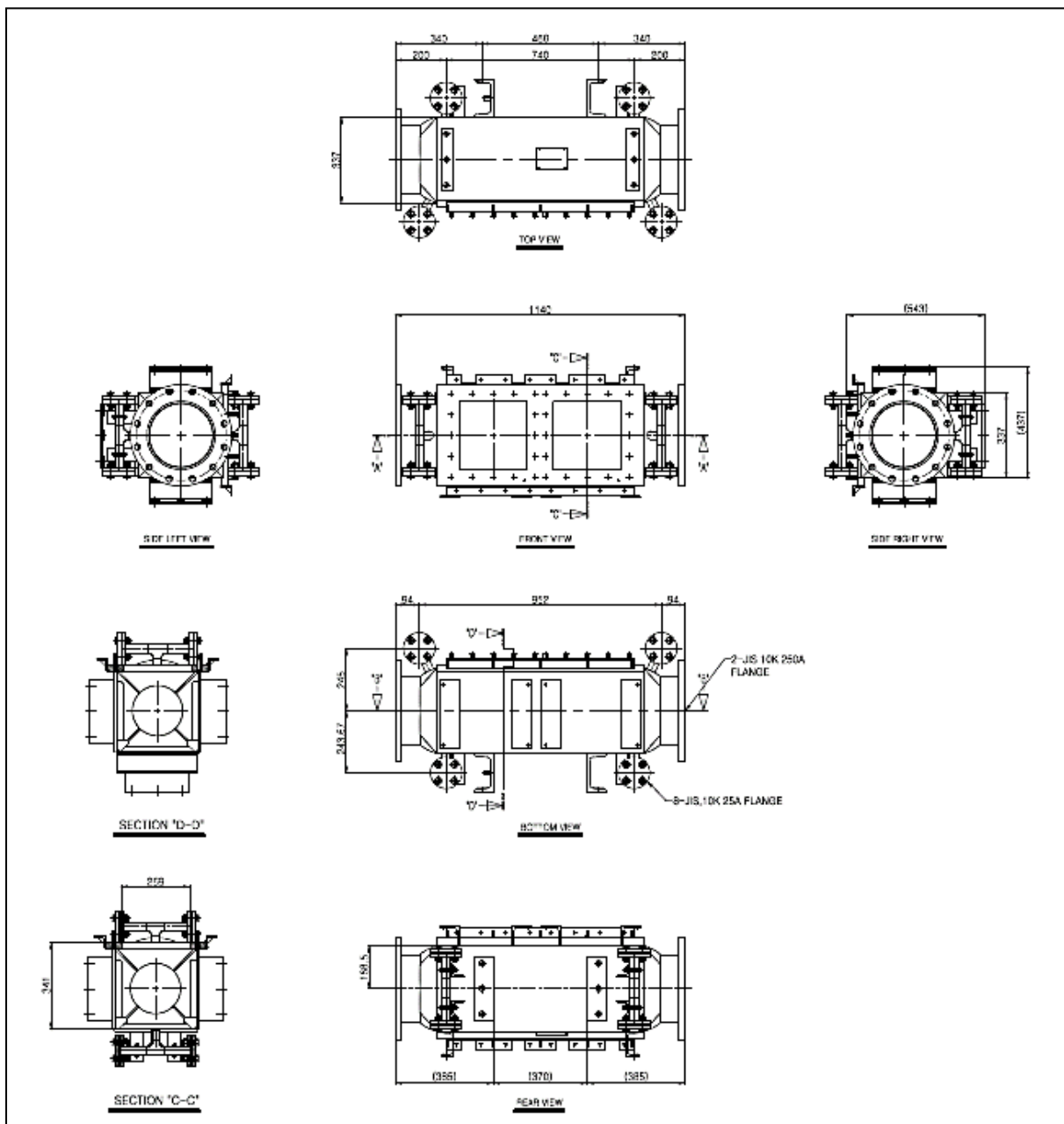
No.	TRC (m <sup>3</sup> /h)	Model	EX-ECU 1.1					PDE			ANU		Ex-TSU 1.1	Ex-FMU	Ex-CSU 1.1	Ex-FTS 1.1	CPC	T-STRAINER	
			150B 1.1	300B 1.1	450B 1.1	600B 1.1	1000B 1.1	24A 1.1K	12A 1.1	A4 1.1	5T 1.1	10T 1.1							
1	150	Ex-ECS-150B 1.1X1set	1																
2	300	Ex-ECS-300B 1.1X1set		1															
3	450	Ex-ECS-450B 1.1X1set			1														
4	600	Ex-ECS-600B 1.1X1set				1													
5	750	Ex-ECS-750B 1.1X1set					1												
6	900	Ex-ECS-900B 1.1X1set						1											
7	1,050	Ex-ECS-1000B 1.1X1set							1										
8	1,050	Ex-ECS-1050B 1.1X1set								1									
9	1,200	Ex-ECS-1200B 1.1X1set									1								
10	1,300	Ex-ECS-1300B 1.1X1set										1							
11	1,350	Ex-ECS-1350B 1.1X1set											1						
12	1,450	Ex-ECS-1450B 1.1X1set												1					
13	1,600	Ex-ECS-1600B 1.1X1set													1				
14	1,800	Ex-ECS-1800B 1.1X1set														1			
15	2,000	Ex-ECS-2000B 1.1X1set															1		
16	2,300	Ex-ECS-2300B 1.1X1set																1	
17	2,400	Ex-ECS-2400B 1.1X1set																	1
18	2,450	Ex-ECS-2450B 1.1X1set																	1
19	2,600	Ex-ECS-2600B 1.1X1set																	1
20	3,000	Ex-ECS-3000B 1.1X1set																	1
21	3,000	Ex-ECS-3000B 1.1X1set																	1
22	3,300	Ex-ECS-3300B 1.1X1set																	1
23	3,300	Ex-ECS-3300B 1.1X1set																	1
24	3,450	Ex-ECS-3450B 1.1X1set																	1
25	3,450	Ex-ECS-3450B 1.1X1set																	1
26	3,600	Ex-ECS-3600B 1.1X1set																	1
27	3,600	Ex-ECS-3600B 1.1X1set																	1
28	4,000	Ex-ECS-4000B 1.1X1set																	1
29	4,300	Ex-ECS-4300B 1.1X1set																	1
30	4,450	Ex-ECS-4450B 1.1X1set																	1
31	4,600	Ex-ECS-4600B 1.1X1set																	1
32	5,000	Ex-ECS-5000B 1.1X1set																	1
33	5,300	Ex-ECS-5300B 1.1X1set																	1
34	5,450	Ex-ECS-5450B 1.1X1set																	1
35	5,600	Ex-ECS-5600B 1.1X1set																	1
36	6,000	Ex-ECS-6000B 1.1X1set																	1
37	6,000	Ex-ECS-6000B 1.1X1set																	1

3.5.1.4 Equipment scheme by scale up/down Ex-ECS-B1.1 (Ballast pump 2 lines)

No.	TRC (m <sup>3</sup> /h)	Model	Ex-ECU					PDE			ANU		Ex-TSU 1,1	Ex-FMU	Ex-CSU 1,1	Ex-FTS 1,1	CPC	T-STRAINER		
			150B 1,1	300B 1,1	450B 1,1	600B 1,1	1000B 1,1	24A 1,1K	12A 1,1	A4 1,1	5T 1,1	10T 1,1								
1	300	Ex-ECS-150B 1,1X2set	2																	
2	600	Ex-ECS-300B 1,1X2set		2																
3	900	Ex-ECS-450B 1,1X2set			2															
4	1,200	Ex-ECS-600B 1,1X2set				2														
5	1,500	Ex-ECS-750B 1,1X2set					2													
6	1,800	Ex-ECS-900B 1,1X2set						2												
7	2,000	Ex-ECS-1000B 1,1X2set							2											
8	2,100	Ex-ECS-1050B 1,1X2set								2										
9	2,400	Ex-ECS-1200B 1,1X2set									4									
10	2,600	Ex-ECS-1300B 1,1X2set										2								
11	2,700	Ex-ECS-1350B 1,1X2set											6							
12	2,900	Ex-ECS-1450B 1,1X2set												2						
13	3,200	Ex-ECS-1600B 1,1X2set													2					
14	3,600	Ex-ECS-1800B 1,1X2set														6				
15	4,000	Ex-ECS-2000B 1,1X2set															4			
16	4,600	Ex-ECS-2300B 1,1X2set																4		
17	4,800	Ex-ECS-2400B 1,1X2set																	8	
18	4,900	Ex-ECS-2450B 1,1X2set																		2
19	5,200	Ex-ECS-2600B 1,1X2set																		2
20	6,000	Ex-ECS-3000B 1,1X2set																		10
21	6,000	Ex-ECS-3000B 1,1X2set																		6
22	6,600	Ex-ECS-3300B 1,1X2set																		10
23	6,600	Ex-ECS-3300B 1,1X2set																		2
24	6,900	Ex-ECS-3450B 1,1X2set																		10
25	6,900	Ex-ECS-3450B 1,1X2set																		6
26	7,200	Ex-ECS-3600B 1,1X2set																		12
27	7,200	Ex-ECS-3600B 1,1X2set																		2
28	8,000	Ex-ECS-4000B 1,1X2set																		8
29	8,600	Ex-ECS-4300B 1,1X2set																		8
30	8,900	Ex-ECS-4450B 1,1X2set																		2
31	9,200	Ex-ECS-4600B 1,1X2set																		8
32	10,000	Ex-ECS-5000B 1,1X2set																		2
33	10,600	Ex-ECS-5000B 1,1X2set																		10
34	10,900	Ex-ECS-5000B 1,1X2set																		10
35	11,200	Ex-ECS-5000B 1,1X2set																		2
36	12,000	Ex-ECS-6000B 1,1X2set																		12
37	12,000	Ex-ECS-6000B 1,1X2set																		20

### 3.5.2 Main Components

#### 3.5.2.1 Electro-Chamber Unit (ECU)



## ECU Specification

No.	Item	Standard	Remark
1	FLOW RATE	30% ~ 110% of TRC	
2	PRU & EPJ POWER SUPPLY	AC 440V, 3ph, 60Hz	
3	PRU COOLING WATER CONDITION	INLET PRESSURE: MIN. 1.5BAR / MAX. 5BAR	
		FLOW RATE VOLUME: MIN. 0.45m <sup>3</sup> /h(Per PRU 1EA)	
		COOLING F.W TEMPERATURE(INLET): +36°C	
		PRESSURE DROP: 0.5BAR	
4	Flange connection	ECU-150B/Ex-ECU-150B : JIS 10K 250A ECU-300B/Ex-ECU-300B : JIS 10K 250A ECU-450B/Ex-ECU-450B : JIS 10K 250A ECU-600B/Ex-ECU-600B : JIS 10K 250A ECU-1000B/Ex-ECU-1000B : JIS 10K 350A	

## ECU Weight and Dimension

No.	Model	Weight (kg)	Dimension (L x D x H : mm)	Remark
1	ECU-150B 1.1	380	790 x 540 x 862	
2	ECU-300B 1.1	420	1243 x 763 x 862	
3	ECU-450B 1.1	585	1490 x 763 x 862	
4	ECU-600B 1.1	685	1840 x 763 x 862	
5	ECU-1000B 1.1	1,300	2000 x 1124 x 914.5	

## ECU Weight and Dimension

No.	Model	Weight (kg)	Dimension (L x D x H : mm)	Remark
1	Ex-ECU-150B 1.1	310	790 x 754 x 688	
2	Ex-ECU-300B 1.1	480	1140 x 754 x 688	
3	Ex-ECU-450B 1.1	650	1490 x 754 x 688	
4	Ex-ECU-600B 1.1	820	1840 x 754 x 688	
5	Ex-ECU-1000B 1.1	1,500	2000 x 1004 x 836	

**EM Weight and dimension**

No.	Model	Weight (kg)	Dimension (L x D x H : mm)	Remark
1	EM-150 1.1	380	790 x 540 x 862	
2	EM-1000 1.1	420	1243 x 763 x 862	

**EM Material**

No.	Part Name	Standard	Material	Remark
1	Top cover	JIS H 4000	AL6061	
2	Electrode	JIS H 4600	Titanium	
3	Busbar	JIS H 3100	Copper	
4	Body	ASTM	PVC	

**PRU Material**

No.	Part Name	Standard	Material	Remark
1	Base / Side body	JIS H 4000	AL6061	
2	Front Cover	JIS H 4000	AL6061	
3	Busbar	JIS H 3100	Copper	

**Ex-PRU Material**

No.	Part Name	Standard	Material	Remark
1	Top cover	JIS H 5202	AC2A	
2	Body	JIS H 5202	AC2A	
3	Heat sink	JIS H 4000	AL6061	

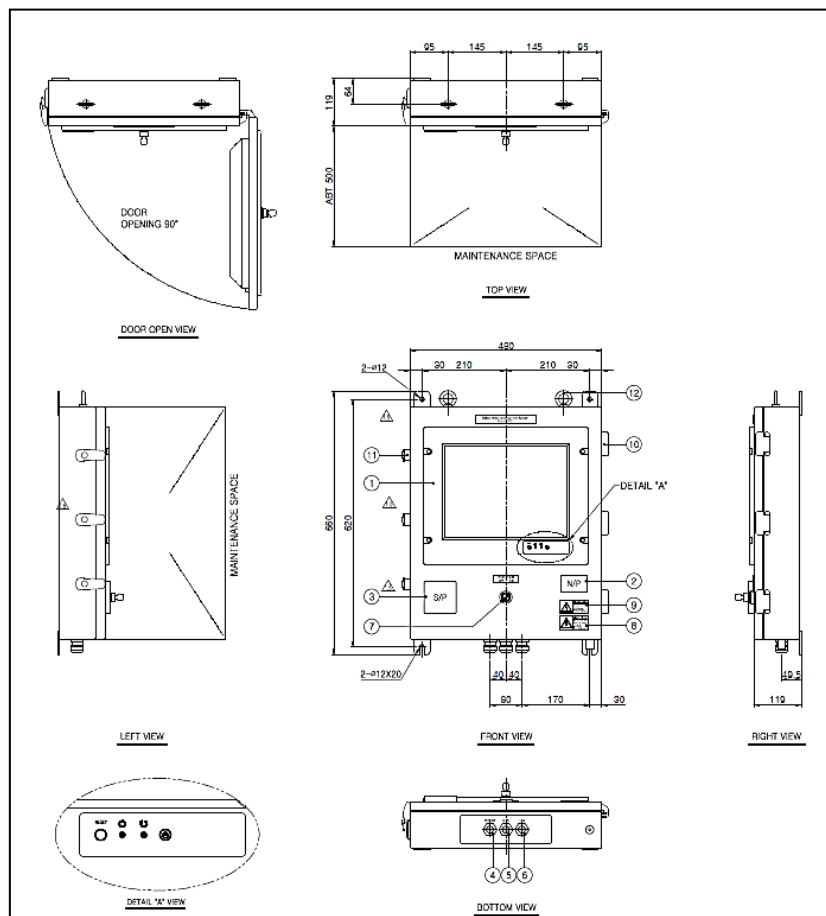
**ESJ Material**

No.	Part Name	Standard	Material	Remark
1	Housing	JIS G 3141	SPCC	

**EPJ Material**

No.	Part Name	Standard	Material	Remark
1	Housing	JIS G 3141	SPCC	

### 3.5.2.2 Control PC (CPC)



#### CPC Specification

No.	Item	Standard	Remark
1	Input Power	AC220V, 60Hz	
2	Install type	Wall mounting	
3	IP Grade	IP22	

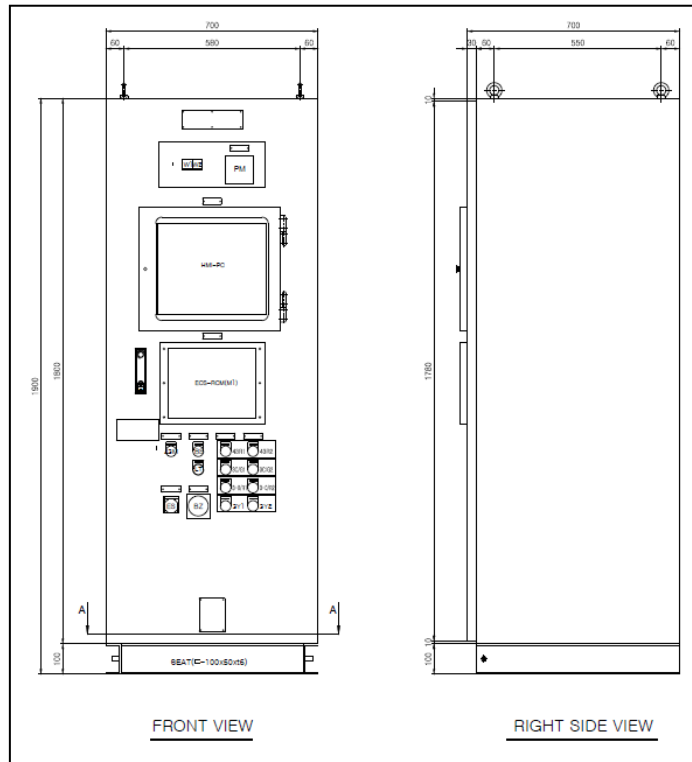
**CPC Weight and dimension**

No.	Model	Weight (kg)	Dimension (L x D x H : mm)	Remark
1	CPC 1.1	35	480 x 119 x 660	

**CPC Material**

No.	Part Name	Standard	Material	Remark
1	Housing	JIS G 3141	SPCC	

**3.5.2.3 Power Distributor Equipment (PDE)**



**PDE Specification**

No.	Item	Standard	Remark
1	Power Supply	3 Phase AC 440V, 60Hz	
2	Install Type	Floor mounting and Self Standing	
3	Cable Entrance	Bottom	
4	IP Grade	IP 44	

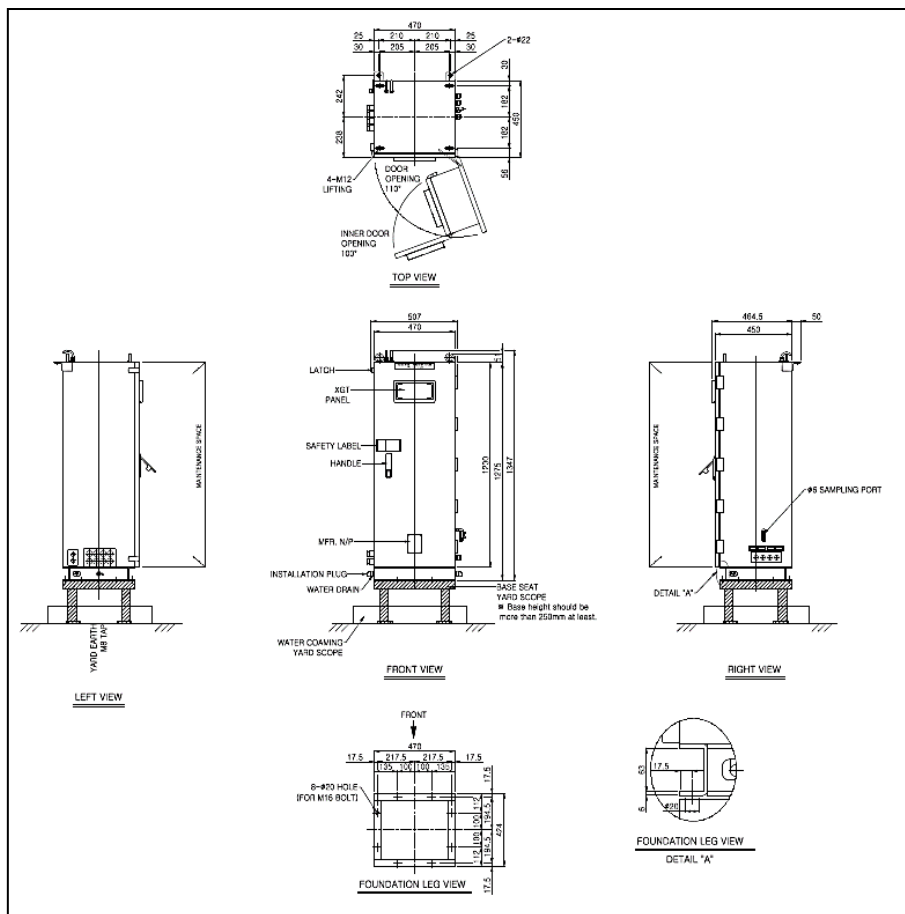
**PDE Weight and Dimension**

No.	Model	Weight (kg)	Dimension (L x D x H : mm)	Remark
1	PDE-24A 1.1K	412	700 x 700 x 1900	
2	PDE-12A 1.1	342	700 x 700 x 1600	
3	PDE-A4 1.1	324	700 x 600 x 1500	

**PDE Material**

No.	Part Name	Standard	Material	Remark
1	Housing.	JIS G 3141	SPCC	

### 3.5.2.4 TRO Sensor Unit (TSU)



#### TSU Specification

No.	Item	Standard	Remark
1	Input Power	AC220V, 60Hz	
2	Install Type	Floor Mounting and Self Standing	
3	IP Grade	IP44	

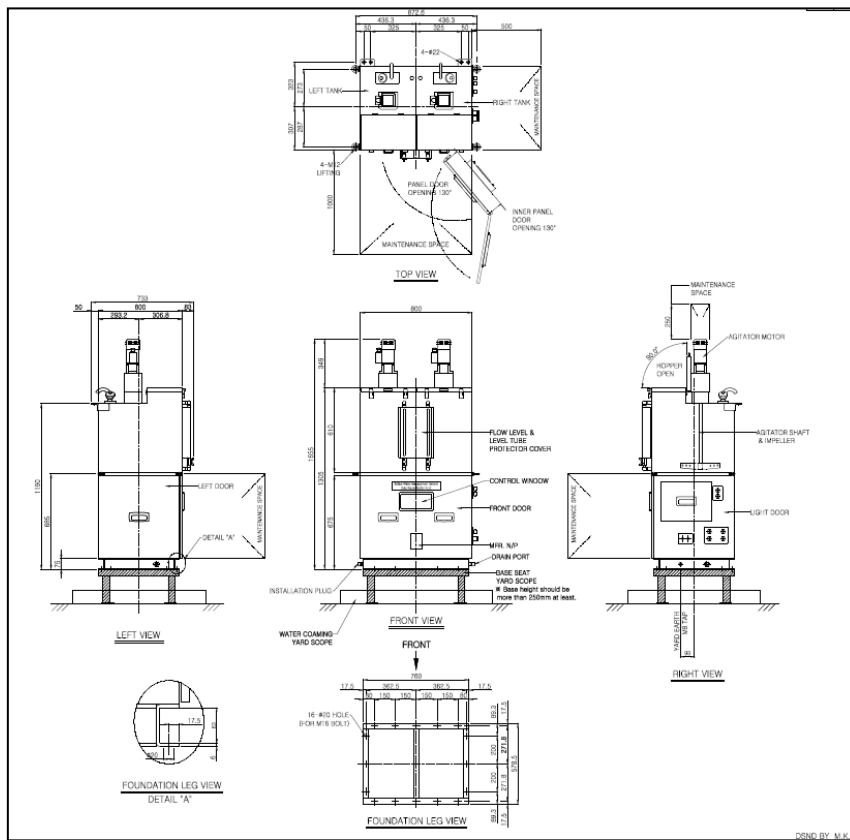
**TSU Weight and Dimension**

No.	Model	Weight (kg)	Dimension (L x D x H : mm)	Remark
1	TSU 1.1	100	470 x 450 x 1347	
2	Ex-TSU 1.1	28	474 x 240 x 733	

**TSU Material**

No.	Part Name	Standard	Material	Remark
1	Housing	JIS G 3141	SPCC	
2	Pipe.	JIS G 3459	STS316L	

### 3.5.2.5 Auto Neutralization Unit (ANU)



#### ANU Specification

No.	Item	Standard	Remark
1	Input Power	AC220V, 60Hz	
2	Install Type	Floor Mounting and Self Standing	
3	Tank Capacity	Approx. 50kg / Each 1 Tank	
4	Neutralizer	Sodium Thiosulfate	
5	IP Grade	IP44	

**ANU Weight and Dimension**

No.	Model	Weight (kg)	Dimension (L x D x H : mm)	Remark
1	ANU – 5T 1.1	261	800 x 733 x 1655	
2	ANU – 10T 1.1	311	1200 x 733 x 1655	

**ANU Material**

No.	Part Name	Standard	Material	Remark
1	Tank	JIS G 4304	SUS	
2	Pipe	JIS G 4304	STS316	
3	Frame	JIS G3141	SPCC	

## **3.6 SAFETY MEASURES**

Pre-test documentation / General SHE impact assessment Potential hazards for the environment, safety of the crew and public health

### **3.6.1 Pre-test document**

Active Substance approval testing in accordance with IMO Resolution MEPC.125(54).

### **3.6.2 General SHE impact Assessment Potential; hazards**

#### **3.6.2.1 Active Substance Generated by Electro-Cleen™ System**

The electrolyzed ballast water includes chemical ingredients which have dynamic equilibrium with gas on the surface of the water or which are completely dissolved. There is no chlorine gas generation since the chlorine gas, generated in pH range of Electro-Cleen™ System operation, is hydrolyzed into hypochlorous acid or hypochlorous acid ion after completely dissolved in ballast water. The electrolyzed ballast water could generate peroxides and the concentrations of hydrogen peroxide and ozone are very low compared to free chlorine. According to treated seawater test using ECS, the maximum concentrations of hydrogen peroxide and ozone are less than 0.1mg/L. Having considered that the hydrogen peroxide concentration of oxyfuel used as a disinfectant is around 40,000mg/L, this substance have little effect on the risk to environment and human.

#### **3.6.2.2 Operating Condition and Active Substance Concentration Management of Electro- Cleen™ System**

For the ballast water management system using electrolysis, the additional filtration system is not necessary because ballast water treatment is conducted after large sediments in inflowing water are removed with a strainer. This electrolysis system disinfects with potential difference, radicals, and electrode oxidization which are generated instantaneously and disappeared in several seconds. The maintaining disinfectant is TRO. TRO concentration generated during ballast water treatment in this system is around 10mg/L even though the generated concentration is different by characteristics such as ballast water temperature, conductivity, types and concentration of materials dissolved in water. As reviewed in the next paragraph, this range of concentration does not require particular cautions when the crew or operators handle ballast water. Since the active substance in ballast water, hypochlorous acid, is affected by voltage and current, TRO generation is being managed by controlling voltage and current automatically so that the maximum concentration does not exceed 10mg/L.

### 3.6.2.3 Effect of Hypochlorous Acid on Human

TRO, generated as active substance during ballast water treatment with Electro-Cleen™ System, is dissolved in water when its concentration is low, and then most of it turns to hypochlorous acid in pH range of seawater. The maximum concentration generated from ECS operation is less than 10mg/L, that is, less than 0.001%. Acute and chronic toxicity test result of hypochlorous acid is as follows and it represents it has little effect on human.

#### 1. Short-term (acute) exposure

1) Inhalation Hypochlorite does not easily form into vapour. The amount of chlorine released from dilute solution of hypochlorite solutions (less than 5.25%) under normal condition therefore is not significant. However, with more concentrated solutions and if the pH is powered, or if the solution is heated or if mixed with acids, higher amount of chlorine may be released. Mists formed from solutions can cause mild to severe irritation of the nose and throat, depending mainly upon the airborne concentration and the strength of the solution. There is no information about the short-term inhalation exposure to mists from hypochlorite solutions for human or animal.

#### 2) Skin contact

Hypochlorite solutions can cause mild irritation to corrosive injury depending on the duration of contact, the concentration and pH of the solution, based on human and animal information. No irritation was experienced by 20 volunteers following the application of 1% hypochlorite solution (pH unspecified) for 48 hours in the form of a covered patch. When 2% solution (pH unspecified) was used, weak or moderate irritation was experienced by 15 out of 69 volunteers. No skin reaction was observed in 3 volunteers following a 48-hour application of 0.252% solutions in the form of a covered patch. Severe irritation was experienced by volunteers after 4-hour application of 5.25% hypochlorite solution (pH 10.7) to unbroken skin in the form of a covered patch.

#### 3) Eye contact

Hypochlorite solutions can cause mild irritation to corrosive injury, depending on the concentration and pH of the solution, and the duration of the contact, based on human and animal information. There are several reports of pain, and in some cases, slight damage to the surface of the eye and/or cornea, being experienced after direct contact with commercial products containing sodium hypochlorite (approximately 5%). The eyes were washed with water or a salt solution (saline) and the injury cleared within 1-2 days. There are 3 reports of burning to the eyes with slow recovery following exposure to concentrated solutions (concentration unspecified).

#### 4) Ingestion

Swallowing hypochlorite solutions can cause irritation, pain and inflammation of the mouth, throat and stomach, as well as vomiting. In severe cases, serious effects including ulceration and perforation of

the gastrointestinal tract and death can result. The effects depend on several factors, e.g., the amount ingested, the concentration and pH of the solution. About 29.5ml of a solution with 15% available chlorine may be lethal. For sodium hypochlorite solution with 3-6% of available chlorine, a lethal dose for humans of 200 ml has been reported. Severe injury has been observed in a person who ingested approximately 1 liter of 5.25% sodium hypochlorite having pH of 10.8. A woman who intentionally swallowed approximately 700ml of 5.25% sodium hypochlorite having pH of 11.5, showed falling mental status, perforation of the stomach, and died of cardiac arrest 4.5 hours after ingestion. Deaths have also resulted from aspiration of sodium hypochlorite solution into the lungs.

## 2. Long-term (chronic) exposure

1) Skin Prolonged or repeated contact with hypochlorite may cause dry, red, cracked skin (dermatitis). In a 5-year survey, 17/130 (13.1%) of first-time attacks of dermatitis reported among chemical factory workers were attributed to the misuse of hypochlorite to the clear skin (frequency of use and concentration not reported).

### 2) Skin sensitization

It is not possible to conclude hypochlorite as an occupational skin sensitizer. A few cases of skin sensitization have been reported, in all but one case, the individuals were predisposed to this type of reaction (reacting to other common allergens as well). Two non-occupational cases of sensitization to sodium hypochlorite have been confirmed by patch tests. Both individuals reported a history of skin reactions following exposures to products containing sodium hypochlorite or chlorine. Other family or personal history of allergies has not been reported. Negative results (0/86 and 0/90 individuals sensitized) have been obtained in two unpublished sensitization tests on human volunteers (human repeated insult patch test) using 4% sodium hypochlorite solution.

### 3) Carcinogenicity

The International Agency for Research on Cancer (IARC) has concluded that hypochlorite is not classifiable as to its carcinogenicity to humans

4) Teratogenicity and embryo toxicity No specific conclusions can be drawn about the potential developmental toxicity of sodium hypochlorite from a human population study that examined the potential effects of chlorinating drinking water with sodium hypochlorite. Exposure in this study was based on the chlorination method, and not the measured amount of sodium hypochlorite or its byproducts in the water.

### 5) Reproductive toxicity

There is no human information available for reproductive toxicity. No firm conclusion can be drawn based on the limited animal information available.

6) **Mutagenicity** There is no information available for human. The available information for animal suggests that sodium hypochlorite is not mutagenic. A positive result (sperm-head abnormalities) was obtained in one test using live mice. This test did not directly measure genetic damage. Negative results have been obtained in other tests with live mice.

7) **Potential for accumulation** Hypochlorite does not accumulate in the body. It reacts with tissues (21). A rat study using radio labelled hypochlorous acid has shown that it is absorbed fairly rapidly in serum and eliminated from plasma with a half-life of 44 hours.

#### **3.6.2.4 Ship and personnel safety**

Total residual chlorine produced typically ranges from 6 to 10mg/L in the Electro-Clean system operating with an applied voltage lower than 13 volts. No skin irritation was experienced by 20 volunteers after application of a 1% hypochlorite solution (pH unspecified) for 48 hours under a patch. The possibility of risk from the electrochemically treated water to personnel does not exist. The system is also sealed tightly. This makes human exposure to treated water impossible under normal operational conditions. Since the Electro-Clean system is fully automated, cutting-off electricity to the system alone can ensure the safety of the ship and personnel at the time of emergency.

#### **3.6.2.5 Environment protection**

The concentration levels of total residual chlorine in treated water discharged from the Electro-Clean system is extremely low. TRC is easily decomposed by sunlight, micro-organisms and other reductants. Thus, residual chlorine will not be accumulated in harbors or ports. Octanol/ water partition coefficient of TRC is calculated to be  $\log P(\text{oct}) = -3.42$ . TRC is not persistent and bio-accumulative. In reality, chlorine is used for the disinfection of drinking water not only in the United Kingdom and the United States, but also in most other countries.

#### **3.6.2.6 Hazard documentation and labeling**

The reactivity of the total residual chlorine in electrolytically disinfected ballast water is extremely high so that it is rapidly decomposed in seawater. The concentration level of total residual chloride in the ballast water is below 10mg/L. There is no possibility of explosion. Although there are only few precautions to be taken for management, there may be need to ventilate hydrogen generated during the electrolytic disinfection in order to prevent accumulation. A document that deals with the harmful substances produced during electrolysis including the MSDS (IMDG code entry) data has been summarized and provided below.

1) **MSDS** The Material Safety Data of 2~3% w/w sodium hypochlorite solution have been reported to be hazardous in case of eye and skin contact. For the carcinogenic effects, this material is not known

to cause cancer in animals or humans. There is no available Material Safety Data sheet for the 0.001% w/w sodium hypochlorite solution which is generated in the Electro-Clean system.

2) **IMDG** IMDG Code 8186, UN No.1791, Class 8, Packaging Group II/III, EmS No.8-08, MFAG table No.741 covers the hypochlorite solutions with more than 5% available chlorine. However, it does not cover the 0.001% sodium hypochlorite solution which is generated in the Electro-Clean system.

### **3.6.2.7 Potential effects of the BWMS**

1) **TRO** The operative conditions of Electro-Clean™ System(ECS) is designed to generate 6 to 10mg/L of TRO(Total Residual Oxidant) with less than 10mg/L of TRO in the worst cases to satisfy IMO D-2 standard. ECS has been tested and proven to have not made a significant effect on corrosion of ballast tank. The corrosive effect of ECS was evaluated with the 'International Paint Ltd' in June 2010. Please refer to Ch. 9.1 Letter of International Paint Ltd.

2) **H<sub>2</sub> gas** There are no potential effect by low concentration of hydrogen gas on a Vessel's infrastructure so far.

When the H<sub>2</sub> gas is leaked, an alarm shall be activated in case the concentration of H<sub>2</sub> gas is over 25% of LEL and the system shall be shut down in case the concentration of H<sub>2</sub> gas is over 50% of LEL. In such cases the ship's crew must ensure that enough ventilation (at least 6 air changes per hour) has been carried out by mechanical ventilation fan or natural ventilation by air vent heads prior to entering the space where the ECS is installed.

### **3.6.3 Hazard documentation and labeling**

1) It was found that total residual chlorine at the concentration of 10mg/L recommended for ballast water treatment is completely degraded already after 1.1 days under light condition.

2) The hydrogen peroxide and ozone concentration of the electrolytic solution is very low in comparison with the free chlorine. The maximum concentration produced during electrolysis of seawater is below 0.1 mg/L for both hydrogen peroxide and ozone.

3) From the acute toxicity test, no skin irritation was experienced by 20 volunteers after application of a 1% hypochlorite solution (pH unspecified) for 48 hours under a patch. The possibility of danger to personnel from the electrolytically treated water does not exist.

4) Since chlorine is being used to disinfect drinking water not only in the United Kingdom and the United States, but also in most other countries, there is almost no concern over PBT levels.

The half-life of total residual chlorine was 0.58 day under light condition and 2.0 days under dark condition. No danger to humans and environment is expected.

## 4. DESIGN GUIDE LINE FOR EQUIPMENT

### 4.1 Introduction

#### 4.1.1 Material requirements

This design guidance is to recommend suitable materials for installation of Techcross ECS Suitable material for ECS is not limited to our recommendation.

According to importance of below table, application of material can be changed based on Ship Owner's or Ship yard's standard.

The column of Importance is divided as A and B, and each meaning of character is as below.

\* A : Strongly recommended.

\* B : Material recommendation is not limited to specified material.

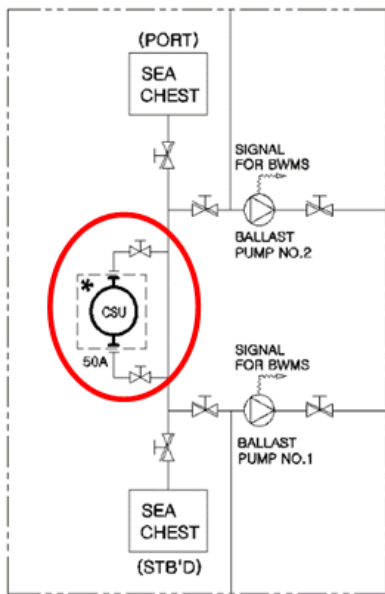
Application of material can be applied based on experience

No.	System	Material Recommendation	Importance	Remark
1	Ballast Sea Water	Suitable materials for sea water	B	
2	TRO Sampling & By-pass	1) A312 - TP316, TP316L Grade 2) A53 - Gr A Grade pipe with Suitable or Protective coating or treatment 3) Equivalent / Higher grade material	B	
3	ANU Dosing	1) A312 - TP316, TP316L Grade 2) Suitable materials for Sodium thiosulfate 3) Equivalent / Higher grade material	A	
4	PRU Cooling	1) A53 Gr A Grade with acid pickling & phosphate for Chemical treated fresh water 2) A53 Gr A Grade with Galvanizing for untreated fresh water 3) Equivalent / Higher grade material	B	
5	Air Supply	1) C1100 Tube 2) Equivalent / Higher grade material	B	
6	F.W Supply	1) A53 Gr A Grade with Galvanizing coat 2) B88 3) Equivalent / Higher grade material	B	
7	Ventilation	1) A53 Gr A Grade with Galvanizing coat 2) Suitable material for H2 gas	B	
8	Instruments	1) B88 or A213 which is suitable for Intended Fluid (Please refer to above) 2) Equivalent / Higher grade material	B	

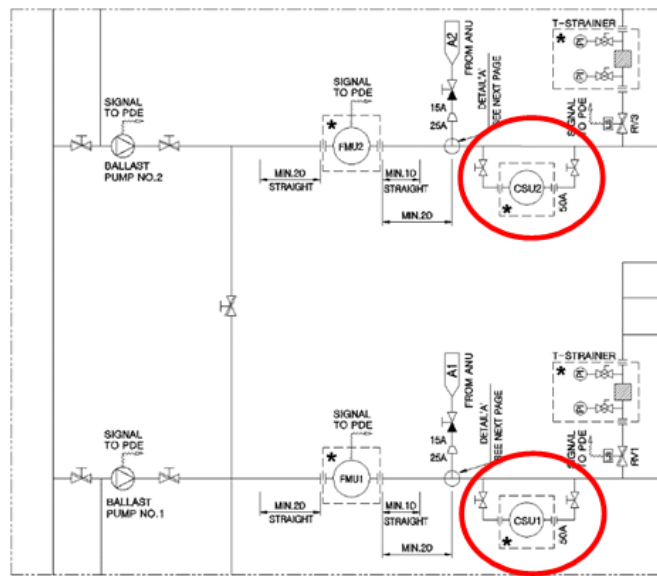
## 4.2 General Design & Installation Guide

### 4.2.1 CSU (Conductivity Sensor Unit)

- Install CSU on sea chest common line. When it is unfeasible due to space limit, it can be installed on ballast line which is located on the front part of ECU chamber.
- If shore power or shore cooling system is not used on the ship during ballasting, CSU can be installed on the cooling sea water line also.
- Basically, CSU shall be installed on the line which flows sea water continuously during ballast operation

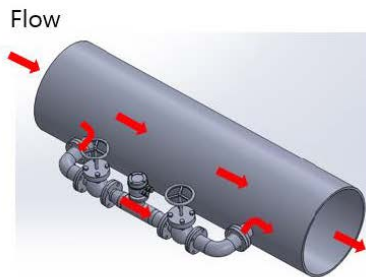


CSU installation on the Sea Cross Line

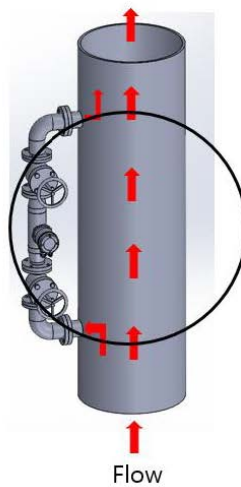


CSU installation between FMU and ECU Chamber

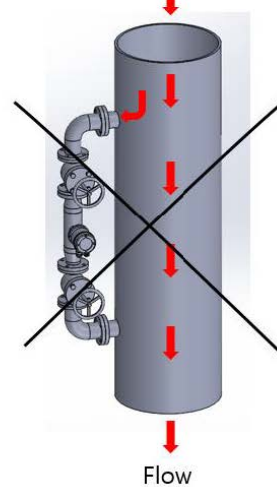
Horizontal



Vertical

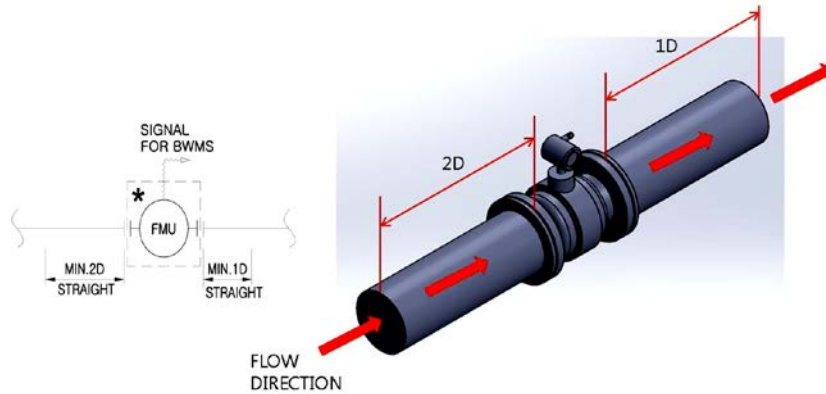


Vertical

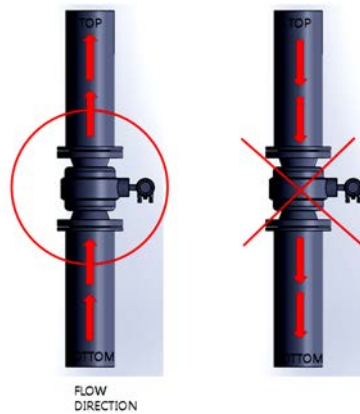


### 4.2.2 FMU (Flow Meter Unit)

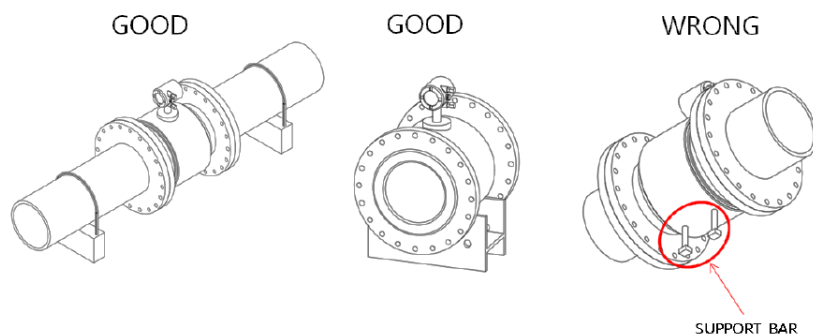
- Check the pipe length of FMU inlet & outlet as shown in the picture below to ensure FMU's accuracy. (Inlet side: Min. 2D, Outlet side: Min. 1D, D: Pipe diameter)



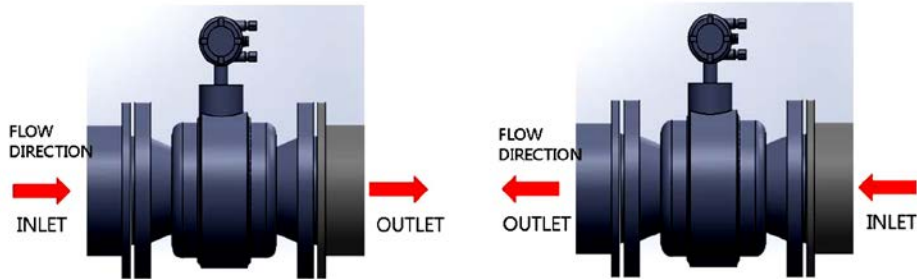
- When installing FMU vertically, the ballast water should flow from bottom to upward.



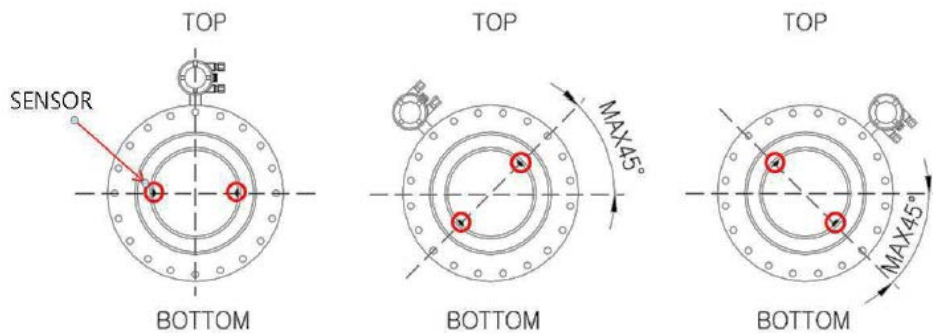
- Use appropriate gasket for fluid component and fluid temperature.
- When installing a flow meter larger than 400A, housing bending and damage of internal electric coil may occur. It is recommended to install support at the end of housing as in the picture below.



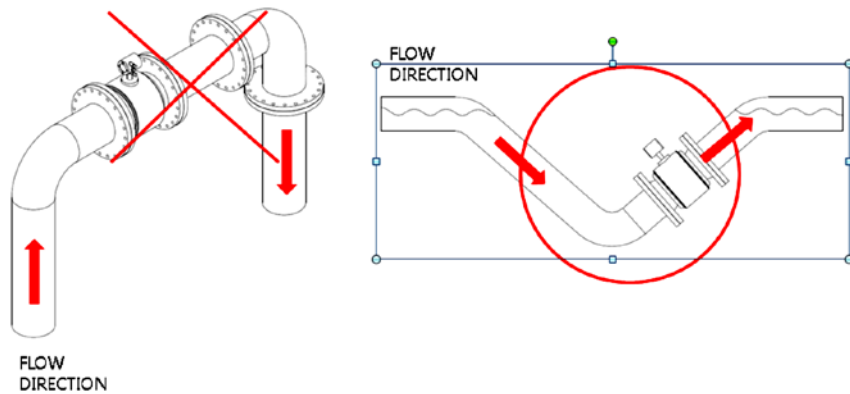
- Flow meter can be used for both directions.



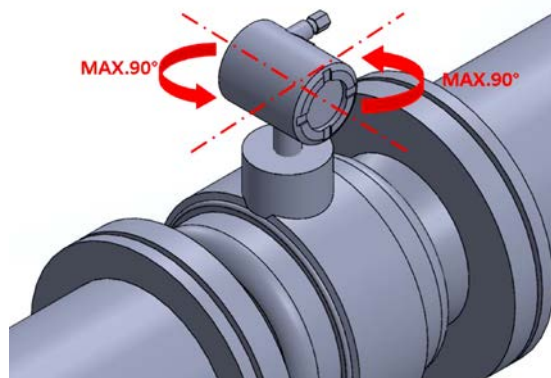
- It is necessary to keep elec. rod's position horizontally. If it is hard to maintain it horizontally, it should not tilt more than 45 degrees from horizontal line.



- When installing FMU on the highest point or discharge point, inaccurate value may be measured as full water condition is not fulfilled. In this case, install it as shown in the right picture so full water condition can be fulfilled.



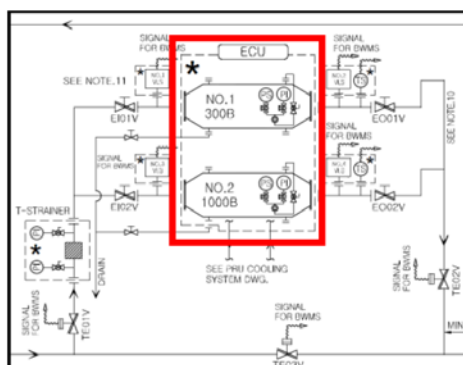
- Display can be turned into 4 directions, 90 degrees (total of 360 degrees).

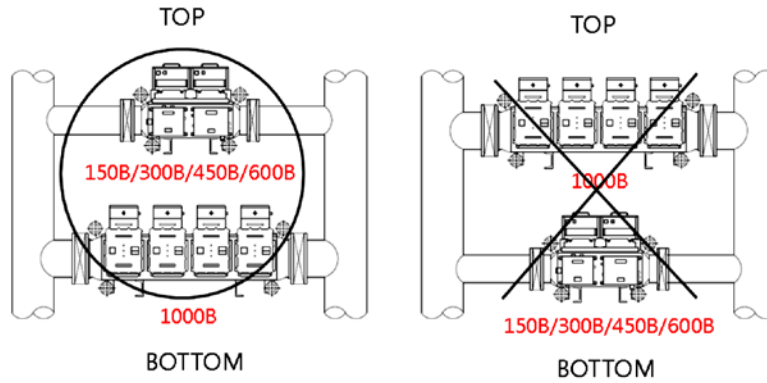


- When installing FMU, FMU power should be turned off before starting any work.

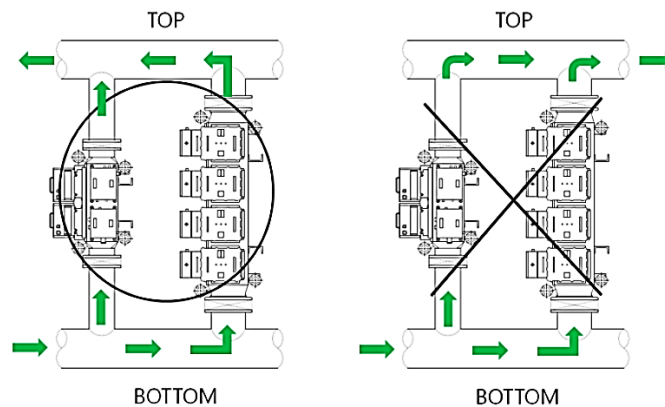
#### 4.2.3 ECU (Electro Chamber Unit)

- When installing combined chambers horizontally (if the capacities of the chambers are different), place the chamber with smaller capacity on the top side.  
(If the chamber with bigger capacity is installed on the upper side, a problem may occur during ECU chamber maintenance.)

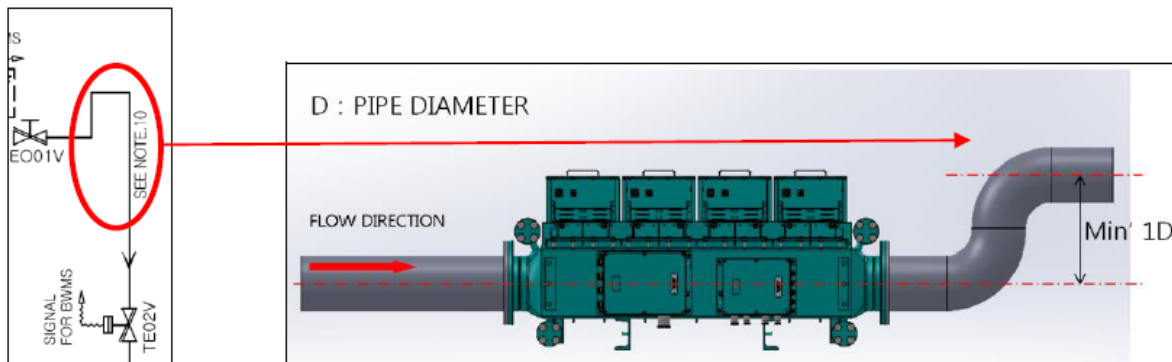




- When more than two (2) chambers are installed, there can be a large difference between capacities of chambers. If so, please request CFD (Computational Fluid Dynamics) to Techcross engineering team to check flow distribution.
- Adjust yard pipe size to ensure that flow rate at chamber entrance is approx. 2~2.5 m/sec
- When installing more than two (2) chambers vertically, note that the flow distribution of each chamber can be changed according to in/out flow direction. Arrange in/out flow direction as shown in the picture below.



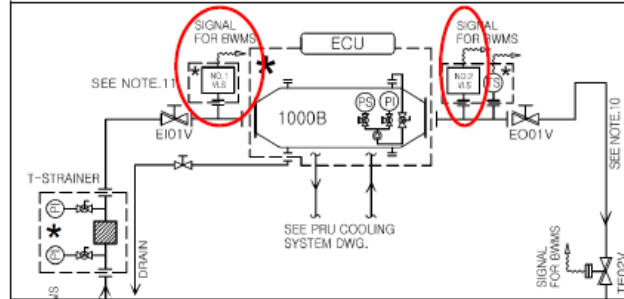
- In case of installing a horizontal pipe, it is recommended to install outlet at the higher position than inlet as in the picture below to fulfill full condition for ECU. (Min. 1D, D: Pipe diameter)



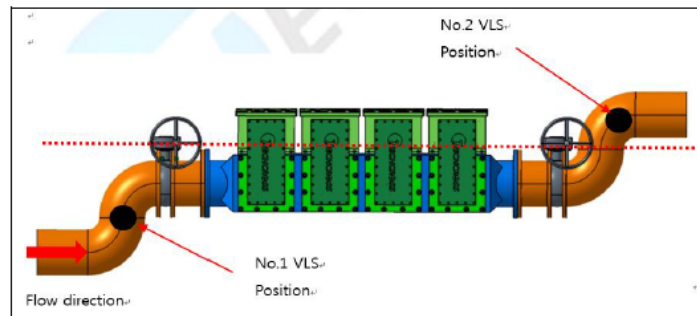
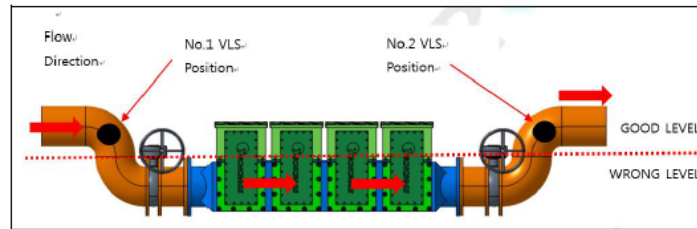
### 4.2.4 VLS(Vibration Level sensor)

- VLS should be installed on the outlet of ECU where ballast pipe can be filled with water.

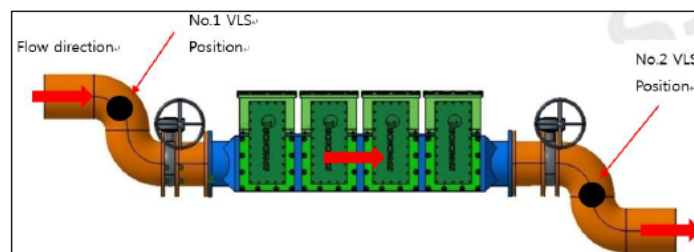
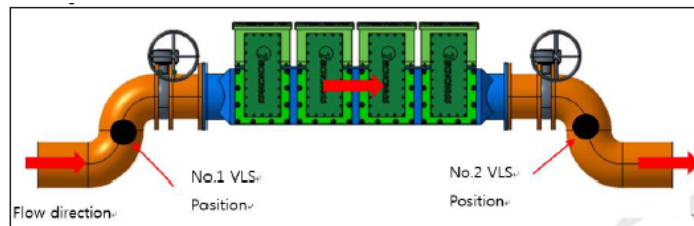
- Horizontal type



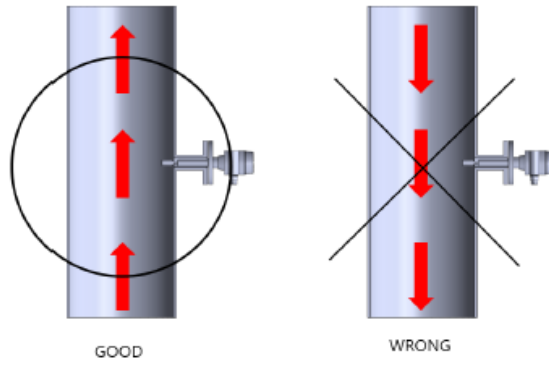
- Reference of Good Installaion



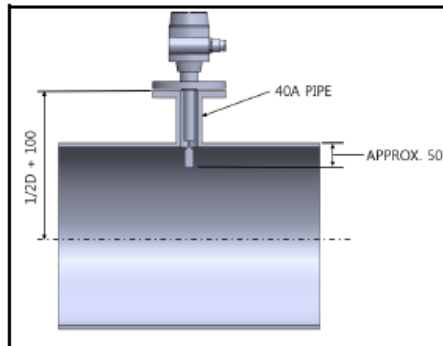
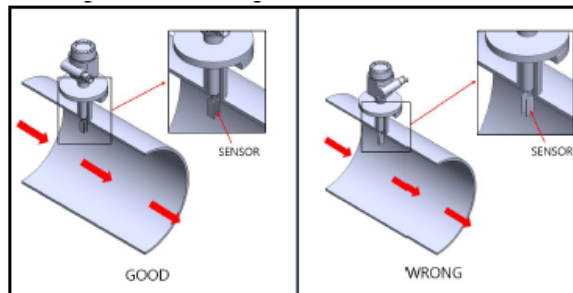
- Reference of Wrong Installation



- Reference of Vertical Installation

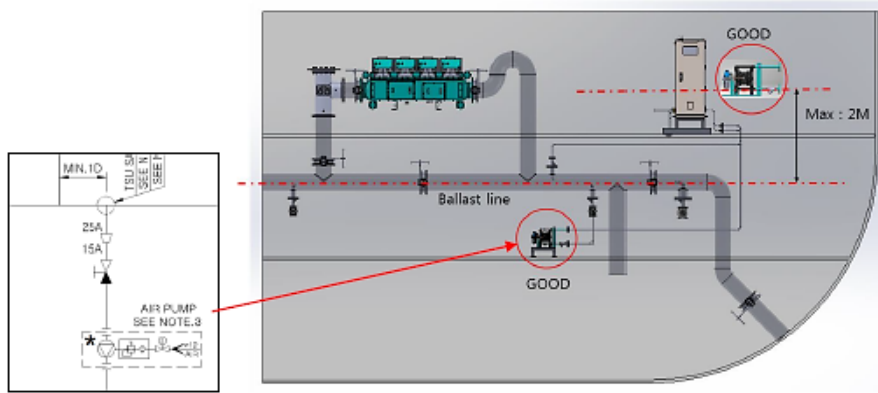


Refer to the drawing below for installing VLS

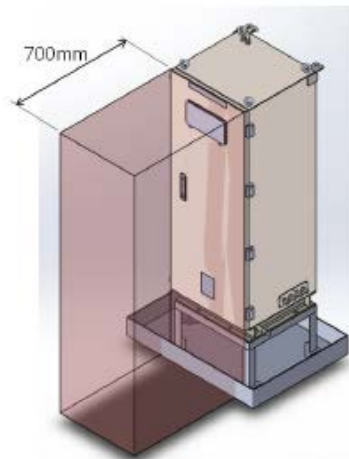


### 4.2.5 TSU(TRO Sensor Unit)

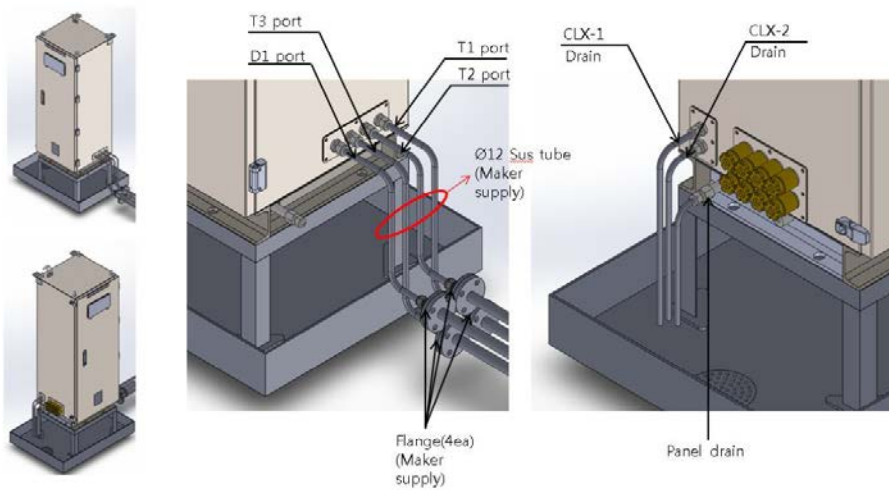
- When installing APU suction line, the height should be 2m from the sampling or dosing port.



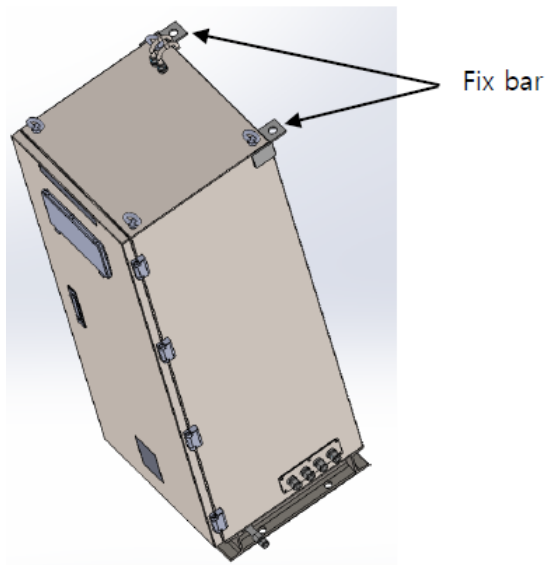
- Secure the space for maintenance (at least 700mm from the front part).



- For pipe connection, please refer to the drawing below.

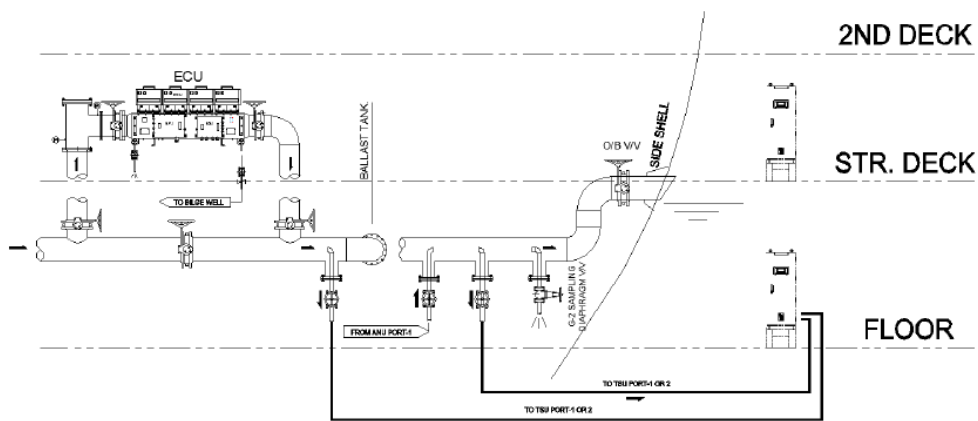


- To protect equipment from vibration, support should be installed using fix bar connecting hole on the top part.



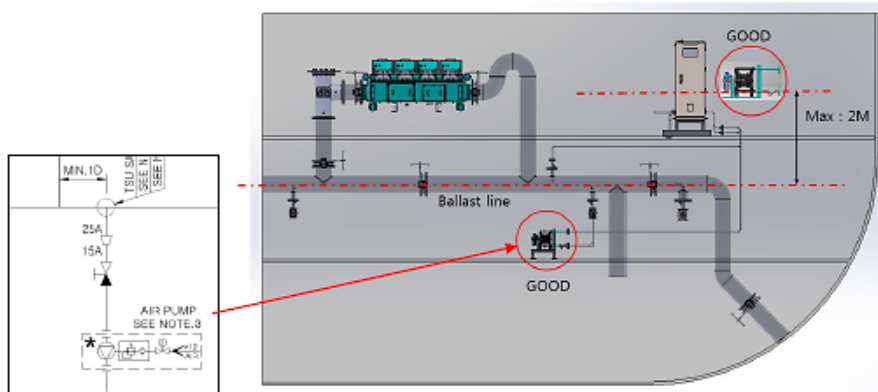
- It is recommended to install TSU on one deck lower than ECU or on the same deck.

TSU should be installed in the place where it is high enough to make sure that sampling water is provided to TSU by pipe pressure.



### 4.2.6 ANU (Auto Neutralization Unit)

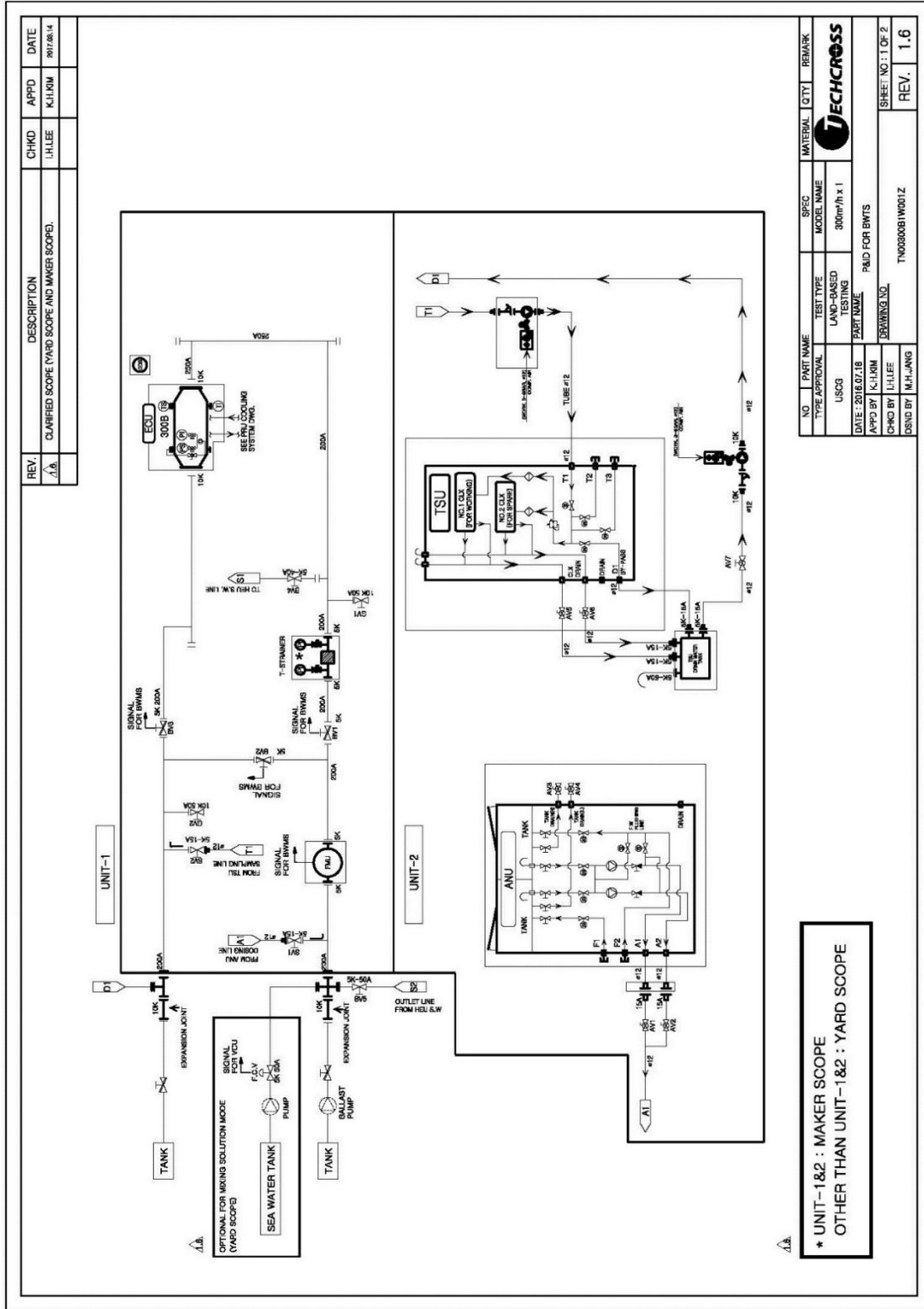
- When installing APU suction line, the height should be 2m from the sampling or dosing port.



# 5. Operation

## 5.1 Drawings of ECS

### 5.1.1 Piping and instrument diagram

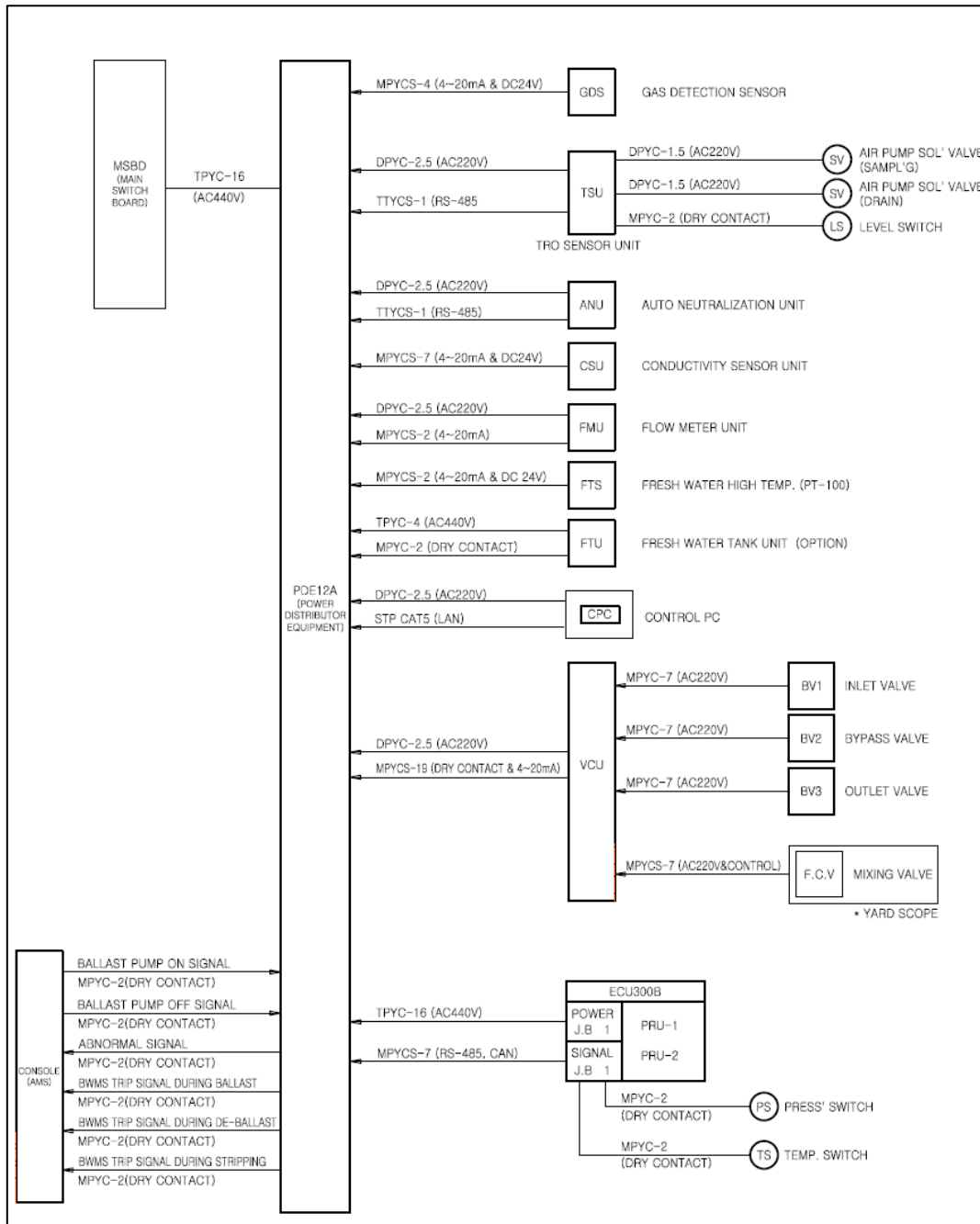


### 5.1.2 Wiring diagram

Basically ECS wiring is same but based on the ship's control system grade, there are some difference as shown below.

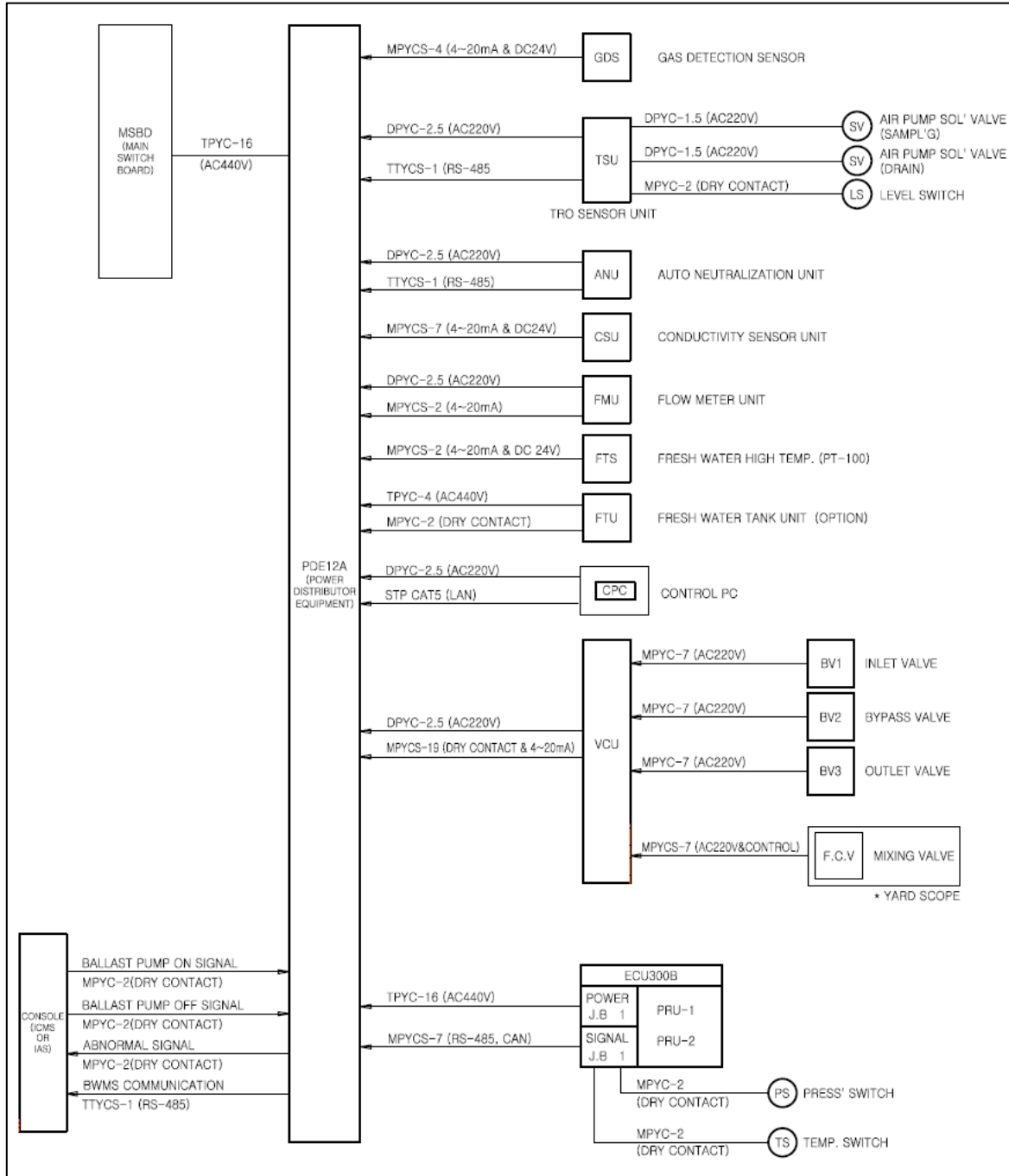
1) AMS grade system application and ICMS/IAS grade system with dry contact signal application (When Valve Remote Control System is available)

- AMS (ALARM MONITORING SYSTEM) does not have function that can judge the operation mode. And when the ICMS/IAS requires dry contact signal, ECS can send the trip signal for each operation mode as shown below. And if ICMS/IAS requires dry contact signal, also dry contact signal can be sent to ICMS/IAS but quantity of signal can be changed according to ICMS/IAS program. (e.g. one(1) common trip signal can be applied based on ICMS/IAS program condition)



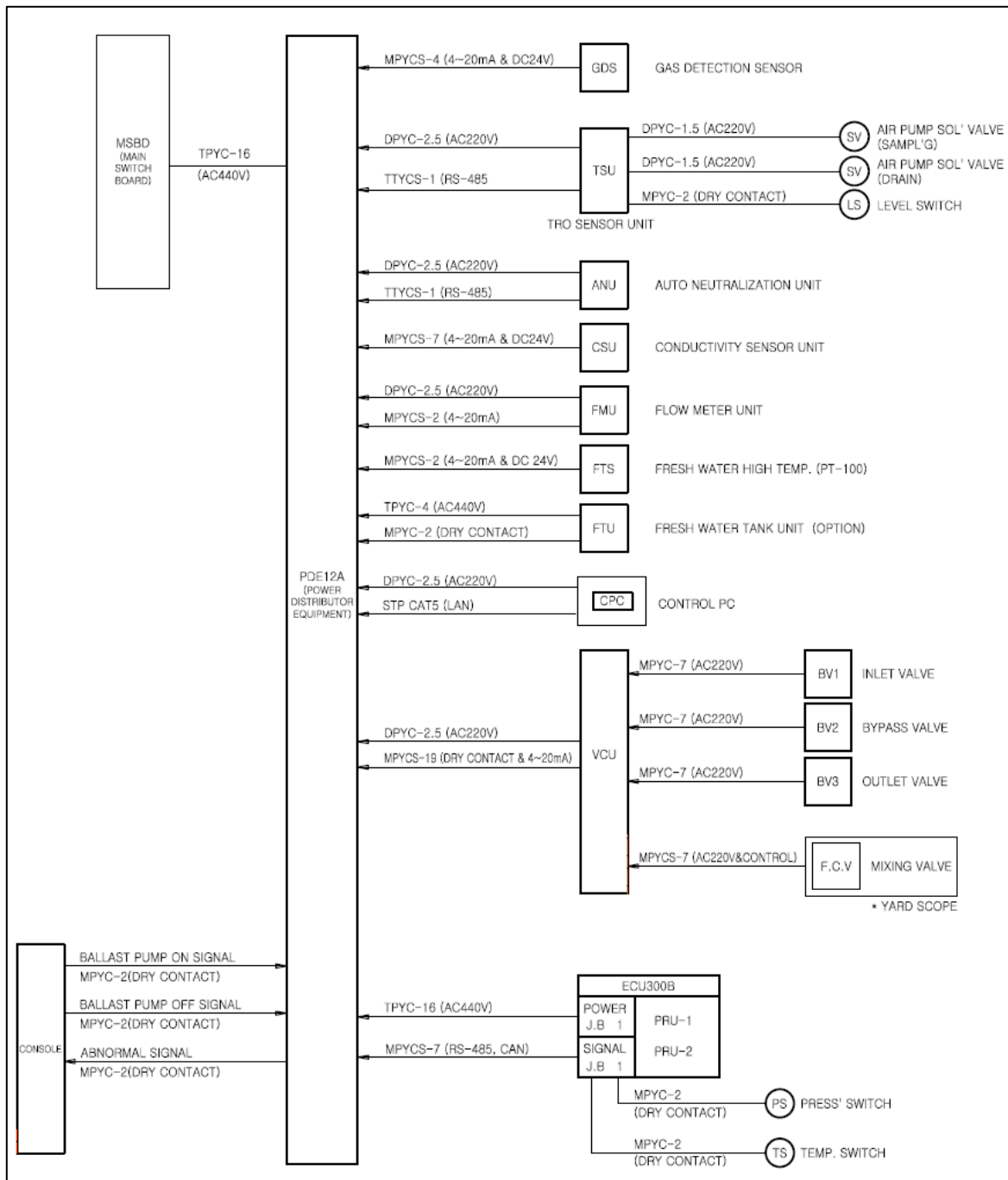
2) ICMS/IAS grade system application with RS-485 communication (When Valve Remote Control System is available)

- ICMS (Integrated Control and Monitoring System) and IAS (Integrated Automation System) have function that can judge the operation mode by programming itself. So ECS send the common trip (fail) signal to ship's control system by RS-485 communication as shown below.



3) Application when the Valve Remote Control System is not available.

- The ships which have does not have VRCS (e.g. Manual control of Valves)



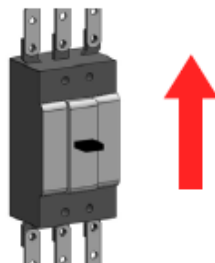
## 5.2 Preparation for operation

### 5.2.1 Preparation for Power up

Component	What to do
MSBD/PDE	Turn on MCCB.
CPC	Turn on the power.
TSU	Check remaining quantity and expiration date of CLX reagents.
ANU	Check whether ANU Fresh Water Tank contains a sufficient amount of neutralization solution. If “tank full” message is on, put sodium thiosulfate. Open Inlet valve of freshwater and Outlet valve of neutralizing agent.
HEU/FTU	Check whether water level of FTU Tank is normal. If water is not sufficient, replenish the tank manually with clean water. Open inlet / outlet valves of freshwater of both FTU and HEU.

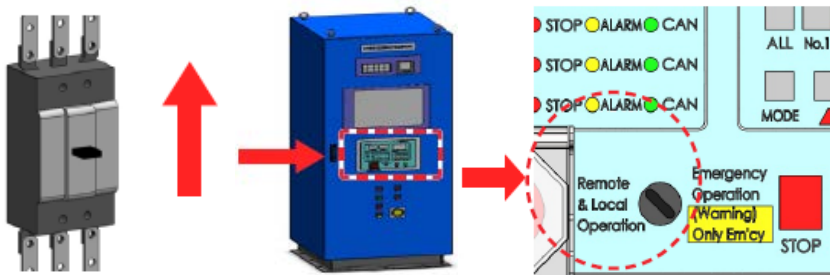
#### 5.2.1.1 MSBD

1. Turn on **BWMS MAIN MCCB** in MSBD.



#### 5.2.1.2 PDE

1. Open the door of PDE and **Turn on the MAIN MCCB**.
2. On the front door of PDE, **flip** the switch to “Remote Mode”.



3. **Turn on** OPERATION switch of the PDE to set HMI of CPC to Remote.

Remote (Default): HMI controlled by CCR / Local: HMI controlled by PDE.

3 -1 When OPERATION switch is located inside PDE:

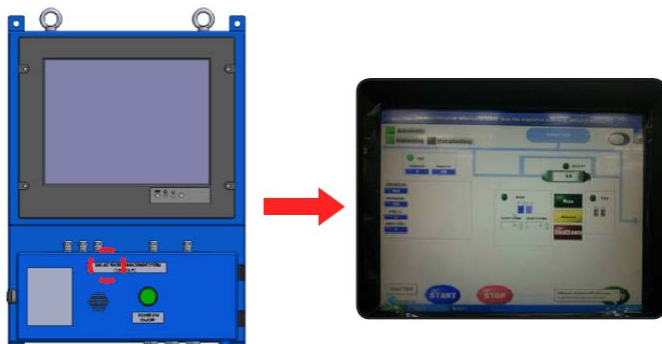


3 -2 When OPERATION switch is located on the PDE front door:



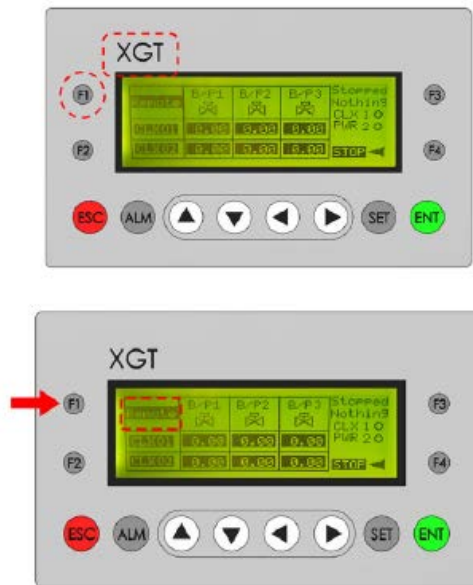
### 5.2.1.3 CPC

1. Press the **Power** button.
2. The computer will boot up and HMI will operate automatically



### 5.2.1.4 TSU

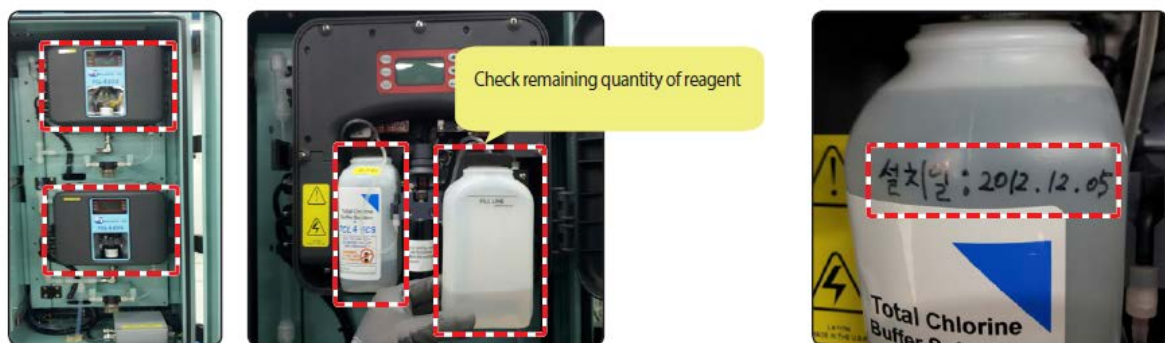
1. Check **XGT** on the front door of **TSU**.
2. Press "**F1**" if it is in "**Emergency Mode**"; then, make sure that "Remote Mode" is set.



3. Inside TSU, **open** the door of **TRO Sensor #1** and **#2**.

**Check** replacement cycle and remaining quantity of TRO Sensor before using it.

**Replace** it with new one if it is expired or remaining quantity of reagents is lower than 20%.

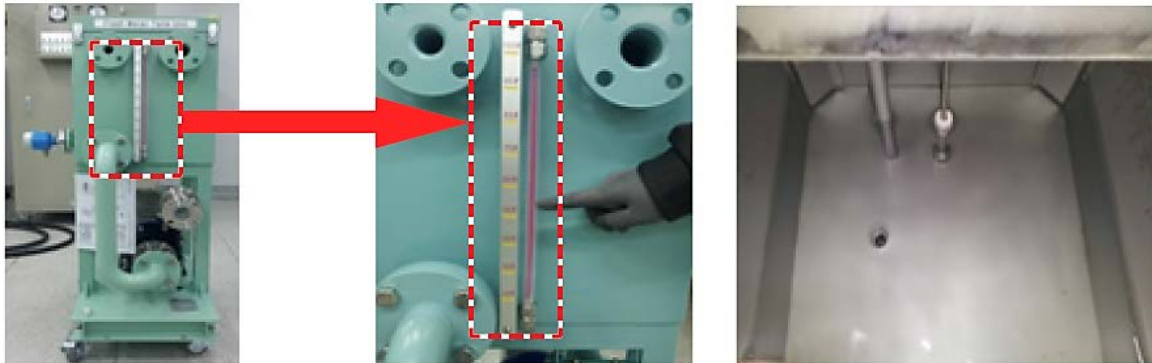


### 5.2.1.5 ANU

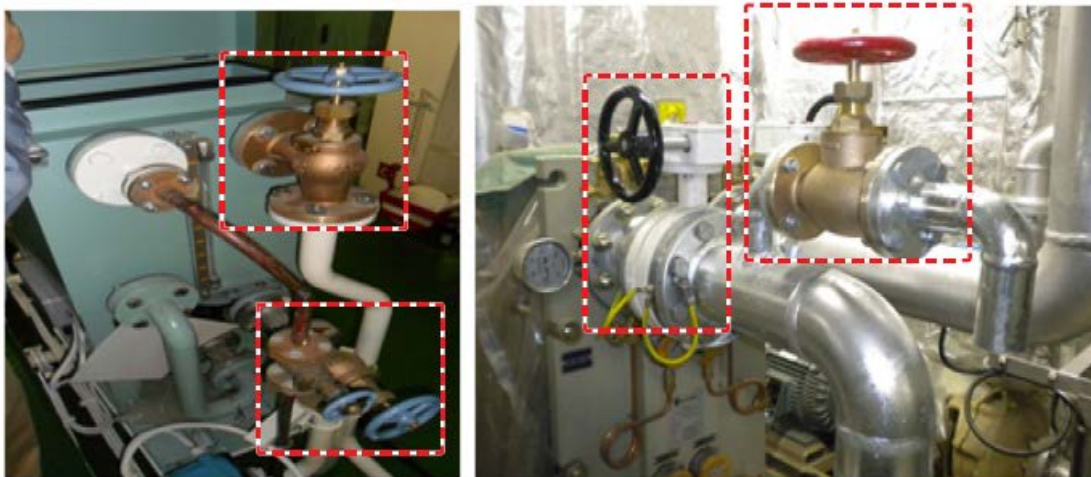
1. Refer to Ch. 6.8.2 Replacement of Sodium Thiosulfate

### 5.2.1.6 HEU/FTU

1. Fill cooling water more than medium level of FTU

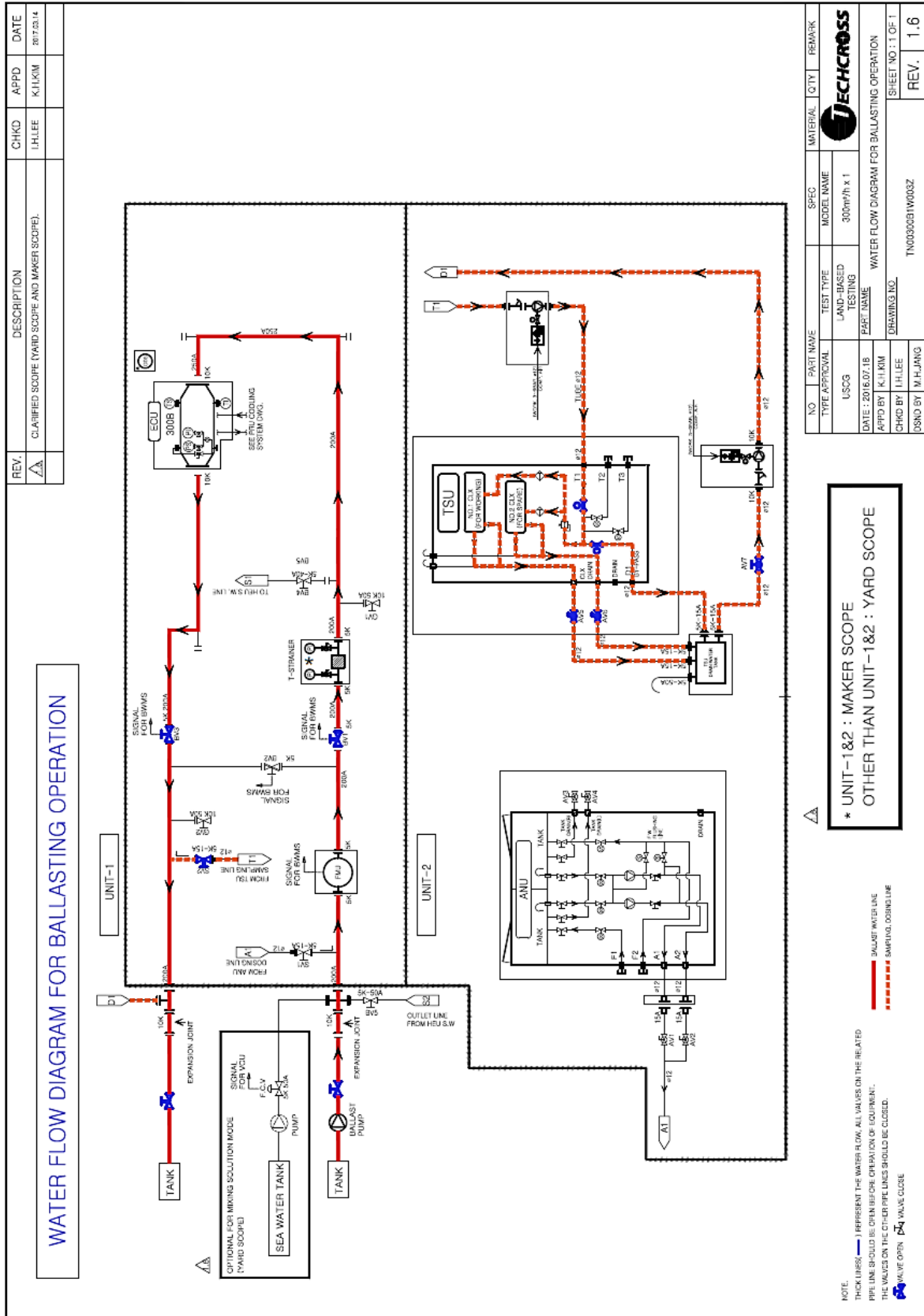


2. Open FTU Inlet and Outlet valve of freshwater.
3. Open HEU Inlet and Outlet valve of freshwater.



4. Refill cooling water more than medium level of FTU after "2" and "3"

5.2.2 Ballasting Operation Flows

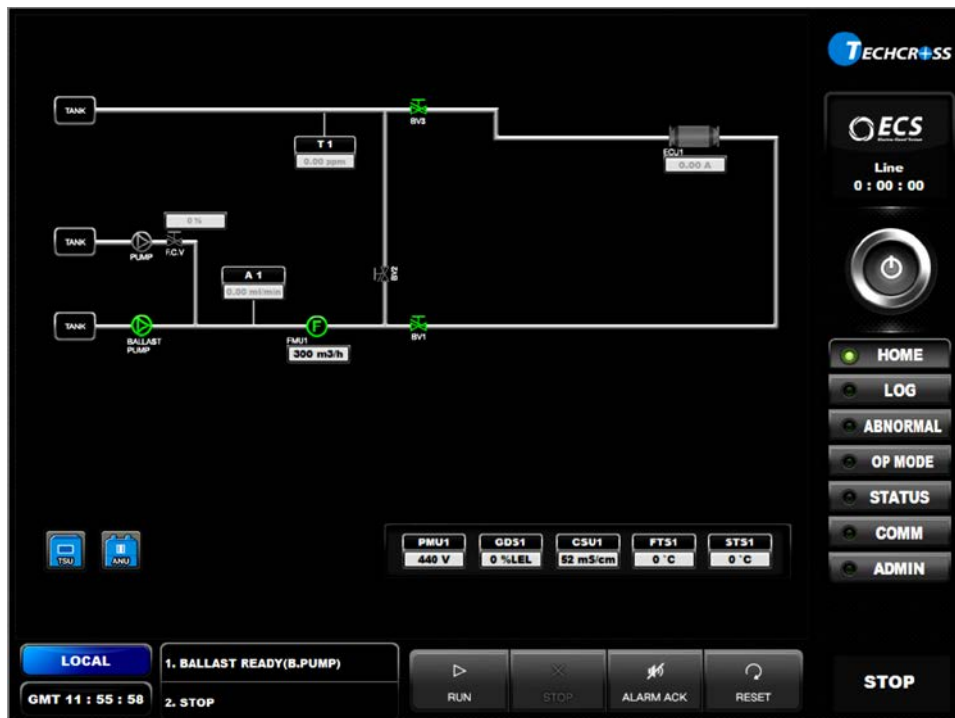


## Preparation for Ballasting Operation

\* **CAUTION!!** Make sure that all the valves on pipelines for ballasting are open.

1. **Open "Inlet Valve"** and **"Outlet Valve"**
2. **Open** Manual Valves.
3. **Close** drain valve(s) connected to **ECU**.
4. **Open** Inlet and **Outlet** valves of the cooling water.
5. **Close "Bypass Valve(s)"**
6. **Open** Manual Valve of **TSU Sampling port**.
8. **Start** LT Cooling Pump for Cooling Water.
9. **Operate** ballast pump.
10. Check **Ship's Signal** by following the procedure below.

Step 1: **Click "OP MODE"** on **HMI MAIN** screen.



Step 2: Click "BALLAST" in "SELECT OPERATION MODE".



Conditions for ballasting operation in the picture

HMI operating requirements will be displayed in Required Signal.

Step 3: Ship's Valve and Pump Signal will be displayed in Ship's Signal.

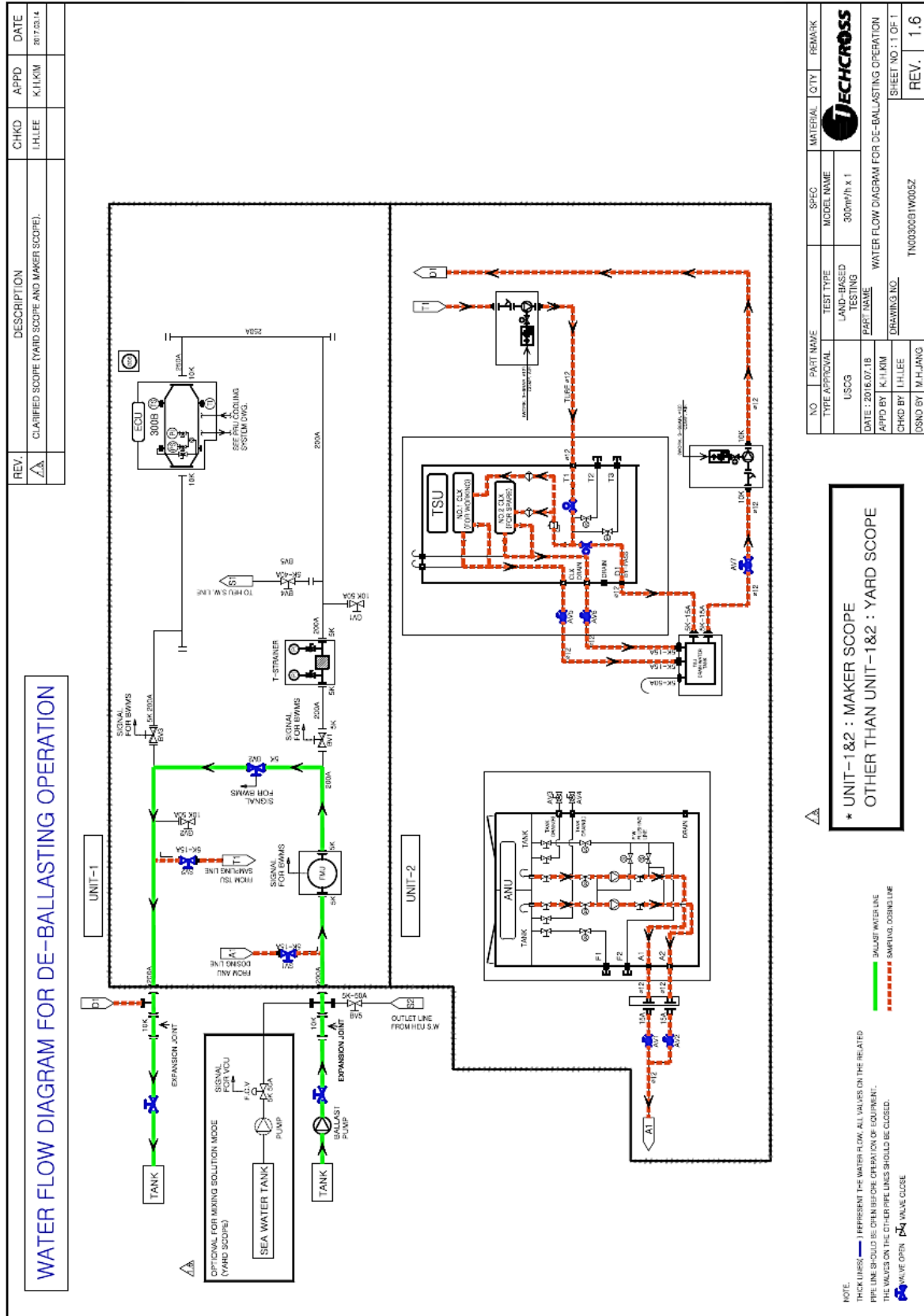
**Match** Ship's Signal (ship's conditions) with Required Signal.

If these two requirements match, Ballast in Current Status will be selected automatically.

("Ballasting Operation")

If "Ballasting Operation" is not selected, **match** the ship's conditions with operating requirements.

5.2.3 Deballasting Operation Flows

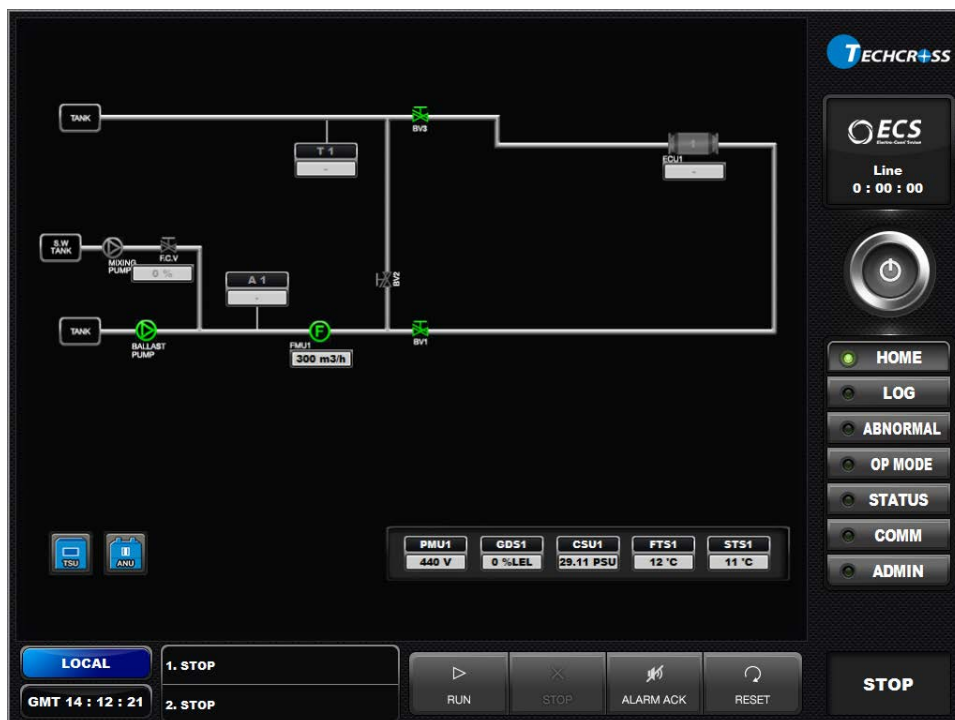


## Preparation for Deballasting Operation

\* **CAUTION!!** Make sure that all the valves on pipelines for deballasting are open.

1. Open "Bypass Valve(s)"
2. Close "Inlet Valve" and "Outlet Valve"
3. Open Manual Valve of ANU Dozing Port.
4. Open Manual Valve of TSU Sampling Port.
5. After ECS Starts, Operate the ballast Pump.
6. Check Ship's Signal by following the procedure below.

Step 1: Click "OP MODE" on HMI MAIN screen.



Step 2: Click "BALLAST" in "SELECT OPERATION MODE".



Conditions for deballasting operation in the picture.

HMI operating requirements will be displayed in Required Signal.

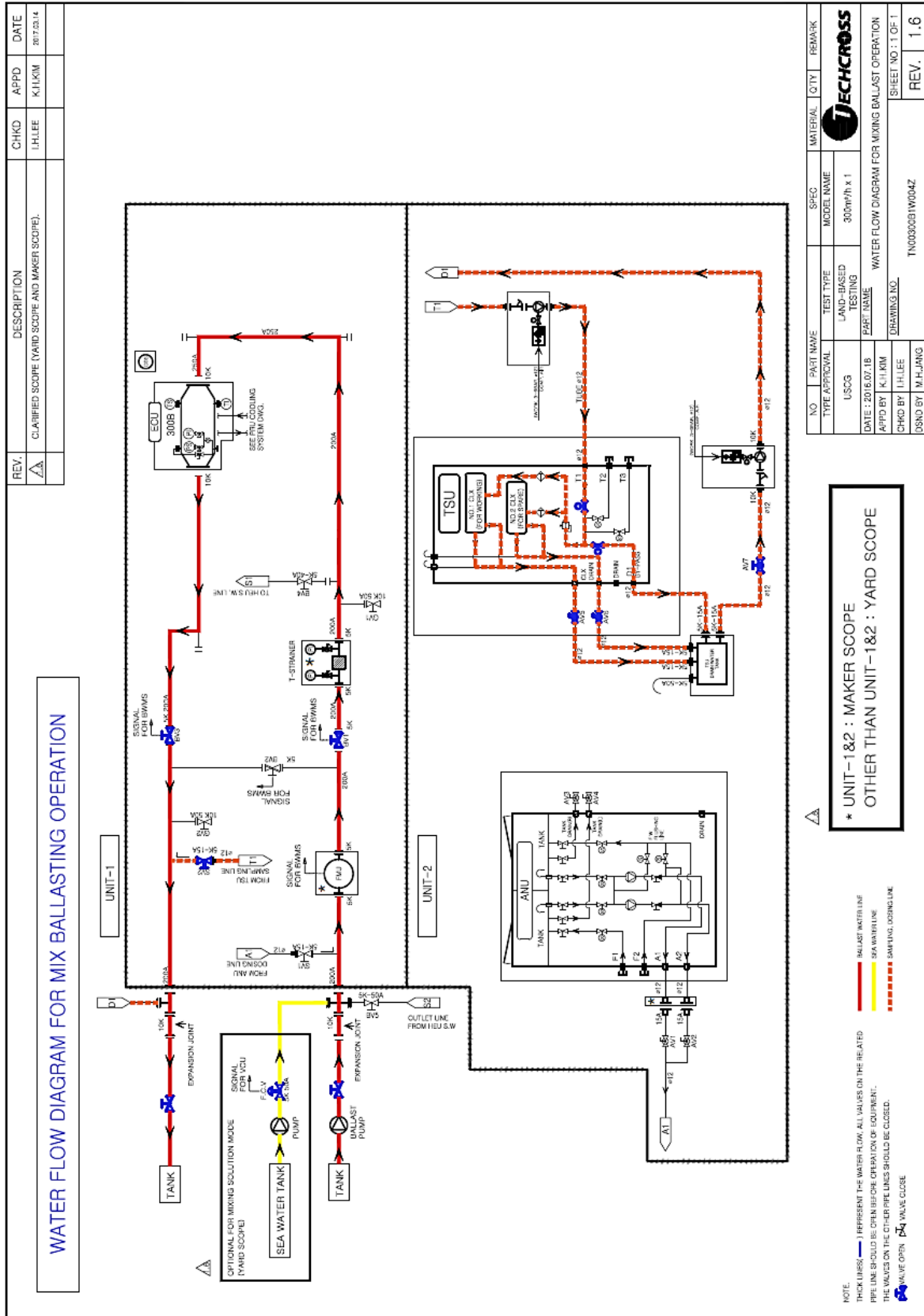
Step 3: Ship's Valve and Pump signal of ship will be displayed in Ship's Signal.

**Match** Ship's Signal (ship's conditions) with Required Signal.

If these two requirements match, **Deballast in Current Status** will be selected automatically. ("Deballasting Operation")

If "Deballasting operation" is not selected, match the **ship's conditions** with **operating requirements**.

5.2.4 Mixing Ballasting Operation(Optional) Flows



## Preparation for Mixing Ballasting Operation(Optional)

\* If an alarm(Low salinity) occurs in freshwater zone, please operate according to the below procedure.

※ Fill sea water(4~5% of total ballast volume) into Sea Water Holding Tank(APT or WBT) before sailing the fresh water zone. The amount of sea water for mixing ballasting operation is subject to be changed depending on the salinity of the area where the sea water is pumped in to sea water holding tank.

Salinity of Marine Water (PSU)	Ratio between Fresh water and Marine water	
	Fresh water <sup>1)</sup> (%)	Marine Water (%)
30	95.00	5.00
31	95.16	4.84
32	95.31	4.69
33	95.45	4.55
34	95.59	4.41
35	95.71	4.29
36	95.83	4.17
37	95.95	4.05

1) Salinity of fresh water: 0PSU

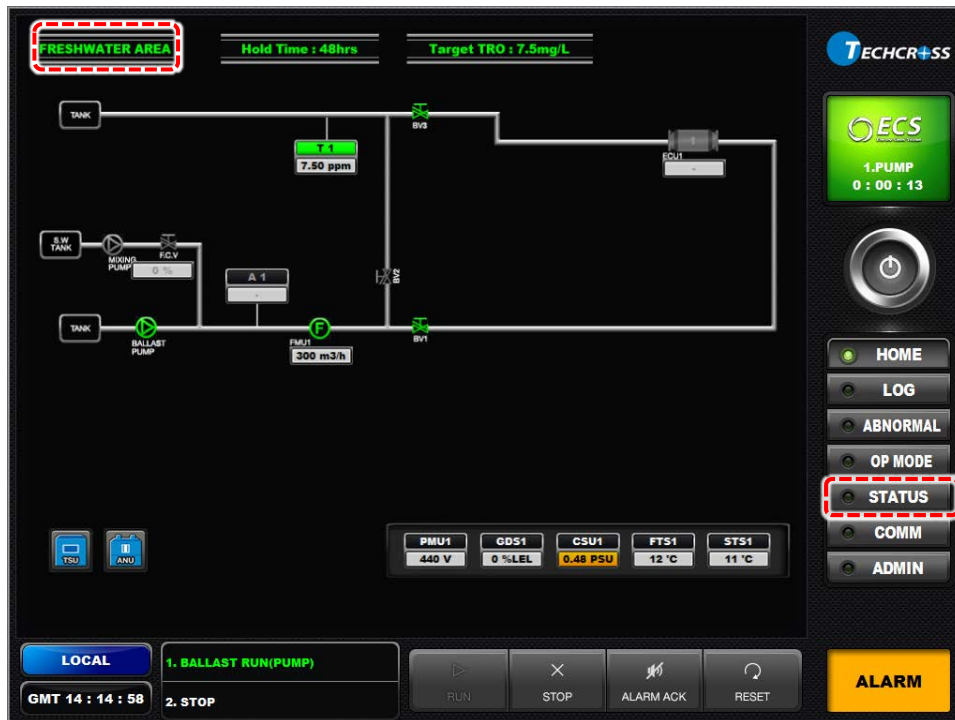
- ※ Open the valve installed before Sea Water Holding Tank (APT or WBT) to be use.
- ※ Check the status of related pumps and valves
- ※ Automatic Flow Control Valve function throttling flow rate based on the measured Salinity of mixed water(1.5 ~ 2PSU). Check "Measured value of CSU" on HMI screen.

1. Open "Inlet Valve" and "Outlet Valve"
2. Open Manual Valves.
3. Close drain valve(s) connected to ECU.
4. Open Inlet and Outlet valves of the cooling water.
5. Close "Bypass Valve(s)"
6. Open Manual Valve of TSU Sampling port.
7. Start LT Cooling Pump for Cooling Water.
8. Operate ballast pump and mixing pump.

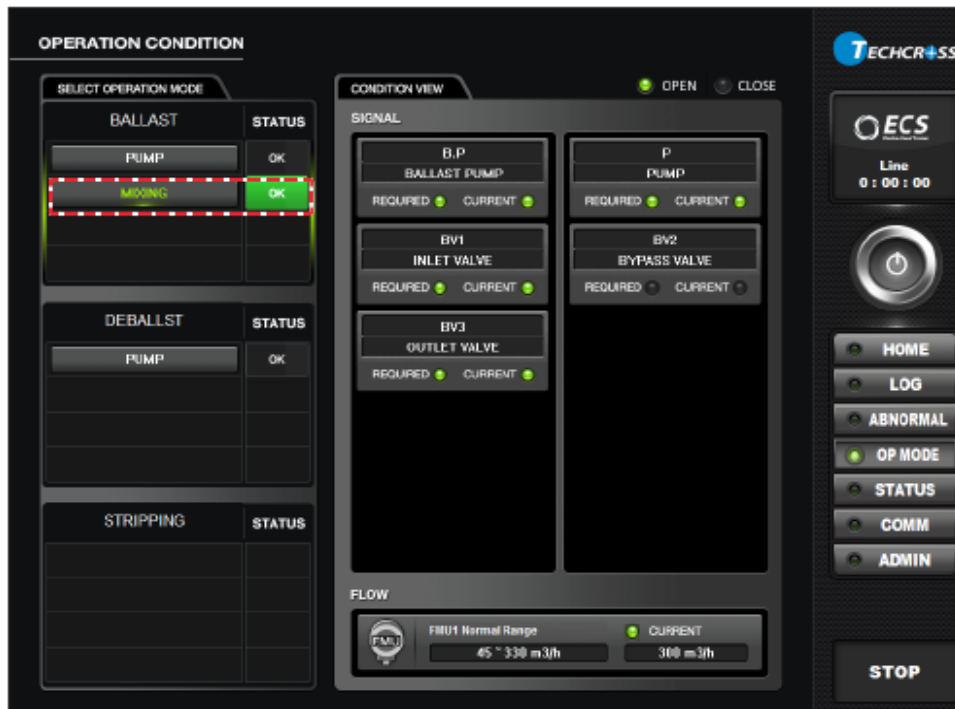
**The valve after the ballast pump should be adjusted so that the flow can be controlled 70% of treatment rated capacity(TRC).**

9. Check Ship's Signal by following the procedure below.

Step 1: Click "OP MODE" on HMI MAIN screen.



Step 2: Click "BALLAST" in "SELECT OPERATION MODE".



Conditions for mixing ballasting operation in the picture.

HMI operating requirements will be displayed in Required Signal.

Step 3: **Ship's Valve** and **Pump Signal** will be displayed in **Ship's Signal**.

**Match Ship's Signal** (ship's conditions) with **Required Signal**.

If these two requirements match, Ballast in Current Status will be selected automatically.

("Mixing Ballasting Operation")

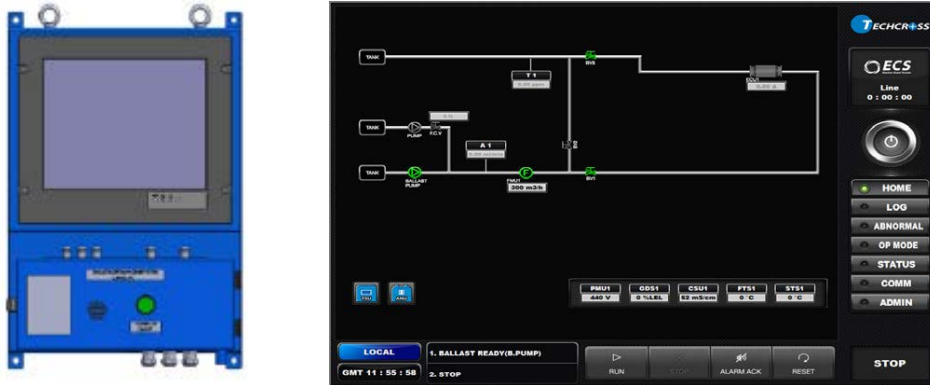
If "Mixing Ballasting Operation" is not selected, **match** the **ship's conditions** with **operating requirements**.

### 5.3 Automatic Operation

#### 5.3.1 Selection of Control position of ECS

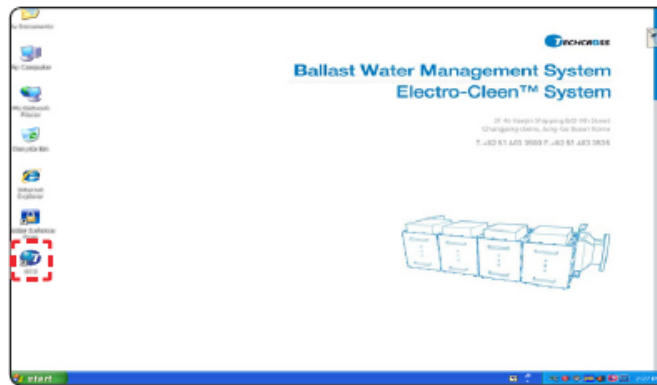
Step 1: REMOTE CPC (CONTROLLER)

HMI is designed to start automatically when the power of REMOTE CPC is ON.



Step 2: LOCAL CPC (VIEWER)

HMI of LOCAL CPC is not designed to start automatically like HMI of REMOTE CPC.



**Click** to start HMI of LOCAL CPC in the front part of PDE.

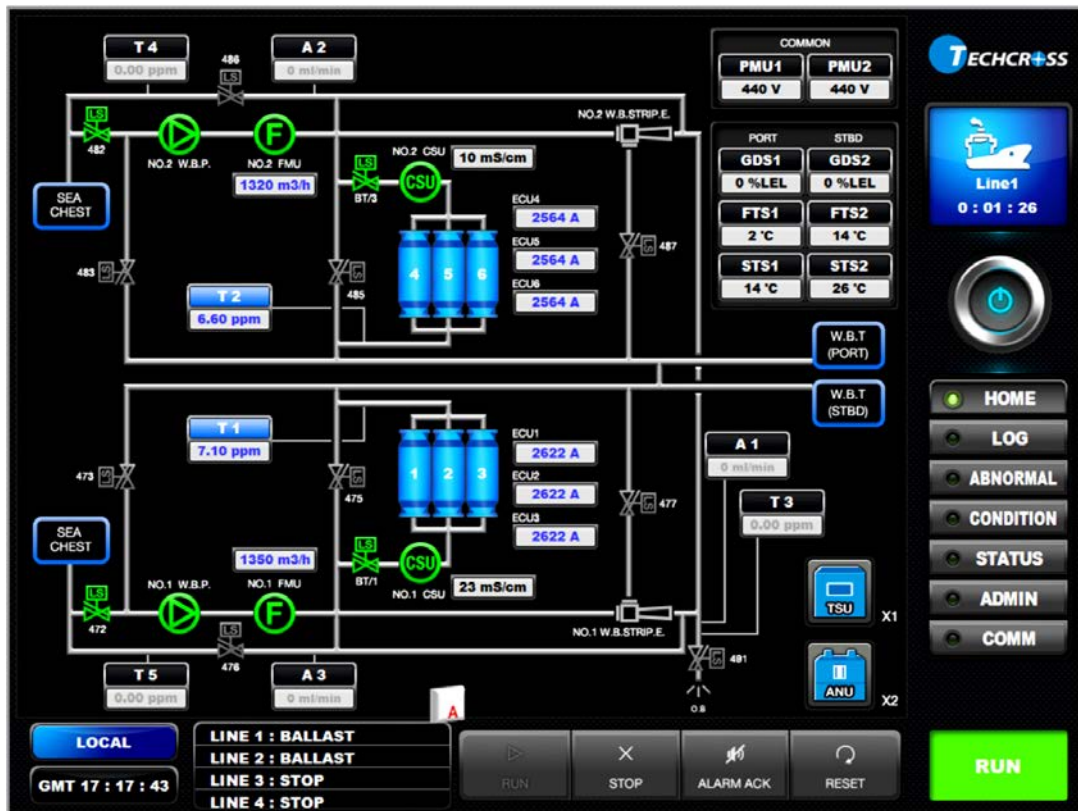


### 5.3.2 HMI Overview

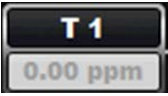
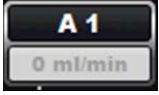


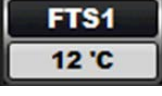








#### 5.3.2.1 Configuration of HMI Screen

HMI(Human Machine Interface) screen displays the overall operation status of ECS. Operation and Abnormal status can be checked in each Ballast/De-Ballast/Mixing Ballast mode. Values of components and sensors are observed respectively on HMI screen as well.

(1) HMI MIMIC (HOME)



\* Above image can be different from actual system.

No.	Name	Icon	Description
1	TRO VALUE		TRO value of each TSU sampling line
2	ANU VALUE		Injected neutralizer
3	PMU		Input voltage of PDE
4	GDS		Concentration of H <sub>2</sub> gas
5	FTS		Fresh(Cooling) water temperature
6	STS		Ballast Sea water temperature
7	FMU		Ballast water flow rate in the pipe
8	CSU		Conductivity of sea water
9	ECU		Current value supplied to each EM/ECU operation state
10	PUMP		Operation state of the PUMP
11	VALVE		Valve status (Open / Close)
12	TSU		Operation state of TSU
13	ANU		Operation state of ANU

## (2) Menu(Side bar)

The menu bar is found on right side of the screen.



No.	Name	Icon
A	Operation Time	Operation time of each line
B	Power Button	Click it to control HMI ON/OFF
C	HOME Button	Click it to return to the Home screen
D	LOG Button	Click it to check the log history
E	ABNORMAL Button	Click it to check the alarm/trip status
F	CONDITION Button	Click it to check the operation conditions
G	STATUS Button	Click it to check the analog/digital signal
H	COMM Button	Click it to check the communication conditions between each equipment
I	ADMIN Button	Click it to set and check the enable/disable status

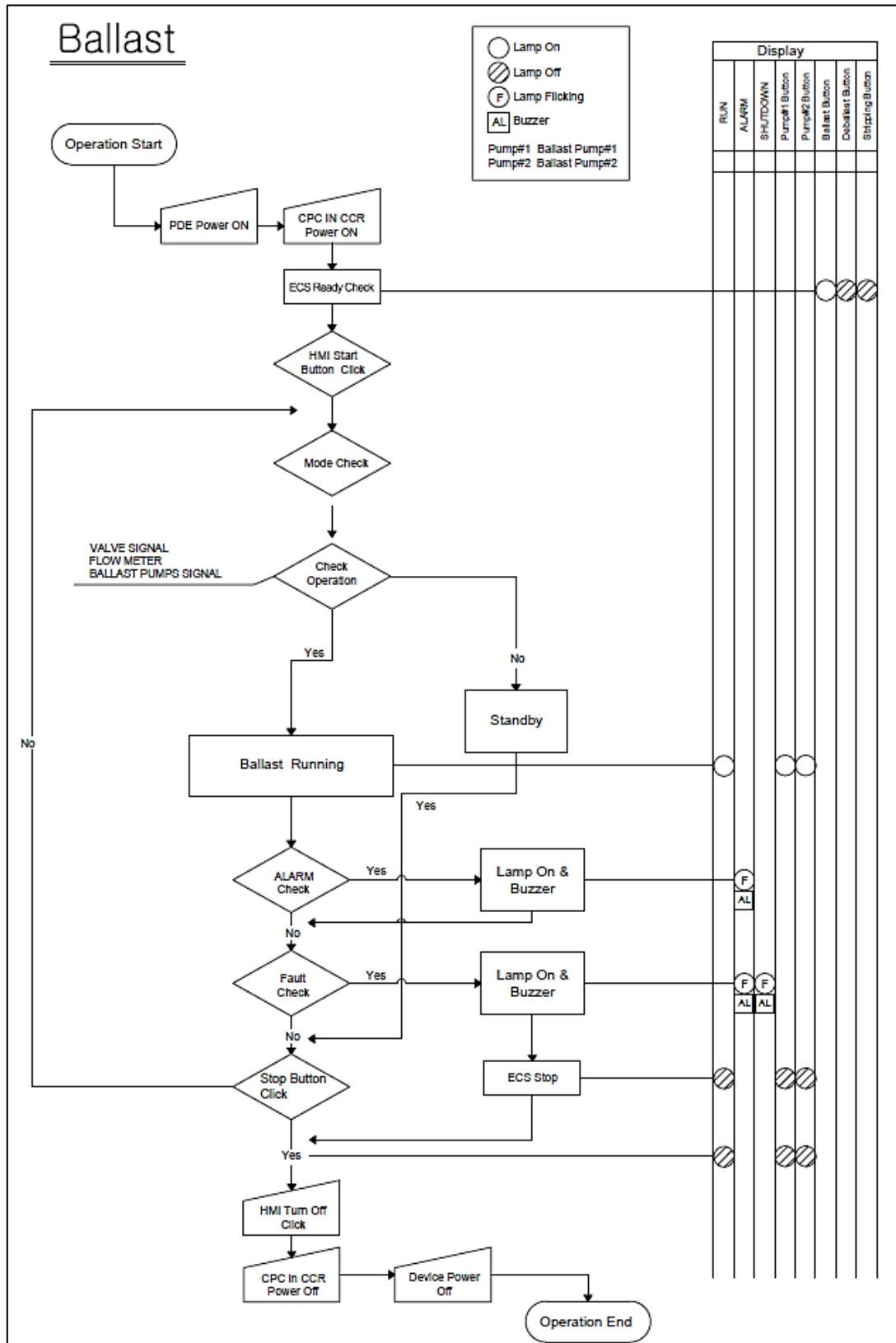
(3) Operation menu (Bottom side)



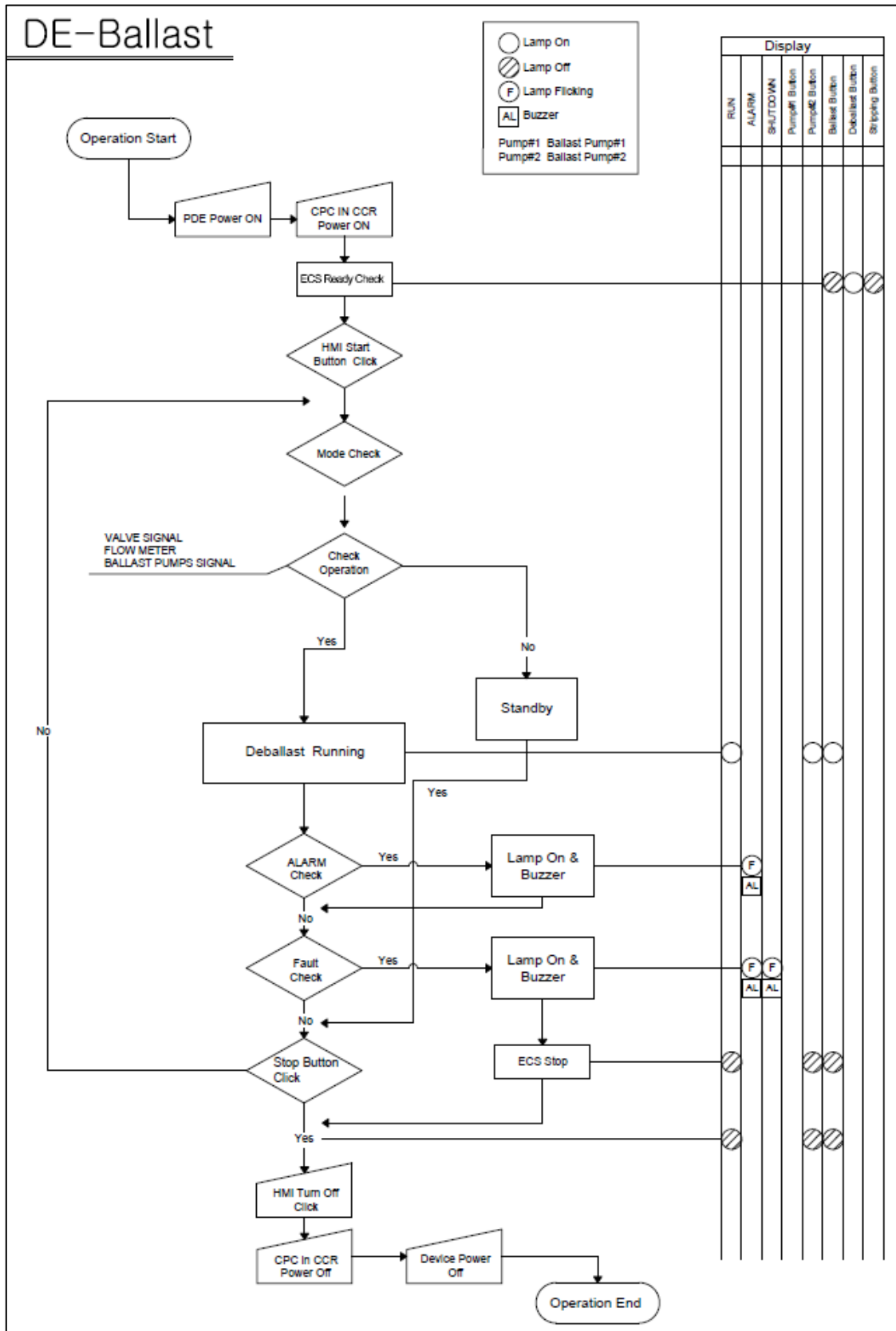
No.	Name	Icon
A	REMOTE/LOCAL	HMI LOCAL / REMOTE Selection (Check the possibility of control)
B	TIME	Greenwich Mean Time (GMT)
C	LINE OPERATION	Operation status of each line (Ballast / Deballast / Stop)
D	RUN Button	Run ECS Operation
E	STOP Button	Stop ECS Operation
F	ALARM ACK Button	Stop Alarm (Buzzer)
G	RESET Button	Abnormal Reset
H	OPERATION STATUS	Run / Stop / Alarm / Trip

### 5.3.3 Operation Flow Chart

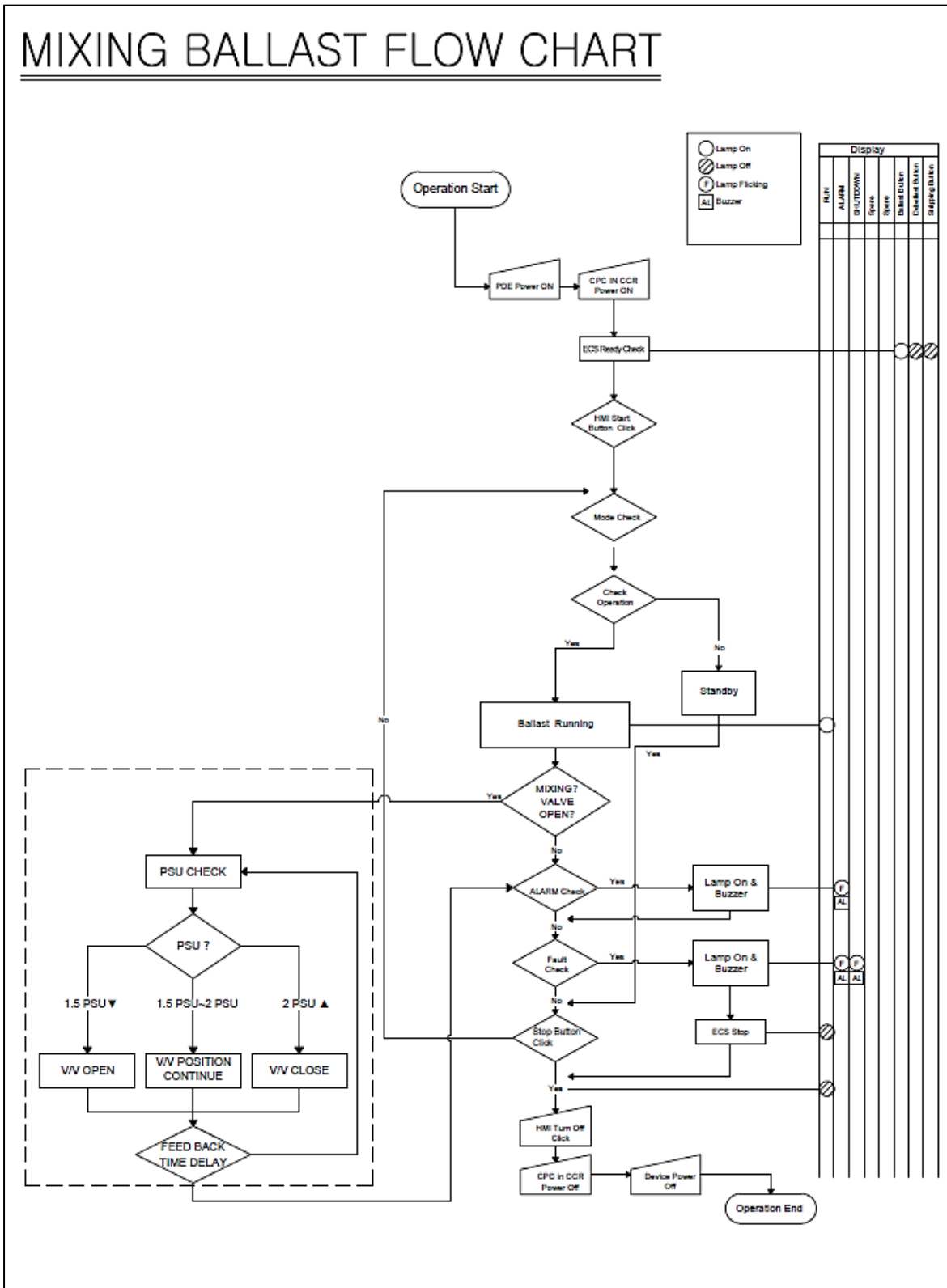
#### 5.3.3.1 Ballasting Operation Flow Chart



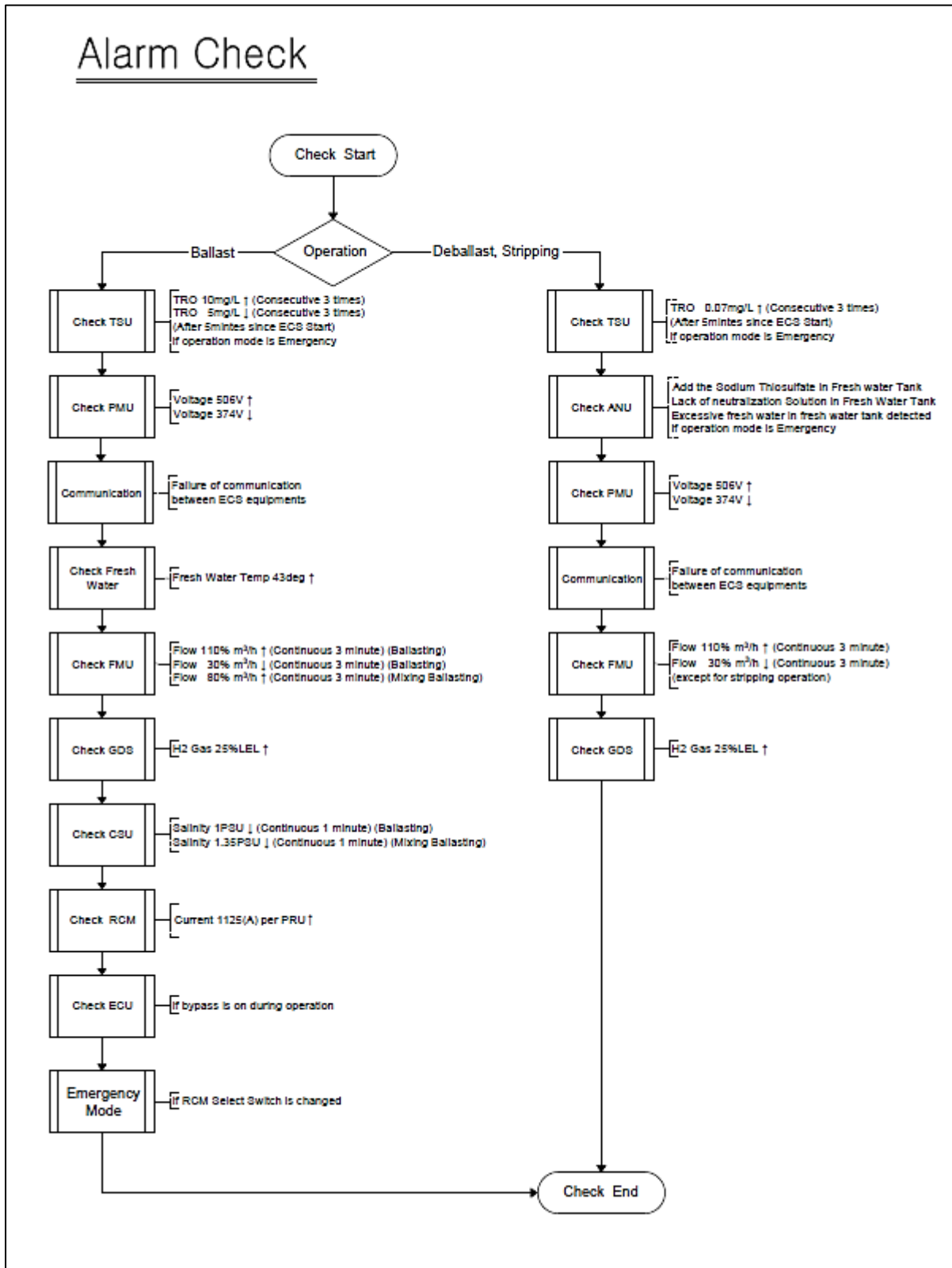
5.3.3.2 Deballasting Operation Flow Chart



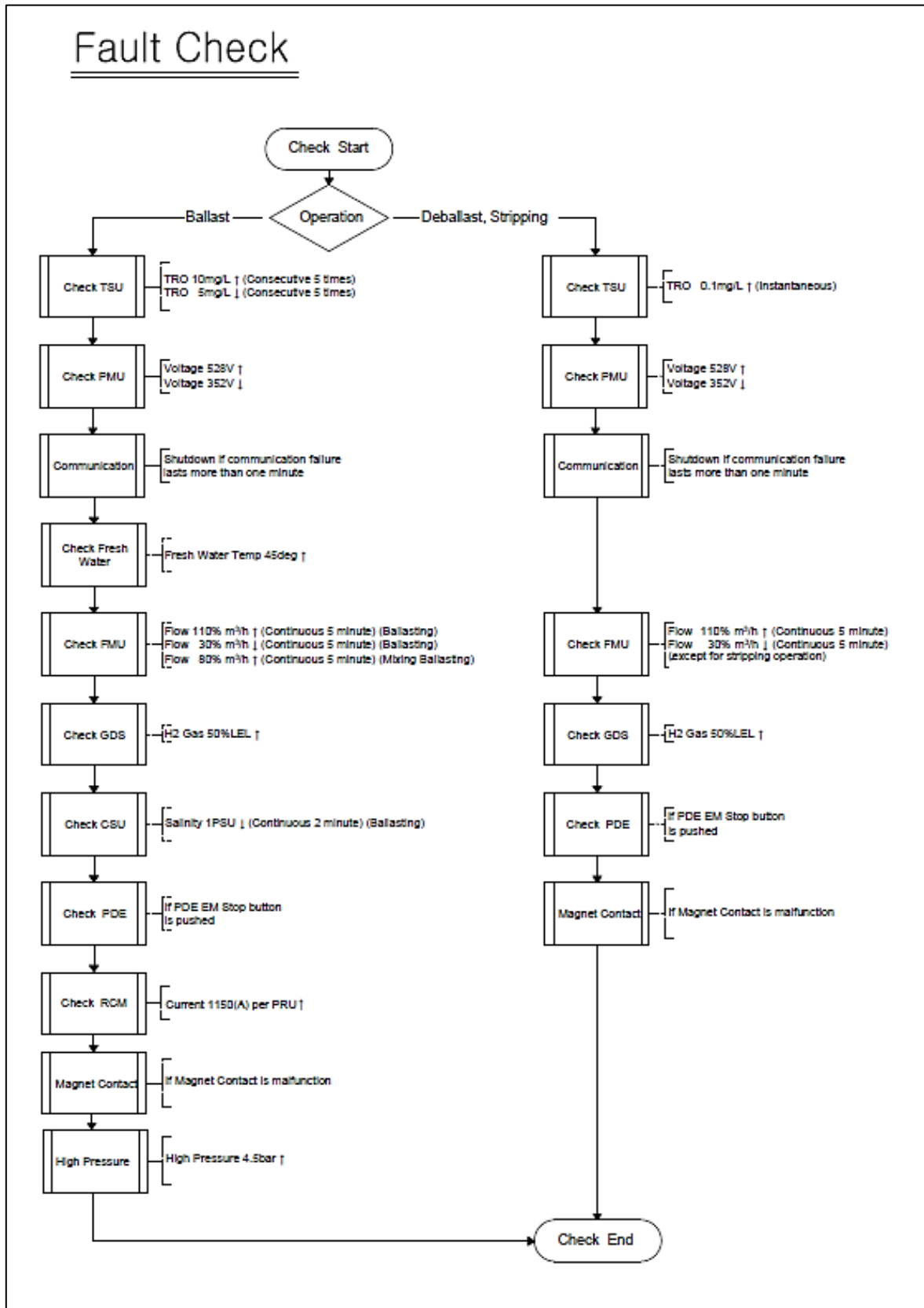
5.3.3.3 Mixing Ballast Operation Flow Chart



5.3.3.4 Alarm Check Flow Chart



5.3.3.5 Fault Check Flow Chart



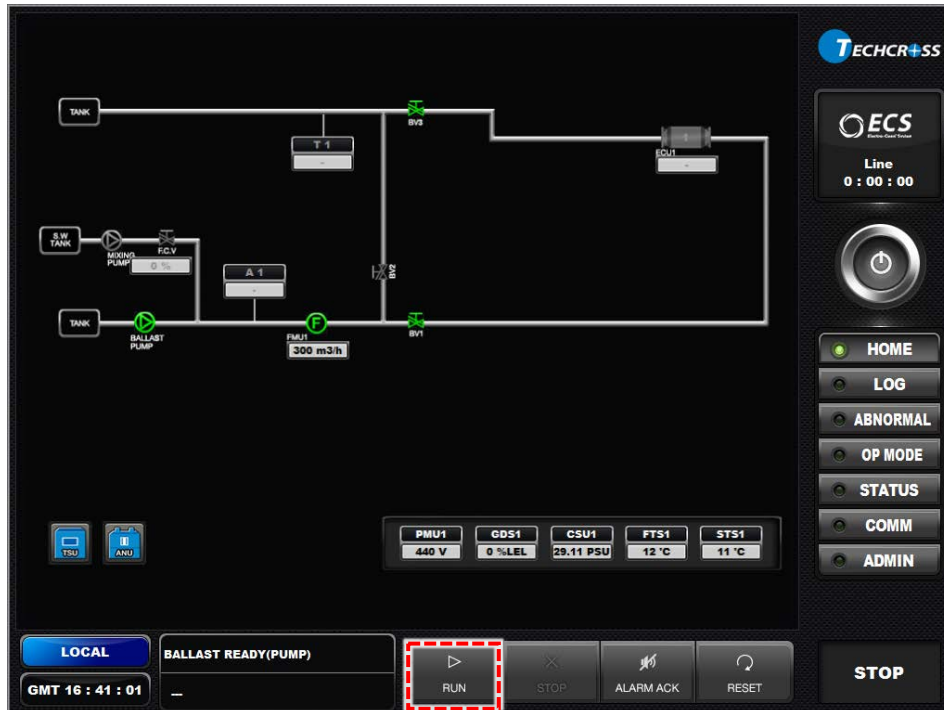
### 5.3.4 Ballasting Operation

Step 1: **Select** appropriate operation mode after checking related pumps and valves.

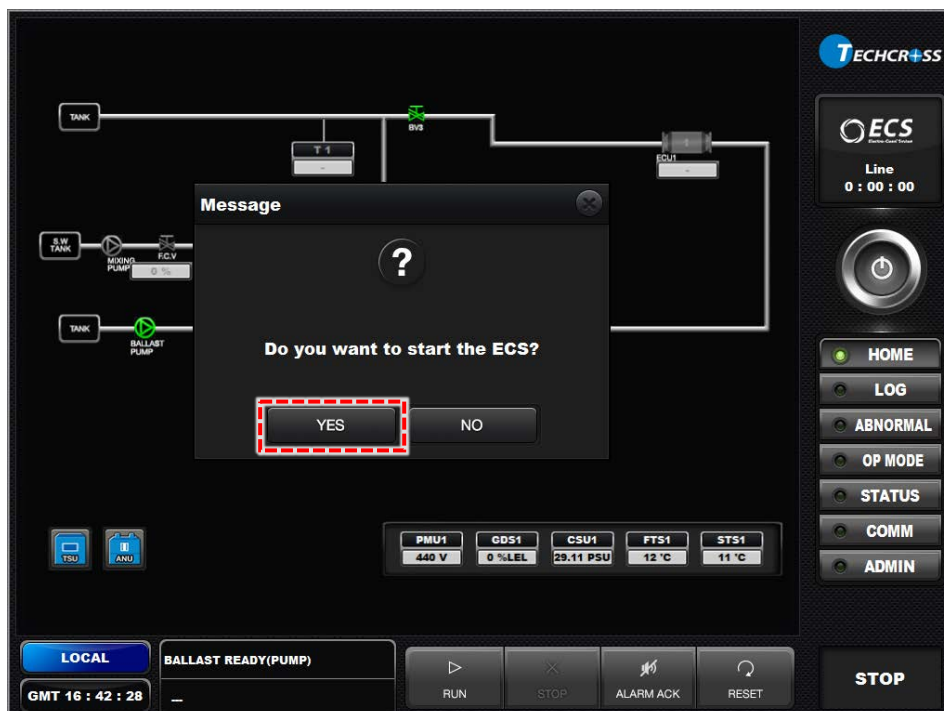
(Please refer to “[Preparation for Ballast Operation](#)”.)

**Check** mode display to see if all the ballasting operation requirements are fulfilled.

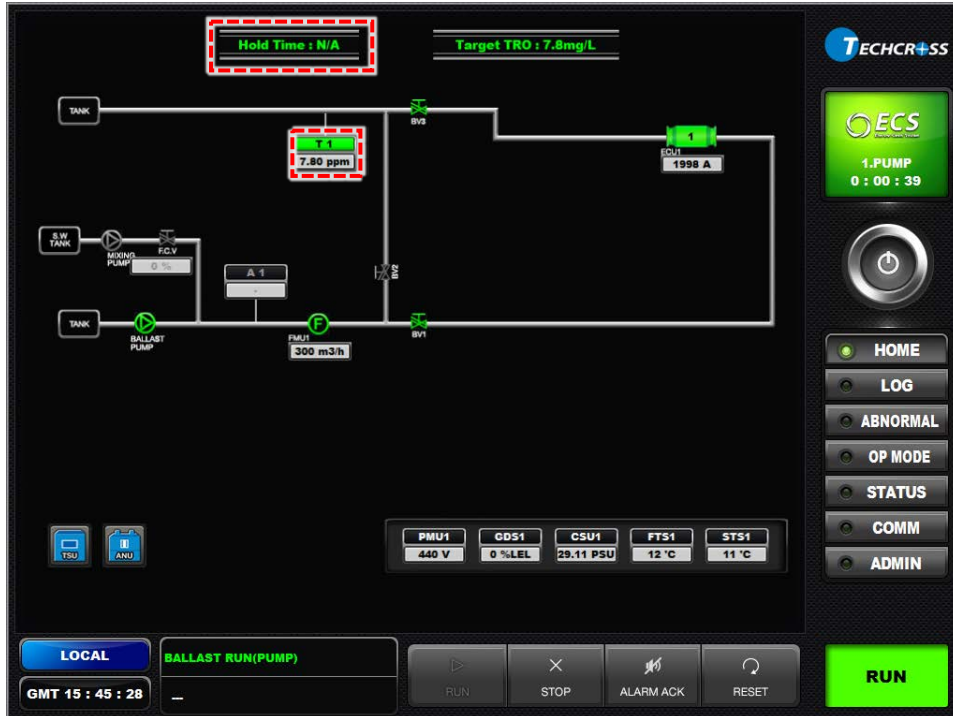
Click “**RUN**” button on HMI Screen to start ECS.



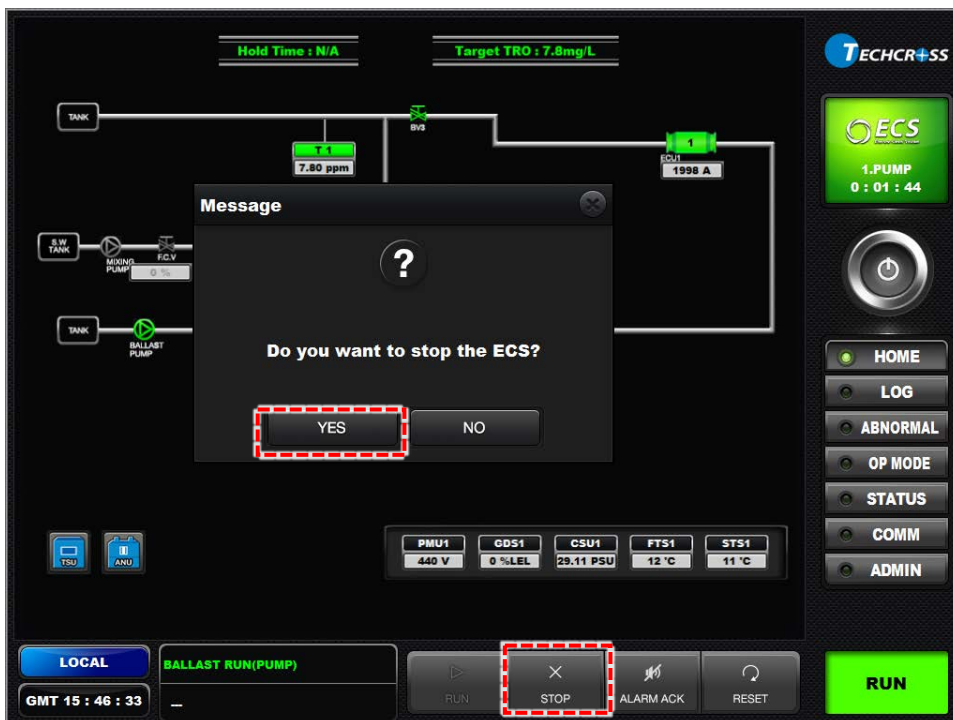
Step 2: **Ensure that** message says, “Do you want to start the ECS?” Click “**YES**” button.



Step 3: **Check** the notice of **Hold Time** according to salinity measured through the CSU.  
**Ensure** that **ECU value** and **TRO value** are displayed in 5 minutes after starting ECS.  
 (Alarm or Shutdown should not occur during normal operation.)



Step 4: **Click** “STOP” and **Ensure** that message says, “Do you want to stop the ECS?”  
**Click** “YES” button. **Stop** ballast pump after stopping ECS operation.



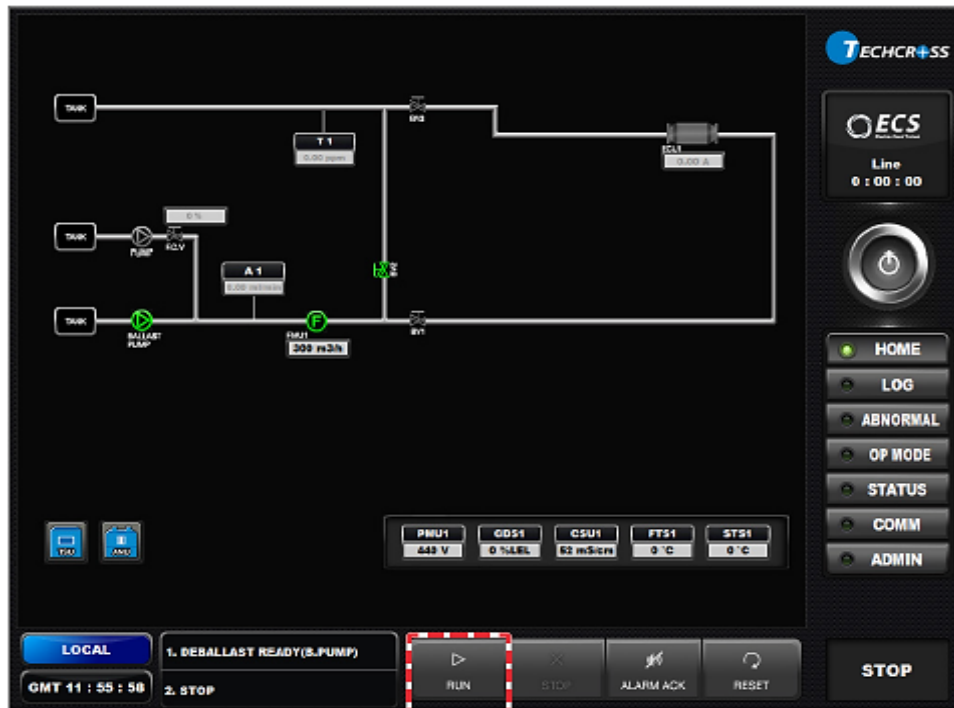
### 5.3.5 Deballasting Operation

Step 1: **Select** appropriate operation mode after checking related pumps and valves.

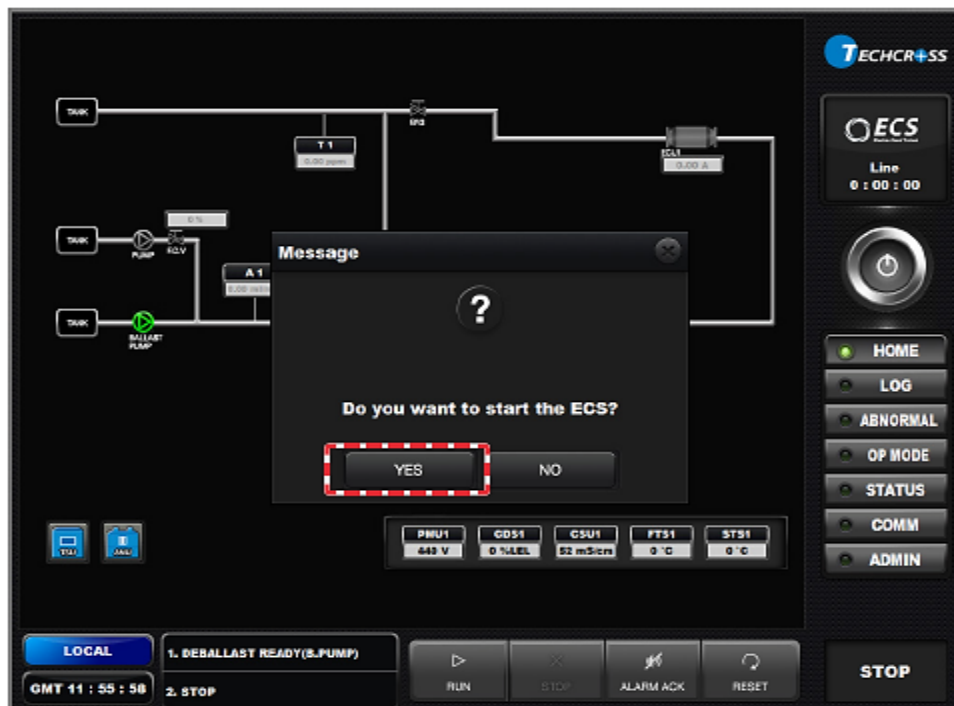
(Please refer to “[Preparation for De-ballast Operation](#)”).

**Check** mode display to see if all the ballasting operation requirements are fulfilled.

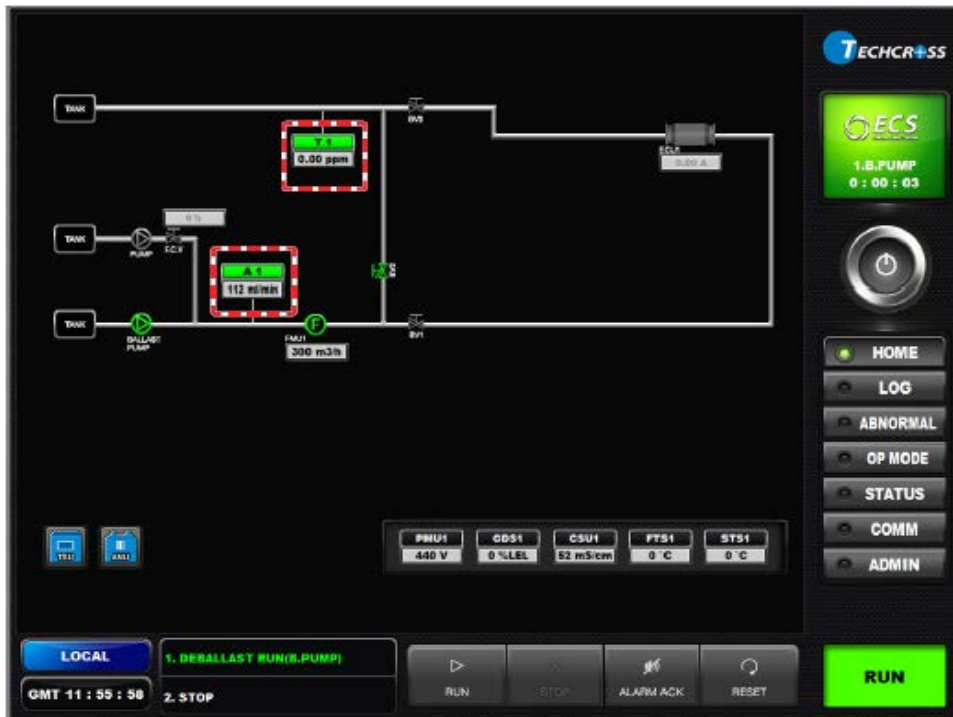
**Click** “**RUN**” button on HMI Screen to start ECS.



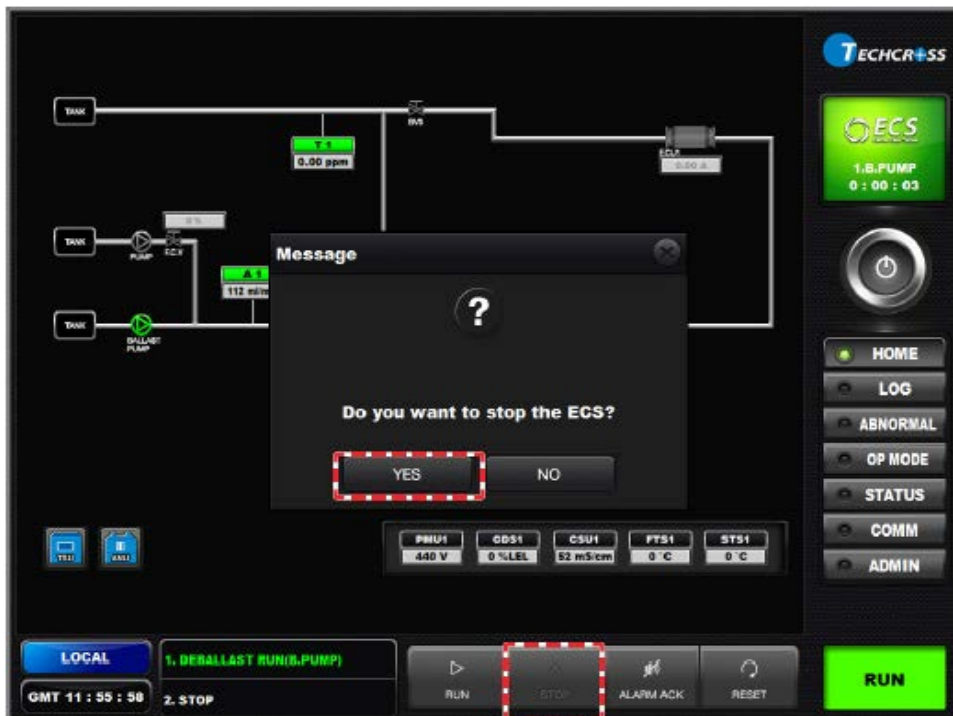
Step 2: **Ensure that** message says, “**Do you want to start the ECS?**” Click “**YES**” button



Step 3: **Ensure** that **ANU value** and **TRO value** are displayed immediately after operating ECS.  
 (Alarm or Shutdown should not occur during normal operation.)



Step 4: **Click “STOP”** and **Ensure** that message says, **“Do you want to stop the ECS?”**  
**Click “YES”** button. **Stop** ballast pump after stopping ECS operation.



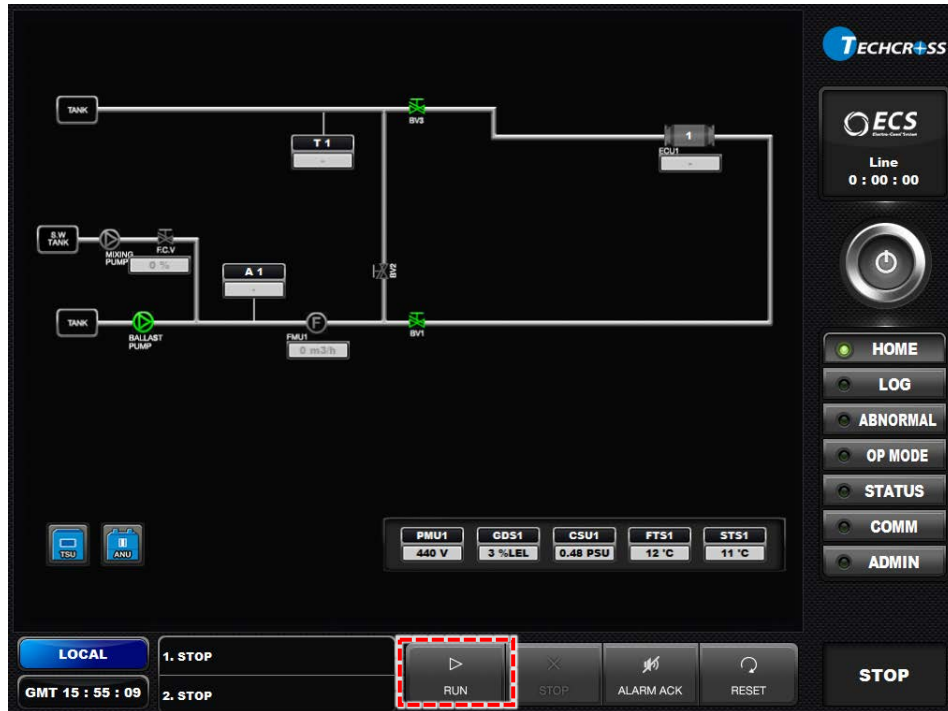
### 5.3.6 Mixing ballasting Operation(Optional)

Step 1: **Select** appropriate operation mode after checking related pumps and valves.

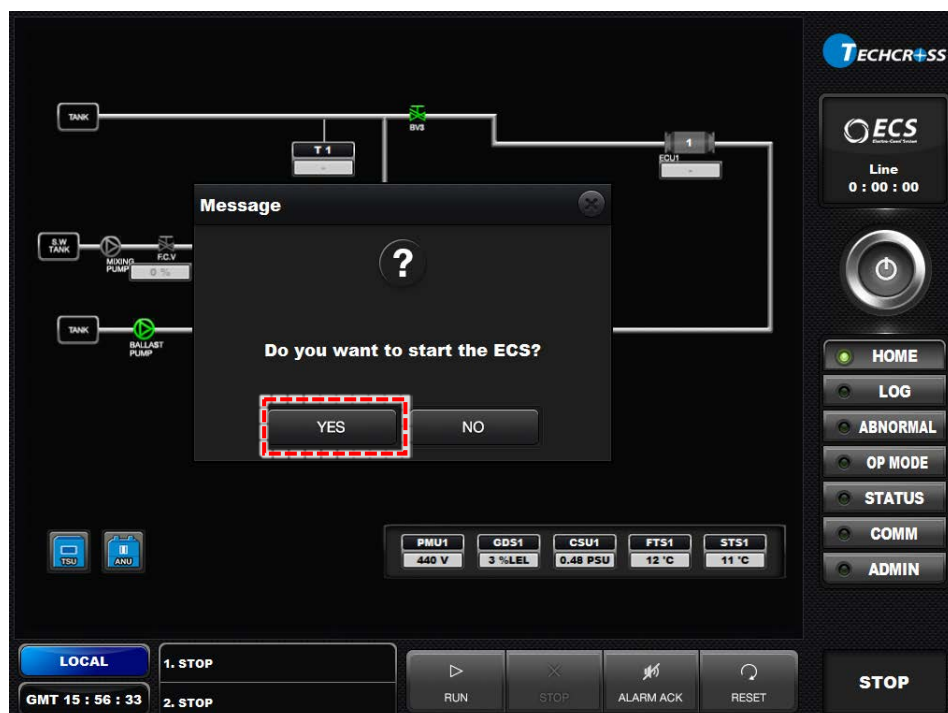
(Please refer to “[Preparation for Mixing Ballast Operation](#)”.)

**Check** mode display to see if all the ballasting operation requirements are fulfilled.

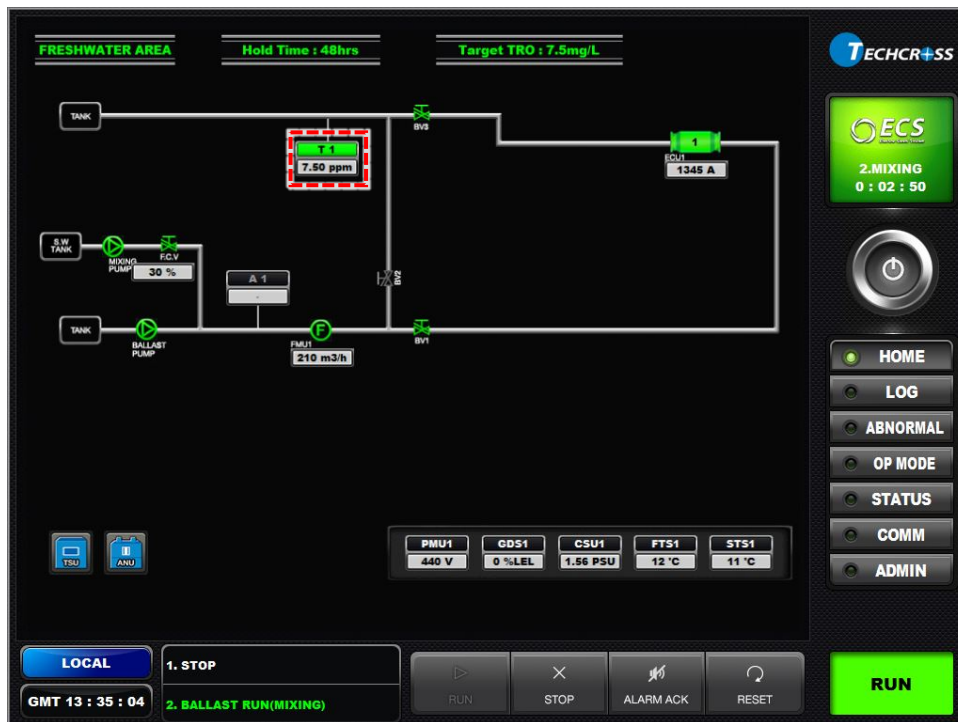
**Click** “**RUN**” button on HMI Screen to start ECS.



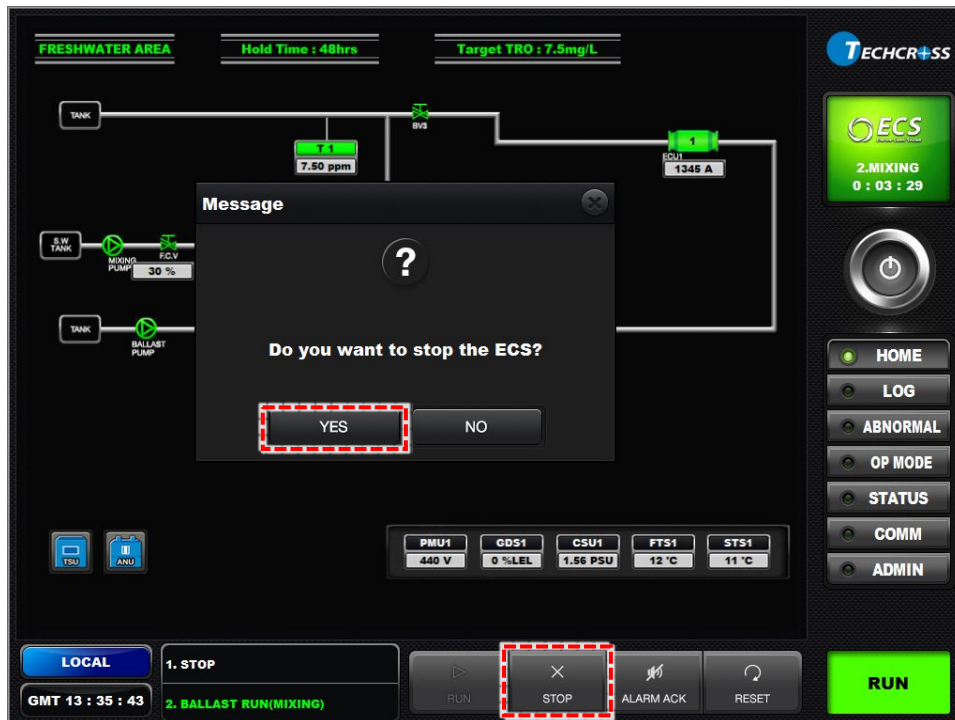
Step 2: **Ensure that** message says, “**Do you want to start the ECS?**” Click “**YES**” button.



Step 3: **Ensure** that **ECU value** and **TRO value** are displayed in 5 minutes after starting ECS.  
 (Alarm or Shutdown should not occur during normal operation.)



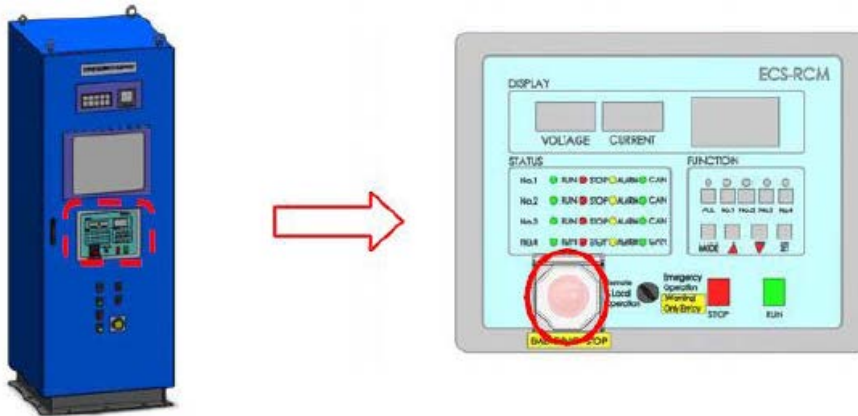
Step 4: **Click “STOP”** and **Ensure** that message says, **“Do you want to stop the ECS?”**  
**Click “YES”** button. **Stop** ballast pump after stopping ECS operation.



## 5.4 Emergency Operation (By-pass)

### 5.4.1 Emergency Situation

If crew judge that the vessel is in danger during BWMS operation, emergency stop can be done by touching stop button of HMI or pressing EM'CY stop button of PDE.



#### ※ Emergency By-pass operation

In case the following situation occurs during BWMS operation, please operate the ballast pump **by-passing BWMS** to ensure the safety of the vessel and the crew's safety.

1) In the event of a major fault in the equipment.

- After checking shutdown for BWMS, please check the troubleshooting and take an adequate action following the troubleshooting in operation manual.

2) In the event of emergency situation on the vessel.

- If crew judge that the vessel is in danger during BWMS operation, emergency stop can be done by pressing EM'CY stop button of PDE.

3) After power loss.

- In case the malfunction of the generators onboard or power supply for BWMS itself, countermeasures are as follows.

① Please replace with the new one.

② if ① is not infeasible, operate ballast system onboard except for BWMS.

In those three(3) cases, please conduct ballast, de-ballast operation only by opening by-pass valve and operating the ballast pump(s).

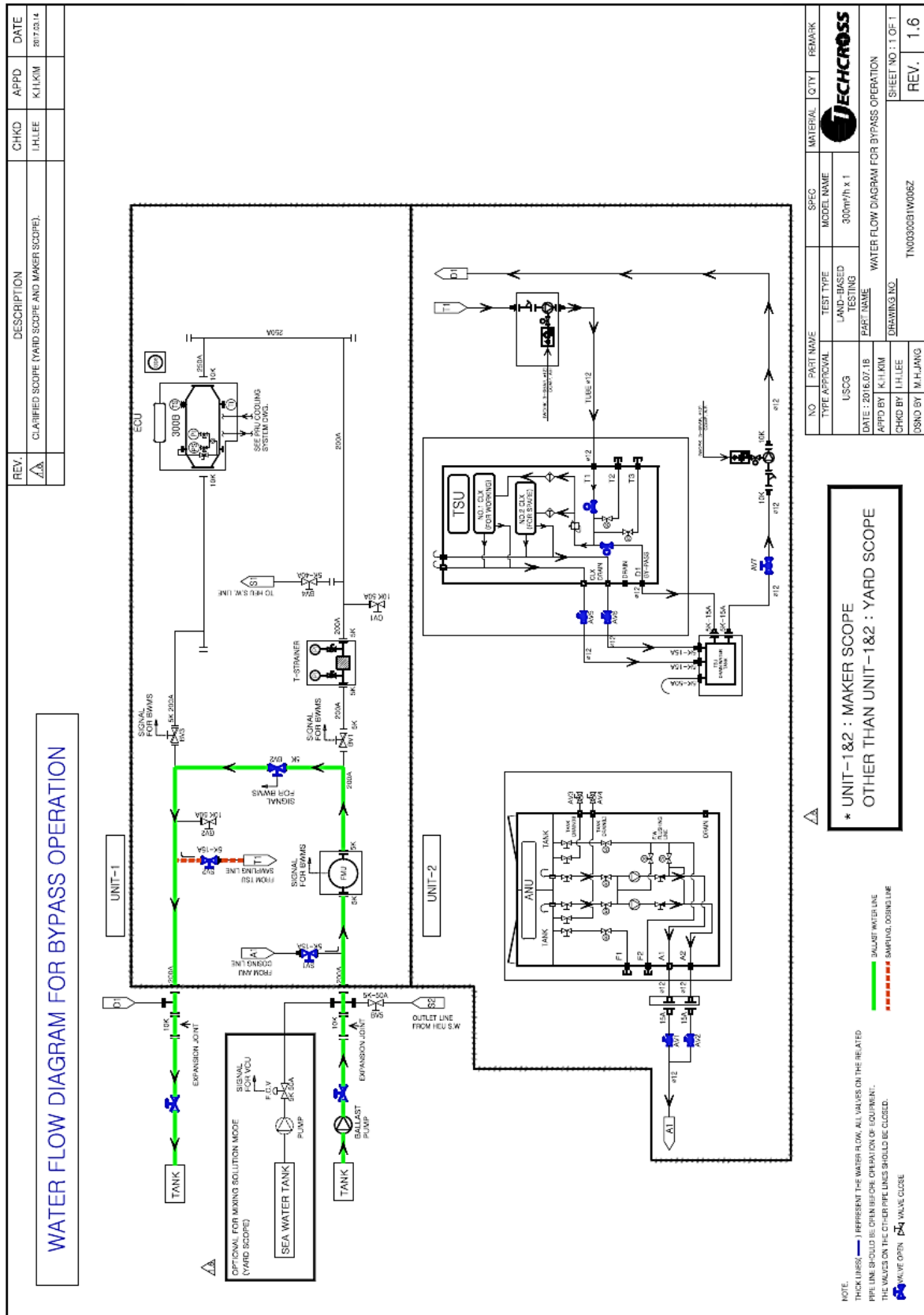
Please be noted that visual, audible alarms shall be activated and automatically recorded upon the opening of by-pass valve when

- 1) The power supply(AC220V) to CPC is on.
- 2) HMI(Human machine Interface) is in operation.

However, please be noted that visual, audible alarms shall not be activated and automatically recorded upon the opening of by-pass valve when HMI is not in operation due to the failure of power supply to CPC.

In case of the failure of power supply to CPC, the record about ballast/de-ballast by opening by-pass valve must be in writing manually.

### 5.4.2 By-pass Operation Flows



## 5.5 Stop Procedure

### 5.5.1 Stop Procedure of CPC

**Caution!!** Abnormal shut down of CPC will cause damage to main memory of CPC.

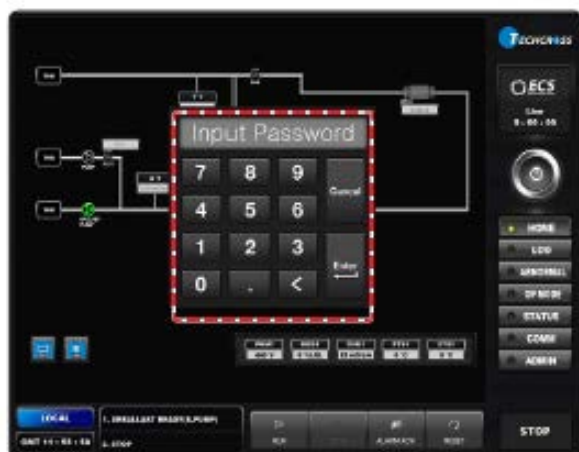
Step 1: **Click** “POWER” button on HMI screen of Main CPC to turn off HMI.

Step 2: **Ensure that** message says, “Are you sure you want to quit the ECS?”

Step 3: **Click** “YES” button.

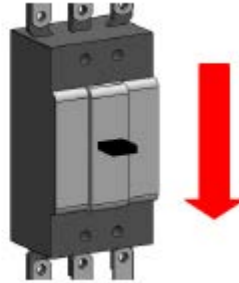
Step 4: **Click** the password

Step 5: **Click** “Turn off” button on Window XP

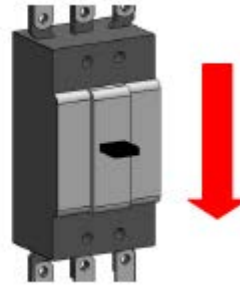


### 5.5.2 Stop Procedure of ECS

Step 1: Turn off MCCB power of PDE.



Step 2: Turn off BWMS power of MSBD.



## 5.6 Abnormal Status of ECS

### 5.6.1 When the BWMS is failed

**5.6.1.1** The ships which can be composed valve operation by Valve Remote Control System (VRCS) and ship's system is applicable for sea to sea mode, circulation mode and driving water stop or other method so that untreated water cannot be flowed into ballast tank or un-neutralized water cannot be discharged to sea.

- If ECS is abnormally stopped during operation, ECS send the BWMS fail (trip) signal to ship's control system (AMS, ICMS and IAS).
- The ships which have Alarm Monitoring System (AMS) with VRCS,
  - i) ECS send the separated signals for each operation mode. Then AMS send these signals to ship's Valve Remote Control System (VRCS). According to this signal, VRCS will control the valves to make sea to sea mode or circulate flowed sea water in the system or stop the water stripping, as applicable.
- The ships which have Integrated Control and Monitoring System (ICMS) or Integrated Automation System (IAS) with VRCS,
  - i) Basically, Programmed ICMS or IAS which can judge the BWMS operation mode is necessary.

If not, above i) will be applied.

If possible, ECS send the common fail (trip) signal to ICMS or IAS so that ships' control system can send this signal to ship's Valve Remote Control System (VRCS). According to this signal, VRCS will control the valves to make sea to sea mode or circulate flowed sea water in the system or stop the water stripping, as applicable.

Regarding to above signals, please refer to 5.1.2 Wiring diagram on this OMSM.

### 5.6.1.2 The ships which cannot be composed automatical valve operation

If ECS is abnormally stopped during operation, a message will be appeared on HMI screen as below on each operation mode and proper action by BWMS operator is necessary.

- When message is appeared during ballast operation mode, related valves need to be operated manually so that untreated sea water cannot be flowed to Water Ballast Tank.
- When message is appeared during de-ballast operation mode, related valves need to be operated manually so that un-neutralized ballast water cannot be flowed to overboard.
- When message is appeared during stripping operation mode, related valves need to be operated manually so that un-neutralized ballast water cannot be flowed to overboard.

**Message**

In case that BWTS operation fails or stopped by Emergency Stop during ballasting operation, untreated water must be prevented from flowing to B.W. Tank by Valve (VRCS).

OK

PMU1	PMU2	FTS1	GD51	GSU2	STS1
440 V	440 V	5 C	0 N.LEL	0 N.LEL	11 C
PMU2	CSU1	FTS2	GD52	GSU4	0 N.LEL
440 V	22 mS/cm	5 C	0 N.LEL	0 N.LEL	

LOCAL  
GMT 08 : 53 : 58

1. BALLAST READY(No.1)  
2. BALLAST READY(No.2)  
3. STOP

RUN STOP ALARM ACK RESET TRIP

**Message**

In case that BWTS operation fails or stopped by Emergency Stop during De-ballasting Operation, untreated water must be prevented from flowing to OVBD by Valve (VRCS).

OK

PMU1	PMU2	FTS1	GD51	GSU2	STS1
440 V	440 V	5 C	0 N.LEL	0 N.LEL	11 C
PMU2	CSU1	FTS2	GD52	GSU4	0 N.LEL
440 V	22 mS/cm	5 C	0 N.LEL	0 N.LEL	

LOCAL  
GMT 08 : 56 : 50

1. DEBALLAST READY(No.1)  
2. DEBALLAST READY(No.2)  
3. STOP

RUN STOP ALARM ACK RESET TRIP

**Message**

In case that BWTS operation fails or stopped by Emergency Stop during Stripping Operation, untreated water must be prevented from flowing to OVBD by Valve (VRCS).

OK

PMU1	PMU2	FTS1	GD51	GSU2	STS1
440 V	440 V	5 C	0 N.LEL	0 N.LEL	11 C
PMU2	CSU1	FTS2	GD52	GSU4	0 N.LEL
440 V	22 mS/cm	5 C	0 N.LEL	0 N.LEL	

LOCAL  
GMT 08 : 59 : 36

1. STRIPPING READY  
2. STOP  
3. STOP

RUN STOP ALARM ACK RESET TRIP

## **6. MAINTENANCE**

### **6.1 General Information**

#### **Purpose**

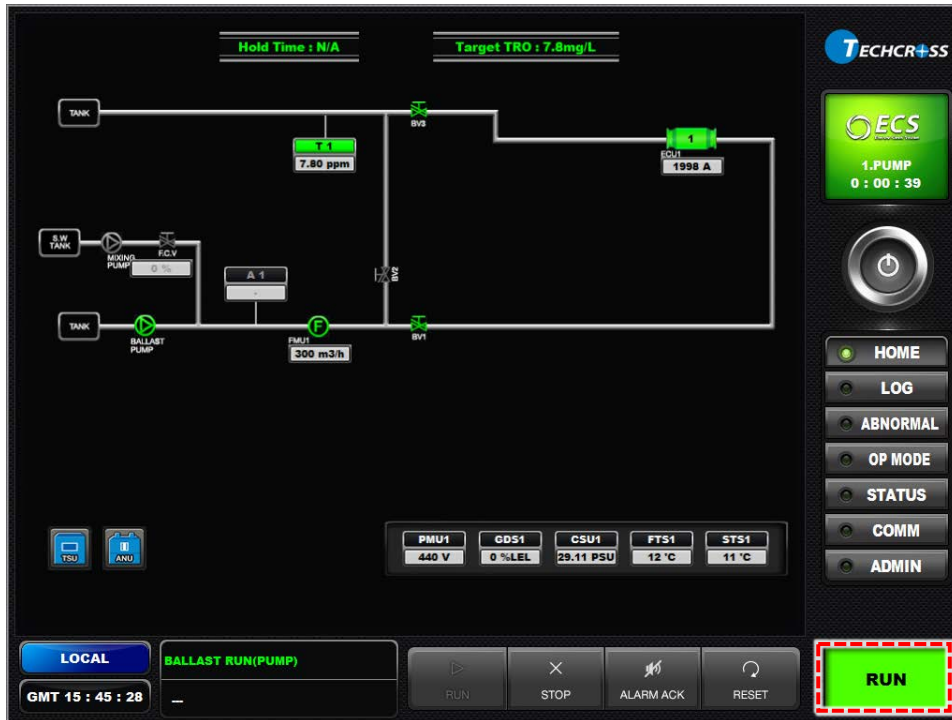
Potential accidents during ECS operation can be prevented through a systematic maintenance plan.

- The inspection / maintenance of ECS components should be performed based on the inspection / maintenance schedule recommended by ECS manufacturer.
- It is important to ensure the condition of functions of ECS operation through regular or intermittent inspection / maintenance.
- A person in charge should check maintenance schedule sheet and equipment history card to make sure that it is being executed as planned
- Inspection of spare parts should be performed on a regular basis in order to maintain them in good condition.

## 6.2 Preparation of maintenance

### Before maintenance

- Before the maintenance of ECS, please check that ECS is in operation.
- If ECS is in operation, operator can check the running status on right lower side of HMI Screen as below and stop ECS according to stop procedure.



- Press the menu button in order, Log → Maintain → Maintain Mode
- Then input of Password required as below.



- A message indicates maintenance mode will be appeared. During this message is on, ECS cannot be operated.



- After finishing of maintenance, authorized person should select the “maintain clear” and then input the password so that BWMS is ready for operation.



## 6.3 Routine maintenance of Equipment

### 6.3.1 Electro-Chamber Unit (ECU)

This design guidance is to recommend suitable materials for installation of Techcross ECS. Suitable material for ECS is not limited to our recommendation

Code	Description	Interval (M)	Main Check Points	Countermeasures
ECU-M-001	Electro-Chamber Module	Weekly	Appearance status of ECM	Cleaning it with soft cloth.
		Weekly	Appearance status of drain bolt	If broken, replace it with spare part. Refer to Ch. 8.3.1 Replacement of Spare parts
		Weekly	Appearance status of gasket	If drain gasket is defective, replace it with spare part. Refer to Ch. 8.3.1 Replacement of Spare parts.
ECU-M-002	Electro-Chamber Module	Weekly	Appearance status of name plate	Cleaning it with soft cloth.
		3	Check if painting of ECM is damaged	Painting.
		200 Hour	Total Ballast Operation Time on HMI	Cleaning EM with EM Washing Unit (EWU). Refer to Ch. 8.3.2 Procedure for ECU Cleaning.
ECU-M-003	ECM Protector Cover	Weekly	Connection status Of ECM protector Cover with ECM	Tightening bolts and nuts with washer.
		Weekly	Appearance status of electric label	Cleaning it with soft cloth.
		Weekly	Appearance status of general avoidance Label	Cleaning it with soft cloth.
		Weekly	Appearance status of name plate	Cleaning it with soft cloth.
ECU-M-004	PS & PI	Weekly	Cleaning cooling water inlet pipe	Cleaning it with air brushing by air compressor.
		1	Operation status of PS	If defective, contact Techcross.
		12	Connection status of joint and check if joint is leaking	Reconnecting quick coupler socket with quick coupler plug.
ECU-M-005	TS & TI	Weekly	Cleaning cooling water inlet pipe	Cleaning it with air brushing by air compressor.
		1	Operation status of PS	If defective, contact Techcross.
		12	Connection status of joint and check if joint is leaking	Reconnecting quick coupler socket with quick coupler plug.

### 6.3.2 Power Rectifier Unit (PRU)

Code	Description	Interval (M)	Main Check Points	Countermeasures
PRU-M-001	Name Plate	Weekly	Appearance status of name plate	Cleaning it with soft cloth.
PRU-M-002	Handle	Weekly	Operation status of handle	If defective, contact Techcross.
PRU-M-003	Joint (20A-Water in)	Weekly	Connection status of joint and check if joint is leaking	Reconnecting quick coupler socket with quick coupler plug.
			Check for leaks on PRU piping assembly (Flange, Female plug, Socket, Plug, Coupling)	If defective, contact Techcross.
PRU-M-004	Joint (20A-Water Out)	Weekly	Connection status of joint and check if joint is leaking	Reconnecting quick coupler socket with quick coupler plug.
			Check for leaks on PRU piping assembly (Flange, Female plug, Socket, Plug, Coupling)	If defective, contact Techcross.
PRU-M-005	Run Light	Weekly	Operation status of run light	If defective, replace it with spare part. Refer to Ch. 8.3.1 Replacement of Spare parts.
			Appearance status of run light cover	Cleaning it with soft cloth. If broken, contact Techcross.
PRU-M-006	Alarm Light	Weekly	Operation status of alarm light	If broken, replace it with spare part. Refer to Ch. 8.3.1 Replacement of Spare parts.
			Appearance status of alarm light cover	Cleaning it with soft cloth. If broken, contact Techcross.
PRU-M-007	Power Terminal	Weekly	Connection status of power terminal	If power cable is defective, contact Techcross.
PRU-M-008	Communication Terminal	Weekly	Connection status of communication terminal	If communication cable is defective, contact Techcross.
PRU-M-009	Cooling Water Inlet Hose	24	Cleaning cooling water inlet hose	Cleaning it with air brushing by air compressor

**6.3.3 Power Distributor Equipment (PDE)**

Code	Description	Interval (M)	Main Check Points	Countermeasures
PDE-M-001	Square Light	Weekly	Operation status of alarm light	If defective, replace it with spare part. Refer to Ch. 8.3.1 Replacement of Spare parts.
			Appearance status of alarm light cover	Cleaning it with soft cloth If broken, contact Techcross.
PDE-M-002	Square Light	Weekly	Operation status of square light	If defective, replace it with spare part. Refer to Ch. 8.3.1 Replacement of Spare parts.
			Appearance status of alarm light cover	Cleaning it with soft cloth. If broken, contact Techcross.
PDE-M-003	Digital Power Meter	Weekly	Appearance status of LCD display	Cleaning it with air brushing and soft cloth. If defective, contact Techcross.
PDE-M-004	ECS-RCM	Weekly	Appearance status of RCM	Cleaning it with air brushing and soft cloth. If defective, contact Techcross.
PDE-M-005	Selector Switch	Weekly	Operation status of selector switch	If defective, contact Techcross.
PDE-M-006	Switch On / Off	Weekly	Operation status of switch on / off	If defective, contact Techcross.
PDE-M-007	PB Switch	Weekly	Operation status of PB switch	If defective, contact Techcross.
PDE-M-008	Name Plate	Weekly	Appearance status of name plate	Cleaning it with soft cloth.
PDE-M-009	Power Distributor Equipment	Weekly	Appearance status of PDE	Cleaning it with air brushing and soft cloth.
PDE-M-010	Electric Sub Assembly	Weekly	Attachment status of electric sub assembly	Tightening bolts and nuts.
PDE-M-011	PCB Connection	Weekly	Appearance status of PCB connection	Tightening bolts and nuts.
PDE-M-012	Power Cable and Communication Cable	Weekly	Insulation status of power cable and communication cable	If defective, contact Techcross

**6.3.4 Control PC(CPC)**

Code	Description	Interval (M)	Main Check Points	Countermeasures
CPC-M-001	LCD Display (Touch Screen)	Weekly	Operation status of LCD display (Touch Screen)	Cleaning it with air brushing and soft cloth.
CPC-M-002	LAN Port	Weekly	Connection status of LAN port	If LAN Port is defective, contact Techcross.
CPC-M-003	USB Port	Weekly	Connection status of USB port	If USB Port is defective, contact Techcross.
CPC-M-004	Power On/Off Switch	Weekly	Operation status of power on/off switch	If defective, contact Techcross.
CPC-M-005	Name Plate	Weekly	Appearance status of name plate	Cleaning it with soft cloth.
CPC-M-006	Cable Entry	Weekly	Appearance status of cable entry	If defective, contact Techcross.
CPC-M-007	Wall Mount Bracket	Weekly	Attachment status of wall mount bracket	Tightening bolts and nuts.
CPC-M-008	A/Vibration Rubber	Weekly	Appearance status of anti-vibration rubber	If defective, contact Techcross.
CPC-M-009	Cable Gland	Weekly	Appearance status of cable gland	If defective, contact Techcross.
CPC-M-010	Control PC	Weekly	Overhaul	Overhaul CPC by ship's service engineer.

## 6.3.5 TRO Sensor Unit (TSU)

Code	Description	Interval (M)	Main Check Points	Countermeasures
TSU-M-001	Hinge	Weekly	Appearance status of hinge	Tightening bolts and nuts. Cleaning it with soft cloth.
TSU-M-002	Body	Weekly	Appearance status of body	Cleaning it with soft cloth.
TSU-M-003	Name Plate	Weekly	Appearance status of name plate	Cleaning it with soft cloth.
TSU-M-004	Door	Weekly	Appearance status of door	Cleaning it with soft cloth.
TSU-M-005	Handle	Weekly	Operation status of handle	If defective, contact Techcross.
TSU-M-006	Control Panel Cover	Weekly	Appearance status of control panel cover	If broken, contact Techcross. Cleaning it with soft cloth
TSU-M-007	Male Connector	Weekly	Connection status of WASTE male connector and SUS tube	Reconnecting coupling of SUS tube with WASTE male connector
		Weekly	Connection status of BYPASS male connector and SUS tube	Reconnecting coupling of SUS tube with BYPASS male connector
		Weekly	Connection status of DISCHARGE male connector and SUS tube	Reconnecting coupling of SUS tube with DISCHARGE male connector
		Weekly	Connection status of STARBOARD male connector and SUS tube	Reconnecting coupling of SUS tube with STARBOARD male connector
		Weekly	Connection status of PORT male connector and SUS tube	Reconnecting coupling of SUS tube with PORT male connector
		1	Operation status of pump	If defective, contact Techcross.
TSU-M-008	Air Pump	Weekly	Check the status of Air pump	If defective, contact Techcross.
		1	Operation status of pump	If defective, contact Techcross.
		24	Overhaul	Overhaul pump by ship's service engineer
TSU-M-009	2-Way Solenoid Valve	6	Clean it with Maintenance procedure.	If defective, contact Techcross. Refer to Ch. 8.3.3 Procedure for maintenance of Solenoid valve.
TSU-M-010	TRO Sensor Unit	Weekly	Check for leaks in TSU	If leaking, reconnect fittings tighten. If defective, contact Techcross.
TSU-M-011	CLX OnLine Residual Chlorine Monitor	Weekly	Connection status of inline T-strainer	Tightening bolts and nuts If defective, contact Techcross.
		1	Cleaning inline T-strainer	Cleaning it with air brushing by air compressor. Refer to Ch. 6.4.1 (Regular maintenance Procedure)TSU.

### 6.3.6 Auto Neutralization Unit (ANU)

Code	Description	Interval (M)	Main Check Points	Countermeasures
ANU-M-001	Front Door	Weekly	Appearance status of front door	Tightening bolts and nuts. Cleaning it with soft cloth.
ANU-M-002	Inbox Assembly	Weekly	Appearance status of inbox assembly	Tightening bolts and nuts. Cleaning it with soft cloth.
ANU-M-003	Side Door	Weekly	Appearance status of side door	Tightening bolts and nuts. Cleaning it with soft cloth.
ANU-M-004	T/Body, B/Frame Assembly	Weekly	Appearance status of T/body, B/frame assembly	Tightening bolts and nuts. Cleaning it with soft cloth.
		24	Cleaning F.W Tank	Cleaning F.W tank with fresh water.
ANU-M-005	Tank Top Cover	Weekly	Appearance status of tank top cover	Tightening bolts and nuts. Cleaning it with soft cloth.
ANU-M-006	Tower Lamp	Weekly	Appearance status of tower lamp	Tightening bolts and nuts. Cleaning it with soft cloth. If tower lamp is defective, contact Techcross.
ANU-M-007	XGT Housing Assembly	Weekly	Appearance status of XGT housing assembly	Cleaning it with air brushing and soft cloth.
ANU-M-008	Sensor Cover	Weekly	Appearance status of sensor cover	Tightening bolts and nuts. Cleaning it with soft cloth. If broken, contact Techcross.
ANU-M-009	Torque Hinge	Weekly	Appearance and operation status of torque hinge	Tightening bolts and nuts. If broken, Contact to Techcross.
ANU-M-010	Draw Latch	Weekly	Appearance and operation status of draw latch	Tightening bolts and nuts. If broken, contact Techcross.
ANU-M-011	Tank Window	Weekly	Appearance status of tank window	Cleaning it with soft cloth. If broken, contact Techcross.
ANU-M-012	Window Plate	Weekly	Appearance status of window plate	Tightening bolts and nuts. Cleaning it with soft cloth.
ANU-M-013	Level Sensor	1	Operation status of level sensor	If defective, contact Techcross.
ANU-M-014	Agitator	1	Operation status of agitator	If defective, contact Techcross.
ANU-M-015	Metering Pump	1	Operation status of quantity pump	If broken, contact Techcross.
		24	Overhaul	Overhaul quantity pump by ship's service engineer.
ANU-M-016	Strainer	6	Cleaning strainer of ANU tank.	Cleaning strainer of ANU tank Refer to Ch. 6.4.2 (Regular maintenance) ANU.

**6.3.7 Flow meter Unit (FMU)**

Code	Description	Interval (M)	Main Check Points	Countermeasures
FMU-M-001	Flange	Weekly	Connection status of flange	Tightening nuts and bolts. If gasket is defective, replace it with spare part. Refer to Ch. 8.3.1 Replacement of Spare parts.
FMU-M-002	Body	Weekly	Appearance status of body	Cleaning it with soft cloth.
FMU-M-003	Head	Weekly	Appearance status of head	Cleaning it with soft cloth.
FMU-M-004	LCD Display	Weekly	Appearance and operation status of LCD display (Screen Display)	Cleaning it with air brushing and soft cloth. If LCD display is defective, contact Techcross.
FMU-M-005	Lining	Weekly	Appearance status of lining. (Hard Rubber) Check for leaks	If defective, contact Techcross.
FMU-M-006	Electrode Signal Cable	Weekly	Insulation status of electrode signal cable	If defective, contact Techcross.
FMU-M-007	Grounding Ring	Weekly	Appearance status of grounding ring. Check if the status of grounding is normal	If defective, contact Techcross.
FMU-M-008	Gasket	60	Gasket of flange	Replace gasket every dock. Refer to Ch. 8.3.1 Replacement of Spare parts.
FMU-M-009	KTM Detector	1	Operation status of TMS pro-gram	Conducting self-function test.

**6.3.8 Conductivity Sensor Unit (CSU)**

Code	Description	Interval (M)	Main Check Points	Countermeasures
CSU-M-001	Conductivity Sensor Unit	Weekly	Operation status of CSU	If defective, contact Techcross.
		Weekly	Appearance status of CSU	Cleaning it with soft cloth.
		Weekly	Connection and leakage status of CSU with ECM	If teflon is defective, contact Techcross.
		6	Cleaning CSU	Cleaning it with air brushing with an air compressor.
CSU-M-002	Conductivity Sensor Unit	Weekly	Appearance status of CSU	Cleaning it with air brushing and soft cloth.
		Weekly	Connection status of CSU	Tightening bolts and nuts.

**6.3.9 Freshwater Temperature Sensor (FTS)**

Code	Description	Interval (M)	Main Check Points	Countermeasures
FTS-M-001	F.W. Temperature Input Cable	Weekly	Appearance status of F.W. temperature input cable	If defective, contact Techcross.
FTS-M-002	F.W. Temperature Sensor	Weekly	Appearance status of FTS	Cleaning it with air brushing and soft cloth.

**6.3.10 Gas Detection Sensor (GDS)**

Code	Description	Interval (M)	Main Check Points	Countermeasures
GDS-M-001	GDS Input cable	3	Appearance status of GDS input cable	If defective, contact Techcross.
GDS-M-002	GDS Sensor	3	Appearance status of GDS	Cleaning it with air brushing and soft cloth.

**6.3.11 T-strainer**

Code	Description	Interval (M)	Main Check Points	Countermeasures
TST-M-001	differential pressure	0.5 bar	Clean filter Clean residuals in the strainer	If defective, contact Techcross. Refer to Ch. 6.4.4 (Regular maintenance) T-STRAINER.

## 6.4 Regular maintenance Procedure

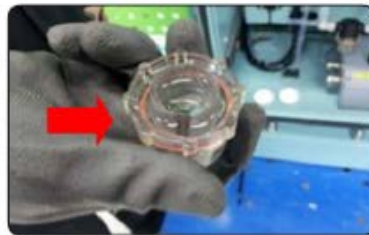
### 6.4.1 TSU



#### 1)-1 Clean CLX Filter and Check leakage

Step 1: **Disassemble** the CLX filter by turning to the left.

Step 2: **Drain** the water from the filter and clean it with an air compressor (4~7kg/cm<sup>2</sup>).



Step 3: Reassemble the filter, following instructions in reverse order (from step 2 to step 1).

Step 4: Check that all pipe connections and valves are not leaking.

#### 1)-2 Adjust pressure level of Regulator

Step 1: **Set** pressure level of regulator (on the right side of circulating pump) at 1.5 bar by adjusting dial of regulator.



## 6.4.2 ANU

### 2)-1 Cleaning strainer of ANU tank

Step 1: **Open** the valve of drain line and **drain** the remaining neutralizing solution from both left and right tank.

Step 2: **Clean** both left and right tank with freshwater.



Step 3: Clean the strainer with an air compressor (4~7kg/cm<sup>2</sup>).



Step 4: **Open** the front cover and the side cover of ANU.

Check that all pipe connections and valves are not leaking.



### 6.4.3 PRU

#### 3)-1 Check leakage of cooling water connector

Step 1: **Check** leakage from both Inlet and Outlet cooling water connector.

Step 2: **Tighten** the connector using tools in case of leakage.

Step 3: **Reassemble** the connector if the leakage continues.



#### 4)-1 Check the strainer\* of cooling water line.

Step 1. **Disassemble** the cooling water line and take out the strainer.

Step 2. **Check** the strainer. If it is blocked, **clean** it.

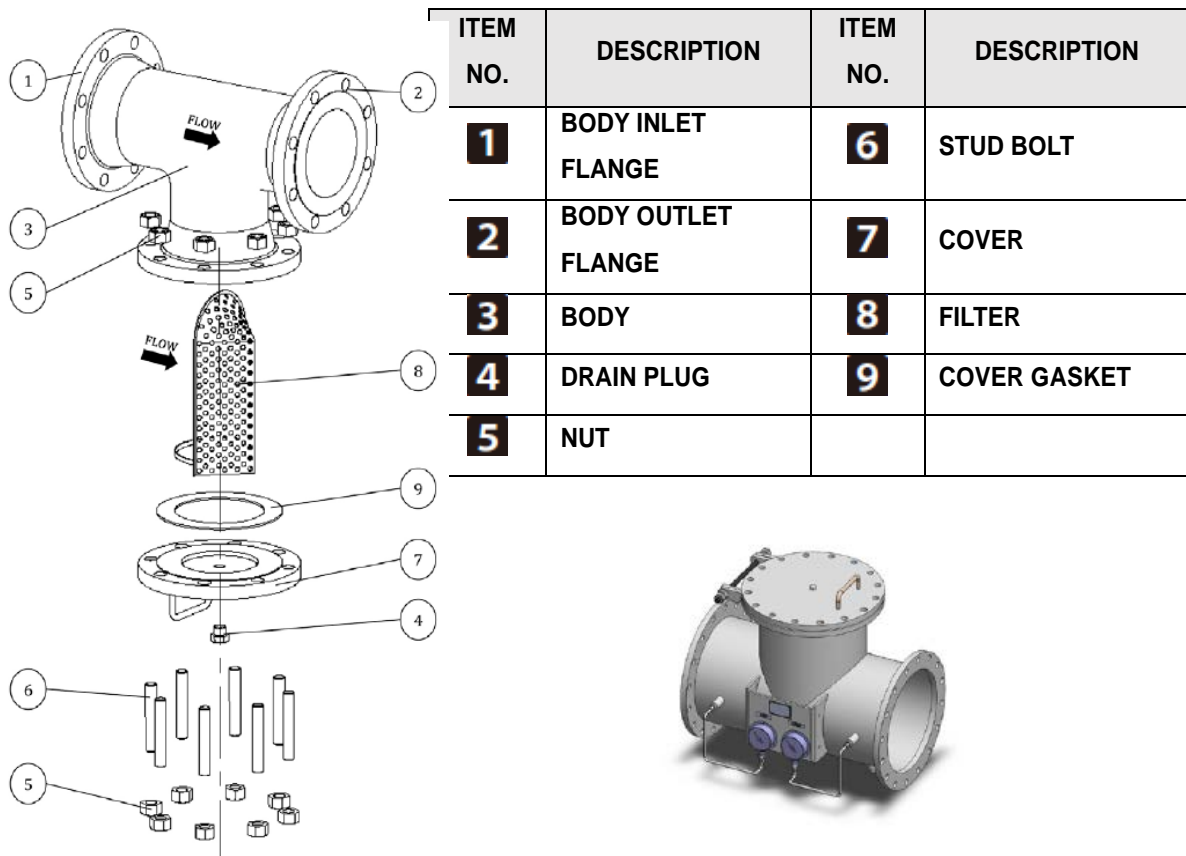
Step 3. **Reassemble** the cooling water line. And check the all pipe connections are not leaking.



\* Strainer have been installed to prevent the blockage of cooling water line from PRU.

Crew should be check the condition once every quarter.

### 6.4.4 T-STRAINER



Procedure of cleaning and replacing strainer filter

1. **Clean** the strainer if the difference between the pressure of Inlet and Outlet is over 0.5 bar.
2. **Close** both front and back valves of the strainer.
3. **Open** drain plug (4) slowly to drain all the fluid.
4. **Unscrew** nut (5) to remove cover (7).
5. **Remove** filter (8) and **clean** it.  
(**Clean** residuals with high-pressure water and air.)
6. **Check** condition of filter. If it is damaged, replace it with its cover Gasket (9).
7. **Clean** residuals in the strainer.
8. **Reassemble** the filter, following instructions in reverse order.  
(Please consider the flow direction and shape of filter.)

## 6.5 Long-term Lay-up

When the system is not in use for long-term period due to the international purposes such as “Don’t want to use before IMO D2 ratification”, long-term anchorage, etc.

Component	What to do
CPSs	Turn it off.
PDE and MSBD	Turn off MCCB.
ANU	<p><b>Open</b> the front and side covers.</p> <p><b>Check</b> that all pipe connections and valves are not leaking.</p> <p><b>Close</b> all Inlet valves of freshwater.</p> <p><b>Turn</b> draining rubber hose facing outward.</p> <p><b>Open</b> drain valve to drain neutralizing solution.</p> <p><b>Clean</b> the filter with an air compressor and reassemble the front and side covers</p>
TSU	<p><b>Close</b> sampling valves and <b>Disassemble</b> CLX filter.</p> <p><b>Remove</b> all sampling water and <b>Clean up</b> strainer and <b>Reassemble</b> CLX filter.</p> <p><b>Remove</b> reagent from CLX sensor.</p> <p><b>Clean</b> pipe by injecting fresh water with flushing kit.</p>
ECU	<p><b>Close</b> inlet / outlet / drain valves.</p> <p><b>Close</b> PRU cooling water inlet / outlet valves</p>
HEU&FTU	<p>Close inlet / outlet valves for sea / fresh water of HEU.</p> <p>Close fresh water inlet / outlet valves of FTU.</p> <p>Open drain valve at the bottom of FTU tank.</p> <p>Drain cooling water from FTU tank to empty the tank</p>

## 6.5.1 MAIN PC

Power OFF Main CPC

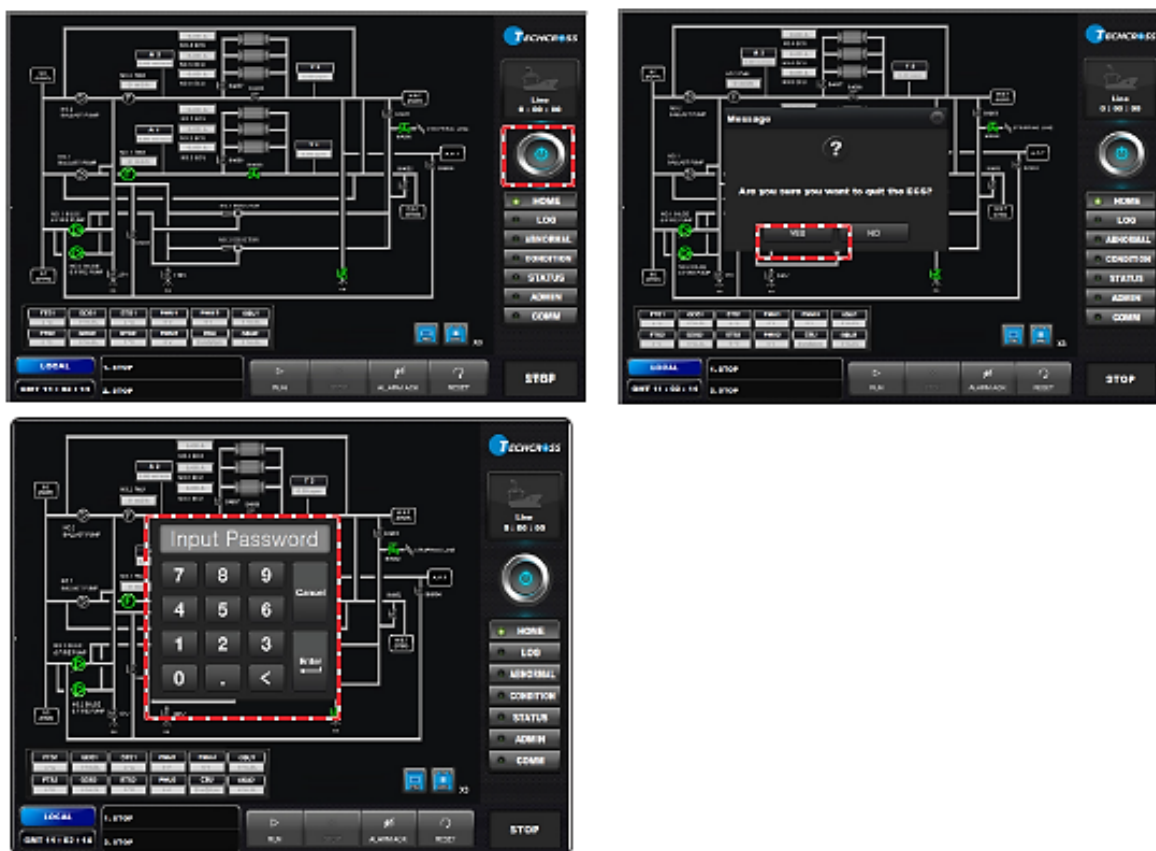
Step 1: **Click** “POWER” button on HMI screen of Main CPC to turn off HMI.

Step 2: **Ensure that** message says, “Are you sure you want to quit the ECS?”

Step 3: **Click** “YES” button.

Step 4: **Click** the password

Step 5: **Click** “Turn off” button on Window XP

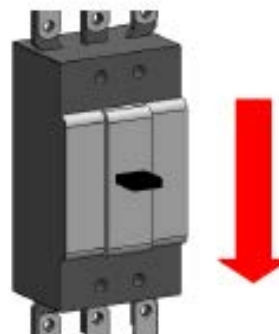
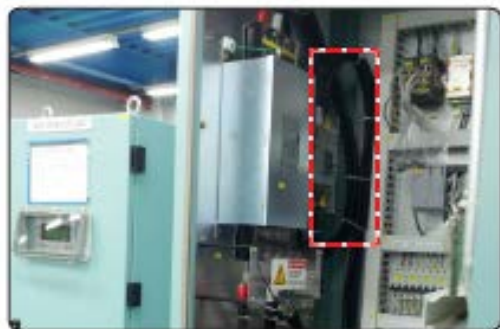


\* Above image can be different from actual system

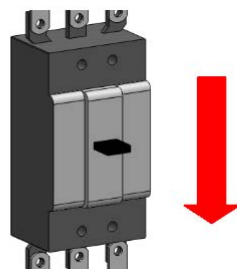
### 6.5.2 PDE and MSBD

Step 1: Turn off MCCB power of PDE.

Step 2: Turn off MAIN MCCB.



Step 3: Turn off BWMS power of MSBD.



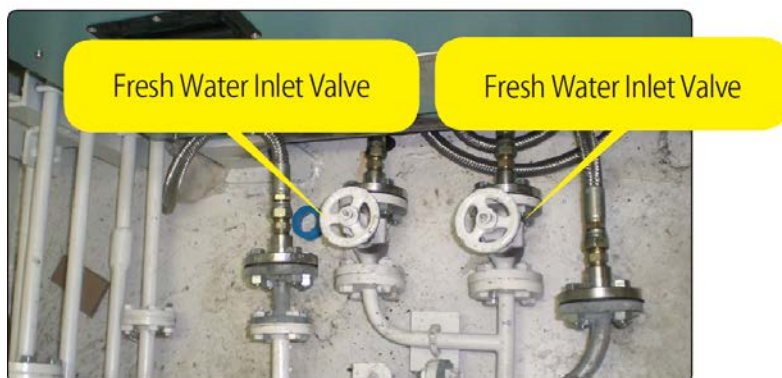
### 6.5.3 ANU Tank

Step 1: Open the front cover and the side cover of ANU.

**Check** all pipe connections and valves are not leaking.



Step 2: **Close** all **Inlet valves** of freshwater.



Step 3: **Turn** the draining rubber hose at the bottom of **ANU** facing outward.

**Open drain valve** (right and left side of the tank at the bottom) to drain neutralizing solution from the tank.

Use air to clean up **ANU strainer**.



Step 4: **Reassemble** the front and the side cover of ANU.

### 6.5.4 TSU valve and remove reagent

Step 1: **Close** Sampling valves (Port 1~3).



Step 2: **Disassemble** CLX filter of TSU.

**Remove** all the sampling water and clean up strainer.

**Reassemble** CLX filter.



Step 3: **Remove** reagent from **CLX sensor**.

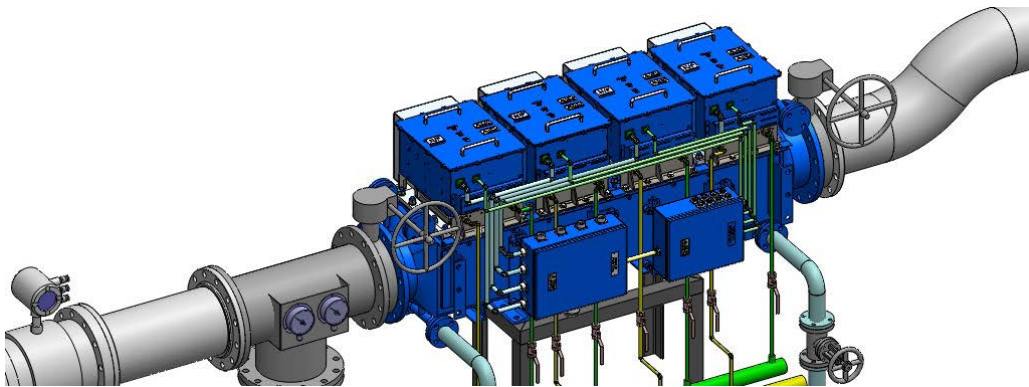
**Clean** the pipe by injecting fresh water to the pipe with flushing kit.

(Flushing kit is placed in TSU Drawing Pocket.)

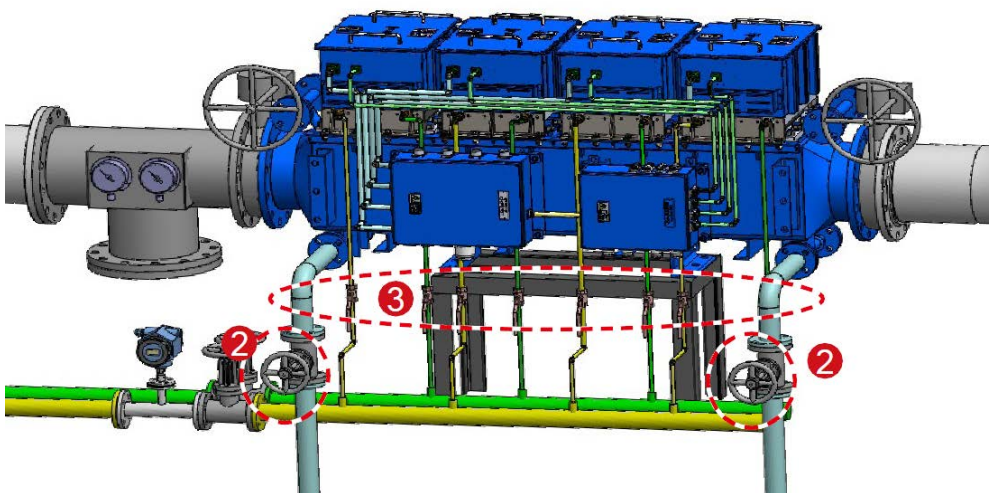


### 6.5.5 Close all the ECU valves

Step 1: **Close** Inlet, Outlet, and Drain valves of ECU.



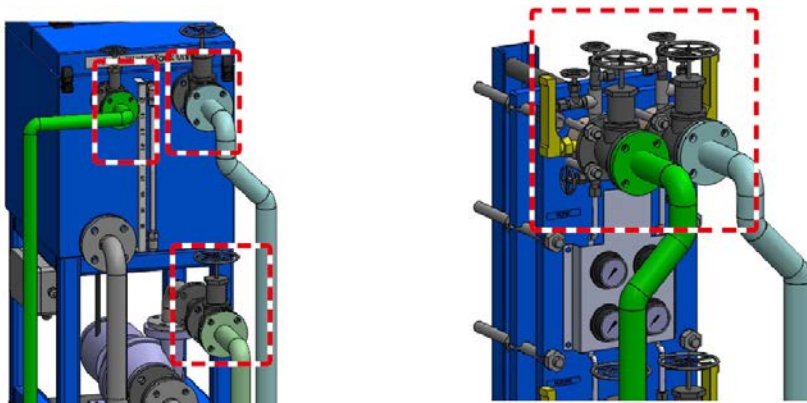
Step 2: **Close** PRU cooling water Inlet and Outlet valves of ECU.



### 6.5.6 HEU & FTU

Step 1: **Close** Inlet / Outlet valves for Sea / fresh water of HEU.

**Close** Inlet / Outlet valves for fresh water of FTU.



Step 2: **Open** drain valve at the bottom of FTU Tank.

**Drain** cooling water from FTU Tank to empty the tank.



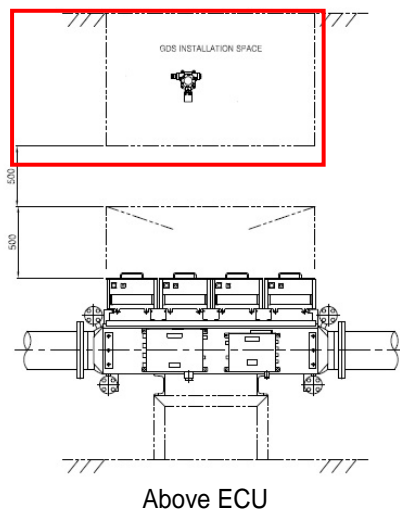
Step 3: To re-operate ECS, follow the instruction for "Preparation for Operation".

## 6.6 Calibration Guide for Sensors

### 6.6.1 Sensors to be periodically calibrated by Crews

#### 6.6.1.1 GDS (Gas Detection Sensor)

##### 1. Checking installation position of GDS



##### 2. Precautions prior to inspection

A. Ballast Pumps and ECS should not be operated.

##### 3. Preparations prior to inspection

A. GDS Power On

- In case GDS is installed separately, turn on the switch of circuit breaker(DC 24V) inside the PDE.
- In case GDS I installed on the side of TSU, turn on the switch of circuit breaker(220V) inside the PDE
















4. Calibration procedure

A. Calibration procedure

- GDS calibration item is Zero Setting only.

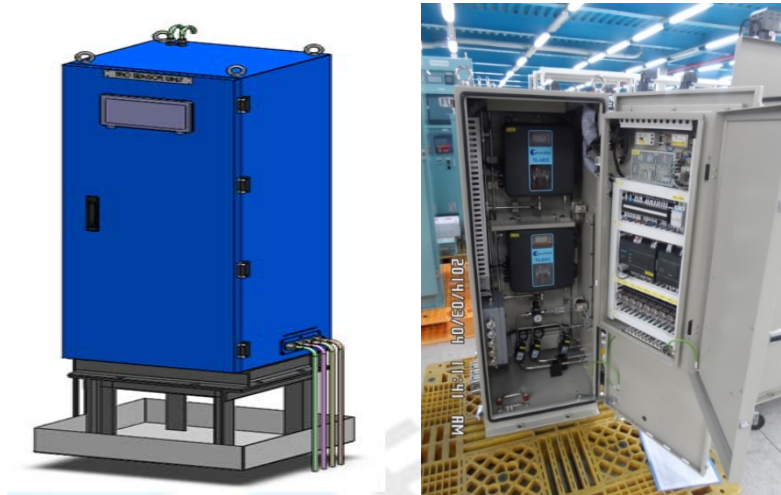
- It is recommended that GDS should be calibrated every 6 month.

<p>1</p>	<ul style="list-style-type: none"> <li>▶ Check the display.</li> <li>▶ Let the GDS stabilize for about 30mins before calibration.</li> <li>※ If the display shows the mark , zeroing is required.</li> </ul>	
<p>2</p>	<ul style="list-style-type: none"> <li>▶ Hold the end of the enclosed magnet over the  button for 5 seconds.</li> <li>▶ If the display shows the mark , remove the magnet.</li> </ul>	
<p>3</p>	<ul style="list-style-type: none"> <li>▶ If the display shows Set CAL, touch  button.</li> </ul>	
<p>4</p>	<ul style="list-style-type: none"> <li>▶ The display changes 1 second after "ZERO" shows on the display.</li> </ul>	
<p>5</p>	<ul style="list-style-type: none"> <li>▶ Let the GDS stabilize for 3 to 5 minutes.</li> <li>▶ Touch  button once it is stabilized.</li> </ul>	
<p>6</p>	<ul style="list-style-type: none"> <li>▶ Check "ZERO PASS" on the display before the display changes.</li> <li>▶ The display passes automatically in 1 second.</li> </ul>	
<p>7</p>	<ul style="list-style-type: none"> <li>▶ Touch  button after selecting 'YES' on the display for span.</li> </ul>	

**6.6.1.2 CLX (TRO Sensor)**

- Calibration is basically not required according to the original maker's manual.  
 However, calibration can easily be performed if required.

1. Checking installation position of CLX



2. Precautions prior to inspection

- A. Calibration should be conducted during normal ballasting operation.
- B. Make sure that fluctuations of flow rate during ballasting should be less than  $\pm 10\%$ .
- C. The same sampling water should be used when measured by CLX and Colorimeter









3. Precautions prior to inspection







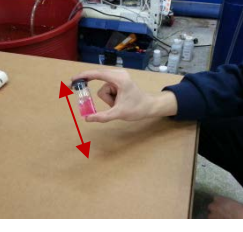

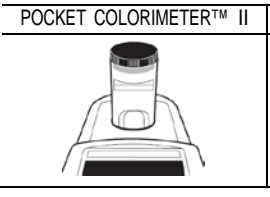
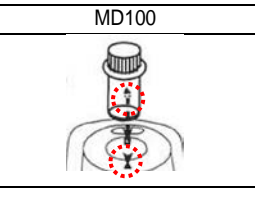


- A. Check a pocket colorimeter kit in the spare part case
- B. Prepare colorimeter, vial and reagent.












4. Calibration procedure

- Error tolerance of CLX should be less than  $\pm 10\%$ .
- In case of  $6 \pm 2$ ppm of TRO generation, error tolerance should be less than 10%.
- It is recommended that CLX should be calibrated every 12 month.

<p>1</p>	<p>▶ TRO measurement should be conducted 3~5 times during ballasting operation.</p> <p>▶ Calculate a mean value after measurements.</p> <p>[ Measurement by colorimeter should also be conducted as shown below from step 2 to 11 for comparison with measurement by TSU. ]</p>		
<p>2</p>	<p>▶ Prepare colorimeter, vial and reagent.</p>	<p>POCKET COLORIMETER™ II</p> 	<p>MD100</p> 
<p>3</p>	<p>▶ Obtain the sampling water from the valve on the side of TSU.</p>		
<p>4</p>	<p>▶ Check the measurement level on the vial.</p> <p>▶ Fill the vial with 5ml of sampling water.</p>	<p>POCKET COLORIMETER™ II</p> 	<p>MD100</p> 
<p>5</p>	<p>▶ Put the vial with sampling water into the colorimeter.</p>	<p>POCKET COLORIMETER™ II</p> 	<p>MD100</p> 

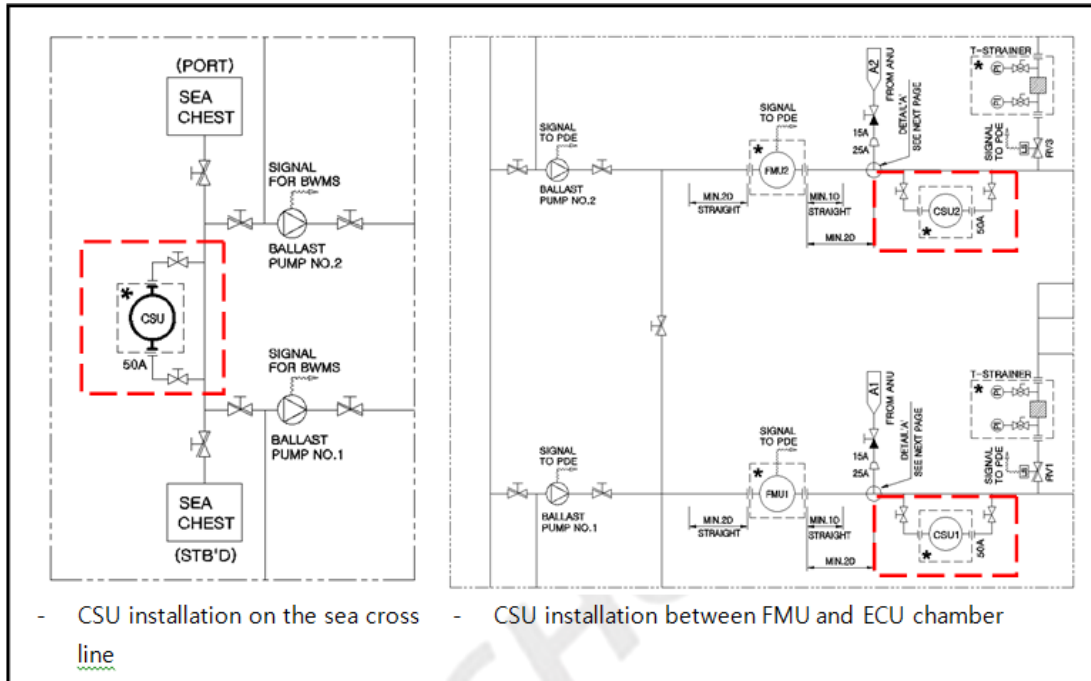
6	▶ Place the cover of pocket colorimeter onto the vial.	POCKET COLORIMETER™ II	MD100
			
7	▶ Press the zero button.	POCKET COLORIMETER™ II	MD100
			
8	▶ Put two reagents (DPD Total Chlorine Powder) into the vial.	POCKET COLORIMETER™ II	MD100
			
9	▶ Cover the lid of the vial. ▶ Shake well for about one and a half minutes. ▶ Check if there is a light blockage(ex. bubble, frost, etc.) on the vial.	POCKET COLORIMETER™ II	MD100
			
10	▶ Put the vial into colorimeter. ▶ Check the correct position(△) of the vial.	POCKET COLORIMETER™ II	MD100
			
			
	▶ Place the cover of colorimeter onto the vial.		

		POCKET COLORIMETER™ II	MD100
11	<ul style="list-style-type: none"> <li>▶ Press the measurement button.</li> <li>▶ Check the measured value (PPM).</li> </ul>		
12	<ul style="list-style-type: none"> <li>▶ In case the measured value is not in the range of the error tolerance when compared with that of pocket colorimeter, press the mode button  on the left.</li> <li>[ Tolerance: 6PPM↓: ±5%, 6PPM↑: 10% ]</li> </ul>		
13	<ul style="list-style-type: none"> <li>▶ If the screen shows ADJ (CAL), press  button to get the following screen.</li> </ul>		
14	<ul style="list-style-type: none"> <li>▶ Harmonize the value of CLX with that of pocket colorimeter by pressing ▲ &amp; ▼ buttons.</li> </ul>		
15	<ul style="list-style-type: none"> <li>▶ If value setting is done, complete CAL by pressing  ENT button.</li> <li>▶ Check if calibration has been properly done through 3 to 5 times of measurement.</li> </ul>		

## 6.6.2 Sensors to be periodically checked by Crews

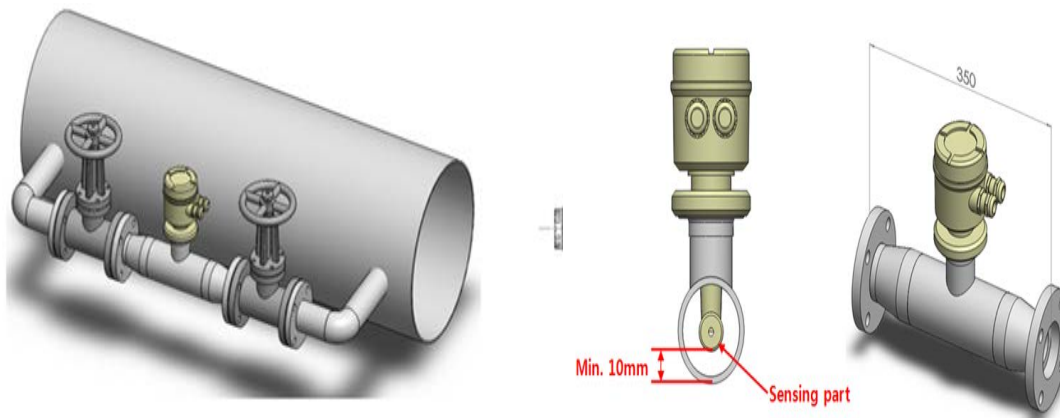
### 6.6.2.1 CSU (Conductivity Sensor Unit)

#### 1. Checking installation position of CSU



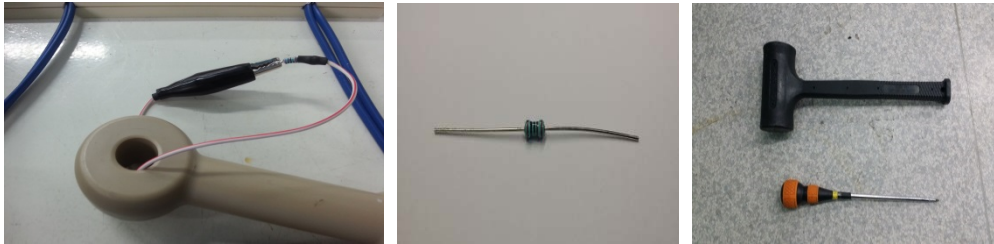
#### 2. Precautions prior to inspection

- A. ECS and ballast pump should not be operated.
- B. Make sure that inlet/outlet valves of CSU pipe are closed.
- C. Be careful with water scattering when CSU is separated from the pipe.
- D. CSU should be inspected without calibration every year



3. Precautions prior to inspection




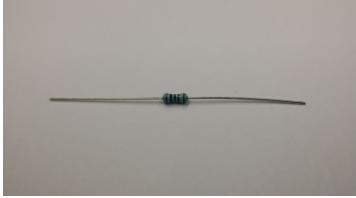

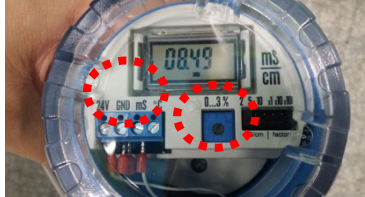
- A. Check 1000Ω register, cable and clip in the spare part case.
- B. Prepare a rubber hammer and a flat tip screw driver.





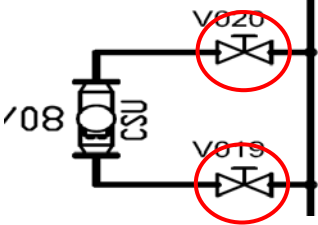



4. Inspection procedure

- Error tolerance of CSU should be less than ±5%.
- Error tolerance of the register should be less than ±5%.
- CSU should be inspected without calibration every year.
- Conductivity formula:  $1/1000(\text{register}) \times 8.5 \times 1000 = 8.5 \text{ mS/cm} \pm 10\%$
- Error tolerance should be less than  $8.50\text{mS/cm}^2 \pm 0.85 \text{ mS/cm}^2$  at 25°C (1000Ω register)

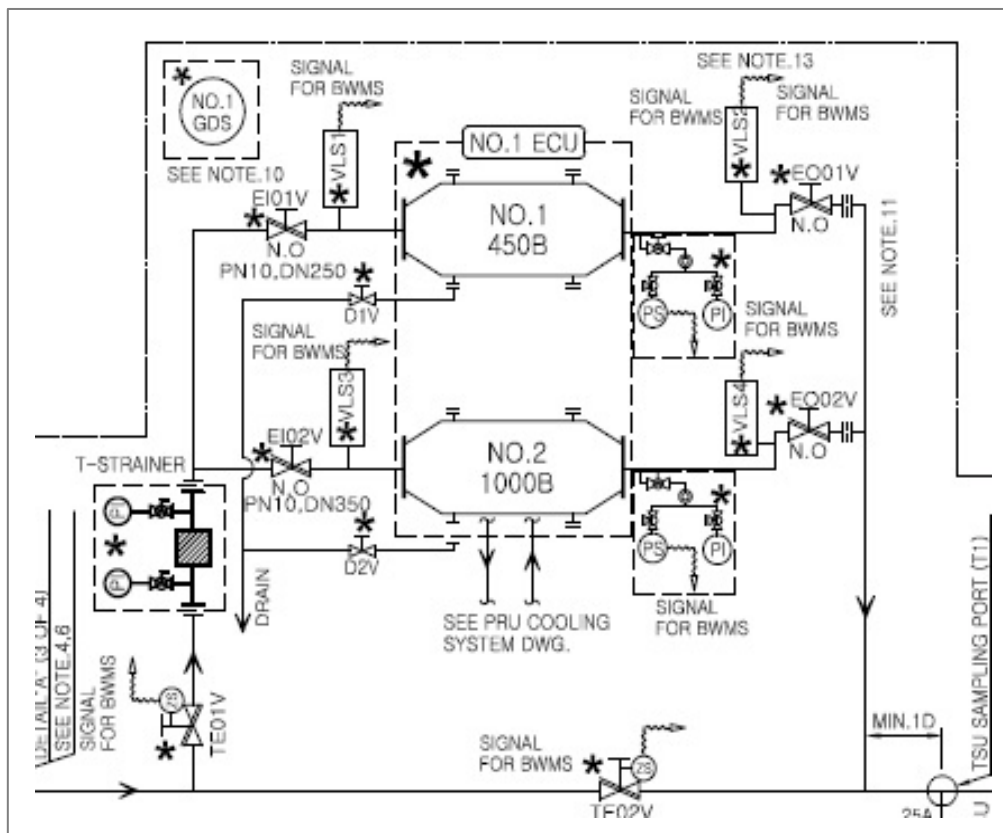
<p>1</p>	<p>▶ Close inlet / outlet valves of CSU pipe.</p>	
<p>2</p>	<p>▶ Turn off the switch of circuit breaker (DC24V) inside PDE.</p>	
<p>3</p>	<p>▶ Prepare a rubber hammer and a flat tip screw driver.</p>	
<p>4</p>	<p>▶ Disconnect CSU holder with the rubber hammer and flat tip screwdriver.</p>	

<p>5</p>	<p>▶ Separate CSU from the pipe.</p>	
<p>6</p>	<p>▶ Turn on the switch of circuit breaker (DC24V) inside the PDE to supply power to CSU</p>	
<p>7</p>	<p>▶ Check the conductivity value on the CSU. If the value is abnormal, CSU should be replaced. <b>(Normal : 0mS/cm / Abnormal : 0mS/cm ±0.3mS)</b></p>	
<p>8</p>	<p>▶ Prepare 1000Ω resistor.</p>	
<p>9</p>	<p>▶ Put the register through the hole of the probe. The both ends of the register should be connected.</p>	
<p>10</p>	<p>▶ If difference between conductivity values of CSU and normal valve below is out of tolerance range, CSU should be replaced. <b>EX) at 25°C in case of connection of 1000Ω register:</b> <b><math>1/1000 \times 8.5 \times 1000 = 8.50\text{mS/}</math></b> <b>Normal conductivity: <math>8.50\text{mS/cm}^2 \pm 0.85\text{mS/cm}^2</math></b></p>	

<p>11</p>	<p>▶ Turn off the switch of circuit breaker (DC24V) inside the PDE to cut the power supply to CSU..</p>	
<p>12</p>	<p>▶ Check if O-RING is properly inserted into CSU pipe.</p>	
<p>13</p>	<p>▶ Reattach the CSU to the original pipe.</p>	
<p>14</p>	<p>▶ Assemble CSU holder with rubber hammer and flat tip screwdriver.</p>	
<p>15</p>	<p>▶ Open inlet / outlet valves of CSU pipe. <b>Caution: Check the leakage after opening the pipe.</b></p>	
<p>16</p>	<p>▶ Complete the inspection after power on by turning up DC24V circuit breaker inside the PDE.</p>	

### 6.6.2.2 VLS(Vibration Level Sensor)

#### 1. Checking installation position of VLS



(It can be installed in Former & latter part of ECU or its latter part.)

#### 2. Precautions prior to inspection

- A. ECS & ballast pump should not be operated.
- B. Be careful with water scattering when VLS is separated from the main pipe.
- C. VLS should be inspected only without calibration.

#### 3. Preparations prior to inspection

- A. Separate VLS from the main pipe.
- B. Prepare water basket containing water and immerse the bottom part of VLS in the water for normal operation.



4. Inspection procedure



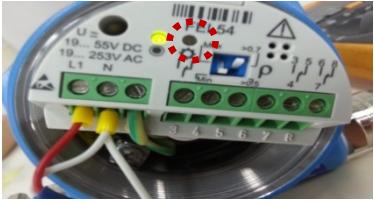
A. VLS Power On

- Turn on the switch of circuit breaker (DC24V) inside the PDE to supply power to VLS.



B. Inspection procedure

<p>1</p>	<p>▶ Check if DIP switch is set on MIN value.</p>	
<p>2</p>	<p>▶ Turn on the switch of circuit breaker (DC24V) inside the PDE.</p>	

<p>3</p>	<p>▶ Check if power is on and lamp works properly.</p>	
<p>4</p>	<p>▶ Immerse switch points in the water.</p>	
<p>5</p>	<p>▶ Check if the lamp on the right is off.</p>	

## 6.7 Spare parts

### 6.7.1 General Information

Spare parts of ECS component installed on ship are defined as the supplies(incl. supplies for repair) of parts. The spare parts in the ECS manual is classified into standard spare parts and additional consumable parts of ECS component.

Spare parts	ECS components	End products of ECS components
	Standard spare parts	Parts and measuring device for ECS components
	General consumables	Additional consumables




### 6.7.2 Standard spare part

No.	Component Name	External Appearance	External Appearance
1	Spare Part Case	400 X 800 X 300	
2	Portable TRO Sensor	MD100	
3	DC RELAY	YM2-LD	
4	AC RELAY	YM2-L	
5	LAMP 1	YS3324(White)	
6	LAMP 2	YS3324(Red)	
7	LAMP 3	220/6V(White)	

No.	Component Name	External Appearance	External Appearance
8	LAMP 4	24V(Red)	
9	LAMP 5	24V(Green)	
10	LAMP 6	24V(Yellow)	
11	FUSE	SB-C1 1A	
12	FUSE	FR14AM50V50	
13	PRU LAMP	P12PSDR(Green)	
14	PRU LAMP	P12PSDG(Red)	
14	PRU LAMP	P12PSDW(White)	
15	AC RELAY	SZR-MY4-N1	
16	Solenoid Valve	HSR103PD	
17	Solenoid Valve	HSR043D	

No.	Component Name	External Appearance	External Appearance
18	MAGNET SWITCH	MC-65A	
19	ECU Stud Bolt & Nut Set	M16 X 60L	
20	ECU Non-Asbestos Gasket	330 X 330	
21	EM EYEBOLT	M8	
22	CPC Repair part	Fuse/CD	
23	CLX Filter	A Filter	
24	Diaphragm	93111 Diaphragm(T) 93465 Diaphragm BUS(SP)	
25	Air Pump Filter & Regulation	PP3-03BDG	

## 6.7.3 Additional consumables

No.	Component Name	Description	Model	External Appearance
1	CLX Reagent	Checking TRO density during ballasting or deballasting	JAW (Just Add Water) Reagents(12EA=1Set)	
2	Neutralizing Agent for ANU	Neutralizing TRO density during deballasting	Pentahydrate 98.5% CAS No. : 10102-17.7 (25Kg=1PKT)	
3	Purified Water	Diluting CLX Reagent to adjust proper concentration	General Product	

To order spare parts, please send e-mail to TECHCROSS or ECS dealer.



For the information about ECS dealers, please visit TECHCROSS website

<http://www.techcross.com>

## 6.8 Replacement of consumables

### 6.8.1 Replacement of TRO Sensor (CLX) Reagent



**Caution**

- **CLX Reagent**, a corrosive substance can cause burns on your skin and stain your clothes.
- **Do not handle** this reagent without protective equipment such as protective clothes, gloves and glasses.

Step 1: **Prepare** Chlorine Indicator, Buffer Solution, DPD Powder and Distilled water.

(Reagent replacement interval: 1 to 2 months)



Step 2: Chlorine Indicator reagent (on the left side of TRO sensor)

1. **Fill** the bottle **3/4 full** with **distilled water**.
2. **Add** **DPD powder** and **pour** the distilled water to the line.
3. **Close** the cap and **mix** thoroughly.

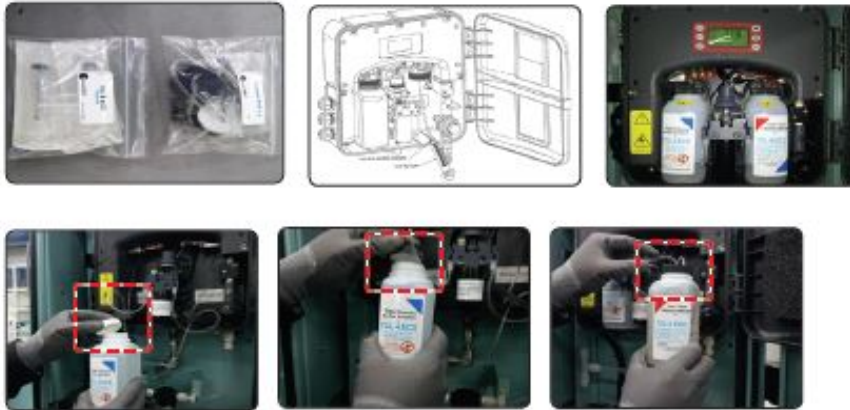


Step 3: Buffer Solution (on the right side of TRO sensor)

1. **Pour** **distilled water** to the line.
2. **Close** the cap and **mix** thoroughly.
3. **Do not add** DPD powder.



Step 4: **Install** the CLX Reagent




**Remove** the cap of buffer solution. → **Insert** the hose into the solution. → **Install** the solution.  
 → Assemble indicator hose. →



**Place** hose in the right place. → **Switch** to XGT "F1" Local Mode. → **Press** "▶" to run. → **Make** sure that CLX power is ON.



Press **PRIME** button. → Press **ENTER**. → Set as approximately "70 times pumping". → Check injection of Reagent.

 **Buffer needs to be placed on the left side and indicator needs to be placed on the right side.**



## 6.8.2 Replacement of Sodium Thiosulfate

Step 1: **Check** whether the fresh water is automatically filled to the high level of Tank.

**Ensure** that “ALM Left Tank Full” or “ALM Right Tank Full” message with “SDT” is displayed on the ANU XGT Control Panel and Tower Lamp is operated.



Step 2: Press "ESC" button to turn off alarm.

**Open** top cover of fresh water tank.

**Add** two bags of Sodium thiosulfate (25Kg) to each fresh water tank for ANU 5T.

**Add** four bags of Sodium thiosulfate (25Kg) to each fresh water tank for ANU 10T



Step 3: Press “F1” button for the left tank and “F3” for the right tank to operate each agitator.

The operation of agitator will be stopped after approximately 15 to 20 minutes.

Check [RDY] on XGT after the agitators are stopped.



Re-operate the agitator (stirrer) until the neutralization solution is completely dis-solved if it is not dissolved due to certain circumstances or water temperature.



Storage of Sodium Thiosulfate:

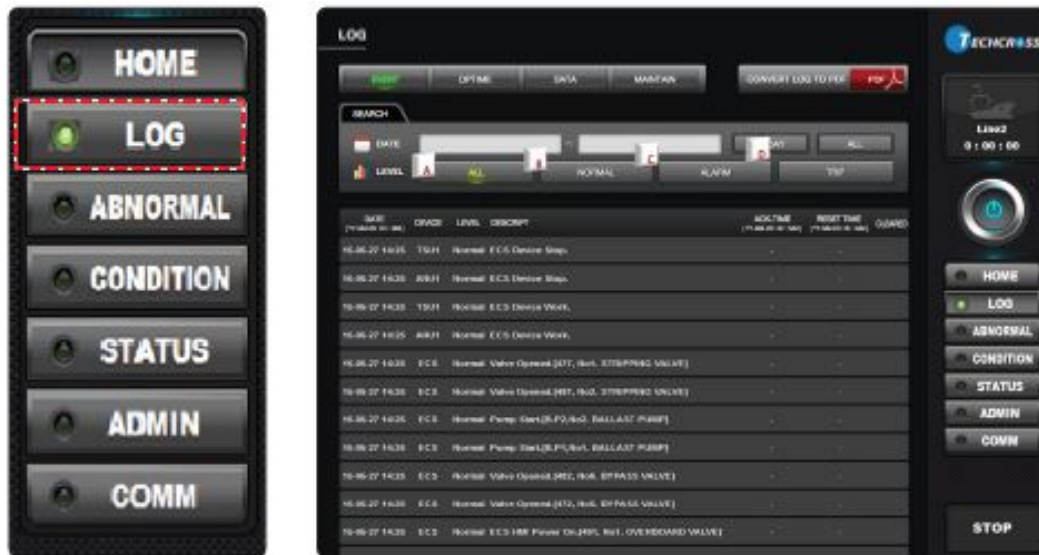
- Sodium Thiosulfate should be kept dry and well-ventilated in an air-tight bag.
- The temperature of storage should be under 45°C.
- Sodium Thiosulfate should be kept separately

## 7. TROUBLESHOOTING

### 7.1 Checking Alarms & Log messages

Step 1. Click “LOG” button on the bottom right of HMI screen.

Step 2. It shows a list of alarms that occur during ECS operation.



- Click one of four items on "All / Normal / Warning / Trip" to sort out the list of alarms.
  - “ALL” button: All of log level will be sorted & displayed.
  - “Normal” button: Only the NORMAL part of log level will be sorted & displayed
  - “Alarm” button: Only the ALARM part of log level will be sorted & displayed.
  - “Trip” button: Only the TRIP part of log level will be sorted & displayed
- Click one of two items on "TODAY / ALL" to sort out the list of alarms.
  - “TODAY” button: Only the alarms which occurred on today will be sorted & displayed.
  - “ALL” button: All alarms during operation will be sorted & displayed.
- If “Close” button is clicked, it will go back to HMI’s main menu

## 7.2 Trouble shooting for ECS Major Alarm Message

Device	List	Description
TSU*	Error message	[CODE201]TRO Concentration High.
	Alarm (Warning)	TRO concentration in Ballast >10mg/L * (Consecutive 3 times) (The alarm will operate after 5 minutes since ECS starts)
	Fault	TRO concentration in Ballast >10mg/L * (Consecutive 5 times)
	Trouble Shooting	(1) Measure the TRO concentration with pocket colorimeter in the spare parts box on your own. (2) Compare TRO concentration measured by pocket colorimeter with TRO level as shown on the HMI. (3) If TRO level on HMI is higher than the level by the colorimeter, restart TSU after replacing CLX reagent. (4) If the problem persists, stop operating ECS and contact Techcross A/S team.
	Error message	[CODE200]TRO Concentration Low.
	Alarm (Warning)	TRO concentration in Ballast < 5mg/L * (Consecutive 3 times) (The alarm will operate after 5 minutes since ECS starts)
	Fault	TRO concentration in Ballast < 5mg/L * (Consecutive 5 times)
	Trouble shooting	(1) Check if other valves except the valve for sampling are closed. (2) Check that sampling water flows smoothly into TRO sensor. (3) While sampling water is flowing in, if message (Too fast / slow) pops up, adjust regulator adequately. (4) Check the expiration date (1 month) of CLX reagent. If it is expired, replace the CLX reagent. (5) Measure TRO level with pocket colorimeter. (6) If TRO level measured by colorimeter is lower than standard, contact Techcross A/S team.
TSU*	Error message	[CODE201]TRO Concentration High.
	Alarm (Warning)	TRO concentration in De-ballast > 0.07 mg/L * (Consecutive 3 times) (The alarm will operate after 5 minutes since ECS starts)
	Fault	TRO concentration in De-ballast > 0.1mg/L * (Instantaneous)
	Trouble Shooting	(1) Check that sodium thiosulfate has been added to ANU tank. (2) Check if other valves except the valve for sampling are closed. (3) Check that the valve for sampling is not clogged up and pump in the ANU is properly working. (4) If TRO level is over standard when neutralizing agent is injected properly, contact Techcross A/S team.

\* Basic logic of the TSU: The first TRO measurement after 120 seconds from the initiation is excluded from the logic of Alarm/SHD as the remaining water in the sampling pipeline may not be flushed properly and may cause a measurement error. As a result, TSU takes values from the second measurement to include in the logic of Alarm/SHD.

Device	List	Description
TSU	Error message	[CODE706]EM`CY Mode.
	Alarm (Warning)	If operation mode is Emergency
	Fault	
	Trouble Shooting	(1) Check if selector switch of TSU control panel is in Emergency Mode. (2) If yes, switch to Remote Mode according to the manual.
ANU	Error message	[CODE301]Add the neutralizing agent [Left]. [CODE302]Add the neutralizing agent [Right].
	Alarm (Warning)	Add the Sodium thiosulfate is fresh water tank
	Fault	
	Trouble Shooting	(1) Put sodium thiosulfate into the tank according to the manual.
	Error message	[CODE303]ANU Tank Level Low [Left]. [CODE304]ANU Tank Level Low [Right]
	Alarm (Warning)	Lack of neutralization Solution in Fresh water Tank.
	Fault	
Trouble Shooting	(1) If neutralization solution has run out, freshwater is automatically supplied and alarm stops. (2) If alarm continues, follow the instructions below. - If valve for water supply is closed, open the valve. - If pipe for water supply is clogged up, unclog the pipe or Y-strainer. - If pipe is okay, clean solenoid valve inside the ANU according to the manual. - If the problem persists, contact Techcross A/S team.	
	Error message	[CODE305]ANU Tank Level Overflow [Left]. [CODE306]ANU Tank Level Overflow [Right].
	Alarm (Warning)	Excessive fresh water in Fresh water Tank detected.
	Fault	
	Trouble Shooting	(1) Check that solenoid valve in the ANU is completely closed. (2) If solenoid valve is not closed by foreign materials, clean the solenoid valve according to the manual. (3) If alarm continues when ANU tank is not fully filled with water, contact Techcross A/S team.

Device	List	Description
ANU	Error message	[CODE706]EM`CY Mode.
	Alarm (Warning)	If operation mode is Emergency
	Fault	
	Trouble Shooting	(1) Check if operation mode on ANU control panel is set to Remote Mode. (2) If not, reset it to Remote Mode according to the manual.
PMU	Error message	[CODE406]The Input Voltage Low.
	Alarm (Warning)	Master input voltage is < 440V-15% (374V)
	Fault	Master input voltage is < 440V-20% (352V)
	Trouble Shooting	(1) Check if voltage from MSBD is normal after turning off MCCB of PDE. (2) If voltage from MSBD is normal, measure insulation resistance ECS. (3) If insulation fails, contact Techcross A/S team
	Error message	[CODE407]The Input Voltage High
	Alarm (Warning)	Master input voltage is > 440V+15% (506V)
	Fault	Master input voltage is > 440V+20% (528V)
	Trouble Shooting	Check whether the voltage from MSBD is normal or not
FMU	Error message	[CODE605]FMU Flow Rate High.
	Alarm (Warning)	Flow velocity >110% m <sup>3</sup> /h * (Continue during 3 minute)
	Fault	Flow velocity >110% m <sup>3</sup> /h * (Continue during 5 minute)
	Trouble Shooting	(1) Regulate the flow rate so that the flow does not exceed 110% of ECS capacity. (2) If flow rate on HMI shows -20 value, check if power supply and cable connection of FMU are normal. (3) If they are normal, refer to the troubleshooting for sensor failure as described in communication. (4) If FMU display shows errors, contact Techcross A/S team.

Device	List	Description
FMU	Error message	[CODE604]FMU Flow Rate Low.
	Alarm (Warning)	Flow velocity <30% m <sup>3</sup> /h * (Continue during 3 minute)
	Fault	Flow velocity <30% m <sup>3</sup> /h * (Continue during 5 minute)
	Trouble Shooting	<p>(1) Regulate the flow rate so that the flow can exceed at least 30% of ECS capacity.</p> <p>(2) If flow rate on HMI shows -20 value, check if power supply and cable connection of FMU are normal.</p> <p>(3) If they are normal, refer to troubleshooting for sensor failure as described in communication.</p> <p>(4) If FMU display shows errors, contact Techcross A/S team.</p>
FMU	Error message	[CODE612]FMU Flow Rate High (Mixing).
	Alarm (Warning)	Flow velocity >80% m <sup>3</sup> /h * (Continue during 3 minute)
	Fault	Flow velocity >80% m <sup>3</sup> /h * (Continue during 5 minute)
	Trouble Shooting	<p>(1) Regulate the flow rate so that the flow does not exceed 60% of ECS capacity.</p> <p>(2) If flow rate on HMI shows -20 value, check if power supply and cable connection of FMU are normal.</p> <p>(3) If they are normal, refer to the troubleshooting for sensor failure as described in communication.</p> <p>(4) If FMU display shows errors, contact Techcross A/S team.</p>
	Error message	[CODE611]FMU Flow Rate Low (Mixing).
	Alarm (Warning)	Flow velocity <30% m <sup>3</sup> /h * (Continue during 3 minute)
	Fault	Flow velocity <30% m <sup>3</sup> /h * (Continue during 5 minute)
	Trouble Shooting	<p>(1) Regulate the flow rate so that the flow can exceed at least 30% of ECS capacity.</p> <p>(2) If flow rate on HMI shows -20 value, check if power supply and cable connection of FMU are normal.</p> <p>(3) If they are normal, refer to troubleshooting for sensor failure as described in communication.</p> <p>(4) If FMU display shows errors, contact Techcross A/S team.</p>

Device	List	Description
CSU	Error message	[CODE607] CSU Low.
	Alarm (Warning)	Salinity < 1PSU *(Continue during 1 minute)
	Fault	Salinity < 1PSU *(Continue during 2 minute)
	Error message	[CODE613] CSU Low (Mixing).
	Alarm (Warning)	Salinity < 1.35PSU *(Continue during 1 minute)
	Trouble Shooting	(1) Check the display of CSU. (2) If yes, please operate according to the mixing ballast operation procedure.
GDS	Error message	[CODE606]Detected H <sub>2</sub> Gas.
	Alarm (Warning)	H <sub>2</sub> gas concentration > 25% LEL
	Fault	H <sub>2</sub> gas concentration > 50% LEL
	Trouble Shooting	(1) Turn off MCCB of PDE or MSBD and check if alarm for H <sub>2</sub> gas rings through AMS of the vessel. (2) Check if there is any leakage of H <sub>2</sub> gas with H <sub>2</sub> gas detector equipped in the vessel. (3) If alarm rings or GDS shows - 20 value when there is no leakage of H <sub>2</sub> gas, check if power and cable connection is normal. (4) If no problem is found, refer to the troubleshooting for sensor failure.
PDE	Error message	[CODE400]PDE EM`CY Stop.
	Alarm (Warning)	
	Fault	The PDE operation has been stopped by an operator as an emergency measure PDE[Number]
	Trouble Shooting	(1) If Emergency Stop Button on PDE is on, release the button by turning it clockwise. (2) If fault continues, check malfunction of button and cable connection to RTU for Emergency signal. (3) If fault persists without connection problems, contact Techcross A/S team.

Device	List	Description
ESJ	Error message	[CODE405]The Input Current High
	Alarm (Warning)	Current > (Number of PRU per ECU x 1125A)
	Fault	Current > (Number of PRU per ECU x 1150A)
	Trouble Shooting	(1) Check if selector switch is in Emergency Mode. (2) If yes, switch to Remote & Local Operation Mode.
ESJ	Error message	[CODE706]EM`CY Mode.
	Alarm (Warning)	If RCM Select switch is changed (Emergency mode)
	Fault	
	Trouble Shooting	(1) Check if selector switch is in Emergency Mode. (2) If yes, switch to Remote & Local Operation Mode.
ESJ	Error message	[CODE100][ERROR31]ECU EM`CY State.
	Alarm (Warning)	
ESJ	Fault	In case of Emergency situations. 1) High Pressure > 4.5bar 2) High Temperature >45°C
	Trouble Shooting	(1) If alarm rings during ballasting, check the followings. - Check if inlet / outlet remote valves of ECU are closed. (Should be open during ballasting & deballasting) - Check if manual valves of ECU for maintenance are closed. (Should be always open except for maintenance) (2) If alarm rings when ECS is not in operation, check if Emergency Stop Button of RCM is on. - If yes, release the button by turning it clockwise. (3) If alarm rings when ECS is not in operation and when there is no problem with Emergency button, contact Techcross after checking pressure of pressure switch & gauge including cable connection of pressure switch.
ECS	Error message	[CODE704]Bypass Valve Opened.
	Alarm (Warning)	if bypass is on during ballasting operation
	Fault	
	Trouble Shooting	Check if signal from VRCS and signal shown on HMI match according to the manual. (2) If two signals do not match, check cable connection. (3) If alarm persists, contact Techcross A/S team.

Device	List	Description
FTS (Cooling water)	Error message	[CODE603]F.W TEMP. High.
	Alarm (Warning)	freshwater temperature(Outlet) is 43°C
	Fault	freshwater temperature(Outlet) is >45°C
	Trouble Shooting	<p>(1) Check if temperature of freshwater supplied from freshwater pipeline is &lt;38°C.</p> <p>(2) Check if amount of freshwater is supplied according to design value.</p> <p>(3) Check if LT cooling pump is in operation</p> <p>(4) If alarm rings when there is no problem with flow rate &amp; temperature, check if FTS is normal.</p> <p>(5) If FTS has no problem, check cable connection between FTS and PDE.</p> <p>(6) If cable connection is normal, refer to the troubleshooting for sensor failure as described in communication.</p>
Magnetic Contactor	Error message	[CODE402]440V MC Fail
	Alarm (Warning)	
	Fault	440V Magnet malfunction
	Trouble Shooting	<p>(1) Refer to the following instructions to check if magnetic contactor is defective.</p> <ul style="list-style-type: none"> <li>- Turn off the MCCB of PDE or MSBD to cut off power to ECS.</li> <li>- If the contactor has no short circuit, fasten loose cables tightly after checking cable connection.</li> <li>- Check insulation resistance of 440V line in PDE.</li> <li>- Contact Techcross A/S team if no problem is found with insulation.</li> <li>- If the contactor is found to be defective, replace the contactor without repair.</li> <li>- If the problem persists, contact Techcross A/S team.</li> </ul> <p>(2) If power of ECS shuts off automatically of itself within 1 min after the magnetic contactor fails, contact Techcross A/S team immediately without checking the magnetic contactor on your own.</p>

Device	List	Description
Communi- cation	Error message	[CODE701]Communication Fail.
	Alarm (Warning)	Failure of communication between ECS equipment.
	Fault	Shutdown if communication failure lasts more than one minute
	Trouble Shooting	<p>(1) In case of communication failure in CPC / RTU / ESJ / PRE / ANU / TSU / PLC</p> <ul style="list-style-type: none"> <li>- Check power supply &amp; LAN cable connection between HUB and each module above.</li> </ul> <p>(2) In case of communication failure in ESJ / PRE / PMU / ANU / TSU relating to RS-485</p> <ul style="list-style-type: none"> <li>- Check power supply &amp; communication cable connection between of PLC and each module above.</li> </ul> <p>(3) In case of communication failure in sensors</p> <ul style="list-style-type: none"> <li>- Check power supply &amp; communication cable connection between PLC and each module above.</li> </ul> <p>(4) Check if MCCB in the PDE is on. If it is turned off, turn it on</p> <p>(5) If MCCB is not working properly after it is turned on, contact Techcross A/S team.</p> <p>(6) If communication failure persists without power &amp; connection problems, contact Techcross A/S team.</p>

### 7.3 Main Problems and Measures

Problem:

- ECS shuts down 5 minute after alarm message “[CODE612] FMU Flow Rate High” appears.

Reason:

- Flow rate is above the normal range. (Normal Range: 30% ~ 110% of pump capacity)

Solution:

- Valve throttling is required to ensure that the measured flow rate of FMU is within the normal range of rated flow of ECS.
- Lower the flow rate by turning the valve to the close direction. (Make sure that the flow rate of ECS is within normal range.)



Lower the flow rate by turning the valve to the close direction

Problem:

- ECS shuts down after alarm message, “[CODE 200] TRO Concentration Low” appears.

Solution:

- Open the door of TSU and check that sampling water has flowed into TRO Sensor.



1. When Sampling water does not flow into the sensor:
  - 1) Raise the pressure of the main pipe in order to let sampling water flow smoothly.
  - 2) Check whether pipe is clogged up or not.
  - 3) When the pipe is clogged up, disassemble the Solenoid valve of TSU and remove the foreign materials after disassembling.  
(Please refer to Ch. 6.4.2 (Regular maintenance Procedure) ANU.)
  
2. When the same problem persists even if sampling water flows into the sensor:
  - 1) Check replacement date of TRO Sensor.  
(Please refer to "Check points before operation-Selecting Remote mode and Checking Supplies – step3".)
  - 2) Make sure to prevent air coming into the tube between CLX and the sensor when replacing the solution.  
(Please refer to "6.4.1 Replacement of TRO Sensor(CLX) Reagent".)
  - 3) If the same problem persists, please contact the manufacturer.
  
3. If ECS operates outside the range of the salinity from 0.1 to 4.2%, it is not possible to produce normal TRO concentrations.  
If CSU displays the value lower than 1.7ms, ECS may not operate properly.  
(There are exceptions in case control valve for conductivity concentration is supplied as an option.)



Problem:

- ECS shuts down 1 minute after alarm message *"The communication failure has occurred between ECU and RCM"* appears.

Solution:

- Please refer to "Troubleshooting for communication section of the equipment".

Problem:

- It is not sure which valve to control to operate ECS.

Solution:

- Please refer to "Troubleshooting for automatic operation of ECS".

Problem:

- ECS shuts down after alarm message *"[CODE 200] TRO Concentration High"* appears.

Reason:

- Discharged neutralizing solution is not injected to the pipe properly during deballasting operation.
- Outlet pipe of ANU is clogged up.

Solution:

- Disassemble the ANU Solenoid valve and clean the inside of the valve in case ANU is not in operation for a long period.
- See if ball in CHECK Valve behind ANU Pump injection is moving up and down.



Loosen the CHECK Valve to remove air in the pipe and see if injection is proper



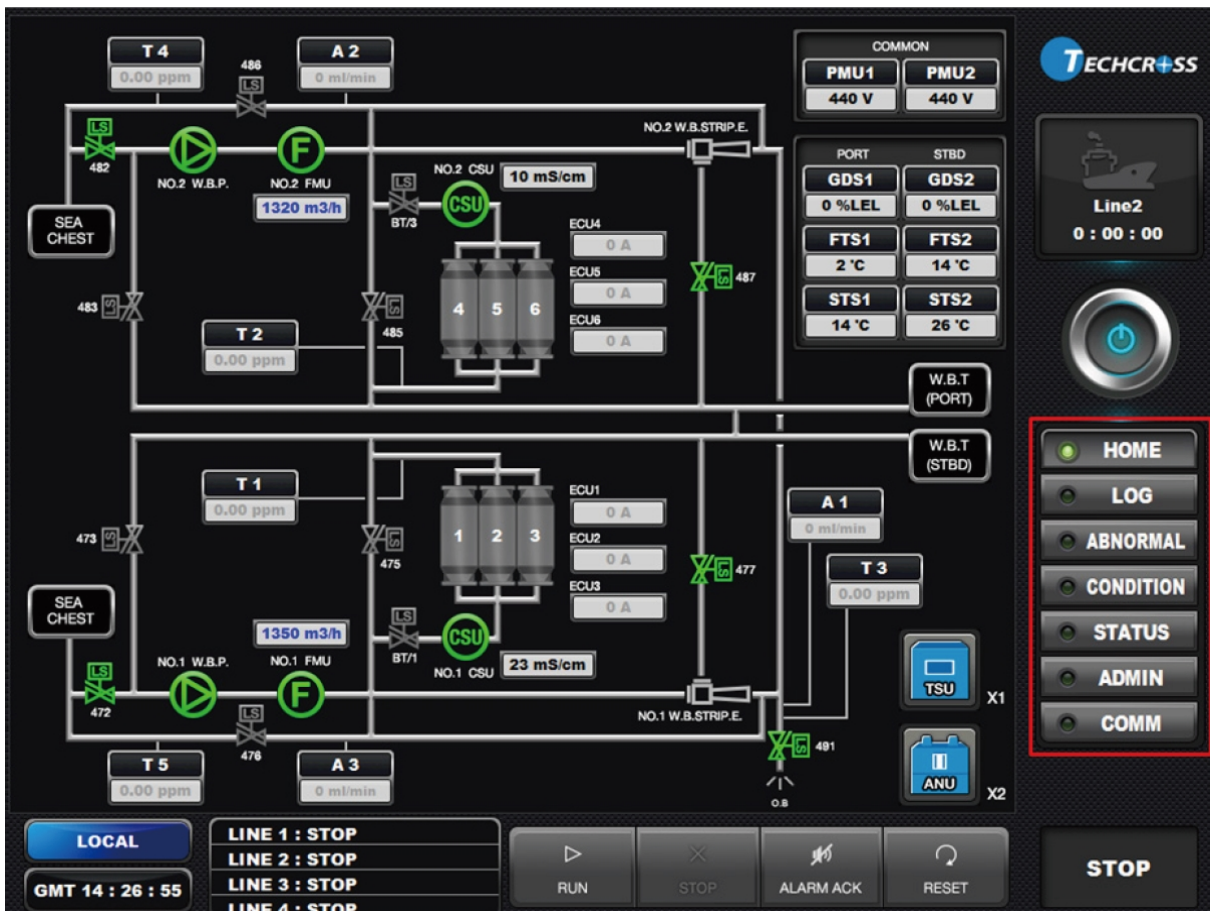
## 8. APPENDIX I

\* Below image can be different from actual system.

### 8.1 Additional function

Additional function offers more information which are not included on HOME screen such as LOG history. Current status of equipment, Operation status and communication among equipment.

#### (1) HMI MIMIC (HOME)



### 8.1.1 Log

ECS records proper function status and failure of BWMS operation. This is implemented as LOG function and LOG function makes it possible to confirm and save every situation occurring during the ECS operation.

As shown below, normal operating status, alarms and fault (trip) situations of BWMS are recorded in ECS.

The screenshot displays the ECS LOG interface. At the top, there are navigation buttons: EVENT, O.P. HOURS, DATA, MAINTAIN, and a 'CONVERT LOG TO PDF' button with a PDF icon. Below these is a search section with a 'SEARCH' label, a date range selector (DATE), and level filters (ALL, NORMAL, ALARM, TRIP). The main area is a table of log entries. Two entries are highlighted: a red 'Trip' and a yellow 'Alarm', both with the description '[CODE406]The Input Voltage Low.[0.00]'. The right sidebar contains the TECHCR+SS logo, ECS logo, 'Line 0:00:00', a power button, and a vertical stack of buttons: HOME, LOG (highlighted), ABNORMAL, OP MODE, STATUS, COMM, ADMIN, and a large STOP button at the bottom.

DATE [YY-MM-DD HH:MM]	DEVICE	LEVEL	DESCRIPT	ACK.TIME [YY-MM-DD HH:MM]	RESET TIME [YY-MM-DD HH:MM]	CLEARED
18-01-15 10:49	ECS	Normal	Valve Opened.[WB/105, NO.1 STRIPPING]	-	-	-
18-01-15 10:49	ECS	Normal	Pump Start.[B.P2, NO.2 BALLAST PUMP]	-	-	-
18-01-15 10:49	ECS	Normal	Pump Start.[B.P1, NO.1 BALLAST PUMP]	-	-	-
18-01-15 10:49	ANU3	Normal	ECS Device Work.	-	-	-
18-01-15 10:49	ECS	Normal	ECS HMI Power On.	-	-	-
18-01-12 15:43	ECS	Normal	ECS HMI Power Off.	-	-	-
18-01-12 15:43	PMU1	Trip	[CODE406]The Input Voltage Low.[0.00]	-	-	-
18-01-12 15:43	PMU1	Alarm	[CODE406]The Input Voltage Low.[0.00]	-	-	-
18-01-12 15:43	ECS	Normal	Pump Stop.[FG.P, FG PUMP RUN]	-	-	-
18-01-12 15:43	ECS	Normal	Valve Opened.[010VWB,NO.2 STRIPPING]	-	-	-
18-01-12 15:43	ECS	Normal	Valve Opened.[031VWB,NO.1 STRIPPING]	-	-	-
18-01-12 15:43	ECS	Normal	Pump Start.[B.P2, NO.2 B.P]	-	-	-

To check the meaning of each operational code levels, please refer to chapter 7.2 of this OMSM.

And operators can convert recorded logs in PDF form. To check the log data,

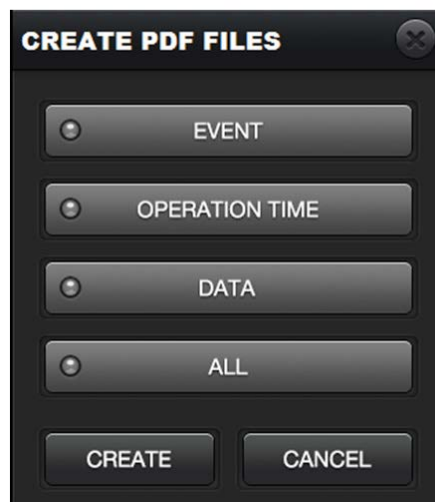


on each “EVENT”, “OPTIME”, “DATE”, “MAINTAIN” tab to choose the period of LOG data.

- After selecting the date, the selected date is shown on the screen by clicking “OK” button. If clicking “TODAY” button, the records saved today is shown on the screen, and clicking “ALL” button, all records is shown.



- Click “PDF” button on upper side of the page. After pop up the window, choose one or more options and click “CREATE” button to save the LOG data as PDF file.



After converting to PDF, recorded logs can be saved as PDF file below directory.

- c:\TECHCROSS\V2\ECS\Log

- d:\

- Inserted USB driver or External HDD which are connected with CPC of ECS.

Below shows reference of converted PDF document.

And for more detailed reference, please find attachment #2. Reference report.

## HMI Operation Log Display

SHIP NAME : SM TIGER

Log Date : 2017-7-27

DATE	DEVICE	LEVEL	DESCRIPTION	Ack.Time	Reset.Time	Clear
2017-1-20 6:49:49	ECS	Normal	ECS HMI Power On.	-	-	X
2017-1-20 6:49:49	ECS	Normal	Valve Opened.[BA088, BV1]	-	-	X
2017-1-20 6:49:49	ECS	Normal	Valve Opened.[BA086, BV2]	-	-	X
2017-1-20 6:53:12	ECS	Normal	Valve Opened.[51V, OV1]	-	-	X
2017-1-20 7:8:47	ECS	Normal	Deballast Start.[BWT]	-	-	X
2017-1-20 7:8:50	ANU1	Normal	ECS Device Work.	-	-	X
2017-1-20 7:8:50	ANU3	Normal	ECS Device Work.	-	-	X
2017-1-20 7:8:50	ANU2	Normal	ECS Device Work.	-	-	X
2017-1-20 7:8:56	TSU1	Normal	ECS Device Work.	-	-	X
2017-1-20 7:16:11	TSU(T1)	Alarm	[CODE201]TRO Concentration High.[2.57]	-	2017-1-20 7:21:45	O
2017-1-20 7:17:0	ECS	Normal	Deballast Stop.[BWT]	-	-	X
2017-1-20 7:17:5	ANU1	Normal	ECS Device Stop.	-	-	X
2017-1-20 7:17:5	ANU2	Normal	ECS Device Stop.	-	-	X
2017-1-20 7:17:5	ANU3	Normal	ECS Device Stop.	-	-	X
2017-1-20 7:17:6	TSU1	Normal	ECS Device Stop.	-	-	X
2017-1-20 7:17:10	ECS	Normal	Pump Stop.[B.P1,BALLAST PUMP1]	-	-	X
2017-1-20 7:37:17	ECS	Normal	Pump Start.[B.P1,BALLAST PUMP1]	-	-	X
2017-1-20 7:37:31	ECS	Normal	Deballast Start.[BWT]	-	-	X
2017-1-20 7:37:34	ANU1	Normal	ECS Device Work.	-	-	X
2017-1-20 7:37:35	ANU2	Normal	ECS Device Work.	-	-	X
2017-1-20 7:37:35	ANU3	Normal	ECS Device Work.	-	-	X
2017-1-20 7:37:41	TSU1	Normal	ECS Device Work.	-	-	X
2017-1-20 8:30:25	ECS	Normal	Deballast Stop.[BWT]	-	-	X
2017-1-20 8:30:29	TSU1	Normal	ECS Device Stop.	-	-	X
2017-1-20 8:30:30	ANU1	Normal	ECS Device Stop.	-	-	X
2017-1-20 8:30:31	ANU2	Normal	ECS Device Stop.	-	-	X
2017-1-20 8:30:31	ANU3	Normal	ECS Device Stop.	-	-	X

- ① Operation and abnormal status of all equipment connected to ECS can be check in EVENT tab. It can be categorized by LEVEL. Please see below.

**LOG**

EVENT OPTIME DATA MAINTAIN CONVERT LOG TO PDF PDF

SEARCH

DATE [YY-MM-DD HH:MM] ~ [YY-MM-DD HH:MM] DAY ALL

LEVEL A ALL B NORMAL C ALARM D TRIP

DATE [YY-MM-DD HH:MM]	DEVICE	LEVEL	DESCRIPT	ACK.TIME [YY-MM-DD HH:MM]	RESET TIME [YY-MM-DD HH:MM]	CLEARED
15-05-27 14:25	TSU1	Normal	ECS Device Stop.	-	-	-
15-05-27 14:25	ANU1	Normal	ECS Device Stop.	-	-	-
15-05-27 14:25	TSU1	Normal	ECS Device Work.	-	-	-
15-05-27 14:25	ANU1	Normal	ECS Device Work.	-	-	-
15-05-27 14:25	ECS	Normal	Valve Opened,[477, No1. STRIPPING VALVE]	-	-	-
15-05-27 14:25	ECS	Normal	Valve Opened,[487, No2. STRIPPING VALVE]	-	-	-
15-05-27 14:25	ECS	Normal	Pump Start,[B.P2,No2. BALLAST PUMP]	-	-	-
15-05-27 14:25	ECS	Normal	Pump Start,[B.P1,No1. BALLAST PUMP]	-	-	-
15-05-27 14:25	ECS	Normal	Valve Opened,[482, No6. BYPASS VALVE]	-	-	-
15-05-27 14:25	ECS	Normal	Valve Opened,[472, No5. BYPASS VALVE]	-	-	-
15-05-27 14:25	ECS	Normal	ECS HMI Power On,[491, No1. OVERBOARD VALVE]	-	-	-

TECHCR+SS

Line2  
0 : 00 : 00

HOME LOG ABNORMAL CONDITION STATUS ADMIN COMM STOP

- ② OPTIME shows the information of operations such as operation time, location, operated line and that sort of things. It can be checked separately by date and operation mode. Please see below for more details.

**LOG**

EVENT OPTIME DATA MAINTAIN CONVERT LOG TO PDF PDF

SEARCH

DATE [YY-MM-DD HH:MM] ~ [YY-MM-DD HH:MM] TODAY ALL

INDEX	TIME	CSU1	CSU2	BW_3	REC1_CURRENT	REC1_VOLTAGE	REC2_CURRENT	REC
2305	2015-05-27 16:10	22	10	0	0	0	0	
2304	2015-05-27 16:09	22	10	0	0	0	0	
2303	2015-05-27 16:08	22	10	0	0	0	0	
2302	2015-05-27 16:07	22	10	0	0	0	0	
2301	2015-05-27 16:06	22	10	0	0	0	0	
2300	2015-05-27 16:05	22	10	0	0	0	0	
2299	2015-05-27 16:04	22	10	0	0	0	0	
2298	2015-05-27 16:03	22	10	0	0	0	0	
2297	2015-05-27 16:02	22	10	0	0	0	0	
2296	2015-05-27 16:01	22	10	0	0	0	0	
2295	2015-05-27 16:00	22	10	0	0	0	0	

TECHCR+SS

Line2  
0 : 00 : 00

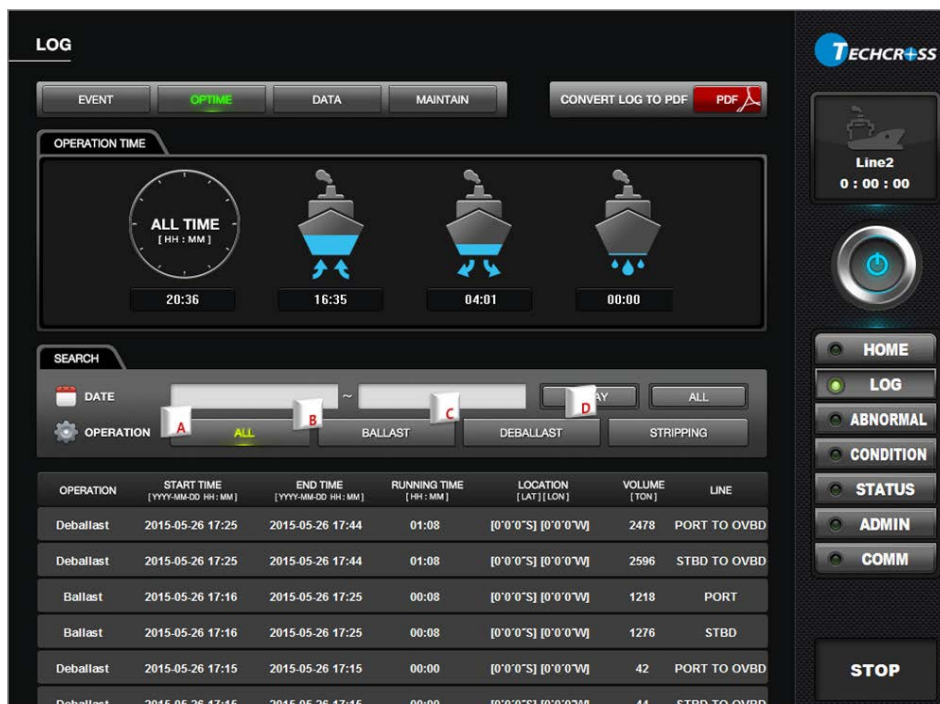
HOME LOG ABNORMAL CONDITION STATUS ADMIN COMM STOP

- ③ Data tab on LOG page includes the variation of values according to the time. It is also available to be checked separately by date. Please see below.



- ④ History of ECS maintenance can be check in MAINTAIN tab by selecting “SELECT UNIT” and “SELECT WORK” sessions.

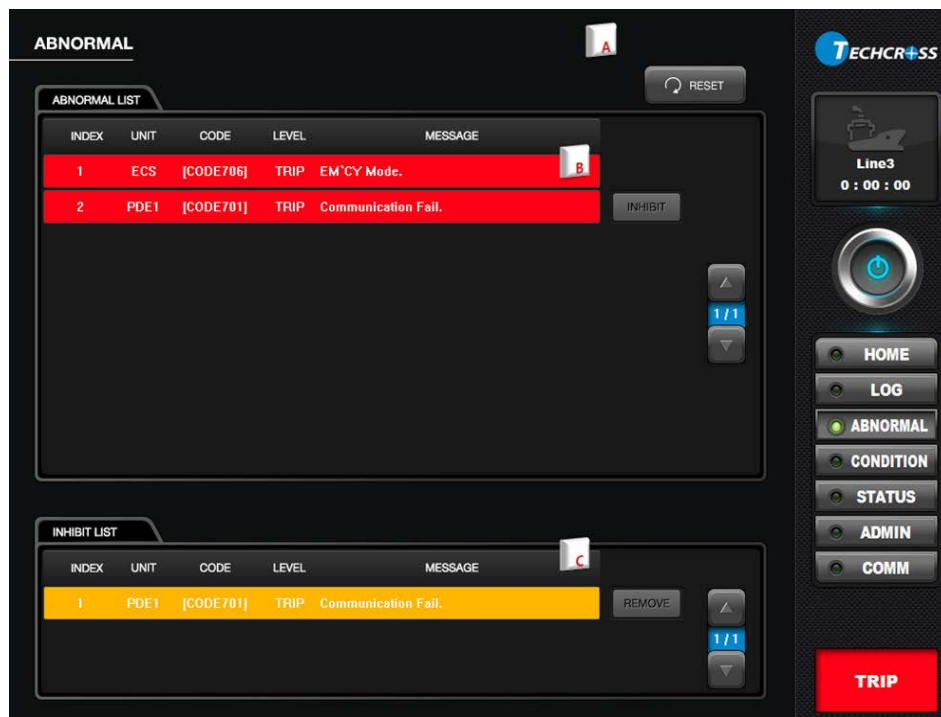
- A. The ANU neutralizer supplement is recorded automatically.
- B. Click “REGISTER” button to make cleaning records with selecting line which is cleaned before.
- C. Click “REGISTER” button to make TSU reagent changing records with selecting TSU.



## 8.1.2 ABNORMAL

Abnormal status records are indicated on ABNORMAL page. In case administrator be aware of the reason of abnormal, it can be set to be invisible using INHIBIT function. Please see below for more details.

- ① In case of “Alarm” situation, the text will be shown on a yellow background, and “Trip” situation the text will be shown on a red background.
- ② After solve the abnormal situation, click “RESET” button to remove.
- ③ Registration of inhibit conditions: Click “INHIBIT” button and enter the password. Please make sure that the user must be aware of abnormal situations before set the inhibit function.
- ④ Removal of inhibit



### 8.1.3 CONDITION

Condition page shows the preparation for ECS operation which helps operator check ECS operation comparing current signals to signals needed on each mode. Please see below for more details.

- ① Select the mode in section “Select Operation Mode”.
- ② Conditions for the selected mode will be listed in section “Condition view”. The ship signal has to be correspond with the list of the conditions.
- ③ Match up the flow within normal range in section “FLOW”.
- ④ If the conditions in section “Condition view” and “Flows” are in accordance with the conditions required for each operation, the green light will turned on to show the possibility of operation.
- ⑤ The contents in section “CONDITION VIEW”



## 8.1.4 STATUS

This page shows detailed states and conditions of ECS components. ①All values and conditions of ECS components can be checked in section “DIVICE”.

The screenshot displays the 'STATUS' page of the TECHCR+SS system. The interface is divided into several sections:

- Navigation:** At the top left, there are tabs for 'DEVICE' (highlighted with a red box), 'ANALOG', and 'DIGITAL'. On the right side, there is a vertical menu with buttons for 'HOME', 'LOG', 'ABNORMAL', 'CONDITION', 'STATUS' (highlighted with a red box), 'ADMIN', and 'COMM'. A 'STOP' button is located at the bottom right.
- ECU Section:** Titled 'ECU' with 'Total Qt'y : 6'. It shows 'ECU #1' with 'VOLTAGE 0.0 V' and 'CURRENT 0 A'. Below this is a table of PRU (Power Relay Unit) current values:
 

PRU #1	100 A	PRU #5	-
PRU #2	100 A	PRU #6	-
PRU #3	100 A	PRU #7	-
PRU #4	100 A	PRU #8	-
- PDE Section:** Titled 'PDE' with 'Total Qt'y : 2'. It shows 'PDE #1' with 'VOLTAGE (AVG) 440.0 V', 'CURRENT (AVG) 0 A', and 'POWER (SUM) 0.0 kW'. Below this is a table of R, S, and T parameters:
 

R			S			T		
VOLTAGE	440.0 V		440.0 V		440.0 V			
CURRENT	0 A		0 A		0 A			
POWER	0.0 kW							
- TSU Section:** Titled 'TSU' with 'Total Qt'y : 1'. It shows 'TSU #1' with two CLX (Chlorine) sensors:
 

CLX #1		CLX #2	
B/P #1	0.00 PPM	B/P #1	0.00 PPM
B/P #2	0.00 PPM	B/P #2	0.00 PPM
B/P #3	0.00 PPM	B/P #3	0.00 PPM
B/P #4	0.00 PPM	B/P #4	0.00 PPM
B/P #5	0.00 PPM	B/P #5	0.00 PPM
B/P #6	-	B/P #6	-
- ANU Section:** Titled 'ANU' with 'Total Qt'y : 2'. It shows 'ANU #1' with two tanks:
 

TANK 1		TANK 2	
AMOUNT	0 ml/min	AMOUNT	0 ml/min
STATUS	R O A E	STATUS	R O A E
READY		READY	
- Location:** At the bottom, there is a 'LOCATION (GPS)' section with fields for 'LAT' and 'LON'.

- ECU: State of ECU connected to PDE
  - PRU: Current supplied to each EM
  - Voltage: Voltage supplied to ECU
  - Current: Current supplied to ECU
- PDE: State of PDE
  - Voltage: Voltage supplied to PDE
  - Current: Current supplied to PDE
  - Power: Power supplied to PDE
- TSU: Measurements by TSU
  - CLX#1 on TSU: TRO concentration measured by CLX#1
  - CLX#2 on TSU: TRO concentration measured by CLX#2

-ANU: Injection amount of neutralization solution of ANU and the operating state of ANU

- R(Ready): The status of neutralization solution in the tank for the normal operation
- O(Overflow): Overflow of neutralization solution
- A(Add): The status of adding neutralizer in ANU tank.
- E(Empty): Neutralization solution is empty or not

LOCATION (GPS): Location of ship received from GPS(latitude/longitude) Recorded with ECS operation records.

All status and the measurement values of ECS analog components can be checked in this section.

**STATUS**

TECHCR+SS

Line2  
0 : 00 : 00

HOME  
LOG  
ABNORMAL  
CONDITION  
**STATUS**  
ADMIN  
COMM

STOP

1 / 1

Component	Normal Range	QMax	Value
CSU1	2~200	200100	23 mS/cm
CSU2	2~200	100	10 mS/cm
FMU1	240~1590	10000	1350 m3/h
FMU2	240~1590	10000	1320 m3/h
FTS1	0~43	100	2 °C
FTS2	0~43	100	14 °C
GDS1	0~25	100	0 %LEL
GDS2	0~25	100	0 %LEL
STS1	0~25	100	14 °C
STS2	0~25	100	26 °C

- Normal Range: Normal range of measured values
- Q Max: The maximum measurable value
- Value: Real time measurement

Status and signal of ECS digital components can be checked in this section.




## 8.1.5 ADMIN

Admin page can set an equipment of ECS such as ECU, TSU(CLX), ANU(PUMP), and Sensors as disabled to forcedly operate ECS in case of that equipment is faulty or broken down.

\*CAUTION: when equipment is set disabled, additional trouble on the disabled equipment cannot be detected. Once trouble is solved, it is required to set the equipment enabled.

- ① Click the equipment to disable (color changes into grey) and click again to enable (color changes into green).



- ② Click  to set other equipment





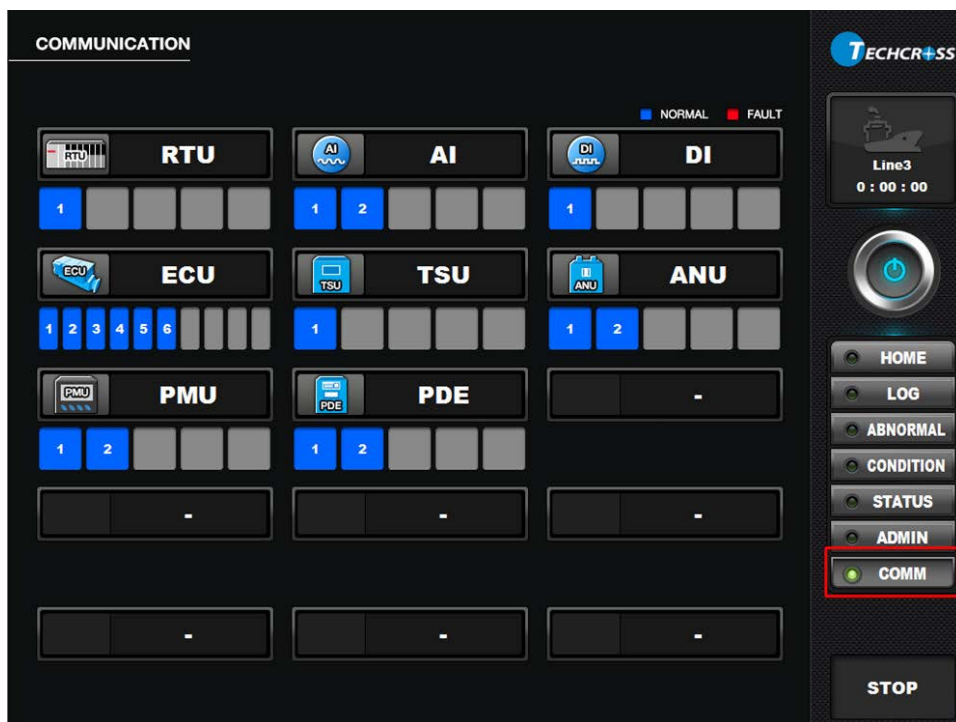
Please enter the password to access Admin.

### 8.1.6 COMM(Communication)

① The communication among ECS Components connected to PDE can be monitored in real time.

Normal operation: BLUE / Abnormal operation: RED.

② Numbers in square mean the quantity of equipment and order.



## 8.1.7 Detail view of HMI Innovation

Operator easily can get information of ECS components from HMI. If some errors occur during the ECS operation, color of symbols will be changed to yellow or red. Click the symbols on HMI home screen to see more details of each ECS component.

### 8.1.7.1 PMU

Operation signs of PMU

Digital Power Meter checks input power and current consumption of main power supplied for PDE. Measurement values will be shown on LCD screen of DPM.



A. Current consumption of 440V main power

(If the ECU is operated current consumption will be increased)

B. Input voltage of 440V main power.

### 8.1.7.2 ECU (ECU Signal Junction box)

1) ECU (Electro-Chamber Unit)

Operation signs of ECU



A. ECU status indicator (Run / Stop)

B. Current consumption / Voltage of ECU.

If the power is supplied to ECU during ballasting, each EM of PRU measures the current consumption.

### 8.1.7.3 TSU (TRO Sensor Unit)

Operation signs of TSU

There are two CLX sensors installed in TSU. HMI indicates the measurement value by using an activated CLX of two.



A. TSU status indicator (Run / Stop)

B. The measurement values of CLX

### 8.1.7.4 ANU (Auto Neutralization Unit)

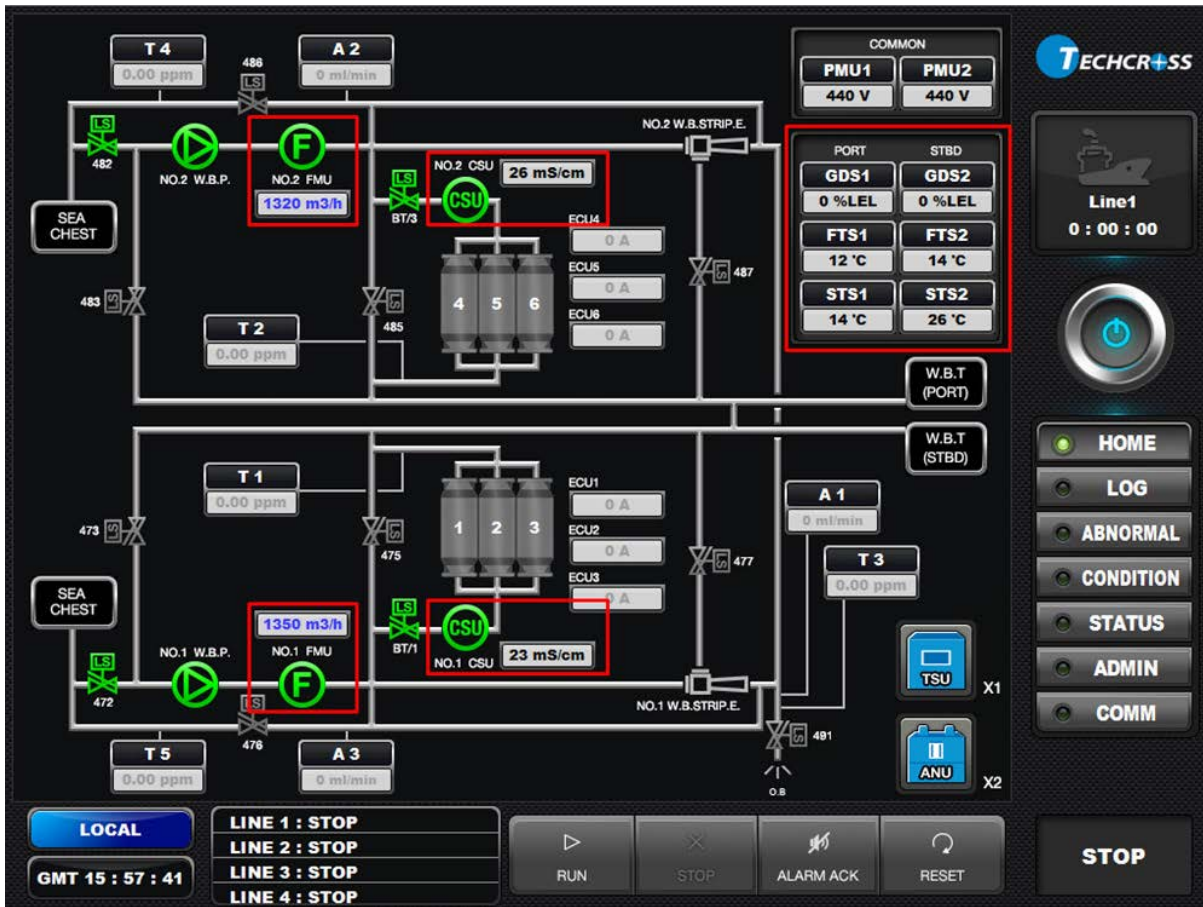
Operation signs of ANU



- A. ANU status indicator (Run / Stop)
- B. The amount of injected neutralizer

There are two fresh water tanks to inject neutralization solution. In case of normal communication state during de-ballasting, ANU is displayed on HMI screen as above. If one fresh water tank uses up neutralization solution, the other fresh water tank is filled with neutralization solution automatically. Then, fresh water is automatically supplied to a fresh water tank using up the solution and indication lamp is on HMI screen if fresh water is filled up to a specific level. When indication lamp is on ECS operator have to inject neutralization solution then operate the agitator.

8.1.7.5 SENSORS



The sensors installed on ECS are indicated on HMI main screen as follows.

Sensor	Operation range	Description
CSU	1 PSU ~	Conductivity Sensor Unit
FMU	Normal Operational Condition: 30% ~ 110%	Detection ballast water flow rate (m <sup>3</sup> /h)
	Less than 1PSU: 30%~80%	
FTS	~ 45°C	Fresh Water Temperature Sensor
STS	-	Sea Water Temperature Sensor
GDS	0 ~ 25%LEL	Gas Detected Sensor

## 8.1.8 Stopping ECS operation

### 8.1.8.1 ECS stop procedure

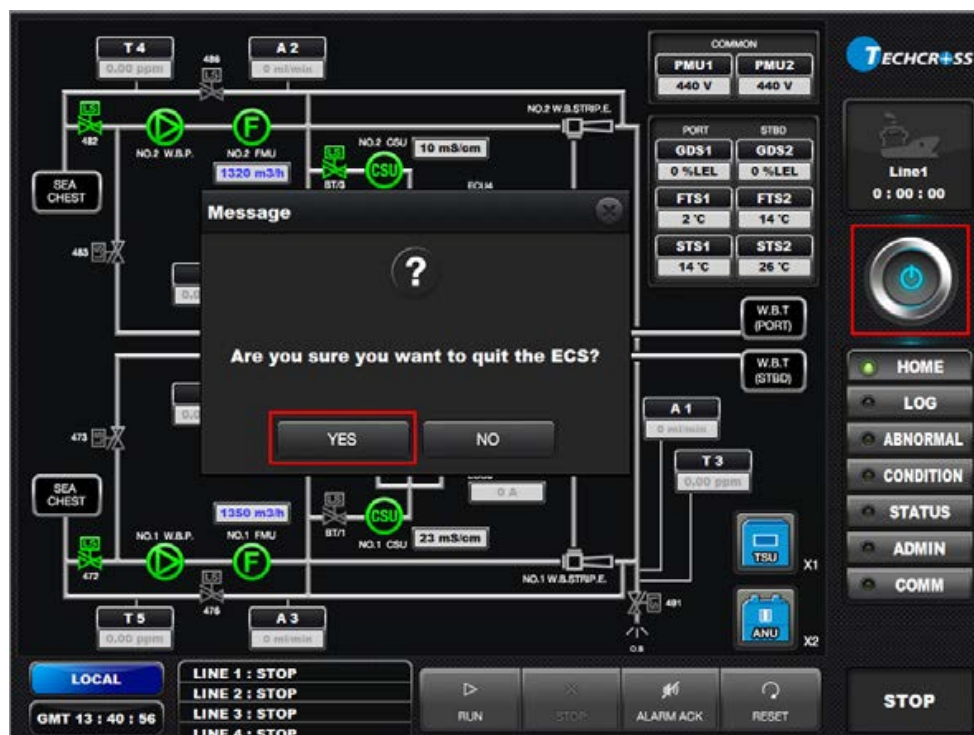
To stop the ECS operation, click "STOP" button.

\* If the flow rate of ballast water goes down under 10% during operation, ECS will be stopped automatically. However when it goes back up, ECS will be started again.

- ① Stop the Ballast pump.
- ② Click "STOP" button on HMI screen of CPC on PDE or in CCR.
- ③ Close the ballast valve.
- ④ Click (Power button) on HMI screen of CPC. Click "Yes" button, after the message "Are you sure you want to quit the ECS?" is appeared. Then HMI will be shut down.
- ⑤ Exit the operation system (Windows)
- ⑥ If the message "IT is now to turn off your computer" is appeared on CPC screen, turn off the power of CPC. \* It is not important which of CPC's is turned on first between CCR and PDE \* CPC must be turned off after exiting the operation system(Windows). Otherwise, the program can be damaged.
- ⑦ Turn off 440V MCCB power of PDE. (CAUTION \*)

Caution!!!

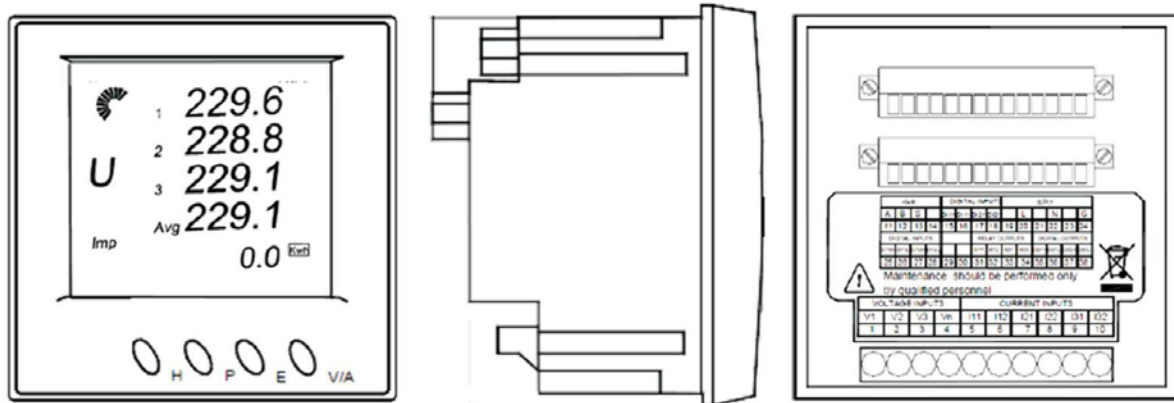
Carelessness in the above may cause fatal error of ECS due to the residual current.



## 8.2 Additional functions of Equipment

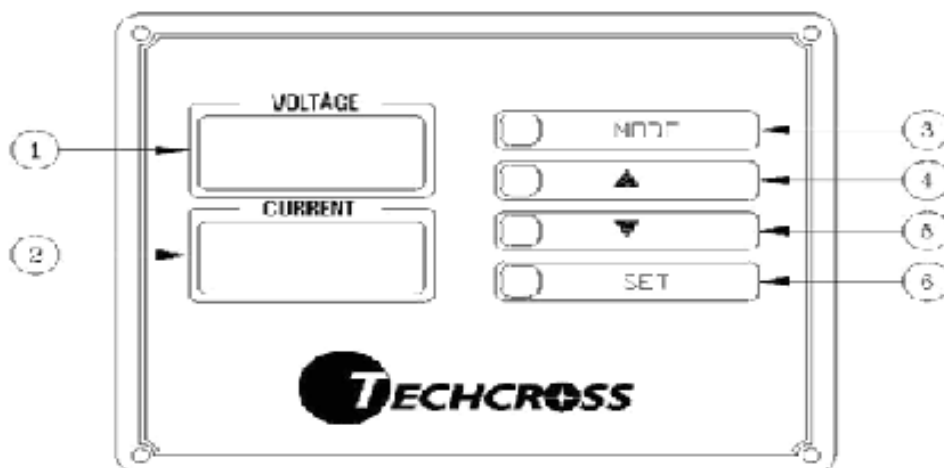
### 8.2.1 Digital Power Meter

Digital Power Meter is a microprocessor-based unit, and measures all the powers in the PDE. The measured values can be read from the built-in display. By pressing 4 buttons marked as H, P, E and V/A, you can read off the measured voltage and amperes of the PDE.



## 8.2.2 RCM(M1)

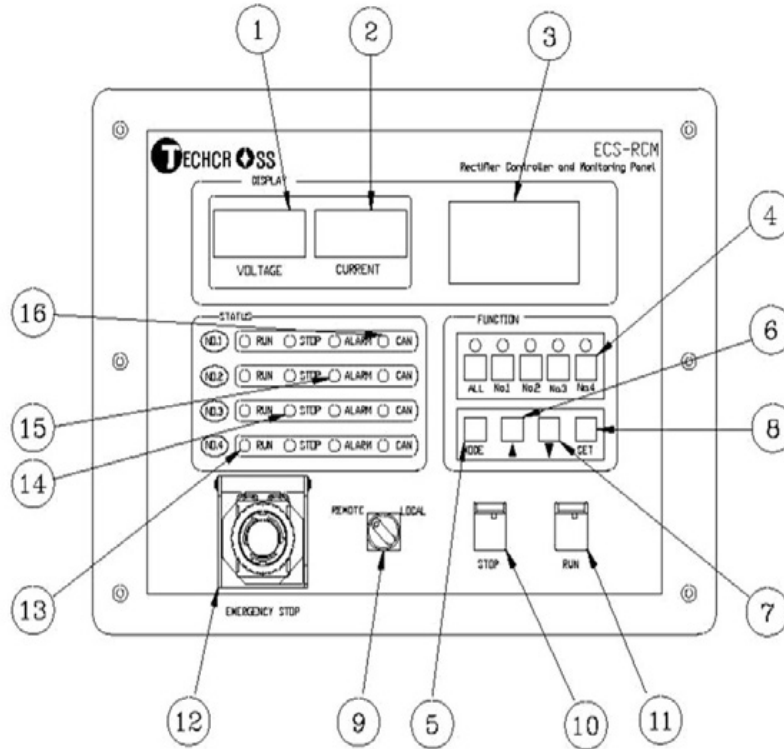
RCM consists of 4 Digit 7-Segment LEDs, and MODE / SET buttons; setting and checking menus as well as controlling and monitoring PRU will be done with the buttons.



No.	PART NAME	FUNCTION
1	VOLTAGE DISPLAY	Display setting voltage or running voltage (color : green)
2	CURRENT DISPLAY	Display setting current or running current (color : green)
3	MODE KEY	Select operation mode or cancellation of parameter setting
4	UP KEY	Select setting parameter to upward position or increase setting value of parameter
5	DOWN KEY	Select setting parameter to downward position or decrease setting value of parameter
6	SET KEY	Select parameter value position to change by pressing key shortly or save parameter by pressing key more than 1sec

### 8.2.3 RCM (M4)

RCM consists of 4 Digit 7-Segment LEDs, and MODE / SET buttons; setting and checking menus as well as controlling and monitoring PRU will be done with the buttons.



No.	PART NAME	FUNCTION
1	VOLTAGE DISPLAY	Display setting voltage or running voltage (color : green)
2	CURRENT DISPLAY	Display setting current or running current (color : green)
3	LCD DISPLAY	Display operation status and setting parameter for PRU
4	PRU SELECTION KEY	Select operation of PRU by switching on of All or NO1 to NO4 button respectively
5	MODE KEY	Select operation mode or cancellation of parameter setting
6	UP KEY	Select setting parameter to upward position or increase setting value of parameter
7	DOWN KEY	Select setting parameter to downward position or decrease setting value of parameter
8	SET KEY	Select parameter value position to change by pressing key shortly or save parameter by pressing key more than 1sec
9	REMOTE/EMERGENCY SWITCH	Select Remote or Emergency control mode
10	STOP SWITCH	Stop and reset operation of power rectifier equipment (lamp color : red)

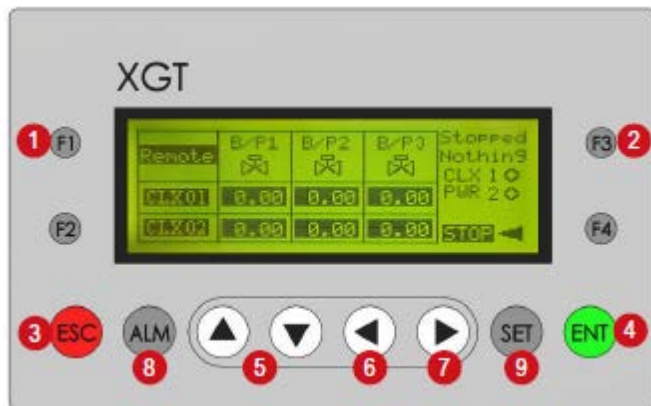
No.	PART NAME	FUNCTION
11	RUN SWITCH	Start and run operation of power rectifier equipment (lamp color : green)
12	EM'CY STOP SWITCH	Stop operation of power rectifier equipment in emergency status
13	RUN LED	Indicate operation of power rectifier equipment
14	STOP LED	Indicate stop of power rectifier equipment
15	ALARM LED	Indicate alarm state of power rectifier equipment
16	OPERATION OF CAN LED	Indicate CAN communication status

## 8.2.4 TSU

### 8.2.4.1 Main Components

Main Components	Description
XGT control panel	User interface of TSU It stops in emergency during remote operation. Operators can perform local operation on XGT control panel.
PLC	Direct control of TSU It can be operated by remote signal of HMI. For TRO measurement, operate CLX, solenoid valve and pump automatically and sequentially. It displays TRO concentration on HMI or Control Panel. In local mode, it can be operated without remote signal of HMI.
CLX	Measuring TRO concentration of ballast water using DPD method It sends the measured TRO concentration with analog output
Air pump and Solenoid valve	It delivers sample water to measure TRO concentration to necessary parts through solenoid valves.


### 8.2.4.2 Configuration of TSU SGT control panel



1. Selection of Remote or Emergency mode
2. Set valves of sampling pipe line from B/P1, B/P2, and discharge ballast pipe line in Local mode **B/P2 B/P1 B/P3**.
3. Menu Screen
4. Save changes  
Move on to additional function setting screen if press for seconds.
5. Move among LCD lines
6. Emergency stop in Remote and Local mode (**Stopped STOP**)
7. Run TSU in Local mode
8. Alarm report
9. Sett treating time
10. ETC TRO concentration of CLX01 or CLX02 by selected valves
11. ETC Power status of CLX01 and CLX02

The text shadow is changed and dark color indicates the current selection





### 8.2.4.3 Additional Features and Options


1. Press  to set Additional functions shown below:



1. PASSWORD UNLOCK
2. PASSWORD LOCK
3. PASSWORD CHANGE
4. DATE/TIME SET
5. BUZZER VOLUME SET
6. BACK LIGHT SET
7. DOWNLOAD SPEED
8. SYSTEM INFORMATION


2. Move LCD lines with   and press .

3. Use   to change parameters and change the position of cursor with  .

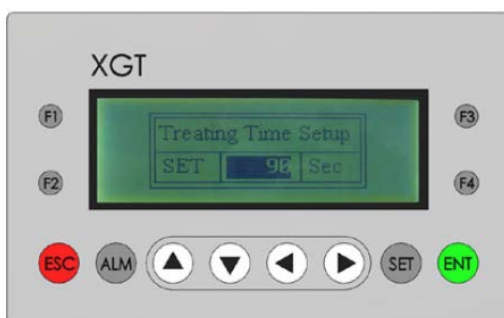
4. Press  to save the changes.





### 8.2.4.4 Set up the Measuring Time


The measuring time is a duration, during which TRO concentrations can be read off from CLX. The measuring time can be changed remotely through HMI, and it can be set manually in the case of emergency or operators' intention.

1. Press  to go to Treating Time Setup screen.

2. Or press  and move to **3. Management #1**. Press .



3. Use   to change parameters and change the position of cursor with  .

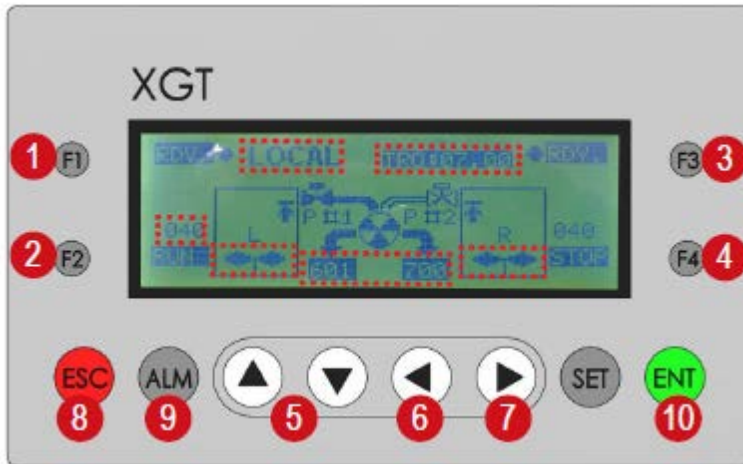
4. Press  to save the change.

## 8.2.5 ANU

### 8.2.5.1 Main Components

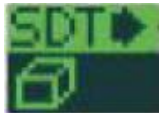









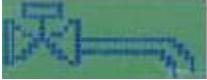











Main Components	Description
XGT control panel	<ul style="list-style-type: none"> <li>• User interface of ANU</li> <li>• It stops in emergency during remote operation. Operators can perform local operation on XGT control panel.</li> </ul>
PLC	<ul style="list-style-type: none"> <li>• Direct control of TSU</li> <li>• It can be operated by remote signal of HMI. For TRO measurement, operate CLX, solenoid valve and pump automatically and sequentially.</li> <li>• It displays TRO concentration on HMI or Control Panel. In local mode, it can be operated without remote signal of HMI</li> </ul>
Metering Pump	<ul style="list-style-type: none"> <li>• Injection of neutralization solution to neutralize TRO of treated ballast water during deballasting work</li> <li>• Appropriate amount of neutralization solution is adjusted by ECS main controller, HMI or PLC in ANU.</li> </ul>
Level sensor	<ul style="list-style-type: none"> <li>• Measurement of water level in the fresh water tank</li> <li>• High/Low Water level sensor</li> </ul>
Panel Pilot Lamp	<ul style="list-style-type: none"> <li>• When fresh water is supplied to high water level, tower lamp is turned on to inform operators to put neutralizing agent.</li> </ul>
Solenoid valve	<ul style="list-style-type: none"> <li>• It controls fresh water supply and the amount of neutralization solution to be injected automatically by controlling the valves.</li> </ul>

### 8.2.5.2 Configuration of ANU XGT Control panel



1. Run the agitator of left fresh water tank
2. Run ANU in **Emergency mode**
3. Run the agitator of right fresh water tank
4. Emergency stop in Remote and **Emergency mode**
5. Moving among LCD lines  
Setting the injection amount of neutralization solution in Local mode
6. Closing the all opened valves to inject neutralizations solution in Local mode
7. Selection of the valve to inject neutralization solution in direction to P#1 or P#2 in Local mode
8. Clearing the alarm / Conversion to Menu screen
9. Alarm report
10. Saving changes
11. Current mode status
12. TRO concentration after neutralizing
13. Agitator operation time duration. It indicates remaining time for the agitator to be operated
14. Injection amount of neutralization solution (Unit: ml/min)

## 8.2.5.3 Icons used in ANU XGT control panel

Icons	Status	Icons	Status
	Agent to put into the left tank		Agent to put into the right tank
	Left fresh water tank not ready		Right fresh water tank not ready
	Left fresh water tank ready		Right fresh water tank ready
	Abort the chosen valve in the direction of P#1		Abort the chosen valve in the direction of P#2
	Choose valve in the direction of P#1		Choose valve in the direction of P#2
	Abort the valve on the left fresh water tank		Abort the valve on the right fresh water tank
	Choose the valve on the left fresh water tank		Choose the valve on the right fresh water tank
	Supply the left fresh water tank with fresh water		Supply the right fresh water tank with fresh water
	Left fresh water tank overflows		Right fresh water tank overflows
	High water level		On Metering pump
	Low water level		On Agitator

### 8.3 Detailed Maintenance Procedure

#### 8.3.1 Replacement of Spare parts

**Caution!! All power should be disconnected when spare parts are replaced.**

##### 8.3.1.1 Replay

Voltage: DC 24V



Voltage: AC 220V



Applicable equipment and location: PDE / ANU / TSU



PDE(DC24V)



ANU(AC220V )



TSU(AC220v)

Step 1: **Remove** Relay supporting hook.

Step 2: **Remove** defective Relay by shaking up and down.

Step 3: **Install** a new relay in the relay socket after checking voltages

(LED Lamp Color: red - AC220V / blue - DC24V)

Step 4: **Check** the operation.

(LED Lamp light and operation state)



### 8.3.1.2 Indication Lamp

(White)



(Red)



Applicable equipment and location: PDE



Step 1: **Disassemble lamp part** and **Acryl cover** with a screw driver.

Step 2: **Remove lamp** from the **lamp part** with a screw driver.

Step 3: **Check** socket and voltages of a new lamp and reassemble the lamp, following instructions in reverse order (from step 2 to step 1).

Step 4: After the power is **ON**, **check** the operation state using lamp test switch.



### 8.3.1.3 Lamp (Bulb)

White



Red



Yellow



Green



Applicable equipment and location: PDE



Step 1: **Take apart** the power part of button lamp and **remove** the defective lamp by turning to the left.

Step 2: **Remove** defective lamp by turning 90 degrees to the left while pressing inward.

Step 3: **Check** color and voltages of a new lamp and **replace** it, following instructions in reverse order (from step 2 to step 1).

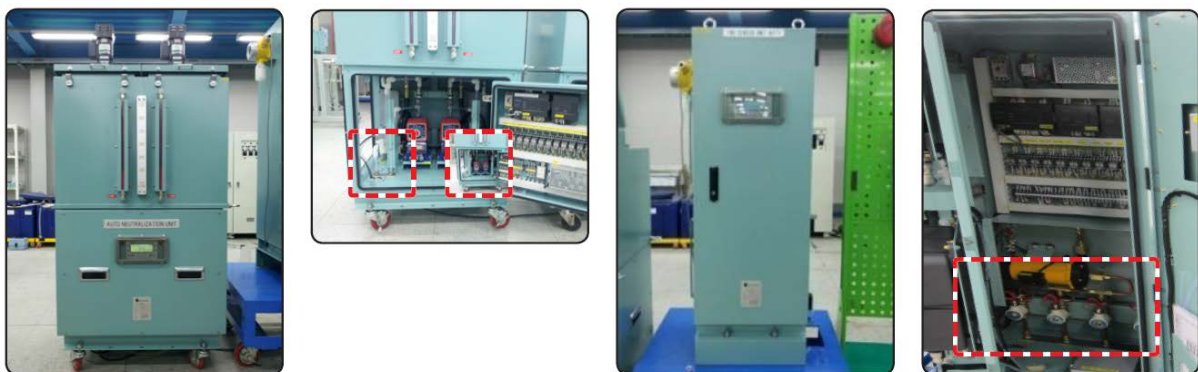
Step 4: After the power is **ON**, **Check** operation of lamp. (Lamp light)



### 8.3.1.4 Solenoid Valve(Sol V/V)



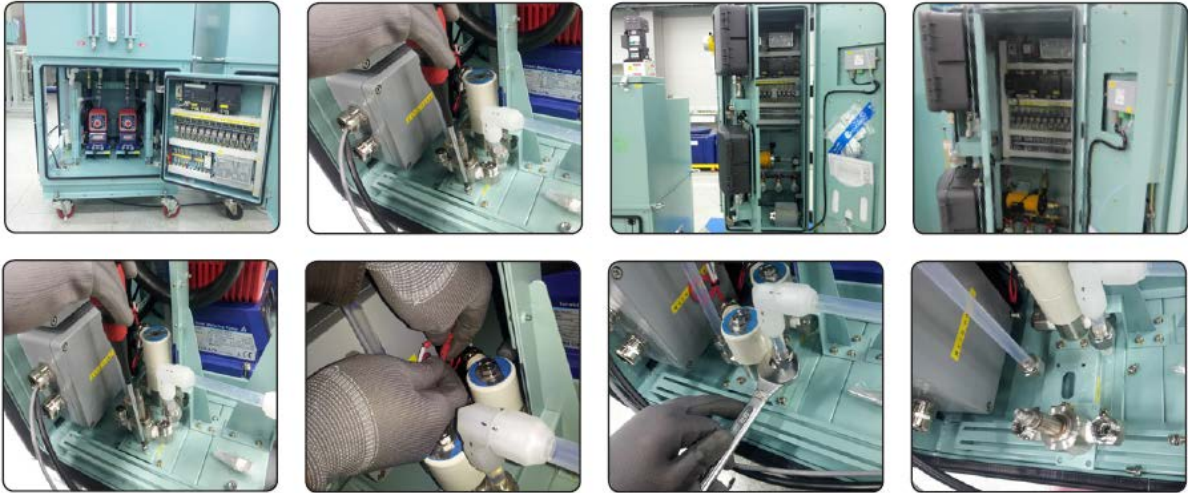
Applicable equipment and location: ANU / TSU



Step 1: **Remove** body / pipe / wiring of defective SOL V/V with a screw driver and a wrench.

Step 2: **Check** installation direction of a new SOL V/V and **replace** it, following instructions in reverse order (from step 2 to step 1)

Step 3: After the power is **ON**, **Check** operation state.



### 8.3.2 Procedure for ECU Cleaning

Cleaning the EM in the ECU with EWU (EM Washing Unit)

#### 8.3.2.1 EWU Components

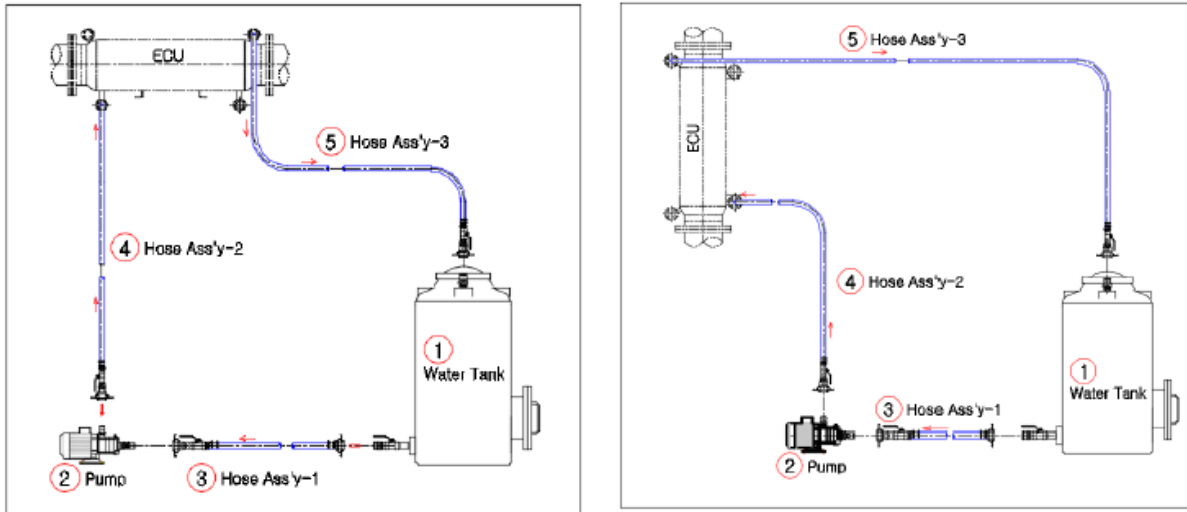



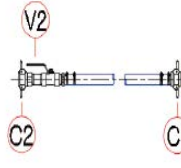

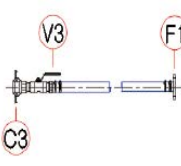



Figure 1. EWU Components

No.	Item	Description	Remark
1.	Water tank	1. Steel Tank Support 1. Material : LLDPE 2. Capacity : 300L	
2.	Pump	1. PUMP MODEL : DOOCH, DHF4- 30 2. POWER : AC 220V 3. POWER CONSUMPTION : 1kW 4. WEIGHT : 17KG 5. Size : 485 X 130 X 170	

No.	Item	Description	Remark
3.	Hose Ass'y-1	Q'TY : 1EA / SET EWU Tank(25A Coupling) ↔ Pump (25A Coupling)	 
4.	Hose Ass'y-2	Q'TY : 1EA / SET Pump (25A Coupling) ↔ ECU Drain Port (10K-25A Flange)	 
5.	Hose Ass'y-3	Q'TY : 1EA / SET EWU Tank(25A Coupling) ↔ ECU Drain Port (10K-25A Flange)	 
6.	Hose Ass'y-4	Q'TY : 1EA / SET Pump (25A Coupling) ↔ EWU Tank(25A Coupling)	 
7.	Hose Storage Box	1. Material : Steel 2. Size : 700 X 700 X 380	
8.	Chemical Tank Caster	1. Rotation Brake Type : 2EA 2. Fixed Type : 2EA	
9.	Cleaning Agent	1. Citric acid (Powder) To purchase, please contact TECHCORSS	

### 8.3.2.2 Input of fresh water

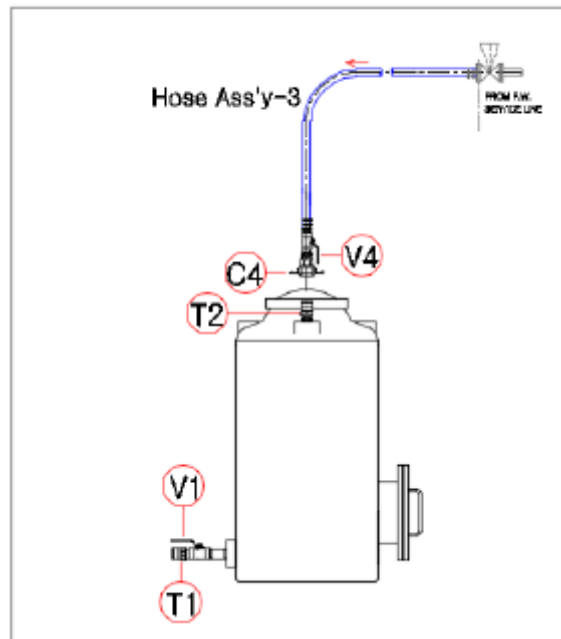


Figure. 2 Pipe connection for input of fresh water

1. **CLOSE** Valve (V1) at Tank Outlet.
2. **CLOSE** Valve of fresh water cooling service line
3. **CONNECT** the **fresh water cooling service line** of ship to **Tank (T2)** using **Hose Ass'y-3**.
4. **OPEN** Valve of F.W. cooling service line (Yard pipe).
5. INJECT CLEANING AGENT.

Please refer to the Table 1 (below) for the appropriate amount of cleaning agent and fresh water.

6. **DISCONNECT** the **fresh water pipe** from **Tank (T1)**.

<Table 1>

(Unit: Liter)

Model	Space volume	Amount of Fresh Water(Liter)	Amount of Cleaning agent(Kg)	Dilution ratio (%)
ECS 150	60	80	8	10
ECS 300	80	100	10	10
ECS 450	110	130	13	10
ECS 600	140	160	16	10
ECS 1000	250	270	27	10

\* Mixing ratio of fresh water and cleaning agent: 5~15%

### 8.3.2.3 Mixing of Citric acid(by using Hose Ass'y-1 and Hose Ass'y-4)

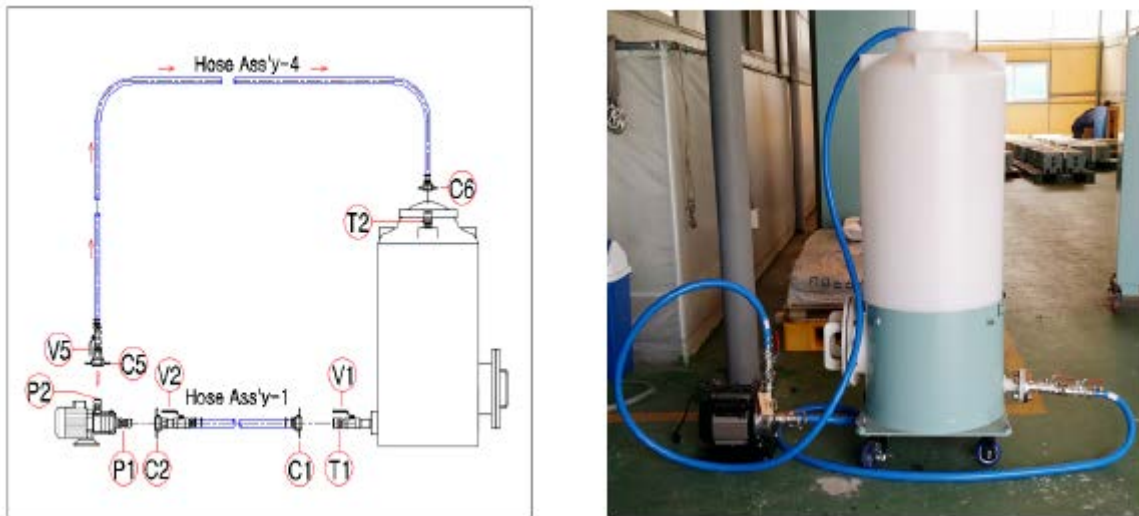


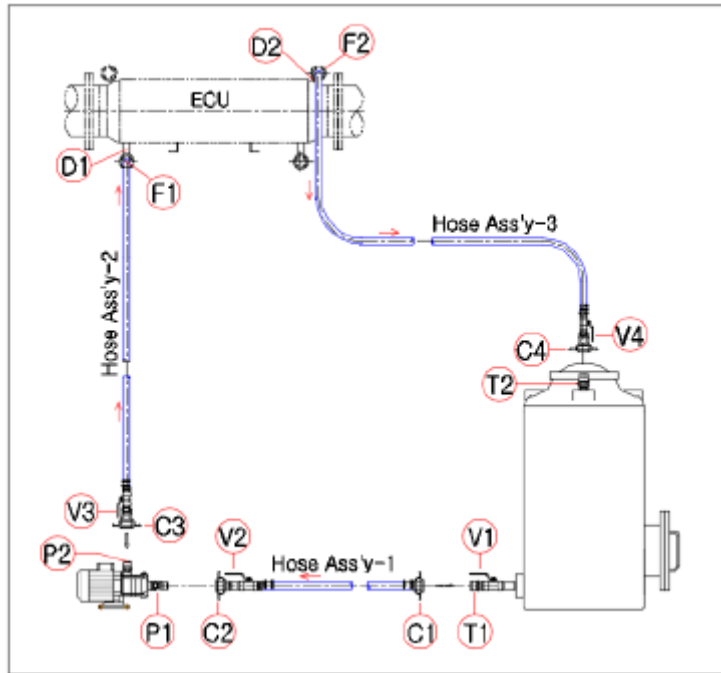
Figure 3. Pipe connection for Mixing of Citric acid

1. **Connection the pump and water tank by using hoses (Hose Ass'y-1 and Hose Ass'y-4)**
  - A. **CONNECT** coupling (C1) of Hose Ass'y-1 to Tank (T1).
  - B. **CONNECT** coupling (C2) of Hose Ass'y-1 to coupling (P1) to Pump.
  - C. **CONNECT** coupling (C5) of Hose Ass'y-4 to coupling (P2) to Pump.
  - D. **CONNECT** coupling (C6) of Hose Ass'y-4 to Tank (T2).
2. **OPEN** all the valves (V1, V2 and V5).
3. **CONNECT** power cable (220VAC) to the Pump and **Operate** the Pump.
  - Pump Power can be connected from the receptacle of PDE if power source is not available.

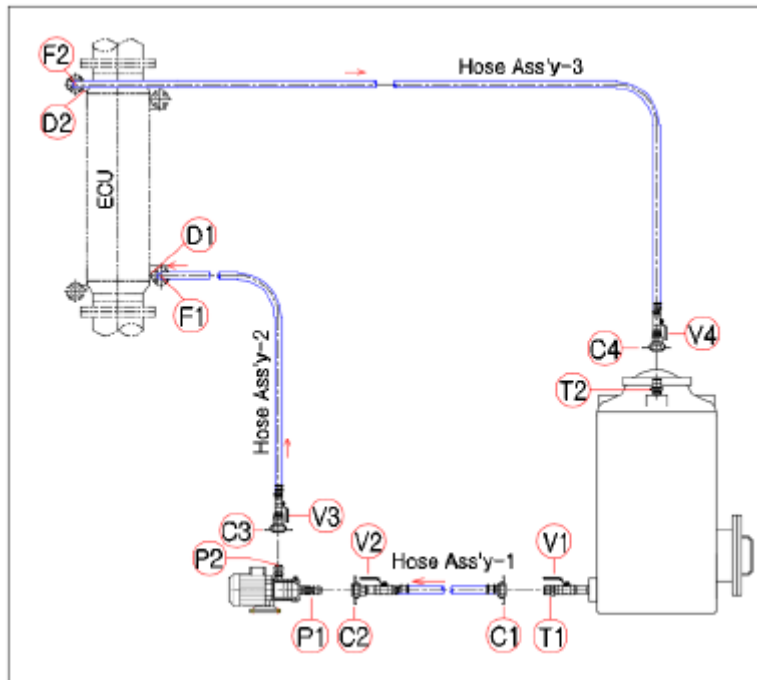


4. Circulating Time: **Min. 20 minutes**.
5. **CLOSE** valves(V1, V2 and V5). and disassemble hose Ass'y-4.
6. **MOVE** on to the next step, "**Circulating cleaning agent**".

8.3.2.4 Circulating cleaning agent



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Figure 4. Components of pipe (injecting cleaning agent)

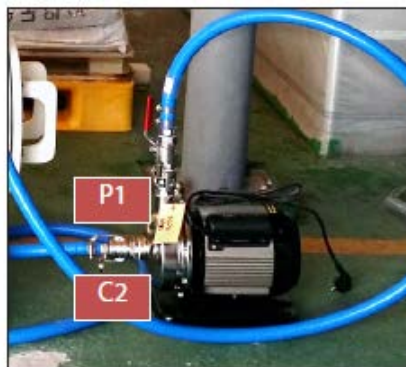
1. Drain sea water from chamber through Drain (D1, D2) of ECU.



2. Connecting Pump to Tank

A. **CONNECT** coupling (C1) of Hose Ass'y-1 to Tank (T1).

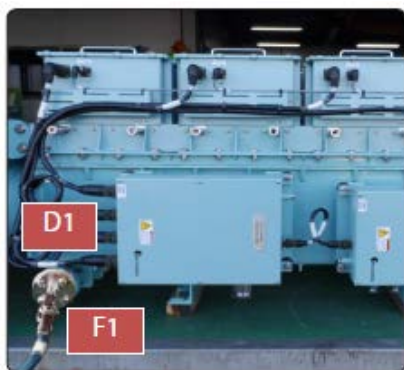
B. **CONNECT** coupling (C2) of Hose Ass'y-1 to coupling (P1) to Pump.



3. Connecting Pump to ECU

A. **CONNECT** flange (F1) of Hose Ass'y-2 to Drain (D1) of ECU.

B. **CONNECT** coupling (C3) of Hose Ass'y-2 to coupling (P2) of Pump.



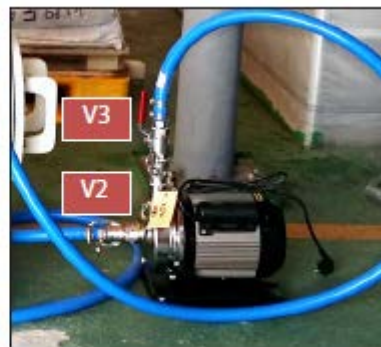
#### 4. Connecting ECU to Tank

A. **CONNECT** flange (F2) of Hose Ass'y-3 to Drain (D2) of ECU.

B. **CONNECT** coupling (C4) of Hose Ass'y-3 to Tank (T2).



#### 5. **OPEN** all the valves (V1, V2, V3, and V4).



#### 6. **CONNECT** power cable (220VAC) to the Pump and **Operate** the Pump.

Pump Power can be connected from the receptacle of PDE if power source is not available.



7. **CLOSE** valves (V2, V3, and V4) after circulating for 60 minutes.

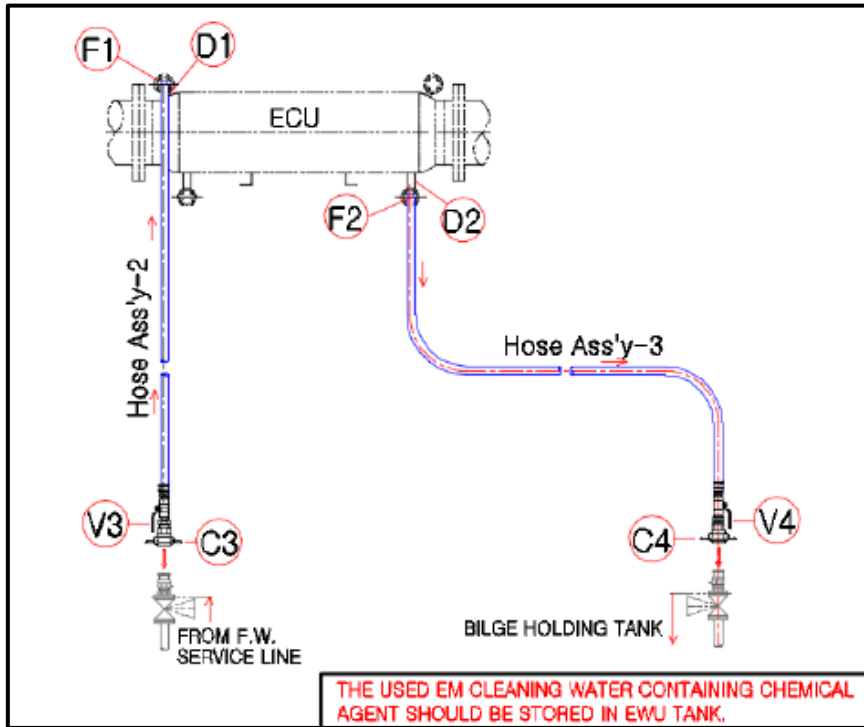


**NOTE!!**

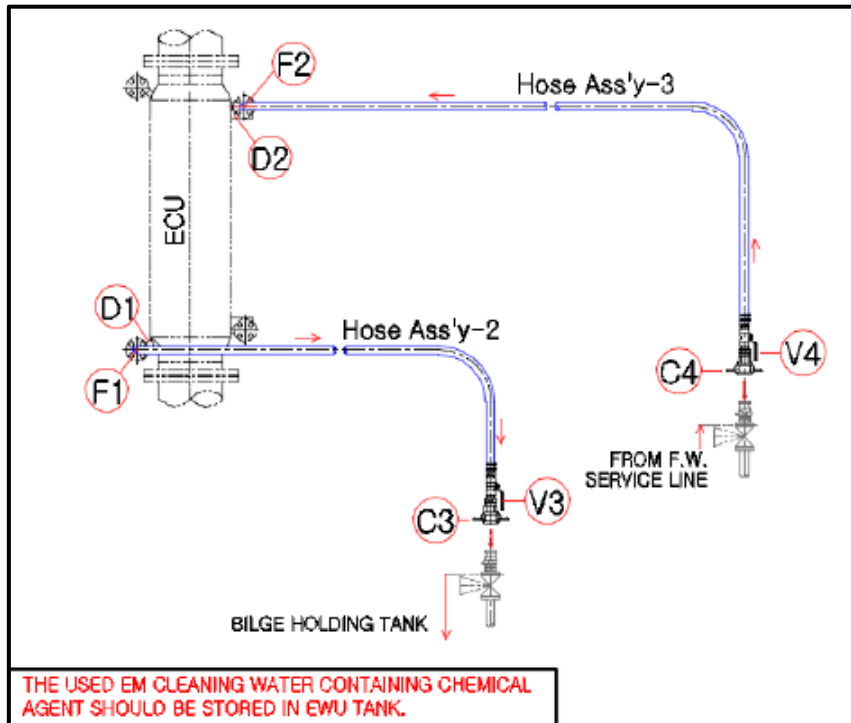
THE USED EM CLEANING WATER CONTAINING CHEMICAL AGENT SHOULD BE STORED IN EWU TANK. AND DISCHARGED AT SEA MORE THAN 12 NAUTICAL MILES AND 25M IN DEPTH.

8. **MOVE** on to the next step, "Cleaning with fresh water".

8.3.2.5 Cleaning with fresh water



<Horizontal type>



<Vertical type>

Figure 5. Components of pipe(collecting cleaning agent)

1. **DISCONNECT** coupling (C3) of Hose Ass'y-2 from coupling (P2) of Pump.
2. **DISCONNECT** coupling (C4) of Hose Ass'y-3 from Tank (T2).



3. **CONNECT** F.W cooling service line of ship to coupling (C3) of Hose Ass'y-3 using connector.
4. **CONNECT** coupling (C4) of Hose Ass'y-3 to Bilge holding tank pipe of ship using connector.  
(Connector will be provided by the manufacturer.)



5. **Drain** waste water containing cleaning agent and **open valves** (V3, V4) to clean inside of ECU.



6. **CLOSE** Valve (V3) after flushing out fresh water for approximately 15 minutes.
7. **Disassemble** the Hose Ass'y-2 and Hose Ass'y-3.
8. **Dispose of** the collected cleaning agent according to the rules and regulations.

**NOTE!!**

THE USED EM CLEANING WATER CONTAINING CHEMICAL AGENT SHOULD BE STORED IN EWU TANK. AND DISCHARGED AT SEA MORE THAN 12 NAUTICAL MILES AND 25M IN DEPTH.

**8.3.2.6 Cleaning Interval**

Recommended cleaning cycle is approximately 200 hours of operation.

※In case of multiple chamber, repeat the process to each ECU same as Ch.8.3.2.2 ~ 8.3.2.5

### 8.3.3 Procedure for maintenance of solenoid Valve

Step 1: **Turn off** the power of **ANU**.



Step 2: **Remove** the front and the side cover of **ANU**.



Step 3: **Disconnect** power cable of **Solenoid Valve**.



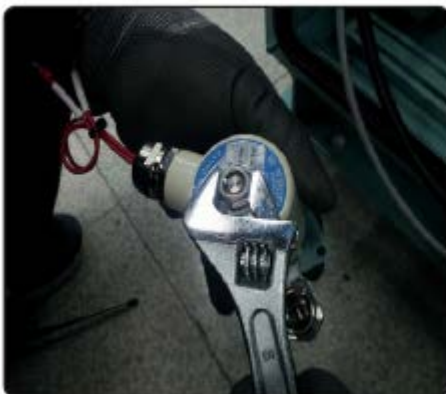
Step 4: **Disassemble** pipes of Solenoid Valve.



Step 5: **Remove** Solenoid Valve from ANU.



Step 6: **Disassemble** Solenoid Valve case.



Step 7: **Disassemble** the inner pipe of Solenoid Valve.



Step 8: **Immerse** the valve in hot water (over 60°C) for 3 minutes and **clean** inside of the valve with an air compressor (4~7kg/cm<sup>2</sup>).



Step 9: **Reassemble** the valve, following instructions in reverse order (from step 6 to step 1).

### 8.3.4 Procedure of ANU Flushing

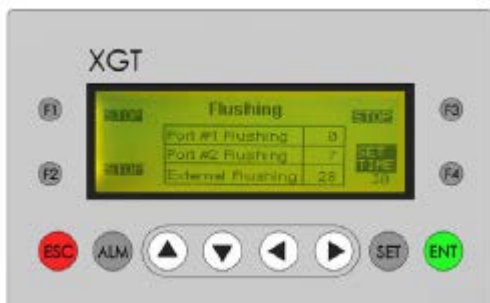
Step. 1 **Press** "ESC" button to enter Menu of XGT Panel and **select** "5.Flushing Mode" using up / down button and Press "ENT".



Step. 2 **Press** “F2” button to flushing all Pipe (P#1, P#2).



Step. 3 **Make sure** that flushing with all pipes (Port#1, Port#2, and External) are operating.



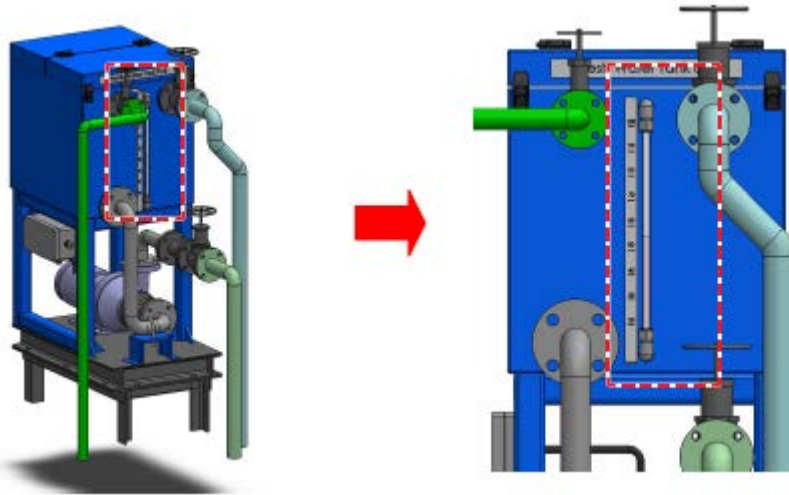
Step. 4 After Flushing, **Press** “ESC” button to enter Menu of XGT Panel and **select** “1.Remote Mode” using up / down button and Press “ENT”.



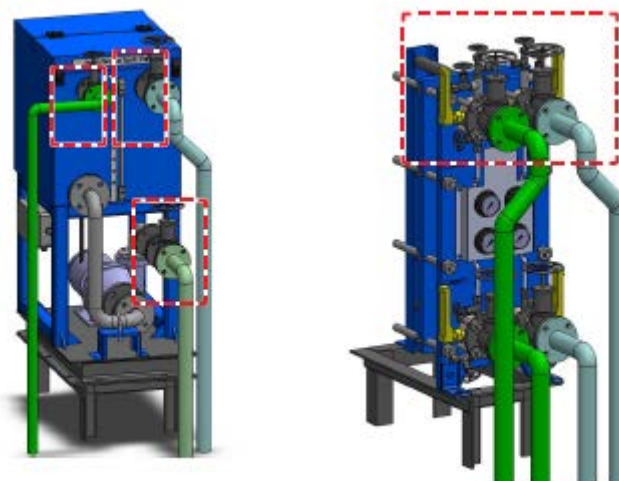
### 8.3.5 When HEU/FTU are located in BWTS room on deck without heater

#### 8.3.5.1 When HEU/FTU are located in engine room:

1. Fill the tank with anti-freezer and cooling water (Refer to 8.3.5.3 cooling mixture ①~⑥) up to more than medium level of FTU.



2. Open FTU Inlet and Outlet valve of freshwater.
3. Open HEU Inlet and Outlet valve of freshwater.
4. Open HEU Inlet and Outlet valve of seawater.



5. Refill the tank with cooling water up to more than medium level of FTU after 2 and 3.

### 8.3.5.2 Coolant Quality Requirement

#### Caution

- Anti-freeze liquid is hazardous to health. Avoid contact with the eyes and skin.
- Never use only water as coolant because it will cause corrosion and cavitation.

#### Coolant Quality Requirement

The used coolant must meet the requirements of standard ASTM D 3306 or BS6580:1992.

### 8.3.5.3 Cooling mixture

- The cooling mixture should consist 40-60% of ethylene- or propylene-glycol based antifreeze and water. The best proportion is 50% of antifreeze liquid and 50% of water.
  - The used water must be cleaned mechanically; it must not be too acidic (e.g. swamp water) or too hard (calcareous well water).
  - Check the proportion of antifreeze (the frost resistance) in the coolant on a regular basis. Change the coolant every two years.
1. Fill freshwater up to more than medium level of FTU.
  2. Fill up FTU with antifreeze liquid.  
(Freshwater 50%: Antifreeze liquid 50 %)
  3. Open [FTU Outlet valve](#) of coolant.
  4. Open [HEU Inlet](#) and [Outlet valve](#) of coolant.
  5. Open [HEU Inlet](#) and [Outlet valve](#) of seawater.
  6. Repeat 1, 2 process in order to re-fill FTU with antifreeze liquid and freshwater up to more than medium level of FTU after 3, 4 process.

## 8.4 Detailed Trouble shooting Procedure

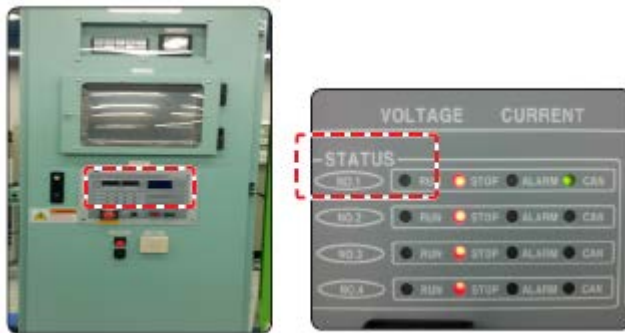
### 8.4.1 PDE

Problem:

- ECS shuts down 1 minute after alarm message “Communication Failure” appears.

Solution:

- Check the state of CAN communication of RCM in the PDE



#### Normal Communication Mode

CAN LED LAMP: Green light blinks every 1 or 2 seconds.

#### Abnormal Communication Mode

CAN LED LAMP: Light stays either on or off.

(In case of communication failure, check the connections of RCM connector and cables. If cables are loose, connect them tightly again.)



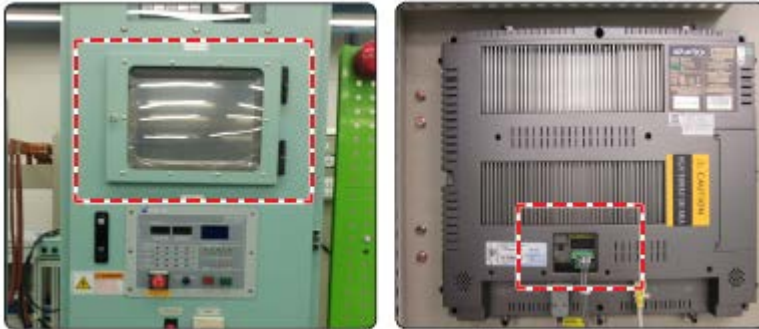
\* If the same problem persists, please contact the Techcross.

Problem:

- The sub CPC of PDE is not turned on.

Solution:

- Check the power of sub CPC of PDE, as shown in the picture.
- Check if power and communication cables are connected properly.
- Check if the power switch is “ON”.



- If it is not turned on with its switch “ON”, check the fuse of CPC.
- If the fuse is broken, replace it with new fuse for CPC.  
(Refer to “Ch. 6.7 Spare parts”)
- If the same problem persists, please contact the Techcross.

## 8.4.2 TSU

### Problem:

- TSU is not turned on.

### Solution:

- Check breaker in the TSU and make sure it is “ON”.



\* In case circuit breaker shuts off automatically, do not turn it on and contact the Techcross.

### Problem:

- Communication Failure between HMI and TSU

### Solution:

- Check connection of the cables linked to PDE communication parts. If the cables are loose, connect them tightly again until a “click” sound is made.



- If the same problem persists when there is no problem with cables and LED LAMP, please contact The Techcross.

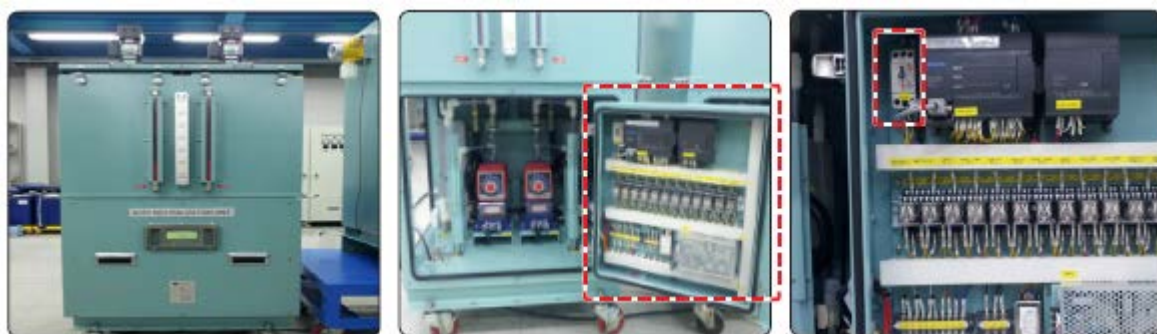
### 8.4.3 ANU

Problem:

- ANU is not turned on.

Solution:

- Make sure that circuit breaker of ANU is "ON".



\* In case circuit breaker shuts off automatically, do not turn it on and contact the Techcross.

Problem:

- Failure of communication between HMI and ANU

Solution:

- Check connection of the cables linked to PDE communication parts. If the cables are loose, connect them tightly again until a "click" sound is made.



- If the same problem persists when there is no problem with cables and LED LAMP, please contact the Techcross

## 8.4.4 ECU (PRU)

### Problem:

- ECS shuts down immediately after alarm message "*PRU module Fault*" appears.

### Reason:

- There are problems in PRU of ECU.
- Insufficient cooling water causes overheating of PRU.

### Solution:

- Make sure that manual valves (front and back of PRU cooling pipe) are open.  
(Refer to check points before operation.)
- Flush the Cooling lines
  - Dismantle the lines and blow by service air
  - If cooling water flows out well, reassemble the lines.

## 8.4.5 SENSOR

### Problem:

- ECS shuts down 1 minute after alarm message "*The sensor communication failed Value=-20*" appears.

### Reason:

- Sensors (FMU/GDS) fail to transmit the values due to communication failures.

### Solution:

- Check if the power of each sensor is "ON".
- Check connection of communication cables attached to each sensor.
- If all the sensors are found to be defective, check power state and connection of cables & connectors in the PDE.
- If the same problem persists, please contact the Techcross.



### 8.4.6 FTU

Problem:

- ECS shuts down immediately after alarm message “*The freshwater is insufficient*” appears.

Reason:

- Cooling water level in FTU TANK is lower than water level sensor.

Solution:

- Need to provide sufficient cooling water to cool down PRU of ECU
- Open the valve installed in the Inlet and Outlet of FTU.

(Refer to check points before operation.)

Check leakage from FTU TANK and ECU (PRU) Cooling pipes



### 8.4.7 HEU

Problem:

- ECS shuts down immediately after alarm message “*The fresh water temperature is higher than the regulated temperature*” appears.

Reason:

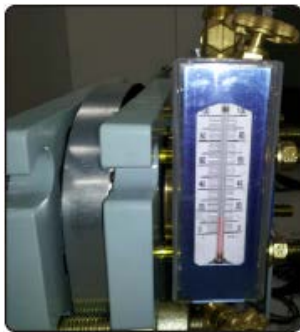
- The temperature of cooling water is over 40°C

Solution:

- Check if sea water is supplied properly.
- Check if there is any problem with circulation of sea water and cooling water which can be caused by foreign materials in the HEU through a pressure gauge and a thermometer installed in HEU.



Check if the pressure gauge installed in both Inlet and Outlet of sea water and fresh water (cooling water) shows pressure of sea water and fresh water properly.



If the temperature of fresh water (cooling water) is over 40°C, check the temperature of sea water.

Check that HEU shows the temperature of circulating sea water and fresh water properly.

## 8.5 Health and safety

### 8.5.1 Safety warning – TRO Solution

The hypochlorite solution produced in the electrolysis unit is much more highly concentrated compared to the hypochlorite solution diluted to the ballast water.

If splashed onto skin it should be washed off, removing any affected clothing. If the eye is affected, irrigate immediately using an approved eyewash station or fresh running water for at least 15 minutes, keeping the eyelid open and rotating the eye. Seek medical treatment immediately. If swallowed, do not induce vomiting. Keep patient warm and quiet and seek immediate medical help. If breathing stops, apply rescue breaths and cardiopulmonary resuscitation as necessary until medical help arrives.

Warning notices advising operatives of the possible dangers should be prominently displayed wherever hypochlorite is generated



*Warning*

*TRO solution is alkaline and will cause oxidisation and bleaching. It is corrosive and could cause damage to skin or clothing. When handling solution we recommend wearing protective clothing and goggles.*

### 8.5.2 Safety warning – electrical hazards

Before carrying out any form of inspection, maintenance or repair work on the system, operatives must carry out tests to ensure that the plant has been satisfactorily isolated.

### 8.5.3 Safety warning – hydrogen gas

The electrolytic process of converting brine into sodium hypochlorite generates very low concentration of hydrogen gas which is flowed in to the ballast tank during ballast operation by ECS. There are no reports that there is potential effect by low concentration of hydrogen gas on a Vessel's infrastructure so far. But for the precaution and prevention for H<sub>2</sub> gas, the GDS is installed in ECS installed area.

The equipment should be regularly checked to ensure that no gas leakages occur. Always use a hydrogen detector to check for leakages, never a match or any form of naked flame. A sign prohibiting smoking and naked flames should be displayed within the room.

If required, a hydrogen detector can be fitted within the plant room to inhibit the Electro-Clean™ System in the unlikely event of a build-up of hydrogen levels, thereby preventing the situation of an operator ever working in a potentially explosive environment.

**Warning**

*When checking equipment only hydrogen detectors should be used, never use a match or any type of flame.*

### 8.5.4 Safety warning – Neutralizing agent

The residual oxidant in the treated water is automatically neutralized by ANU. The Neutralizing material applied to ANU is sodium thiosulfate. The caution is required to the operator who carries and inserts neutralizing material to ANU.

If the eye is affected, Flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid.

**Warning**

*When handling agent and solution, avoid breathing dust, avoid contacting with skin and eyes. We recommend wearing protective clothing and goggles.*

### 8.5.5 Safety warning – Treated water in ballast tank

The stored water in the ballast tank after electrolysis may contain TRO, which is not degraded for a long time. Even after the ballast water tank is empty, the harmful gas(H<sub>2</sub> gas) may be still present in the air of the tank.

When personnel enters to the ballast tank for the inspection etc., below procedure should be followed.

- allow sufficient time for the space to be thoroughly ventilated naturally or mechanically
- emptying of a full ballast tank and thereby replacing the atmosphere in the tank;
- full ventilation of a ballast tank prior to personnel entry;
- atmosphere testing before tank entry and regularly testing throughout tank entry
- do not enter an enclosed space alone – enter in pairs and monitor each other
- continuous ventilation during tank entry;
- adequate lighting
- respiratory protection; or breathing apparatus equipment available
- skin and eye protection.

### **8.5.6 Personal protective equipment**

Due to the range of hazardous chemicals any information provided in this section is only general. It is the duty of the operative to ensure that they have obtained information on all safety precautions relevant to the type of task they are undertaking and to ensure that they are adhered to. Grundfos Alldos would recommend that good practice is always followed when handling any substance, to include the use of basic 'personal protective equipment' such as ventilated, enclosed goggles, face shields, chemical aprons, boots and gloves. An eye irrigation unit may also be advisable.

## 8.6 Active substances

### 8.6.1 List of Active Substances

The Active Substance (AS), as produced by the Electro-Cleen™ System and their simulated concentrations, are presented in Table below. A chlorine-based compound, hypochlorous acid, is commonly accepted term for measuring biocide and/or algaecide concentration. Therefore, the TRO term will be used in this application and it will be conservatively assumed that all TRO is composed of HOCl.

Active Substance of the Electro-Cleen™ System

Ingredient (IUPAC name)	CAS number	Molecular weight	Empirical formula	Structural formula
Hypochlorous acid	7790-92-3	52.46	HCIO	Cl—OH

## 8.7 MSDS

### 8.7.1 MSDS of Hypochlorous Acid

Data on Hypochlorous Acid (CAS No. 7790-92-)

MOL WT : 52.46

#### RISK CHARACTERIZATION

Persistence <sup>a</sup> (V/T) <sup>b</sup> YES or NO	Bioaccumulation <sup>c</sup> (B/P) <sup>d</sup> YES or NO	Toxicity <sup>e</sup> YES or NO
3.0832/15 d NO	0.8976/- 0.87 NO	0.1 mg/L/0.417 d (Acute LC50, Fish) NO

<sup>a</sup> Persistence Half life: > 60 days in marine water or > 40 days in freshwater or > 180 days in marine sediment or > 120 days in freshwater sediment.

<sup>b</sup> V, numerical value from ultimate biodegradation timeframe model; T, total degradation time

<sup>c</sup> Bioaccumulation: BCF > 2,000 or log Pow ≥ 3.

<sup>d</sup> B, BCF from Arnot-Gobas Method; P, log Pow

<sup>e</sup> Toxicity: Chronic NOEC < 0.01 mg/L.

#### GHS CLASSIFICATION\*\*

Physical hazards	Health hazards	Environmental hazards
Corrosive to metals: Category 1		

AQUATIC ORGANISM TOXICITY – This active ingredient of this product is expected to be toxic to aquatic organisms. However, the low concentration in the solution makes it unlikely that mammals and other warm-blooded organisms will be harmed by incidental contact with this product. Aquatic organisms and air-breathing amphibians and reptiles may have greater exposure and effects (Wysiwash, 2010).

#### 1. Acute Aquatic Toxicity

	Species	LC50	EC50	NOECs	Reference
Fish Toxicity	<i>Ictalurus punctatus</i>	0.15 mg/L/0.417 d			ECOTOX : Aquatic report, 2011
	<i>Notropis atherinoides</i>	0.1 mg/L/0.417 d			
	<i>Oncorhynchus mykiss</i>	0.2 mg/L/0.083 d			
Crustacea Toxicity	N/A				
Algal Toxicity	N/A				

**2. Chronic Aquatic Toxicity – N/A**

**3. Information on Endocrine Disruption** – A thorough review of the literature found no indications that either of the Active Substances in the TRO as Cl<sub>2</sub> (HOCl/HOBr) or the chemically more complex THMs/HAAAs were EDCs (IMO, 2011a).

**4. Sediment Toxicity** – Hypochlorous acid might be not to have the potential to be absorbed to sediments to a significant extent based on their low Koc (< 500 L/kg) (IMO, 2011a).

**5. Bioconcentration**

	Measured/Calculated	Reference
BCF	3.162 L/kg wet-wt (regression-based method)	EPI Suite, 2012
	0.8976 L/kg wet-wt (Arnot-Gobas method)	

**MAMMALIAN TOXICITY****6. Acute Mammalian Toxicity**

	Value	Species	LOAEL	NOAEL	NOEL	Reference
Oral LD50 (mg/kg)	> 5 000					Wysiwash, 2010
	8 900	Rat				IMO, 2011a
	5 800	Mouse				
Dermal LD50 (mg/kg)	N/A					
Inhalation LC50 (mg/kg/4 hr)	N/A					

**7. Chronic Mammalian Toxicity**

	Value	Species	LOAEL	NOAEL	Reference
Oral LD50 (mg/kg)		Mouse, Rat		14 mg/kg/d	IMO, 2011a
Dermal LD50 (mg/kg)	N/A				
Inhalation LC50 (mg/kg/4 hr)	N/A				

**8. Corrosion/Irritation**

	Species	Method	Results	Reference
Skin			May cause mild irritation.	Wysiwash, 2010
Eye			May cause eye irritation.	

**9. Sensitization**

	Species	Method (e.g., Beuhler, M&K)	Results (Sensitizer Y/N)	Reference
Skin			N/A	
Inhalation			While low vapor pressure eliminates inhalation as a major route of exposure, misting of the liquid can lead to inhalation. Inhalation exposure may cause respiratory irritation.	Wysiwash, 2010

**10.Repeated-Dose Toxicity** – From the literature, in case of hypochlorous acid, the repeated dose toxicity on oral intake of rats is reported as NOAEL 10 mg/kg/day after exposed 90 days of drinking water. That on oral intake of mice is reported that spleen/liver weight of mice depressed in males, but not females at the higher doses (IMO, 2011a).

**11. Development and Reproductive Toxicity** – N/A

**12. Carcinogenicity/Mutagenicity/Reprotoxicity** – N/A

**ENVIRONMENTAL FATE****13. Modes of Degradation (biotic and abiotic)**

	Seawater or Fresh Water	Test Duration	Results	Reference
Hydrolysis pH 5	Hypochlorous acid decay in seconds to hours; this is after all their mechanism of action and how they produce an oxidizing environment. As a consequence of this oxidizing environment, along with the presence of organic matter, THMs and HAAs are also produced. Biotic degradation for all of these simple halogenated organic compounds is on the order of days to weeks. Abiotic degradation of these compounds is longer.			IMO, 2011a
Hydrolysis pH 7				
Hydrolysis pH 9				
Biodegradatioin				
1/2-Life	Water		15 d	EPI Suite, 2012

## PHYCALAND CHEMICAL PROPERTIES

Property	Value	Reference
Melting point (°C)	194.89 °C (MPBPVP v. 1.43)	EPI Suite, 2012
Boiling point (°C)	507.10 °C (MPBPVP v. 1.43)	EPI Suite, 2012
Flammability (flash point for liquids; °C)	N/A	
Density (20°C; kg/m3)	1.401	IMO, 2011a
Vapour pressure (20°C; Pa)	1.85E-012 mmHg at 25 °C (MPBPVP v. 1.43)	EPI Suite, 2012
Vapour density (air = 1)	N/A	
Water solubility (temp; effect of pH; mg/L)	1e+006 mg/L at 25 °C (WSKOW v. 1.42)	EPI Suite, 2012
pH in solution	N/A	
Dissociation constant (pKa)	N/A	
Oxidation-reduction potential	N/A	
Corrosivity to material or equipment	N/A	
Reactivity to container material	N/A	
Auto-ignition temperature (°C)	N/A	
Explosive properties	N/A	
Oxidizing properties	N/A	
Surface tension (newtons/m (SI) or dynes/cm (cgs))	N/A	
Viscosity (mPa.s)	N/A	
Henry's Law Constant (Pa.m3/mol)	1.28E-019 atm-m3/mole (via VP/WS estimate)	EPI Suite, 2012
Partition Coefficient (Koc)	0.1756 (KOCWIN v. 2.00)	EPI Suite, 2012
Log Pow (Kow)	- 0.87 (KOWWIN v. 1.68)	EPI Suite, 2012

## 8.7.2 MSDS of Sodium Thiosulfate

### Material Safety Data Sheet

**Material Name: Sodium Thiosulfate Pentahydrate, Technical Grade ID: C1-153**

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Issue Date: 09/09/98 10:48:51 CLW Page 1 of 7 Revision Date: 12/27/2010 2:58 PM SEP

#### **\* \* \* Section 1 - Chemical Product and Company Identification \* \* \***

**Chemical Name:** Sodium Thiosulfate Pentahydrate, Technical Grade

**Product Use:** For Commercial Use

**Synonyms:** Chlorine control, Declor-it, Disodium thiosulfate, S-hydril, Sodium hyposulfite, Sodium oxide sulfide, Antichlor, Sodothiol, Sulfothiorine, Ametox

#### **Supplier Information**

Chem One Ltd. Phone: (713) 896-9966

14140 Westfair East Drive Fax: (713) 896-7540

Houston, Texas 77041-1104 Emergency # 1-800-424-9300 or 703- 527-3887

**General Comments: FOR COMMERCIAL USE ONLY; NOT TO BE USED AS A PESTICIDE.**

NOTE: Emergency telephone numbers are to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure, or accident involving chemicals. All non-emergency questions should be directed to customer service.

#### **\* \* \* Section 2 - Composition / Information on Ingredients \* \* \***

##### **CAS # Component Percent**

10102-17-7 Sodium Thiosulfate Pentahydrate > 90

##### **Component Related Regulatory Information**

No information available.

##### **Component Information/Information on Non-Hazardous Components**

This product is considered hazardous under 29 CFR 1910.1200 (Hazard Communication).

#### **\* \* \* Section 3 - Hazards Identification \* \* \***

##### **Emergency Overview**

Sodium Thiosulfate Pentahydrate is a colorless solid found in crystalline or powder forms. May cause irritation to the eyes, skin, and mucous membranes of the upper respiratory tract. Keep material away from sodium nitrite and metal nitrates. Product is not combustible. Use extinguishing media appropriate for surrounding fire. Thermal decomposition of this product produces irritating vapors and toxic gases (e.g. sulfur oxides). At 100 degrees C, highly irritating sulfur dioxide gas is given off. Sulfur dioxide is toxic, corrosive, flammable and a strong oxidizer. Emergency responders should wear proper personal protective equipment for the releases to which they are responding.

##### **Hazard Statements**

WARNING! MAY CAUSE EYE AND SKIN IRRITATION. RELEASES TOXIC, IRRITATING GAS AT

HIGH TEMPERATURES (100 deg. C). MAY CAUSE ALLERGIC SKIN REACTIONS. Avoid contact with eyes and skin. Avoid breathing dusts. Avoid exposure of material to high temperatures. Wash thoroughly after handling. Keep container closed. Use with adequate ventilation.

**Potential Health Effects: Eyes**

Exposure to particulates or solution of this product may cause irritation of the eyes with symptoms such as stinging, tearing, redness and pain.

**Potential Health Effects: Skin**

This product can cause irritation of the skin, especially after prolonged exposures. Repeated skin contact may lead to dermatitis (red, cracked skin). In sensitive individuals, exposure to this product can cause allergic reaction.

**Potential Health Effects: Ingestion**

Ingestion of this product (especially in large volumes) can irritate the tissues of the mouth, esophagus, and other tissues of the digestive system. Symptoms of exposure can include vomiting, diarrhea, and nausea and systemic effects of cyanosis. Large doses by ingestion can also have a cathartic action, causing diarrhea.

**Potential Health Effects: Inhalation**

Breathing dusts or particulates generated by this product can lead to irritation of the nose, throat or respiratory system. Symptoms of such exposure could include coughing, sneezing, and chest discomfort. Inhalation of vapors and fumes given off when Sodium Thiosulfate Pentahydrate is heated above 100 degrees C, (sulfur dioxide gas) will cause significant irritation.

**HMIS Ratings: Health Hazard: 2\* Fire Hazard: 0 Instability Hazard: 0**

Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe \* = Chronic hazard

**\* \* \* Section 4 - First Aid Measures \* \* \***

**First Aid: Eyes**

In case of contact with eyes, rinse immediately with plenty of water for at least 20 minutes. Seek immediate medical attention.

**First Aid: Skin**

Remove all contaminated clothing. For skin contact, wash thoroughly with soap and water for at least 20 minutes. Seek immediate medical attention if irritation develops or persists.

**First Aid: Ingestion**

DO NOT INDUCE VOMITING. If swallowed, wash out mouth with water provided person is conscious. Never give anything by mouth to a victim who is unconscious or having convulsions. Contact a physician or poison control center immediately.

**First Aid: Inhalation**

Remove source of contamination or move victim to fresh air. Apply artificial respiration if victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Get immediate medical attention.

**First Aid: Notes to Physician**

Provide general supportive measures and treat symptomatically.

**\* \* \* Section 5 - Fire Fighting Measures \* \* \***

**Flash Point:** Not flammable **Method Used:** Not applicable

**Upper Flammable Limit (UEL):** Not applicable **Lower Flammable Limit (LEL):** Not applicable

**Auto Ignition:** Not applicable **Flammability Classification:** Not applicable

**Rate of Burning:** Not applicable

**General Fire Hazards**

Heating this product above 100 degrees C will release hazardous sulfur dioxide gas. Explosion hazard with sodium nitrite and metal nitrites.

**Hazardous Combustion Products**

Sulfur dioxide gas.

**Extinguishing Media**

Use methods for the surrounding fire and other materials involved in the fire.

**Fire Fighting Equipment/Instructions**

Firefighters should wear full protective clothing including self-contained breathing apparatus. If possible control runoff from fire control or dilution water to prevent environmental contamination.

**NFPA Ratings: Health: 2 Fire: 0 Instability: 0 Other: None.**

Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe

**\* \* \* Section 6 - Accidental Release Measures \* \* \*****Containment Procedures**

Stop the flow of material, if this can be done without risk. Contain the discharged material. If sweeping of a contaminated area is necessary use a dust suppressant agent, which does not react with product (see Section 10 for incompatibility information).

**Clean-Up Procedures**

Small releases can be cleaned-up wearing gloves, goggles and suitable body protection. In case of a large spill (in which excessive dusts can be generated), clear the affected area, protect people, and respond with trained personnel. Do not allow the spilled product to enter public drainage system or open water courses. Place all spill residues in an appropriate container and seal. Thoroughly wash the area after a spill or leak clean-up. Prevent spill rinsate from contamination of storm drains, sewers, soil or groundwater.

**Evacuation Procedures**

Evacuate the area promptly and keep upwind of the spilled material. Isolate the spill area to prevent people from entering. In case of large spills, follow all facility emergency response procedures.

**Special Procedures**

Remove soiled clothing and launder before reuse. Avoid all skin contact with the spilled material. Have

emergency equipment readily available.

### **\* \* \* Section 7 - Handling and Storage \* \* \***

#### **Handling Procedures**

All employees who handle this material should be trained to handle it safely. Do not breathe dust. Avoid all contact with skin and eyes. Avoid accumulation of dusts of this product. Use this product only with adequate ventilation. Wash thoroughly after handling.

#### **Storage Procedures**

Keep container tightly closed when not in use. Store containers in a cool, dry location, away from direct sunlight, sources of intense heat, or where freezing is possible. Material should be stored in secondary containers or in a diked area, as appropriate. Store containers away from incompatible chemicals (see Section 10, Stability and Reactivity). Storage areas should be made of corrosion- and fire resistant materials. Post warning and "NO SMOKING" signs in storage and use areas, as appropriate. Use corrosion-resistant structural materials, lighting, and ventilation systems in the storage area. Floors should be sealed to prevent absorption of this material.

Inspect all incoming containers before storage, to ensure containers are properly labeled and not damaged. Have appropriate extinguishing equipment in the storage area (i.e., sprinkler system, portable fire extinguishers). Empty containers may contain residual particulates; therefore, empty containers should be handled with care. Do not cut, grind, weld, or drill near this container. Never store food, feed, or drinking water in containers that held this product. Keep this material away from food, drink and animal feed. Do not store this material in open or unlabeled containers. Limit quantity of material stored.

### **\* \* \* Section 8 - Exposure Controls / Personal Protection \* \* \***

#### **Exposure Guidelines**

##### **A: General Product Information**

Sulfur dioxide, which may be released at high temperatures, has an OSHA established exposure limit of 2 ppm TWA and 5 ppm

STEL (15 minutes). NIOSH has recommended an exposure limit of 2 ppm TWA and has established a level of 100 ppm as Immediately Dangerous to Life and Health (IDLH).

##### **B: Component Exposure Limits**

ACGIH, OSHA, and NIOSH have not developed exposure limits for any of this product's components.

**The exposure limits given are for Particulates Not Otherwise Classified.**

OSHA: 15 mg/m<sup>3</sup> TWA (Total dust):5 mg/m<sup>3</sup> TWA (Respirable fraction)

DFG MAKs 4 mg/m<sup>3</sup> TWA (Inhalable fraction) 1.5 mg/m<sup>3</sup> TWA (Respirable fraction)

#### **Engineering Controls**

Use mechanical ventilation such as dilution and local exhaust. Use a corrosion-resistant ventilation system and exhaust directly to the outside. Supply ample air replacement.

#### **PERSONAL PROTECTIVE EQUIPMENT**

*The following information on appropriate Personal Protective Equipment is provided to assist employers in complying with OSHA regulations found in 29 CFR Subpart I (beginning at 1910.132). Please reference applicable regulations and standards for relevant details.*

**Personal Protective Equipment: Eyes/Face**

Wear safety glasses (or goggles). . If necessary, refer to U.S. OSHA 29 CFR 1910.133.

**Personal Protective Equipment: Skin**

Wear impervious gloves, boots and coveralls to avoid skin contact. If necessary, refer to U.S. OSHA 29 CFR 1910.138.

**Personal Protective Equipment: Respiratory**

No specific guidelines are available. If airborne concentrations are above the applicable exposure limits, use NIOSH-approved respiratory protection. An approved dust and mist air-purifying respirator may be adequate. If respiratory protection is needed, use only protection authorized in the U.S. Federal OSHA Standard (29 CFR 1910.134), applicable U.S. State regulations. Oxygen levels below 19.5% are considered IDLH by OSHA. In such atmospheres, use of a full-facepiece pressure/demand SCBA or a full facepiece, supplied air respirator with auxiliary self-contained air supply is required under OSHA's Respiratory Protection Standard (1910.134-1998).

**Personal Protective Equipment: General**

Wash hands thoroughly after handling material. Do not eat, drink or smoke in work areas. Have a safety shower or eye-wash fountain available

**\* \* \* Section 9 - Physical & Chemical Properties \* \* \*****Physical Properties: Additional Information**

The data provided in this section are to be used for product safety handling purposes. Please refer to Product Data Sheets, Certificates of Conformity or Certificates of Analysis for chemical and physical data for determinations of quality and for formulation purposes.

**Appearance:** White crystalline or powder **Odor:** Odorless

**Physical State:** Solid **pH:** 6.5-8.0 (1% solution)

**Vapor Pressure:** Zero **Vapor Density:** Not applicable

**Boiling Point:** Decomposes above 100 deg C **Freezing/Melting Point:** 118 deg F (48 deg C)

**Solubility (H2O):** 42% by wt. @ 0 deg C **Specific Gravity:** 1.69 (H2O = 1)

**Softening Point:** Not applicable **Particle Size:** Not determined

**Molecular Weight:** 248.17 **Bulk Density:** Not available

**Chemical Formula:** Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>·5H<sub>2</sub>O

**\* \* \* Section 10 - Chemical Stability & Reactivity Information \* \* \*****Chemical Stability**

Product is normally stable in solid form. May be unstable in solution. Sodium Thiosulfate is hygroscopic; on exposure to air it will absorb water.

**Chemical Stability: Conditions to Avoid**

Avoid high temperatures, exposure to air, moisture and incompatible materials.

**Incompatibility**

This material is incompatible with strong oxidizers and acids. Sodium Thiosulfate can react violently with Sodium Nitrite. Sodium Thiosulfate is also incompatible with mercury and iodine.

**Hazardous Decomposition**

Sulfur oxides and hydrogen sulfide.

**Hazardous Polymerization**

Will not occur.

**\* \* \* Section 11 - Toxicological Information \* \* \*****Acute and Chronic Toxicity****A: General Product Information**

Poisonous by intravenous route. Mildly toxic by ingestion. Human systemic effects by ingestion, including cyanosis.

Chronic: Long term skin overexposure to this product may lead to dermatitis (red, itchy skin).

**B: Component Analysis - LD50/LC50****Sodium Thiosulfate:**

Intraperitoneal-Mouse LD<sub>50</sub>: 5600 mg/kg; Intravenous-Mouse LD<sub>50</sub>: 2350 mg/kg; Intravenous-Dog, adult LDLo: 3000 mg/kg;

Intravenous-rat LD<sub>50</sub>: >2500 mg/kg

**B: Component Analysis - TDLo/LDLo;**

Oral-Human TDLo: 300 mg/kg/7 days: Pulmonary system effects

**Carcinogenicity:****A: General Product Information**

Sodium Thiosulfate is not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.

**B: Component Carcinogenicity** - No information available.

**Epidemiology**

Prolonged skin contact may cause allergic skin reactions (allergic dermatitis).

**Neurotoxicity** - No information available.

**Mutagenicity** - No information available.

**Teratogenicity** - No information available.

**Other Toxicological Information**

Thiosulfate occurs naturally in the body.

**\* \* \* Section 12 - Ecological Information \* \* \*****Ecotoxicity****A: General Product Information**

This compound may be harmful to aquatic life in high concentrations.

**B: Aquatic Toxicity** - No information available.

**Environmental Fate**

No potential for food chain concentration.

**\* \* \* Section 13 - Disposal Considerations \* \* \*****US EPA Waste Number & Descriptions****A: General Product Information**

As shipped, this product is not considered a hazardous waste.

**B: Component Waste Numbers**

No EPA Waste Numbers are applicable for this product's components.

**Disposal Instructions**

All wastes must be handled in accordance with local, state and federal regulations. This product, if unaltered by use, may be disposed of by treatment at a permitted facility or as advised by your local hazardous waste regulatory authority.

**\* \* \* Section 14 - Transportation Information \* \* \***

NOTE: The shipping classification information in this section (Section 14) is meant as a guide to the overall classification of the product. However, transportation classifications may be subject to change with changes in package size. Consult shipper requirements under I.M.O., I.C.A.O. (I.A.T.A.) and 49 CFR to assure regulatory compliance.

**US DOT Information**

**Shipping Name:** Not applicable.

**Hazard Class:** Not applicable

**UN/NA #:** Not applicable

**Packing Group:** Not applicable

**Required Label(s):** Not applicable

**RQ Quantity:** Not applicable

**50<sup>th</sup> Edition International Air Transport Association (IATA):**

For Shipments by Air transport: This information applies to air shipments both within the U.S. and for shipments originating in the U.S., but being shipped to a different country.

**UN/NA #:** UN 3077

**Proper Shipping Name:** Environmentally Hazardous Substance, solid, n.o.s. (Sodium Thiosulfate)

**Hazard Class:** 9 (Miscellaneous Dangerous Goods)

**Packing Group:** III

**Passenger & Cargo Aircraft Packing Instruction:** 911

**Passenger & Cargo Aircraft Maximum Net Quantity:** 400 kg

**Limited Quantity Packing Instruction (Passenger & Cargo Aircraft):** Y911

**Limited Quantity Maximum Net Quantity (Passenger & Cargo Aircraft):** 30 kg G

**Cargo Aircraft Only Packing Instruction:** 911

**Cargo Aircraft Only Maximum Net Quantity:** 400 kg

**Excepted Quantities:** E1

**Special Provisions:** A97, A158

**ERG Code:** 9L

**Limited Quantity Shipments:** Shipments for air must be marked with the Proper Shipping Name Environmentally Hazardous Substance, solid, n.o.s. (Sodium Thiosulfate) and shall be marked with the UN Number (3077) preceded by the letters "UN", placed within a diamond. The width of the line forming the diamond shall be at least 2 mm; the number shall be at least 6 mm high. The total weight of each outer packaging cannot exceed 30 kg.

**Excepted Quantities:** The maximum quantity of this material per inner receptacle is limited to 30 g per receptacle and the aggregate quantity of this material per completed package does not exceed 1kg. The inner receptacles must be securely packed in an intermediate packaging with cushioning material to prevent movement in the inner receptacles and packed in a strong outer box with a gross mass not to exceed 29kg. The completed package must meet a drop test. The requirements are found in 2.7.6.1. The package must not be opened or otherwise altered until it is no longer in commerce. For air transportation no shipping paper is required. The package must be legibly marked with the following marking:

**NOTE:** The "" must be replaced by the primary hazard class, or when assigned, the division of each of the hazardous materials contained in the package. The "" must be replaced by the name of the shipper or consignee if not shown elsewhere on the package. The symbol shall be not less than 100 mm x 100 mm and must be durable and clearly visible.

#### **International Maritime Organization (I.M.O.) Classification**

**I.M.O. Classification:** Sodium Thiosulfate is not regulated under I.M.D.G./I.M.O. regulations.

### **\* \* \* Section 15 - Regulatory Information \* \* \***

#### **US Federal Regulations**

##### **A: General Product Information**

Sodium Thiosulfate (CAS # 10102-17-7) is not on the TSCA Inventory. As Sodium Thiosulfate is a hydrate, it is exempt from TSCA Inventory requirements per 40 CFR 720.3 (u)(2)).

##### **B: Component Analysis**

Sodium Thiosulfate is not listed under SARA Section 302 (40 CFR 355 Appendix A), SARA Section 313 (40 CFR 372.65), or CERCLA (40 CFR 302.4). SARA 302 (EHS TPQ)

There are no specific Threshold Planning Quantities for Sodium Thiosulfate. The default Federal MSDS submission and inventory requirement filing threshold of 10,000 lbs (4,540 kg) therefore applies, per 40 CFR 370.20.

##### **C: Sara 311/312 Tier II Hazard Ratings:**

Component CAS #	Fire Hazard	Reactivity Hazard	Pressure Hazard	Immediate Health Hazard	Chronic Health Hazard
Sodium Thiosulfate 10102-17-7	No	No	No	Yes	Yes

## State Regulations

### A: General Product Information California Proposition 65

Sodium Thiosulfate is not on the California Proposition 65 chemical lists.

### B: Component Analysis – State

Component CAS #	CA	FL	MA	MN	NJ	PA
Sodium Thiosulfate 10102-17-7	No	No	No	No	No	No

## Other Regulations

### A: General Product Information

Not determined.

### B: Component Analysis – Inventory

Component CAS #	TSCA	DSL	EINECS
Sodium Thiosulfate 10102-17-7	Yes	Yes	Yes

### B: Component Information (Canada)

The following components are identified under the Canadian Hazardous Products Act Ingredient Disclosure List:

Component CAS #	Minimum Concentration
Sodium Thiosulfate 10102-17-7	No disclosure limit

Canadian WHMIS Classification: D2B


### ANSI LABELING (Z129.1):

**CAUTION!** MAY CAUSE SKIN AND EYE IRRITATION. HARMFUL IF INGESTED OR INHALED. MAY CAUSE ALLERGIC REACTION IN SENSITIVE INDIVIDUALS. Avoid contact with skin, eyes, or clothing. Do not taste or swallow. Avoid breathing dusts and particulates. Use only with adequate ventilation. Wash thoroughly after handling. Wear gloves, goggles, faceshields, suitable body protection, and NIOSH-approved respiratory protection, as appropriate. **FIRST-AID:** In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. If inhaled, remove to fresh air. If ingested, do not induce vomiting. Get medical attention.

**IN CASE OF FIRE:** Use water fog, dry chemical, CO<sub>2</sub>, or “alcohol” foam.

**IN CASE OF SPILL:** Absorb spill with inert material. Place residue in suitable container. Consult Material Safety Data Sheet for additional information.

## 8.7.3 MSDS of Hydrogen gas

		 <b>BOC</b> A Member of The Linde Group
<b>SAFETY DATA SHEET</b> <b>Hydrogen, compressed</b>		
Issue Date:	16.01.2013	Version: 1.4
Last revised date:	07.09.2016	SDS No.: 000010021694 1/13
<b>SECTION 1: Identification of the substance/mixture and of the company/undertaking</b>		
<b>1.1 Product identifier</b>		
<b>Product name:</b>	Hydrogen, compressed	
<b>Trade name:</b>	Hydrogen High Purity, Hydrogen CP Grade N5.0, Hydrogen Research Grade N5.5, Hydrogen Zero Grade N4.5	
<b>Additional identification</b>		
<b>Chemical name:</b>	hydrogen	
<b>Chemical formula:</b>	H <sub>2</sub>	
<b>INDEX No.</b>	001-001-00-9	
<b>CAS-No.</b>	1333-74-0	
<b>EC No.</b>	215-605-7	
<b>REACH Registration No.</b>	Listed in Annex IV/V of Regulation (EC) No 1907/2006 (REACH), exempted from registration.	
<b>1.2 Relevant identified uses of the substance or mixture and uses advised against</b>		
<b>Identified uses:</b>	Industrial and professional. Perform risk assessment prior to use. Aerosol propellant. Balance gas for mixtures. Calibration gas. Carrier gas. Chemical synthesis. Combustion, melting and cutting processes. Fuel cells. Fuel gas for welding, cutting, heating, brazing and soldering applications. Laboratory use. Laser gas. Process gas. Test gas. Consumer use.	
<b>Uses advised against</b>	Fuel gas Propellant gas. Shielding gas in gas welding. This gas is not intended to be filled into balloons for consumer use and advertising purposes because of the danger of explosion. Do not inflate commercial balloons.	
<b>1.3 Details of the supplier of the safety data sheet</b>		
<b>Supplier</b>	BOC Priestley Road, Worsley M28 2UT Manchester	
	<b>Telephone:</b> 0800 111 333	
	<b>E-mail:</b> ReachSDS@boc.com	
<b>1.4 Emergency telephone number:</b> 0800 111 333		
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**SECTION 2: Hazards identification**

**2.1 Classification of the substance or mixture**

**Classification according to Directive 67/548/EEC or 1999/45/EC as amended.**

F+; R12

The full text for all R-phrases is displayed in section 16.

**Classification according to Regulation (EC) No 1272/2008 as amended.**

**Physical Hazards**

Flammable gas	Category 1	H220: Extremely flammable gas.
Gases under pressure	Compressed gas	H280: Contains gas under pressure; may explode if heated.

**2.2 Label Elements**



**Signal Words:** Danger

**Hazard Statement(s):** H220: Extremely flammable gas.  
H280: Contains gas under pressure; may explode if heated.

**Precautionary Statement**

**Prevention:** P210: Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.

**Response:** P377: Leaking gas fire: Do not extinguish, unless leak can be stopped safely.  
P381: Eliminate all ignition sources if safe to do so.

**Storage:** P403: Store in a well-ventilated place.

**Disposal:** None.

**2.3 Other hazards:** None.

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**SECTION 3: Composition/information on ingredients**

**3.1 Substances**

<b>Chemical name</b>	hydrogen
<b>INDEX No.:</b>	001-001-00-9
<b>CAS-No.:</b>	1333-74-0
<b>EC No.:</b>	215-605-7
<b>REACH Registration No.:</b>	Listed in Annex IV/V of Regulation (EC) No 1907/2006 (REACH), exempted from registration.
<b>Purity:</b>	100% The purity of the substance in this section is used for classification only, and does not represent the actual purity of the substance as supplied, for which other documentation should be consulted.
<b>Trade name:</b>	Hydrogen High Purity, Hydrogen CP Grade N5.0, Hydrogen Research Grade N5.5, Hydrogen Zero Grade N4.5

**SECTION 4: First Aid Measures**

**General:** In high concentrations may cause asphyxiation. Symptoms may include loss of mobility/consciousness. Victim may not be aware of asphyxiation. Remove victim to uncontaminated area wearing self contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.

**4.1 Description of first aid measures**

**Inhalation:** In high concentrations may cause asphyxiation. Symptoms may include loss of mobility/consciousness. Victim may not be aware of asphyxiation. Remove victim to uncontaminated area wearing self contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.

**Eye contact:** Adverse effects not expected from this product.

**Skin Contact:** Adverse effects not expected from this product.

**Ingestion:** Ingestion is not considered a potential route of exposure.

**4.2 Most important symptoms and effects, both acute and delayed:** Respiratory arrest.

**4.3 Indication of any immediate medical attention and special treatment needed**

**Hazards:** None.

**Treatment:** None.

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**SECTION 5: Firefighting Measures**

<b>General Fire Hazards:</b>	Heat may cause the containers to explode.
<b>5.1 Extinguishing media</b>	
<b>Suitable extinguishing media:</b>	Water. Dry powder. Foam.
<b>Unsuitable extinguishing media:</b>	Carbon dioxide.
<b>5.2 Special hazards arising from the substance or mixture:</b>	None.
<b>Hazardous Combustion Products:</b>	None.
<b>5.3 Advice for firefighters</b>	
<b>Special fire fighting procedures:</b>	In case of fire: Stop leak if safe to do so. Do not extinguish flames at leak because possibility of uncontrolled explosive re-ignition exists. Continue water spray from protected position until container stays cool. Use extinguishants to contain the fire. Isolate the source of the fire or let it burn out.
<b>Special protective equipment for firefighters:</b>	Firefighters must use standard protective equipment including flame retardant coat, helmet with face shield, gloves, rubber boots, and in enclosed spaces, SCBA. Guideline: EN 469 Protective clothing for firefighters. Performance requirements for protective clothing for firefighting. EN 15090 Footwear for firefighters. EN 659 Protective gloves for firefighters. EN 443 Helmets for fire fighting in buildings and other structures. EN 137 Respiratory protective devices - Self-contained open-circuit compressed air breathing apparatus with full face mask - Requirements, testing, marking.

**SECTION 6: Accidental Release Measures**

<b>6.1 Personal precautions, protective equipment and emergency procedures:</b>	Evacuate area. Provide adequate ventilation. Consider the risk of potentially explosive atmospheres. Eliminate all ignition sources if safe to do so. Monitor the concentration of the released product. Prevent from entering sewers, basements and workpits, or any place where its accumulation can be dangerous. Wear self-contained breathing apparatus when entering area unless atmosphere is proved to be safe. EN 137 Respiratory protective devices - Self-contained open-circuit compressed air breathing apparatus with full face mask - Requirements, testing, marking.
<b>6.2 Environmental Precautions:</b>	Prevent further leakage or spillage if safe to do so.
<b>6.3 Methods and material for containment and cleaning up:</b>	Provide adequate ventilation. Eliminate sources of ignition.
<b>6.4 Reference to other sections:</b>	Refer to sections 8 and 13.

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**SECTION 7: Handling and Storage:**

**7.1 Precautions for safe handling:**

Only experienced and properly instructed persons should handle gases under pressure. Use only properly specified equipment which is suitable for this product, its supply pressure and temperature. Purge system with dry inert gas (e.g. helium or nitrogen) before gas is introduced and when system is placed out of service. Purge air from system before introducing gas. Containers, which contain or have contained flammable or explosive substances, must not be inerted with liquid carbon dioxide. Assess the risk of a potentially explosive atmosphere and the need for suitable equipment i.e. explosion-proof. Take precautionary measures against static discharges. Keep away from ignition sources (including static discharges). Provide electrical earthing of equipment and electrical equipment usable in explosive atmospheres. Use only non-sparking tools. Refer to supplier's handling instructions. The substance must be handled in accordance with good industrial hygiene and safety procedures. Ensure the complete system has been (or is regularly) checked for leaks before use. Protect containers from physical damage; do not drag, roll, slide or drop. Do not remove or deface labels provided by the supplier for the identification of the container contents. When moving containers, even for short distances, use appropriate equipment eg. trolley, hand truck, fork truck etc. Secure cylinders in an upright position at all times, close all valves when not in use. Provide adequate ventilation. Suck back of water into the container must be prevented. Do not allow backfeed into the container. Avoid suckback of water, acid and alkalis. Keep container below 50°C in a well ventilated place. Observe all regulations and local requirements regarding storage of containers. When using do not eat, drink or smoke. Store in accordance with local/regional/national/international regulations. Never use direct flame or electrical heating devices to raise the pressure of a container. Leave valve protection caps in place until the container has been secured against either a wall or bench or placed in a container stand and is ready for use. Damaged valves should be reported immediately to the supplier. Close container valve after each use and when empty, even if still connected to equipment. Never attempt to repair or modify container valves or safety relief devices. Replace valve outlet caps or plugs and container caps where supplied as soon as container is disconnected from equipment. Keep container valve outlets clean and free from contaminants particularly oil and water. If user experiences any difficulty operating container valve discontinue use and contact supplier. Never attempt to transfer gases from one container to another. Container valve guards or caps should be in place.

**7.2 Conditions for safe storage, including any incompatibilities:**

All electrical equipment in the storage areas should be compatible with the risk of a potentially explosive atmosphere. Segregate from oxidant gases and other oxidants being stored. Containers should not be stored in conditions likely to encourage corrosion. Stored containers should be periodically checked for general conditions and leakage. Container valve guards or caps should be in place. Store containers in location free from fire risk and away from sources of heat and ignition. Keep away from combustible material.

**7.3 Specific end use(s):**

None.

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**SECTION 8: Exposure Controls/Personal Protection**

**8.1 Control Parameters**

**Occupational Exposure Limits**

None of the components have assigned exposure limits.

**8.2 Exposure controls**

**Appropriate engineering controls:**

Consider a work permit system e.g. for maintenance activities. Ensure adequate air ventilation. Provide adequate general and local exhaust ventilation. Keep concentrations well below lower explosion limits. Gas detectors should be used when quantities of flammable gases or vapours may be released. Provide adequate ventilation, including appropriate local extraction, to ensure that the defined occupational exposure limit is not exceeded. Systems under pressure should be regularly checked for leakages. Product to be handled in a closed system. Use only permanent leak tight installations (e.g. welded pipes). Take precautionary measures against static discharges.

**Individual protection measures, such as personal protective equipment**

**General information:**

A risk assessment should be conducted and documented in each work area to assess the risks related to the use of the product and to select the PPE that matches the relevant risk. The following recommendations should be considered. Keep self contained breathing apparatus readily available for emergency use. Personal protective equipment for the body should be selected based on the task being performed and the risks involved. Refer to local regulations for restriction of emissions to the atmosphere. See section 13 for specific methods for waste gas treatment. Do not eat, drink or smoke when using the product.

**Eye/face protection:**

Wear eye protection to EN 166 when using gases.  
Guideline: EN 166 Personal Eye Protection.

**Skin protection**

**Hand Protection:**

Wear working gloves while handling containers  
Guideline: EN 388 Protective gloves against mechanical risks.

**Body protection:**

Wear fire/flare resistant/retardant clothing.  
Guideline: ISO/TR 2801:2007 Clothing for protection against heat and flame --  
General recommendations for selection, care and use of protective clothing.

**Other:**

Wear safety shoes while handling containers  
Guideline: ISO 20345 Personal protective equipment - Safety footwear.

**Respiratory Protection:**

Not required.

**Thermal hazards:**

No precautionary measures are necessary.

**Hygiene measures:**

Specific risk management measures are not required beyond good industrial hygiene and safety procedures. Do not eat, drink or smoke when using the product.

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**Environmental exposure controls:** For waste disposal, see section 13.

**SECTION 9: Physical And Chemical Properties**

**9.1 Information on basic physical and chemical properties**

**Appearance**

<b>Physical state:</b>	Gas
<b>Form:</b>	Compressed gas
<b>Colour:</b>	Colorless
<b>Odour:</b>	Odorless
<b>Odour Threshold:</b>	Odour threshold is subjective and is inadequate to warn of over exposure.
<b>pH:</b>	not applicable.
<b>Melting Point:</b>	-259.2 °C
<b>Boiling Point:</b>	-253 °C
<b>Sublimation Point:</b>	not applicable.
<b>Critical Temp. (°C):</b>	-240.0 °C
<b>Flash Point:</b>	Not applicable to gases and gas mixtures.
<b>Evaporation Rate:</b>	Not applicable to gases and gas mixtures.
<b>Flammability (solid, gas):</b>	Flammable Gas
<b>Flammability limit - upper (%):</b>	77 %(V)
<b>Flammability limit - lower (%):</b>	4 %(V)
<b>Vapour pressure:</b>	No reliable data available.
<b>Vapour density (air= 1):</b>	0.069
<b>Relative density:</b>	0.07
<b>Solubility(ies)</b>	
<b>Solubility in Water:</b>	1.62 mg/l
<b>Partition coefficient (n-octanol/water):</b>	Not known.
<b>Autoignition Temperature:</b>	560 °C
<b>Decomposition Temperature:</b>	Not known.
<b>Viscosity</b>	
<b>Kinematic viscosity:</b>	No data available.
<b>Dynamic viscosity:</b>	No data available.
<b>Explosive properties:</b>	Not applicable.
<b>Oxidising Properties:</b>	not applicable.

**9.2 Other information:** None.

**Molecular weight:** 2.02 g/mol (H2)

**SECTION 10: Stability and Reactivity**

**10.1 Reactivity:** No reactivity hazard other than the effects described in sub-section below.

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<b>10.2 Chemical Stability:</b>	Stable under normal conditions.
<b>10.3 Possibility of Hazardous Reactions:</b>	Can form a potentially explosive atmosphere in air. May react violently with oxidants.
<b>10.4 Conditions to Avoid:</b>	Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
<b>10.5 Incompatible Materials:</b>	Air and oxidisers. For material compatibility see latest version of ISO-11114.
<b>10.6 Hazardous Decomposition Products:</b>	Under normal conditions of storage and use, hazardous decomposition products should not be produced.

**SECTION 11: Toxicological Information**

**General information:** None.

**11.1 Information on toxicological effects**

**Acute toxicity - Oral Product** Based on available data, the classification criteria are not met.

**Acute toxicity - Dermal Product** Based on available data, the classification criteria are not met.

**Acute toxicity - Inhalation Product** Based on available data, the classification criteria are not met.

**Skin Corrosion/Irritation Product** Based on available data, the classification criteria are not met.

**Serious Eye Damage/Eye Irritation Product** Based on available data, the classification criteria are not met.

**Respiratory or Skin Sensitisation Product** Based on available data, the classification criteria are not met.

**Germ Cell Mutagenicity Product** Based on available data, the classification criteria are not met.

**Carcinogenicity Product** Based on available data, the classification criteria are not met.

**Reproductive toxicity Product** Based on available data, the classification criteria are not met.

**Specific Target Organ Toxicity - Single Exposure Product** Based on available data, the classification criteria are not met.

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**Specific Target Organ Toxicity - Repeated Exposure**

**Product**      Based on available data, the classification criteria are not met.

**Aspiration Hazard**

**Product**      Not applicable to gases and gas mixtures..

**SECTION 12: Ecological Information****12.1 Toxicity****Acute toxicity**

**Product**      No ecological damage caused by this product.

**12.2 Persistence and Degradability**

**Product**      Not applicable to gases and gas mixtures..

**12.3 Bioaccumulative Potential**

**Product**      The product is expected to biodegrade and is not expected to persist for long periods in an aquatic environment.

**12.4 Mobility in Soil**

**Product**      Because of its high volatility, the product is unlikely to cause ground or water pollution.

**12.5 Results of PBT and vPvB assessment**

**Product**      Not classified as PBT or vPvB.

**12.6 Other Adverse Effects:**

No ecological damage caused by this product.

**SECTION 13: Disposal Considerations****13.1 Waste treatment methods****General information:**

Do not discharge into any place where its accumulation could be dangerous. Consult supplier for specific recommendations. Do not discharge into areas where there is a risk of forming an explosive mixture with air. Waste gas should be flared through a suitable burner with flash back arrestor.

**Disposal methods:**

Refer to the EIGA code of practice (Doc.30 "Disposal of Gases", downloadable at <http://www.eiga.org>) for more guidance on suitable disposal methods. Dispose of container via supplier only. Discharge, treatment, or disposal may be subject to national, state, or local laws.

**European Waste Codes****Container:**

16 05 04\*: gases in pressure containers (including halons) containing dangerous substances

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**SECTION 14: Transport Information**

**ADR**

14.1 UN Number: UN 1049  
14.2 UN Proper Shipping Name: HYDROGEN, COMPRESSED  
14.3 Transport Hazard Class(es)  
Class: 2  
Label(s): 2.1  
Hazard No. (ADR): 23  
Tunnel restriction code: (B/D)  
Emergency Action Code: 2SE  
14.4 Packing Group: -  
14.5 Environmental hazards: not applicable  
14.6 Special precautions for user: -

**RID**

14.1 UN Number: UN 1049  
14.2 UN Proper Shipping Name: HYDROGEN, COMPRESSED  
14.3 Transport Hazard Class(es)  
Class: 2  
Label(s): 2.1  
14.4 Packing Group: -  
14.5 Environmental hazards: not applicable  
14.6 Special precautions for user: -

**IMDG**

14.1 UN Number: UN 1049  
14.2 UN Proper Shipping Name: HYDROGEN, COMPRESSED  
14.3 Transport Hazard Class(es)  
Class: 2.1  
Label(s): 2.1  
EmS No.: F-D, S-U  
14.3 Packing Group: -  
14.5 Environmental hazards: not applicable  
14.6 Special precautions for user: -

**IATA**

14.1 UN Number: UN 1049  
14.2 Proper Shipping Name: Hydrogen, compressed  
14.3 Transport Hazard Class(es)  
Class: 2.1  
Label(s): 2.1  
14.4 Packing Group: -  
14.5 Environmental hazards: not applicable  
14.6 Special precautions for user: -  
Other information  
Passenger and cargo aircraft: Forbidden.  
Cargo aircraft only: Allowed.

**14.7 Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code:** not applicable

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**Additional identification:**

Avoid transport on vehicles where the load space is not separated from the driver's compartment. Ensure vehicle driver is aware of the potential hazards of the load and knows what to do in the event of an accident or an emergency. Before transporting product containers ensure that they are firmly secured. Ensure that the container valve is closed and not leaking. Container valve guards or caps should be in place. Ensure adequate air ventilation.

**SECTION 15: Regulatory information**

**15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture:**

**EU Regulations**

**Regulation (EC) No. 1907/2006 Annex XVII Substances subject to restriction on marketing and use:**

Chemical name	CAS-No.	Concentration
hydrogen	1333-74-0	100%

**Directive 96/82/EC (Seveso II): on the control of major accident hazards involving dangerous substances:**

Chemical name	CAS-No.	Concentration
hydrogen	1333-74-0	100%

**Directive 98/24/EC on the protection of workers from the risks related to chemical agents at work:**

Chemical name	CAS-No.	Concentration
hydrogen	1333-74-0	100%

**National Regulations**

Dangerous Substances and Explosive Atmospheres Regulations (DSEAR 2002 No. 2776). Management of Health and Safety at Work Regulations (1999 No. 3242). The Regulatory Reform (Fire Safety) Order 2005 (2005 No. 1541). Control of Substances Hazardous to Health Regulations (COSHH, 2002 No. 2677). Provision and Use of Work Equipment Regulations (PUWER, 1998 No. 2306). Personal Protective Equipment Regulations (1992 No. 2966). Control of Major Accident Hazards Regulations (COMAH, 2015 No. 483). Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations (EPS, 1996 No. 192). Pressure Systems Safety Regulations (PSSR, 2000 No. 128). Only products that comply with the food regulations (EC) No. 1333/2008 and (EU) No. 231/2012 and are labelled as such may be used as food additives.  
This Safety Data Sheet has been produced to comply with Regulation (EU) 453/2010.

**15.2 Chemical safety assessment:** No Chemical Safety Assessment has been carried out.

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**SECTION 16: Other Information**

**Revision Information:** Not relevant.

**Key literature references and sources for data:** Various sources of data have been used in the compilation of this SDS, they include but are not exclusive to:  
Agency for Toxic Substances and Diseases Registry (ATSDR) (<http://www.atsdr.cdc.gov/>).  
European Chemical Agency: Guidance on the Compilation of Safety Data Sheets.  
European Chemical Agency: Information on Registered Substances <http://apps.echa.europa.eu/registered/registered-sub.aspx#search>  
European Industrial Gases Association (EIGA) Doc. 169 Classification and Labelling guide.  
International Programme on Chemical Safety (<http://www.inchem.org/>)  
ISO 10156:2010 Gases and gas mixtures - Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets.  
Matheson Gas Data Book, 7th Edition.  
National Institute for Standards and Technology (NIST) Standard Reference Database Number 69.  
The ESIS (European chemical Substances Information System) platform of the former European Chemicals Bureau (ECB) ESIS (<http://ecb.jrc.ec.europa.eu/esis/>).  
The European Chemical Industry Council (CEFIC) ERICards.  
United States of America's National Library of Medicine's toxicology data network TOXNET (<http://toxnet.nlm.nih.gov/index.html>)  
Threshold Limit Values (TLV) from the American Conference of Governmental Industrial Hygienists (ACGIH).  
Substance specific information from suppliers.  
Details given in this document are believed to be correct at the time of publication.  
EH40 (as amended) Workplace exposure limits.

**Wording of the R-phrases and H-statements in sections 2 and 3**

H220	Extremely flammable gas.
H280	Contains gas under pressure; may explode if heated.
R12	Extremely flammable.

**Training information:** Users of breathing apparatus must be trained. Ensure operators understand the flammability hazard.

**Classification according to Regulation (EC) No 1272/2008 as amended.**

Flam. Gas 1, H220  
Press. Gas Compr. Gas, H280

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**Other information:**

Before using this product in any new process or experiment, a thorough material compatibility and safety study should be carried out. Ensure adequate air ventilation. Ensure all national/local regulations are observed. Ensure equipment is adequately earthed. Whilst proper care has been taken in the preparation of this document, no liability for injury or damage resulting from its use can be accepted. Note: When the Product Name appears in the SDS header the decimal sign and its position comply with rules for the structure and drafting of international standards, and is a comma on the line. As an example 2,000 is two (to three decimal places) and not two thousand, whilst 1.000 is one thousand and not one (to three decimal places).

**Last revised date:**

07.09.2016

**Disclaimer:**

This information is provided without warranty. The information is believed to be correct. This information should be used to make an independent determination of the methods to safeguard workers and the environment.

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## 8.7.4 MSDS of DPD



3170 Metro Parkway  
Ft. Myers, FL 33916 USA  
Telephone: 888-203-7248  
CHEMTREC™ 24 hr Emergency: US 800-424-9300;  
CHEMTREC™ 24 hr Emergency: International 703-527-3887

## Material Safety Data Sheet

**1. PRODUCT IDENTIFICATION:**  
DPD Powder for Free and Total Analyzers

Catalog Numbers-HF scientific: 14275 09935 09936 09937 09938  
09947 09948 09951 09951H 09952  
09952H 09953 09953H 09954 09954H  
09955 09955H 09956 09956H 09991  
09942

PRODUCT USE: Analytical / Laboratory Reagent

NFPA RATINGS: HEALTH: 2 FLAMMABILITY: 0 REACTIVITY: 0

**2. HAZARDS IDENTIFICATION**

TARGET ORGANS: Eyes, Skin, Respiratory System  
ACUTE TOXICITY: May Cause Eye, Skin, or Respiratory System Irritation  
CHRONIC TOXICITY: May be Toxic if Ingested. May Cause Allergic Reaction.  
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-Existing Eye, Skin, or Respiratory System Conditions

**3. COMPOSITION / INFORMATION ON INGREDIENTS**

Component	N,N-Diethyl-p-phenylenediamine Sulfate Salt	Percent
CAS No.	6283-63-2	100

**4. FIRST AID MEASURES**

EYE CONTACT: Rinse Thoroughly With Plenty of Water for at Least 15 Minutes. Consult a Physician.  
SKIN CONTACT: Wash Thoroughly With Soap and Water. Consult a Physician.  
INHALATION: Remove to Fresh Air. If Not Breathing, Give Artificial Respiration. Consult a Physician  
INGESTION: Never Give Anything By Mouth to an Unconscious Person. Rinse Mouth with Water. Consult a Physician.

**5. FIRE FIGHTING MEASURES**

FLASH POINT: No Data Available  
AUTOIGNITION POINT: No Data Available  
EXTINGUISHING MEDIA: Water, Alcohol-Resistant Foam, Dry Chemical or Carbon Dioxide

**6. ACCIDENTAL RELEASE MEASURES**

Use Personal Protective Equipment Such as Safety Glasses, Dust Mask, Latex or Nitrile Gloves, and Lab Coat. Avoid Dust Formation. Avoid Breathing Dust. Ensure Adequate Ventilation. Pick Up and Arrange Disposal Without Creating Dust. Keep in Suitable, Closed Containers for Disposal.

**7. HANDLING AND STORAGE**

HANDLING: Avoid Formation of Dust and Aerosols. Provide Appropriate Exhaust Ventilation at Places Where Dust is Formed. Normal Measures for Preventive Fire Protection.  
STORAGE: Keep Container Tightly Closed in a Dry, Well Ventilated Place. Light and Moisture Sensitive.

**8. EXPOSURE CONTROLS / PERSONAL PROTECTION**

Contains No Substances with Occupational Exposure Limit Values.  
RESPIRATORY PROTECTION: Dust Mask  
HAND PROTECTION: Handle with Gloves  
EYE PROTECTION: Safety Glasses  
SKIN AND BODY PROTECTION: Lab Coat  
HYGENE MEASURES: Handle in Accordance with Good Industrial Hygiene and Safety Practice. Wash Hands Thoroughly After Handling Product.

**9. PHYSICAL AND CHEMICAL PROPERTIES**

PHYSICAL STATE: Solid  
pH: No Data Available  
MELTING POINT: 184-187°C (363-369 °F)  
BOILING POINT: No Data Available  
FLASH POINT: No Data Available  
IGNITION TEMPERATURE: No Data Available  
LOWER EXPLOSION LIMIT: No Data Available  
UPPER EXPLOSION LIMIT: No Data Available  
WATER SOLUBILITY: No Data Available

**10. STABILITY AND REACTIVITY**

Stable Under Recommended Storage Conditions. Avoid Strong Oxidizing Agents. Hazardous Decomposition Products Formed Under Fire Conditions Such as Carbon Oxides, Nitrogen Oxides, and Sulfur Oxides.

**11. TOXICOLOGICAL INFORMATION**

Route of Exposure: Eyes, Skin, Ingestion, Inhalation  
Teratogen Status: None Found  
Mutagen Status: None Found  
Reproductive Toxicity: None Found  
Carcinogen Status: None Found

**12. ECOLOGICAL INFORMATION**

No Ecological Data Available

**13. DISPOSAL CONSIDERATIONS**

Dispose of in a manner consistent with Federal, State and Local Regulations.

**14. TRANSPORT INFORMATION**

US DOT (United States Department of Transportation): Not Regulated  
IATA (International Air Transport Association): Not Regulated  
IMO (International Maritime Organization): Not Regulated

**15. REGULATORY INFORMATION**

US / CANADA INFORMATION:


SARA/Title III Section 302: None  
SARA/Title III Section 313: None  
SARA/Title III Section 311/312: Acute Health Hazard  
Cal. Proposition 65: None  
US TSCA Inventory: Listed

**16. OTHER INFORMATION**


THE ABOVE INFORMATION IS BELIEVED TO BE ACCURATE AND REPRESENTS THE BEST INFORMATION CURRENTLY AVAILABLE TO US. ALL PRODUCTS ARE OFFERED IN ACCORDANCE WITH THE MANUFACTURER'S CURRENT PRODUCTION SPECIFICATIONS AND ARE INTENDED SOLELY FOR USE IN ANALYTICAL TESTING. THE MANUFACTURER SHALL IN NO EVENT BE LIABLE FOR ANY INJURY, LOSS OR DAMAGE RESULTING FROM THE HANDLING, USE OR MISUSE OF THESE PRODUCTS.

0344 Rev. 9 Oct 14, 2011


## 8.7.5 MSDS of Indicator

 <p>3170 Metro Parkway Fl Myers, FL 33916 USA Telephone: 888-203-7248 CHEMTREC™ 24 hr Emergency: US 800-424-9300 CHEMTREC™ 24 hr Emergency: International 703-697-0887</p>		<h2>Material Safety Data Sheet</h2>										
<p><b>1. PRODUCT IDENTIFICATION:</b> Free / Total Indicator</p> <p>Catalog Numbers-HF scientific: 09991 09942</p> <p>PRODUCT USE: Analytical / Laboratory Reagent</p> <p>NFPA RATINGS: HEALTH: 3 FLAMMABILITY: 0 REACTIVITY: 1</p>		<p><b>10. STABILITY AND REACTIVITY</b></p> <p>Product is Stable Under Normal Handling and Storage Conditions. Hazardous Polymerization Will Not Occur.</p>										
<p><b>2. HAZARDS IDENTIFICATION</b></p> <p>TARGET ORGANS: Eyes, Skin, Respiratory Tract ACUTE TOXICITY: Corrosive. May Cause Burns of the Eyes, Skin, and Respiratory Tract CHRONIC TOXICITY: Repeated Inhalation of Dust Can Produce Varying Degree of Respiratory Irritation or Lung Damage MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-Existing Eye, Skin, or Respiratory Conditions</p>		<p><b>11. TOXICOLOGICAL INFORMATION</b></p> <p>Route of Exposure: Eyes, Skin, Inhalation, Ingestion Teratogen Status: None Listed Mutagen Status: None Listed Reproductive Toxicity: None Listed Carcinogen Status: None Listed</p>										
<p><b>3. COMPOSITION / INFORMATION ON INGREDIENTS</b></p> <table border="1"> <thead> <tr> <th>Component</th> <th></th> <th>Percent</th> </tr> </thead> <tbody> <tr> <td>P-Toluenesulfonic Acid</td> <td>CAS No. 6192-52-5</td> <td>&lt;10</td> </tr> <tr> <td>Deionized Water</td> <td>CAS No. 7732-18-5</td> <td>&gt;90</td> </tr> </tbody> </table>		Component		Percent	P-Toluenesulfonic Acid	CAS No. 6192-52-5	<10	Deionized Water	CAS No. 7732-18-5	>90	<p><b>12. ECOLOGICAL INFORMATION</b></p> <p>No Ecological Data Available</p>	
Component		Percent										
P-Toluenesulfonic Acid	CAS No. 6192-52-5	<10										
Deionized Water	CAS No. 7732-18-5	>90										
<p><b>4. FIRST AID MEASURES</b></p> <p>EYE CONTACT: Immediately Flush Eyes with Plenty of Water for at Least 15 Minutes. Get Medical Attention. SKIN CONTACT: Immediately Flush Skin with Plenty of Water for at Least 15 Minutes While Removing Contaminated Clothing and Shoes. Wash Clothing Before Reuse. Get Medical Attention. INHALATION: Remove to Fresh Air. If Not Breathing, Give Artificial Respiration. If Breathing is Difficult, Give Oxygen. Get Medical Attention. INGESTION: Do NOT Induce Vomiting Unless Directed by Medical Personnel. Never Give Anything By Mouth to an Unconscious Person. Get Medical Attention.</p>		<p><b>13. DISPOSAL CONSIDERATIONS</b></p> <p>Dispose of in a manner consistent with Federal, State and Local Regulations.</p>										
<p><b>5. FIRE FIGHTING MEASURES</b></p> <p>FLASH POINT: NA AUTOIGNITION POINT: NA FLAMMABILITY: NA EXTINGUISHING MEDIA: Dry Chemical, Water Spray, or Foam</p>		<p><b>14. TRANSPORT INFORMATION</b></p> <p>US DOT (United States Department of Transportation): CLASSIFICATION: Class 8 Corrosive Material IDENTIFICATION: Aryl Sulfonic Acid, Liquid, with not more than 5% free Sulfuric Acid UN NUMBER: 2586 PACKING GROUP: III</p> <p>IATA (International Air Transport Association) CLASSIFICATION: Class 8 Corrosive Material IDENTIFICATION: Aryl Sulfonic Acid, Liquid, with not more than 5% free Sulfuric Acid UN NUMBER: 2586 PACKING GROUP: III</p> <p>IMO (International Maritime Organization) CLASSIFICATION: Class 8 Corrosive Material IDENTIFICATION: Aryl Sulfonic Acid, Liquid, with not more than 5% free Sulfuric Acid UN NUMBER: 2586 PACKING GROUP: III</p>										
<p><b>6. ACCIDENTAL RELEASE MEASURES</b></p> <p>Take up liquid with absorbent material and place in marked container for disposal. Material May be Neutralized with Dilute Sodium Carbonate. Wear Personal Protective Equipment such as Safety Glasses, Latex or Nitrile Gloves, Lab Coat, and Dust Mask.</p>		<p><b>15. REGULATORY INFORMATION</b></p> <p>DSL (EEC): R36/37/38-Irritating to Eyes, Respiratory System, and Skin. S25-In Case of Contact with Eyes, Rinse Immediately with Plenty of Water and Seek Medical Advice. S28-After Contact with Skin, Wash Immediately with Plenty of Water. S36/37/39-Wear Suitable Protective Clothing, Gloves, and Eye/Face Protection.</p> <p>US / CANADA INFORMATION: OSHA: Hazardous By Definition of Hazard Communication Standard (29 CFR 1910.1200) WHMIS (Canada): CLASS E: Corrosive Liquid</p>										
<p><b>7. HANDLING AND STORAGE</b></p> <p>HANDLING: Use Appropriate Personal Protective Equipment Listed in Section 8. Do Not Ingest. Avoid Contact with Eyes and Skin. STORAGE: Keep Container Tightly Closed and Store in a Well Ventilated Area.</p>		<p><b>16. OTHER INFORMATION</b></p> <p>THE ABOVE INFORMATION IS BELIEVED TO BE ACCURATE AND REPRESENTS THE BEST INFORMATION CURRENTLY AVAILABLE TO US. ALL PRODUCTS ARE OFFERED IN ACCORDANCE WITH THE MANUFACTURER'S CURRENT PRODUCTION SPECIFICATIONS AND ARE INTENDED SOLELY FOR USE IN ANALYTICAL TESTING. THE MANUFACTURER SHALL IN NO EVENT BE LIABLE FOR ANY INJURY, LOSS OR DAMAGE RESULTING FROM THE HANDLING, USE OR MISUSE OF THESE PRODUCTS.</p>										
<p><b>8. EXPOSURE CONTROLS / PERSONAL PROTECTION</b></p> <p>EXPOSURE LIMITS: NOT AVAILABLE PERSONAL PROTECTIVE EQUIPMENT: Safety Glasses, Latex or Nitrile Gloves, Lab Coat</p>		<p># 0580 Rev. 4 November 21, 2011</p>										
<p><b>9. PHYSICAL AND CHEMICAL PROPERTIES</b></p> <p>PHYSICAL STATE: Liquid ODOR: Odorless APPEARANCE: Clear pH: 1-2, Acidic BOILING POINT: 100 °C MELTING POINT: NA SPECIFIC GRAVITY: 1.00-1.10 SOLUBILITY: Soluble in Water</p>												

## 8.7.6 MSDS of Buffer

 <p>3170 Metro Parkway Ft. Myers, FL 33916 USA Telephone: 888-203-7248 CHEMTREC® 24 hr Emergency: US 800-424-9300; CHEMTREC® 24 hr Emergency: International 703-527-3687</p>	<h2>Material Safety Data Sheet</h2>																											
<p><b>1. PRODUCT IDENTIFICATION: Total Chlorine Buffer</b></p> <p>Catalog Number-HF scientific: 09991 09942</p> <p>PRODUCT USE: Analytical / Laboratory Reagent</p> <p>NFPA RATINGS: HEALTH: 2 FLAMMABILITY: 0 REACTIVITY: 0</p> <p><b>2. HAZARDS IDENTIFICATION</b></p> <p>TARGET ORGANS: Eyes, Skin, Respiratory Tract ACUTE TOXICITY: May Cause Eye, Skin, or Respiratory Tract Irritation CHRONIC TOXICITY: None Listed MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-Existing Eye, Skin, or Respiratory Disorders</p> <p><b>3. COMPOSITION / INFORMATION ON INGREDIENTS</b></p> <table border="1" data-bbox="245 763 614 987"> <thead> <tr> <th>Component</th> <th></th> <th>Percent</th> </tr> </thead> <tbody> <tr> <td>Component</td> <td>Trisodium Citrate Salt</td> <td></td> </tr> <tr> <td>CAS No.</td> <td>68-04-2</td> <td>&lt;15</td> </tr> <tr> <td>Component</td> <td>Potassium Iodide</td> <td></td> </tr> <tr> <td>CAS No.</td> <td>7681-11-0</td> <td>&lt;10</td> </tr> <tr> <td>Component</td> <td>Ethylenediaminetetraacetic Acid (EDTA)</td> <td></td> </tr> <tr> <td>CAS No.</td> <td>6381-92-6</td> <td>&lt;1</td> </tr> <tr> <td>Component</td> <td>Deionized Water</td> <td></td> </tr> <tr> <td>CAS No.</td> <td>7732-18-5</td> <td>&gt;75</td> </tr> </tbody> </table> <p><b>4. FIRST AID MEASURES</b></p> <p>EYE CONTACT: Flush Eyes with Plenty of Water for at Least 15 Minutes. Get Medical Aid</p> <p>SKIN CONTACT: Flush Skin with Water for at Least 15 Minutes While Removing Contaminated Clothing and Shoes</p> <p>INHALATION: Remove from Exposure and Move to Fresh Air Immediately. If Not Breathing, Give Artificial Respiration. If Breathing is Difficult, Give Oxygen. Get Medical Aid if Cough or Other Symptoms Appear.</p> <p>INGESTION: Never Give Anything by Mouth to an Unconscious Person. Get Medical Aid. Do NOT Induce Vomiting. If Conscious and Alert, Rinse Mouth and Give Milk or Water.</p> <p><b>5. FIRE FIGHTING MEASURES</b></p> <p>FLASH POINT: NA AUTOIGNITION POINT: NA FLAMMABILITY LIMITS: UPPER: NA LOWER: NA EXTINGUISHING MEDIA: Water Spray, Dry Chemical, Carbon Dioxide, or Foam</p> <p><b>6. ACCIDENTAL RELEASE MEASURES</b></p> <p>Clean Up Spills Immediately Wearing Appropriate Personal Protective Equipment listed in section 8. Take up liquid with absorbent material and place in marked container for disposal. Provide Ventilation.</p> <p><b>7. HANDLING AND STORAGE</b></p> <p>HANDLING: Wash Thoroughly After Handling. Remove Contaminated Clothing and Wash Before Reuse. Use in Adequate Ventilation. Avoid Contact with Eyes, Skin, and Clothing. Keep Container Tightly Closed. Do not ingest.</p> <p><b>8. EXPOSURE CONTROLS / PERSONAL PROTECTION</b></p> <p>EXPOSURE CONTROLS Use Adequate Ventilation to Keep Airborne Concentrations Low ACGIH: Trisodium Citrate Salt- None Listed EDTA-None Listed OSHA PELs: Trisodium Citrate Salt- None Listed EDTA-None Listed NIOSH: Trisodium Citrate Salt- None Listed EDTA-None Listed</p> <p>PERSONAL PROTECTIVE EQUIPMENT: Safety Glasses, Latex or Nitrile Gloves, Lab Coat, Dust Mask</p> <p><b>9. PHYSICAL AND CHEMICAL PROPERTIES</b></p>	Component		Percent	Component	Trisodium Citrate Salt		CAS No.	68-04-2	<15	Component	Potassium Iodide		CAS No.	7681-11-0	<10	Component	Ethylenediaminetetraacetic Acid (EDTA)		CAS No.	6381-92-6	<1	Component	Deionized Water		CAS No.	7732-18-5	>75	<p>PHYSICAL STATE: Liquid APPEARANCE: Clear ODOR: Odorless pH: 6-7</p> <p><b>10. STABILITY AND REACTIVITY</b></p> <p>Stable at Room Temperature in Closed Containers Under Normal Storage and Handling Conditions.</p> <p><b>11. TOXICOLOGICAL INFORMATION</b></p> <p>Route of Exposure: Eyes, Skin, Inhalation, Ingestion Teratogen Status: None Listed Mutagen Status: Potassium Iodide Listed as Mutagenic for Mammalian Somatic Cells Reproductive Toxicity: Potassium Iodide Classified Reproductive System/toxin/female Carcinogen Status: None Listed</p> <p><b>12. ECOLOGICAL INFORMATION</b></p> <p>No Ecological Data Available</p> <p><b>13. DISPOSAL CONSIDERATIONS</b></p> <p>Dispose of in a manner consistent with Federal, State and Local Regulations.</p> <p><b>14. TRANSPORT INFORMATION</b></p> <p>US DOT (United States Department of Transportation): Not Regulated IATA (International Air Transport Association): Not Regulated IMO (International Maritime Organization): Not Regulated</p> <p><b>15. REGULATORY INFORMATION</b></p> <p>EUROPEAN INFORMATION:</p> <p>RISK PHRASES: R 36/38 Irritating to Eyes and Skin SAFETY PHRASES: S 26 In Case of Contact with Eyes, Rinse Immediately with Plenty of Water and Seek Medical Advice. S37/39 Wear Suitable Gloves and Eye/Face Protection</p> <p>US / CANADA INFORMATION:</p> <p>SARA/Title III: None Listed Cal. Proposition 65: None Listed US TSCA Inventory: Listed</p> <p><b>16. OTHER INFORMATION</b></p> <p>THE ABOVE INFORMATION IS BELIEVED TO BE ACCURATE AND REPRESENTS THE BEST INFORMATION CURRENTLY AVAILABLE TO US. ALL PRODUCTS ARE OFFERED IN ACCORDANCE WITH THE MANUFACTURER'S CURRENT PRODUCTION SPECIFICATIONS AND ARE INTENDED SOLELY FOR USE IN ANALYTICAL TESTING. THE MANUFACTURER SHALL IN NO EVENT BE LIABLE FOR ANY INJURY, LOSS OR DAMAGE RESULTING FROM THE HANDLING, USE OR MISUSE OF THESE PRODUCTS.</p> <p># 0591 Rev. 4 November 21, 2011</p>
Component		Percent																										
Component	Trisodium Citrate Salt																											
CAS No.	68-04-2	<15																										
Component	Potassium Iodide																											
CAS No.	7681-11-0	<10																										
Component	Ethylenediaminetetraacetic Acid (EDTA)																											
CAS No.	6381-92-6	<1																										
Component	Deionized Water																											
CAS No.	7732-18-5	>75																										

## 8.7.7 MSDS of Citric acid

<b>SIGMA-ALDRICH</b>		<small>sigma-aldrich.com</small>
		<b>SAFETY DATA SHEET</b>
		<small>Version 4.8 Revision Date 09/27/2017 Print Date 11/29/2017</small>
<b>1. PRODUCT AND COMPANY IDENTIFICATION</b>		
<b>1.1 Product identifiers</b>		
Product name	: Citric acid	
Product Number	: 251275	
Brand	: Sigma-Aldrich	
CAS-No.	: 77-92-9	
<b>1.2 Relevant identified uses of the substance or mixture and uses advised against</b>		
Identified uses	: Laboratory chemicals, Synthesis of substances	
<b>1.3 Details of the supplier of the safety data sheet</b>		
Company	: Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA	
Telephone	: +1 800-325-5832	
Fax	: +1 800-325-5052	
<b>1.4 Emergency telephone number</b>		
Emergency Phone #	: +1-703-527-3887 (CHEMTREC)	
<b>2. HAZARDS IDENTIFICATION</b>		
<b>2.1 Classification of the substance or mixture</b>		
GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)	Eye irritation (Category 2A), H319	
	For the full text of the H-Statements mentioned in this Section, see Section 16.	
<b>2.2 GHS Label elements, including precautionary statements</b>		
Pictogram		
Signal word	Warning	
Hazard statement(s)	H319 Causes serious eye irritation.	
Precautionary statement(s)	P264 Wash skin thoroughly after handling. P280 Wear eye protection/ face protection. P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. P337 + P313 If eye irritation persists: Get medical advice/ attention.	
<b>2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none</b>		
<b>3. COMPOSITION/INFORMATION ON INGREDIENTS</b>		
<b>3.1 Substances</b>		
Formula	: C <sub>6</sub> H <sub>8</sub> O <sub>7</sub>	
<small>Sigma-Aldrich - 251275</small>		<small>Page 1 of 7</small>

Molecular weight : 192.12 g/mol  
 CAS-No. : 77-92-9  
 EC-No. : 201-069-1

**Hazardous components**

Component	Classification	Concentration
Citric acid	Eye Irrit. 2A; H319	90 - 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

**4. FIRST AID MEASURES****4.1 Description of first aid measures****General advice**

Move out of dangerous area. Consult a physician. Show this safety data sheet to the doctor in attendance.

**If inhaled**

If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

**In case of skin contact**

Wash off with soap and plenty of water. Consult a physician.

**In case of eye contact**

Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

**If swallowed**

Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

**4.2 Most important symptoms and effects, both acute and delayed**

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

**4.3 Indication of any immediate medical attention and special treatment needed**

No data available

**5. FIREFIGHTING MEASURES****5.1 Extinguishing media****Suitable extinguishing media**

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

**5.2 Special hazards arising from the substance or mixture**

No data available

**5.3 Advice for firefighters**

Wear self-contained breathing apparatus for firefighting if necessary.

**5.4 Further information**

No data available

**6. ACCIDENTAL RELEASE MEASURES****6.1 Personal precautions, protective equipment and emergency procedures**

Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Avoid breathing dust.

For personal protection see section 8.

**6.2 Environmental precautions**

Do not let product enter drains.

**6.3 Methods and materials for containment and cleaning up**

Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

**6.4 Reference to other sections**

For disposal see section 13.

**7. HANDLING AND STORAGE****7.1 Precautions for safe handling**

Avoid contact with skin and eyes. Avoid formation of dust and aerosols. Further processing of solid materials may result in the formation of combustible dusts. The potential for combustible dust formation should be taken into consideration before additional processing occurs.

Provide appropriate exhaust ventilation at places where dust is formed.

For precautions see section 2.2.

**7.2 Conditions for safe storage, including any incompatibilities**

Keep container tightly closed in a dry and well-ventilated place.

**7.3 Specific end use(s)**

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

**8. EXPOSURE CONTROLS/PERSONAL PROTECTION****8.1 Control parameters****Components with workplace control parameters**

Contains no substances with occupational exposure limit values.

**8.2 Exposure controls****Appropriate engineering controls**

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

**Personal protective equipment****Eye/face protection**

Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

**Skin protection**

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

**Full contact**

Material: Nitrile rubber

Minimum layer thickness: 0.11 mm

Break through time: 480 min

Material tested: Dermatril® (KCL 740 / Aldrich Z677272, Size M)

**Splash contact**

Material: Nitrile rubber

Minimum layer thickness: 0.11 mm

Break through time: 480 min

Material tested: Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374

If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

**Body Protection**

Impervious clothing. The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

**Respiratory protection**

For nuisance exposures use type P95 (US) or type P1 (EU EN 143) particle respirator. For higher level protection use type OV/AG/P99 (US) or type ABEK-P2 (EU EN 143) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure  
Do not let product enter drains.

---

## 9. PHYSICAL AND CHEMICAL PROPERTIES

### 9.1 Information on basic physical and chemical properties

a) Appearance	Form: crystalline Colour: white
b) Odour	No data available
c) Odour Threshold	No data available
d) pH	1.8 at ca.50 g/l at 25 °C (77 °F)
e) Melting point/freezing point	Melting point/range: 153 - 159 °C (307 - 318 °F) - lit.
f) Initial boiling point and boiling range	No data available
g) Flash point	No data available
h) Evaporation rate	No data available
i) Flammability (solid, gas)	No data available
j) Upper/lower flammability or explosive limits	Lower explosion limit: 8 %(V)
k) Vapour pressure	No data available
l) Vapour density	No data available
m) Relative density	No data available
n) Water solubility	383 g/l at 25 °C (77 °F)
o) Partition coefficient: n-octanol/water	log Pow: -1.639 at 20 °C (68 °F)
p) Auto-ignition temperature	No data available
q) Decomposition temperature	No data available
r) Viscosity	No data available
s) Explosive properties	No data available
t) Oxidizing properties	No data available

### 9.2 Other safety information

No data available

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## 10. STABILITY AND REACTIVITY

### 10.1 Reactivity

No data available

### 10.2 Chemical stability

Stable under recommended storage conditions.

### 10.3 Possibility of hazardous reactions

No data available

### 10.4 Conditions to avoid

No data available

### 10.5 Incompatible materials

Oxidizing agents, Bases, Reducing agents, Nitrates

**10.6 Hazardous decomposition products**

Other decomposition products - No data available

Hazardous decomposition products formed under fire conditions. - Carbon oxides

In the event of fire: see section 5

---

**11. TOXICOLOGICAL INFORMATION****11.1 Information on toxicological effects****Acute toxicity**

LD50 Oral - Rat - 5,400 mg/kg

(OECD Test Guideline 401)

Inhalation: No data available

LD50 Dermal - Rat - > 2,000 mg/kg

(OECD Test Guideline 402)

No data available

**Skin corrosion/irritation**

Skin - Rabbit

Result: Mild skin irritation

(OECD Test Guideline 404)

**Serious eye damage/eye irritation**

Eyes - Rabbit

Result: Irritating to eyes.

(OECD Test Guideline 405)

**Respiratory or skin sensitisation**

Prolonged or repeated exposure may cause allergic reactions in certain sensitive individuals.

**Germ cell mutagenicity**

No data available

**Carcinogenicity**

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

**Reproductive toxicity**

No data available

No data available

**Specific target organ toxicity - single exposure**

No data available

**Specific target organ toxicity - repeated exposure**

No data available

**Aspiration hazard**

No data available

**Additional Information**

RTECS: GE7350000

Vomiting, Diarrhoea, Damage to tooth enamel., Dermatitis, To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

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**12. ECOLOGICAL INFORMATION****12.1 Toxicity**

Toxicity to fish                      mortality LC50 - *Leuciscus idus melanotus* - 440 mg/l - 48 h  
(OECD Test Guideline 203)

Toxicity to daphnia and      static test - *Daphnia magna* (Water flea) - 1,535 mg/l - 24 h  
other aquatic  
invertebrates

**12.2 Persistence and degradability**

No data available

**12.3 Bioaccumulative potential**

No data available

**12.4 Mobility in soil**

No data available

**12.5 Results of PBT and vPvB assessment**

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

**12.6 Other adverse effects**

No data available

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**13. DISPOSAL CONSIDERATIONS****13.1 Waste treatment methods****Product**

Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

**Contaminated packaging**

Dispose of as unused product.

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**14. TRANSPORT INFORMATION****DOT (US)**

Not dangerous goods

**IMDG**

Not dangerous goods

**IATA**

Not dangerous goods

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**15. REGULATORY INFORMATION****SARA 302 Components**

No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

**SARA 313 Components**

This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

**SARA 311/312 Hazards**

Acute Health Hazard

**Massachusetts Right To Know Components**

No components are subject to the Massachusetts Right to Know Act.

**Pennsylvania Right To Know Components**

Citric acid

CAS-No.  
77-92-9

Revision Date

**New Jersey Right To Know Components**

Citric acid

CAS-No.  
77-92-9

Revision Date

**California Prop. 65 Components**

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

**16. OTHER INFORMATION**

Full text of H-Statements referred to under sections 2 and 3.

Eye Irrit. H319	Eye irritation Causes serious eye irritation.
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**HMIS Rating**

Health hazard:	2
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

**NFPA Rating**

Health hazard:	2
Fire Hazard:	0
Reactivity Hazard:	0

**Further information**

Copyright 2016 Sigma-Aldrich Co. LLC. License granted to make unlimited paper copies for internal use only. The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See [www.sigma-aldrich.com](http://www.sigma-aldrich.com) and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

**Preparation Information**

Sigma-Aldrich Corporation  
Product Safety – Americas Region  
1-800-521-8956

Version: 4.8

Revision Date: 09/27/2017

Print Date: 11/29/2017

### 8.8 Training Materials

Training for Vessel Owner’s representative and on board training courses for Vessel’s staff on the control system to be included.

Training software programs about the whole control system, easy running on any Personal Computer, to be provided for Vessel’s staff.

Refer to the form “Crew Training Confirmation”


<b>Crew Training Confirmation</b>				
<p>■ <b>Vessel Name</b> :</p> <p>■ <b>Vessel Hull No.</b> :</p> <p>■ <b>Date &amp; Time</b> :</p> <p>■ <b>Location</b> :</p> <p>■ <b>Contents</b></p> <p><b>1. Introduction of ECS for Ballast Water Management System</b></p> <p><b>2. Explanation of equipments and operation theory of ECS</b></p> <p style="padding-left: 20px;">2-1. Software parts, including with report generation method for ECS operation to PDF file</p> <p style="padding-left: 20px;">2-2. Hardware parts</p> <p><b>3. Demonstration in order to be operated actually by ship's crews for ECS operation</b></p> <p style="padding-left: 20px;">3-1. Check points of ECS operation before operation by each operation mode</p> <p style="padding-left: 20px;">3-2. Check points of ECS operation after operation by each operation mode</p> <p><b>4. Maintenance of ECS</b></p> <p style="padding-left: 20px;">4-1. Replacement procedure and replacement cycle of CLX reagent</p> <p style="padding-left: 20px;">4-2. Refill Procedure of neutralizing agent(sodium thiosulfate) into the ANU tank</p> <p style="padding-left: 20px;">4-3. Cleaning procedure of T-strainer</p> <p style="padding-left: 20px;">4-4. Procedure for using EWU(EM Washing Unit)</p> <p>※ Above training items are going to be carried out according to training manual by skilled TECHCROSS engineer during commissioning period for ship's crews.</p>				
<b>[On-board Training of BALLAST WATER MANAGEMENT SYSTEM]</b>				
No.	Date	Position	Name	Trainee Signature
<p>※ <b>Remark :</b></p>				
<p>_____</p> <p><b>CAPTAIN</b></p>			<p>_____</p> <p><b>TEHCROSS(Trainer)</b></p>	

## 9. APPENDIX II

### 9.1 Letter of International Paint Ltd


<b>International Paint Ltd</b> Worldwide Marine and Protective Coatings	Stoneygate Lane Felling, Gateshead Tyne & Wear NE10 0JY U.K.	T +44 191 469 8111 F +44 191 438 3711 www.internationalpaint.com	
			<b>AkzoNobel</b> Tomorrow's Answers Today
<p>11<sup>th</sup> November 2010</p>			
<p>To whom it may concern,</p>			
<p><b><u>TechCross Electroclean ballast water treatment system</u></b></p>			
<p>Although not carried out in conjunction with International Paint, and without International Paint products being included, TechCross Electroclean ballast water treatment system has been tested for its effect on epoxy ballast tank coatings.</p>			
<p>It is the view of International Paint that the test, carried out in Korea and reported 28<sup>th</sup> June 2010, was appropriate and that results showed that, when operating under normal conditions and with active substances within the specified levels, i.e. ≤10ppm hypochlorite, the treatment system is unlikely to have a detrimental effect on epoxy ballast tank coatings approved to IMO Resolution MSC.215(82).</p>			
<p>This assumes that active substances will be present in ship's water ballast tanks at similar levels to those used in the test.</p>			
<p>Yours faithfully          For and on behalf of International Paint Ltd.</p>			
			
<p><b>Colin Watson</b>  <u>Worldwide Marine Technical Operations Manager</u></p>			
<p><i>"Unless otherwise agreed in writing, all products supplied and technical advice or recommendations given are subject to the Conditions of Sale of our supplying company and the provisions of the relevant product data sheet".</i></p>			
<p><small>Registered in England No. 63604          Registered Office 26th Floor, Portland House, Bressenden Place, London SW1E 5BG</small></p>			

## 9.2 IMO Final Approval

INTERNATIONAL MARITIME ORGANIZATION			<b>E</b>
		IMO	
MARINE ENVIRONMENT PROTECTION COMMITTEE 58th session Agenda item 23			MEPC 58/23 16 October 2008 Original: ENGLISH
<b>REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS FIFTY-EIGHTH SESSION</b>			
<b>Section</b>		<b>Paragraph Nos.</b>	<b>Page No.</b>
1	INTRODUCTION	1.1 – 1.9	5
2	HARMFUL AQUATIC ORGANISMS IN BALLAST WATER	2.1 – 2.63	8
3	RECYCLING OF SHIPS	3.1 – 3.56	20
4	PREVENTION OF AIR POLLUTION FROM SHIPS	4.1 – 4.57	30
5	CONSIDERATION AND ADOPTION OF AMENDMENTS TO MANDATORY INSTRUMENTS	5.1 – 5.46	41
6	INTERPRETATIONS OF AND AMENDMENTS TO MARPOL AND RELATED INSTRUMENTS	6.1 – 6.17	51
7	IMPLEMENTATION OF THE OPRC CONVENTION AND THE OPRC-HNS PROTOCOL AND RELEVANT CONFERENCE RESOLUTIONS	7.1 – 7.17	55
8	IDENTIFICATION AND PROTECTION OF SPECIAL AREAS AND PARTICULARLY SENSITIVE SEA AREAS	8.1 – 8.9	57
9	INADEQUACY OF RECEPTION FACILITIES	9.1 – 9.10	59
10	REPORTS OF SUB-COMMITTEES	10.1 – 10.76	60
11	WORK OF OTHER BODIES	11.1 – 11.15	68
12	STATUS OF CONVENTIONS	12.1 – 12.2	71

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60 YEARS IN THE SERVICE OF SHIPPING

**REPORTS OF THE SIXTH AND SEVENTH MEETINGS OF THE GESAMP-BWWG**

2.4 After resuming the consideration of this agenda item on Wednesday, 8 October 2008, the Committee noted that the sixth and seventh meetings of the GESAMP-BWWG were held from 19 to 23 May 2008 and from 30 June to 4 July 2008, at the IMO Headquarters, under the chairmanship of Mr. Jan Linders and Mr. Finn Pedersen, respectively. During the two meetings, the GESAMP-BWWG reviewed a total of six proposals for approval of ballast water management systems that make use of Active Substances submitted by Germany, Japan, the Netherlands, Norway and the Republic of Korea.

2.5 The Committee further noted that the seventh meeting of the GESAMP-BWWG was held as an extraordinary meeting in addition to the regular meeting scheduled between MEPC 57 and MEPC 58, to review the proposals which could not be reviewed by the sixth meeting and which had been submitted before the deadline for submission of proposals for approval to MEPC 58. The Committee expressed its appreciation for the efforts made by the members of the GESAMP-BWWG to accomplish this task and to facilitate timely development of new ballast water technologies.

**Basic Approval**

2.6 The Committee, having considered the recommendations contained in annexes 5 and 6 of the "Report of the sixth meeting of the GESAMP-BWWG" (MEPC 58/2/7) as well as recommendations contained in annex 5 of the "Report of the seventh meeting of the GESAMP-BWWG" (MEPC 58/2/8), agreed to give **Basic Approval** to:

- .1 the TG Ballastcleaner and TG Environmentalguard System proposed by Japan in document MEPC 57/2/8;
- .2 the Greenship's Ballast Water Management System proposed by the Netherlands in document MEPC 57/2/7; and
- .3 the Ecochlor® Ballast Water Treatment System proposed by Germany in document MEPC 58/2/2.

2.7 The Committee then invited the Administrations of Japan, the Netherlands and Germany to take into account all the recommendations made in annexes 5 and 6 of the sixth report and annex 5 of the seventh report, respectively, during the further development of the systems.

**Final Approval**

2.8 Having examined the recommendations contained in annex 7 of the "Report of the sixth meeting of the GESAMP-BWWG" (MEPC 58/2/7), the Committee agreed to give **Final Approval** to the Electro-Clean™ System proposed by the Republic of Korea in document MEPC 58/2.

2.9 Following consideration of the recommendations contained in annex 4 of the "Report of the seventh meeting of the GESAMP-BWWG" (MEPC 58/2/8) regarding the OceanSaver® Ballast Water Management System proposed by Norway in document MEPC 58/2/1, the Committee noted the concerns expressed by the delegations of the Netherlands and FOEI and invited these delegations to have additional consultations with the Co-Chairman of the GESAMP-BWWG during the lunch break.

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## Appendix 1

## Product Description and/or Approval Condition

Certificate No : GCH35216-AC001

Date of Issue : 2nd December, 2015.

## 1. Product Description : Control System for BWMS

## 1) Specifications:

Component	Model	Specification
Power Distributor Equipment	PDE-12/PDE-24/PDE-A4	- Max treatment Capacity (m <sup>3</sup> /h): 1200 / 2400 / 2400 - Input power : AC 440 V (3 ph, 60 Hz)
Auto Neutralisation Unit	ANU 5T/ANU 10T	- Input power : AC 220 V (1 ph, 60 Hz) - Water inlet pressure : Max. 5 bar - Neutraliser : Sodium Thiosulfate
Power Rectifier Unit	PRU	- Input power : AC 440 V (3 ph, 60 Hz) - Output Voltage : Max. 10 V DC - Output Current : Max. 1100 A - Treatment Capacity : 150 m <sup>3</sup> /h
TR0 Sensor Unit	ECS-TSU / Ex-ECS-TSU	- Range : 0 to 10.0 mg/L - Input power : AC 220 V (1 ph, 60 Hz) - Max working pressure : 10 bar - Operating Temperature : 0 to 55 °C

## 2. Documentation

- 1) Drawings : PRU000-GA-A001Z, PDE24A-GA-C001Z, PDE12A-GA-C001Z, PDE0A4-GA-C001Z, TSU000-GA-A001Z, TSU000-EA-P001Z, ANU05T-GA-A001Z, ANU10T-GA-A001Z
- 2) Technical Data : Specification list (2015.11.24, issued by TECHCROSS)
- 3) Test Reports (issued by SGS Korea):  
 SGS-R14-1747-EN00 (2014.12.17), SGS-R14-1748-EN00 (2014.12.17),  
 SGS-R14-1749-EN00 (2014.12.17), SGS-R14-1750-EN00 (2014.12.17),  
 SGS-R14-1751-EN00 (2014.12.17), SGS-R14-1758-EN00 (2014.12.17),  
 SGS-R14-1759-EN00 (2014.12.17), SGS-E14-0139 (2014.12.06),  
 SGS-E14-0140 (2014.12.09), SGS-E14-0141 (2014.12.09),  
 SGS-E14-0142 (2014.12.09), SGS-E14-0143 (2014.12.09),  
 SGS-E14-0144 (2014.12.09), SGS-E14-0145 (2014.12.09),  
 SGS-E14-0146 (2014.12.09)

&lt;The End&gt;

AC-2B(2011.06)

## **# Attachment**

**#1-1. TC1712-USCG(MD)\_Rev00\_BOM of ECS B-1.1**