U.S. Department of Transportation

Maritime Administration

EMPIRE STATE

Machinery Operating Manual

IMO: 9910313

First Draft - May 2022

WMT MARINE

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Anything to update?

It is important that this manual is kept up to date as a live document. If you believe there are any errors or omissions in this manual, or you are aware of changes to the equipment or systems on board then please contact the publishers:

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SECTION 7: HOTEL EQUIPMENT & SERVICES

SECTION 8: MACHINERY TRAINING SPACES

Authors note: To be completed once photographs are taken during research visit.

Illustrations

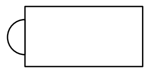
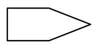
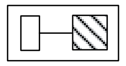
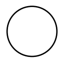
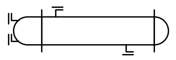
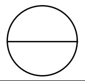
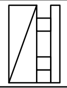
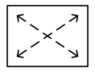
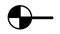
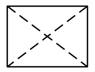
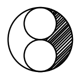
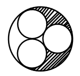
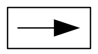
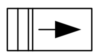
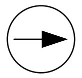
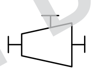
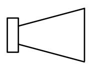
Standard Symbols List (i)

VALVES			
SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	B'FLY LUG TYPE		PRESS. CONT. PRIM./SEC. PNEU./DIRECT
	B'FLY WAFER TYPE		PRESS. REDUCING
	B'FLY FLANGE TYPE		QUICK CLOSING PNEU. (STR./ANG.)
	BALL FULL BORE SOLID		QUICK CLOSING WIRE (STR./ANG.)
	BALL 3-WAY (T-TYPE/L-TYPE)		REM. HYD. B'FLY LUG
	COCK 2-WAY		REM. HYD. B'FLY WAFER
	COCK 3-WAY (T-TYPE/L-TYPE)		REM. HYD. B'FLY FLANGE
	DEAERATING (STR/ANG)		SELF CLOSING SPRING (STR./ANG.)
	FLOW CONT. BALL FLOAT		SAFTY (STR./ANG.)
	FLOW CONT. BALL FLOAT CHECK		STORM VERT. SDNR (STR./ANG)
	GLOBE (STR/ANG)		STORM VERT. SWING CHECK STR.
	GLOBE SDNR		TEMP. CONT. 2-WAY WAX
	GATE VALVE		TEMP. CONT. 2-WAY PNEU.
N.O N.C	LOCK (OPEN/CLOSE)		TEMP. CONT. 3-WAY WAX
	HOSE VALVE (STR/ANG)		TEMP. CONT. 3-WAY ROTARY PISTON
	SOLENOID 2-WAY (STR/ANG)		TEMP. CONT. 3-WAY PNEU.
	SOLENOID 3-WAY		3-WAY MOTOR VALVE
	NON-RETURN FLAP		HOSE CONN. BALL VALVE
	NON-RETURN SWING TILTING CHECK		ORIFICE PLATE
	NON-RETURN LIFT (STR/ANG)		ORIFICE VALVE
	NEEDLE STRAIGHT		NEEDLE 3-WAY TEST

VALVES AND FITTINGS			
SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	AIR VENT GOOSE NECK PIPE		SEPARATOR
	AIR VENT GOOSE NECK PIPE WITH SCREEN		SLEEVE COUPLING
	AIR VENT GOOSE NECK PIPE WITH SCREEN & DRAIN COWL		SOUNDING CAP DK PIECE
	AIR VENT HEAD (FLOAT BALL / FLOAT DISC)		SOUNDING CAP NORMAL
	BELL MOUTH		SOUNDING CAP SELF CLOS'G WEIGHT PEDAL WITH COCK
	BELLOWS COUPLING		SOUNDING CAP SELF CLOS'G WEIGHT WITH COCK
	BLANK FLANGE		SOUNDING CAP SELF CLOS'G GATE TYPE
	BOSS & PLUG		SPECTACLE FLANGE (NORMAL OPEN/CLOSE)
	SIGHT GLASS		SPOOL PIECE
	DRESSER COUPLING		STEAM TRAP DISC TYPE WITH VALVE
	FILLING CAP		STEAM TRAP BALL FLOAT TYPE
	FLEXIBLE HOSE		STRAINER DUPLEX
	HOPPER		STRAINER SIMPLEX
	LEVEL GAUGE WITH VALVE (FLAT/CYLINDRICAL TYPE)		STRAINER Y-TYPE
			REDUCER
	LEVEL GAUGE (FLOAT/DIAL FLOAT) TYPE		ROSE BOX
			REM. HYD. GLOBE SDNR
	DIAL LEVEL GAUGE WITH VALVE (CONTENT TYPE)		DECK STAND NORMAL
			DECK STAND LOCAL HYD.
	MUD BOX (STR/ANG)		
	OVERBOARD		

Reference Drawing: NSMV-536-B702

Standard Symbols List (ii)

EQUIPMENT, INSTRUMENTATION			
SYMBOL	**DESCRIPTION**	**SYMBOL**	**DESCRIPTION**
	F.W FOUNTAIN		CONNECTED TO MARKED PAGE (OTHER SYS DWG)
	FLOW METER		AUX. SWITCH
	AUTO FILTER		LOCAL INSTRUMENT
	TUBULAR TYPE HEAT EXCHANGER		REMOTE CONTROL INSTRUMENT
	COOLER PLATE TYPE		MAKER SUPPLY ITEM
	HULL TANK		PIPE UP
	INDEPENDENT TANK		PIPE DOWN
	MAKER SUPPLY		
	GEAR PUMP		
	SCREW PUMP		
	MONO PUMP		
	PISTON PUMP		
	CENTRIFUGAL PUMP		
	HAND PUMP		
	EJECTOR		
	HORN		

ABBREVIATIONS			
SYMBOL	**DESCRIPTION**	**SYMBOL**	**DESCRIPTION**
CP	COMPOUND GAUGE	SAH	SALINITY ALARM HIGH
DPI	DIFFERENTIAL PRESS. INDICATOR	SD	SALINITY DETECTOR
DPS	DIFFERENTIAL PRESS. SWITCH	SI	SALINITY INDICATOR
DPT	DIFFERENTIAL PRESS. TRANSMITTER	TAH	TEMPERATURE ALARM HIGH
FD	FLOW DETECTOR	TAL	TEMPERATURE ALARM LOW
FS	FLOW SWITCH	TI	TEMPERATURE INDICATOR
FT	FLOW TRANSMITTER	TIAH	TEMP. INDICATOR ALARM HIGH
LAH	LEVEL ALARM HIGH	TIAL	TEMP. INDICATOR ALARM LOW
LAL	LEVEL ALARM LOW	TIAHL	TEMP. INDICATOR ALARM HIGH LOW
LCH	LEVEL CONTROL HIGH	TIC	TEMPERATURE INDICATING CONTROLLER
LCL	LEVEL CONTROL LOW	TS	TEMPERATURE SWITCH
LI	LEVEL INDICATOR	TT	TEMPERATURE TRANSMITTER
LIAHL	LEVEL INDICATOR ALARM HIGH LOW	VAH	VISCOSITY ALARM HIGH
LIC	LEVEL INDICATING CONTROLLER	VAL	VISCOSITY ALARM LOW
LS	LEVEL SWITCH	VCA	VACUUM ALARM
LT	LEVEL TRANSMITTER	VCT	VACUUM TRANSMITTER
PAH	PRESSURE ALARM HIGH	VI	VISCOSITY INDICATOR
PAL	PRESSURE ALARM LOW	VIAHL	VISCOSITY INDICATOR ALARM HIGH LOW
PI	PRESSURE INDICATOR	VT	VISCOSITY TRANSMITTER
PIAH	PRESS. INDICATOR ALARM HIGH	VIC	VISCOSITY INDICATING CONTROLLER
PIAL	PRESS. INDICATOR ALARM LOW	XA	ABNORMAL ALARM
PIAHL	PRESS.INDICATOR ALARM HIGH LOW	XS	AUX. UNSPECIFIED SWITCH
PIC	PRESSURE INDICATING CONTROLLER	ZI	POSITION INDICATOR
PS	PRESSURE SWITCH	ZS	LIMIT SWITCH
PSL	PRESSURE LOW SWITCH	EP	E/P TRANDUCER
PT	PRESSURE TRANSMITTER	RS	REMOTE SOUNDING (AIR PURGE TYPE)

Reference Drawing: NSMV-536-B702

Electrical Symbols and Color Scheme

ELECTRICAL SYMBOLS

SYMBOL	DESCRIPTION
D/G	DIESEL GENERATOR
P/M	PROPULSION MOTOR
M	AC MOTOR
	TRANSFORMER
	AIR CIRCUIT BREAKER (FIXED)
	AIR CIRCUIT BREAKER (DRAW OUT)
VCB	VACUUM CIRCUIT BREAKER FOR HIGH VOLTAGE SYS(DRAW OUT)
	MCCB
	DISCONNECTING SWITCH
	6,600V
	440V
	120V
	24V DC

ILLUSTRATION COLOR SCHEME

COLOR	DESCRIPTION
	High Temperature Cooling Water
	Low Temperature Cooling Water
	Domestic Fresh Water Fresh Water Ballast
	Sea Water
	Hydraulic Oil Lubricating Oil
	Saturated Steam
	Condensate Feed Water
	Fire/Deck Water CO2
	Marine Gas Oil
	Sludge/Waste Oil
	Air
	Bilges/Drains
	Chemical
	Refrigeration Liquid
	Refrigeration Gas
	Electrical Signal
	Instrumentation

Piping Color Stripes
Authors note: To be updated.

BALLAST WATER	GREEN	VIOLET	GREEN
WASTE OIL / USED OIL	BLACK	BROWN	BLACK
BILGE WATER	BLACK	GREEN	BLACK
COMPRESSED AIR(LO-PRESS)	GRAY	ORANGE	GRAY
CHILLED WATER	BLUE	WHITE	BLUE
COOLING SEA WATER	GREEN	YELLOW	GREEN
EXHAUST GAS	BLACK	GRAY	BLACK
SPRINKLER WATER	RED	ORANGE	RED
FIRE FIGHTING GAS	RED	GRAY	RED
POTABLE WATER	BLUE	GREEN	BLUE
HYDRAULIC FLUID	ORANGE	GRAY	ORANGE
FIRE FIGHTING FOAM	RED	YELLOW	RED
CONTROL AIR/REGULATORY AIR	GRAY	VIOLET	GRAY
COOLING FRESH WATER	BLUE	VIOLET	BLUE
LUBRICATION OIL-ENGINES	ORANGE	YELLOW	ORANGE
WASTE OIL / USED OIL	BLACK	BROWN	BLACK
MDO (MARINE DIESEL FUEL)	BROWN	YELLOW	BROWN
REFRIGERANT	GRAY	MAROON	GRAY
BILGE WATER	BLACK	GREEN	BLACK
BLACK WATER	BLACK	BLUE	BLACK
GRAY WATER	BLACK	WHITE	BLACK
FRESH WATER SANITARY	BLUE	BROWN	BLUE
COMPRESSED AIR(LO-PRESS)	GRAY	ORANGE	GRAY
FIRE FIGHTING WATER	RED	GREEN	RED
SPRINKLER WATER	RED	ORANGE	RED

Reference Drawing: NSMV-321-B607

Introduction

Although this ship is supplied with shipbuilder's plans and manufacturer's instruction books, there is no single document which gives guidance on operating complete systems as installed on board, as distinct from individual items of machinery.

The purpose of this 'one-stop' manual is to assist, inform and guide competent ship's staff and trainees in the operation of the systems and equipment on board, and to provide additional information that may not be otherwise available. In some cases, the competent ship's staff and trainees may be initially unfamiliar with this vessel and the information in this manual is intended to accelerate the familiarisation process.

It is intended to be used in conjunction with shipyard drawings and manufacturer's instruction manuals, bulletins, Fleet Regulations, the ship's Senior Officers Standing Orders, and in no way replaces or supersedes these publications, all of which take precedence over this manual.

Information relevant to the operation of this vessel has been carefully collated in relation to the systems of the vessel and is presented in three on-board volumes, a MACHINERY, DECK, BRIDGE and SOLAS OPERATING MANUALS.

The vessel is constructed to comply with MARPOL 73/78. These regulations can be found in the Consolidated Edition, 2017, and in the latest Amendments.

The information, procedures, specifications and illustrations in this manual have been compiled by WMT personnel by reference to shipyard drawings and manufacturer's publications that were made available to WMT and believed to be correct at the time of publication. The systems and procedures have been verified as far as is practicable in conjunction with competent ship's staff under operating conditions.

It is impossible to anticipate every circumstance that might involve a potential hazard, therefore, warnings and cautions used throughout this manual are provided to inform of perceived dangers to ship's environment or equipment. In many cases, the best operating practice can only be learned by experience.

If any information in these manuals are believed to be inaccurate or incomplete, the officer must use his professional judgement and other information available on board to proceed.

Any such errors or omissions or modifications to the ship's installations, set points, equipment or approved deviation from published operating procedures, must be reported immediately to the company's Technical Operations Office, who should inform WMT so that a revised document may be issued to this ship and in some cases, others of the same class.

Safe Operation

The safety of the ship depends on the care and attention of all on board. Most safety precautions are a matter of common sense and good housekeeping and are detailed in the various manuals available on board. However, records show that even experienced operators sometimes neglect safety precautions through over-familiarity and the following basic rules must be remembered at all times.

- Never continue to operate any machine or equipment which appears to be potentially unsafe or dangerous and always report such a condition immediately.
- Make a point of testing all safety equipment and devices regularly. Always test safety trips before starting any equipment. In particular, overspeed trips on auxiliary turbines must be tested before putting the unit to work.
- Never ignore any unusual or suspicious circumstances, no matter how trivial. Small symptoms often appear before a major failure occurs.
- Never underestimate the fire hazard of hydrocarbon products, whether liquid or vapour.
- Never start a machine remotely from the cargo and engine control room without confirming visually that the machine is able to operate satisfactorily.

In the design of equipment, protection devices have been included to ensure that, as far as possible, in the event of a fault occurring, whether on the part of the equipment or the operator, the equipment concerned will cease to function without danger to personnel or damage to the machine. If any of these safety devices are bypassed, overridden or neglected, then the operation of any equipment or machinery in this condition is potentially dangerous.

Description

The concept of this manual is to provide information to technically competent ship's officers, unfamiliar to the vessel, in a form that is readily comprehensible, thus aiding their understanding and knowledge of the specific vessel. Special attention is drawn to emergency safety and fire fighting systems.

The manual consists of a number of parts and sections which describe the systems and equipment fitted and their method of operation related to a schematic diagram where applicable.

The valves and fittings identifications and symbols used in this manual are the same as those used by the shipbuilder.

Illustrations

All illustrations that are referred to in the text are located either in-text where sufficiently small, or above the text, so that both the text and illustration are accessible when the manual is laid open. When text concerning an illustration covers several pages, the illustration is duplicated above each page of text.

Where flows are detailed in an illustration, these are shown in colour. A key of all colours and line styles used in an illustration is provided on the illustration.

Details of colour coding used in the illustrations are given in the Cargo/ Machinery Valves and Colour Scheme which is detailed on previous pages in this Front Matter section.

Symbols given in the manual adhere to international standards and keys to the symbols used throughout the manual are also given on previous pages in this Front Matter section.

Notices

The following notices occur throughout this manual:

WARNING
Warnings are given to draw reader's attention to operations where DANGER TO LIFE OR LIMB MAY OCCUR.

CAUTION
Cautions are given to draw reader's attention to operations where DAMAGE TO EQUIPMENT MAY OCCUR.

Note: Notes are given to draw reader's attention to points of interest or to supply supplementary information.

Safety Notice

It has been recorded by International Accident Investigation Commissions that a disproportionate number of deaths and serious injuries occur on ships each year during drills involving lifesaving craft. It is therefore essential that all officers and crew make themselves fully conversant with the launching, retrieval and the safe operation of the lifeboats, liferafts and rescue boats.

Issue and Update Control

This manual is provided with a system of issue and update control. Controlling documents ensures that:

- Documents conform to a standard format.
- Amendments are carried out by relevant personnel.
- Each document or update to a document is approved before issue.
- A history of updates is maintained.
- Updates are issued to all registered holders of documents.
- Sections are removed from circulation when obsolete.

Document control is achieved by the use of the footer provided on every page and the issue and update table.

In the right-hand corner of each footer are details of the pages, the section number and the page number of the section. In the left-hand corner of each footer is the issue number.

Details of each section are given in the first column of the issue and update control table. The table thus forms a matrix into which the dates of issue of the original document and any subsequent updated sections are located.

The information and guidance contained herein is produced for the assistance of certificated officers who by virtue of such certification are deemed competent to operate the vessel to which such information and guidance refers.

Any conflict arising between the information and guidance provided herein and the professional judgement of such competent officers must be immediately resolved by reference to the company's Technical Operations Office.

For any new issue or update contact:

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Worldwide Marine Technology Limited
Dee House
Parkway, Zone 2
Deeside Industrial Park
Flintshire
CH5 2NS
United Kingdom

E-mail: manuals@wmtmarine.com

Author's Note: The Issues and Update Table will be compiled and completed at Final Issue.

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ANYTHING TO UPDATE?

It is important that this manual is kept up to date as a live document. If you believe there are any errors or omissions in this manual, or you are aware of changes to the equipment or systems on board then please contact the publishers:

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Tel: +44 (0)1244 287 850 • Fax: +44(0)1244 288 609 • Email: manuals@wmtmarine.com

1.1 PRINCIPAL SHIP PARTICULARS

Builders:	Philly Shipyard Inc.
Building Number:	H 033
Keel Laid:	XXX
Delivery Date:	XXX
IMO Number:	9910313
Call Sign:	XXX
MMSI Number:	XXX
Classification:	ABS (American Bureau of Shipping) +A1(E), “Training Ship”, +AMS, +ACC, SPS, UWILD, CRC, CPS, ENVIRO, IHM, BWT, RW
Flag:	United States
Registered Owner:	United States Maritime Administration (MARAD)
Max Passengers:	760
Tonnage:	Gross XXXt; Net XXXt
Deadweight:	XXXt (At design draught)
Displacement:	XXXt (At design draught)
Displacement at maximum draught:	XXXt (sea water density 1.025)
Service Speed:	18.0knts

Dimensions

Length overall:	160.05m
Length BP:	154.00m
Breadth overall	XXXm
Breadth moulded:	27.0m
Air draught:	XXXm
Radar mast height above keel:	XXXm
Funnel height above keel:	XXXm
Design draught:	6.50m
Maximum draught:	7.35m

(Authors Note: Missing items to be confirmed during WMT verification visit)

1.2 PRINCIPAL MACHINERY PARTICULARS

Authors note: To be completed at Final Draft once all equipment specifications have been confirmed.

1.3 ENGINE ROOM ARRANGEMENTS

Illustration 1.3a Engine Room - Tank Top

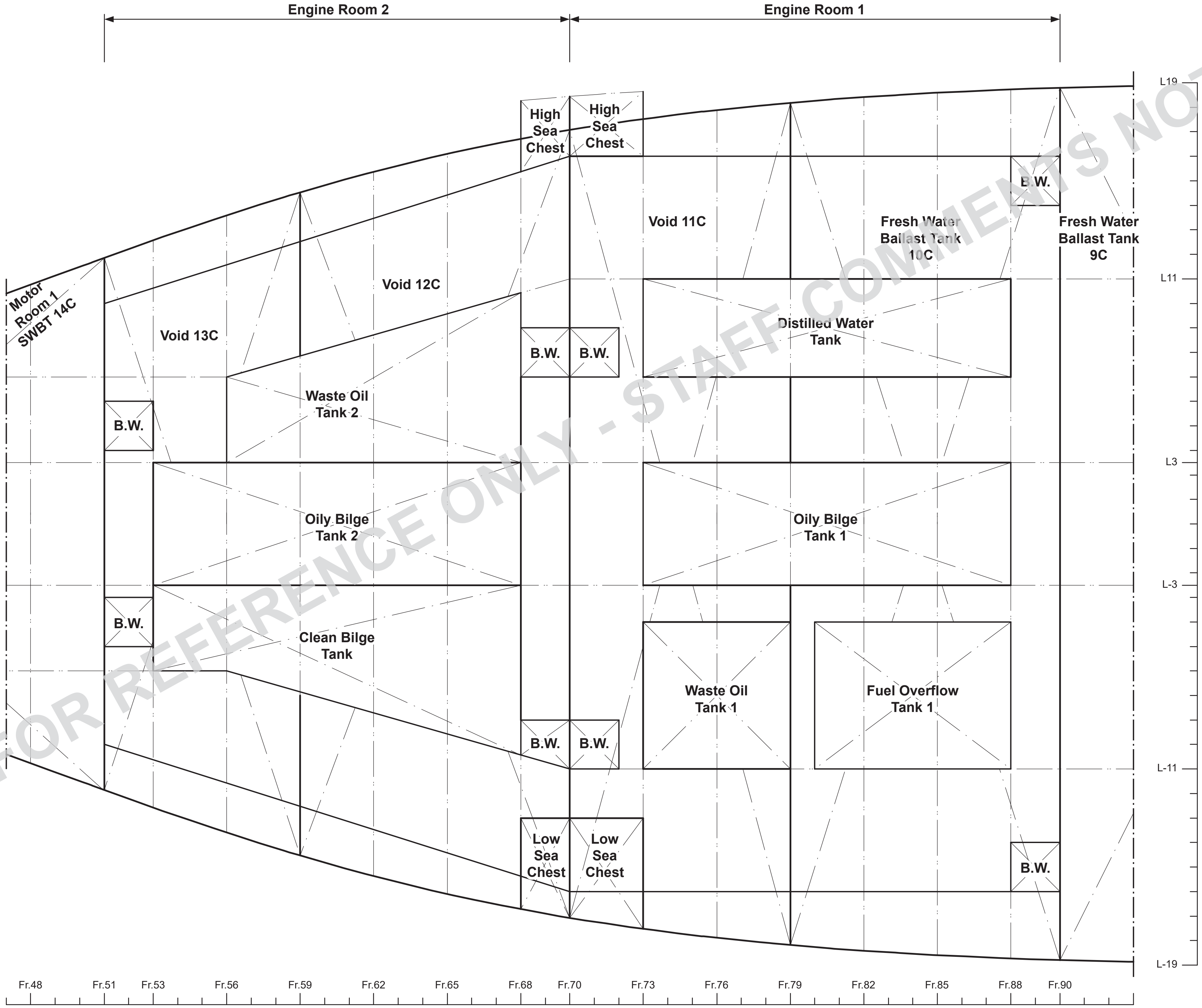
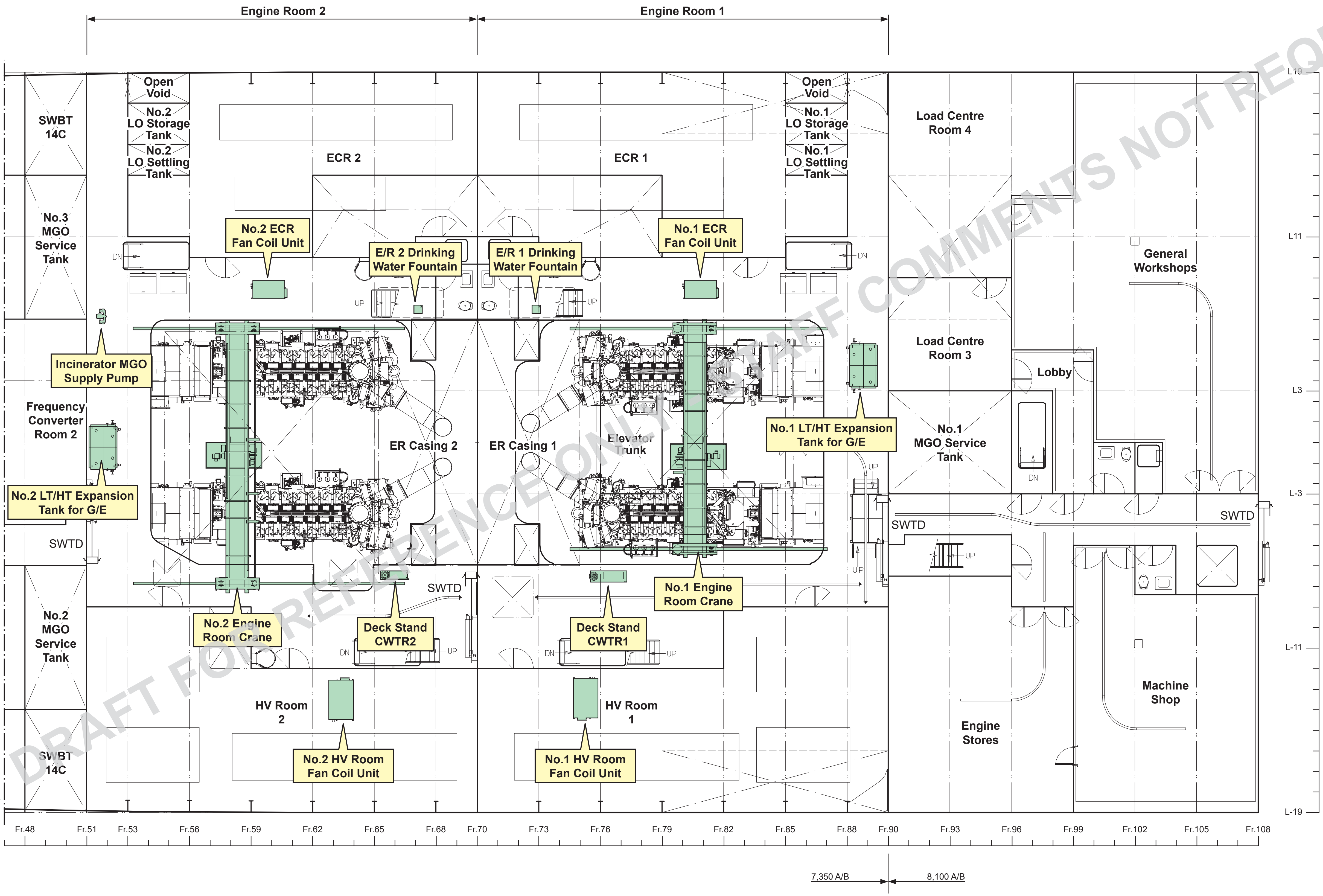
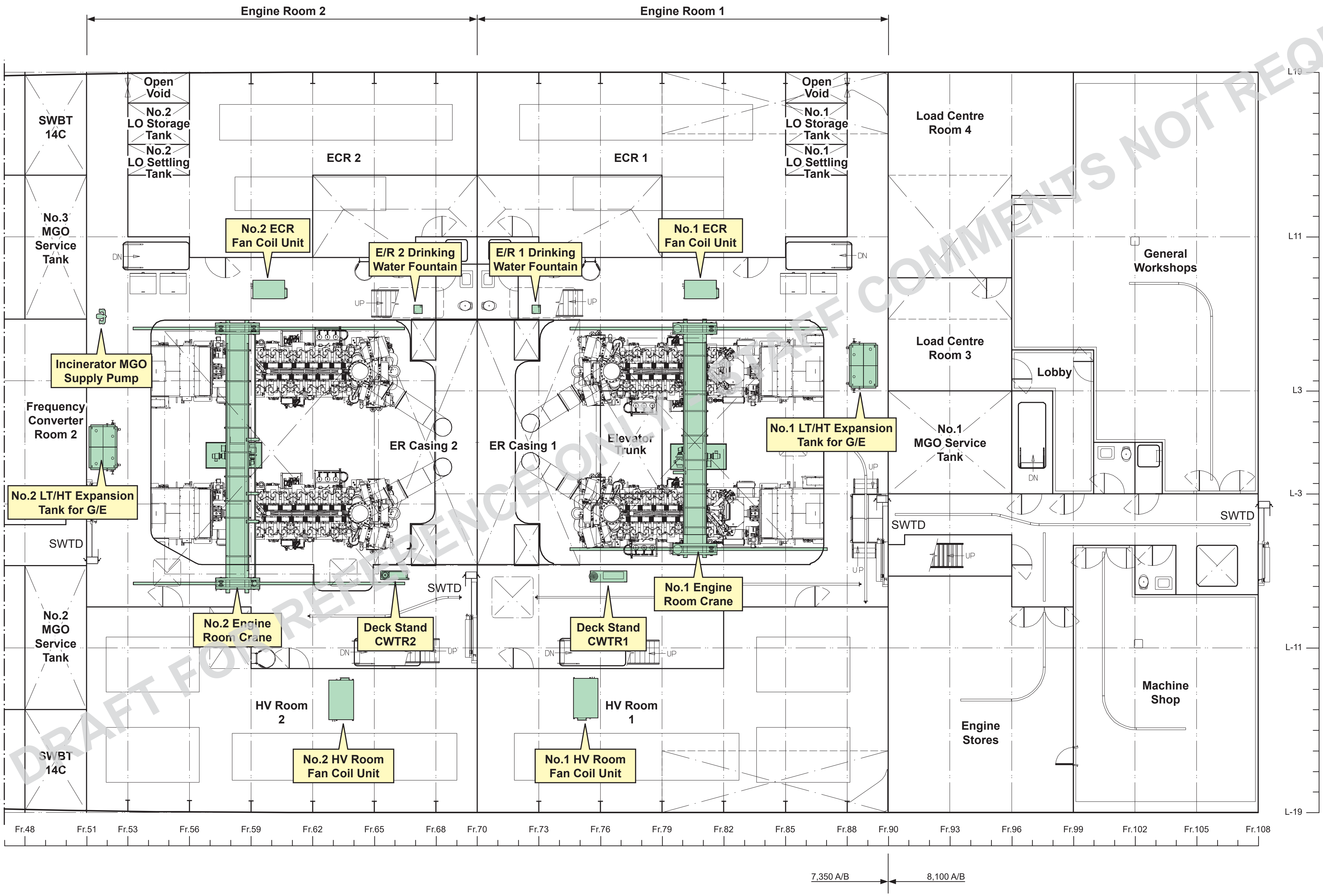


Illustration 1.3c Engine Room - 4th Deck



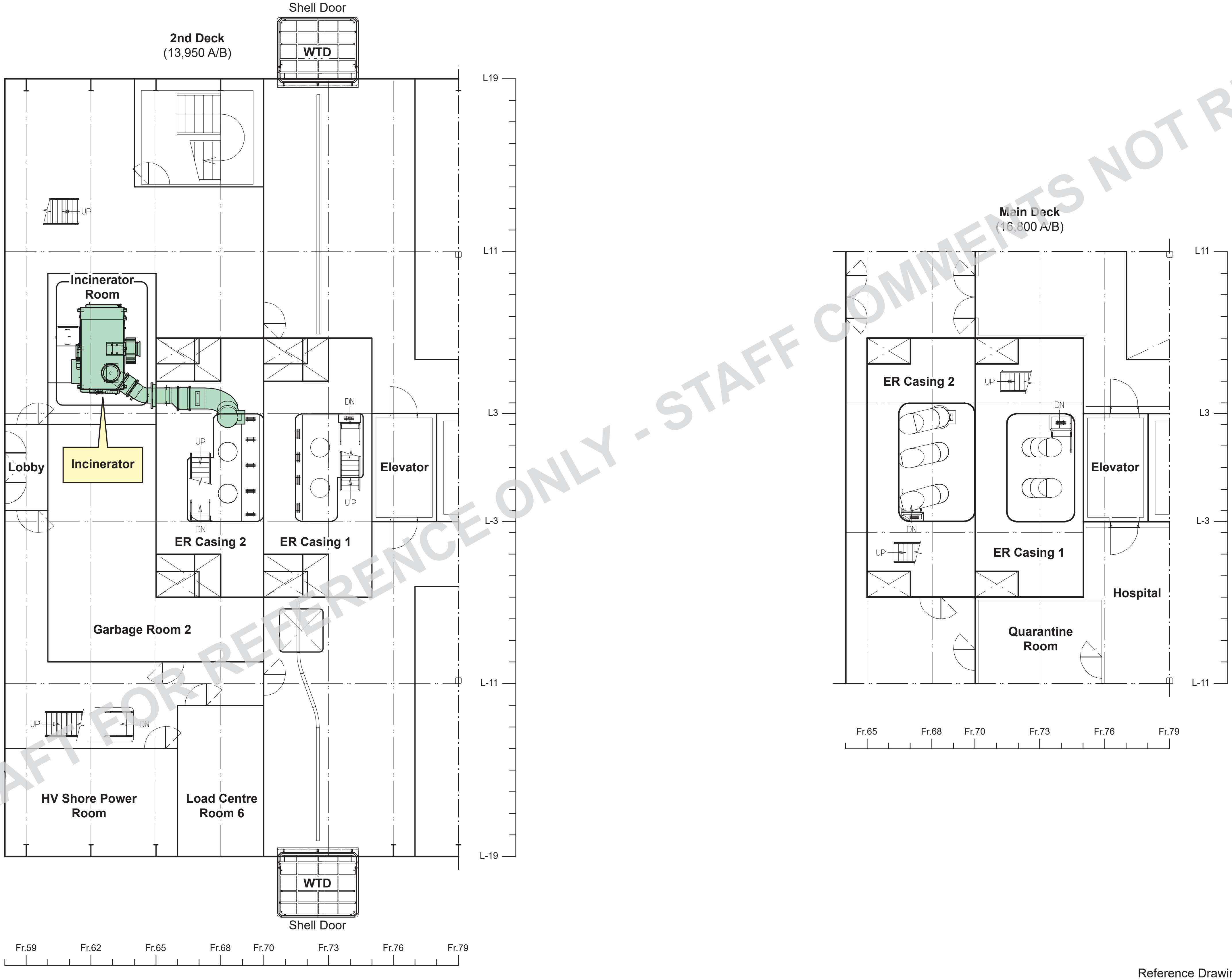
Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

Illustration 1.3c Engine Room - 4th Deck



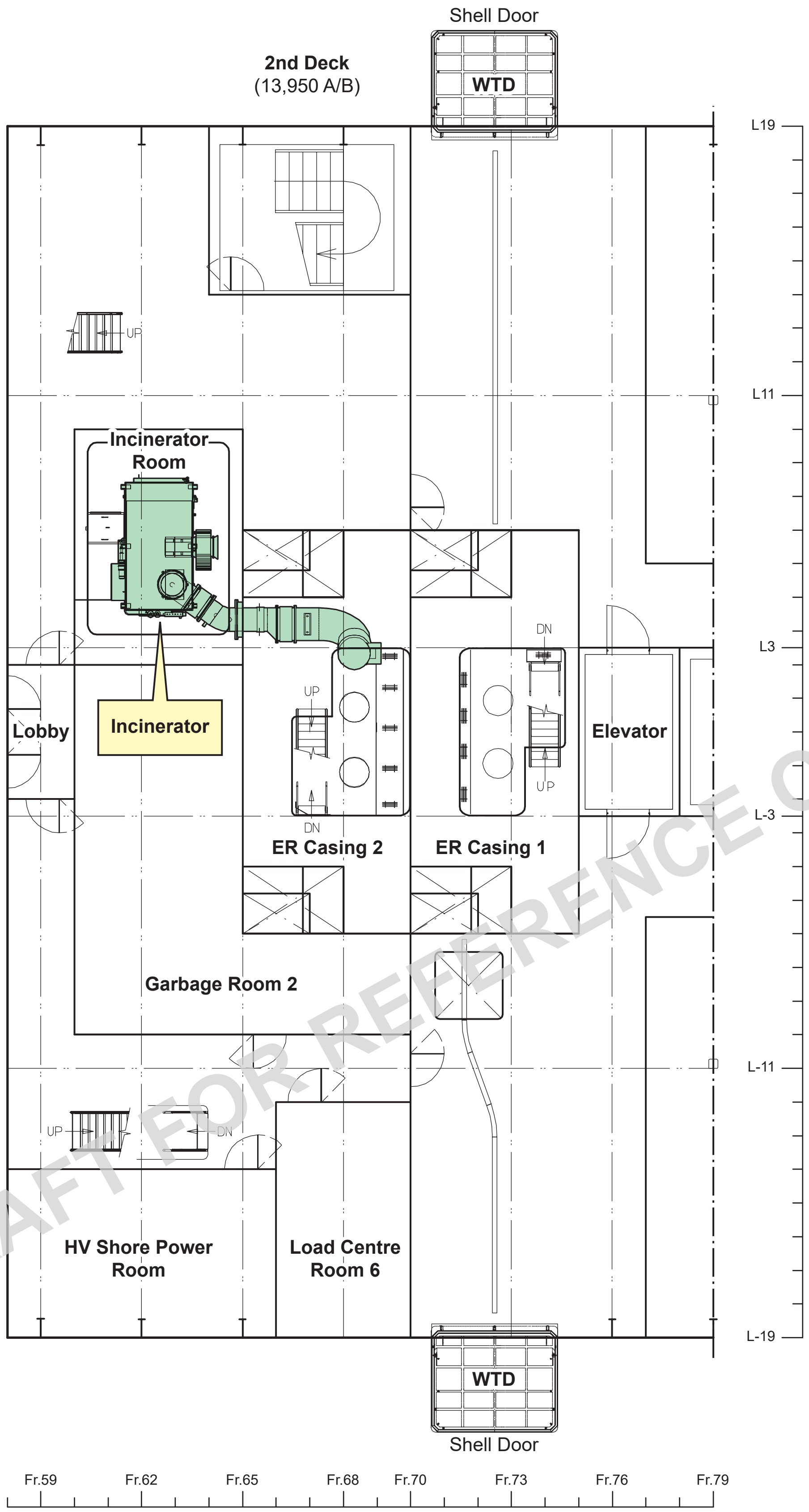
Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

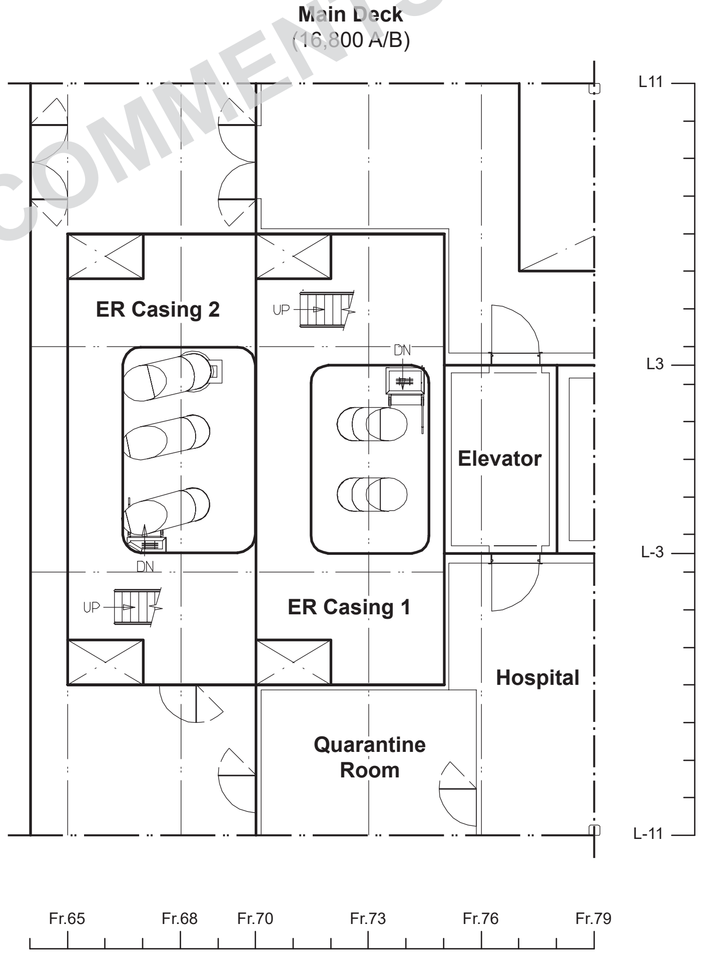
Illustration 1.3e Engine Room Casing - 2nd Deck and Main Deck



Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

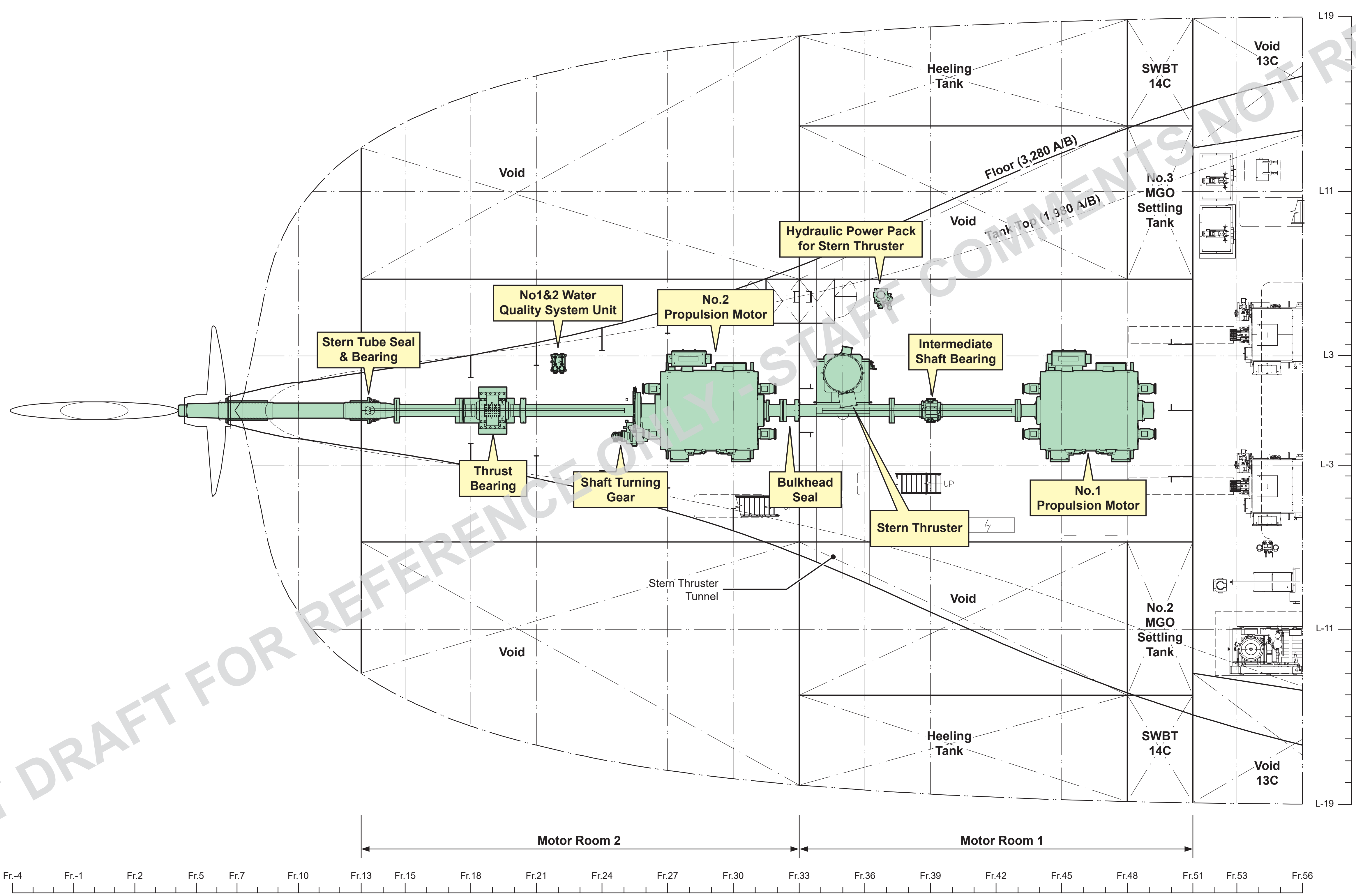
Illustration 1.3e Engine Room Casing - 2nd Deck and Main Deck





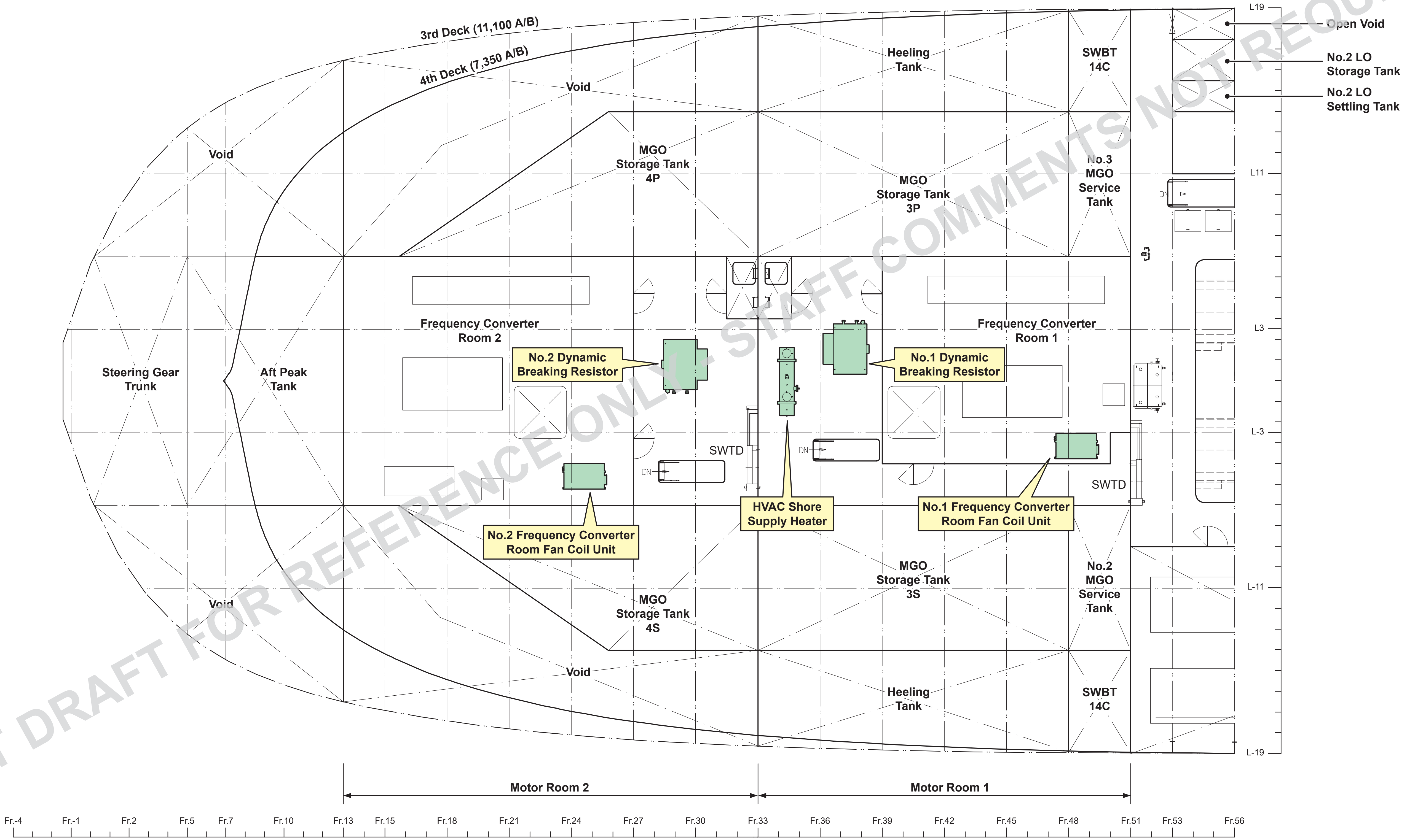
Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

Illustration 1.3g Motor Room - Floor



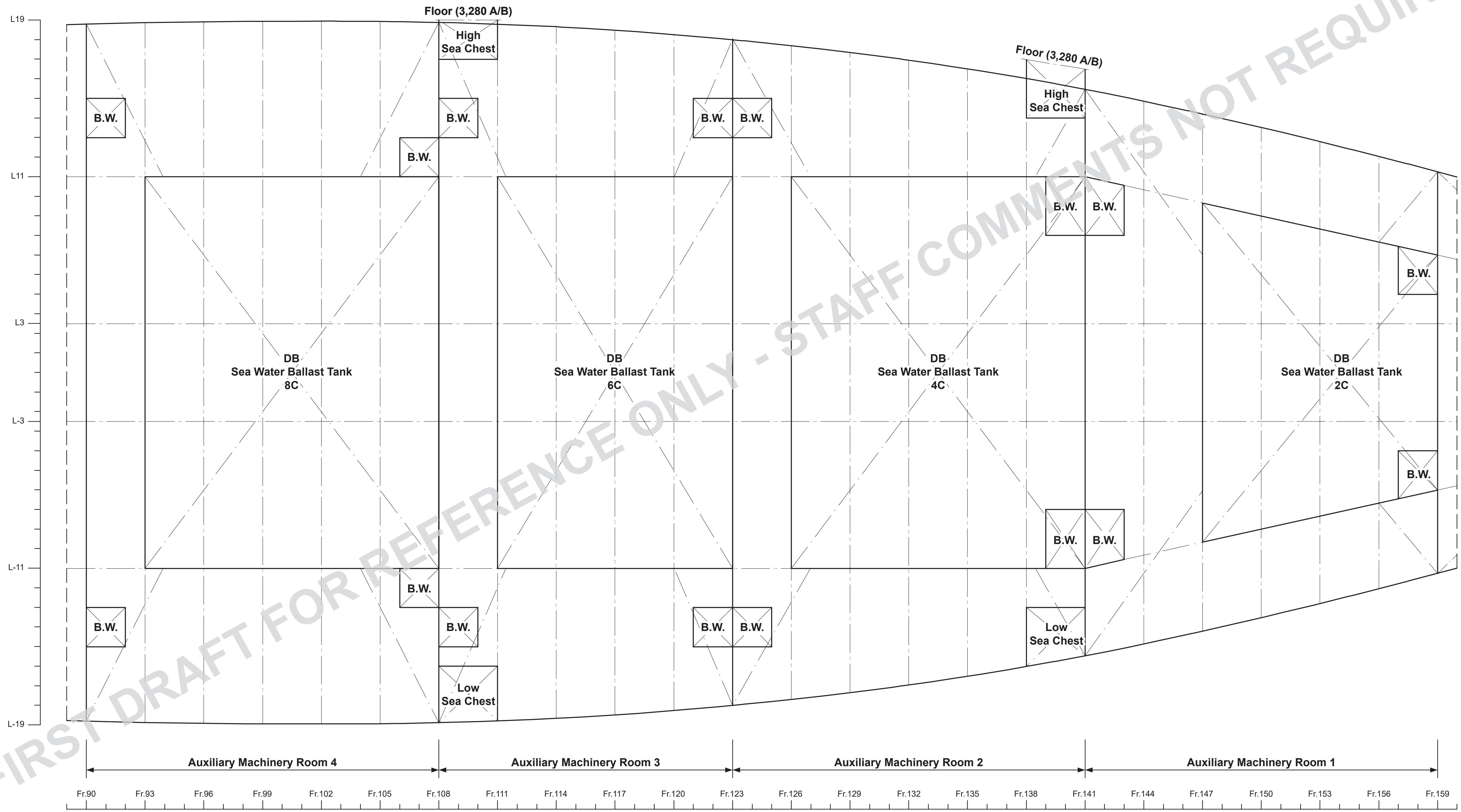
Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

Illustration 1.3h Motor Room - 4th Deck



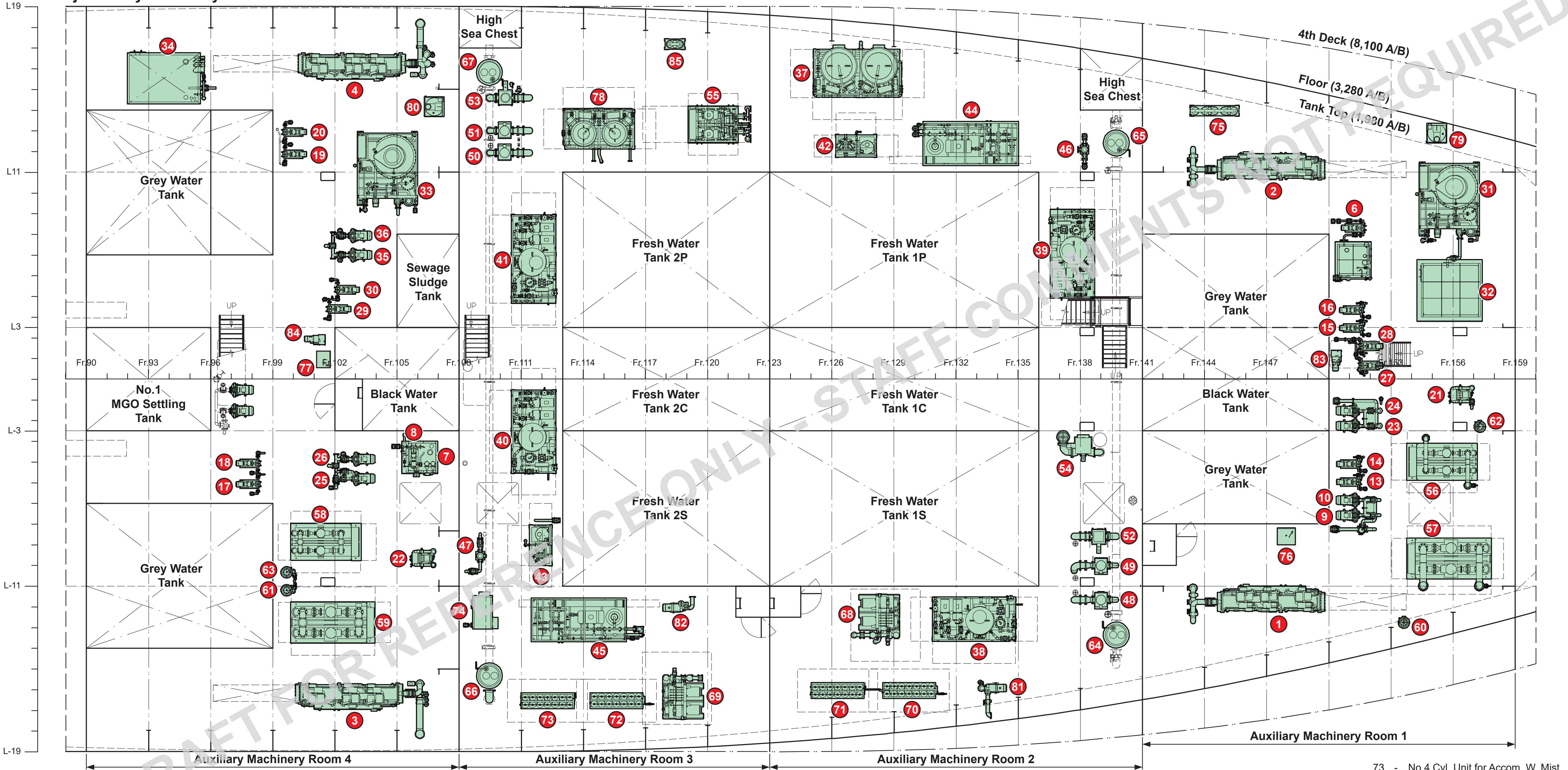
Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

Illustration 1.3i Auxiliary Machinery Room - Tank Top



Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

Illustration 1.3j Auxiliary Machinery Room - Floor

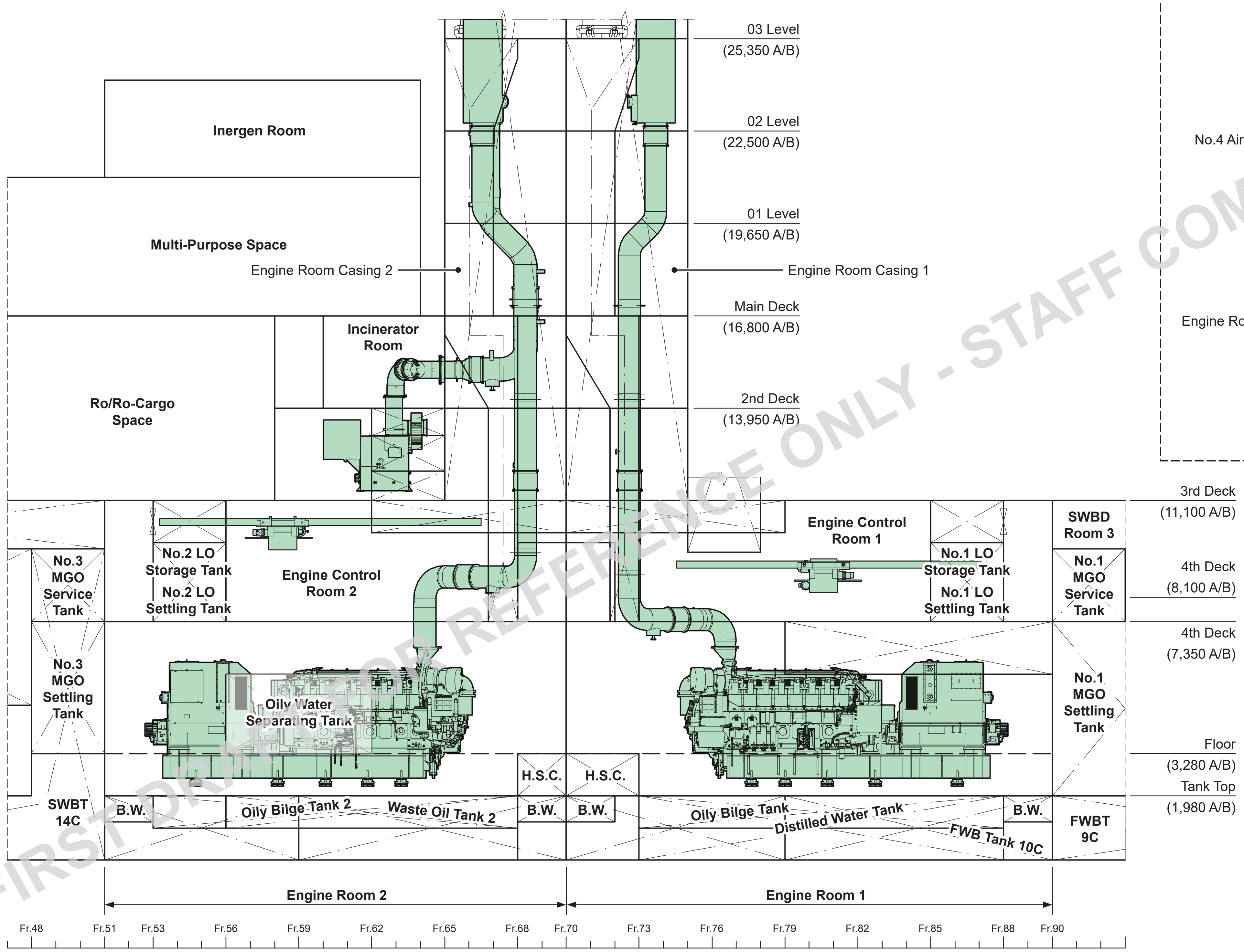


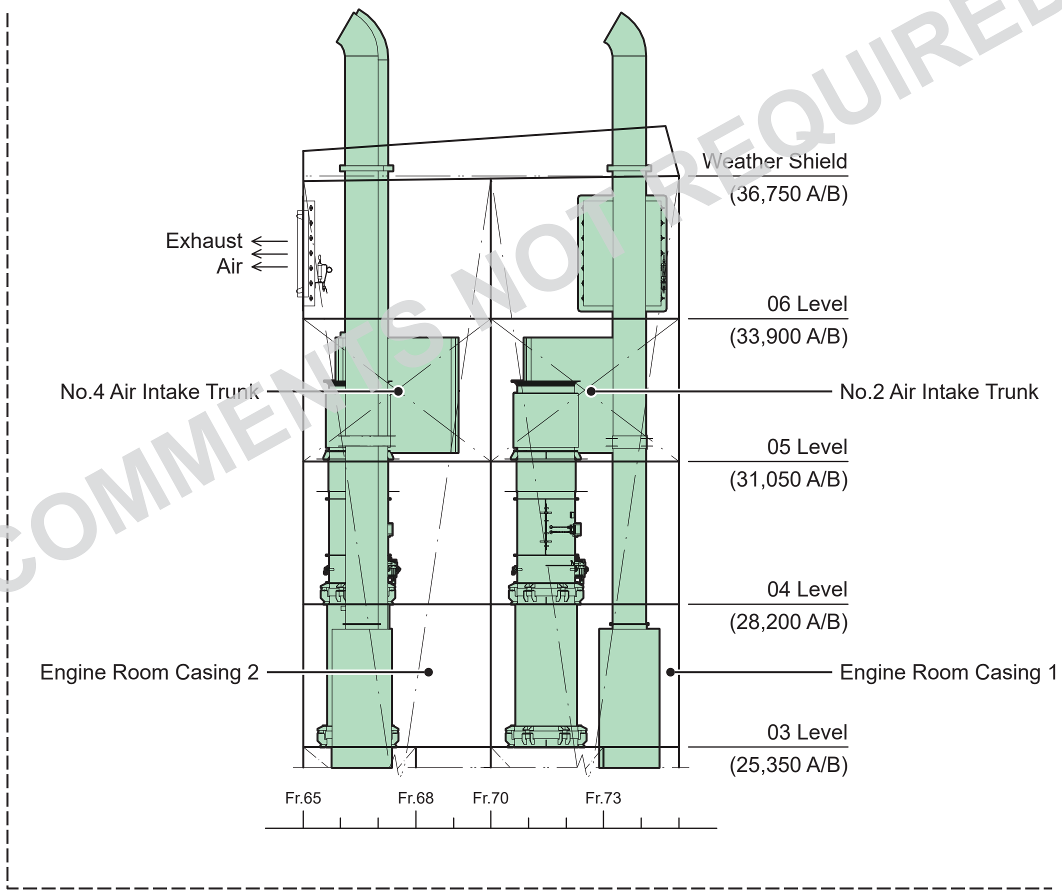
Key

1 - No.1 A/C Chilled Water Plant
2 - No.2 A/C Chilled Water Plant
3 - No.3 A/C Chilled Water Plant
4 - No.4 A/C Chilled Water Plant
5 - AMR 1 GW Lift Station Drain Tank
6 - AMR 1 GW Lift Station Transfer Pump
7 - AMR 4 GW Lift Station Drain Tank
8 - AMR 4 GW Lift Station Transfer Pump
9 - No.1 Gray Water Discharge Pump
10 - No.2 Gray Water Discharge Pump
11 - No.3 Gray Water Discharge Pump
12 - No.4 Gray Water Discharge Pump
13 - No.1 GW Treatment Supply Pump
14 - No.2 GW Treatment Supply Pump
15 - No.3 GW Treatment Supply Pump
16 - No.4 GW Treatment Supply Pump
17 - No.5 GW Treatment Supply Pump
18 - No.6 GW Treatment Supply Pump
19 - No.7 GW Treatment Supply Pump
20 - No.8 GW Treatment Supply Pump
21 - No.1 Vacuum Collecting Unit
22 - No.2 Vacuum Collecting Unit
23 - No.1 Black Water Discharge Pump
24 - No.2 Black Water Discharge Pump
25 - No.3 Black Water Discharge Pump
26 - No.4 Black Water Discharge Pump
27 - No.1 Black Water Treatment Supply Pump
28 - No.2 Black Water Treatment Supply Pump
29 - No.3 Black Water Treatment Supply Pump
30 - No.4 Black Water Treatment Supply Pump
31 - AMR 1 Waste Water Treatment Plant
32 - AMR 1 Waste Water Mixing Tank
33 - AMR 4 Waste Water Treatment Plant
34 - AMR 4 Waste Water Mixing Tank
35 - No.1 Sewage Sludge Discharge Pump
36 - No.2 Sewage Sludge Discharge Pump
37 - No.7/8 Hot Water Calorifier Unit
38 - No.1 Fresh Water Supply Unit
39 - No.2 Fresh Water Supply Unit
40 - No.3 Fresh Water Supply Unit
41 - No.4 Fresh Water Supply Unit
42 - No.1 FW Rehardening Filter & Chlorinator
43 - No.2 FW Rehardening Filter & Chlornator
44 - No.1 Fresh Water Generator (RO Type)
45 - No.2 Fresh Water Generator (RO Type)
46 - No.1 Fresh Water Generator Feed Pump
47 - No.2 Fresh Water Generator Feed Pump
48 - No.1 Auxiliary Cooling SW Pump
49 - No.2 Auxiliary Cooling SW Pump
50 - No.3 Auxiliary Cooling SW Pump
51 - No.4 Auxiliary Cooling SW Pump
52 - No.1 Bilge/Aux SW Cooling Pump
53 - No.2 Bilge/Aux SW Cooling Pump
54 - Emergency Fire Pump
55 - Provision Refrigerant Plant
56 - No.1&2 Heated Water Pump Skid
57 - No.1&2 Chilled Water Pump Skid
58 - No.3&4 Heated Water Pump Skid
59 - No.3&4 Chilled Water Pump Skid
60 - No.1 Chilled Water Expansion Tank
61 - No.2 Chilled Water Expansion Tank
62 - No.1 Heated Water Expansion Tank
63 - No.2 Heated Water Expansion Tank
64 - AMR 2 Seachest Strainer & MGPS (Low)
65 - AMR 2 Seachest Strainer & MGPS (High)
66 - AMR 3 Seachest Strainer & MGPS (Low)
67 - AMR 3 Seachest Strainer & MGPS (High)
68 - No.1 Water Mist Pump Unit for Accom.
69 - No.2 Water Mist Pump Unit for Accom.
70 - No.1 Cyl. Unit For Accom. W. Mist
71 - No.2 Cyl. Unit For Accom. W. Mist
72 - No.3 Cyl. Unit For Accom. W. Mist
73 - No.4 Cyl. Unit for Accom. W. Mist
74 - Water Mist Pump Unit For E/R
75 - AMR 1 Refrigerant Recovery Cylinder
76 - AMR 1 Washbasin
77 - AMR 4 Washbasin
78 - No.1/2 Hot Water Calorifier Unit
79 - AMR 1 Flocculant Dosing Station
80 - AMR 4 Flocculant Dosing Station
81 - No.1 FW Feed Pump for Accom. W. Mist
82 - No.2 FW Feed Pump for Accom. W. Mist
83 - AMR 1 Aeration Compressor
84 - AMR 4 Aeration Compressor
85 - AMR 3 Refrigerant Recovery Cylinder

Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

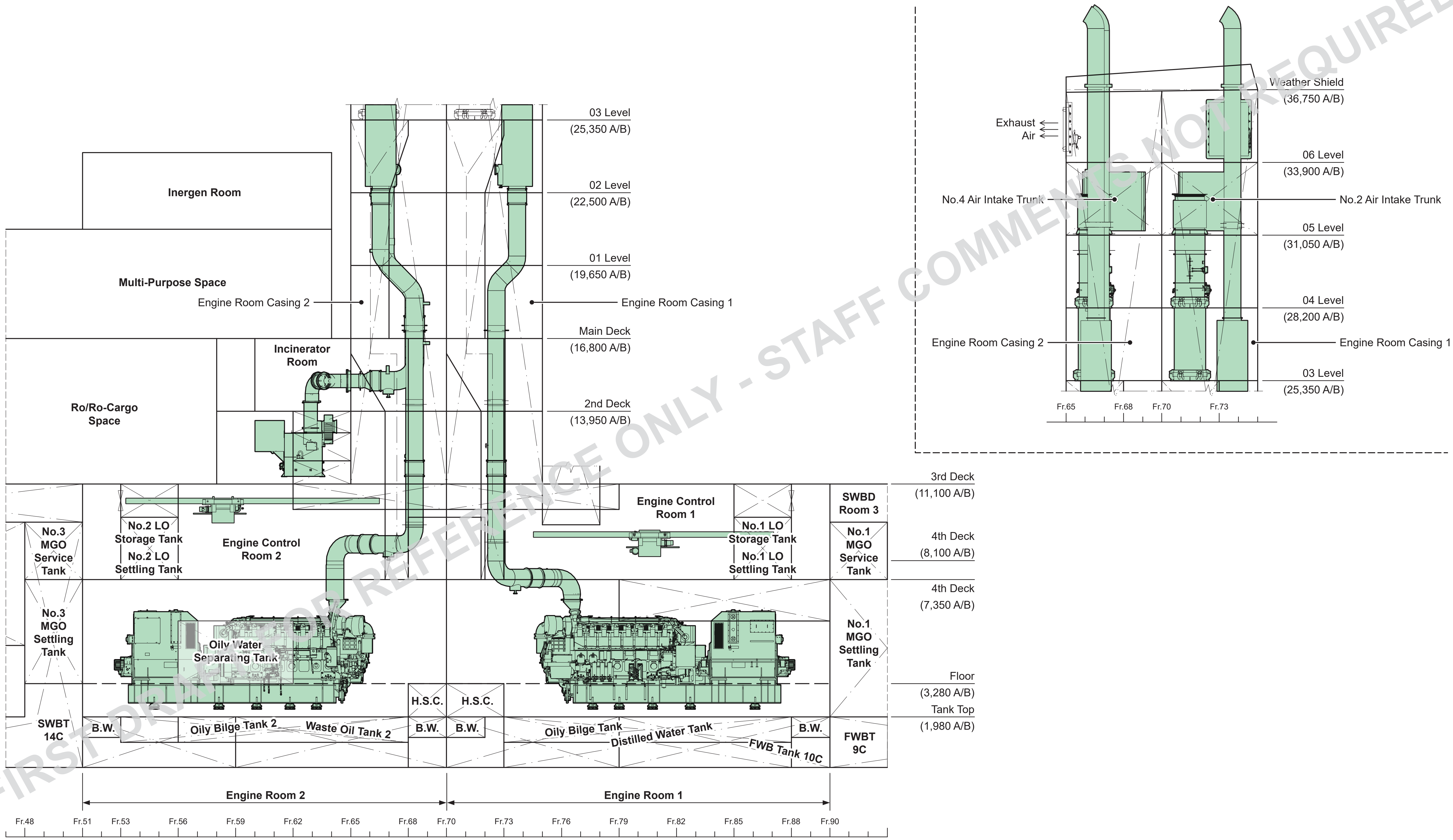
Illustration 1.3k Engine Room Elevation (Port)





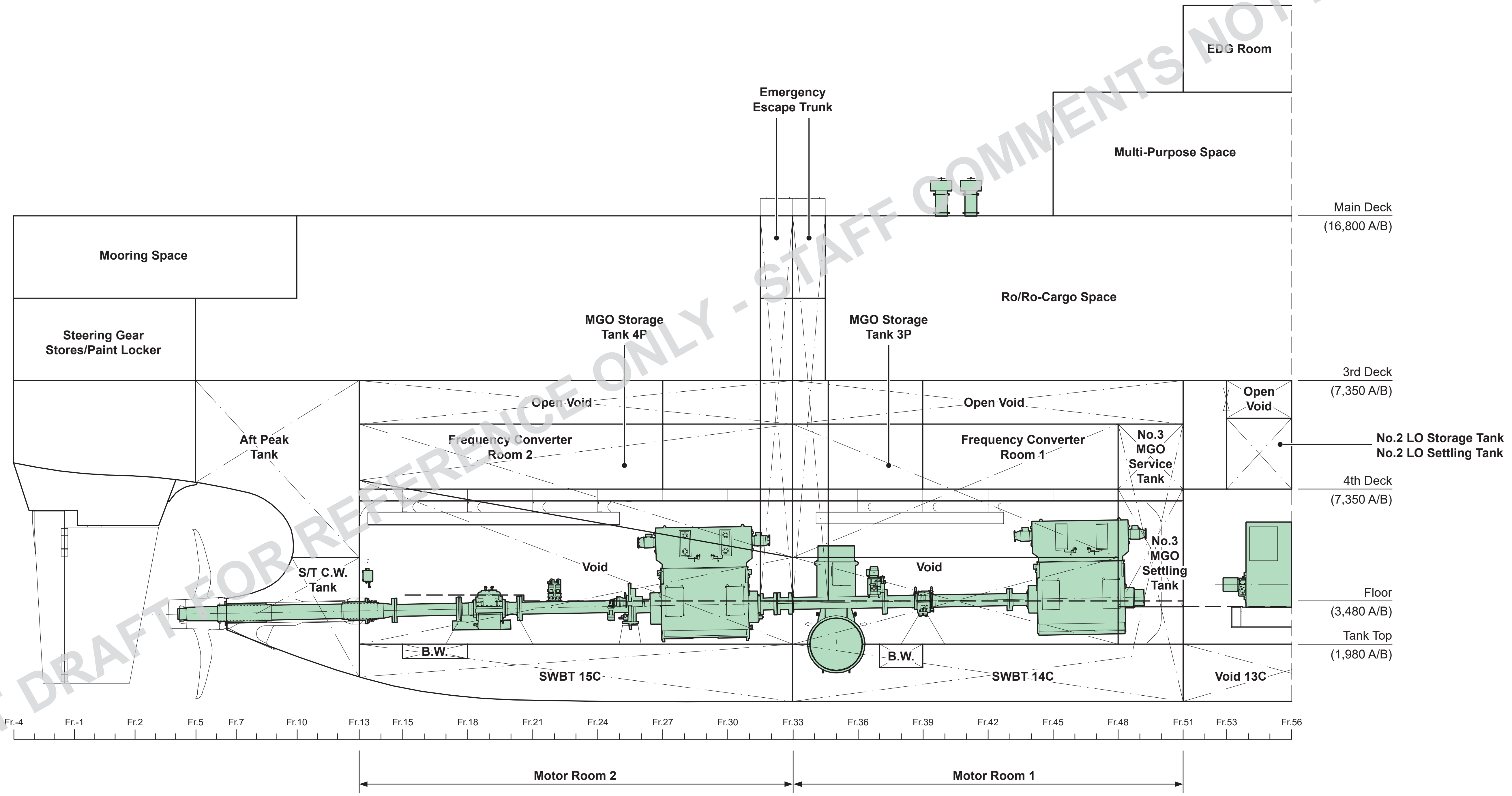
Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

Illustration 1.3k Engine Room Elevation (Port)



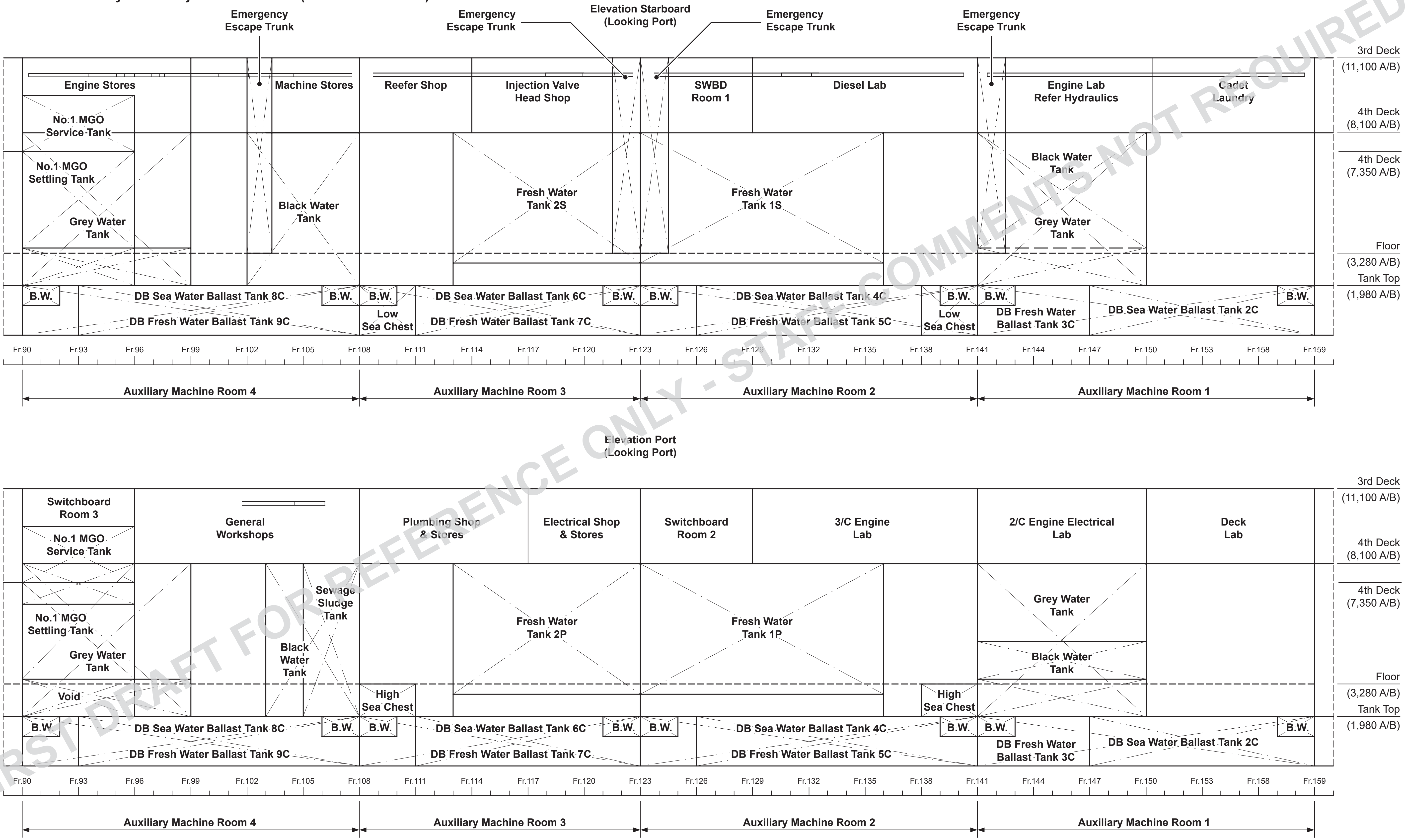
Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

Illustration 1.3l Motor Room Elevation (Port)



Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

Illustration 1.3m Auxiliary Machinery Room Elevation (Port and Starboard)



Reference Drawing: DA106M001R1 - NSMV-501-B701, Rev.1

1.4 TANK CAPACITIES

Abbreviations

The following abbreviations can be seen in the tank capacity tables below:

- Forward (Fwd).
- Port (P).
- Starboard (S).
- Center (C).
- Double Bottom (DB).
- Sea Water Ballast Tank (SWBT).
- Fresh Water Ballast Tank (FWBT).
- Fresh Water Tank (FWT).
- Marine Gas Oil (MGO).

Tank Capacity Tables

Water Ballast (Specific Gravity = 1.025)		
Tank	**Frame**	**Volume (m³)**
Fore Peak Tank	194-212	218.7
No.1 Fwd SWBT	190-194	144.0
No2 Fwd SWBT	176-182	165.7
SWBT 1C	159-176	232.5
DB SWBT 2C	147-159	156.7
DB SWBT 3C	141-159	256.4
DB SWBT 4C	126-141	327.1
DB SWBT 6C	111-123	262.0
DB SWBT 8C	93-108	327.4
SWBT 14C	33-51	332.6
SWBT 15C	13-33	100.1
Aft Peak Tank	5-13	195.5
Fwd Heeling Tank (P)	159-176	200.1
Fwd Heeling Tank (S)	159-176	200.1
Aft Heeling Tank (P)	33-48	223.6
Aft Heeling Tank (S)	33-48	223.6
	Total	3567.0

Fresh Water Ballast (Specific Gravity = 1.000)		
Tank	**Frame**	**Volume (m³)**
DB FWBT 5C	123-141	230.7
DB FWBT 7C	108-123	272.3
DB FWBT 9C	90-108	342.6
FWBT 10C	79-90	429.4
	Total	1275.0

Fresh Water (Specific Gravity = 1.000)		
Tank	**Frame**	**Volume (m³)**
No.1 FWT (P)	123-136	280.6
No.1 FWT (C)	123-136	187.0
No.1 FWT (S)	123-136	280.6
No.2 FWT (P)	113-123	215.8
No.2 FWT (C)	113-123	143.9
No.2 FWT (S)	113-123	215.8
	Total	1323.7

Marine Gas Oil (Specific Gravity = 0.840)		
Tank	**Frame**	**Volume (m³)**
MGO Storage Tank 1C	176-182	311.3
MGO Storage Tank 2P	159-176	228.7
MGO Storage Tank 2C	159-176	288.2
MGO Storage Tank 2S	159-176	228.7
MGO Storage Tank 3P	33-48	231.0
MGO Storage Tank 3S	33-48	231.0
MGO Storage Tank 4P	13-33	204.4
MGO Storage Tank 4S	13-33	204.4
No.1 MGO Settling Tank (C)	90-96	64.3
No.1 MGO Service Tank (C)	90-96	37.4
No.2 MGO Settling Tank	48-51	42.6
No.2 MGO Service Tank	48-51	26.2
No.3 MGO Settling Tank	48-51	42.6
No.3 MGO Service Tank	48-51	26.2
	Total	2166.8

Miscellaneous Oil (Specific Gravity = 1.000)		
Tank	**Frame**	**Volume (m³)**
Distilled Water Tank (P)	73-88	65.4
S/T C.W Tank	7-13	20.6
Waste Oil Tank 2 (P)	56-68	34.5
Waste Oil Tank 1 (S)	73-79	19.8
Oily Bilge Tank 1 (C)	73-88	41.3
Oily Bilge Tank 2 (P)	53-68	41.3
Clean Bilge Tank (S)	53-68	78.0
Black Water Tank	141-150	75.9
Gray Water Tank 1P	141-150	175.3
Gray Water Tank 1S	141-150	136.6
Black Water Tank 2	102-108	90.0
Gray Water Tank 2P	90-99	152.7
Gray Water Tank 2S	90-99	190.2
Sludge Tank (P)	105-108	45.5
Fuel Overflow Tank (S)	80-88	26.5
	Total	1193.8

1.5 CONVERSION TABLES

LENGTH

Multiply	Symbol	By	To obtain value in	Symbol
1 metre	m	39.37	Inch	in
1 metre	m	3.281	Foot	ft
1 metre	m	1.094	Yard	yd
1 metre	m	0.5468	Fathom	fm
1 kilometre	km	0.5397	Nautical mile	n mile
1 inch	in	0.0254	Metre	m
1 foot	ft	0.3048	Metre	m
l yard	yd	0.9144	Metre	m
1 fathom	fm	1.829	Metre	m
1 nautical mile	n mile	1.853	Kilometre	km

AREA

Multiply	Symbol	By	To obtain value in	Symbol
1 square metre	m^2	1550.0	Square inch	in^2
1 square metre	m^2	10.76	Square foot	ft^2
1 square metre	m^2	1.196	Square yard	yd^2
1 square inch	in^2	6.452	Square centimetre	cm^2
1 square foot	ft^2	929.0	Square centimetre	cm^2
1 square yard	yd^2	0.8361	Square metre	m^2

VOLUME AND CAPACITY

Multiply	Symbol	By	To obtain value in	Symbol
1 litre/cubic decimetre	l or dm^3	61.02	Cubic inch	in^3
1 cubic metre	m^3	35.31	Cubic foot	ft^3
1 cubic metre	m^3	1.308	Cubic yard	yd^3
1 cubic metre	m^3	220.0	UK gallon	UK gal
1 cubic metre	m^3	264.2	US gallon	US gal
1 cubic foot	ft^3	28.32	Litre or cubic decimetre	l/dm^3
1 cubic yard	yd^3	0.7646	Cubic metre	m^3
1 UK gallon	UK gal	4.546	Litre or cubic decimetre	l/dm^3
1 US gallon	US gal	3.785	Litre or cubic decimetre	l/dm^3

MASS

Multiply	Symbol	By	To obtain value in	Symbol
1 kilogram	kg	2.205	Pound	lb
1 tonne(metric ton)	t	2205.0	Pound	lb
1 tonne (metric ton)	t	0.9842	UK ton (US long ton)	ton
1 tonne (metric ton)	t	1.102	US short ton	sh ton
1 pound	lb	0.4535	Kilogram	kg
1 UK ton (US long ton)	ton	2240.0	Pound	lb
1 UK ton (US long ton)	ton	1016.0	Kilogram	kg
1 US short ton	sh ton	2000.0	Pound	lb
1 US short ton	sh ton	907.2	Kilogram	kg

FORCE

Multiply	Symbol	By	To obtain value in	Symbol
1 Newton	N	0.1020	Kilogram-force	kgf/kp
1 Newton	N	0.2248	Pound-force	lbf
1 kilogram-force	kgf or kp	9.807	Newton	N
1 pound-force	lbf	4.448	Newton	N

PRESSURE

Multiply	Symbol	By	To obtain value in	Symbol
1 bar	bar	105	Pascal/Newton per sq. metre	Pa or N/m^2
1 bar	bar	14.50	Pound-force per square inch	lbf/in^2 or psi
1 pound-force per sq. inch	lbf/in^2 or psi	6895.0	Pascal	Pa
1 pound-force per sq. inch	lbf/in^2 or psi	0.06895	Bar	bar

POWER: MECHANICAL AND ELECTRICAL

Multiply	Symbol	By	To obtain value in	Symbol
1 watt	W	0.7376	Foot-pound-force per second	ft lbf/s
1 kilowatt	kW	1.360	Metric horsepower	PS, ch, CV
1 kilowatt	kW	1,341	Horsepower (Imperial)	hp
1 metric horsepower	PS, ch, CV	75.0	Kilogram-force metre per sec.	kgf-m/s
1 metric horsepower	PS, ch, CV	735.5	Watt	W
1 horsepower (imperial)	hp	550.0	Foot-pound-force per second	ft lbf/s
1 horsepower (imperial)	hp	745.7	Watt	W

POWER: HEAT FLOW

Multiply	Symbol	By	To obtain value in	Symbol
1 watt	W	0.2388	Calorie per second	Cal/s
1 watt	W	3.412	British thermal unit per hour	Btu/h
1 calorie per second	cal/s	4.1868	Watt	W
1 British thermal unit per hour	Btu/h	0.2931	Watt	W
1 'ton of refrigeration'		12,000.0	British thermal unit per hour	Btu/h
1 'ton of refrigeration'		3,517	Kilowatt	kW

MOMENTS

Multiply	Symbol	By	To obtain value in	Symbol
1 foot pound-force	ft lbf	0.138	Kilogram-force metre	kgf-m
1 foot pound-force	ft lbf	1.44	Tonne metre	t-m
1 metre to the power 4	m^4	115,86	Feet to the power 4	ft^4

LIGHT INTENSITY

Multiply	Symbol	By	To obtain value in	Symbol
1 lux (lumen per sq. metre)	$lx=lm/m^2$	0.0929	Foot-candle (lumens per square foot)	ft-candle lm/ft^2
1 foot-candle	ft-candle	10.76	Lux	lx

TEMPERATURE

Temperature Kelvin (K)	Temperature Celsius (ºC)	Temperature Fahrenheit (ºF)
1	K-273.15	9/5K-459.67
C+273,15	1	9/5C+32
5/9 (F+459.67)	5/9 (F-32)	1

1.6 BUILDER'S DRAWINGS

(Author's Note: Links to be added at Issue 1)

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2.1 Machinery Introduction

2.1 MACHINERY INTRODUCTION

Illustration 2.1a To Bring Vessel Into Live Condition (i)

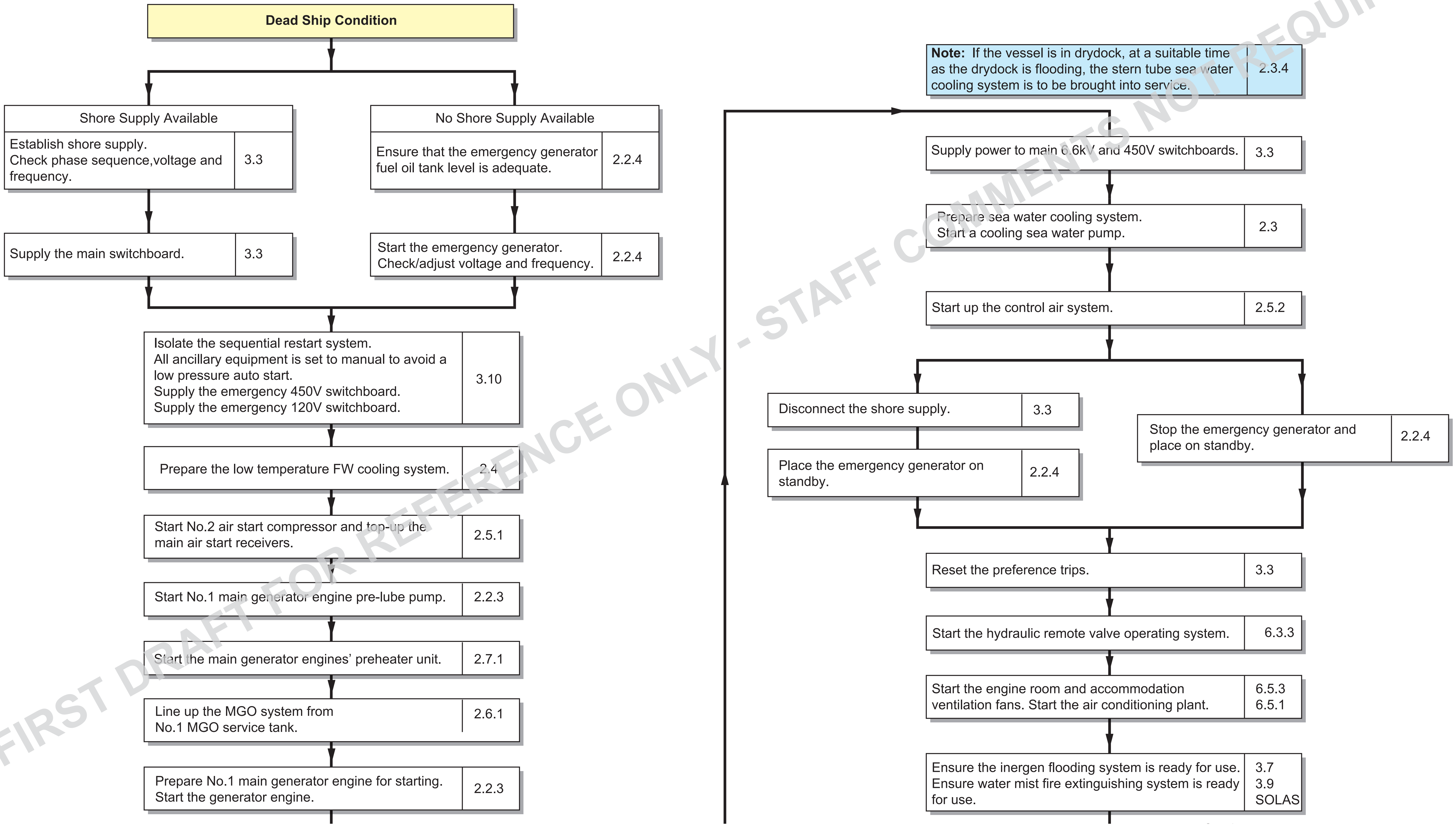

Illustration 2.1a To Bring Vessel Into Live Condition (ii)

Continued from previous page

Start the domestic fresh water system with the electric heater in service.	6.1.5 6.1.6
Put the domestic refrigeration system into operation.	6.5.4
Pressurise the fire hydrant system with fire pump. Start the fire detection system.	3.5 3.6 SOLAS
Put the working air system into operation.	2.5.2
Put all ancillary equipment on standby. Restore the sequential restart system. Put the remaining main generator engines on standby.	3.3 2.2.3
Start the sewage treatment plant.	6.2
Plant is now in Live Condition	
One diesel generator is in use, the other main generator engines are on standby. The emergency generator is on standby. The SW and LT FW cooling systems are in use. The domestic services are in use.	2.2.3 2.2.4 2.4 2.3

Illustration 2.1b Prepare Plant for 'In Port' Operation

Plant is in Live Condition	
One diesel generator in use, the other main generator engines are on standby. The emergency generator is on standby. The SW and LT FW cooling systems are in use. The domestic services are in use.	2.2.3 2.2.4 2.4 2.3 6.5
Start the MGO separating system.	2.6.3
Circulate MGO around the MGO system.	2.6.1
Start additional main generator engines for cargo needs.	2.2.3
Maintain the standby main generator engines in warm condition.	2.2.3
Plant is in 'In Port' Condition	
The main generator engines in use as required for cargo, the other main generator engines are on standby. The emergency generator is on standby. The main generator engine are running on MGO. The other main generator engine JCW systems are in a warm condition.	2.2.3 2.2.4 2.4.2

Illustration 2.1c To Prepare Plant for Manoeuvering from in Port Condition

Plant is in 'In Port' Condition

The main generator engines are in use as required by cargo, the other main generator engines are on standby. The emergency generator is on standby. The main generator engines JCW system is in warm condition.	2.2.3 2.2.4
Start propulsion auxiliaries.	2.7.2 4.6
Request permission from the bridge to start the steering gear motor for function test. Notify bridge when completed.	4.7
Obtain permission from bridge to disengage the shaft lock and turn the shaft as required	4.6
Disengage the turning gear on completion of shaft test.	4.6
Check telegraph, bridge/engine room clock and communications.	
Inform the bridge that the main propulsion is ready.	
Transfer the main propulsion controls to bridge control, and monitor their responce as manoeuvring proceeds.	4.1
Main generator engines in use as required, other main generator engines on auto standby. SGA water and FW cooling systems in use. Main propulsion motor/auxiliary systems in use. Turning gear and shaft lock disengaged.	2.7.2 4.6
Ensure all standby pumps are on AUTO.	
Duty deck officer to test ahead and astern shaft propulsion after first checking all moorings are tight. When pilot is due, test bow thruster units.	4.1 4.7
Prepare the deck machinery for use.	2.1 Deck

Plant is in Maneuvering Condition

Main generator engines are in use as required, remaining available main generator engines on standby. The emergency generator is on standby. Heating system is in use. Main propulsion for use on bridge control. Both steering gears and the thrusters are in use. The deck machinery is ready for use.	

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Illustration 2.1d To Change Main Plant from Manoeuvering to Full Sea Speed

Plant is in Maneuvering Condition

Main generator engines in use a required remaining main generator engines on standby. EDG is on standby. Heating system is in use. Main propulsion system in use on bridge control. Steering gear and thrusters in use. Deck machinery in use.	
Propulsion is in automatic run-up program.	4.1
Select propulsion speed on control screen.	4.1
When bridge notifies engine control room of Standby Departing, record the following: • Time. • Shaft revolution counter. • MGO tank levels. • ME Cylinder LO. • Fresh water tank levels. • Other information as per company rules.	
Stop the bow thruster units.	4.7
Stop one steering gear motor.	4.7
Shut down main generator engines not required. Put the shut down main generator engines on standby.	2.2.3
Change SW suction to low suction as required.	2.3
Transfer and purify MGO as required.	2.6.3
When the run-up program completes, check that pressures and temperatures stabilise.	4.1
Disengage ECR system on leaving ECA.	2.2.3
Reduce the bilge water tank level through the OWS if the vessel is not in a restricted area.	6.3.1 6.3.2

Vessel is Full Away on Bridge Control

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Illustration 2.1e To Prepare for Unmanned Operation

Plant is in Manned Condition

All MGO, LO and fresh water tanks/sumps are adequately filled.	
Bilges are dry and high level alarms are operational.	6.3.1 6.3.2
Fire detection system operational.	3.5 SOLAS
All piping systems are tight and not temporarily repaired.	
All alarms and safety cut-outs are operational.	5.1.1
All drain tanks are empty.	
Compressed air receivers are fully charged. One main air receiver is isolated.	2.5.1 2.5.2
MGO separator feed inlets are suitably adjusted.	2.6.3
Emergency diesel generator is on standby.	2.2.4
The inergen and water mist systems are operational.	3.7 3.9 SOLAS
Sounding cocks are all closed.	
Stopped main generator engines are on standby.	2.2.3
All standby pumps and machinery systems are on auto start, and the sequential restart system is operational.	3.3
Daily test of the three fire alarms, or 10% per month. Daily test of duty engineer and public space alarms.	
All ventilation fans are running.	6.5.3
All combustible material is stored in a safe place.	
All strainers and filters of running and standby machinery are in a clean condition.	
Engine room and steering gear compartment and weathertight doors are shut.	
All operating parameters are within normal range.	5.1.1
ECR air conditioning is operating correctly.	6.5.3
Loose items are secured.	
Workshop welding machine plug is removed.	
Acetylene and oxygen cylinder and pipeline valves are closed in upper deck locker.	
Data logger is programmed to print parameters as required.	5.1.1 5.1.2
Control is on the bridge and the duty officer is informed of the commencement time of UMS.	4.1
Duty deck officer should be aware of the location of the duty engineer.	
Watchkeeper control is switched to the duty engineer's cabin.	5.1.1
The time that the engine room may be unmanned for is to be in accordance with the Chief Engineer's Standing Orders and company requirements.	

Plant is in Unmanned Condition

Illustration 2.1f To Change from Unmanned Operation to Manned Operation

Plant is in UMS Condition

↓

Respond to an alarm condition in the accommodation at the cabin or public room alarm panel.

↓

Change over from UMS to manned condition.

↓

Notifying the bridge of the manned condition of the ER.

↓

Inform bridge why the engine room is manned if outside normal hours.

↓

Maintain contact with the bridge to report on safety when only one person is in the engine room. Report every 30 minutes or less.

↓

Examine the latest parameter printout.

↓

Hand over to the oncoming duty engineer and inform the engineer of any abnormalities.

↓

Discuss any defects with the senior engineer, who will decide if they warrant inclusion in the work list. The duty engineer should be aware of all maintenance work being carried out and informed of any changes that occur during the day.

↓

Plant is in Manned Condition

Illustration 2.1g Change from Full Sea Speed to Manoeuvring Condition

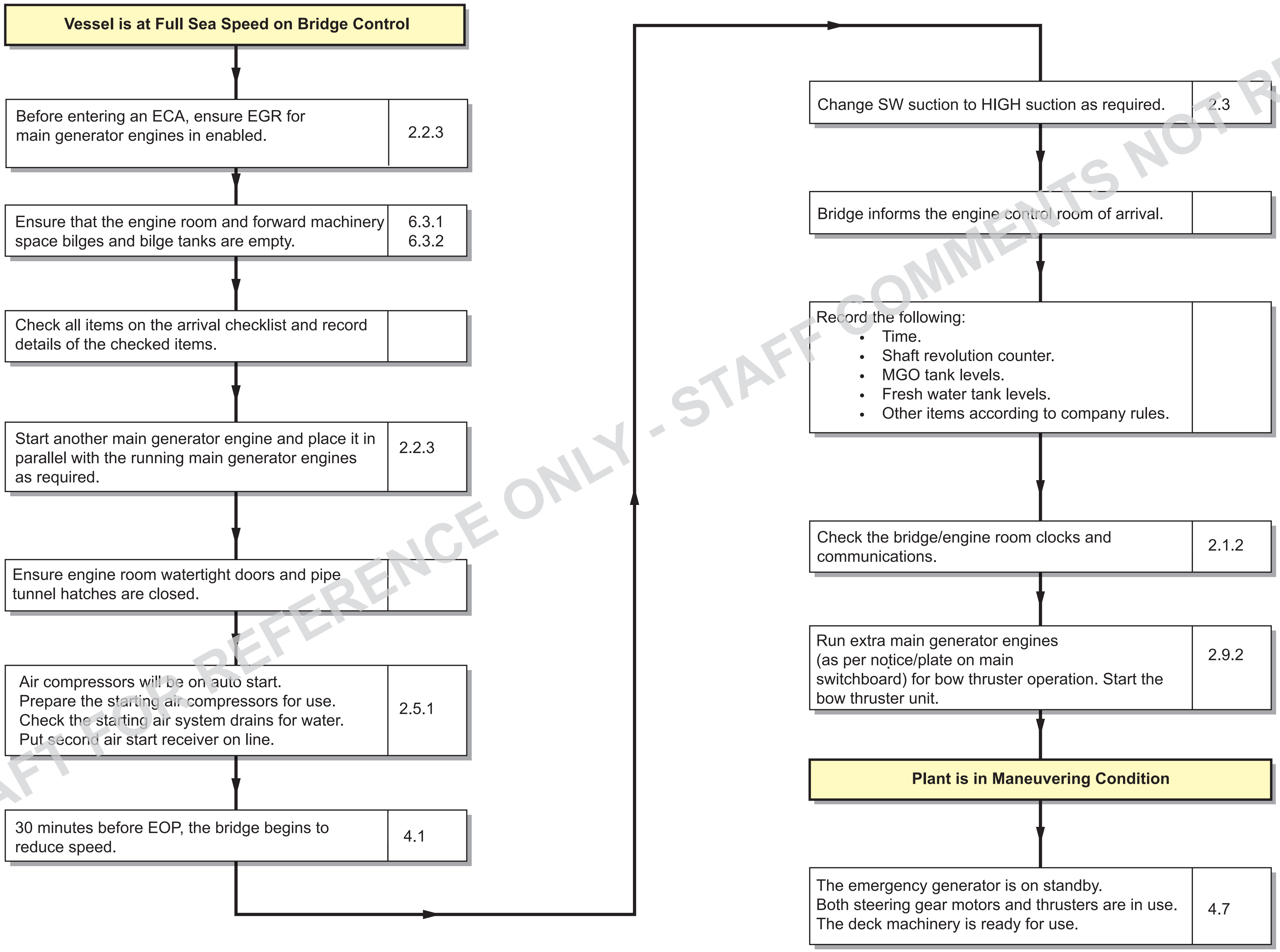

Illustration 2.1h Changing from Bridge Control to Engine Control (ECR)

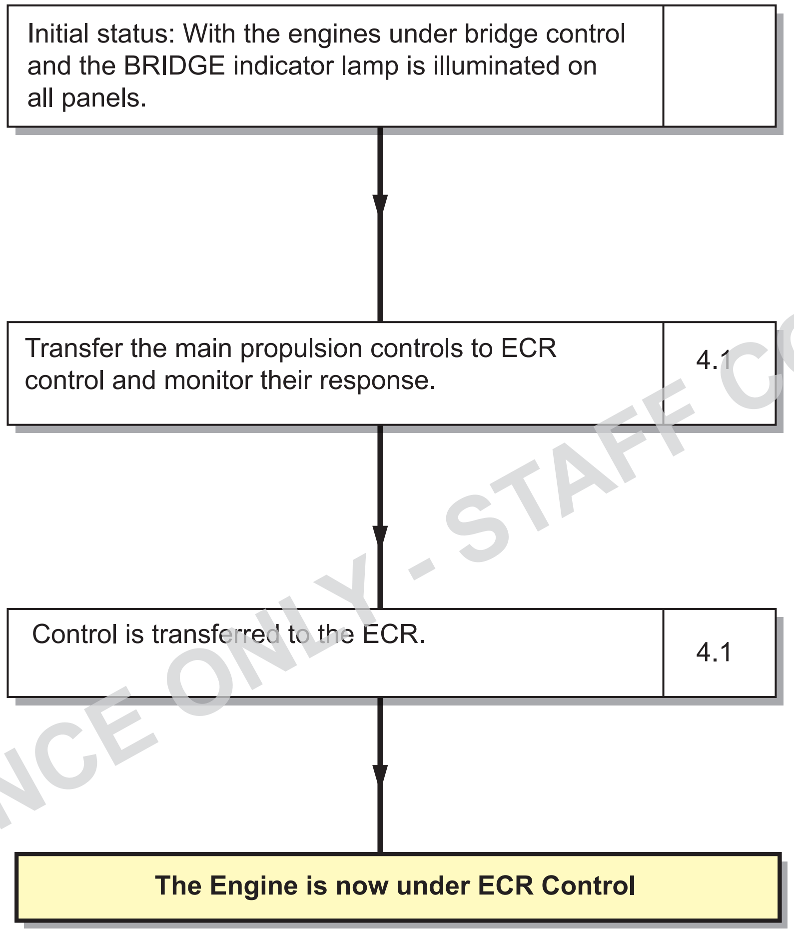

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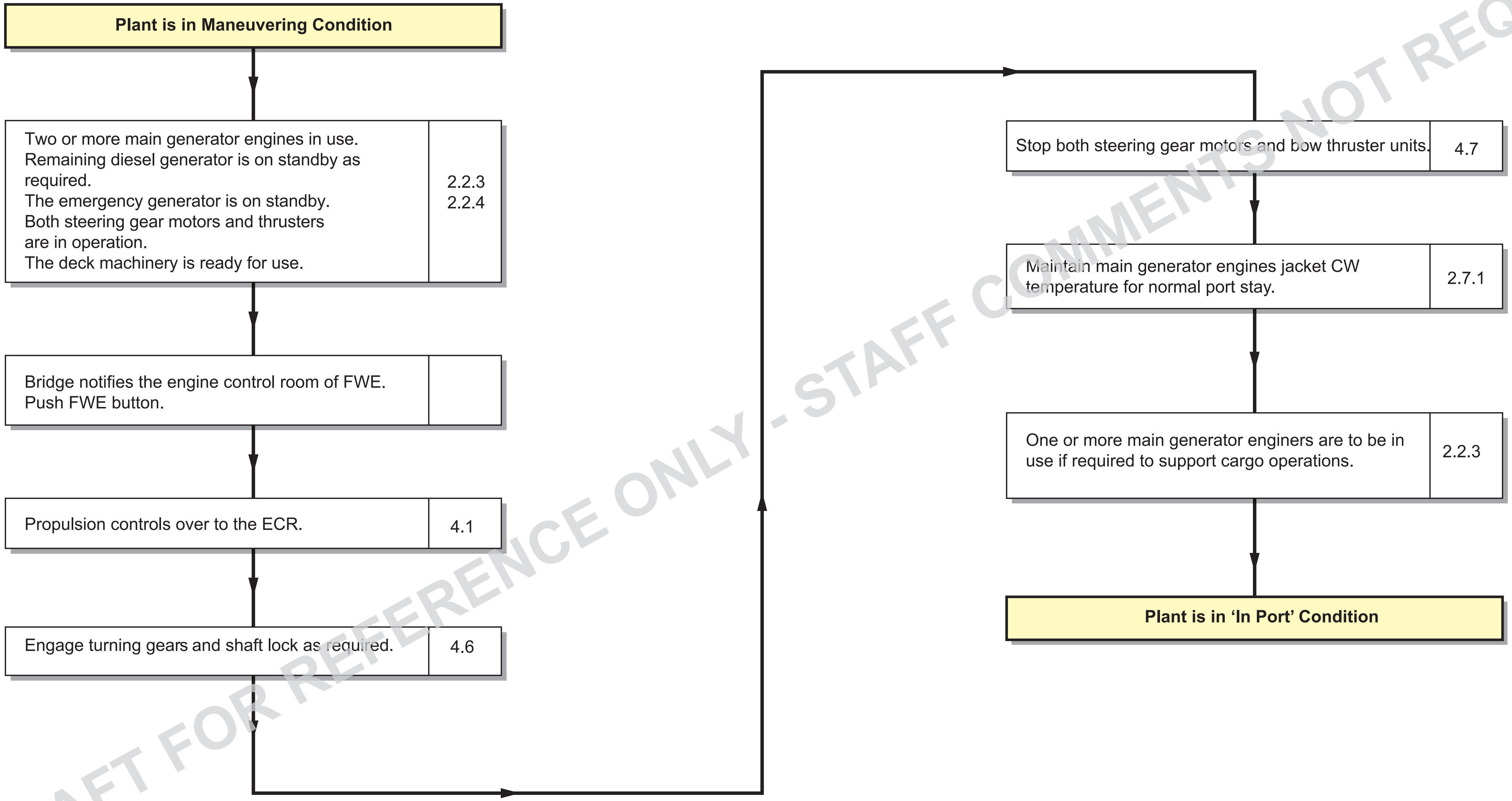
Illustration 2.1i To Secure Main and Auxiliary Plant at Finished with Engines



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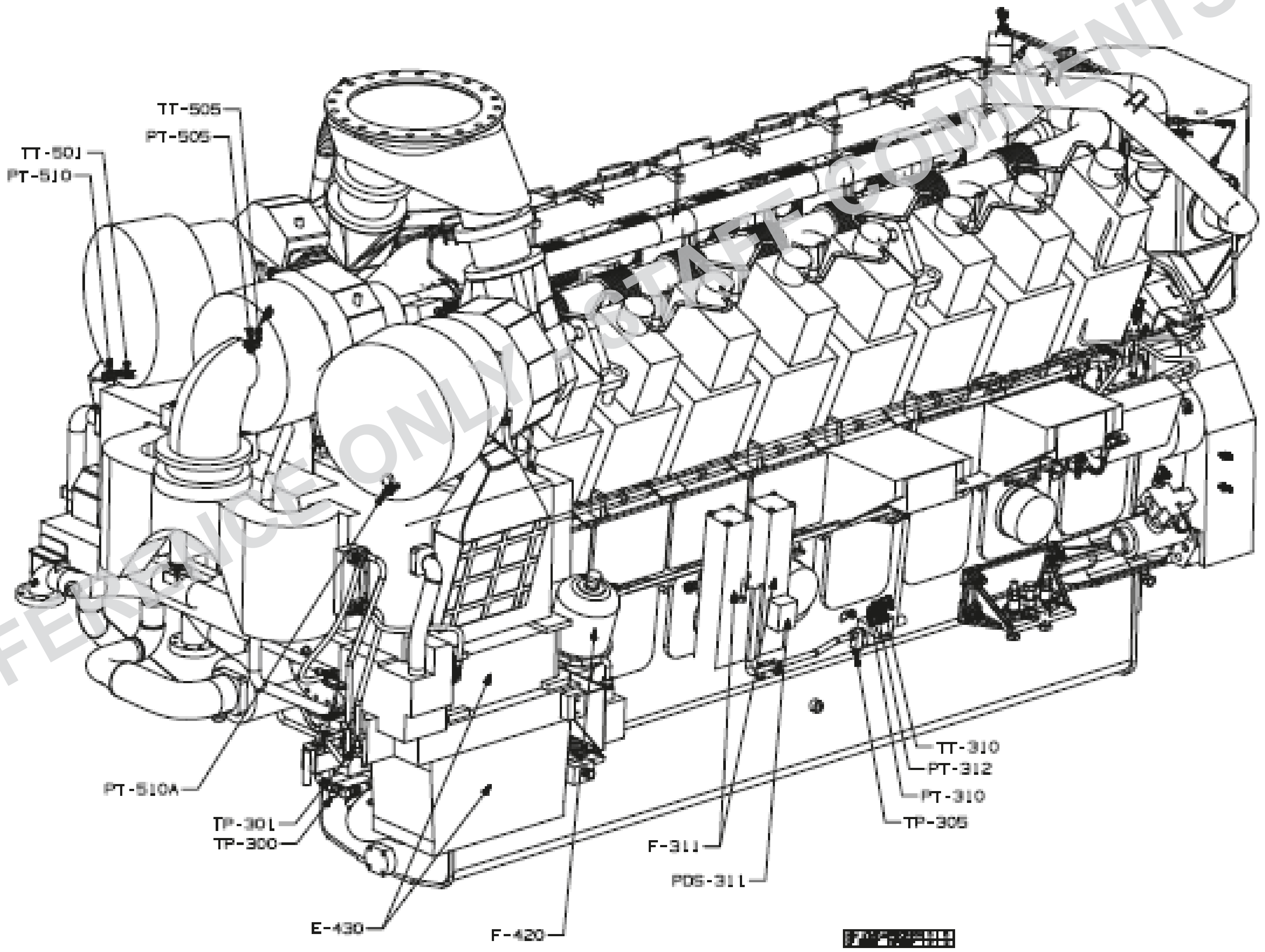
2.2 Diesel Generators

Illustration 2.2.1a Main Diesel Generator Engine *(Authors note: To be replaced with clearer drawing or photograph once viewed)*



2.2 DIESEL GENERATORS

2.2.1 MAIN DIESEL GENERATOR ENGINES

Main Diesel Generator Engines

Manufacturer:	GE Wabtec
Model:	16 V250MDC
Type:	Turbocharged, 4-stroke, single acting, trunk piston, non-reversible, direct fuel injection
No. of sets:	4
No. of cylinders:	16
Maximum power:	4,200kW
Speed:	900 rpm
Direction of rotation:	Clockwise from the flywheel side
Cylinder bore:	9.8 inch (250mm)
Piston stroke:	12.6 (320mm)
BMEP:	3,191psi (220 bar)
Mean piston speed:	9.6m/s

Turbochargers

Manufacturer:	GE
No. of sets/engine:	1 x LP leftside
	1 x LP rightside
	1 x HP centre

Alternator

Manufacturer:	Hyundai
Model:	HSJ9 913-08P
Type:	08 pole, cylindrical rotor, brushless. separately excited
No. of sets:	4
Voltage:	6,600V, 3-phase, 60Hz
Capacity/rating:	5,066.25kVA, 443.2A, 4053kW, 0.8pf
Speed:	900 rpm
Cooling:	Air to water
Space heaters:	120V 1,000W

Introduction

The vessel is fitted with four main diesel generator engines (MGEs), each driving an alternator. The engines are of the four-stroke, trunk piston type, and are unidirectional with an operating speed of 900 rpm. There are eight cylinders in each bank. Constant pressure turbocharging is applied by means of one turbocharger per bank of cylinders, with the temperature of the scavenge air being reduced by a charge air cooler located between the turbocharger compressor, and the charge air manifold.

Cooling Water System

The cylinder jackets and cylinder heads are water cooled by means of circulating fresh water; the lower part of the cylinder liner is not cooled. The water jacket is fitted to the upper part of the liner where it projects above the engine block, which means that there are no cooling water passages in the cylinder block. Engine jacket and cylinder head cooling is provided by the High Temperature (HT) Fresh Water (FW) cooling system. Each engine is also provided with a separate Low Temperature (LT) FW cooling system which supplies for cooling of the LO and second stage charge air cooling. The engine HT cooling water system also supplies the initial cooling of the charge air. The HT circuit controls the water flow and temperature through the Exhaust Gas Recirculation (EGR) cooler, then to the engine frame and power assemblies. Engine-driven HT and LT cooling water circulating pumps operate whenever the engine is running, but electrically-driven HT and LT circulating pumps are also fitted, and circulate HT and LT cooling water systems. The HT cooling water system circulates via a preheater when the engine is stopped. The preheater uses an electric heat element to heat the HT cooling water system. The preheater allows an engine to be warmed-through before starting. The EGR cooler is mounted on the engine. It removes excess heat from the exhaust gas before it is recirculated into the combustion air, to assist the system to meet lower NOx emissions limits.

Lubricating Oil System

From the free-end cover, the engine Lubricating Oil (LO) header directs LO down both camshafts, which then feeds the main bearings. The LO enters the crankshaft from the main bearings, and flows through drilled passages in the shaft to the crank pins and rod bearings. The LO passes from the rod bearings through the connecting rods to lubricate the piston pins, and bushings. The LO then passes into the pistons to the chamber under the piston crown to cool the crown. The LO flows out of the piston crown through an orifice, through the piston skirt, and by gravity back to the crankcase.

LO is pumped throughout the engine through passages running the length of each camshaft. From there, it is fed through drilled passages in the crankcase up to the rocker arms and valves, and fed down to the crank shaft bearings and then to the pistons and cylinder liners through drilled passages in the crankshaft and connecting rods. The LO then flows by gravity back to the oil pan. The LO pump is mounted on the Integrated Forward-End (IFE) cover.

The LO enters the camshaft sections. Radial holes in the journals supply oil to each of the bushings. The camshaft bushings contain annular grooves connecting to passages in the engine main frame, from where LO flows to the valve crossheads. The LO then flows upward through the valve push rods to supply LO to the valve train parts at the top of the cylinders. LO return is through the valve push rod cavities to lubricate the cams, cam rollers, and back to the crankcase by gravity.

The auxiliary drive gear is lubricated internally by LO flowing from a passage within the crankshaft through the gear hub. LO from these bearings returns by gravity to the crankcase. Turbocharger bearings receive LO through an internal passage in the top of the mounting brackets. From the turbocharger, the LO is returned to the crankcase through an internal passage in the mounting brackets, and through an external pipe bolted to the IFE.

LO is supplied to the barring-over gearbox by internal drilling in the main frame to the gearbox. The LO from the gearbox returns to the crankcase internally. The camshaft gears are splash lubricated through an orifice and pipe from the engine oil header. The oil pan bolted to the engine main frame forms the bottom of the crankcase, which holds the LO supply. The LO fill pipe is located on the side of the engine. Dipsticks for measuring the crankcase oil level are located on both sides of the frame.

Each engine is fitted with a centrifugal LO filter which is used to remove fine particles from the LO. The separator is supplied from the LO header tank. Inside the centrifuge, the LO is set into a centrifugal motion where contaminants in the LO are deposited on the walls of the rotor. LO then exits the centrifuge filter through a pair of nozzles on opposite sides of the oil filter base which transmits into a turning motion of the rotor.

The crankcase is fitted with seven crankcase explosion relief doors. These doors must be in good operational condition at all times, and no materials must be placed next to the doors that could impair their effective operation. The crankcase is also fitted with an oil mist detector, which monitors the oil mist concentration in the crankcase. By measuring the opacity of the atmosphere in the individual engine units, abnormal operating conditions such as overheating bearings and piston blow-by are detected. If abnormal oil mist concentrations are detected, the oil mist detector generates an alarm and the engine is shut down.

WARNING

If the engine has been shut down by the oil mist detector, the crankcase doors MUST NOT be opened until at least 20 minutes have elapsed after stopping of the engine in order to allow for cooling. If fresh air is allowed into the crankcase whilst a 'Hot Spot' still exists, there is a high risk that it will initiate a crankcase explosion.

Crankshaft

The drive mechanism consists of the pistons, connecting rods, and crankshaft. The crankshaft connects mechanically to the alternator by a flywheel flange, and flexible plate. The pistons, connecting rods, and crankshaft are arranged in a slider-crank mechanism, which converts the work performed by the hot gases on the piston into torque on the crankshaft.

The crankshaft is suspended on main bearings in the engine crankcase. Counterweights ensure that the internal mass movements are reduced, thus relieving the stress on the crankshaft bearings. During the engine operation, the crankshaft rotates clockwise when viewed from the free end, and counter clockwise when viewed from the alternator end.

The crankshaft is a steel forging, normalized, and heat treated to improve its physical properties. The crankshaft main journals, and crankpins are of solid construction. Oil passages, drilled diagonally through the pins, intersect drilled passages in each adjacent main journal.

The forward end of the crankshaft is fitted with a flange to mount the vibration damper, and is located just ahead of the No. 1 main bearing. The pump drive gear is bolted to the same flange as the vibration damper. A semi-removable gear, mounted on the crankshaft just ahead of the alternator drive flange, drives the camshaft gears (through additional gearing).

Crankshaft Drive Gears

The crankshaft (alternator end) drives the camshaft through a gear train containing a crank gear mounted to the crankshaft, an idler gear set, and a camshaft gear mounted to the camshaft. On the free end, the crankshaft drives both the LO pump, and water pump through a gear bolted to the crankshaft.

Main Bearings

Semicircular main bearings support the crankshaft within the engine. The main bearings are secured by main bearing caps that are bolted in place. The main bearings are a precision type, and are replaceable without machining or scraping. Each bearing has a steel back which supports two or more layers of bearing material. The top main bearing halves have a center oil groove, and are used in the main frame bearing saddle. A partial grooved bearing is used in the lower main bearing position. The partial groove in the lower bearing results in a thicker film of oil, lower unit area loading, and higher LO header pressure. Each top main bearing half (with full oil groove) contains one locating tab which locates and secures the half in its correct position. Each lower bearing half (with partial groove) contains two locating tabs which prevent inadvertent installation in the upper position.

Cylinder Heads

The cylinder heads are manufactured from grey cast iron and are attached to the engine block by four hydraulically tensioned studs and nuts. Cooling water is directed to the cylinder head from the engine block via the cylinder liner water cooling bores; this upward flow of water ensures there are no air pockets in the system and it keeps temperature gradients within acceptable limits. The water leaves the cylinder head through an outlet channel on the top and flows to a common pipe to the outlet connection for the jacket water High Temperature (HT) cooling water system. There is one inlet, exhaust, and fuel valve in each cylinder head.

Camshafts

The camshafts are rotated by the crankshaft through a system of gears with the gear drive arrangement being located at the drive end of the engine. The camshaft is built up of a number of sections that are joined together by bolted flanges. For each unit of the camshaft, there is one fuel injection cam, one air inlet valve cam and one exhaust valve cam. All of these cams have smooth profiles that allow for a controlled lifting and falling of the cam followers.

Turning Gear

An electric turning gear assembly is fitted at the flywheel of the engine. It is engaged manually from a lever on the turning gear housing, and has a manual adjusting handle below which can be used for fine adjustment to assist in engaging the gears. The turning gear is interlocked with the engine's starting system so that the engine cannot be started while it is still engaged.

Fuel Oil System

The MGEs have Electronic Fuel Injection (EFI) systems, which comprise of a Low Pressure (LP) system (approximately 100 psi or 7 bar), and a High Pressure (HP) common rail fuel system (approximately 2,200 bar). The LP fuel system separates fine dirt from the fuel by means of two-stage particulate filtration. Fuel from the day tank flows to the water separator, then to the on-engine Low Pressure Fuel Pump (LPFP). From there it goes to a fuel cooler, and exits to the first-stage filter, which is mounted off-engine. From the first-stage filter, the fuel flows to the engine-mounted second-stage filter, and then flows to the High Pressure Fuel Pump (HPFP).

The LP suction section of the fuel system is between the fuel tank, and the MGE fuel pump. An automatic thermostatic blending valve is fitted to regulate fuel temperature before reaching the pump.

The HP section of the fuel system is between the MGE fuel pump, and the fuel injection equipment on the individual cylinders. The MGE fuel relief valve is integrated into the LP, on-engine fuel transfer pump, and protects the pump from overloading caused by flow restrictions on the HP portion of the fuel system. Fuel discharged by the pump flows through the two-stage MGE fuel filters. From the filter tank, fuel oil passes through the fuel pressure regulating valve, then to the high pressure fuel metering valve(s), and finally to the fuel injection equipment on the individual cylinders. The MGE fuel regulating valve maintains back pressure in the fuel headers for protecting the HP pumps from cavitation.

Excess fuel from the MGE fuel headers passes through the fuel regulating valve to the fuel tank. The MGE fuel cylinder returns on each side of the MGE collect excess fuel oil used to lubricate moving parts of the MGE fuel injection equipment, and directs it back to a gravity return tank or pump if required.

The filtration system consists of two filters separated by a hand-operated selector valve. When one filter starts to clog up, which is indicated by the gradual drop in fuel flow, and header pressure, the hand valve located between the two filters should be turned to switch the flow from one filter to the other.

A pressure relief valve in the LP fuel system is integrated with the mechanical fuel pump. This valve is factory set to open at a pressure of 1,379 kPa (200 psi), and return bypassed fuel to the mechanical pump inlet. The valve protects the priming pump against electrical overload, and protects the system against excessive pressure caused by clogged filter elements, or fuel flow stoppage in the pressure side of the system. There is no maintenance needed for this item.

A pressure regulating valve is located after the LP fuel system pressure sensors, and before the HP fuel pump fuel metering valves. This valve is set to maintain the fuel header pressure of 700 to 900 kPa (102 to 131 psi).

Fuel Injection Equipment

The fuel injectors deliver atomized fuel into the cylinders. An integrated solenoid valve controls the timing, and duration of fuel injection. There is one injector in each cylinder head.

The fuel oil injector receives the fuel from the fuel injection pumps, and atomizes the fuel as it is delivered to the combustion chamber. The injector acts mainly as a valve.

The HPFP generates the pressure required for proper fuel injection. There are two high pressure fuel pumps, located on the left and right hand sides of the engine near the drive end of the MGE.

A pressure limiting valve is to the HP side of the system to protect against over pressurization. This valve will open, and divert excess fuel to the fuel gravity return tank whenever the pressure in the lines exceeds the design tolerances. It is located on the drive end of the engine, on the right hand side.

Fuel Oil Leak Detection

The HP common-rail fuel lines are double walled lines that carry fuel from the HPFPs to the injectors. The inner pipe is the primary fuel carrier from the HPFP to the injector. The outer pipe seals any leaking fuel from an inner pipeline failure or poor seal at either end of the fuel line.

Flexible fuel hoses collect, and carry any fuel leaking into the area between the inner and outer pipes of the HP fuel lines to the leakage collection tank. This tank contains a float switch, which when tripped sends a signal to sound an alarm in the monitoring system.

Starting Air System

Engine starting is by means of compressed air turning a starter motor. A solenoid and relay valve is placed after the regulator. The solenoid governs the starter to run or remain idle. The air then flows through the relay valve, and into the starter motor, cranking the engine until the controller signals the solenoid to disengage the starter pinion from the ring gear. In normal operations, the starter pinion disengages at 100 to 150 engine rpm. The air start system cranks the engine with a turbine type, engine mounted air starter. The air start system accepts a 24 VDC signal via a solenoid valve located on the on-engine mounted multi-valve/regulator. This solenoid can also be operated manually. The on-engine multi-valve also acts as a relay valve, strainer, and regulator. The multi-valve regulator is factory preset to 90 psi (6.3 bar).

Slow Turn

The slow turn facility is fitted to the engines to prevent possible damage occurring by starting engines with liquid present in a cylinder. Operation of the slow turn system is normally set to automatic, but an engine start may be made from the Local Control Panel (LCP) or remotely without slow start if necessary.

The IAMCS will monitor the availability of the diesel generators when set to standby, including the prelubrication and slow turning.

CAUTION
The master start air valve must not be closed when the engine is running.

Turbochargers

The engine mounted turbochargers compress combustion air going into the cylinders using energy from the exhaust gases to perform the work. The turbochargers are mounted on the free end of the engine. For maximum efficiency and minimum emissions, the engine uses a sequential turbocharger arrangement. There are two low pressure turbochargers that feed into one high pressure turbocharger.

There is one LP turbocharger fitted to each bank of cylinders, and an HP turbocharger fitted centrally that can be run sequentially or bypassed. They operates on the constant pressure principle, where exhaust gas from all cylinders in the bank flows into large volume exhaust manifolds which then supply the turbocharger. The turbocharger is equipped with a single-stage axial flow exhaust gas turbine and a single-stage radial flow compressor. The turbine wheel and shaft form one part and the compressor impeller is fitted to the shaft.

The turbocharger casing is uncooled and the rotor has two radial bearing bushes located between the turbine disc and impeller. Lubricating oil is supplied to the bearings from the engine LO circulation system and it drains from the bearing area to the engine LO circulation tank. The main axial bearing consists of a free-floating thrust disc with profiles on both sides. Radial (rotor support) bearing bushes are secured in the housing with screws.

Air Filters and Coolers

Air Filter

There two air filters, and they are attached to the LP turbochargers. The air filters remove particles from the combustion air that might damage the engine.

Intercooler

There are two intercoolers used to cool the combustion air after it is compressed by the LP turbochargers. The intercoolers are cooled by the LT cooling circuit, and are mounted on the left and right hand sides on the free end of the engine.

Aftercooler

There is one aftercooler used to cool the combustion air after it is compressed by the HP turbocharger. The aftercooler is cooled by the LT cooling circuit and is mounted in between the intercoolers on the free end of the engine.

Exhaust Gas Separator

The exhaust gas separator is a small tank located on the left side of the engine, near the rear side of the LO cooler. It separates the after-cooler condensate from the intake air or exhaust gas combination that may escape with the condensate. The after-cooler condensate is drained out the bottom of the exhaust gas separator through a drain trap. The intake air or exhaust gas combination is vented to the exhaust stack through the top of the exhaust gas separator.

Exhaust Silencer

An exhaust silencer is fitted to reduce the noise level of the engine exhaust. The silencer is fitted with spark arrester.

Oil Mist Detector

The engines are each fitted with a Tufmon MEV282213 oil mist detector with an optical system. The oil mist detector activates an engine shutdown (after

load shedding) in the event of a high mist level being detected in any part of the crankcase. The oil mist detector must be checked daily by the duty engineers.

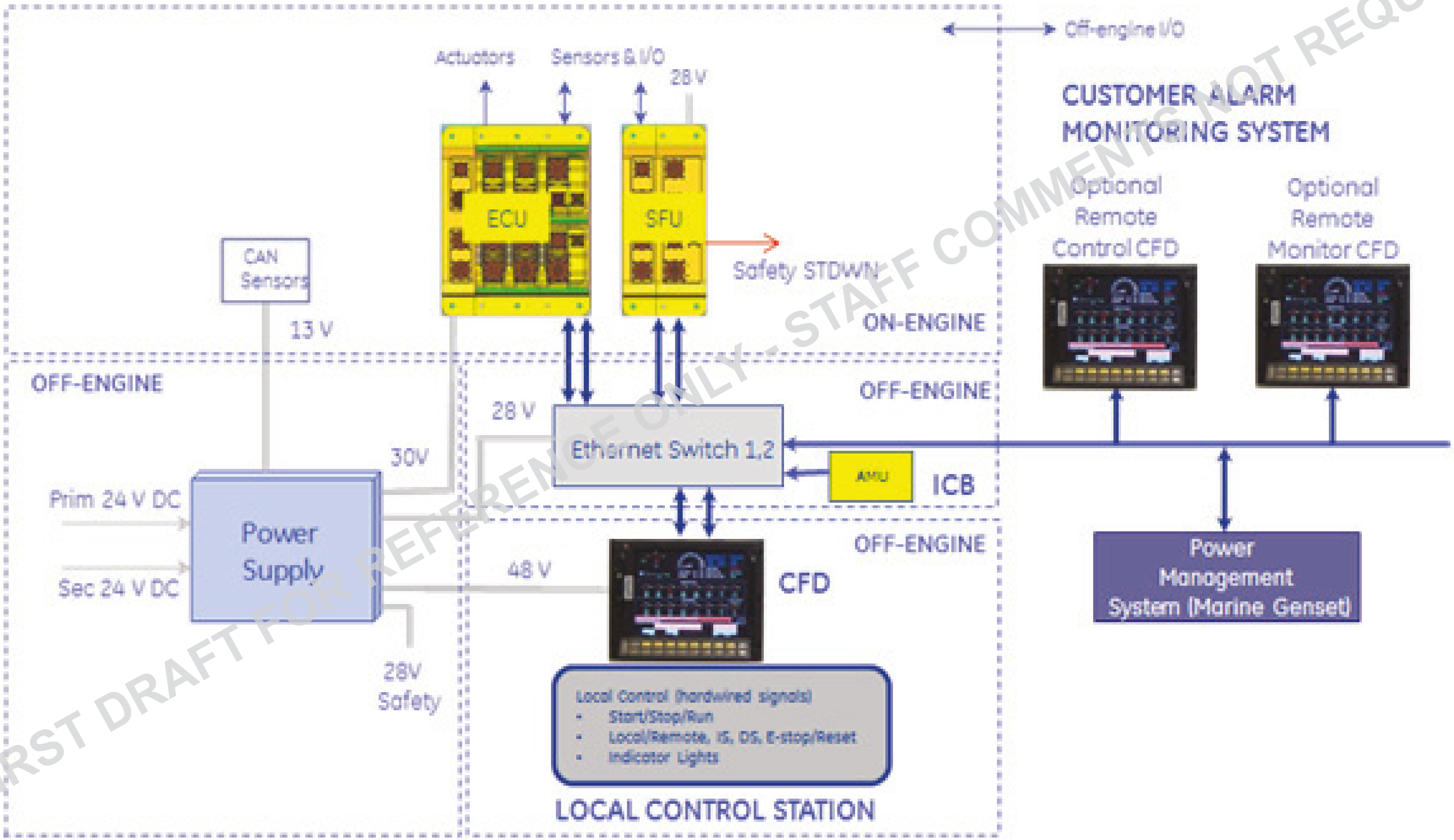
Manual Engine Speed Control

Under normal conditions, the governor regulates the fuel setting of the fuel injection pumps depending upon the load on the engine and the set operating speed which should be constant for electrical generation.

CAUTION
The procedure for manually controlling the engine speed must only be undertaken in emergency situations.

The engine control system is described in the section below in this manual.

Illustration 2.2.2a Engine Control System *(Authors note: To be updated once confirmed)*



2.2.2 DIESEL ENGINE CONTROL, MONITORING, AND SAFETY SYSTEM

Manufacturer: GE
Model: ECS-4 Engine Controller

Introduction

The main function of the GE ECS-4 controller is to control engine speed under varying load conditions. Additional functions, such as engine protection and engine start/stop are also integrated into the controller. As a secondary function, the engine controller acts as an interface with off-engine equipment for engine related equipment.

Controller Components

Engine Control Unit (ECU)

The ECU is mounted on the engine. The ECU is responsible for engine speed control, maintenance of proper emissions levels, and required levels of protection. The ECU consists of several I/O circuit cards, contained in the enclosure mounted on the engine. Under normal operating circumstances, the engine operator will not have to interact with the ECU.

Safety Unit (SFU)

The SFU is mounted on the engine. The SFU performs monitoring of safety critical systems. As with the ECU, engine operators will not interact with the SFU on a regular basis.

Interconnect Box (ICB)

The ICB is designed to be off the engine, but must be within 10 metres of the engine. The ICB acts as a hub or junction box for on and off engine equipment. The ICB is field wired with glands or strain relief connectors. The ICB contains Ethernet switches for electronic communications. Once wired, the ICB will not require regular interaction with the engine operator.

Power Supply Unit (PSU)

The PSU is mounted off engine, but must be within 10 metres of the engine. The power supply provides the power required for the ECU, SFU, and other components. The PSU also monitors incoming and outgoing voltages, and sends an alarm to the Consolidated Function Display (CFD) when one is out of tolerance.

Local Control Station (LCS)

The LCS is the interface with the engine operator. The LCS contains the CFD screen for operator interaction. Italso holds several indicator lights that indicate system status and various switches for engine control.

Emergency Stops

Multiple emergency stop connections are available for the ECS-4. When an emergency stop is triggered, an alarm will be displayed upon the CFD as the engine is shutting down. To reset from an emergency stop:

1) Determine and rectify the reason for the E-stop.
2) Place the emergency stop switch into normal operating position.
3) Pressing the 'RESET' button on the LCS resets the engine, and clearing the emergency stop condition.

Indicating Lights

ECU Indicating Lights

- Green light ON - power supply OK.
- Yellow light ON - fueling enabled.
- Red light ON - CPU not running.

SFU Indicating Lights

- Green light ON - power supply OK.
- Red light ON - CPU not running.

Local Control Panel Lights

- **System OK**:The System OK indication, light (1), will turn off when a restrictive incident is active or any other control system-related faults are present. If the System OK light is off, it can be reset by pressing the 'RESET'button after the fault has been cleared. Note that the System OK signal is a combined signal from the ECU and the SFU.
- **Engine Running**: The Engine Running indication, light (2), will turn on when the engine speed is greater than 250rpm.
- **Load Limit:** The Load Limit indication, light (3), will turn on the when the control is operating at either a smoke limit, static limit, or torque limit for a time greater than 3 minutes.
- **Low Lube Oil Pressure:** The Low Lube Oil Pressure indication, light (4), will turn on when the system detects an alarm.
- **Engine Overspeed:** The Engine Overspeed indication, light (5), will turn on when the system detects an alarm.
- **High Oil Mist/Main Bearing Temperature:** The High Oil Mist/Main Bearing Temp indication, light (6), will turn on when the system detects an alarm.
- **High Crankcase Pressure:** The High Crankcase Pressure indication, light (7), will turn on when the system detects an alarm event.

Local Control Station

Reset Button

The reset pushbutton (8) is located on the front panel of the LCS. The button can be used to reset the control system, allowing the engine to restart after a shutdown or emergency stop has occurred. This reset can only be applied at the LCS, as typically a critical shutdown requires a thorough inspection of the equipment, and root cause of the shutdown determined and corrective action taken. To use the Reset Button, press and hold the button until the System OK LED illuminates (about three seconds). A softkey on the Consolidated Functional Display is also available on the Active Alarms screen.

Emergency Stop Pushbutton

The Emergency Stop pushbutton (9) is located on the LCS. This emergency stop can be used for immediate shutdown of the engine in the event of an emergency. Restarting the engine after an emergency stop will require a manual reset of the system.

System Power Switch

The System Power Switch (10) is located on the front of the LCS. This switch is used to turn power to the system ON or OFF

Note: Do not turn system OFF if the engine is running.

When turning the system off, the power supply will send a signal to the ECU and SFU, instructing these units to conduct a controlled bootdown. The controlled bootdown will allow the ECU and SFU to save information as required, and shut down safely, similar to a computer. When ready, the ECU and SFU will send a signal to the PSU, at which point the PSU will turn off its outputs to these units. This switch will also cause the Local CFD to go into a controlled bootdown. However, there is no interaction between the CFD and the PSU. The PSU will not reset until the switch is turned back to the ON position.

Note: Be aware that the ECU and SFU may or may not power off at the exact same moment, this is normal and expected.

Note: Under normal operational circumstances, do not shut off the ECS-4 Control System by removing the source of power to the PSU.

Start/Run/Stop Control Switch

The Start/Run/Stop switch (11) is located on the front of the LCS. This switch stops, starts, and allows the engine to run. Placing the switch in the 'STOP' position will stop the engine any time the engine is running, regardless of control location. Placing the engine in the 'START' position while in Local Control will allow engine starting, providing all start interlocks are met.

Local/Remote Control Switch

The Local/Remote control switch (12) allows the user to switch between local and remote control methods using a hard-wired switch on the LCS enclosure. Local control can be taken at any time from the LCS. Remote control requires acknowledgment.

Increase/Decrease Speed Switch

The Increase/Decrease Speed switch (13) is located on the LCS enclosure. This switch will increase or decrease the engine speed, on a consistent ramp rate, when the controller is in local mode.

Consolidated Functional Display (CFD)

The CFD (14) is located on the LCS. It is the operator interface for the engine, and the tool to monitor important engine operational parameters.

Interconnect Box

The ICB acts as a junction box for all on and off engine sensors and equipment. The ICB has dry contacts for signals that originate from the control system, and expects a dry contact from signals that originate from off-engine equipment. The ICB includes the necessary Ethernet switches for Modbus communications. There are no indications or other operational or troubleshooting information on or within the ICB.

Power Supply Unit

The PSU provides the necessary DC voltage for control system operation. The PSU is supplied by four separate 24VDC power feeds. Two power feeds are from a primary source (P1 and P2), and two are from a secondary source (S1 and S2). P1 and S1 provide power to the ECU converters; P2 and S2 provide power to the SFU, CFD, CAN Power, and control power converters. All power supply voltages are monitored to indicate a failure. The power supply should be protected by circuit breakers or fuses supplied by the vessel.

Local/Remote Engine Operation

When in Local Mode, engine speed is controlled by the Increase/Decrease Speed switch on the LCS. The engine speed will ramp up or down in a consistent rate. The rate of speed increase and decrease is configurable. In Remote Mode, engine speed is controlled by either a 4-20mA throttle for variable speed engines, or a ±3VDC bias signal for constant speed engines. Similar to the local control, the speed will increase and decrease at a steady rate.

The transition from local mode to remote mode can happen from either the local station or a remote station.

To initiate Remote Control from the remote station, the operator at the remote station is to press and hold the 'Remote Control Acknowledged' button. After being pressed, the CFD at the LCS will alarm 'Remote Control Requested'. At the LCS switches the operator then turns Local/Remote switch to 'Remote'. The engine will now be in remote mode.

To initiate Remote Control from the LCS, the operator must put the Local/Remote switch to 'Remote'. The CFD will alarm 'Local Station Requesting Remote Control'. The remote operator must then press the 'Remote Control Acknowledged' button. The engine will then be in remote mode.

The speed of the engine will not change until the speed signals match, i.e. the engine speed from the remote station will not change until it matches the current engine speed. This is to prevent inadvertent speed increase or decrease upon changing control stations.

To change from remote mode to local mode, the operator at the LCS moves the switch to 'Local'. The engine control is then in local mode. Engine speed will not change.

Droop Mode of Engine Operation

Droop is intended to be used for synchronization purposes. Droop is available on both constant speed and variable speed applications. Operation is the same in both instances as the operator must switch the system from Isochronous Mode to Droop Mode. The engine will automatically increase or decrease speed according to the load. When synchronization is complete, the system must be returned Isochronous Mode to resume constant speed.

For constant speed engines, droop will only be available at Rated Speed. The amount of droop is calculated by the ECU, and is a product of engine speed, estimated load, and percent droop allowed. The less load on the engine, the higher the engine speed will increase. The amount of droop allowed is configurable between 0% and 6% of rated speed.

Engine Operation - Alarms, Alerts, and Messages

Alarms

Faults may be initiated by the control system or by other systems on the engine. When the control system detects a fault, a message describing the fault will appear in the alarm bar area on the CFD screen
.

The alarm can be silenced at any time from the CFD screen by pressing softkey F8 (Silence). Also, indication will be initiated by the ECS-4.

Types Of Alarms

There are two types of alarms present within the control system: Diagnostic Alarms and Engine Protection Alarms.

- Diagnostic Alarms are alarms for events such as wire loss, short circuit, communications failure, sensor out of range high or low, and power failures. These diagnostic alarms are not generally critical to the operation of the engine and system, but should be investigated and remedied at the first available opportunity.
- Engine Protection Alarms are alarms that are related to engine operational parameters. Faults within water, fuel, LO, and air systems are all engine protection alarms. Within Protection Alarms, several layers of protection exist.
  - **Warning:** Warning alarms are informational and considered not critical to engine operation. The protective action should be investigated and repaired at the earliest opportunity.
  - **Slowdown Request:** This is a request from the control system to reduce speed, and load on the engine. Possible conditions are high cooling or LO temperatures, and taking the corrective action may bring the parameter back to proper operating condition. This is not an automatic event.
  - **Speed Restriction:** When this protective action occurs, the engine control system will automatically reduce the speed of the engine to protect the engine. This event is in response to a serious engine condition, and the cause of the alarm should be investigated quickly and repaired.
  - **Engine Load Limited:** When this protective action occurs, the engine control system will automatically reduce the load on the engine to protect the engine. This event is in response to a serious engine condition, and the cause of the alarm should be investigated quickly and repaired.
  - **Shutdown:** When this protective action occurs, the engine control system will automatically shut the engine down in response to a critical engine failure, such as engine overspeed or low LO pressure. Corrective action is to be taken prior to engine restart.

Operator Messages

Operator messages inform the operator of events that have occurred within the ECS-4 Control System. The highest priority message will be displayed on the CFD screen in the operator message bar just above the softkey indicators.
If more messages exist than can be displayed in the message box, the list of messages can be viewed on the CFD Messages screen.

Consolidated Functional Display (CFD) Controls

The CFD is the computer display portion of the GE T4 engine controller. The CFD provides the operator interface with the control system as operator commands from the CFD function softkeys are communicated to the system. Information on the CFD allows the operator to monitor engine performance. The CFD is integral to the Local Control Station. The following sections also apply to remote screens. On power-up, the CFD defaults to the Root Screen.

Each CFD keyboard contains two rows of softkeys:

- The first row contains eight function softkeys (F1 through F8) and the MENU softkey.
- The second row contains ten numeric softkeys (0 through 9).

The Menu Screen has limited softkeys available. A list and description are as follows:

a) **Softkey F1 (Escape):** Returns to the Root Screen. Note that no changes will be saved when pressing this button.

b) **Softkey F2 (Page Up):** Scrolls up through the pages of available alarms. This softkey will only display if there is an available page.

c) **Softkey F8 (Silence):** Silences all active alarms.

d) **Softkey 2 (Page Down):** Scrolls down through the pages of available screens. This softkey will only display if there is an available page.

e) **Softkey 8 (Ack):** Acknowledges all active alarms. Note that this softkey will only display when there is an alarm to acknowledge.

CFD Gauge Area

The gauge area of the CFD consists of the top one-quarter of the CFD screen. This gauge area is always shown on the CFD and provides an instant display of the engine status and RPM.

Gauge Area

- The Fuel Rate bar shows the percentage of fuel being supplied to the engine. This is a percentage of the total allowable fuel limit at the speed at which the engine is running. When the engine is fuel limited or load limited, the bar will flash yellow. Note that depending upon engine settings, fuel can be limited at less than 100% fuel.
- Overrides will only be visible when there is an overrideable event, depending upon engine configuration.
- The color and wording of 'Engine Status' will change depending upon the status of the engine. A display of '**' indicates communication loss with ECU.
- 'Actual Speed' is the actual speed of the engine as indicated by the control system.
- 'Ref Speed' is the reference speed from the customer, whether by analog or bias signal.

CFD Operating Screens

The Root Screen (Shown above) has the following softkeys available with a description below:

a) **Softkey F2 (Engine Control):** Displays the Engine Control Screen.

b) **Softkey F3 (Monitors):** Displays the CFD Monitors Screen.

c) **Softkey F4 (Alarms):** Displays the CFD Alarms Screen.

d) **Softkey F5 (Messages):** Displays the CFD Messages Screen.

e) **Softkey F6 (Tests):** Displays the CFD Test Screen.

f) **Softkey F7 (Access):** Displays the CFD Access Screen.

g) **Softkey F8 (Silence):** Silences all active alarms.

h) **Softkey 1 (Freeze/Unfreeze):** Freezes or unfreezes all data on the screen except for the alarm bar and the message bar.

i) **Softkey 2 (Software):** Displays the CFD Software Screen..

j) **Softkey 3 (Settings):** Displays the CFD Settings Screen.

k) **Softkey 4 (Data Download):** Displays the CFD Data Download Screen.

l) **Softkey 5 (Data Recorder):** Displays the CFD Data Recorder Screen.

m) **Softkey 7 (Language):** Displays the CFD Language Screen.

n) **Softkey 8 (Ack):** Acknowledges all active alarms. Note that this Softkey is only visible when there is an alarm to acknowledge.

CFD Control Screen

The Engine Control Status screens (Shown above) and the Engine Control are used to control the operating status of the following items below:

- Pre-lubrication (Auto/Manual).
- Pre-lubrication (ON/OFF).
- Pre-lubrication Bypass (ON/OFF).
- Heater (ON/OFF).
- Blowdown (ON/OFF).
- Rated/Idle.
- Droop/Isochronous.
- LO Standby Pump (ON/OFF).
- LP Fuel Standby Pump (ON/OFF).
- HT Water Standby Pump (ON/OFF).
- LT Water Standby Pump (ON/OFF).

Operation of Screens

Press softkey F2 (Engine Control) on the Root Screen to display the Engine Control Screen. The active softkeys and descriptions are as follows:

a) **Softkey F1 (Escape):** Returns to the Root Screen.

b) **Softkey F8 (Silence):** Silences all active alarms.

c) **Softkey 2 (Pre-Lube Auto/Manual):** Switches the pre-lubrication function to Auto or Manual operation. When set to Auto, the pre-lubrication will function automatically, allowing the possibility of an immediate start of the engine. When set to Manual, the pre-lubrication pump will display a new Pre-Lube On/Off graphical LED and softkey 3 (Pre-Lube On/Off) to appear on the CFD screen, allowing the operator to manually start/stop the pre-lubrication pump.

d) **Softkey 3 (Pre-Lube On/Off):** This softkey and corresponding graphical LED is only visible when the Pre-Lube Auto/Manual is set to Manual. Pressing this softkey turns the pre-lubrication pump On or Off.

e) **Softkey 4 (Pre-Lube Bypass On/Off):** Turns the pre-lubrication function On or Off. This softkey allows for the pre-lubrication interlock to be bypassed in an emergency situation.

CAUTION

Starting the engine without proper pre-lubrication may result in engine damage and should be avoided when possible. Continuously starting the engine with pre-lube bypassed will damage the engine. Ensure that the pre-lubrication system is only bypassed in an emergency situation. Any damage due to continuous bypassing of engine pre-lube is not covered by warranty.

f) **Softkey 5 (Heater On/Off):** This softkey is only visible if the engine configuration includes a heater. Pressing this softkey turns the heater ON or OFF.

g) **Softkey 6 (Blowdown On/Off):** This softkey is only visible on CFDs configured for local operation. Pressing this softkey turns the blowdown function ON or OFF.

Note: The blowdown function disables the fuel system from the engine control system, but still allows the engine to crank. The engine is blown down to remove any possible water buildup in the engine.

h) **Softkey 7 (Show More):** Displays the Engine Control - Show More screen..

i) **Softkey 8 (Ack):** Acknowledges all active alarms. Note that this Softkey is only visible when there is an alarm to acknowledge.

Press softkey 7 (Show More) on the Engine Control Screen to display the Engine Control. The following softkeys are available and descriptions are as follows:

a) **Softkey F1 (Escape):** Returns to the Engine Control Screen.

b) **Softkey F4 (Lube Oil Standby Pump On/Off):** This softkey is only visible when the engine configuration includes a LO Standby Pump. Pressing the softkey turns the pump OFF if it is running. There is no option to turn ON the pump from the CFD.

c) **Softkey F5 (Low Pressure Fuel Standby Pump On/Off):** This softkey is only visible when the engine configuration includes a LP FO Standby Pump. Pressing the softkey turns the pump OFF if it is running. There is no option to turn ON the pump from the CFD.

d) **Softkey F8 (Silence):** Silences all active alarms.

e) **Softkey 2 (Idle/Rated):** This softkey is only visible for constant speed applications. Pressing the softkey cycles the engine speed to Rated if at Idle and to Idle if at Rated.

f) **Softkey 3 (Droop/Isochronous):** This softkey is only visible if Droop is part of the engine configuration. Pressing the softkey cycles the engine mode to Droop if in Isochronous and to Isochronous if in Droop.

g) **Softkey 4 (High Temp Water Standby Pump ON/OFF):** This softkey is only visible when the engine configuration includes a HT Water Standby Pump. Pressing the softkey turns the pump OFF if it is running. There is no option to turn ON the pump from the CFD.

h) **Softkey 5 (Low Temp Water Standby Pump ON/OFF)**: This softkey is only visible when the engine configuration includes a LT Water Standby Pump. Pressing the softkey turns the pump OFF if it is running. There is no option to turn ON the pump from the CFD.

i) **Softkey 8 (Ack):** Acknowledges all active alarms. Note that this softkey is only visible when there is an alarm to acknowledge.

CFD Monitor Screens

The Monitors screen displays the same information as the Root Screen. However, the Monitors Screen provides additional softkey functions, allowing the operator to access other screens.

Press softkey F3 (Monitors) on the Root Screen to display the Monitors Screen. The active softkeys and descriptions are as follows:

a) **Softkey F1 (Escape):** Returns to the Root screen.

b) **Softkey F4 (Group Display):** Displays the Group Display screen.

c) **Softkey F5 (Interlocks):** Displays the Interlock screen.

d) **Softkey F6 (System Health):** Displays the System Health Screen.

e) **Softkey F7 (Network Health):** Displays the Network Health Screen.

f) **Softkey F8 (Silence):** Silences all active alarms.

g) **Softkey 1 (Freeze/Unfreeze):** Freezes or unfreezes all data on the screen except for the operator message bar and alarm bar.

h) **Softkey 2 (Statistics):** Displays the Statistics/System Life screen.

i) **Softkey 7 (Custom):** Displays the Custom Monitor Screen (2600-0).

j) **Softkey 8 (Ack):** Acknowledges all active alarms.

Group Display Screens

The active softkeys on the Engine I/O screen and brief description of each are as follows:

a) **Softkey F1 (Escape):** Returns to the Group Display screen.

b) **Softkey F2 (Fuel):** Displays the Individual Engine I/O screen for the fuel system. The Fuel System screen displays operating temperatures and pressures related to the fuel of the engine, such as fuel rail pressure, fuel temperature, and filter pressure differentials.

c) **Softkey F3 (Lube):** Displays the Individual Engine I/O screen for the LO system. The LO System screen displays operating temperatures and pressures relating to the LO in the engine, such as LO pressure and temperature, filter differentials, and LO level.

d) **Softkey F4 (Cooling):** Displays the Individual Engine I/O screen for the cooling system. The Cooling screen displays operating temperatures and pressure for the HT and LT systems of the engine, such as expansion tank levels, water pressures, and water temperatures.

e) **Softkey F5 (Crankcase):** Displays the Individual Engine I/O screen for the crankcase system. The Crankcase screen displays parameters such as Main Bearing temperatures, crankcase pressure, and oil mist detection status.

f) **Softkey F6 (Inlet/Exhaust):** Displays the Individual Engine I/O screen for the air intake and exhaust system. The Inlet/Exhaust screen displays engine parameters relating to the air intake and exhaust system such as manifold air pressure, turbocharger speed, and individual cylinder exhaust temperatures.

g) **Softkey F7 (Others):** Displays the Individual Engine I/O screen for other sensors and indications. The Others screen displays engine parameters such as crank sensor status and EGR valve status.

h) **Softkey F8 (Silence):** Silences all active alarms.

i) **Softkey 1 (Freeze/Unfreeze):** Freezes or unfreezes all data on the screen except for the operator message bar and the alarm bar.

j) **Softkey 8 (Ack):** Acknowledges active alarms. Note that This Softkey is only visible when there is an alarm to acknowledge.

The System I/O Screen displays control system parameters similar to the Engine I/O screen. The same format of grouping into individual screens by subsystem is used in System I/O screen. Selecting a system on the System I/O screen will display the Individual System I/O screen for that system.

Interlock Screen

The Interlock Screen details Engine Ready to Start requirements. The interlocks are displayed on the screen. A Green LED indicates that interlock is met or satisfied, and will not block the starting the engine. A Red LED indicates that the interlock is not met or not satisfied. If the engine is not Ready To Start, the Interlocks Screen will aid in troubleshooting, and understanding what conditions are not met.
Press softkey F5 (Interlocks) on the CFD Monitors Screen to display the Interlock screen. The active softkeys and descriptions are as follows:

a) **Softkey F1 (Escape):** Returns to the Monitors screen.
b) **Softkey F8 (Silence):** Silences all active alarms.
c) **Softkey 1 (Freeze or Unfreeze):** Freezes or unfreezes all data on the screen except for the operator message bar and alarm bar.
d) **Softkey 8 (Ack):** Acknowledges active alarms. Note that this softkey is visible only where there are active alarms to acknowledge.

CFD Alarms Screens

There are four different alarms screens that allow the operator to view information about alarms as follows:

- Active Alarms screens.
- Disabled Alarms screen.
- Alarm History screen.
- Individual Alarm screen.

Each of these alarms screens have additional softkey functions, allowing the operator to access other screens and information. Press softkey F4 (Alarms) on the Root Screen to display the Active Alarms screen. The active softkeys and descriptions are as follows:

a) **Softkey F1 (Escape):** Returns to the Root Screen.
b) **Softkey F2 (Page Up):** Scrolls up through the pages of available alarms. This softkey will display even if the highlighted selection is at the top of the list.
c) **Softkey F3 (Up Arrow):** Scrolls up through the available alarms.
d) **Softkey F4 (Reset All):** This softkey is only visible on CFDs configured for local operation. Pressing this softkey resets all active alarms.
e) **Softkey F6 (Alarm History):** Displays the Alarm History Screen.
f) **Softkey F7 (Enter Selected):** This softkey is only visible on CFDs configured for local operation in Level 2 (L2). Pressing this softkey displays the Individual Alarm Screen.
g) **Softkey F8 (Silence):** Silences all active alarms
h) **Softkey 2 (Page Down):** Scrolls down through the pages of available alarms. This softkey will display even if the highlighted selection is at the bottom of the list.
i) **Softkey 3 (Down Arrow):** Scrolls down through the available alarms.
j) **Softkey 5 (Disabled Alarms):** Displays the Disabled Alarms screen.
k) **Softkey 8 (Ack):** Acknowledges active alarms. Note that this softkey is only visible when there are active alarms to acknowledge.

Alarm Handling

Alarm History

Press softkey F6 (Alarm History) on the Active Alarms Screen to display the Alarm History Screen. The Alarm History screen displays a list of all arms in chronological order. The following information about each alarm is displayed:

- Alarm code (unique for each alarm).
- Date and Time. Displays Date and Time for each status change
- Alarm Status:
  - A = when the alarm became active (true).
  - F = when the alarm became inactive (false).
  - Ak = when the alarm was acknowledged.

Disabled Alarms Screen Operation

Press softkey 5 (Disabled Alarms) on the Active Alarms screen to display the Disabled Alarms Screen.

Silencing an Alarm

An alarm can be silenced at any time from the CFD screen. To silence an alarm, use the following procedure:

1) Press softkey F8 (Silence) from any CFD screen. In the event there are multiple alarms, pressing the softkey once will silence all alarms.

2) Navigate to the Active Alarms Screen to confirm what alarms remain active, and require additional troubleshooting using the following procedure:

a) Press softkey F1 (Escape) until the CFD screen has returned to the Root Screen.
b) Press softkey F4 (Alarms) on the Root Screen to display the Active Alarms screen.

Acknowledging an Alarm

An alarm can be acknowledged at any time from the CFD screen. To acknowledge an alarm, use the following procedure:
1) Press softkey F8 (Ack) from any CFD screen. Note that the softkey is visible only when there are active alarms to acknowledge.

2) In the event that there are multiple alarms, each alarm will need to be acknowledged separately.

Note: Acknowledging an alarm only stops the alarm text from flashing on the screen in the alarm bar.

3) Navigate to the Active Alarms screen to confirm what alarms remain active and require additional troubleshooting using the following procedure:

a) Press softkey F1 (Escape) until the CFD screen has returned to the Root Screen.
b) Press softkey F4 (Alarms) on the Root Screen to display the Active Alarms screen.

Disabling an Alarm

CAUTION

Never disable an alarm unless it is determined to be a false alarm. Failure to observe this caution could adversely affect engine operation, potentially resulting in engine damage.

Note: If the cause of an alarm has not been confirmed, the alarm displaying on the CFD screen will be automatically re-enabled when the LCS power is turned off and then on, or after 48 hours (whichever occurs first). The Engine Control System is configured to do this so that an alarm cannot be permanently disabled.

To disable an alarm, use the following procedure:

1) Ensure that the CFD is currently configured for operation in Level 2 (L2).

2) Press softkey F1 (Escape) until the CFD screen has returned to the Root Screen.

3) Press softkey F4 (Alarms) on the Root Screen to display the Active Alarms screen.

4) Navigate to the alarm that is to be displayed using softkey F2 (Page Up), softkey 2 (Page Down), softkey F3 (Up Arrow), and/or softkey (Down Arrow) on the Active Alarms screen.

5) Press softkey F7 (Enter Selected) on the Active Alarms screen to display the Individual Alarm screen.

6) Press softkey F2 (Disable) on the Individual Alarm screen to display the Individual Alarm Disable/Enable Alarm Screen.

7) Press softkey F7 (Yes) once on the Individual Alarm Disable/Enable Alarm Screen to confirm that the alarm is to be disabled.

8) On pressing the softkey F7 (Yes) once, a message will display in the operator message bar indicating 'Disable Alarm and Continue?' This softkey must be pressed a second time to confirm the action.

9) Press softkey F1 (Escape) to return to the Root Screen.

Re-abling an Alarm

To re-enable an alarm, use the following procedure:

1) Ensure that the CFD is currently configured for operation in Level 2 (L2).

2) Press softkey F1 (Escape) until the CFD screen has returned to the Root screen.

3) Press softkey F4 (Alarms) on the Root screen to display the Active Alarms screen.

4) Navigate to the alarm that is to be displayed using softkey F2 (Page Up), softkey 2 (Page Down), softkey F3 (Up Arrow), and/or softkey (Down Arrow) on the Active Alarms screen.

5) Press softkey F7 (Enter Selected) on the Active Alarms screen to display the Individual Alarm screen.

6) Press softkey F2 (Enable) on the Individual Alarm screen to display the Individual Alarm Disable/Enable Alarm Screen.

7) Press softkey F7 (Yes) once on the Individual Alarm Disable/Enable Alarm Screen to confirm that the alarm is to be enabled.

8) Upon pressing the softkey F7 (Yes) once, a message will display in the operator message bar indicating 'Disable Alarm and Continue?' This softkey must be pressed a second time to confirm the action.

9) Press softkey F1 (Escape) to return to the Root Screen.

2.2.3 DIESEL GENERATOR ENGINE OPERATION

Engine Operation

Each engine can be started and stopped from its own local control panel (LCP) or the ECR console. When set to local control, the engines cannot be started from the ECR.

The local control panels have illuminated START and STOP pushbuttons, which allow for local starting and stopping of the engines. In addition, there is a lamp test pushbutton, and illuminated indicators for 'false start', 'start interlock' and 'control from remote control'. Two pushbuttons are provided for adjusting the engine speed, these are marked LOWER and RAISE.

The panels also have various pressure gauges, turbocharger and engine rpm gauges. A digital temperature scanner that can display temperature readings from sensors located on the engine is also provided.

Preparing a Main Generator Engine for Starting

1) Blowdown the air start receivers to ensure that water will not enter the air starter.

2) Ensure that the engine oil level is 'FULL'.

3) Ensure that sufficient coolant water is present by verifying level in expansion tank sight glass.

4) Ensure that sufficient fuel for engine operation.

5) Prime the fuel system, if required.

6) Turn on any necessary vessel ventilation equipment.

7) Inspect the engine to ensure that no leaks or other signs of damage are present.

8) Ensure proper heating of engine cooling water, LO etc. Use HT Water and/or LO heater where applicable. It is recommended to manually shut off the heater once the engine has been started. The control system also contains a shutdown pre- heater as a backup.

9) Ensure that the engine has been pre-lubricated. If the engine has been pre-lubricated, the 'Prelube Complete or Bypassed' indication on the interlocks screen will be Green. The engine can only be started, if the pre-lubrication has been completed. To pre-lubricate the engine, press the 'Start Prelube' softkey on the Engine Control screen on the CFD.

It is recommended that the pre-lubrication pump is manually shut down once the engine has started. As a backup, the pre-lubrication pump will automatically shut down when the engine is running.

To prevent damage to the pre-lubrication pump and/or heater pump, the control system will not allow both to be running at the same time. Starting of the pre-lubrication pump will cause the pre-heat signal from the ECU to shut off, and vice versa.

In an emergency situation only, pre-lubrication can be bypassed to start the engine quickly.

CAUTION
Starting the engine without proper pre-lubrication may result in engine damage and should be avoided when possible. Continuously starting the engine with pre-lubrication bypassed will damage the engine. Ensure that the pre-lubrication system is only bypassed in an emergency situation.

10) Investigate and correct any Start Interlock conditions. This can be done from the Start Interlock screen under the monitors menu of the CFD. Ensure that the following conditions are correct:

a) The engine is currently stopped.

b) The Bar Over Switch and switch door are closed.

c) The main breaker is open, and no other interlocks are present.

d) No stops are requested from any of the engine emergency stops or the Stop/Run/Start switch on the LCS.

e) Pre-lubrication is complete or has been bypassed.

f) No active engine restrictions are present.

If the engine has been stopped for less than 8 hours (and there is no likelihood that water could have since gotten into the engine), blowdown can be bypassed and the following steps can be skipped.

11) Open the blowdown valves on all cylinders.

12) Enable blow down mode via the Engine Control screen from the CFD. When activated, the status indication onthe CFD screen will report 'Blowdown'.

13) Turn and hold the Start/Run/Stop switch on the LCS to the start position. This will crank the engine via the airstart motor, but no fuel will be introduced. Allow the engine to crank, allowing for several engine rotations so that the air coming from the opened blow down valves is free of significant water vapor before releasing theswitch from the start position. This should take approximately 5 to 10 seconds.

14) Close blowdown valves on all cylinders.

15) On the Engine Control screen on the CFD, return the blowdown switch to the OFF position.

16) Proceed to Start the engine.

Starting a Main Generator Engine

1) Ensure that all the pre-start steps have been completed before proceeding.

2) If starting at the LCS, turn and hold the Start/Run/Stop on the LCS in the Start position. This will crank the engine via the starter motor. Hold the switch in the start position until the engine fuel system can support the engine running. This should occur between 50 and 175 rpm.

> **Note:** There is an intentional delay of several seconds between turning the Start/Run/Stop Switch to the Starting position, and the engine cranking.

3) If starting from a remote location via Modbus, enable the Engine Start Modbus signal through the remote CFD. The Modbus signal will crank the engine via the starter motor until the fuel system can support an engine run.

4) If starting from a remote location via a digital hardwired signal, hold the switch or signal in the same fashion asthe Start/Run/Stop switch on the LCS.

> **Note:** The air starter will automatically disconnect at a pre-configured engine speed to avoid damage due to over-cranking.

5) Perform a visual inspection of the engine for any fluid, air, or exhaust leaks.

6) Perform a visual inspection of all operating temperatures and pressures to ensure that the coolant, and LO systems are performing as expected.

7) After the engine starts, there is a period of time in which the engine calibrates the EGR system, and the valves that regulate engine emissions. During this time, which takes approximately three minutes, the operator will hear different tones, and sounds from the engine, as not all cylinders fire, and various pressures within the system change. All of this activity is normal. This period of time is known as system calibration, and happens every time the engine is started.

During system calibration, a message will appear on the CFD screen that reads 'EGR System Calibration Active'. This message is intended for the engine operator to know when the engine is doing its system calibration, as well as when the test is over.

Engine speed will not change during the system calibration time, however, the control system will note engine speed change requests. After system calibration, the engine will respond to previously entered speed commands, possibly causing an unintended speed change. It is NOT recommended trying to adjust engine speed until after system calibration is over.

Running a Main Generator Engine

After an engine start, allow sufficient time for the engine to come to steady state conditions prior to loading or increasing speed to rated. Ensure periodic checks are made of the engine, and operating parameters to ensure there are no leaks or other abnormal operating conditions. If running the engine at the following conditions for extended periods of time:

- At rated speed (i.e. 900 or 1,000 rpm), and low HP (20% and less).
- Idling (350 to 440 rpm) with no load (0% to 5% HP) with de-clutched main engines or disconnected generator.

It is recommended that:

- The engine is run a maximum of 8 hours of continuous operation
- The engine is loaded every 8 operating hours to a minimum of 70% of the rated output for 30 minutes.

Controlling a Running Constant Speed Engine

Constant speed engines can be controlled from either a local station or a remote station. The methods of speed control from both are as below:

Control from LCS

a) Ensure that the CFD Screen is configured for operation in local mode.
   - If the CFD screen is configured for operation in local mode, continue to the next step.
   - If the CFD screen is not configured for operation in local mode, place the Local/Remote switch to the Local position.

b) Use the Increase/Decrease Switch to bring engine speed up to Rated or down to Idle as required. When the engine speed is close to the Rated or Idle setting, it will recognize the Rated or Idle setpoint and maintain that speed.

Control from Remote Station

a) Ensure that the CFD screen is configured for operation in remote mode.
   - If the CFD screen is configured for operation in remote mode, continue to the next step.

b) If the system is configured to use Ethernet controls, Idle/Rated can be controlled via Modbus. The way this is accomplished depends upon system configuration.

c) If the system uses hardwired digital signals, Idle/Rated is controlled through digital input.

d) The remote station should use a ±3VDC bias signal to fine-tune engine speed. The rate of bias speed adjustment is configurable in the system.

Stopping a Main Generator Engine

To stop the engine under non-emergency situations, turn the Start/Run/Stop switch on the LCS to the Stop position. Alternatively, engine stop can be carried out from remote locations via Modbus or digital hardwired signal, depending upon system configuration. This will slowly reduce the engine's reference speed until the engine comes to a stop.

Override

Some applications will allow for the use of override of engine protective actions. If General Override is utilized in an application, then protective actions for Speed Restriction, Engine Load Limited, and Shutdown can be individually configured for Override. When Override is enabled, and a protective event with Override configured occurs, the operator has a set time to engage the override to prevent the protective action. If the override is not engaged within the time frame, the action occurs. When the override is released, the protective action will occur if the condition still exists. Override should be controlled by a maintain-style push button or switch where the operator has access to it under normal operating conditions.

The Oil Mist Detector shutdown event may also be configured for Shutdown Override. Note that a second separate button must be utilized for this override. When an Override is available, indication will be made on the Gauge Panel area of the CFD.

Exhaust Gas Recirculation

Diesel Engine Emissions Control System

The Exhaust Gas Recirculation system (EGR) works by returning a small portion of exhaust gas to the engine's combustion chambers through the intake manifold, lowering combustion temperatures, and therefore reducing the amount of nitrogen oxides (NOx) emitted. This process leads to a significant reduction in NOx emissions because it reduces the two elements underlying its production, excess oxygen, and combustion temperature. The EGR valve is the main component of the EGR system, and is normally closed.

The EGR system in engage on arrival into an Emissions Control Area (ECA), and disengaged on leaving an ECA.

Main Components of The EGR System

EGR Cooler

The EGR cooler removes excess heat from exhaust gas before it is recirculated into the combustion air. The cooling water for the EGR cooler is supplied by the HT cooling circuit. Sulphuric acid condensate is produced in the EGR cooler, and is drained away to a receiving tank. Additionally, the HT vent connection for air removal is also connected to the EGR cooler. Vent piping runs from the HT side of the EGR cooler to the HT expansion tank.

NOx Sensor

The NOx sensor is a CAN based digital sensor that senses the NOx concentration of the MGE exhaust gas. This sensor is located on the right side LP turbocharger exhaust outlet

2.2.4 EMERGENCY DIESEL GENERATOR

Engine

Manufacturer:	Cummins
Type:	4-stroke, 12 cylinder, 60˚ vee turbocharged, after-cooled
Model:	QSK38 DM1
No. of sets:	1
Displacement:	37.7 liters
Bore/stroke:	159mm(6.25ins) x 159mm(6.25ins)
Maximum output:	947kW
Primary starting:	Battery
Secondary starting:	Hydraulic
Engine controller:	Auto Maksin C Command Elite Plus
Compression ratio:	15.0:1
Speed:	1,800 rpm
Overspeed:	2,250 rpm

Engine Control Panel

Manufacturer	AutoMaksin
Model	C-Command Elite Plus

Alternator

Manufacturer:	Leroy Somer
Type:	Horizontal brushless, self-excited, air cooled
No. of sets:	1
Model:	LSAM 50.2 L7 J6S/4
Speed:	1,800 rpm
Space heater:	120V, 500W
Rating:	450V, 900kW, 1,120kVA, 1,443.4A, 0.8PF, IP23

Introduction

The emergency generator is located in the emergency generator room in the engine casing 2nd level, starboard side in FZ4 between frames 50 and 64. The emergency generator is normally kept in AUTOMATIC mode, this allows automatic starting in the event of a blackout.

Engine Control Panel (ECP)

The ECP is an Auto Maksin C Command Elite Plus, this consists of a Customer Interface Box (CIB) which is mounted on the generator set skid. There is a power ON/OFF switch, and an EMEGENCY STOP switch mounted on the front panel of the CIB. Mounted in the upper part of the front panel is a DCU 410E Engine Control Unit (ECU). The ECU provides all the functions of operating the emergency generator.

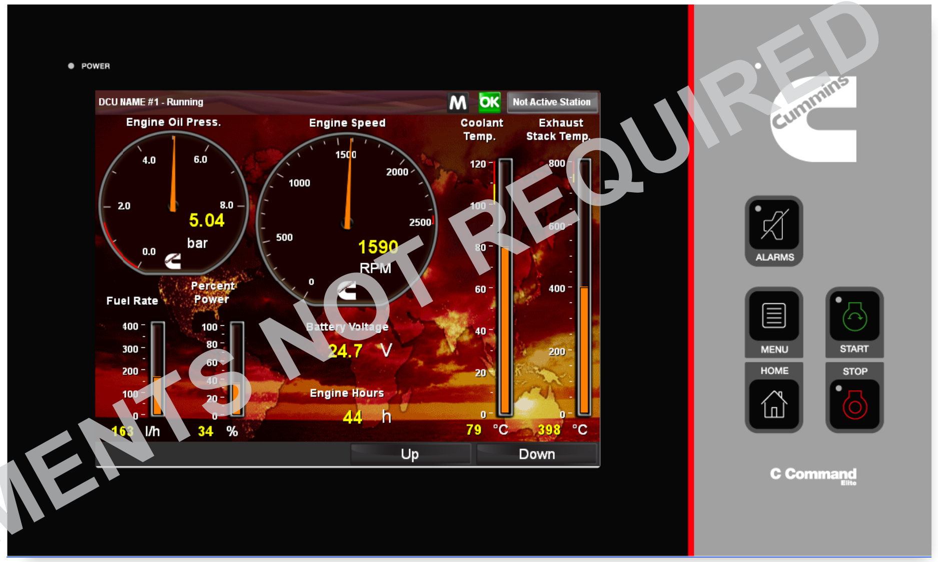
The C-Command Elite Plus control panel consists of the following units:

- DCU 410E, engine control unit (ECU).
- SDU-410, Safety unit (shut down unit SDU).
- RIO-410, Remote input/output unit (RIO).

The DCU 410E has a color touch screen, this is divided up into three sections

At the top is a status bar, this indicated the present status of the generator and any alarms that are extant. The central part is the main screen area. At the bottom of the screen is soft button bar, the soft buttons will have different function depending upon which display has been selected, for example, the MODE soft button will bring up a mode selection screen and the mode of operation can be chosen from there. The generator engine START and STOP switches can be either latched or unlatched, when latched all that is needed is a single push of the soft switch to start or stop the engine, in the unlatched position the START and STOP switches have to be held down until the engine either starts or stops (it is usual to have the Start and Stop switches unlatched).

CIB Integrated Control Panel (DCU).



Elite Remote Panel (ERP).

Digital Gauge Panel (GP)

A digital gauge panel displays engine data. The gauges are installed in a panel mountable frame.

The Gauge Panel consists of the following gauges:

- Tachometer (with Mini display).
- Engine LO pressure.
- Engine coolant temperature.
- System voltage.
- Exhaust stack temperature - right.
- Exhaust stack temperature – left.
- Gear oil pressure.

The mini-display contained in the tachometer allows to view the available engine parameter data in text format. This list of parameters goes beyond the values represented by the gauges. Also, in the event of a fault condition, the mini-display will indicate that active alarms are present, and a buzzer will sound. Each of the active faults will then be available with full text description including the appropriate Cummins Fault Code number.

The individual gauges in this panel indicate a Red alarm fault condition with a Red indicator lamp within the gauge face. This lamp will be in addition to the alarm buzzer, and text description of the fault in the tachometer's mini-display.

Control Panel (CP)

The Control Panel is fitted to allow for remote engine control functions. This panel is designed to be flush mounted into a helm console.

The CP includes the same features as the ERP control panel for the main system with regard to Start, Stop, Alarm Acknowledge, and Alarm Indication. The differences are with the Power and Local Start. These features are described below.

Local Start Only Lamp

This yellow lamp illuminates when the 'Local Start Only' function is activated in the ERP. When the lamp is illuminated, the Start button will not function. The Stop button will function normally when Local Start Only is active.

Power Lamp

This green lamp is illuminated when the CP has power. The power to the CP is controlled by the Power switch on the CIB.

Note: If this lamp is not illuminated, the panel will not function.

Digital Display (ED-3)

The ED-3 gray scale Digital Display can be used at any remote station that requires engine data to be displayed. It is able to display engine data in both text and graphical formats. In addition, the display is capable of showing the active and historical fault codes present during operation.

Prepare the Emergency Diesel Engine for Automatic Starting

The normal method of starting is by electric battery starting. Three attempts are made, and if this fails it will attempt to start with the hydraulic starter.

a) Ensure that the control panel power source switch is turned to the ON position.

b) Check that the engine operating mode is AUTO; it should normally be in the AUTO position unless testing.

c) Check the level of LO in the engine sump using the dipstick and top-up as necessary with the correct grade of oil.

- Only check the LO level after the engine has been switched off for a minimum of 10 minutes to ensure that the LO has settled after the operating period.

d) Check the level of coolant in the radiator and top-up as necessary with a 50/50 antifreeze/clean distilled water mixture.

CAUTION

Opening the radiator expansion tank pressure cap too quickly when the coolant is hot can cause hot fluid or steam to be ejected with the risk of scalding to exposed skin and eyes.

e) Check the level of MGO in the emergency generator MGO storage tank and top-up as required.

f) If the coolant heater is not switched on, switch it on and allow the engine to warm-up.

- The coolant heater is normally left switched on when the engine is stopped and will cut-in and cut-out to maintain the coolant temperature.

g) Open the fuel oil supply quick-closing valve from the MGO storage tank to the diesel engine.

- It is normally left in the open position when the engine is stopped, which allows the engine to start immediately when required.

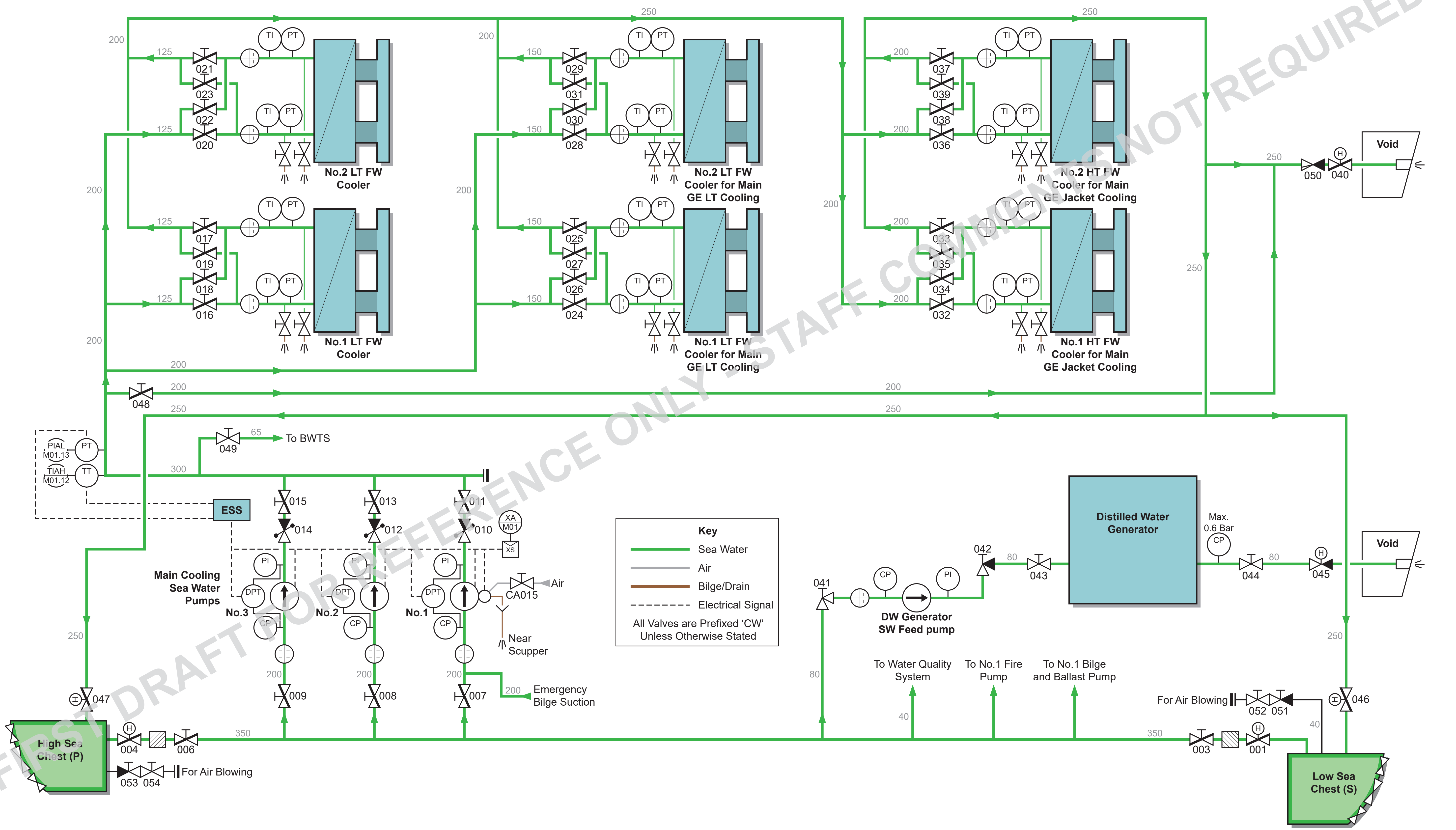
The emergency diesel generator is now ready for operation and it will start automatically and supply power when the emergency bus no-voltage is detected. In the event of loss of power from the main electrical supply, after the emergency generator has established a voltage, the emergency Air Circuit-Breaker (ACB) automatically closes to supply power to all consumers connected to the emergency switchboard.

Alarms and Trips

Item	Setting	Delay (seconds)
Low LO pressure alarm	3.1 bar (45 psi)	10s
Low LO pressure trip	1.38 bar (20 psi)	10s
High cooling fresh water temperature alarm	102°C +/- 2°C (215°F +/- 4°F)	-
High LO temperature alarm	121°C +/- 2°C (250°F +/- 4°F)	-
Pick-up sensor failure alarm	-	-
Battery low voltage alarm	22.5V	30s
Battery charger and PSU failure alarm	-	60s
Fuel oil leakage alarm	-	-
Cooling fresh water low pressure alarm	0.74 bar (11 psi)	10s
Battery source failure alarm	-	25s
ECM fault alarm	-	60s
Engine overspeed trip	2,050 rpm	-

2.3 Sea Water Systems

Illustration 2.3.1a Sea Water Cooling System



Reference Drawing: DA700M103R1 - NSMV-524-B701-R1

2.3 SEA WATER SYSTEMS

2.3.1 ENGINE ROOMS 1+2 SEA WATER COOLING SYSTEM

Main Sea Water Cooling Pumps No.1, 2. 3, 4, 5, 6

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FEV-200D (No.1 with self priming)
No. of sets:	6 ((2 working, 1 on standby per engine room)
Capacity:	220m^3/h (7,769ft^3/h) at 2.7 bar (39psi)
Motor:	440V, 30kW(40hp), 1,765 rpm

LT Fresh Water Coolers No.No.1, 2, 3, 4

Manufacturer:	LHE
Type:	Plate (Titanium, 0.5mm)
Model:	HT102ML-1P-67
No. of sets:	4 (2 in each engine room)
Heat transfer area:	16.9m^2
Operating temperature:	32°C (90°F) to 36°C (97°F) sea water side
	40°C (104°F) to 36°C (97°F) fresh water side
Capacity:	Fresh water flow 90m^3/h
	Sea water flow 100m^3/h

HT Fresh Water Coolers for GE Jacket Cooling No.1, 2

Manufacturer:	LHE
Type:	Plate (Titanium, 0.5mm)
Model:	LT150ML-1P-39
No. of sets:	4 (2 in each engine room)
Heat transfer area:	20m^2
Operating temperature:	41°C (34°F) to 51.5°C (125°F) sea water side
	92°C (198°F) to 70°C (158°F) fresh water side
Capacity:	Fresh water flow 102m^3/h
	Sea water flow 220m^3/h

LT Fresh Water Coolers for GE LT Cooling No.1, 2, 3, 4

Manufacturer:	LHE
Type:	Plate (Titanium, 0.5mm)
Model:	SH102ML-1P-105
No. of sets:	4 (2 in each engine room)
Heat transfer area:	58.7m^2
Operating temperature:	32°C (90°F) to 48.5°C (119°F) sea water side
	57°C (135°F) to 38°C (100°F) fresh water side
Capacity:	Fresh water flow 102m^3/h
	Sea water flow 120m^3/h

Distilled Water Generator Sea Water Feed Pump

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FGV-65D
No. of sets:	1
Capacity:	18m^3/h (635ft^3/h) at 4.5 bar (65psi)
Motor:	440V, 7.5kW(10hp), 3,500 rpm

Introduction

The sea water cooling system is divided into the following sections:

- Engine Room 1.
- Engine Room 2.
- Auxiliary Machinery Rooms 1 and 2 + Bow Thruster Room.
- Auxiliary Machinery Rooms 3 and 4.
- Motor Room 2.

This part of the section describes Engine Room 1 sea water system.

The low suction sea chest is located on the starboard side of engine room 1, with the high suction sea chest located on the port side. Sea water enters the crossover main via large high capacity strainers. Engine room 1 crossover main supplies main sea water cooling pumps No.1, 2 and 3. The high suction is used to prevent any debris eg, sand, silt etc, found in shallow waters from entering the system. Both sea chests include drain and vent holes, and are fitted with connections to supply working air for sea chest weed cleaning, and a recirculation valve from the HT and LT fresh water sea water cooling overboard line for de-icing.

Engine room 1 crossover main arrangement allows all three of the sea water cooling pumps to be supplied from either side of the vessel via the high or low sea chests and strainers. The three pumps have the same rating and discharge capacity. No.1 sea water cooling pump is fitted with suction air ejector priming unit that allows the pump to be used as an emergency bilge pump to clear water from the engine room in the event of flooding.

The cooling sea water pumps are rated at 100% of total capacity (two working, one on standby), therefore in normal operations the main cooling sea water pumps can either be started and stopped locally, or selected for remote operation. When selected for remote operation, one or two cooling sea water pumps would be selected as the duty pump(s) and the other pump selected for automatic operation in standby mode; the standby pump would start if the duty pump(s) could not maintain the required pressure. A pressure switch located on the discharge manifold provides the start signal for the standby pumps. The number of cooling sea water pumps required to operate depends upon the cooling load and the sea water temperature. When the sea water temperature is 25°C (77°F) or above, two sea water pumps should be used.

CAUTION

The use of No.1+4 main cooling sea water pumps for bilge pumping is an emergency procedure and should only be undertaken in circumstances when the stability and safety of the vessel are in danger.

The sea water system is protected by an anti-fouling Marine Growth Prevention System (MGPS) which uses an electrolytic system with copper and aluminium electrodes fed with an impressed current. The high amd low sea suction strainers have their own MGPS with the electrodes being built into the strainer lids.

The two main LT fresh water coolers each have a capacity of 100%, and normally one is in operation. Each cooler is fitted with an internal filter which is used to trap debris from flowing into the passageways, the filter cage is accessed by a plate built onto the strong back. The coolers are also provided with backflushing valves which can be operated as required to remove debris from the heat exchanger surfaces, in doing so they help to maintain the cooler's efficiency. The backflushing interval is determined by an increase in the pressure drop across the cooler as recorded in the engine room log, this will indicate fouling, and cleaning of the cooler will be necessary.

Procedure for Setting No.1 Main Sea Water Suction Crossover

a) Ensure that both suction strainers are clear.

b) Ensure all the pressure gauge and instrumentation valves are open and that the instrumentation is reading correctly.

c) Set up the valves as shown in the table below to the open position. In this case the port high suction is to be used:

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Closed	Low (starboard) sea chest suction valve	001
Closed	Low (starboard) sea strainer outlet valve	003
Closed	Low (starboard) sea chest de-icing valve	046
Open	High (port) sea chest suction valve	004
Open	High (port) sea strainer outlet valve	006
As required	High (port) sea chest de-icing valve	047

d) Set up the valves as shown in the table below to the open position. In this case the starboard low suction is to be used:

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	Low (starboard) sea chest suction valve	001
Open	Low (starboard) sea strainer outlet valve	003
As required	Low (starboard) sea chest de-icing valve	046
Closed	High (port) sea chest suction valve	004
Closed	High (port) sea strainer outlet valve	006
Closed	High (port) sea chest de-icing valve	047

e) The main sea water crossover is now ready for operation.

Note: All sea chest and strainer vent valves are to be opened to vent any air from these units before placing them into service.

Note: All sea suction strainers must be checked and cleaned at frequent intervals.

Operation of Engine Room 1 Cooling Sea Water System

a) Ensure that engine room 1 sea water crossover main is operational as described above, and confirm the MGPS is operating on the correct sea chest.

b) Ensure all the pressure gauge and instrumentation valves are open and that the instrumentation is reading correctly.

c) Set the valves as in the following table to the open position. In this example, both central coolers are in service and all main cooling sea water pumps are operational:

Main Cooling Sea Water Pumps No.1+2+3

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	No.1 main cooling sea water pump suction valve	007
Open	No.1 main cooling sea water pump discharge valve	011
Closed	Emergency bilge suction valve	BG199
Open	No.2 main cooling sea water pump suction valve	008
Open	No.2 main cooling sea water pump discharge valve	013
Open	No.3 main cooling sea water pump suction valve	009
Open	No.3 main cooling sea water pump discharge valve	015
As required	Sea water pumps direct discharge valve to overboard	048
As required	Sea water pumps discharge valve to BWTS	049

LT FW Coolers No.1+2

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	No.1 LT FW cooler sea water inlet valve	016
Open	No.1 LT FW cooler sea water outlet valve	017
Closed	No.1 LT FW cooler sea water back flushing inlet valve	018
Closed	No.1 LT FW cooler sea water back flushing outlet valve	019
Closed	No.2 LT FW cooler sea water inlet valve	020
Closed	No.2 LT FW cooler sea water outlet valve	021
Closed	No.2 LT FW cooler sea water back flushing inlet valve	022
Closed	No.2 LT FW cooler sea water back flushing outlet valve	023

LT FW Coolers No.1+2 for Main Generator Engine (MGE) LT Cooling

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	No.1 MGE LT FW cooler sea water inlet valve	024
Open	No.1 MGE LT FW cooler sea water outlet valve	025
Closed	No.1 MGE LT FW cooler sea water back flushing inlet valve	026
Closed	No.1 MGE LT FW cooler sea water back flushing outlet valve	027
Open	No.2 MGE LT FW cooler sea water inlet valve	028
Open	No.2 MGE LT FW cooler sea water outlet valve	029
Closed	No.2 MGE LT FW cooler sea water back flushing inlet valve	030
Closed	No.2 MGE LT FW cooler sea water back flushing outlet valve	031

HT FW Coolers No.1+2 for Main Generator Engine (MGE) Jacket Cooling

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	No.1 MGE HT FW cooler sea water inlet valve	032
Open	No.1 MGE HT FW cooler sea water outlet valve	033
Closed	No.1 MGE HT FW cooler sea water back flushing inlet valve	034
Closed	No.1 MGE HT FW cooler sea water back flushing outlet valve	035
Open	No.2 MGE HT FW cooler sea water inlet valve	036
Open	No.2 MGE HT FW cooler sea water outlet valve	037
Closed	No.2 MGE HT FW cooler sea water back flushing inlet valve	038
Closed	No.2 MGE HT FW cooler sea water back flushing outlet valve	039
Open	Sea water cooling overboard valve	040

d) Select the duty and the standby pumps, set the switches on the group starter panels on the main switchboard for these pumps to the REMOTE position. At the control panel, start the first duty pump.

e) Ensure that the selected operational pump delivers sea water at the correct pressure to the outlet manifold; if the system operation is satisfactory, start a second duty pump as required according to the cooling load and sea water temperature. Set the standby pump at the control panel. This standby pump will cut-in on low manifold pressure.

f) Operate the sea water systems as required. The above illustration shows No.1 and No.2 MGEs are running with both LT and HT coolers in use, and one LT FW cooler in use.

Distilled Water Generator (DWG) Sea Water Feed Pump System

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	DWG sea water feed pump suction valve	041
Open	DWG sea water feed pump discharge valve	042
Open	DWG sea water feed inlet valve	043
Open	DWG sea water feed outlet valve	044
Open	DWG sea water overboard valve	045

Procedure for Setting No.2 Main Sea Water Suction Crossover

This part of the section describes Engine Room 2 sea water system.

a) Ensure that both suction strainers are clear.

b) Ensure all the pressure gauge and instrumentation valves are open and that the instrumentation is reading correctly.

c) Set up the valves as shown in the table below to the open position. In this case the port high suction is to be used:

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Closed	Low (starboard) sea chest suction valve	201
Closed	Low (starboard) sea strainer outlet valve	203
Closed	Low (starboard) sea chest de-icing valve	246
Open	High (port) sea chest suction valve	204
Open	High (port) sea strainer outlet valve	206
As required	High (port) sea chest de-icing valve	247

d) Set up the valves as shown in the table below to the open position. In this case the starboard low suction is to be used:

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	Low (starboard) sea chest suction valve	201
Open	Low (starboard) sea strainer outlet valve	203
As required	Low (starboard) sea chest de-icing valve	246
Closed	High (port) sea chest suction valve	204
Closed	High (port) sea strainer outlet valve	206
Closed	High (port) sea chest de-icing valve	247

e) The main sea water crossover is now ready for operation.

Operation of Engine Room 2 Cooling Sea Water System

a) Ensure that engine room 2 sea water crossover main is operational as described above, and confirm the MGPS is operating on the correct sea chest.

b) Ensure all the pressure gauge and instrumentation valves are open and that the instrumentation is reading correctly.

c) Set the valves as in the following table to the open position. In this example, both central coolers are in service and all main cooling sea water pumps are operational:

Main Cooling Sea Water Pumps No.4+5+6

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	No.4 main cooling sea water pump suction valve	207
Open	No.4 main cooling sea water pump discharge valve	211
Closed	Emergency bilge suction valve	BG399
Open	No.5 main cooling sea water pump suction valve	208
Open	No.5 main cooling sea water pump discharge valve	213
Open	No.6 main cooling sea water pump suction valve	209
Open	No.6 main cooling sea water pump discharge valve	215
As required	Sea water pumps direct discharge valve to overboard	248
As required	Sea water pumps discharge valve to BWTS	249

LT FW Coolers No.3+4

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	No.1 LT FW cooler sea water inlet valve	216
Open	No.1 LT FW cooler sea water outlet valve	217
Closed	No.1 LT FW cooler sea water back flushing inlet valve	218
Closed	No.1 LT FW cooler sea water back flushing outlet valve	219
Closed	No.2 LT FW cooler sea water inlet valve	220
Closed	No.2 LT FW cooler sea water outlet valve	221
Closed	No.2 LT FW cooler sea water back flushing inlet valve	222
Closed	No.2 LT FW cooler sea water back flushing outlet valve	223

LT FW Coolers No.3+4 for Main Generator Engine (MGE) LT Cooling

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	No.1 MGE LT FW cooler sea water inlet valve	224
Open	No.1 MGE LT FW cooler sea water outlet valve	225
Closed	No.1 MGE LT FW cooler sea water back flushing inlet valve	226
Closed	No.1 MGE LT FW cooler sea water back flushing outlet valve	227
Open	No.2 MGE LT FW cooler sea water inlet valve	228
Open	No.2 MGE LT FW cooler sea water outlet valve	229
Closed	No.2 MGE LT FW cooler sea water back flushing inlet valve	230
Closed	No.2 MGE LT FW cooler sea water back flushing outlet valve	231

HT FW Coolers No.3+4 for Main Generator Engine (MGE) Jacket Cooling

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	No.1 MGE HT FW cooler sea water inlet valve	232
Open	No.1 MGE HT FW cooler sea water outlet valve	233
Closed	No.1 MGE HT FW cooler sea water back flushing inlet valve	234
Closed	No.1 MGE HT FW cooler sea water back flushing outlet valve	235
Open	No.2 MGE HT FW cooler sea water inlet valve	236
Open	No.2 MGE HT FW cooler sea water outlet valve	237
Closed	No.2 MGE HT FW cooler sea water back flushing inlet valve	238
Closed	No.2 MGE HT FW cooler sea water back flushing outlet valve	239
Open	Sea water cooling overboard valve	240

d) Select the duty and the standby pumps, set the switches on the group starter panels on the main switchboard for these pumps to the REMOTE position. At the control panel, start the first duty pump.

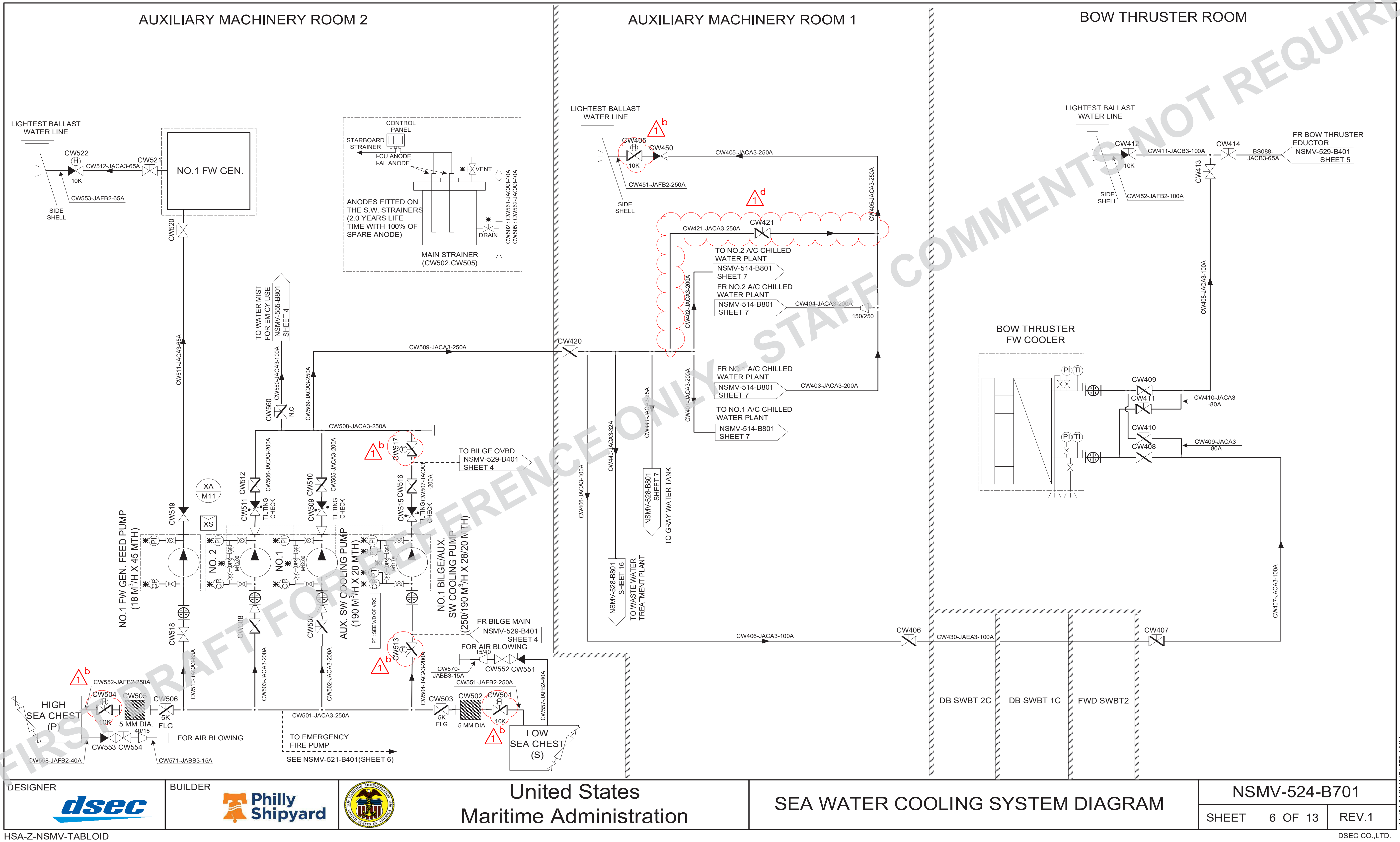
e) Ensure that the selected operational pump delivers sea water at the correct pressure to the outlet manifold; if the system operation is satisfactory, start a second duty pump as required according to the cooling load and sea water temperature. Set the standby pump at the control panel. This standby pump will cut-in on low manifold pressure.

f) Operate the sea water systems as required. The above illustration shows No.1 and No.2 MGEs are running with both LT and HT coolers in use, and one LT FW cooler in use.

Backflushing the Central Fresh Water Cooler

Each FW cooler is designed to take 100% of the cooling load at maximum capacity from the plant, with a margin for overload and fouling. Heavy fouling is identified by a large pressure drop across the cooler sea water system. Backflushing of a cooler should be undertaken before the fouling produces a significant deterioration in cooler performance. The cooler is still operational during backflushing, as sea water is flowing through the cooler. A basket filter is fitted at the inlet to each cooler and this should be manually cleaned when the opportunity presents itself in order to ensure that the cooler remains in good operating condition. In order to clean the filter basket it is necessary to isolate the cooler and drain the sea water side of the cooler into the bilges.

Illustration 2.3.2a Auxiliary Machinery Rooms 1+ 2 + Bow Thruster Room Sea Water Systems *(Authors note: Illustration currently in progress)*



2.3.2 AUXILIARY MACHINERY ROOMS 1+2 AND BOW THRUSTER ROOM SEA WATER COOLING SYSTEM

Auxiliary Sea Water Cooling Pumps No.1, 2

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FEV-150D
No. of sets:	2
Capacity:	190m^3/h (6,710ft^3/h) at 2.0 bar (29psi)
Motor:	440V, 18.5kW(25hp), 1,750 rpm

Bilge/Auxiliary Sea Water Cooling Pump No.1

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FEV-200D
No. of sets:	1
Capacity:	250/190m^3/h (8,829/6,710ft^3/h) at 2.8/2.0 bar (41/29psi)
Motor:	440V, 33kW(44hp), 1,750 rpm

Bow Thruster Fresh Water Coolers

Manufacturer:	LHE
Type:	Plate (Titanium, 0.5mm)
Model:	HT102M-1P-23
No. of sets:	1
Heat transfer area:	5.5m^2
Operating temperature:	32°C (90°F) to 36°C (97°F) sea water side 39°C (102°F) to 36°C (97°F) fresh water side
Capacity:	Fresh water flow 35m^3/h Sea water flow 35m^3/h

Fresh Water Generator Sea Water Feed Pump No.1

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FGV-65D
No. of sets:	1
Capacity:	18m^3/h (283ft^3/h) x 4.5 bar (65psi)
Motor:	440V, 7.5kW(10hp), 3,500 rpm

Introduction

The sea water cooling system is divided into the following sections:

- Engine Room 1.
- Engine Room 2.
- Auxiliary Machinery Rooms 1 and 2 + Bow Thruster Room.
- Auxiliary Machinery Rooms 3 and 4.
- Motor Room 2.

This part of the section describes auxiliary machinery rooms 1 and 2 + bow thruster room sea water system.

The low suction sea chest is located on the starboard side of auxiliary machinery room 2, with the high suction sea chest located on the port side. Sea water enters the crossover main via large high capacity strainers. Auxiliary machinery room 2 crossover main supplies auxiliary sea water cooling pumps No.1+2, No.1 bilge/auxiliary sea water cooling pumps No.1, and No.1 Freshwater Generator (FWG) feed pump. The high suction is used to prevent any debris eg, sand, silt etc, found in shallow waters from entering the system. Both sea chests include drain and vent holes, and are fitted with connections to supply working air for sea chest weed cleaning.

Auxiliary machinery room 2 crossover main arrangement allows all three of the auxiliary sea water cooling pumps, and No.1 FWG feed pump to be supplied from either side of the vessel via the high or low sea chests and strainers. No.1+2 auxiliary sea water cooling pumps have the same rating and discharge capacity. No.1 bilge/auxiliary sea water cooling pump has an additional capacity rating when used as a bilge pump. This pump has a connection to the bilge system.

The auxiliary cooling sea water pumps are rated at 100% of total capacity (two working, one on standby), therefore in normal operations the auxiliary cooling sea water pumps can either be started and stopped locally, or selected for remote operation. When selected for remote operation, one or two cooling sea water pumps would be selected as the duty pump(s) and the other pump selected for automatic operation in standby mode; the standby pump would start if the duty pump(s) could not maintain the required pressure. A pressure switch located on the discharge manifold provides the start signal for the standby pumps. The number of cooling sea water pumps required to operate depends upon the cooling load and the sea water temperature. When the sea water temperature is 25°C (77°F) or above, two sea water pumps should be used.

CAUTION

The use of No.1 bilge/auxiliary cooling sea water pump for bilge pumping is an emergency procedure and should only be undertaken in circumstances when the stability and safety of the vessel are in danger.

The sea water system is protected by an anti-fouling MGPS which uses an electrolytic system with copper and aluminium electrodes fed with an impressed current. The high amd low sea suction strainers have their own MGPS with the electrodes being built into the strainer lids.

The bow thruster fresh water cooler has a capacity of 100%. The cooler is fitted with an internal filter which is used to trap debris from flowing into the passageways, the filter cage is accessed by a plate built onto the strong back. The cooler is provided with backflushing valves which can be operated as required to remove debris from the heat exchanger surfaces, in doing so they help to maintain the cooler's efficiency. The backflushing interval is determined by an increase in the pressure drop across the cooler as recorded in the engine room log, this will indicate fouling, and cleaning of the cooler will be necessary.

Procedure for Setting No.2 Auxiliary Machinery Room Sea Water Suction Crossover

a) Ensure that both suction strainers are clear.

b) Ensure all the pressure gauge and instrumentation valves are open and that the instrumentation is reading correctly.

c) Set up the valves as shown in the table below to the open position. In this case the port high suction is to be used:

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Closed	Low (starboard) sea chest suction valve	501
Closed	Low (starboard) sea strainer outlet valve	503
Open	High (port) sea chest suction valve	504
Open	High (port) sea strainer outlet valve	506

d) Set up the valves as shown in the table below to the open position. In this case the starboard low suction is to be used:

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	Low (starboard) sea chest suction valve	501
Open	Low (starboard) sea strainer outlet valve	503
Closed	High (port) sea chest suction valve	504
Closed	High (port) sea strainer outlet valve	506

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No.1 Fresh Water Generator (FWG) Sea Water Feed Pump System

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	No.1 FWG sea water feed pump suction valve	518
Open	No.1 FWG sea water feed pump discharge valve	519
Open	No.1 FWG sea water feed inlet valve	520
Open	No.1 FWG sea water feed outlet valve	521
Open	No.1 FWG sea water overboard valve	522

e) Auxiliary machinery room 2 sea water crossover is now ready for operation.

Operation of Auxiliary Machinery Room 2 Cooling Sea Water System

a) Ensure that auxiliary machinery room 2 sea water crossover main is operational as described above, and confirm the MGPS is operating on the correct sea chest.

b) Ensure all the pressure gauge and instrumentation valves are open and that the instrumentation is reading correctly.

c) Set the valves as in the following table to the open position. In this example, both central coolers are in service and all main cooling sea water pumps are operational:

Auxiliary Cooling Sea Water Pumps No.1+2 + Bilge/Auxiliary Cooling Sea Water Pumps No.1

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
As required	No.1 bilge/aux. cooling sea water pump suction valve	513
As required	No.1 bilge/aux. cooling sea water pump discharge valve	516
As required	No.1 bilge/aux. cooling sea water pump bilge system suction valves	BS005 BS006 BS008
As required	No.1 bilge/aux. cooling sea water pump bilge system overboard valve	BS011
Open	No.1 aux. cooling sea water pump suction valve	507
Open	No.1 aux.cooling sea water pump discharge valve	519
Open	No.2 aux. cooling sea water pump suction valve	508
Open	No.2 aux.cooling sea water pump discharge valve	512

Position	Description	Valve
Closed(NC)	Aux.cooling sea water pumps discharge valve to water mist	560
Open	Aux.cooling sea water pumps discharge valve overboard	405
Open	Aux.cooling sea water pumps discharge valve to bow thruster FW cooler	406
Open	Aux.cooling sea water pumps discharge valve to auxiliary machinery room 1 consumers	420
Closed	Aux.cooling sea water pumps discharge A/C cooling systems bypass valve	421

Bow Thruster FW Cooler

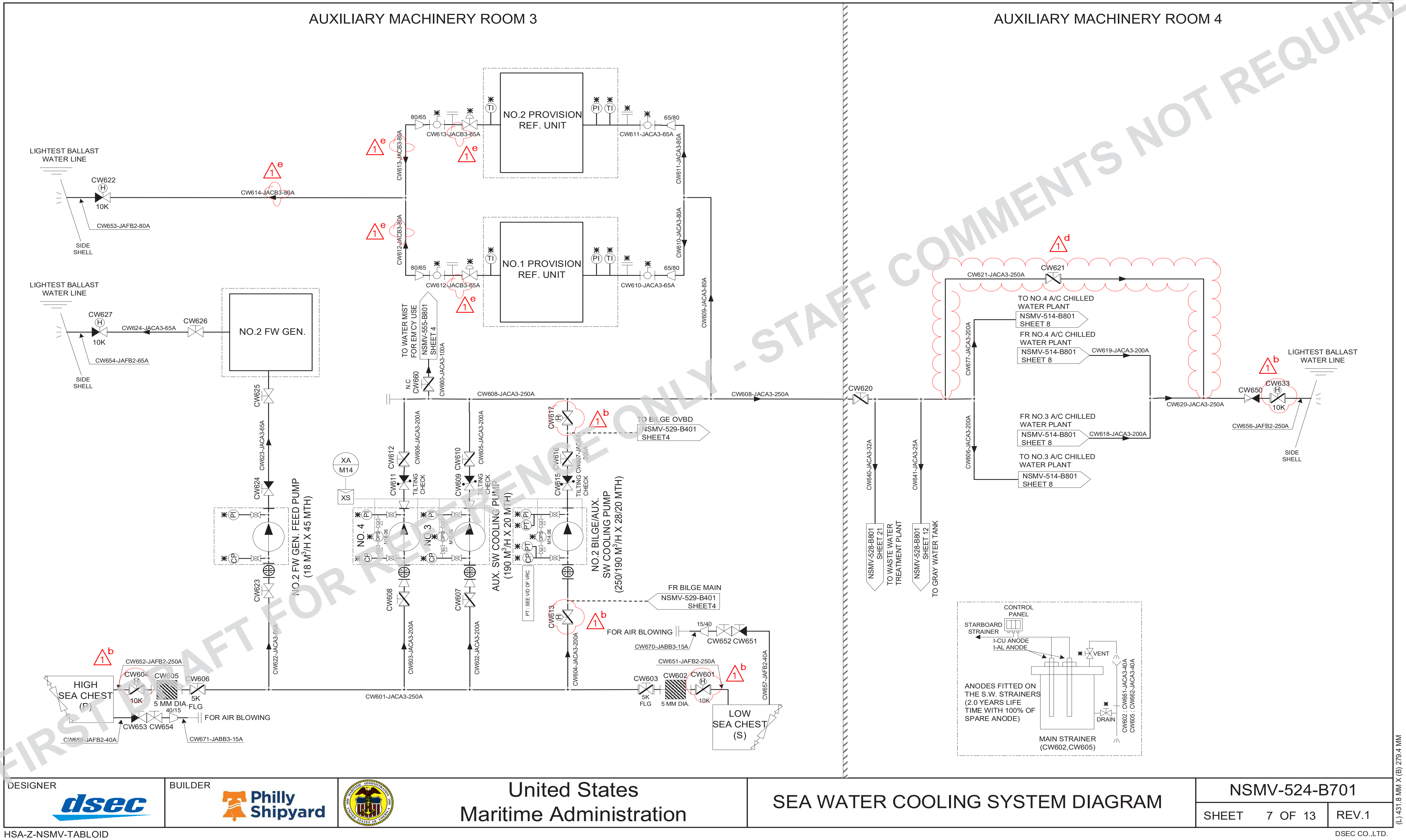
All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	Sea water inlet valve to bow thruster FW cooler	407
Open	Bow thruster FW cooler sea water inlet valve	408
Open	Bow thruster FW cooler sea water outlet valve	409
Closed	Bow thruster FW cooler sea water back flushing inlet valve	410
Closed	Bow thruster FW cooler sea water back flushing outlet valve	411
Open	Bow thruster FW cooler sea water overboard valve	412
Open	Bow thruster FW cooler sea water overboard line isolation valve	413
As required	Bow thruster room bilge eductor valve to overboard	414

d) Select the duty and the standby pumps, set the switches on the group starter panels on the main switchboard for these pumps to the REMOTE position. At the control panel, start the first duty pump.

e) Ensure that the selected operational pump delivers sea water at the correct pressure to the outlet manifold; if the system operation is satisfactory, start a second duty pump as required according to the cooling load and sea water temperature. Set the standby pump at the control panel. This standby pump will cut-in on low manifold pressure.

Illustration 2.3.3a Auxiliary Machinery Rooms 3+4 Sea Water Systems *(Authors note: Illustration currently in progress)*



2.3.3 AUXILIARY MACHINERY ROOMS 3+4 SEA WATER COOLING SYSTEM

Auxiliary Sea Water Cooling Pumps No.3, 4

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FEV-150D
No. of sets:	2
Capacity:	190m^3/h (6,710ft^3/h) at 2.0 bar
Motor:	440V, 18.5kW (25hp), 1,750 rpm

Bilge/Auxiliary Sea Water Cooling Pumps No.2

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FEV-200D
No. of sets:	1
Capacity:	250/190m^3/h (8,829/6,710ft^3/h) at 2.8/2.0 bar (41/29psi)
Motor:	440V, 33kW (44hp), 1,750 rpm

Fresh Water Generator Sea Water Feed Pump No.2

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FGV-65D
No. of sets:	1
Capacity:	18m^3/h (283ft^3/h) x 4.5 bar (65psi)
Motor:	440V, 7.5kW (10hp), 3,500 rpm

Introduction

The sea water cooling system is divided into the following sections:

- Engine Room 1.
- Engine Room 2.
- Auxiliary Machinery Rooms 1 and 2 + Bow Thruster Room.
- Auxiliary Machinery Rooms 3 and 4.
- Motor Room 2.

This part of the section describes auxiliary machinery rooms 3 and 4 .

The low suction sea chest is located on the starboard side of auxiliary machinery room 3, with the high suction sea chest located on the port side. Sea water enters the crossover main via large high capacity strainers. Auxiliary machinery room 3 crossover main supplies auxiliary sea water cooling pumps No.3+4, No.2 bilge/auxiliary sea water cooling pumps No.2, and No.2 Freshwater Generator (FWG) feed pump. The high suction is used to prevent any debris eg, sand, silt etc, found in shallow waters from entering the system. Both sea chests include drain and vent holes, and are fitted with connections to supply working air for sea chest weed cleaning.

Auxiliary machinery room 3 crossover main arrangement allows all three of the auxiliary sea water cooling pumps, and No.2 FWG feed pump to be supplied from either side of the vessel via the high or low sea chests and strainers. No.3+4 auxiliary sea water cooling pumps have the same rating and discharge capacity. No.2 bilge/auxiliary sea water cooling pump has an additional capacity rating when used as a bilge pump. This pump has a connecntion to the bilge system.

The auxiliary cooling sea water pumps are rated at 100% of total capacity (two working, one on standby), therefore in normal operations the auxiliary cooling sea water pumps can either be started and stopped locally, or selected for remote operation. When selected for remote operation, one or two cooling sea water pumps would be selected as the duty pump(s) and the other pump selected for automatic operation in standby mode; the standby pump would start if the duty pump(s) could not maintain the required pressure. A pressure switch located on the discharge manifold provides the start signal for the standby pumps. The number of cooling sea water pumps required to operate depends upon the cooling load and the sea water temperature. When the sea water temperature is 25°C (77°F) or above, two sea water pumps should be used.

CAUTION
The use of No.2 bilge/auxiliary cooling sea water pump for bilge pumping is an emergency procedure and should only be undertaken in circumstances when the stability and safety of the vessel are in danger.

The sea water system is protected by an anti-fouling MGPS which uses an electrolytic system with copper and aluminium electrodes fed with an impressed current. The high amd low sea suction strainers have their own MGPS with the electrodes being built into the strainer lids.

Procedure for Setting No.3 Auxiliary Machinery Room Sea Water Suction Crossover

a) Ensure that both suction strainers are clear.

b) Ensure all the pressure gauge and instrumentation valves are open and that the instrumentation is reading correctly.

c) Set up the valves as shown in the table below to the open position. In this case the port high suction is to be used:

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Closed	Low (starboard) sea chest suction valve	601
Closed	Low (starboard) sea strainer outlet valve	603
Open	High (port) sea chest suction valve	604
Open	High (port) sea strainer outlet valve	606

d) Set up the valves as shown in the table below to the open position. In this case the starboard low suction is to be used:

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	Low (starboard) sea chest suction valve	601
Open	Low (starboard) sea strainer outlet valve	603
Closed	High (port) sea chest suction valve	604
Closed	High (port) sea strainer outlet valve	606

No.2 Fresh Water Generator (FWG) Sea Water Feed Pump System

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
Open	No.2 FWG sea water feed pump suction valve	623
Open	No.2 FWG sea water feed pump discharge valve	624
Open	No.2 FWG sea water feed inlet valve	625
Open	No.2 FWG sea water feed outlet valve	626
Open	No.2 FWG sea water overboard valve	627

e) Auxiliary machinery room 3 sea water crossover is now ready for operation.

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Operation of Auxiliary Machinery Room 3 Cooling Sea Water System

a) Ensure that auxiliary machinery room 3 sea water crossover main is operational as described above, and confirm the MGPS is operating on the correct sea chest.

b) Ensure all the pressure gauge and instrumentation valves are open and that the instrumentation is reading correctly.

c) Set the valves as in the following table to the open position. In this example, both central coolers are in service and all main cooling sea water pumps are operational:

Auxiliary Cooling Sea Water Pumps No.3+4 + Bilge/Auxiliary Cooling Sea Water Pumps No.2

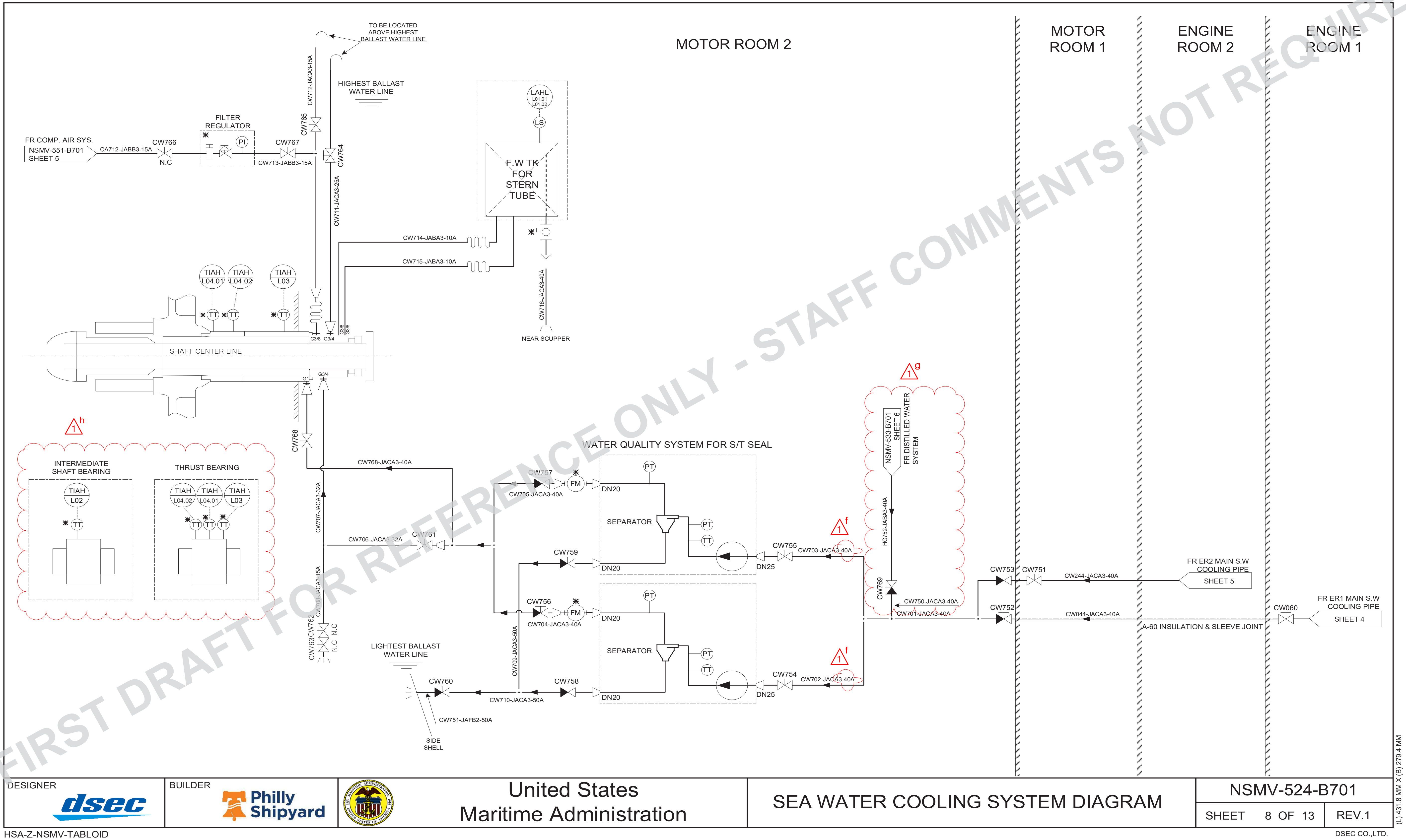
All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
As required	No.2 bilge/aux. cooling sea water pump suction valve	613
As required	No.2 bilge/aux. cooling sea water pump discharge valve	616
As required	No.2 bilge/aux. cooling sea water pump bilge system suction valves	BS116 BS117 BS018
As required	No.2 bilge/aux. cooling sea water pump bilge system overboard valve	BS021
Open	No.3 aux. cooling sea water pump suction valve	607
Open	No.3 aux.cooling sea water pump discharge valve	610
Open	No.4 aux. cooling sea water pump suction valve	608
Open	No.4 aux.cooling sea water pump discharge valve	612
Closed(NC)	Aux.cooling sea water pumps discharge valve to water mist	660
Open	Aux.cooling sea water pumps discharge valve overboard	622
Open	Aux.cooling sea water pumps discharge valve to auxiliary machinery room 4 consumers	620
Closed	Aux.cooling sea water pumps discharge A/C cooling systems bypass valve	621
Open	A/C cooling systems overboard valve	633

d) Select the duty and the standby pumps, set the switches on the group starter panels on the main switchboard for these pumps to the REMOTE position. At the control panel, start the first duty pump.

e) Ensure that the selected operational pump delivers sea water at the correct pressure to the outlet manifold; if the system operation is satisfactory, start a second duty pump as required according to the cooling load and sea water temperature. Set the standby pump at the control panel. This standby pump will cut-in on low manifold pressure.

Illustration 2.3.4a Motor Room 2 Sea Water System *(Authors note: Illustration currently in progress)*



2.3.4 MOTOR ROOM 2 SEA WATER COOLING SYSTEM

Stern Tube Sea Water Quality Pumps

Manufacturer:	Allweiler
Type:	Vertical centrifugal
Model:	NI 20-160/01 U3.12D-S W133
No. of sets:	2
Capacity:	5.4m^3/h (191ft^3/h) at 4.0 bar (58 psi)
Motor:	440V, 2.2kW (3hp), 3,450 rpm

Introduction

The sea water cooling system is divided into the following sections:

- Engine Room 1.
- Engine Room 2.
- Auxiliary Machinery Rooms 1 and 2 + Bow Thruster Room.
- Auxiliary Machinery Rooms 3 and 4.
- Motor Room 2.

This part of the section describes motor rooms 2.

Operating the Stern Tube Cooling/Lubrication Pumps

The supply of sea water to the stern tube is essential to provide cooling and lubrication of the stern bearing when the propeller shaft is turning.

a) Before starting the main engine, prepare the stern tube quality water package system for operation. Description of this system will be found later in this manual.

b) Confirm that there is a sea water supply from engine room 1 or engine room 2 sea water crossovers..

c) Confirm all of the pressure gauges and instrumentation valves are open, and the instrumentation is reading correctly.

d) Confirm the pump suction filters are clear.

Stern Tube Sea Water System

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
As required	Sea water supply valves from engine room 1 sea water crossover main	060 752
As required	Sea water supply valves from engine room 2 sea water crossover main	751 753
Open	No.1 sea water pump suction valve	754
Open	No.1 sea water pump quality water system outlet valve from separator	756
Open	No.1 sea water pump quality water system flushing valve from separator	758
Open	No.2 sea water pump suction valve	755
Open	No.2 sea water pump quality water package outlet valve	757
Open	No.2 sea water pump quality water system flushing valve from separator	759
Open	System flushing overboard valve	760
Open	Stern tube forward sea water inlet valve	761
Open	Stern tube sea water inlet valve	768
Closed(NC)	Stern tube sea water drain valves	762 763

e) Operate the stern tube sea water pumps in accordance with the procedures detailed in the manufacturers literature..

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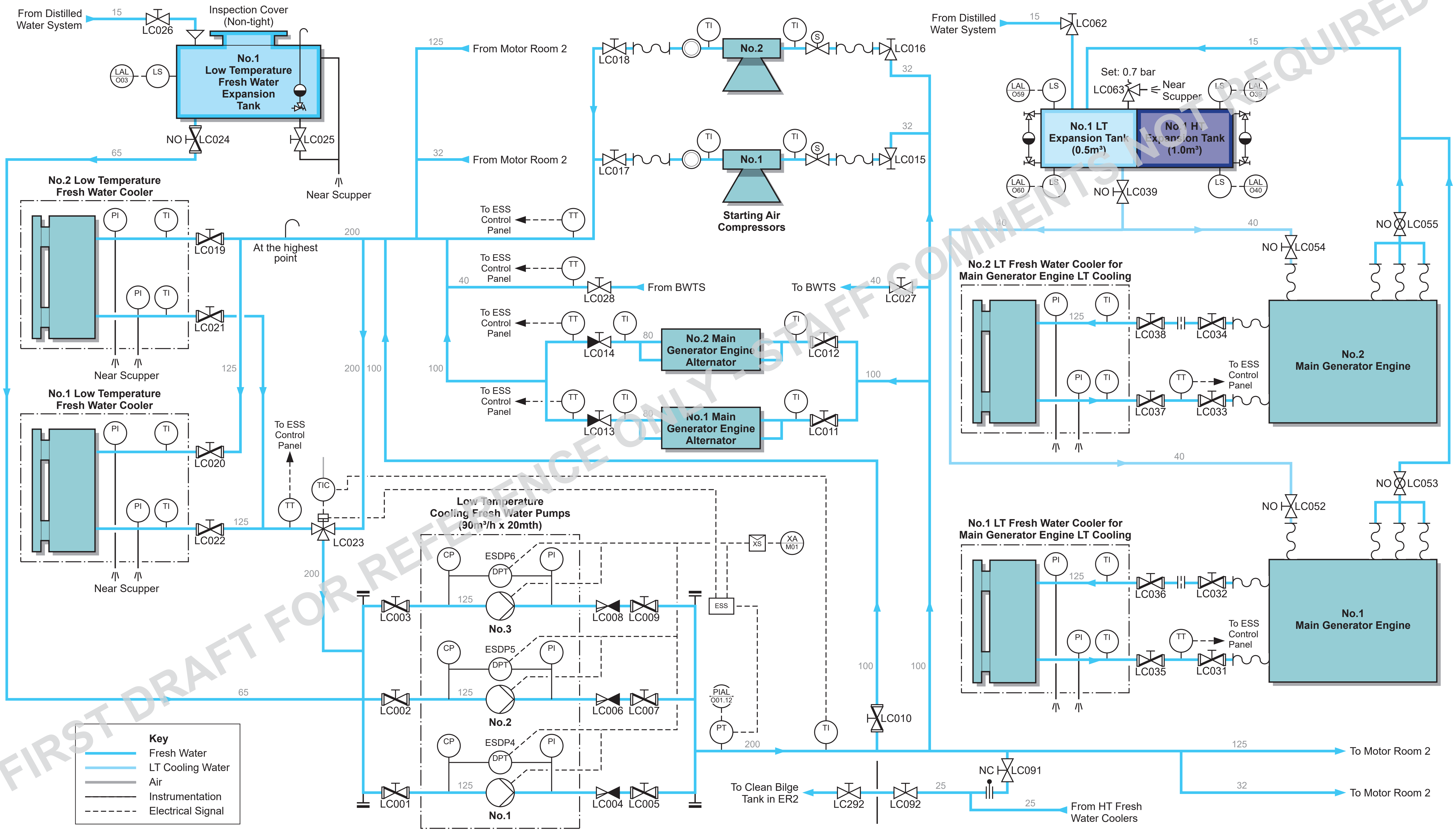
Illustration 2.4.1a Fresh Water Cooling System - Engine Room 1



Reference Drawing: NSMV-536-B701, Rev.2

2.4 FRESH WATER COOLING SYSTEM

2.4.1 ENGINE ROOM 1+2 FRESH WATER COOLING SYSTEM

Low Temperature Cooling Fresh Water Pumps No.1, 2. 3

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FEV-125E
No. of sets:	3 (2 working, 1 on standby)
Capacity:	90m^3/h (3,178ft^3/h) at 2.0 bar (29psi)
Motor:	440V, 11kW(14.75hp), 1,750 rpm

LT Fresh Water Coolers

Manufacturer:	LHE
Type:	Plate (Titanium, 0.5mm)
Model:	HT102ML-1P-67
No. of sets:	2
Heat transfer area:	16.9m^2
Operating temperature:	32°C (90°F) to 36°C (97°F) sea water side
	40°C (104°F) to 36°C (97°F) fresh water side
Capacity:	Fresh water flow 90m^3/h
	Sea water flow 100m^3/h

LT Fresh Water Coolers for GE LT Cooling

Manufacturer:	LHE
Type:	Plate (Titanium, 0.5mm)
Model:	SH102ML-1P-105
No. of sets:	4
Heat transfer area:	58.7m^2
Operating temperature:	32°C (90°F) to 48.5°C (119°F) sea water side
	57°C (135°F) to 38°C (100°F) fresh water side
Capacity:	Fresh water flow 102m^3/h
	Sea water flow 120m^3/h

Bow Thruster Cooling Fresh Water Pumps

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FEV-100E-0
No. of sets:	2
Capacity:	36m^3/h (1,271ft^3/h) at 2.0 bar (29psi)
Motor:	440V, 7.5kW(10hp), 1,750 rpm

Bow Thruster Fresh Water Cooler

Manufacturer:	LHE
Type:	Plate (Titanium, 0.5mm)
Model:	SH102M-1P-23
No. of sets:	1
Heat transfer area:	5.5m^2
Operating temperature:	32°C (90°F) to 36°C (97°F) sea water side
	39°C (102°F) to 36°C (97°F) fresh water side
Capacity:	Fresh water flow 35m^3/h
	Sea water flow 35m^3/h

Introduction

The fresh water cooling system is divided into the following sections:

- Engine Room 1.
- Engine Room 2.
- Motor Room 1.
- Motor Room 2.
- Bow Thruster Room.

Introduction

There are four identical main diesel generators (MGE) arranged in pairs for cooling purposes, one pair is in the engine room 1, and the other pair is in engine room 2. These generator pairs (No.1/No.2 and No.3/No.4) have HT and LT cooling circuits covering the pair. In order to fulfil the SRtP requirements, there are two independent LT fresh water cooling systems, one serving engine room 1 and one serving engine room 2. Each MGE LT cooling circuit deals with its associated engine pair, and also the associated propulsion system for engine room 1, and the other in engine room 2.

Each LT cooling system is self-contained and not linked to any other cooling system, apart from at the heat exchangers within the system. Each LT cooling system has its own header/expansion tank which is replenished from the distilled water system. The header/expansion tank allows for thermal expansion of the water in each LT system as well as providing for make-up and maintaining a pressure head. The tank is replenished from the distilled water system. The expansion tank valve to the system is normally locked open.

Each MGE HT circuit has its own header/expansion tank which has a local gauge glass, level transmitter for indication at the CAMS, and a low level alarm. The header tanks can be manually topped-up from the distilled water system. Chemical treatment can be added to the header tank as required.

Oil detection units are located in the LT fresh water outlet lines from the associated LO coolers. These devices activate an alarm if oil is detected in the water, indicating an oil leak at the associated LO cooler.

Three LT fresh water cooling pumps are fitted to each circuit, two selected as duty pumps, and the third selected for standby, to start should the duty pumps fail to maintain water circulation. The duty pumps circulates LT cooling water through each circuit to the following consumers:

- LT fresh water coolers No.1, 2, 3, 4.
- Alternators No.1, 2, 3, 4.
- Air start compressors No.1, 2, 3, 4.

The LT cooling water is cooled in the LT fresh water coolers, which are circulated with sea water.

Each generator pair has the following separate HT/LT cooling water circuits:

- LT fresh water coolers for MGE LT cooling No.1, 2, 3, 4.
- HT fresh water coolers No.1, 2, 3, 4.
- HVAC water heaters No.1 and No.2 (glycol/water circulation).
- DW generator in engine room1 only.

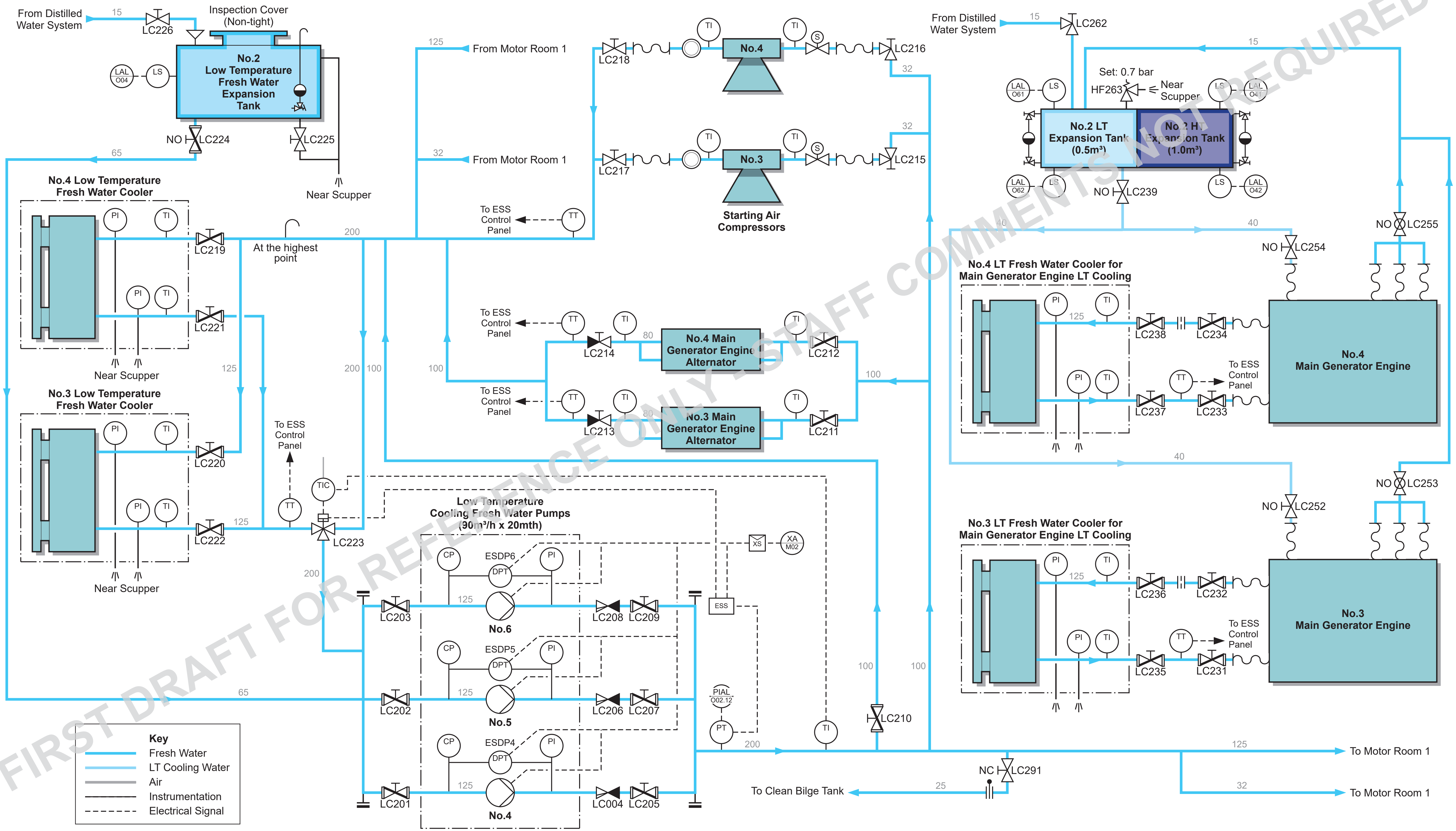
The above coolers are circulated with sea water, except for the HVAC water heaters which are circulated with glycol/water. In addition, the LT cooling water circuits provides cooling for the following cooled items in motor rooms 1 and 2:

- Propulsion motors No.1 and No.2.
- Braking resistors No.1 and No.2.
- Frequency converters No.1 and No.2.
- Propulsion transformers No.1 and No.2.
- Intermediate shaft bearing.
- Thrust bearing.

A further separate system is for cooling of the bow thruster motor, and repeller. This system is a self contained LT cooling system, with the LT cooler being cooled by sea water from the auxiliary machinery room 1,

In the event of a blackout, the selected duty LT cooling fresh water pump in each circuit will start automatically on restoration of electrical power. The LT circulating water temperature is controlled to *xx°C* at the pump suction by three-way temperature controlled valves at the outlet from each LT system cooler which provides for cooler bypass as necessary. Each LT cooler is sized to provide for 100% of the maximum cooling load on each circuit, so only one cooler is per cooling system at any time. Duty coolers should be changed over at frequent intervals so that both coolers have approximately the same running

Illustration 2.4.1b Fresh Water Cooling System - Engine Room 2



Reference Drawing: NSMV-536-B701, Rev.2

hours. The same changeover routine should apply to the LT cooling fresh water pumps.

Each LT FW cooler has a three-way outlet valve which is controlled through the CAMS, and operates to maintain the LT cooler outlet temperature to give a pump suction temperature of *xx°C/°F*. An alarm is raised if the cooler outlet temperature rises above *xx°C/°F*.

The HT cooling water system provides for cooling of the HT cooling water circuit, but the main means of cooling the HT water is by the distilled water generator (DWG), and/or the heat recovery system (HVAC).

In addition to the MGEs, each MGE LT system also supplies cooling to a number of propulsion services, including the associated propulsion cooling systems. Further consumers in each system include associated propulsion transformers, frequency converters, braking resistors, and shaft line support systems.

Corrosion inhibiting treatment chemicals are added to the LT circulating water of each engine by means of a pump at the water treatment unit. It is important that the circulating fresh water is analysed frequently and treatment chemicals added as necessary in order to prevent corrosion in the circulation system.

WARNING

Care must be taken when handling and mixing treatment chemicals. Protective clothing and goggles must be used whenever handling such treatment chemicals.

Procedure for Setting up and Operating the Main Diesel Generator Engine Low Temperature Cooling Fresh Water Systems

The MGE LT fresh water (FW) cooling systems are similar for each engine pair. The procedure below applies to both circuits. This description assumes that the MGE sea water cooling systems are operational:

a) Ensure that all pressure gauge and instrumentation valves/cocks are open, that all instruments are reading correctly and control systems are operational.

b) Ensure that the MGE LT FW cooling systems are fully charged and that the cooling fresh water in the system is correctly treated to prevent corrosion; analyse a water sample and, if necessary, add treatment chemicals.

c) Ensure that the MGEs sea water cooling systems are operational, and that sea water is circulating through the operating LT FW coolers in each cooling system.

d) Set the valves as in the following table; internal engine valve numbers are not shown for individual engines. Valves are to be set as indicated unless an engine has been shut down for maintenance and the power management system configured so that the engine cannot be started. Unless specified, all other valves including line drain valves must be closed.

This part of the section descibes Engine Room 1 fresh water cooling system.

Engine Room 1 LT Cooling Fresh Water Pumps No.1+2+3

All valves are prefixed with 'LC' unless otherwise stated.

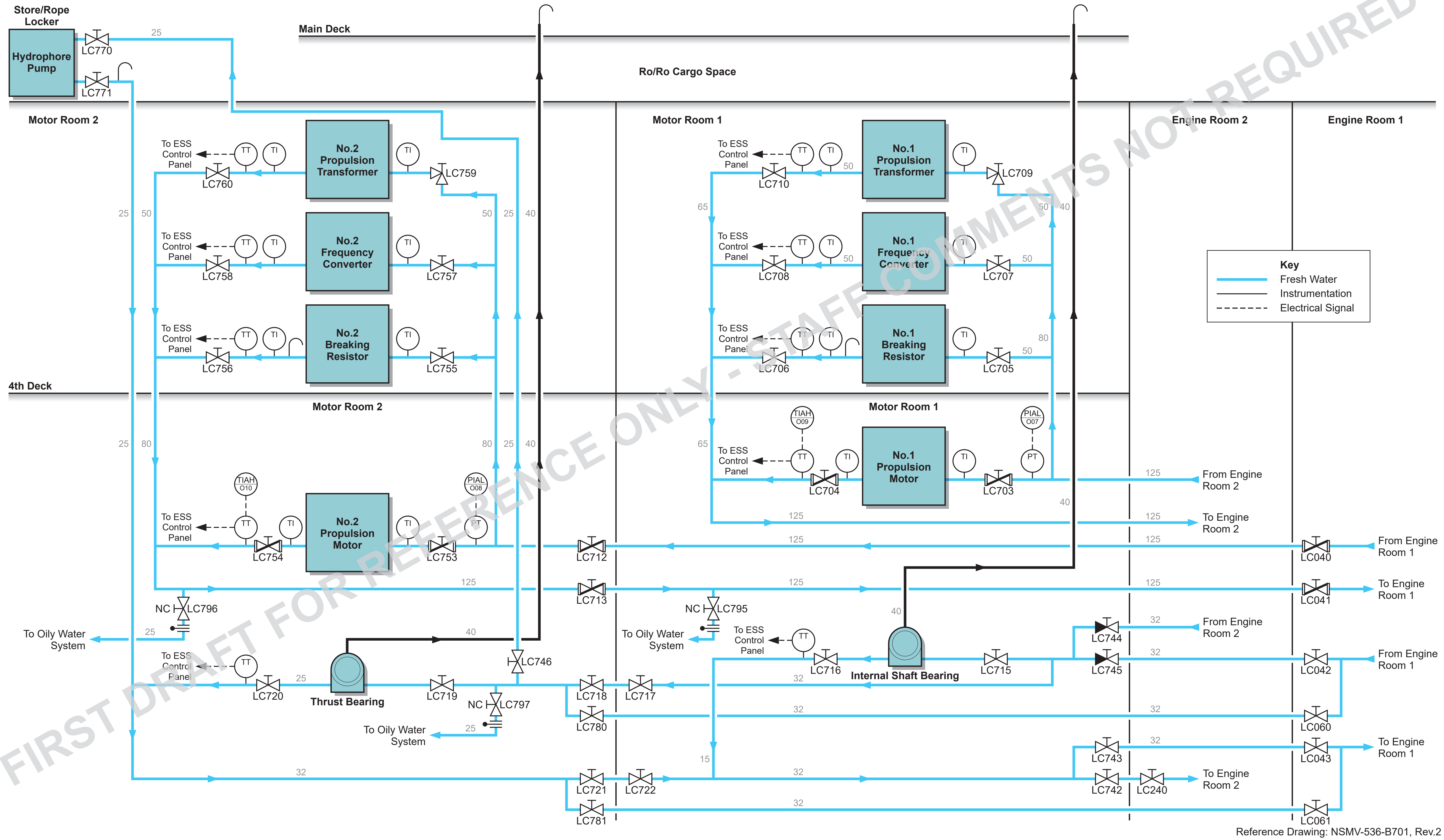
Position	Description	Valve
Open	No.1 LT cooling FW pump suction valve	001
Open	No.1 LT cooling FW pump discharge valve	005
Open	No.2 LT cooling FW pump suction valve	002
Open	No.2 LT cooling FW pump discharge valve	007
Open	No.3 LT cooling FW pump suction valve	003
Open	No.3 LT cooling FW pump discharge valve	009
Closed	LT cooling FW pumps recirculation valve	010
Open (NO)	Line valve from header/expansion tank to pump suction	024
Closed	Header/expansion tank drain valve	025
Closed	Header/expansion tank replenishment valve	026
No.1+2 LT Fresh Water Coolers		
Closed	No.2 LT FW cooler inlet valve	019
Closed	No.2 LT FW cooler outlet valve	021
Open	No.1 LT FW cooler inlet valve	020
Open	No.1 LT FW cooler outlet valve	022
Automatic	LT temperature control valve	023
Engine Room 1 LT Fresh Water Cooling Consumers		
Open	No.1 main alternator LT FW cooling inlet valve	011
Open	No.1 main alternator LT FW cooling outlet valve	013
Open	No.2 main alternator LT FW cooling inlet valve	012
Open	No.2 main alternator LT FW cooling outlet valve	014
Open	BWTS LT FW cooling inlet valve	027
Open	BWTS LT FW cooling outlet valve	028
Open	No.1 start air compressor FW cooling inlet valve	015
Open	No.1 start air compressor FW cooling outlet valve	017
Open	No.2 start air compressor FW cooling inlet valve	016
Open	No.2 start air compressor FW cooling outlet valve	018

Motor Room 2 LT Fresh Water Cooling Consumers		
Position	Description	Valve
Open	LT FW cooling isolating valve to No.2 motor room	040
Open	LT FW cooling isolating valve in No.2 motor room	712
Open	LT FW cooling isolating valve from No.2 motor room	041
Closed	LT FW cooling supply to oily water system (NC)	795
Open	LT FW cooling isolating valve from No.2 motor room	713
Closed	LT FW cooling supply to oily water system (NC)	796
Open	No.2 propulsion motor LT FW cooling inlet valve	753
Open	No.2 propulsion motor LT FW cooling outlet valve	754
Open	No.2 braking resistor LT FW cooling inlet valve	755
Open	No.2 braking resistor LT FW cooling inlet valve	756
Open	No.2 frequency converter LT FW cooling inlet valve	757
Open	No.2 frequency converter LT FW cooling outlet valve	758
Open	No.2 propulsion trans. LT FW cooling inlet valve	759
Open	No.2 propulsion trans. LT FW cooling outlet valve	760

Motor Room 1 LT Fresh Water Cooling Consumers

Position	Description	Valve
Open	No.1 propulsion motor LT FW cooling inlet valve	703
Open	No.1 propulsion motor LT FW cooling outlet valve	704
Open	No.1 braking resistor LT FW cooling inlet valve	705
Open	No.1 braking resistor LT FW cooling inlet valve	706
Open	No.1 frequency converter LT FW cooling inlet valve	707
Open	No.1 frequency converter LT FW cooling outlet valve	708
Open	No.1 propulsion trans. LT FW cooling inlet valve	709
Open	No.1 propulsion trans. LT FW cooling outlet valve	710
Open	LT FW cooling isolating valve to No.1 motor room from No.1 engine room	042
As required	LT FW cooling isolating valve in No.1 motor room from No.2 engine room	744
As required	LT FW cooling isolating valve in No.1 motor room from No.1 engine room	745
Open	Intermediate shaft bearing LT FW cooling inlet valve	715
Open	Intermediate shaft bearing LT FW cooling outlet valve	716
Open	LT FW cooling isolating valve to No.2 motor room from No.1 engine room	717
Open	LT FW cooling isolating valve in No.2 motor room from No.1 engine room	718
Open	HPU LT FW cooling supply valve	746

Illustration 2.4.1c Fresh Water Cooling System - Propulsion Motor



Reference Drawing: NSMV-536-B701, Rev.2

Position	Description	Valve
Open	HPU LT FW cooling inlet valve	770
Open	HPU LT FW cooling outlet valve	771
Closed	LT FW cooling supply to oily water system (NC)	797
Open	Thrust bearing LT FW cooling inlet valve	719
Open	Thrust bearing LT FW cooling outlet valve	720
Open	LT FW cooling isolating valve in No.2 motor room to No.1+2 engine rooms	721
Open	LT FW cooling isolating valve in No.1 motor room to No.1+2 engine rooms	722
As required	LT FW cooling isolating valve in No.2 motor room to No.2 engine room	742
As required	LT FW cooling isolating valve in No.2 motor room to No.1 engine room	743
As required	LT FW cooling isolating valve in No.1 engine room to No.2 engine room	240
As required	LT FW cooling isolating valve in No.1 engine room	043
As required	LT FW cooling isolating valves direct supply from No.1 engine room	060 780
As required	LT FW cooling isolating valves direct return to No.1 engine room	781 061

Alternative LT FW Cooling Supplies to Shaft Bearing and Thrust bearing

Operational circumstances may require LT FW supply to the intermediate shaft bearing, and thrust bearing from either engine room 1 or engine room 2 LT FW cooling systems as indicated below:

Intermediate Shaft Bearing Cooling from Engine Room 1 LT Cooling

Open valves:
LC042, LC745, LC715, LC716, LC743
Close valves:
LC744, LC742, LC240

Thrust Bearing Cooling from Engine Room 1 LT Cooling

Open valves:
LC745, LC717, LC718, LC719, LC720, LC721, LC722, LC743, LC043
Close valves:
LC742, LC240

Intermediate Shaft Bearing Cooling from Engine Room 2 LT Cooling

Open valves:
LC744
Close valves:
LC745, LC042 (maybe left open)

Thrust Bearing Cooling from Engine Room 2 LT Cooling

Open valves:
LC744, LC742, LC240
Close valves:
LC743

This part of the section descibes Engine Room 2 fresh water cooling system.

Engine Room 2 LT Cooling Fresh Water Pumps No.4+5+6

All valves are prefixed with 'LC' unless otherwise stated.

Position	Description	Valve
Open	No.4 LT cooling FW pump suction valve	201
Open	No.4 LT cooling FW pump discharge valve	205
Open	No.5 LT cooling FW pump suction valve	202
Open	No.5 LT cooling FW pump discharge valve	207
Open	No.6 LT cooling FW pump suction valve	203
Open	No.6 LT cooling FW pump discharge valve	209
Closed	LT cooling FW pumps recirculation valve	210
Open (NO)	Line valve from header/expansion tank to pump suction	224
Closed	Header/expansion tank drain valve	225
Closed	Header/expansion tank replenishment valve	226

No.3+4 LT Fresh Water Coolers

Position	Description	Valve
Closed	No.4 LT FW cooler inlet valve	219
Closed	No.4 LT FW cooler outlet valve	221
Open	No.3 LT FW cooler inlet valve	220
Open	No.3 LT FW cooler outlet valve	222
Automatic	LT temperature control valve	223

Engine Room No.2 LT Fresh Water Cooling Consumers

Position	Description	Valve
Open	No.3 main alternator LT FW cooling inlet valve	211
Open	No.3 main alternator LT FW cooling outlet valve	213
Open	No.4 main alternator LT FW cooling inlet valve	212
Open	No.4 main alternator LT FW cooling outlet valve	214
Open	No.3 start air compressor FW cooling inlet valve	215
Open	No.3 start air compressor FW cooling outlet valve	217
Open	No.4 start air compressor FW cooling inlet valve	216
Open	No.4 start air compressor FW cooling outlet valve	218

Motor Room 2 LT Fresh Water Cooling Consumers

Position	Description	Valve
Open	LT FW cooling isolating valve to No.2 motor room	040
Open	LT FW cooling isolating valve in No.2 motor room	712
Open	LT FW cooling isolating valve from No.2 motor room	041
Closed	LT FW cooling supply to oily water system (NC)	795
Open	LT FW cooling isolating valve from No.2 motor room	713
Closed	LT FW cooling supply to oily water system (NC)	796
Open	No.2 propulsion motor LT FW cooling inlet valve	753
Open	No.2 propulsion motor LT FW cooling outlet valve	754
Open	No.2 braking resistor LT FW cooling inlet valve	755
Open	No.2 braking resistor LT FW cooling inlet valve	756
Open	No.2 frequency converter LT FW cooling inlet valve	757
Open	No.2 frequency converter LT FW cooling outlet valve	758
Open	No.2 propulsion trans. LT FW cooling inlet valve	759
Open	No.2 propulsion trans. LT FW cooling outlet valve	760

Generator Engines LT FW System

Engine Room 1 Generator LT FW Cooling No.1 Main Generator Engine

Position	Description	Valve
Open	No.1 MGE LT FW cooling outlet valve	031
Open	No.1 LT FW cooler inlet valve	035
Open	No.1 LT FW cooler outlet valve	036
Open	No.1 MGE LT FW cooling inlet valve	032
Open (NO)	Line valve from header/expansion tank No.1 MGE	052
Open	No.1 MGE LT FW vent valve to header/expansion tank	053
Closed	Header/expansion tank outlet valve	039
Closed	Header/expansion tank replenishment valve	062

Engine Room 1 Generator LT FW Cooling No.2 Main Generator Engine

Position	Description	Valve
Open	No.2 MGE LT FW cooling outlet valve	033
Open	No.2 LT FW cooler inlet valve	037
Open	No.2 LT FW cooler outlet valve	038

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ANYTHING TO UPDATE?

It is important that this manual is kept up to date as a live document. If you believe there are any errors or omissions in this manual, or you are aware of changes to the equipment or systems on board then please contact the publishers:

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Position	Description	Valve
Open	No.2 MGE LT FW cooling inlet valve	034
Open (NO)	Line valve from header/expansion tank No.2 MGE	054
Open	No.2 MGE LT FW vent valve to header/expansion tank	055
Open	Header/expansion tank outlet valve	039
Closed	Header/expansion tank replenishment valve	062

Engine Room 2 Generator LT FW Cooling No.3 Main Generator Engine

Position	Description	Valve
Open	No.1 MGE LT FW cooling outlet valve	231
Open	No.1 LT FW cooler inlet valve	235
Open	No.1 LT FW cooler outlet valve	236
Open	No.1 MGE LT FW cooling inlet valve	232
Open (NO)	Line valve from header/expansion tank No.1 MGE	252
Open	No.1 MGE LT FW vent valve to header/expansion tank	253
Closed	Header/expansion tank outlet valve	239
Closed	Header/expansion tank replenishment valve	262

Engine Room 2 Generator LT FW Cooling No.4 Main Generator Engine

Position	Description	Valve
Open	No.2 MGE LT FW cooling outlet valve	233
Open	No.2 LT FW cooler inlet valve	237
Open	No.2 LT FW cooler outlet valve	238
Open	No.2 MGE LT FW cooling inlet valve	234
Open (NO)	Line valve from header/expansion tank No.2 MGE	254
Open	No.2 MGE LT FW vent valve to header/expansion tank	255
Open	Header/expansion tank outlet valve	239
Closed	Header/expansion tank replenishment valve	262

Bow Thruster LT FW Cooling System

The bow thruster cooling system is independent from the other LT FW cooling systems. This system includes a FW cooler, two FW cooling pumps, and a FW expansion tank. This tank can be replenished from the distilled water system. Preparing this system is the same procedure as described above,

Bow Thruster FW Cooling Pumps

Position	Description	Valve
Open	No.1 bow thruster cooling FW pump suction valve	401
Open	No.1 bow thruster cooling FW pump discharge valve	403
Open	No.2 bow thruster cooling FW pump suction valve	402
Open	No.2 bow thruster cooling FW pump discharge valve	404
Open (NO)	Bow thruster FW expansion tank outlet valve	411
Closed	Bow thruster FW expansion tank drain valve	412
Closed	Bow thruster FW expansion tank replenishment valve	413

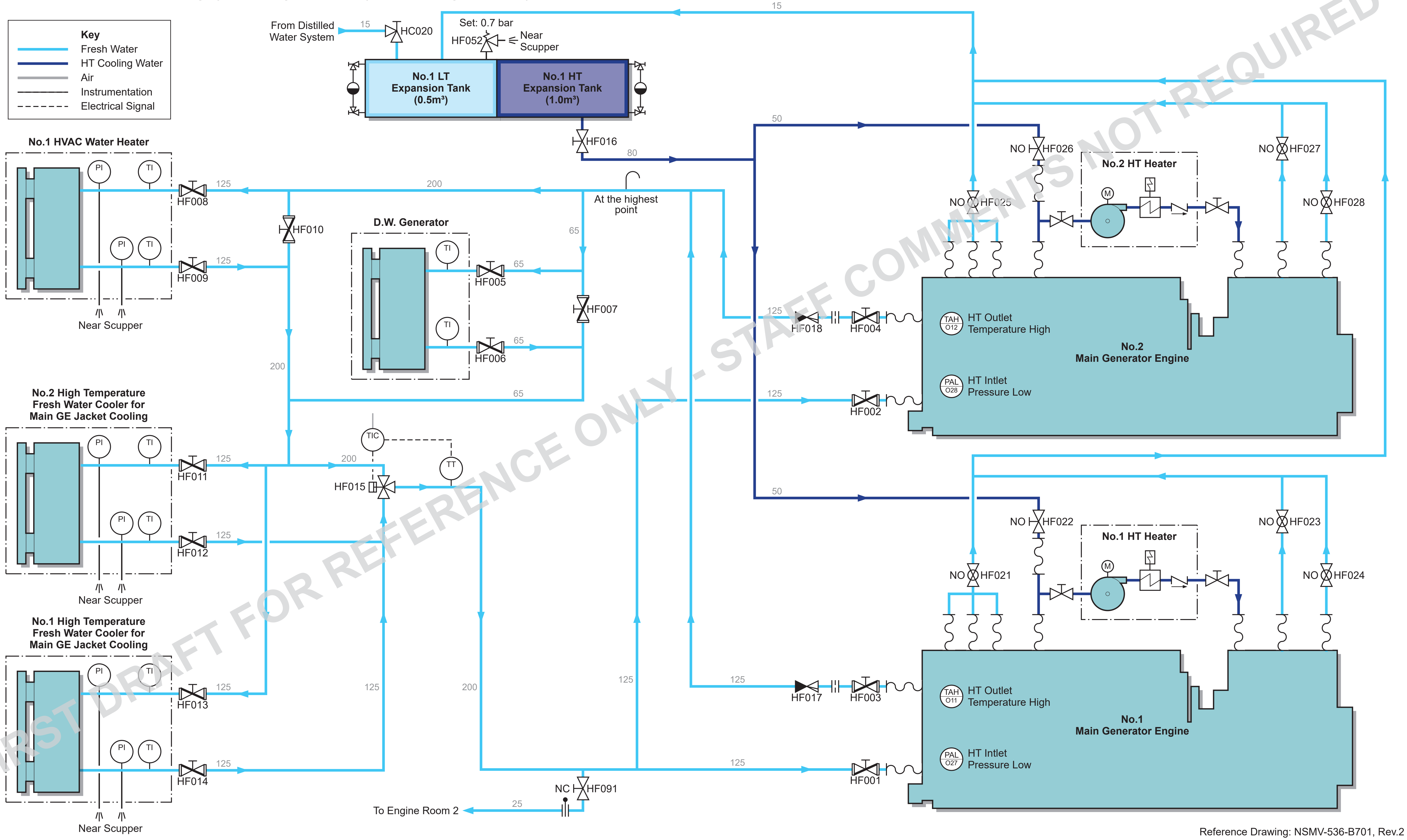
Bow Thruster FW Cooler

Position	Description	Valve
Open	Bow thruster FW cooler inlet valve	409
Open	Bow thruster FW cooler outlet valve	410

Bow Thruster FW Consumers

Position	Description	Valve
Open	No.1 bow thruster cooling FW pump suction valve	401
Open	No.1 bow thruster cooling FW pump discharge valve	403
Open	No.2 bow thruster cooling FW pump suction valve	402
Open	No.2 bow thruster cooling FW pump discharge valve	404
Open (NO)	Bow thruster FW expansion tank outlet valve	411
Closed	Bow thruster FW expansion tank drain valve	412
Closed	Bow thruster FW expansion tank replenishment valve	413

Illustration 2.4.2a Fresh Water Cooling System - Engine Room 1 (Generator Engine 1 and 2)



Reference Drawing: NSMV-536-B701, Rev.2

2.4.2 GENERATOR ENGINES 1+2+3+4 HT FRESH WATER COOLING SYSTEM

HT Fresh Water Coolers for GE Jacket Cooling

Manufacturer:	LHE
Type:	Plate (Titanium, 0.5mm)
Model:	LT150ML-1P-39
No. of sets:	4
Heat transfer area:	20m^2
Operating temperature:	41°C (106°F) to 51.5°C (125°F) sea water side 91.8°C to 70°C fresh water side
Capacity:	Fresh water flow 102m^3/h Sea water flow 220m^3/h

HVAC Water Heaters

Manufacturer:	LHE
Type:	Plate (Titanium, 0.5mm)
Model:	LT150ML-1P-29
No. of sets:	2
Heat transfer area:	14.6m^2
Operating temperature:	38°C (100°F) to 53°C (127°F) glycol water side 92°C (198°F) to 70°C (158°F) fresh water side
Capacity:	Fresh water flow 84m^3/h Glycol water flow 220m^3/

Distilled Water Generator

Manufacturer:	DongHwa Entec
Type:	Plate
Model:	DF07/10
No. of sets:	1
Capacity:	10 ton/day

Introduction

Each Main Generator Engine (MGE) HT circuit has its own header/expansion tank which has a local gauge glass, level transmitter for indication at the CAMS, and a low level alarm. The header tanks can be manually topped-up from the distilled water system. Chemical treatment can be added to the header tank as required.

Each MGE pair has the following separate HT cooling water circuits:

- HT fresh water coolers No.1, 2 in engine room 1, and HT fresh water coolers No.3, 4 in engine room 2.
- HVAC water heater No.1 in engine room 1, and HVAC water heater No.2 in engine room 2 (glycol/water circulation).
- DWG is in engine room 1 only.

Engine Room 1+2 HT Fresh Water Cooling System

HT Fresh Water Coolers for Main Generator Engines Jacket Cooling

These coolers are for cooling MGEs No.1 ~ 4 jacket water systems, and are in turn cooled by the sea water cooling system. Valves are normally left in the open position so that the system may operate at any time as required.

HVAC Water Heater

The HVAC water heater recovers heat from the MGE HT cooling water systems, and uses it to provide heating for the HVAC hot water circulation system. The heat from the MGE HT cooling water heats up the glycol/water circulating through the HVAC water heater, and circulates through accommodation Air Handling Units (AHUs), and various air conditioning Fan Coil Units (FCUs) on the vessel. Circulation of the glycol/water is carried out by hot water circulating pumps, with two pumps in each circuit.

Distilled Water Generator

One Distilled Water Generator (DWG) capable of producing 10 ton of distilled water per day, utilises the MGE HT jacket water cooling system as its heat source, and is located in engine room 1. HT water from the MGEs in engine room 1 is directed to the DWG, but if that is shut down or there is more heat than required by the DWG, the temperature in the MGE HT cooling water is maintained by the three-way temperature control valve HF015.

Procedure for Setting up and Operating the Main Diesel Generator Engine High Temperature Cooling Fresh Water Systems

The MGE HT FW cooling systems are similar for each engine pair. The procedure below applies to both circuits. This description assumes that the MGE sea water cooling, and glycol/water systems are operational:

a) Ensure that all pressure gauge and instrumentation valves/cocks are open, that all instruments are reading correctly and control systems are operational.

b) Ensure that the MGE HT FW cooling systems are fully charged, and that the cooling fresh water in the system is correctly treated to prevent corrosion; analyse a water sample and, if necessary, add treatment chemicals.

c) Ensure that the MGEs sea water cooling systems are operational, and that sea water is circulating through the operating HT FW coolers in each cooling system.

d) Ensure that the HVACs glycol/water systems are operational.

e) Set the valves as in the following table; internal engine valve numbers are not shown for individual engines. Valves are to be set as indicated unless an engine has been shut down for maintenance and the power management system configured so that the engine cannot be started. Unless specified, all other valves including line drain valves must be closed.

Engine Room 1 Generator HT JW Cooling No.1 Main Generator Engine

All valves are prefixed with 'HF' unless otherwise stated.

Position	Description	Valve
Open	No.1 MGE HT JW cooling inlet valve	001
Open	No.1 MGE HT JW cooling outlet valve	003
Open (NO)	No.1 MGE HT JW vent valves to header/expansion tank	021 023 024
Open (NO)	Line valve from header/expansion tank No.1 MGE	022

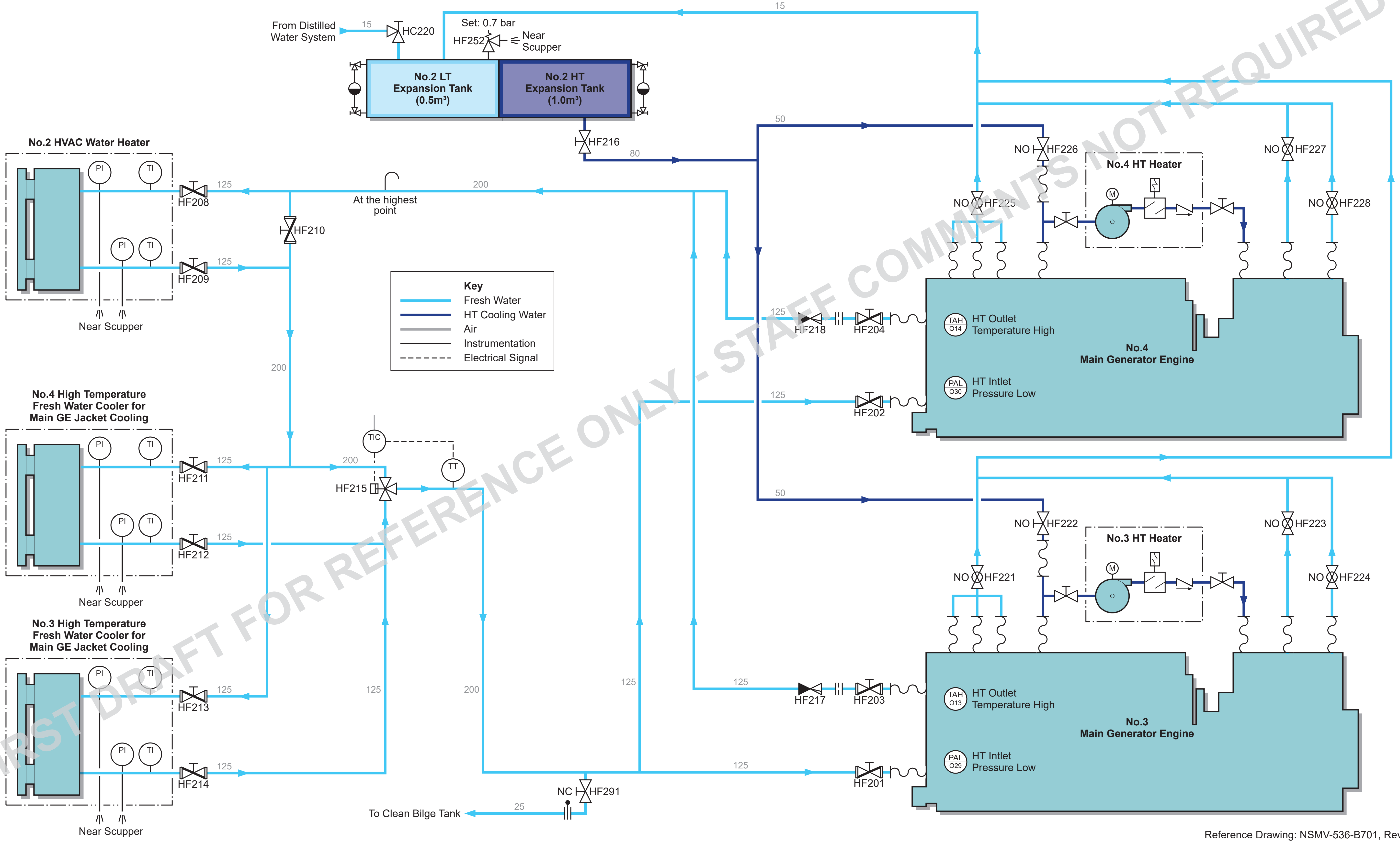
Engine Room 1 Generator HT FW Cooling No.2 Main Generator Engine

Position	Description	Valve
Open	No.2 MGE HT JW cooling inlet valve	002
Open	No.2 MGE HT JW cooling outlet valve	004
Open (NO)	No.2 MGE HT JW vent valves to header/expansion tank	025 027 028
Open (NO)	Line valve from header/expansion tank No.2 MGE	026

Common Header/Expansion Tank Valves

Position	Description	Valve
Open	Header/expansion tank outlet valve	016
Closed	Header/expansion tank replenishment valve	020
Set 0.7 bar	Header/expansion tank relief valve	052

Illustration 2.4.2b Fresh Water Cooling System - Engine Room 2 (Generator Engines 3 and 4)



Reference Drawing: NSMV-536-B701, Rev.2

No.1+2 HT Fresh Water Coolers for GE Jacket Cooling

Position	Description	Valve
Open	No.2 LT FW cooler inlet valve	011
Open	No.2 LT FW cooler outlet valve	012
Open	No.1 LT FW cooler inlet valve	013
Open	No.1 LT FW cooler outlet valve	014
Automatic	LT temperature control valve	015

No.1 HVAC Water Heater

Position	Description	Valve
Open	No.1 HVAC water heater inlet valve	008
Open	No.1 HVAC water heater outlet valve	009
Closed	No.1 HVAC water heater bypass valve	010

Distilled Water Generator

Position	Description	Valve
Open	DWG inlet valve	005
Open	DWG outlet valve	006
Closed	DWG bypass valve	007

Engine Room 2 Generator HT JW Cooling No.3 Main Generator Engine

All valves are prefixed with 'HF' unless otherwise stated.

Position	Description	Valve
Open	No.3 MGE HT JW cooling inlet valve	201
Open	No.3 MGE HT JW cooling outlet valve	203
Open (NO)	No.3 MGE HT JW vent valves to header/expansion tank	221 223 224
Open (NO)	Line valve from header/expansion tank No.3 MGE	222

Engine Room 2 Generator HT FW Cooling No.4 Main Generator Engine

Position	Description	Valve
Open	No.4 MGE HT JW cooling inlet valve	202
Open	No.4 MGE HT JW cooling outlet valve	204
Open (NO)	No.4 MGE HT JW vent valves to header/expansion tank	225 227 228
Open (NO)	Line valve from header/expansion tank No.4 MGE	226

Common Header/Expansion Tank Valves

Position	Description	Valve
Open	Header/expansion tank outlet valve	216
Closed	Header/expansion tank replenishment valve	220
Set 0.7 bar	Header/expansion tank relief valve	252

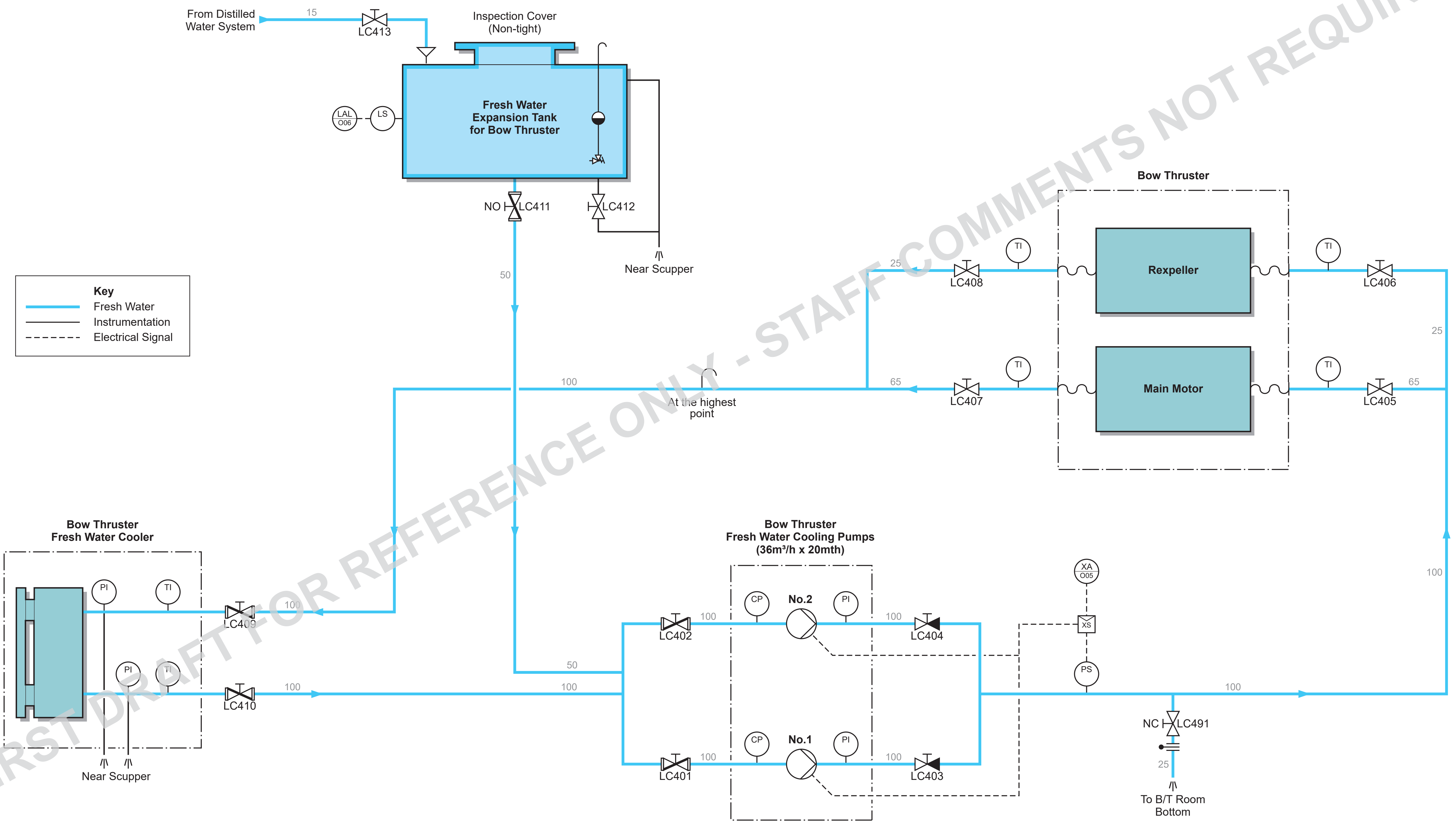
No.3+4 HT Fresh Water Coolers for GE Jacket Cooling

Position	Description	Valve
Closed	No.2 LT FW cooler inlet valve	211
Closed	No.2 LT FW cooler outlet valve	212
Open	No.1 LT FW cooler inlet valve	213
Open	No.1 LT FW cooler outlet valve	214
Automatic	LT temperature control valve	215

No.2 HVAC Water Heater

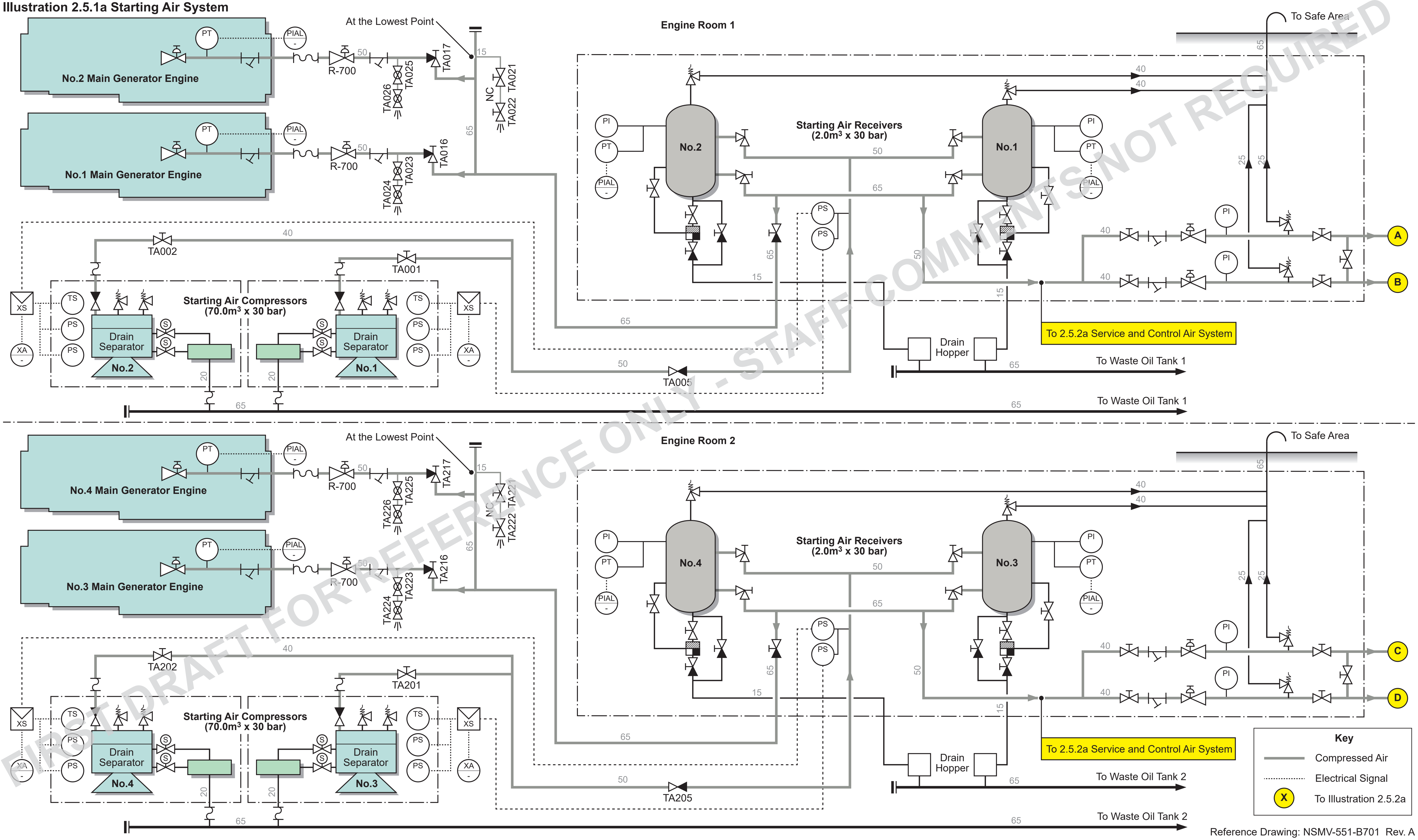
Position	Description	Valve
Open	No.2 HVAC water heater inlet valve	208
Open	No.2 HVAC water heater outlet valve	209
Closed	No.2 HVAC water heater bypass valve	210

Illustration 2.4.2c Fresh Water Cooling System - Bow Thruster Room



Reference Drawing: NSMV-536-B701, Rev.2

Illustration 2.5.1a Starting Air System



Reference Drawing: NSMV-551-B701 Rev. A

2.5 COMPRESSED AIR SYSTEMS

2.5.1 STARTING AIR SYSTEM

Starting Air Compressors

Manufacturer:	Atlas Copco
Type:	Two-stage reciprocating, fresh water cooled
Model:	LT-30-30 W KE
No. of sets:	4
Capacity:	$70m^3/h$ ($2,472ft^3/h$) at 30 bar (435psi)
Motor:	440V, 16.7kW(22.4hp), 1,170 rpm

Starting Air Receiver

Manufacturer:	Kumkang
Type:	Vertical cylindrical
No. of sets:	4
Working pressure:	30 bar (435psi)
Capacity:	$2.0m^3$ (2,000 litre)
Safety valve setting:	33 bar (479psi)

Introduction

Each MGE pair has its own independent starting air system comprising of two starting air compressors, and two starting air receivers. There is a cross connection between the starting air systems for each of the MGE pairs should a failure occur with one starting air system.

Each starting air system is supplied by two main air compressors which provide air to the two starting air receivers. The compressed air is used to start the MGEs. Compressed air from the main 30 bar (435psi) system can, when required, supply the working air and control air systems via the 30 ~ 8 bar air reducing stations.

The starting air receivers are supplied through an oil/water separator located on each discharge from the main air compressors. Each compressor is fitted with two safety valves, one after the first stage and the other after the second stage. The cylinder block cooling water jacket is provided with a safety valve which will operate if the cooling water system is subjected to excessive pressure. Cooling water is supplied by the low temperature (LT) cooling fresh water (FW) system.

A pressure switch connected to the automatic control system stops the compressor should the LO pressure fall below a predetermined value. The bearings are lubricated by a main shaft driven gear pump.

A high temperature sensor is located at the compressor outlet, and this will trip the compressor if the temperature exceeds a predetermined limit.
Each starting air compressor has an automatic unloading arrangement which operates when the compressor starts and stops. This allows the compressor to start and stop off-load, thus reducing the load on the electric motor, and the compressor running gear. The compressors are started and stopped by pressure switches located on the inlet line to the starting air receivers, one switch for each compressor.

Starting air is supplied to the MGEs from the starting air receivers. Normally, one air receiver is designated as the duty air receiver, and the other is fully pressurised with its outlet valves closed when at sea.

The two main valves on each air receiver are designated as follows:

- Outlet to the MGEs.
- Inlet from the starting air compressors.

Switches at the local starter panels enable the compressors to be manually started and stopped. Each compressor has a pressure switch connected to the control system which allows for auto start/stop and manual start/auto stop. The compressors are selected for automatic operation at the selector switch, with one compressor being selected as the lead compressor and the others as the follow-on. The lead compressor will start first to maintain the pressure in the starting air receivers, but if the pressure continues to fall, the follow-on compressor will start as required.

The selected lead compressor should be changed periodically in order to arrange the running hours on the compressors to suit maintenance requirements. The lead and follow-on compressor are selected at each engine control console mode switch in the ECR.

The auxiliary consumers are supplied by the control/service air compressors, and the supply from the starting air receivers is available as a back-up.

Procedure for Operating the Starting Air Receivers

a) Ensure that all pressure gauge and instrumentation valves are open and that gauges and instruments are reading correctly.

b) Check the oil level in the compressors and check the compressor sumps for water.

c) Ensure that the LT cooling fresh water system is operating.

d) Set up valves as in the following table:

No.1+2 Main Generator Engine Starting Air System

Assuming that both compressors are operational, and filling both starting air receivers.

All valves are prefixed with 'TA' unless otherwise stated.

Position	Description	Valve
Open	No.1 starting air compressor discharge valve	001
Open	No.2 starting air compressor discharge valve	002
Operational	Starting air compressor discharge line non-return valve to air receivers	005
Open	No.1 starting air receiver inlet valve	501
Open	No.2 starting air receiver inlet valve	502
Open	No.1 starting air receiver outlet valve	505
Open	No.2 starting air receiver outlet valve	506
Open	No.1 starting air receiver automatic drain trap inlet valve	531
Closed	No.1 starting air receiver automatic drain trap bypass valve	535
Operational	No.1 starting air receiver automatic drain trap outlet valve	543
Open	No.2 starting air receiver automatic drain trap inlet valve	532
Open	No.2 starting air receiver automatic drain trap outlet valve	544
Closed	No.2 starting air receiver automatic drain trap bypass valve	536
Open	No.1+2 staring air receivers outlet line valve	537
Open	No.1 MGE master starting air valve	016
Set	No.1 MGE starting air pressure reducing valve	R-700
Open	No.1 MGE water separator drain valve valve	075
Open	No.2 MGE master starting air valve	017
Set	No.2 MGE starting air pressure reducing valve	R-700
Open	No.2 MGE water separator drain valve valve	076
As required	30/8.0 bar air reducing stations inlet valve	513
Operational	30/8.0 bar air reducing station to control air system	517
As required	30/8.0 bar air reducing stations outlet valve	521
As required	30/8.0 bar air reducing stations inlet valve	514
Operational	30/8.0 bar air reducing station to service air system	518
As required	30/8.0 bar air reducing stations outlet valve	522

e) Check that the starting air compressors are receiving water from the LT cooling FW system and that the circulation is correct.

f) Check that all automatic drain traps are operational and that the unloader gear is functioning.

g) Check that the starting air receiver automatic drains are functioning correctly, and the compressor automatic drains are functioning correctly.

h) Select the air compressors for lead and follow-on duty as required. The lead and follow-on compressor are selected at each engine control console mode switch in the ECR.

i) Drain any liquid from the receivers and oil/water separator.

j) Observe the system for any leaks and remedy as necessary.

The running compressor will operate and supply air to the starting air receivers. Under normal operating conditions, only one air receiver would be in use at any time, with the second receiver fully charged and isolated, but under certain circumstances, both might be opened to ensure that adequate air at the correct pressure is available to meet demand.

The duty engineer needs to assess the rate at which compressed air is being used, and the rate at which the receivers are being replenished.

The starting air receiver high pressure air supply to the control air and service air systems is reduced from 30 bar (435psi) to a working pressure of 8 bar (116psi), the supply to the service air system is only for back-up purposes.

On completion of the valve line-up, the initial start-up of the system will be from a dead ship condition.

When electrical power is established on the main switchboard, the necessary auxiliary systems can be brought into operation, ie, cooling water and fuel, the starting air receivers can be brought up to full charge, and the control air and service air system put into operation.

No.3+4 Main Generator Engine Starting Air System

Assuming that both compressors are operational, and filling both main air receivers. The operational procedure is the same as for No1+2 air systems.

Position	Description	Valve
Open	No.3 starting air compressor discharge valve	201
Open	No.4 starting air compressor discharge valve	202
Operational	Starting air compressor discharge line non-return valve to air receivers	205
Open	No.3 starting air receiver inlet valve	503
Open	No.4 starting air receiver inlet valve	504
Open	No.3 starting air receiver outlet valve	505
Open	No.4 starting air receiver outlet valve	508
Open	No.3 starting air receiver automatic drain trap inlet valve	533
Closed	No.3 starting air receiver automatic drain trap bypass valve	537
Operational	No.3 starting air receiver automatic drain trap outlet valve	545
Open	No.4 starting air receiver automatic drain trap inlet valve	534
Open	No.4 starting air receiver automatic drain trap outlet valve	546
Closed	No.4 starting air receiver automatic drain trap bypass valve	538
Open	No.3+4 staring air receivers outlet line valve	548
Open	No.3 MGE master starting air valve	216
Set	No.3 MGE starting air pressure reducing valve	R-700
Open	No.3 MGE water separator drain valve valve	275
Open	No.4 MGE master starting air valve	217
Set	No.4 MGE starting air pressure reducing valve	R-700
Open	No.4 MGE water separator drain valve valve	276
As required	30/8.0 bar air reducing stations inlet valve	515
Operational	30/8.0 bar air reducing station to control air system	519
As required	30/8.0 bar air reducing stations outlet valve	523
As required	30/8.0 bar air reducing stations inlet valve	516
Operational	30/8.0 bar air reducing station to service air system	520
As required	30/8.0 bar air reducing stations outlet valve	524

WARNING

It is important that the oil level of the air compressors is monitored closely. Excessive consumption of oil could indicate oil carry-over into the air receivers and starting air lines, thus leading to potentially hazardous operating conditions.

Back-up Air Supply for Control and Working Air Systems

There are back-up supply valves from the starting air system to the associated working and control air systems which are normally maintained in the closed position. However, these valves should be operated (opened and closed) once each month to ensure that they remain in operating condition at all times. They are normally only used in an emergency when the associated working/control air compressor/receiver system cannot operate. It is essential that the back-up facility from the associated starting air system is available in such circumstances.

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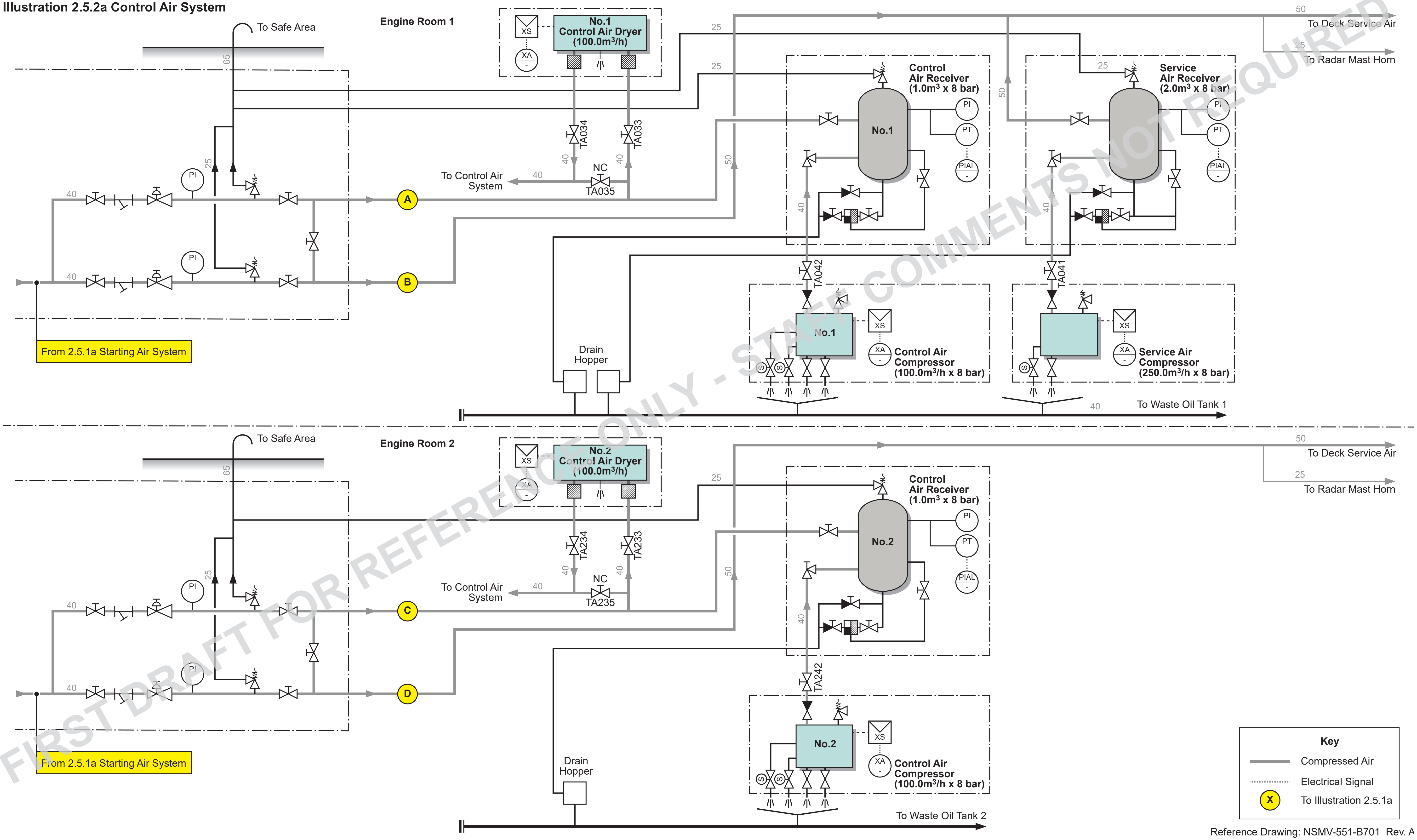
Illustration 2.5.2a Control Air System



Reference Drawing: NSMV-551-B701 Rev. A

2.5.2 CONTROL AIR SYSTEM

Control Air Compressors

Manufacturer:	Atlas Copco
Type:	Screw, water cooled 2 stage
Model:	ZT15-8.6 bar-60
No. of sets:	2
Capacity:	$112m^3/h$ ($3,955ft^3/h$) at 8 bar (116psi)
Motor:	440V, 14.3kW(19kW), 3,540 rpm

Control Air Receivers

Manufacturer:	Kumkang
Type:	Vertical cylindrical
No. of sets:	2
Capacity:	$1.0m^3$ (1,000 litre)
Safety valve setting:	8.8 bar (128psi)

Control Air Dryers

Manufacturer:	Samkun
Model:	MAX-10
Type:	Refrigerated, air cooled
No. of sets:	2
Capacity:	$100m^3/h$ ($3,315ft^3/h$) at 8 bar (116psi)

Introduction

There are two air systems for the production of control air. No.1 system is located in engine room 1, and No.2 system is located in engine room 2. The two systems operate independently from each other, but can be cross-connected by opening valves LA011 and LA211 if there is a failure of a system.

Each system consists of a two stage screw-type air compressor rated at $112m^3/h$ ($3,955ft^3/h$) at a pressure of 8 bar (128psi) in an acoustic cabinet. Each system is fitted with an air cooled control air dryer of the refrigeration type. These units are used to remove moisture from the control air supply.

The control air compressors are normally switched to automatic where they will be started and stopped by a pressure switch located on the compressor outlet manifold. The compressors will start when the pressure in the manifold falls to the load pressure setting (adjustable), and will unload when it has recovered to the unload pressure setting (adjustable), and stop after running offload for the standby run on time. Any alarm and shutdown signals generated are activated through the local controller and relayed to the CAMS.

On leaving the acoustic cabinet, the compressed air enters the respective control air receiver. These air receivers have a capacity of $1m^3$ and are fitted with a low pressure alarm that operates through the CAMS. On the discharge side of the receivers is a refrigerant type air dryer, and a network of pipes that supply the instruments and controllers that need compressed air to operate.

Control air should always be supplied to the end users via the dryers to ensure any entrapped moisture is removed. Moisture in the air can, over a period of time, cause damage to the inside of the control devices, and may result in the devices becoming inoperative, therefore, the dryer should only ever be bypassed in an emergency, and then for as short a period of time as possible. If the dryer is bypassed for any reason, the air lines must be blown through with dry-air as soon as they are operational again.

Control Air Dryers

One control air dryer is fitted downstream of the control air reservoir. The incoming air passes into the dryer, and is cooled by an internal refrigeration system, which primarily comprises an hermetically sealed compressor, a condenser and a water separator filter dryer unit. When the compressor is switched on and running, the temperature of the incoming air is reduced to the dew point temperature which causes any moisture in the air to condense. The condensate is then separated from the air in the moisture separator and is discharged through an auto drain outlet. The evaporated refrigerant is returned to the inlet of the compressor where it compressed again and discharged to the condenser. Here the refrigerant gas is converted to liquid and circulated around the system, allowing the cycle to start again.

To start a dryer, proceed as follows:

a) Confirm electrical power is available to the dryer, and the controller on the front of the enclosure is switched on.

b) Slowly pressurise the unit by opening the compressed air inlet valve. Check for any leaks.

c) After 15 minutes, slowly open the compressed air outlet valve.

d) Switch the dryer to manual or automatic (scheduled) control on the local controller. To operate the dryer manually, use the ON/OFF buttons on the control panel. To allow automatic (scheduled) operation, press the SET/RUN button on the controller.

Air dryers should be operated continuously in order to ensure that all air delivered into the control air system is free from moisture. Control and instrument systems may be damaged by the presence of moisture, and the operation of instruments and control devices can be seriously impaired by the presence of moisture. Air dryers must be operated in accordance with the manufacturer's operating instructions. When shutting down an air dryer, the air outlet valve is closed first, followed by the inlet valve about 2 minutes later.

Although the control air passes through a dryer, it is important that the operator checks the control air pipe system for the presence of water at frequent intervals and drains any water which is present.

Back-up Air Supply for Control Air System

There is a back-up supply valve system from the starting air system to the control air system which is normally maintained in the closed position. However, these valves should be operated (opened and closed) once each month to ensure that they remain in operating condition at all times. They are normally only used in an emergency when the associated control air compressor/receiver system cannot operate. It is essential that the back-up facility from the associated starting air system is available in such circumstances.

Procedure for Operating the Control Air System

Engine Room 1

a) It is assumed that the control air system is operational.

b) Set the control air system valves as in the following tables.

All valves are prefixed 'TA' unless otherwise stated.

Position	Description	Valve
Open	No.1 control air compressor outlet valve	042
Open	No.1 control air receiver inlet valve from compressor	549
Open	No.1 control air receiver outlet valve to consumers	551
Open	No.1 control air receiver drain trap inlet valve	553
Closed	No.1 control air receiver drain trap bypass valve	559
Open	No.1 control air receiver drain valve	561
Open	No.1 control air dryer inlet valve	033
Open	No.1 control air dryer outlet valve	034
Closed	No.1 control air dryer bypass valve	035

Engine Room 2

Position	Description	Valve
Open	No.2 control air compressor outlet valve	242
Open	No.2 control air receiver inlet valve from compressor	550
Open	No.2 control air receiver outlet valve to consumers	552
Open	No.2 control air receiver drain trap inlet valve	554
Closed	No.2 control air receiver drain trap bypass valve	560
Open	No.2 control air receiver drain valve	562
Open	No.2 control air dryer inlet valve	233
Open	No.2 control air dryer outlet valve	234
Closed	No.2 control air dryer bypass valve	235

c) Check the air dryers have an electrical supply and are ready for operation. Ensure that no alarms are present and the system is functioning correctly. Start the air dryers and check the system operation; ensure that water is being drained correctly from the air dryers.

d) The control air system may be operated. Control and instrumentation air valves to machinery equipment should be opened as necessary and should remain in the open position whilst that item of equipment is required for operation. In the table below it is assumed that all users are being supplied with control air.

Back-up Air Supply for Control Air System

There is a back-up supply valve system from the starting air system to the control air system which is normally maintained in the closed position. However, these valves should be operated (opened and closed) once each month to ensure that they remain in operating condition at all times. They are normally only used in an emergency when the associated control air compressor/receiver system cannot operate. It is essential that the back-up facility from the associated starting air system is available in such circumstances.

Back-up Pressure Reducing Valve Engine Room 1

Position	Description	Valve
As required	Pressure reducing valve inlet valve	513
Set	Pressure reducing valve set 30~8 bar	517
As required	Pressure reducing valve outlet valve	521
Closed	Pressure reducing valve bypass valve	529

Back-up Pressure Reducing Valve Engine Room 2

Position	Description	Valve
As required	Pressure reducing valve inlet valve	515
Set	Pressure reducing valve set 30~8 bar	519
As required	Pressure reducing valve outlet valve	523
Closed	Pressure reducing valve bypass valve	530

Control Air Consumers from Engine Room 1 Control Air System

Engine Room 1

All valves are prefixed 'LA' unless otherwise stated.

Position	Description	Valve
Closed(NC)	System 1/System 2 cross connection valve	011
Open(NO)	QCV air bottle filling valve	001
Open	BWTS air supply valve	012
As required	Fire hydrophore unit air filling valve	014
Open	No.1+2 LT FW coolers temperature control valve	005
Open	No.1+2 MGE JCFW cooling temperature control valve	006
Open(LO)	No.1+2 MGE FO inlet emergency closing valves	010
Open	No.1+2 MGO purifiers emergency closing valves	007
As required	Distilled water hydrophore unit air filling valve	015

Auxiliary Machinery Room 4

Position	Description	Valve
Open	HVAC HW temperature control valve for FZ 3	603

Auxiliary Machinery Room 3

Position	Description	Valve
Open	HVAC HW temperature control valve for FZ 1+2	552
As required	Potable water hydrophore unit air filling valve	551
Open	Auxiliary machinery room 3 isolating valve	550

Auxiliary Machinery Room 2

Position	Description	Valve
As required	Potable water hydrophore unit air filling valve	502

Auxiliary Machinery Room 1

Position	Description	Valve
As required	Drain valve	451
Open	Auxiliary machinery room 1 isolating valve	550

Bow Thruster Room

Position	Description	Valve
Open	Bow thruster room isolating valve	452
Closed(NC)	Inflatable ring isolating valve	455

Engine Room 2

Position	Description	Valve
Closed(NC)	System 1/System 2 cross connection valve	211
Open(NO)	QCV air bottle filling valve	201
Open	No.3+4 LT FW coolers temperature control valve	205
Open	No.3+4 MGE JCFW cooling temperature control valve	206
Open(LO)	No.3+4 MGE FO inlet emergency closing valves	210
Open	No.3+4 MGO purifiers emergency closing valves	207

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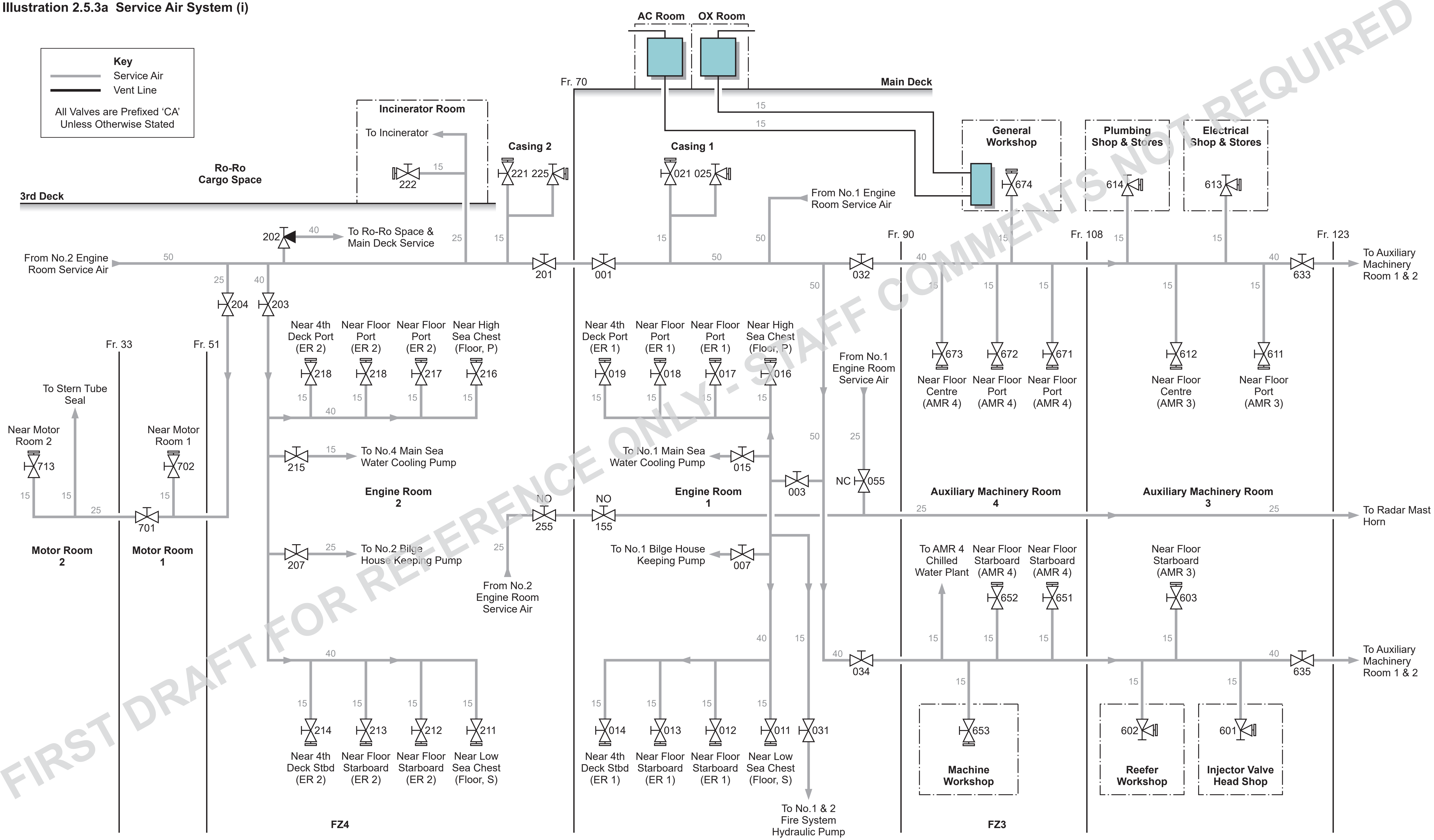
Illustration 2.5.3a Service Air System (i)



Reference Drawing: NSMV-551-B701, Rev.3

2.5.3 SERVICE AIR SYSTEM

Service Air Compressor

Manufacturer:	Atlas Copco
Type:	Screw, air cooled single stage
Model:	MAS 30-125-60
No. of sets:	1
Capacity:	325m³/h (11,477ft³/h) at 8 bar (116psi)
Motor:	440V, 35.1kW(47hp), 3,565 rpm

Service Air Reservoir

Manufacturer:	Kumkang
Type:	Vertical cylindrical
No. of sets:	2
Capacity:	2.0m³ (2,000 litre)
Safety valve setting:	8.8 bar (128psi)

Introduction

The working air system is supplied with air from an electrically-driven air cooled screw compressor mounted inside an acoustic cabinet.

Only one compressor has been fitted, therefore, air from the starting air system can be used to supply the service air system if required from 30 bar to 8 bar pressure reducing valve units TA518/20 located in each engine room; this facility would normally only ever be used if the service air compressor was unavailable for use.

The service air compressor is driven by an electric motor with a direct driveto the compressor. The air flows from the engine room into the acoustic cabinet in which the compressor is housed, and into a suction filter. The air then passes through a remotely operated valve into the suction side of the compressor where the rotors operate to compress the air. The compressor unloading relief valve closes and the suction valve opens during start-up and the reverse occurs when the upper pressure set point has been reached. The compressed air then passes into a tank under the compressor in which approximately 98% of the oil contained in the air is removed. The air then passes through an air de-oiling filter which further reduces the remaining oil in the air. After this the air passes through an after-cooler and then leaves the acoustic cabinet via the compressed air outlet. The after-cooler and an oil cooler mounted inside the acoustic cabinet, are air cooled.

The compressor is normally switched to automatic where it will be started and stopped by a pressure switch located on the compressor's outlet manifold.

On leaving the acoustic cabinet, the air enters the service air reservoir which has a capacity of 2m³ and is fitted with a low pressure alarm that operates through the CAMS when activated. On the discharge side of the reservoir is a distribution network to supply service air around the engine room and out on deck. The working air reservoir is protected from being over-pressurized by a relief valve set to operate at 8.8 bar (128psi).

Operating the Service Air System

a) Check all pressure gauge and instrumentation root valves are open and confirm the instruments are reading correctly.

b) Check the oil level in the service air compressor and replenish with oil of the correct grade as necessary.

c) Set the system valves in accordance with the following table. The end user valves are mostly shown as being closed, but in practice, they will be opened and closed for use as required.

Service Air Compressor

All valves are prefixed 'TA' unless otherwise stated.

Position	Description	Valve
Open	Service air compressor discharge valve	041
Open	Service air receiver inlet valve	563
Open	Service air receiver outlet valve	564
Open	Service air receiver drain trap inlet valve	566
Closed	Service air receiver drain trap bypass valve	567
Open	Service air receiver drain valve	569

Back-up Air Supply for Service Air System

There is a back-up supply valve system from the starting air system to the service air system which is normally maintained in the closed position. However, these valves should be operated (opened and closed) once each month to ensure that they remain in operating condition at all times. They are normally only used in an emergency when the associated control air compressor/receiver system cannot operate. It is essential that the back-up facility from the associated starting air system is available in such circumstances.

Back-up Pressure Reducing Valve Engine Room 1

Position	Description	Valve
As required	Pressure reducing valve inlet valve	513
Set	Pressure reducing valve set 30~8 bar	517
As required	Pressure reducing valve outlet valve	521
Closed	Pressure reducing valve bypass valve	529

Back-up Pressure Reducing Valve Engine Room 2

Position	Description	Valve
As required	Pressure reducing valve inlet valve	516
Set	Pressure reducing valve set 30~8 bar	520
As required	Pressure reducing valve outlet valve	524
Closed	Pressure reducing valve bypass valve	530

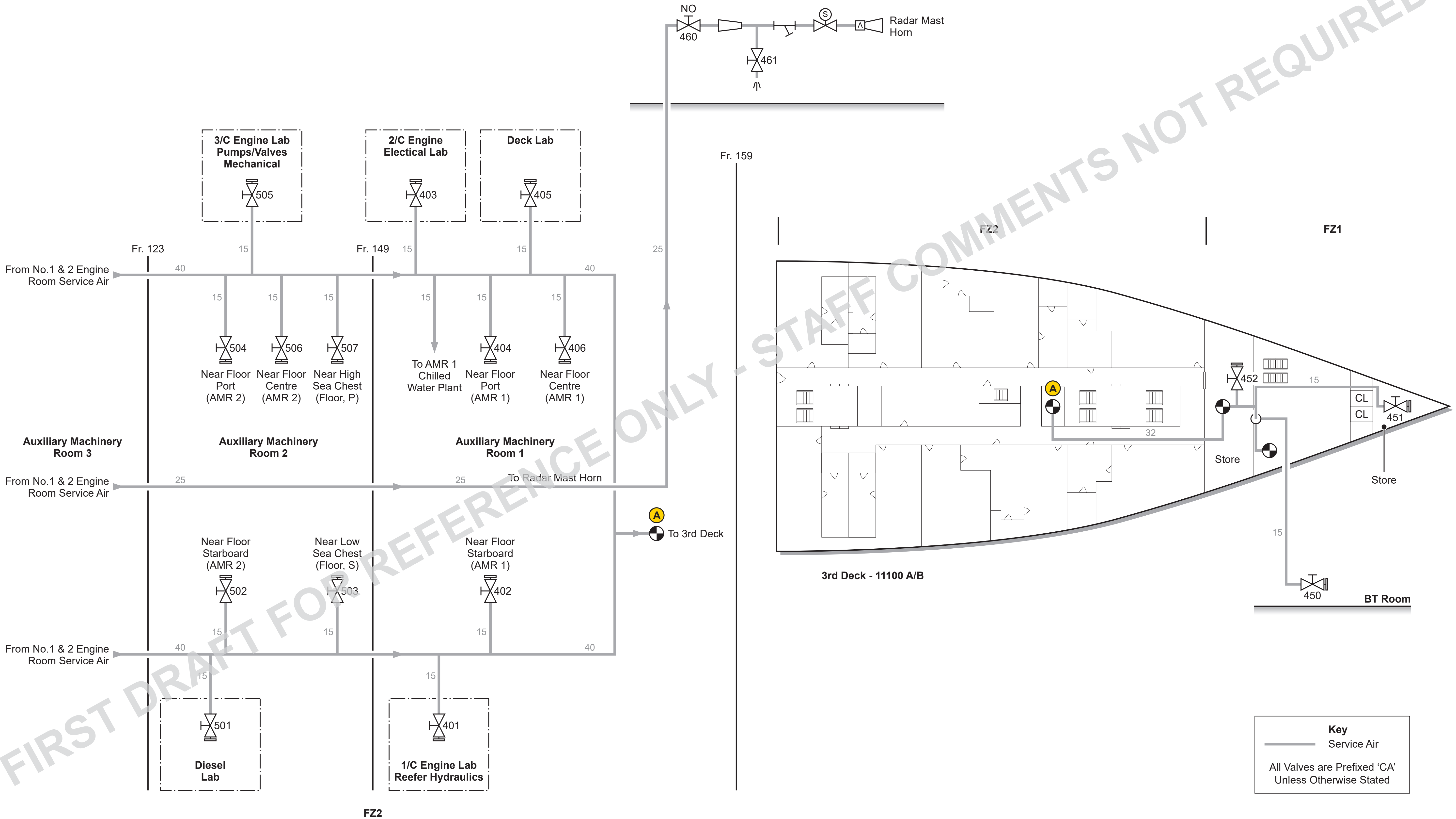
Service Air Distribution System for Engine Room Hose Connections

The service air system supplies the following hose valve connections, the vales of which will remain closed when not in use:

All valves are prefixed 'CA' unless otherwise stated.

Description of Service	Valve
Near motor room 1	702
Near motor room 2	713
Near high sea chest floor (P)	216
Near floor (P) x 2 ER2	217/8
Near 4th deck (P) ER2	219
Near low sea chest floor (S)	211
Near floor (S) x 2 ER2	212/3
Near 4th deck (S) ER2	214
In incinerator room	222
Engine casing 2 x 2(FZ4)	221/5
Engine casing 1 x 2(FZ3)	021/5
Near high sea chest floor (P)	016
Near floor (P) x 2 ER1	017/8
Near 4th deck (P) ER1	019
Near low sea chest floor (S)	011
Near floor (S) x 2 ER1	012/3
Near 4th deck (S) ER1	014
Near floor (P) x 2 AMR4	671/2
Near floor (C) AMR4	673
General workshop	674
Near floor (P) AMR3	611
Near floor (C) AMR3	612
Electrical shop and stores	613
Plumbing shop and stores	614
Machine shop	653
Near floor (S) x 2 AMR4	651/2
Injector valve head shop	601
Reefer shop.	602
Near floor (S) AMR3	603

Illustration 2.5.3b Deck Service Air System (ii)



Reference Drawing: NSMV-551-B701, Rev.3

Description of Service	Valve
Diesel lab.	501
Near floor (S) AMR2	502
Near low sea chest floor (S)	503
Near floor (P) AMR2	504
3/C engine lab. pumps/valves mechanical	505
Near floor (C) AMR2	506
Near high sea chest floor (P)	507
1/C engine lab.	401
Near floor (P) AMR1	402
2/C engine electical lab	403
Near floor (P) AMR1	404
Deck lab.	405
Near floor (C) AMR1	406
Bow thruster room	450
Engine casing 2 01 level(P)	737
Engine casing 2 02 level(S)	738
Engine casing 2 03 level(P)	739
Engine casing 2 04 level(S)	740
Engine casing 2 05 level(P)	741

Note: AMR= Auxiliary Machinery Room

Other Service Air Systems

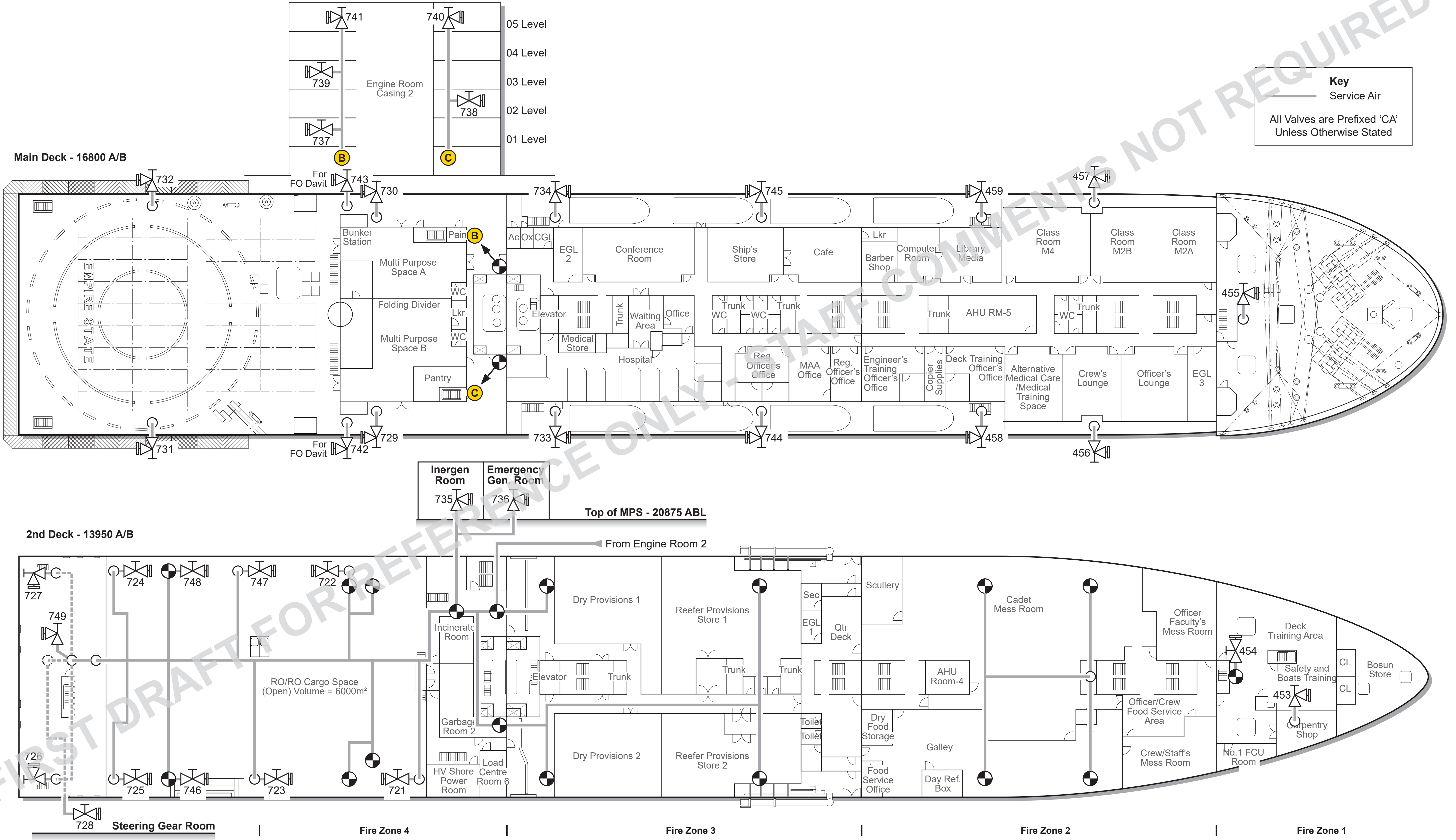
All valve are assumed to be open unless otherwise advised

Description	Valve
Stern tube seal inlet valve	
Incinerator	
Isolation valve to ro-ro space and main deck services	202
To No.1 bilge house keeping pump	007
To No.2 bilge house keeping pump	207
To No.1 main sea water cooling pump	015
To No.4 main sea water cooling pump	215
To No.1+2 fire system hydraulic pumps	031
To radar mast horn (NO)	460
To chilled water plant	CF033/73

Note: The service air reservoir should be maintained at its full working pressure at all times, but should the air consumption be very high, or if the service air compressor is unavailable for working, the pressure reducing valves from the starting air system can be opened. Care must be exercised when doing this to ensure the starting air system is not depleted to the point where insufficient air remains to allow an immediate start of a main or auxiliary diesel generator engine.

Note: It is important that all of the reducing valves used throughout the compressed air systems are correctly set and the set points are not changed.

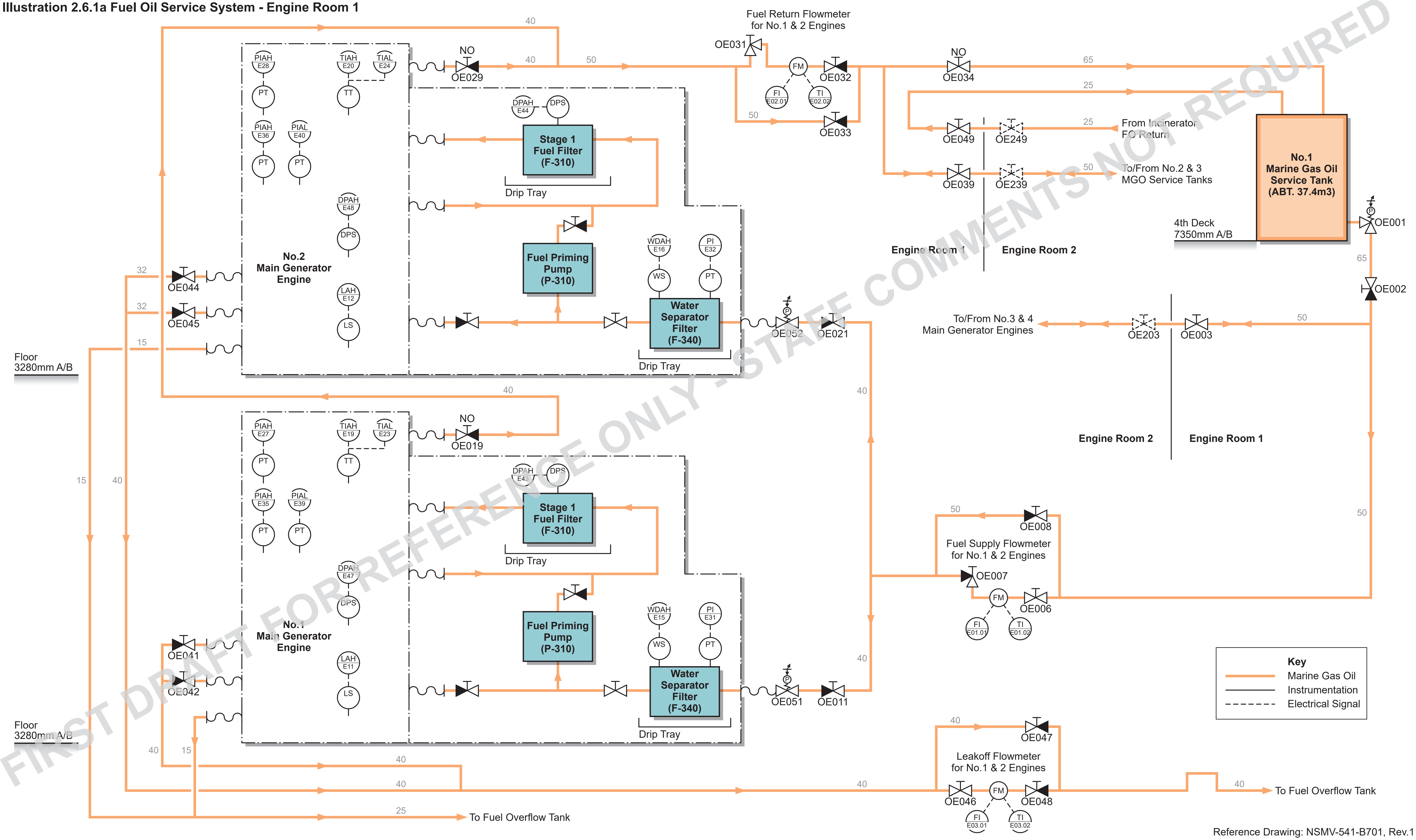
Illustration 2.5.3c Deck Service Air System - Main Deck and 2nd Deck



Reference Drawing: NSMV-551-B701, Rev.3

2.6 Fuel Oil Systems

Illustration 2.6.1a Fuel Oil Service System - Engine Room 1



Reference Drawing: NSMV-541-B701, Rev.1

2.6 FUEL OIL SYSTEMS

2.6.1 DIESEL GENERATOR FUEL OIL SYSTEM

Introduction

There are four Main Generator Engines (MGEs) fitted on the ship. They operate on MGO.

Each MGE pair (No.1 and No.2 in ER1, and No.3 and No.4 ER2) have independent fuel oil supply systems that are fed from MGO service tanks No1, 2, and 3.

Each generator pair FO supply system is fed by gravity from the MGO service tanks, which are in turn filled by the MGO separators, which take suction from the MGO settling tanks.

Each system comprises the following equipment:

- One fuel oil supply flow meter with bypass for each engine pair.
- One fuel oil return flow meter with bypass for each engine pair.
- One fuel oil leak-off flow meter with bypass for each engine pair.
- One water separator filter for each MGE.
- One stage 1 fuel filters for each MGE.
- One stage 2 fuel filters for each MGE.

MGO is drawn from an MGO service tank by gravity via a quick-closing valve on the tank outlet. These quick-closing valves can be operated from the QCV panel in emergency gear locker 2. The fuel then flows towards the MGEs through a flow meter for each engine pair, a water separator, LP FO pump, stage 1 filter, stage filter, then to the HP FO pumps. A return FO pressure regulator set to 115psi returns excess MGO back to the MGO service tank via a return FO flowmeter.

The MGEs are supplied with excess MGO to cater for changes in fuel demand due to increased electrical load. Excess fuel spilling back from each engine is returned to the MGO service tank.

The main fuel injection pumps take their suction from an engine mounted stage No.2 filter. The MGO is then directs the pressurised fuel to the injectors via the HP FO pumps. The HP FO lines on the MGEs are sheathed, and any leakage into the annular spaces is led to a FO gravity drain tank. The drain line to this tank is fitted with a leak detector. This gives warning of a leaking injector pipe. The drains from the leak tanks go to the FO overflow tank via a flow meter.

The main fuel oil inlet line to each engine is fitted with a quick-closing valve that can be tripped remotely from the fire control station.

Operating the Main Generator Engine Fuel Oil System

Preliminary checks will be common to both FO systems as follows.

a) Confirm the FO suction filters are all clean, and ready for operation.

b) Confirm all instrumentation valves are open, and the instruments are working correctly.

c) Check the drains on the MGO service tank to be used, for water and sludge. assume No.1 MGO service tank is to be used.

d) Set the system valves in accordance with the following tables:

Engine Room 1 Fuel Oil System for No.1+No.2 MGEs

Assume No.1 MGO service tank is to be used.
All valves are prefixed with 'OE' unless otherwise stated.

Position	Description	Valve
Open	No.1 MGO service tank quick-closing outlet valve	001
Open	No.1 MGO service tank line valve to MGEs	002
Open	MGO bulkhead supply valves between ER1/ER2 to/from No.3/4 MGEs	003/203
Open	MGO supply flowmeter inlet valve	006
Open	MGO supply flowmeter outlet valve	007
Closed	MGO supply flowmeter bypass valve	008
Open	No.1 MGE MGO supply valve	011
Set	No.1 MGE MGO emergency shut off valve	051
Open (NO)	No.1 MGE MGO return valve to MGO tanks	019
Open	No.1 MGE MGO leak off valves	041/2
Open	MGO leak off flowmeter inlet valve	046
Closed	MGO leak off flowmeter bypass valve	047
Open	MGO leak off flowmeter outlet valve	048
Open	No.2 MGE MGO supply valve	021
Set	No.2 MGE MGO emergency shut off valve	052
Open (NO)	No.2 MGE MGO return valve to MGO tanks	029
Open	No.2 MGE MGO leak off valves	044/5
Open	MGO return flowmeter inlet valve	031
Open	MGO return flowmeter outlet valve	032
Closed	MGO return flowmeter bypass valve	033
Open (NO)*	MGO return valve to No.1 MGO service tank	034

Note: * Valve not to be closed whilst an MGE is running.

Engine Room 2 Fuel Oil System No.3+No.4 MGEs

Assume No.2 MGO service tank is to be used.

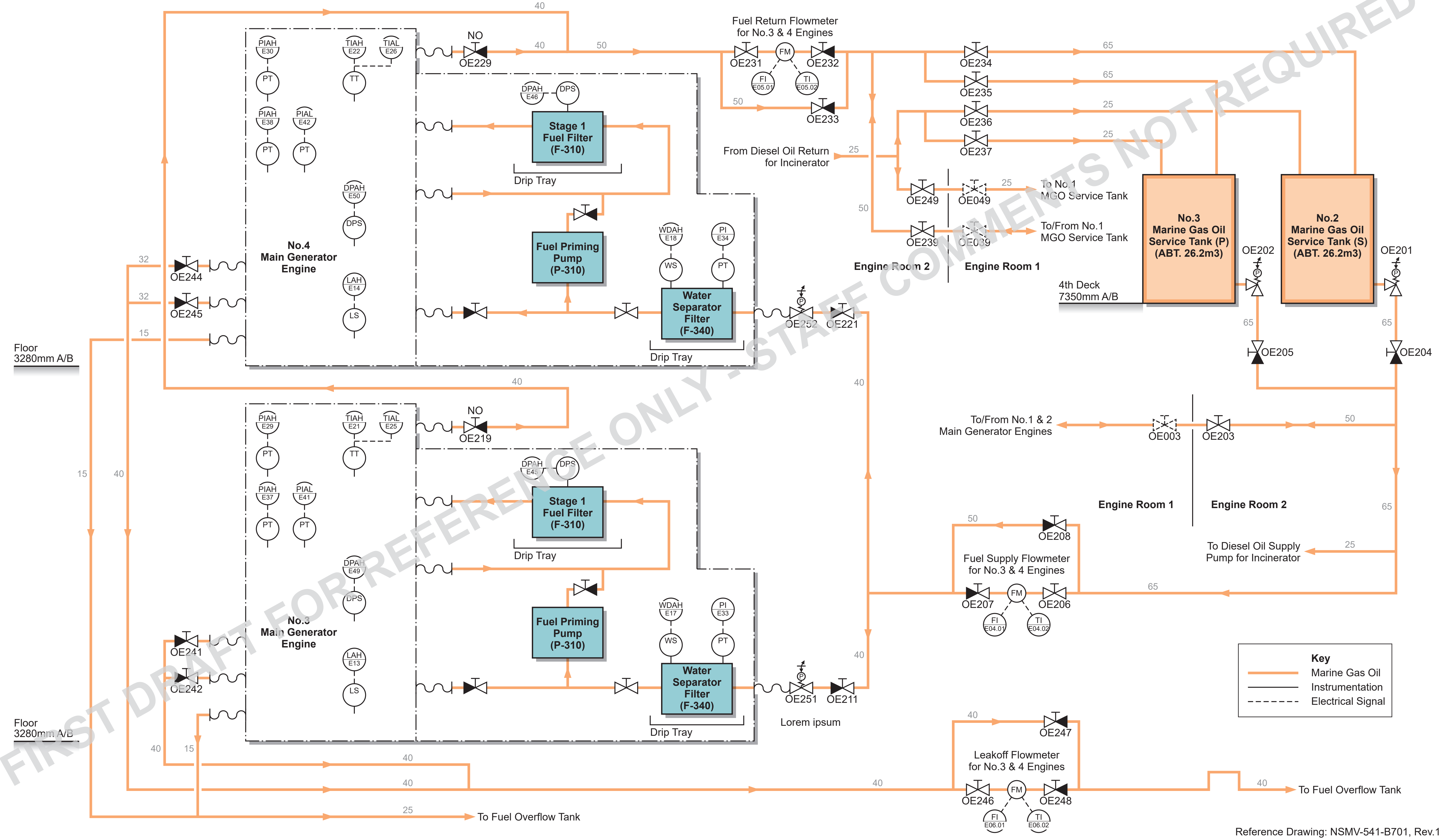
Position	Description	Valve
Open	No.2 MGO service tank quick-closing outlet valve	201
Closed	No.3 MGO service tank quick-closing outlet valve	202
Open	No.2 MGO service tank line valve to MGEs	204
Closed	No.3 MGO service tank line valve to MGEs	205
Open	MGO bulkhead supply valves between ER1/ER2 to/from No.3/4 MGEs	003/203
Open	MGO supply flowmeter inlet valve	206
Open	MGO supply flowmeter outlet valve	207
Closed	MGO supply flowmeter bypass valve	208
Open	No.3 MGE MGO supply valve	311
Set	No.3 MGE MGO emergency shut off valve	251
Open (NO)	No.3 MGE MGO return valve to MGO tanks	219
Open	No.3 MGE MGO leak off valves	241/2
Open	MGO leak off flowmeter inlet valve	246
Closed	MGO leak off flowmeter bypass valve	247
Open	MGO leak off flowmeter outlet valve	248
Open	No.4 MGE MGO supply valve	221
Set	No.4 MGE MGO emergency shut off valve	252
Open (NO)	No.4 MGE MGO return valve to MGO tanks	229
Open	No.4 MGE MGO leak off valves	244/5
Open	MGO return flowmeter inlet valve	231
Open	MGO return flowmeter outlet valve	232
Closed	MGO return flowmeter bypass valve	233
Open*	MGO return valve to No.2 MGO service tank	234
Open*	MGO return valve to No.3 MGO service tank	235

Note: * Valve not to be closed whilst an MGE is running.

Marine Gas Oil Operation

Operating the MGEs on MGO, close attention must be paid to pipe connections, seals, and mechanical seals. Vulnerable points in the supply system are more susceptible to fuel leaks when using a fuel oil grade with a reduced viscosity. The refinery process of removing sulfur from fuels, such as MGO, reduces the natural lubricity of the oil which can therefore cause a lack of lubrication between the barrel and plunger within the fuel pump, leading to excessive friction and elevated internal temperatures.

Illustration 2.6.1b Fuel Oil Service System - Engine Room 2



Reference Drawing: NSMV-541-B701, Rev.1

2.6.2 EMERGENCY DIESEL GENERATOR FUEL OIL SYSTEM

Introduction

The Emergency Diesel Generator (EDG) uses MGO stored in the EDG service tank which has a capacity of $11.0m^3$, and is located in the emergency generator room starboard side above multi purpose space. It is filled by No.2 MGO transfer pump through valve OP351. The tank is fitted with low level alarm set at 50% tank level, and a high level alarms set at 90% tank level. If the tank is overfilled, the overflow is in to an overflow coaming of capacity of 1 barrel.

The service tank is also fitted with a local gauge glass, and a self-closing ‘sludge’ cock for draining water that may have settled out from the MGO over a period of time. This drains to the separated waste oil tank No.2 via normally closed drain valve OP304.

The connection from the service tank to the EDG is fitted with a quick-closing valve OP301 that can be operated remotely by a pull wire from outside the generator room in the event of an emergency. If tripped, the valve must be manually reset before the engine can be operated. It is important this valve is opened again, and the system vented and primed immediately after being tripped to allow the engine to start automatically in the event of mains power failure.

Preparing the Emergency Diesel Generator Engine Fuel Oil System

a) Check the quantity of fuel oil in the EDG MGO service tank and replenish as necessary.

b) Sludge the service tank using valves OP302/3 to remove any water that may be present. Sludging the service tank should be done before the engine is started on test, and the day after the tank has been replenished.

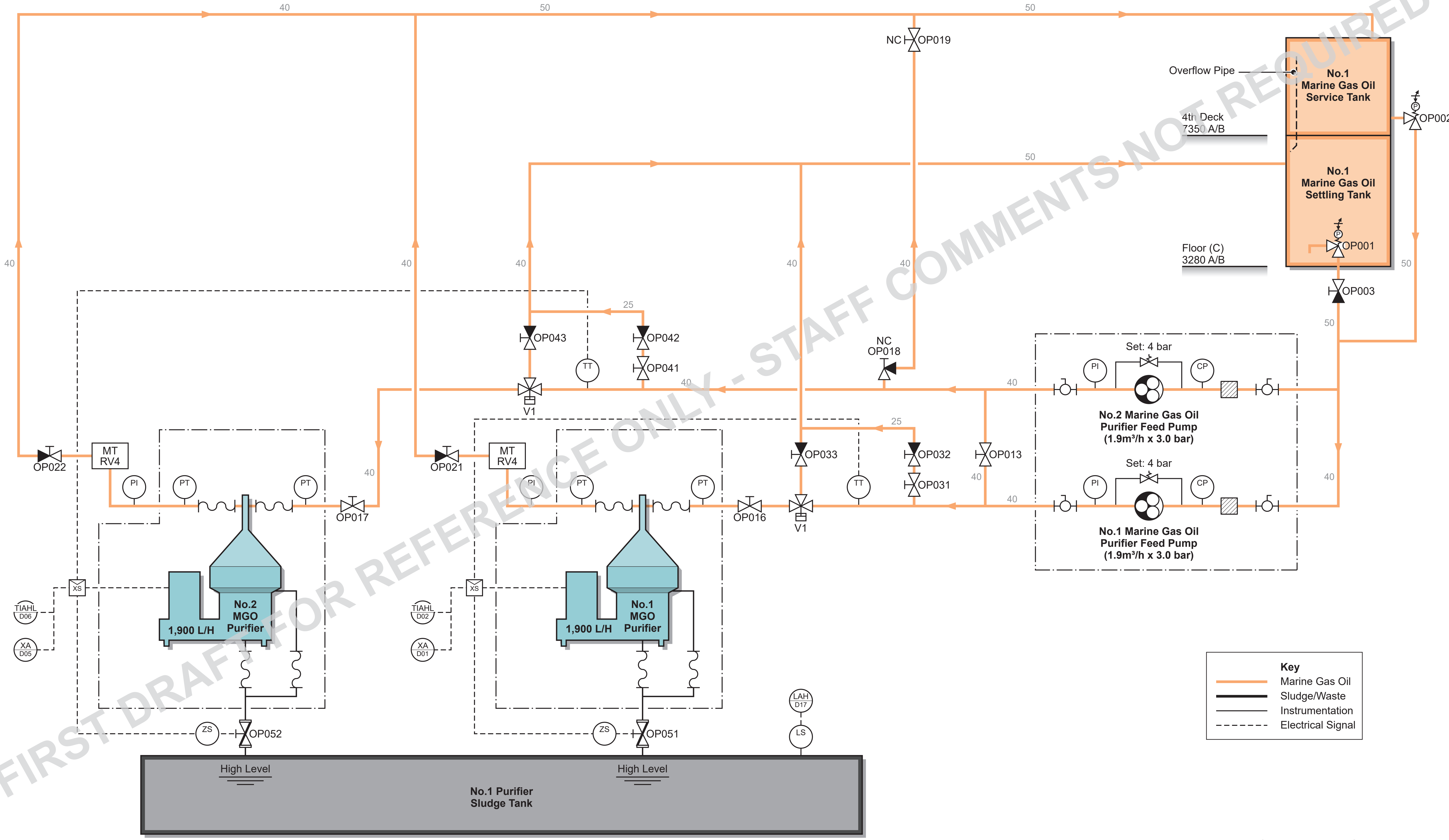
c) Check the condition of the duplex fuel oil filters at the engine inlet. Ensure the standby filter is clean and ready for use.

d) Confirm the emergency generator service tank quick-closing outlet valve OP981 is open.

e) Check the engine fuel system is primed and any engine-mounted fuel oil supply and return valves on the engine are open. These are normally left open when the engine is stopped. The engine’s fuel oil system is now ready for operation.

II

Illustration 2.6.3a Fuel Oil Purifier System - Engine Room 1



Reference Drawing: NSMV-541-B702, Rev.1

2.6.3 MARINE GAS OIL PURIFYING SYSTEM

Marine Gas Oil Separator

Manufacturer:	Alfa Laval
Model:	S805
Type:	Centrifugal self-cleaning, disc type, belt drive
No. of sets:	4
Capacity:	1,900 litres/h
Bowl speed:	9,307 rpm
Operating water:	2 to 8 bar (29~116psi)
Motor:	440V, 2.5kW(3.35hp), 3,600 rpm
Control Unit:	EPC 60

Marine Gas Oil Separator Supply Pumps

Manufacturer:	IMO
Type:	Horizontal screw
Model:	T4V 025N3 NTBP 80 001
No. of sets:	2 (2 pumps/set)
Capacity:	2.24m^3/h (79.1ft^3/h) at 3 bar (43.5psi)
Motor:	440V, 1.28kW(1.7hp), 1,740 rpm

Introduction

There are four centrifugal self-cleaning MGO separators, each separator is equipped with a supply pump and filter. No.1 + No.2 MGO separators are located in ER1, and No.3 + No.4 MGO separators are located in ER2. This arrangement allows for independent fuel systems for ER1 and ER2.

Instrument air is supplied to the separators to control the supply of oil to the bowl and the automatic discharge facility. Fresh water is supplied for sealing and flushing purposes.

The MGO separators draw from the MGO settling tanks, the cleaned MGO is processed, and returned to the MGO service tanks. The MGO service tanks overflow to the MGO settling tanks. The separator throughput should be set to match the fuel consumption in the MGEs.

Separator Operation

Liquid mixtures and solid/liquid mixtures can be separated by two methods, the gravity field of a settling tank or the centrifugal field of a separator bowl. Both systems rely on the product components having different densities. Since the centrifugal force of a separator is considerably more effective than the gravity field of a settling tank, the centrifugal force method is used.

The MGO enters the separator, and the centrifugal force created by the rotating bowl causes the liquid mixture to separate into its different constituents within the disc stack. The solid particles suspended in the oil settle on the underside of the discs, and slide down into the solids holding space at the periphery of the bowl. The smooth disc surfaces allow the solids to slide down, and provide self-cleaning of the discs.

Being of the self-cleaning type, the accumulated solids within the holding space are ejected at predetermined intervals depending on the quality of the oil. The cleaning cycle is achieved automatically; a number of control valves act to allow the oil to bypass the separator, and to open the bowl for a set time.

Separator Control System

The separation system is operated automatically by the EPC 60 controller. The MGO is fed continuously to the separator, which is driven by an electric motor via a friction clutch and belt.

The separator bowl is fixed at the top of a spindle, which is supported by bearings and special composite springs. During operation, separated sludge and water accumulate at the bowl periphery and are intermittently discharged to the sludge tank.

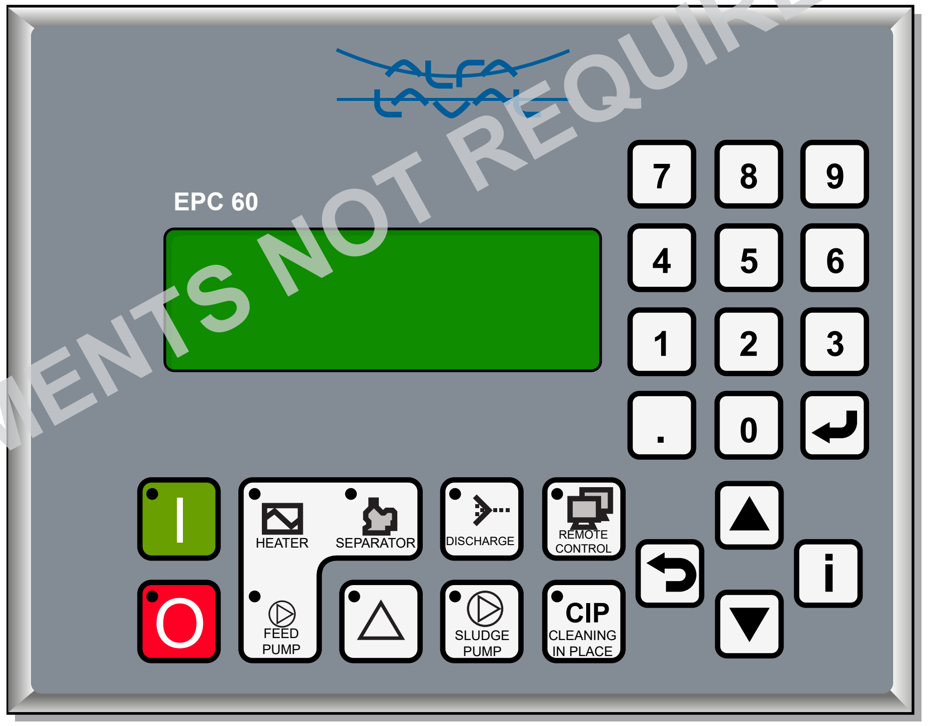
The separator's operation automatically adjusts to the nature of the oil. No gravity disc is needed. A water transducer in the clean oil outlet measures capacitative resistance and signals changes to the EPC 60 controller.

Depending on the water content, the EPC 60 either opens the drain valve or expels the water through the bowl discharge ports during sludge discharge. A patented paring tube adapts itself to remove the water from the bowl while a paring disc pumps away the clean oil.

During normal operation, vital process parameters are monitored. These parameters, as well as alarms, are indicated by easy-to-understand text messages on the LCD display of the EPC 60 controller. The EPC 60 controller provides many alarm functions, including alarms for low oil pressure, high sludge tank level and power failure.

The MGO separators require compressed air and fresh water supplies for control and bowl operation/flushing. Supply systems for these are covered in the relevant control air system and fresh water sections of this manual. Each separatorseparator

Illustration 2.6.3b EPC60 Separator Control Panel



Marine Gas Oil Separator System

The MGO is drawn from an MGO settling tank by a supply pump, then enters a separator. The processed MGO is then discharged to an MGO service tank.

Operating the Marine Gas Oil Separator

Preliminary checks will be common to both FO separating systems as follows.

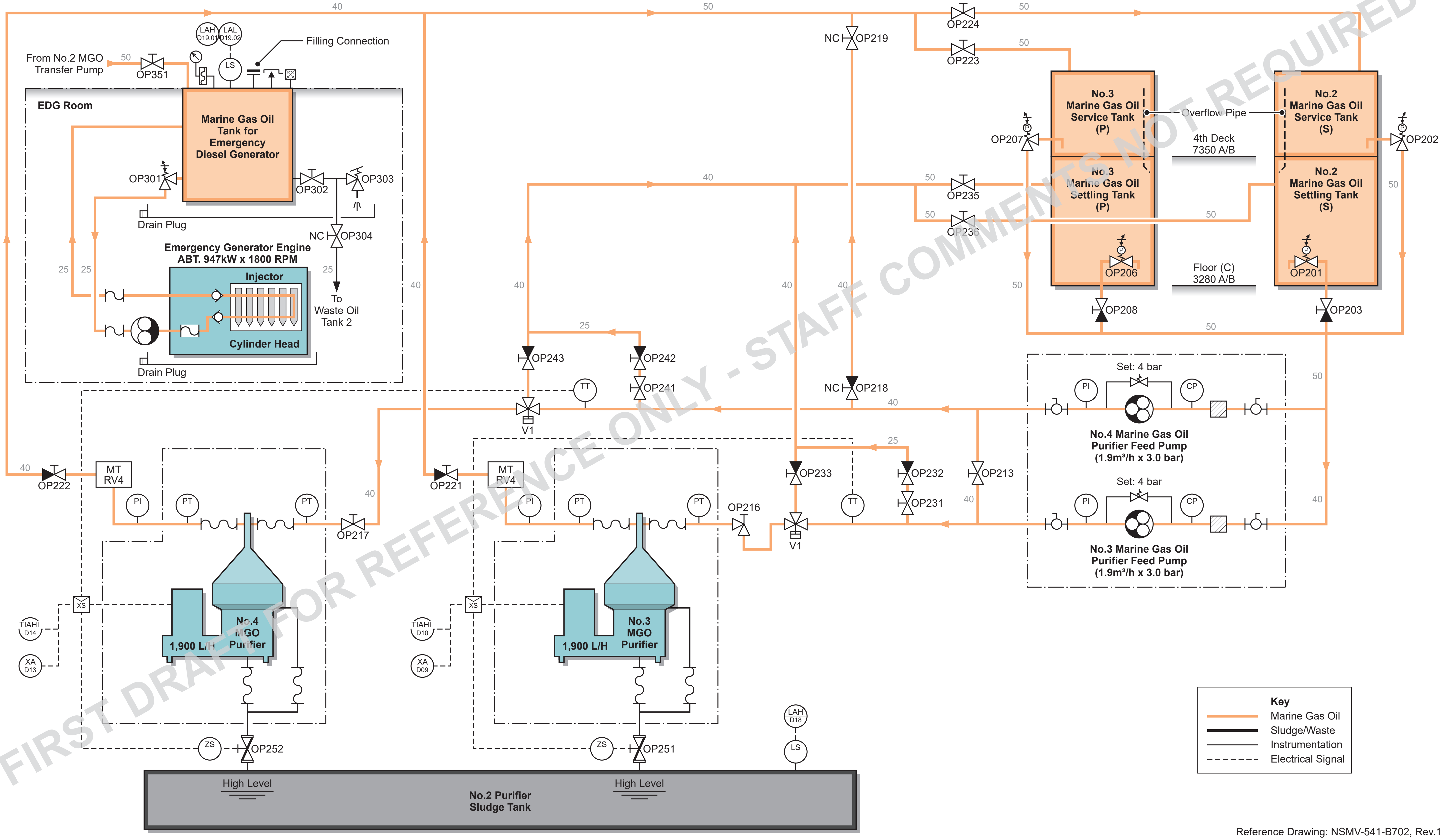
a) Confirm the FO suction filters are all clean, and ready for operation.

b) Confirm all instrumentation valves are open, and the instruments are working correctly.

c) Check the drains on the MGO settling tank to be used, for water and sludge

d) Set the system valves in accordance with the following tables:

Illustration 2.6.3c Fuel Oil Purifier System - Engine Room 2



Reference Drawing: NSMV-541-B702, Rev.1

Engine Room 1 Fuel Oil System for No.1+No.2 MGEs

a) All valves in the separator system are to be initially closed.

b) Clean the separator feed pump filter.

c) Set the valves as in the table below.

Assume No.1 MGO settling tank is to be purified into No.1 MGO service tank. All valves are prefixed with 'OP' unless otherwise stated.

Position	Description	Valve
Tank and Feed Pump Valves		
Open	No.1 MGO settling tank quick-closing suction valve	001
Closed	No.1 MGO service tank quick-closing suction valve	002
Open	No.1 MGO settling tank line suction valve	003
Open	No.1 MGO purifier feed pump suction/delivery valves	
Closed	No.2 MGO purifier feed pump suction/delivery valves	
Closed	No.1/2 MGO purifier feed pumps crossover valve	013
Closed*	Transfer valves from No.1 MGO settling to No.1 MGO service tank	018/9
Note:* Valves only to be opened when separator is unavailable.		
Separator System Valves		
Open	No.1 MGO separator inlet valve	016
Set	No.1 MGO separator flow control valves	031/2
Open	No.1 MGO separator recirc.valve to No.1 MGO settling tank	033
Operational	No.1 MGO separator 3-way control valve	V1
Open	No.1 separator clean outlet non-return valve	RV4
Open	No.1 MGO separator purfied oil outlet valve	021
Open	No.1 separator sludge discharge valve	051

Engine Room 2 Fuel Oil System for No.3+No.4 MGEs

a) All valves in the separator system are to be initially closed.

b) Clean the separator feed pump filter.

c) Set the valves as in the table below.

Assume No.2 MGO settling tank is to be purified into No.2 MGO service tank. All valves are prefixed with 'OP' unless otherwise stated.

Position	Description	Valve
Tank and Feed Pump Valves		
Open	No.2 MGO settling tank quick-closing suction valve	201
Closed	No.2 MGO service tank quick-closing suction valve	202
Open	No.2 MGO settling tank line suction valve	203
Closed	No.3 MGO settling tank quick-closing suction valve	206
Closed	No.3 MGO service tank quick-closing suction valve	207
Closed	No.3 MGO settling tank line suction valve	208
Open	No.3 MGO purifier feed pump suction/delivery valves	
Closed	No.4 MGO purifier feed pump suction/delivery valves	
Closed	No.3/4 MGO purifier feed pumps crossover valve	213
Closed*	Transfer valves from No.2/3 MGO settling tanks to No.2/3 MGO service tanks	218/9
Note:* Valves only to be opened when separator is unavailable.		
Separator System Valves		
Open	No.3 MGO separator inlet valve	216
Closed	Purified MGO valve to No.3 MGO service tank	223
Open	Purified MGO valve to No.2 MGO service tank	224
Set	No.3 MGO separator flow control valves	231/2
Open	No.3 MGO separator recirc.valve to No.2/3 MGO settling tanks	233
Closed	No.3/4 MGO separators recirculation valve to No.3 MGO settling tank	235
Open	No.3/4 MGO separators recirculation valve to No.2 MGO settling tanks	236
Operational	No.3 MGO separator 3-way control valve	V1
Open	No.3 separator clean outlet non-return valve	RV4
Open	No.3 MGO separator purified oil outlet valve	221
Open	No.3 separator sludge discharge valve	251

CAUTION
Before operating a separator, a second check must be made to ensure that the correct valves are open for the separator, and pump to be operated, as well as the MGO tank system.

Note: The MGO separators are fitted with an electrical interlock that will prevent them from being started if the separator discharge valve to the sludge tank is closed.

The separator regulating inlet valve should be set for the desired flow rate and should not be adjusted during normal running conditions.

Operation of No.2 and No.4 MGO separators will be the same as the procedures above except for the valve numbering.

For Both Separator System:

d) Ensure that the separator bowl has been assembled correctly and that the bowl and cover are secure.

e) Check that the separator bowl is free to rotate.

f) Confirm that the separator gearbox oil level is correct.

g) Start the feed pump. The oil flow can be read from the panel display. If necessary, set the desired flow by means of the regulating valve.

Prepare for separation using the EPC 60 controller, set the control mode on the separator local group started panel to the EPC 60 position.

h) When all of the questions have been answered on the control panel LCD screen display, start the separator.

When the separator is at full speed, 'Standby' will be shown on the operator panel display.

i) When the separator has reached the correct speed, start the separation process.

j) Operating information may be displayed for various parameters by pressing the + pushbutton until the desired parameter is shown on the display.

Automatic Operation

The system can be run automatically after the first manual start-up. For automatic operation, the steps below are carried out.

k) Select automatic mode.

l) At the operator panel, start the separation process.

m) Answer the questions indicated on the display by pressing the + pushbutton for YES or the - pushbutton for NO.

n) When the questions have been answered satisfactorily, an automatic system calibration is carried out, and when this is successful, the separation process will start and run automatically.

Note: The manufacturer's manual covering the operation of the separation system must be consulted regarding operation of the system and the operator panel display parameters. No part of the operating control system or the parameters must be changed without good reason, consulting the manual and the authority of the engineer officer in charge.

Stopping a Separator

a) Stop the system by pressing the Separation STOP pushbutton on the EPC 60 operator panel. The stop sequence is initiated and a bowl sludge discharge initiated.

The separator will commence the shutdown sequence.

b) On completion of the stop sequence, isolate the separator electrically if it is to be dismantled for cleaning.

c) Shut off the water supplies.

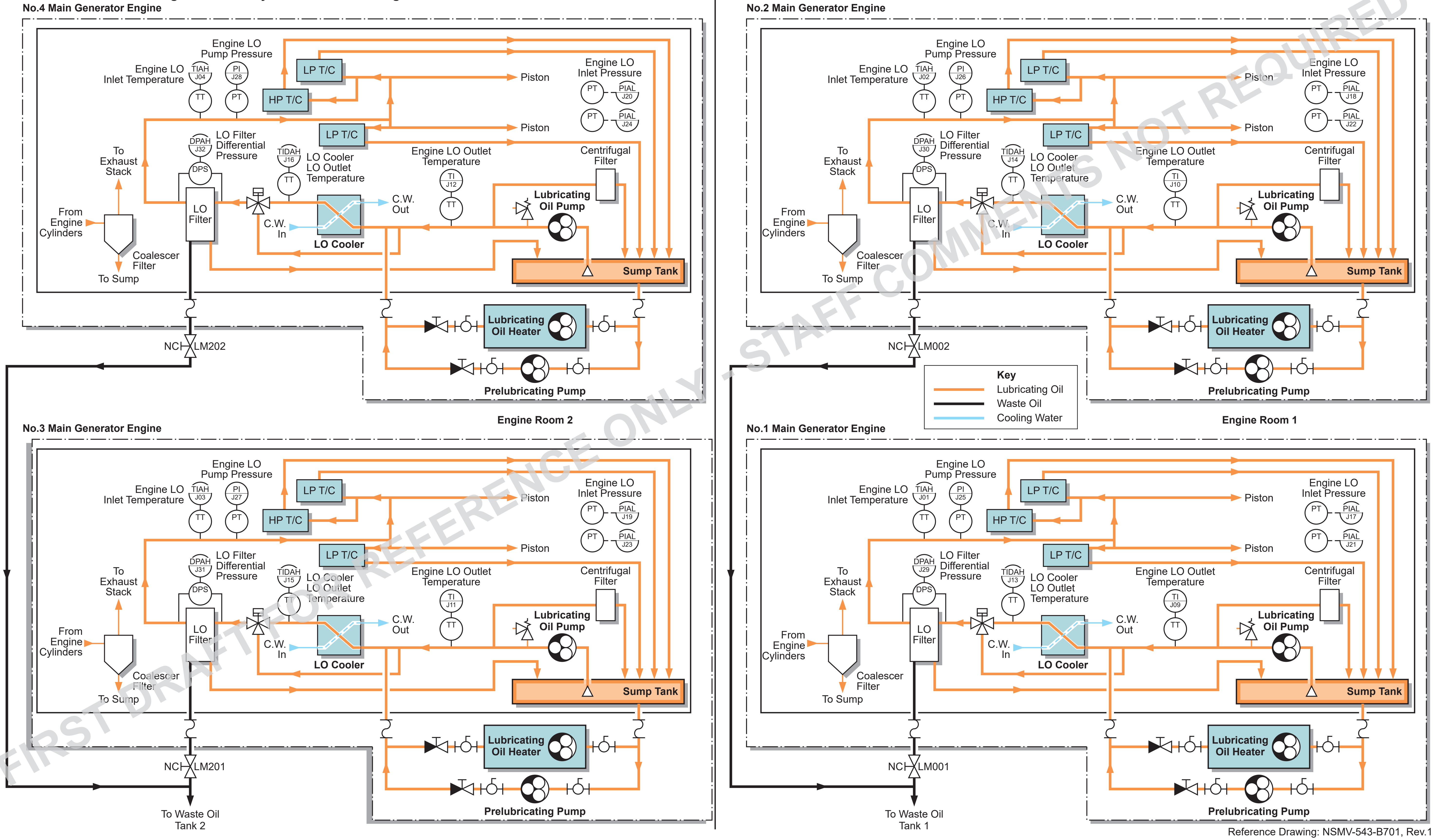
d) Shut all valves.

CAUTION
It is essential that the manufacturer's instructions regarding the stopping and dismantling of the separator are followed to avoid the risk of damage. Separator bowls rotate at very high speed and any imbalance or loose connection may have serious consequences.

CAUTION
Centrifuges operate on an automatic sludging system, but failure of the system to effectively discharge sludge can cause overload and subsequent breakdown of the bowl arrangement which rotates at high speed. After manual cleaning, care is needed to ensure that the bowl is assembled correctly, as incorrect assembly can result in disintegration at high rotational speed. All operating and maintenance precautions stipulated by the manufacturer in the maintenance manual must be observed.

2.7 Lubricating Oil Systems

Illustration 2.7.1a Lubricating Oil Service System - Generator Engines



Reference Drawing: NSMV-543-B701, Rev.1

Produced by: WMT Limited, UK
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2.7 LUBRICATING OIL SYSTEMS

2.7.1 DIESEL GENERATOR ENGINE LUBRICATING OIL SYSTEM

Main Diesel Generator Lubricating Oil Pumps

Manufacturer:	*XXX*
Type:	Engine driven screw
Model:	*XXX*
No. of sets:	4 (1 per engine)
Capacity:	150m^3/h (550gph) at 10.0 bar at 900 rpm

Main Diesel Generator Pre-lubricating Oil Pumps

Manufacturer:	*XXX*
Type:	Screw
Model:	*XXX*
No. of sets:	4 (1 per engine)
Capacity:	7.2m^3/h (32gph)
Motor:	440V, 12kW, 1,750 rpm

Main Diesel Generator Lubricating Oil Coolers

Manufacturer:	*XXX*
Type:	Plate
Model:	*XXX*
No. of sets:	4 (1 per engine)
Capacity:	LO 82°C - 74°C (179°F - 165°F)
	LT 54°C - 38°C (129°F - 100°F)

Introduction

Each MGE has its own independent lubricating oil (LO) cooling circuit that circulates LO around the engine in order to lubricate the moving components, provide cooling, and for corrosion protection against acidic products from the combustion process. There are various items that make up the LO service system, with each individual system containing the following:

- Engine-driven LO pump.
- Motor-driven prelube pump.
- Automatic back-wash filter
- Centrifugal filter.
- LO cooler with self-actuated thermo-regulating valve.

Each MGE has its own LO sump. A level transmitter is fitted to each sump tank and this relays a volume reading to the CAMS on the corresponding mimic page. High and low level alarms are sounded when the level in the sump tank exceeds the set alarm set points. A sounding pipe with striker plate is also fitted that allows for manual sounding of the sump tanks and access to the sounding pipes is through a self-closing cock valve with securing cap. To ensure compliance with safety regulations, it is important that these valves remain in their correct working state and the securing cap is in place at all times when soundings are not being taken. A detailed description and operating procedures for the transfer of LO to and from the engine sump tanks is described below in this manual.

Note: Manual soundings of each sump tank should be done every watch and the values recorded appropriately. Close attention must be paid to level trends to ensure the gradual LO consumption is within normal limits.

Each MGE is fitted with a vertical, screw-type prelubricating pump with a pumping capacity of 7.2m^3/h (32gph). The prelube pump will be running when the engine is stopped in standby, and on its run-down period when coming to a stop. The purpose of the pump is to supply pressured LO to the generator bearings to provide a sufficient oil wedge between the bearing shells, and the journals. The pump is driven by an electric motor, and is given a start signal from the engine control system during the conditions listed above. It takes suction from the associated engine sump tank before discharging the LO through the cooler, filter, then into the engine.

The pump is not required to operate when the engine is running at normal speed, and a speed pick-up sensor will stop the prelube pump once at normal operating revolutions. The prelube pump is also connected to the engine emergency shutdown system. The pump will immediately stop with the engine upon activation. Following a blackout scenario, the prelube pump will be restarted as a part of the engine sequential restart program.

An integrated engine-driven LO pump is fitted to each of the MGEs. The pump is fitted with a pressure control valve, and supplies LO to the system at the required flow rate and pressure, negating the need for the prelube pump when at operating revolutions. The engine-driven pump takes suction from the sump tank through a separate suction line. From here, the LO discharge joins a common line from the prelube pump discharge, and flows through the service system in the same manner.

LO is supplied from the pumps to the distribution manifold by first passing through an auto LO filter. After the pump discharge, LO is recirculated back to the sump through a centrifugal LO filter. The centrifugal LO filter takes part of the engine LO circulation, and backflushes the LO before being returning it to the engine sump tank. The auto filter is fitted with a differential pressure sensor that activates the flushing cycle through the control panel. The control panel displays the flush counter, and also allows the operator to activate a manual flushing cycle.

The LO passes through the associated LO cooler and thermostatic regulating valve before passing through the auto filter. The LO cooler uses cooling water from the LT cooling water system, and cools the LO through a process of heat transfer across the surface area of the stainless steel plates. One cooler is provided for each MGE system, and has a cooling capacity of 100%.

The thermostatic three-way bypass valve is located at the outlet of the LO cooler, and is set to maintain an engine inlet LO temperature of 74°C (165°F) by bypassing the flow of LO around the cooler. It is possible to adjust the temperature set point of the thermo-regulating valve up to 65°C (149°F) on the engine local control panel.

The cooled LO then passes through an auto filter before flowing into the engine distribution manifold. From the engine LO distribution manifold, oil is directed to the turbocharger bearings, the pushrod guide blocks, the camshaft system (camshaft bearings and rocker boxes), and to the main bearings. The main bearing connections also supply the bottom end bearings and the gudgeon pins. The LO also flows through bores in the connecting rods up to the pistons where it serves as a coolant. The main bearing temperatures are monitored by means of temperature probes and this information is relayed to the engine control system and the CAMS workstations.

The LO is returned to the crankcase sump tank, where it may then be processed through the service system for reuse. The crankcase is provided with an oil mist detector in order to safeguard against the risk of a crankcase explosion. It is essential that this detector device is regularly checked and its alarm operation must be tested frequently. The crankcase and sump tank are fitted with a breather system which prevents over-pressure due to piston blow-by.

Each MGE crankcase vent is led to to its exhaust pipe that exits at the funnel stack to atmosphere via a silencer. The drains from the silencer drain down to a sealing pot that overflows to bilge.

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Anything to update?

It is important that this manual is kept up to date as a live document. If you believe there are any errors or omissions in this manual, or you are aware of changes to the equipment or systems on board then please contact the publishers:

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Setting-up and Operating the Diesel Generator

Engine Lubricating Oil System

The procedure below is applicable for all the MGEs.

a) Ensure that the LO level in the MGE sump tank is at an adequate level. If top-up is required, please follow the LO transfer procedures.

b) Ensure that the MGE LT fresh water cooling system is operating, and that the main cooling sea water system is in operation for cooling of the LT water. Check that cooling water is circulating effectively through the LO cooler of each engine.

c) Ensure that there is power at the automatic backflushing filter and that the filter is operating correctly.

d) Ensure that all pressure gauge and instrumentation valves/cocks are open, and that all instruments are reading correctly and control systems are operational.

e) The prelube pump should be set for REMOTE operation at the local control panel and then for AUTO at the engine mimic. The alternator DE and NDE LO pumps should be set to remote operation and automatic; this ensures that the prelube pump and the alternator LO pumps will start when an engine is in standstill condition.

f) When the engine starts, check that the prelube pump stops above a predetermined engine speed level. When the engine is running, check the LO pressures at all parts of the system and ensure the temperature is being correctly regulated and no leaks are present in the system.

Alternator Bearings Lubrication

Alternator Lubricating Oil Pumps

Manufacturer:	Hyundai
Type:	Gear
Model:	1L16DC23R
No. of sets:	8 (2 per alternator)
Capacity:	16 litre/minute
Motor:	440V, 1.5kW, 1,735 rpm

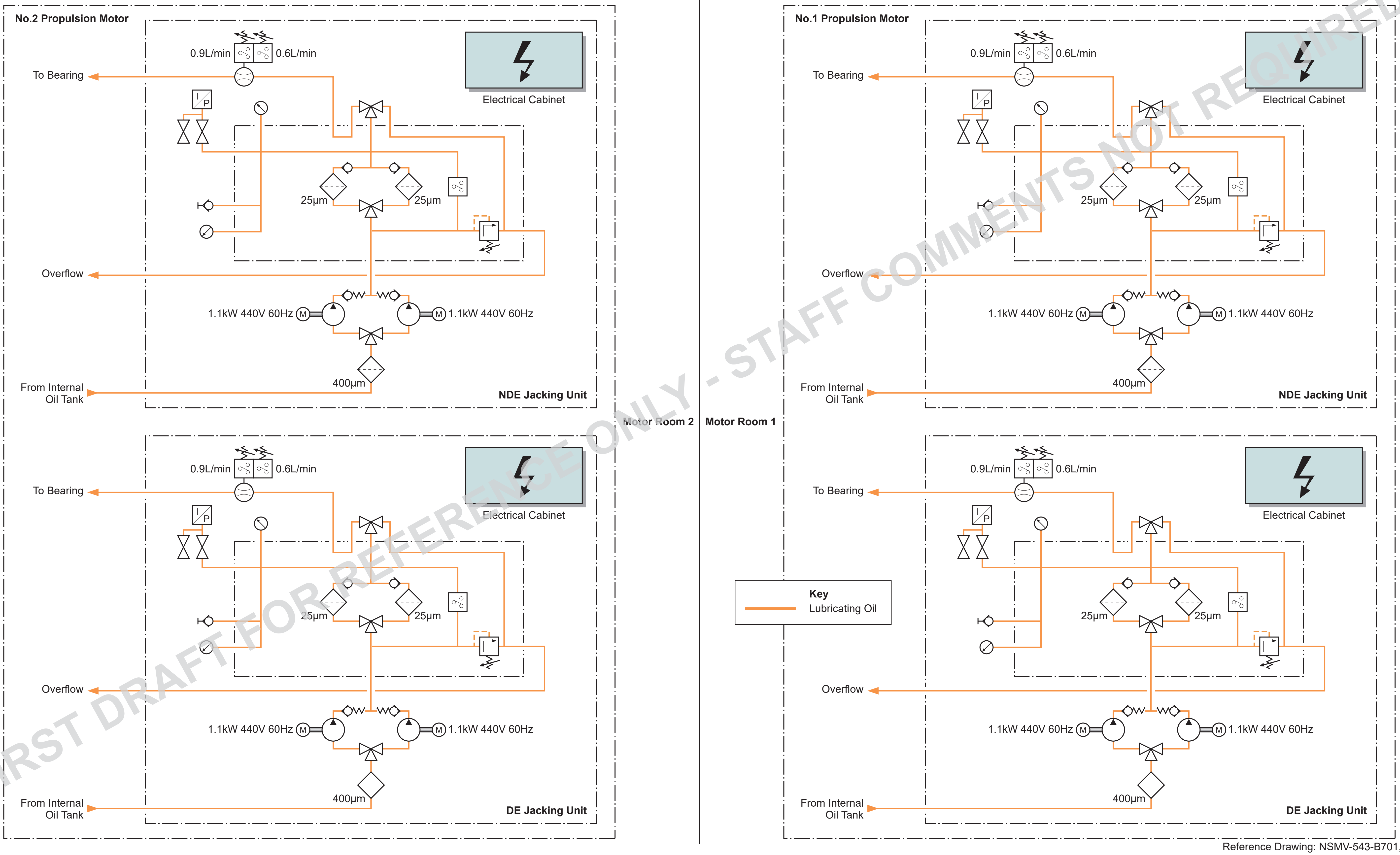
Introduction

The alternator bearings are lubricated by their own independent systems. Each alternator is fitted with two sleeve-type bearings each lubricated by its own LO pump. The LO is cooled by a water cooler supplied by the FW cooling system supplied at 28 litre/minute..

Alarm Setting Values:

- Relief valve lift pressure 6 bar.
- LO pressure Low 0.5 bar.
  LO pressure Low Low 0.2 bar.
- LO filter differential pressure 2.5 bar.
- Flow switch 6 litre/minute

Illustration 2.7.2a Lubricating Oil Service System - Propulsion Motors



Reference Drawing: NSMV-543-B701, Rev.1

2.7.2 PROPULSION MOTOR/SHAFT LUBRICATING OIL SYSTEMS

Propulsion Electric Motor Lubrication Pump

Type:	Screw, Twin pump
No. of sets:	8 (4 for each propulsion motor)

Thrust Block Lubrication

Type:	Self contained
No. of sets:	2 (one for each thrust bearing)

Propulsion Electric Motor Lubrication

The Propulsion Electric Motors (PEMs) have two pedestal journal bearings, one at the drive end and one at the non-drive end. Each PEM bearing system has two LO jacking pumps. Each bearing is self-lubricated under normal running conditions. For low speed <55 rpm, the jacking units, consisting of two motor-driven pumps (one in service, one in standby), jack up or lift the motor shaft at starting, and at low speeds. In case of a blackout, the shaft line must stop within 15 minutes maximum when running down from 55 rpm to 0 rpm, or the bearing white metal will be damaged.

The jacking units are not oil circulating units as their function is only to lift the rotor when it is running between 0 rpm to 55 rpm. Above 55 rpm, the oil film into the bearing is self-created by rotation of the shaft and bearing design. There is no need for the jacking units to run above 55 rpm. One jacking pump is set to run at <55 rpm, with the second pump on standby should the selected running pump fail to start. The pumps are controlled by the automatic system in the propulsion auxiliaries group, and are selected for remote operation.

The bearing pump LO system is supplemented by an oil pick-up ring and scraper system. The oil ring sits on the journal and its lower end dips into the oil bath. When the PEM is turning, the oil pick-up ring is rotated by the journal, and the oil which adheres to the pick-up ring is scraped off the ring by the scraper and distributed to the journal bearing. The oil ring pick-up system is assisted by the jacking pump which circulates oil from the bearing sump back to the bearing via an oil filter.

Each PEM system is controlled by two control devices that receive the following signals:

- Bearing oil temperature, high temperature, alarm and slowdown.
- Shell bearing oil temperature, high temperature, alarm and slowdown.
- Low oil level alarm.
- Low flow jacking oil system alarm.
- Low pressure jacking oil system alarm.
- Jacking oil system filter alarm.
- Jacking oil system low-low pressure alarm, low pressure alarm and standby pump start.

The bearings are fitted with temperature sensors for alarm/trip functions, and the oil circulation system has pressure and flow switches which activate alarms should the system operating conditions move outside the preset levels. The LO level in the bearing sump must be checked, and replenished as necessary. There is a level switch which activates a level alarm should the LO level fall below a predetermined value. A PEM jacking pump must be running, and the LO pressure must be above a threshold before a PEM may be started.

Thrust Block Lubrication

The thrust bearing is of the self lubricated type, and composed of two faces of tilting pad thrust bearings resting over a pivoting surface that transmits the thrust load to the bearing housing. The rigidity of the thrust bearing creates resistance, and the position of the supporting legs minimizes the tilting effect.

The thrust bearing is designed for supporting axial, and radial loads. The thrust bearing is designed with identical thrust pads at both sides of the thrust flange, and one radial bearing shell installed at forward side of the thrust flange.

The LO circulation system is of the self-lubricated type, with a LT fresh water supplied cooling coil integrated in the oil sump of the unit for LO cooling.

A seal system is fitted at both sides of the thrust bearing unit to prevent any LO leakage at different pitch inclinations, during the normal operation of the ship. Other functions of the seal system is to prevent the sea water ingress into the unit if the engine room is in flooded (emergency condition) for SRtP conditions of 8 metres above the shaft.

The thrust bearing includes all the devices for measuring the temperatures (remote and local control) of the ahead and astern thrust bearings, the radial bearing, and the temperature of the oil sump. There is an LO level dipstick for checking the LO level inside the unit.

Intermediate Shaft Bearing Lubrication

The intermediate shaft bearing absorbs the radial forces of the shaft, and transfers these forces into the foundations of the ship. The intermediate shaft bearing does not absorb axial forces but supports that part of the shaft system located between PEM1 and PEM2. The intermediate shaft bearing meets the requirements for continued operation in case of flooding (SRtP rerquirements) by having a 'SIMPLEX' seal mounted on each side of the bearing.

The intermediate shaft bearing is lubricated without an external oil supply. While the shaft is rotating, lubrication takes place from the lower housing, below of the intermediate shaft bearing, which is filled with LO up to the 'MAX' mark on the dipstick. A two-part oil ring, which is attached to the shaft, transfers the oil from the lower housing, to the upper part of the upper housing. A movable oil scraper fitted to the oil ring ensures that the intermediate shaft bearing is sufficiently, and evenly supplied with LO. The LO is cooled via a cooling coil which is supplied with fresh water from the LT fresh water cooling system. Because oil is thrown over the bearing by the oil ring, the actual level of oil in the shaft bearing can only be determined accurately when the propeller shaft is stationary. The oil ring is rotated by the shaft, and the lower part of the ring dips into the oil bath. LO is picked up by the oil ring as the shaft rotates and the oil is removed from the ring by the scraper, and distributed to the bearing. From the bearing the oil falls back to the bottom of the bearing housing. The level of LO in the bearing housing must be checked frequently, and the oil in the bearing housing replenished as necessary.

The operating temperature is monitored by the temperature monitoring system. A temperature sensor is mounted on the intermediate shaft bearing. The temperature sensor of the resistance thermometer measures the operating temperature in the bearing shell. The measured temperature is transmitted electronically to the alarm control system. A dial thermometer is also attached to the intermediate shaft bearing.

The intermediate shaft bearings are fitted with the following alarm limits:

- High LO temperature alarm set at 65°C.
- High-high LO temperature alarm set at 85°C.

Temperature Increases to Maximum Alarm Temperature

Too high operating temperatures can damage the intermediate shaft bearing.

1) Reduce speed immediately if the alarm temperature is reached or exceeded.

2) Do not stop the shaft as there is a risk that the shaft will fuse with the white metal layer of the bearing shell, which will make restarting impossible.

3) Keep the speed just above the minimum speed until the temperature has reduced sufficiently.

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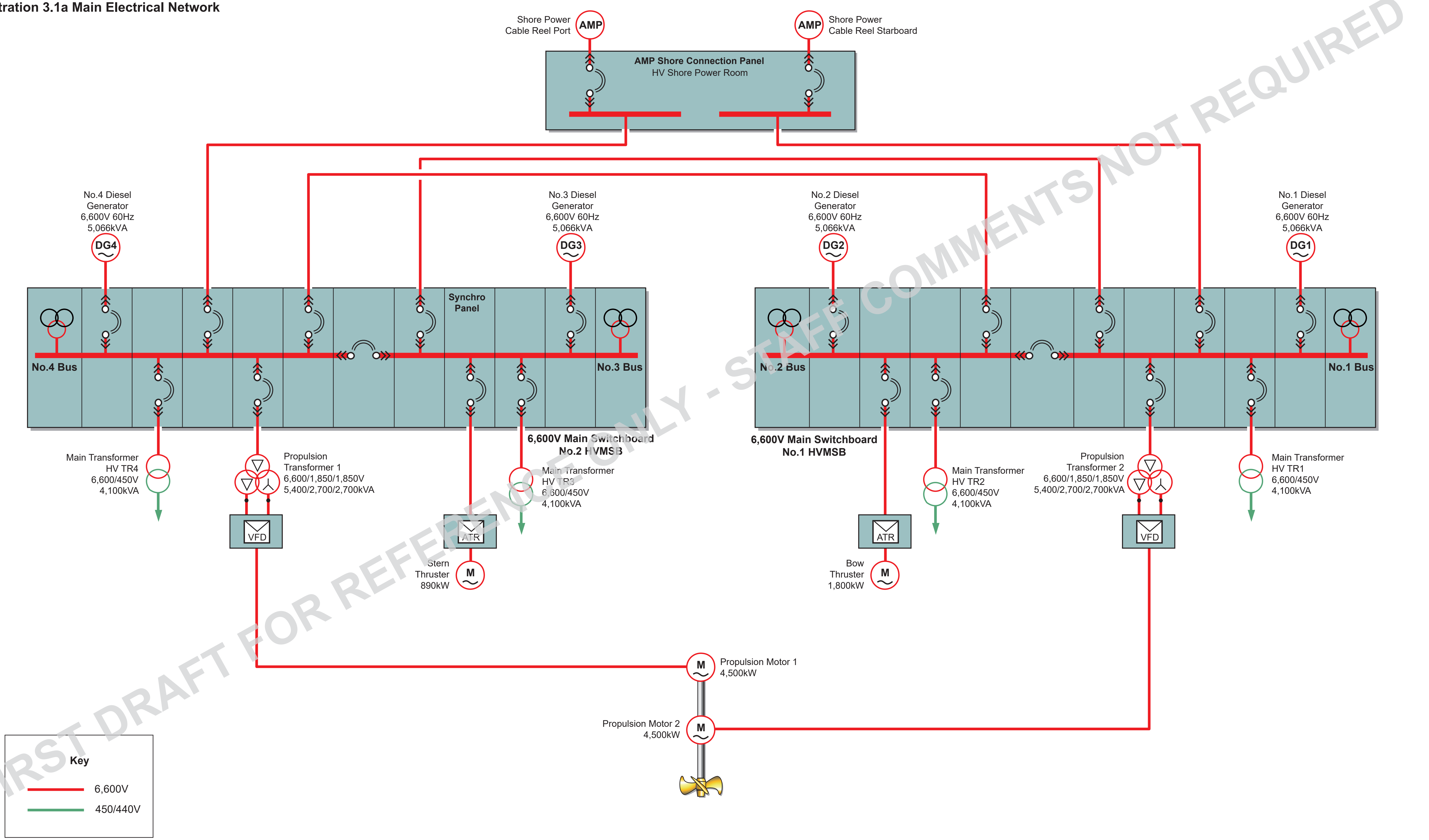
Illustration 3.1a Main Electrical Network



Reference Drawing: NSMV-321-B607 Sht 1 Rev. 4

3.1 MAIN ELECTRICAL NETWORK

Power Generation

The generating plant consists of 4 main generators and 1 emergency generator.

Main Diesel Generators

Manufacturer	Hyundai Heavy Industries
Model	HSJ9 913-08P
Capacity	6.6kV, 443.2A, 5066.25kVA, 4053kW
Number of units	4

The generators are located as follows:

No.1 and No.2 in engine room 1 in Fire Zone 3 (FZ3), between frames 50 - 70, and No.3 and No.4 in engine room 2 in Fire Zone 4 (FZ4), between frames 70 - 90.

Emergency Diesel Generator

Manufacturer	Leroy Somer
Model	LSA 50.2 L7/4P
Capacity	450V, 1443A, 1125kVA, 900kW
Number of units	1

The emergency generator is located in the emergency generator room in the engine room casing 2nd level starboard center line, in FZ3 between frames 51 - 64.

Power Distribution

The power distribution system consists of the following:

- 2 off HV switchboards (6.6kV)
- 2 off LV switchboards (450V)
- 1 off Emergency switchboard (450/120V)
- 4 off LV load center panels (440V)
- 3 off Emergency load center panels (440V)
- 3 off Emergency load center panels (120V)
- 16 off Distribution boards (440V)
- 18 off Distribution boards (120/240V)
- 24 off Light distribution boards (120V)
- 13 off Emergency light distribution boards (120V)
- 3 off Laundry distribution boards (120/240V)
- 3 off Receptacle distribution boards (120V)
- 1 off RORO lighting control panel. (120V)

Due to this vessel's employment and different operating modes, the electrical power network has to be versatile.

Each of the 6.6kV switchboards consists of two busses, No.1 switchboard - No.1 and No.2 bus and No.2 switchboard - No.3 and No.4 bus.

Generator No.1 feeds No.1 bus and generator No.2 feeds No.2 bus.

Generator No.3 feeds No.3 bus and Generator No.4 feeds No.4 bus.

Each pair of busbar section are connected by a bus tie circuit breaker and both 6.6kV switchboards are connected by interconnecting circuit breakers.

If a major problem occurs, say in one of the switchboard's bus bars, the system can be reconfigured, to provide full power to the network.

No.1 66kV switchboard, bus No.1 feeds No.1 450V bus by way of a 6.6kV/450V transformer (No.1 HVTR).

No.1 66kV switchboard, bus No.2 feeds No.2 450V bus by way of a 6.6kV/450V transformer (No.2 HVTR)

No.2 6.6kV switchboard, bus No.3 feeds No.3 450V bus by way of a 6.6kV/450V transformer (No.3 HVTR)

No.2 6.6kV switchboard, bus No.4 feeds No.4 450V bus by way of a 6.6kV/450V transformer (No.4 HVTR)

Each of the 450V switchboards consists of two busses, No.1 switchboard - No.1 and No.2 bus, No.2 switchboard - No.3 and No.4 bus. Interlocks are provided to prevent the ties between the busses from closing if the circuit breakers of the main transformers are closed. There are also mechanical locks in place to prevent the circuit breakers interconnecting between LV switchboard No.1 and No.2 (this interconnection is solely for emergency purposes for emergency crossfeeding).

The emergency switchboard can be fed by either LV switchboard No.1 bus 1 or LV switchboard No.2 bus 4, interlocks are provided to prevent both these interconnections connecting at the same time and also preventing them from closing if the emergency generator ACB is closed.

Load center panel No.1 and No.2 can be fed from either LV switchboard No.1 bus 1, or LV switchboard No.2 bus 3.

Load center panel No.3 and No.4 can be fed from either LV switchboard No1 bus 2 or LV switchboard No.2 bus 4.

Nos.1, 2 and 3 440V emergency load center panels are fed from the 440V emergency switchboard.

If part of the system should blackout there is an automatic changeover mechanism which will change the feed for the load centers as follows:

Load center panel	Prim power source	Sec. power source
No.1	No.1 LVMSB	No.2 LVMSB
No.2	No.2 LVMSB	No.1 LVMSB
No.3	No.1 LVMSB	No.2 LVMSB
No.4	No.2 LVMSB	No.1 LVMSB

No.1 120V emergency load center panel is fed via a transformer from the 440V emergency switchboard.

Nos.2 and 3 120V emergency load center panels are fed from the 120V emergency switchboard.

The distribution boards and local group starters are fed from the 440V switchboards and the load center panels.

Operating Modes

This vessel has a number of operating modes, the configuration of the power distribution system can be adapted to cover all of these operating modes:

- Transit at 18 knots
- Transit at 12 knots
- Manoeuvring
- In port with full complement (via AMP 6.6kV shore power)
- 450V switchboard to switchboard crossfeed mode (emergency only)
- Laid up or repair work (via 440V shore power)
- Safe return to port (SRPT) with one propulsion motor
- Safe return to port (SRPT) with retractable forward thruster
- Blackout mode

1. Transit at 18 knots.

- All four generators are required
- Both 6.6kV main switchboards are energised and are configured to operate in open ring mode, with the bustie of either one open and both interconnecting breakers between them closed
- Two propulsion motors operating
- Each main 450V engine room LV switchboard is fed from their respective 6.6kV switchboard bus via redundanr transformers, each of which is rated to carry 100% of the total load. Under normal operation the bus tie is open with each transformer

feeding its own bus. Interlocking is provided to allow two out of three circuit breakers to close at any one time.

- If a transformer should fail the bus tie will close automatically, and the remaining transformer will supply both busses.
- The No.1 LV main switchboard to No.2 LV main switchboard interconnector circuit breakers are mechanically locked to prevent inadvertent closure.
- The four main 440V load center panels are fed via redundant feeds from either No.1 or No.2 LV main switchboard the circuit breakers of which are always closed. The redundant circuit breakers at the load centers are interlocked to prevent closure of both at the same time. If primary power should be lost, an auto changeover circuit will activate and repower the boards. Manual control of the incoming circuit breaker is also available using the LOCAL/REMOTE switch.
- The emergency switchboard is fed from either No.1 LVMSB or No.2 LVMSB the circuit breakers of which are always closed. The two incomer circuit breakers at the emergency switchboard are interlocked so only one can be closed at the same time. If primary power is lost the incomer circuit breaker will trip on under voltage and an auto changeover circuit will close the other breaker and power the emergency switchboard. This auto changeover should take minimum time so as not to cause the emergency generator to start.

2. Transit at 12 knots

- This mode allows the engineers to shut down one complete engine room for training purposes.
- Two generators and one propulsion motor operating at 60% nominal power, either of the propulsion motors can be used.
- Both 6.6kV main switchboards are energised and are configured to operate in open ring mode, with the bus tie of either one open and both interconnecting breakers between them closed
- Each main 450V engine room LV switchboard is fed from their respective 6.6kV switchboard bus via redundanr transformers, each of which is rated to carry 100% of the total load. Under normal operation the bus tie is open with each transformer feeding its own bus. Interlocking is provided to allow two out of three circuit breakers to close at any one time.
- If a transformer should fail the bus tie will close automatically, and the remaining transformer will supply both busses.
- The four main 450V load center panels are fed from the active engine room LV main switchboard.
- Should electrical training or repair work be required on the inactive engine room HV main switchboard or the LV main switchboard, both can be shut down and isolated, the vessel can then be run from the active engine room. In this case the load centers would receive their power from the active switcboards but with no backup.

3. Manoeuvring Mode

- In this mode all four generators must be running.
- Both propulsion motors, the bow and stern thrusters will be operating in this mode.
- The 6.6kV switchboard bus ties will be closed and the interconnecting circuit breakers will be open this will result in two independent power systems. This minimizes the consquences should a failure occur on the main busses during critical manoeuvering operations.
- As the power system is divided into two separate power sources with each one using two generators, under normal operating conditions with a loading factor of 90% the available power on each system will be approximately 7.2MW. Should a generator trip, the load shedding system has to take into account the No.1 load center panel (PT-1 group) might be fed from the non-failure switchboard.
- Should a transformer fail the bus tie will close and the remaining transformer will feed both busses.

4. In Port Full Compliment (AMP)

- Due to the vessel's service it will spend a considerable period of time alongside, during this time all the vessel's generators will be shut down and power will be obtained from shore side by way of one of the 6.6kV AMP connections one to port and one to starboard, these are rated at 6.4MW/700A.
- To prevent black out during connection, interlocking and synchronizing facilities are provided.
- The two 6.6kV HV main switchboards operate in open ring mode with the bus tie of either one open and the interconnecting circuit breakers between them closed.
- Each main 450V engine room LV switchboard is fed from their respective 6.6kV switchboard bus via redundanr transformers, each of which is rated to carry 100% of the total load. Under normal operation the bus tie is open with each transformer feeding its own bus. Interlocking is provided to allow two out of three circuit breakers to close at any one time.
- Should a transformer fail the bus tie will close and the remaining transformer will feed both busses.
- If the shore power should becomes unavailable, one or two of the main generators will be started and put online depending upon summer/winter loading.

5. Cross Feed Mode 450V LV Switchboard to Switchboard

(for emergency use only)

- This operation is used if there is some kind of catastrophic failure such as a multiple transformer failure on one LV main switchboard, or during a vessel.
- The cross feed connection circuit breakers are normally physically locked out and interlocks are provided to prevent connecting two live LV main switchboards.
- Monitoring of the load will have to take place to ensure that the transformers are not overloaded.

6. Laid Up, Repair modes.

- Shore 440V supply connections are available on both port and starboard side, these connect to No.1 LV main switchboard bus 1 and No.2 LV main switchboard bus 4. These can be used during repairs to the HV system, or during drydock periods.
- Interlocks are provided between the shore supply circuit breakers and the transformer secondary circuit breakers.
- The emergency 450V switchboard to switchboard crossfeed can be closed to power the opposite LV main switchboards.

7. Safe Return to Port (SRTP) Via Own Propulsion

- This mode is basically the same as the transit mode at 12 knots except depending upon the catastrophic damage, different combinations of generator have to be used.
- Two generators with one propulsion motor are required.

8. Safe Return to Port (SRTP) via Bow Thruster

- One generator with the bow thruster running with an approximate speed of 8 knots.

9. Black Out Mode

- If a complete power failure should occur, both No.1 and No.2 LV main switchboard interconnection circuit breakers to the emergency switchboard in the emergency switchboard will trip on undervoltage. The emergency generator will start automatically and will connect to the dead emergency switchboard and will supply power to all the emergency loads (this should happen within 40 seconds of the detection of a power failure.
- Once power has been re-established to the vessel's critical systems, the black start sequence can be initiated and the main generators restarted, and the main power returned to the system.

Transformers

This vessel has the following transformers:

High Voltage Transformers

Manufacturer	Sanil Electric Co. Ltd
Model	SMT-3H4100KMD
Type	Cast resin/VPI
Units	4
Capacity	4,100kVA
Primary voltage	6,600V
Secondary voltage	450V
Primary current	358.7A
Secondary current	5,260A
Windings	Al/Al
Cooling	AN (air natural)
Protection	IP23
Heater	120V 200W x 3

The secondaries of these tranformers have nine embedded PT100 temperature probes, three for temperature control, three for customer use and three spare. The temperature and humidity are controlled by a thermostat and a humidistat, that detect the humidity and temperature of the windings and adjust the heating accordingly. The thermostat is set at 10^{o}C and the humidistat is set at 90%

There are pre-magnetizing transformers installed in the enclosures of these transformers as follows:

Manufacturer	Sanil Electric Co. Ltd
Type	VPI/VPI
Units	4
Capacity	30kVA
Primary voltage	440V
Secondary voltage	450V
Windings	Al/Al
Cooling	AN (air natural)

These transformers are located as follows:

- Main HV transformers No.1 and No.2 are located in HV switchboard room No.1, 4th deck of engine room, starboard side, between frames 70 and 90.
- Main HV transformers No.3 and No.4 are located in HV switchboard room No.2, 4th deck of engine room, starboard side, between frames 51 and 70.

Low Voltage Transformers

Main 440/120V Transformers

Manufacturer	Sanil Electric Co. Ltd
Model	SMT-3H170KLD
Type	VPI/VPI
Units	4
Capacity	170kVA
Primary voltage	440V
Secondary voltage	120V
Primary current	223.1A
Secondary current	817.9A
Windings	Cu/Cu
Cooling	AN (air natural)
Protection	IP44
Heater	120V 100W x 2

There are six embedded PT100 temperature probes in the secondaries, three active and three spare. The heaters are thermostatically controlled with the thrmostat being set at 10^{o}C.

These transformers are located load center room No.4, this is located on the 4th deck of the engine room, port side between frames 90 and 99.

No.1 Load Center Panel Transformers No.1 and No.2

Manufacturer	Sanil Electric Co. Ltd
Model	SDT-3H100KD
Type	VPI/VPI
Units	2
Capacity	100kVA
Primary voltage	440V
Secondary voltage	120V
Primary current	131.2A
Secondary current	481.1A
Windings	Cu/Cu
Cooling	AN (air natural)
Protection	IP23
Heater	120V 100W x 2

There are six embedded PT100 temperature probes in the secondaries, three active and three spare. The heaters are thermostatically controlled with the thrmostat being set at 10^{o}C.

These transformers are located in load center room No.2, this is located on the 4th deck, port side between frames 123 and 129.

No.2 Load Center Panel Transformers No.1 and No.2

Manufacturer	Sanil Electric Co. Ltd
Model	SDT-3H150KD
Type	VPI/VPI
Units	2
Capacity	150kVA
Primary voltage	440V
Secondary voltage	120V
Primary current	196.8A
Secondary current	721.7A
Windings	Cu/Cu
Cooling	AN (air natural)
Protection	IP23
Heater	120V 100W x 2

There are six embedded PT100 temperature probes in the secondaries, three active and three spare. The heaters are thermostatically controlled with the thrmostat being set at 10^{o}C. These transformers are located in load center room No.2, this is located on the 4th deck, port side between frames 123 and 129.

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No.1 Receptacle Transformer

Manufacturer	Sanil Electric Co. Ltd
Model	SDT-3H160KD
Type	VPI/VPI
Units	1
Capacity	160kVA
Primary voltage	440V
Secondary voltage	120V
Primary current	209.9A
Secondary current	769.8A
Windings	Cu/Cu
Cooling	AN (air natural)
Protection	IP23
Heater	120V 100W x 2

There are six embedded PT100 temperature probes in the secondaries, three active and three spare. The heaters are thermostatically controlled with the thrmostat being set at 10^{O}C.

This transformer is located in load center room No.2, this is located on the 4th deck, port side between frames 123 and 129.

No.2 Receptacle Transformer

Manufacturer	Sanil Electric Co. Ltd
Model	SDT-3H130KD
Type	VPI/VPI
Units	1
Capacity	130kVA
Primary voltage	440V
Secondary voltage	120V
Primary current	170.6A
Secondary current	625.5A
Windings	Cu/Cu
Cooling	AN (air natural)
Protection	IP23
Heater	120V 100W x 2

There are six embedded PT100 temperature probes in the secondaries, three active and three spare. The heaters are thermostatically controlled with the thrmostat being set at 10^{O}C.

This transformer is located in load center room No.4, this is located on the 4th deck, port side between frames 90 and 100.

No.3 Receptacle Transformer

Manufacturer	Sanil Electric Co. Ltd
Model	SMT-3H130KLD
Type	VPI/VPI
Units	1
Capacity	20kVA
Primary voltage	440V
Secondary voltage	120V
Primary current	26.24A
Secondary current	96.22A
Windings	Cu/Cu
Cooling	AN (air natural)
Protection	IP23
Heater	120V 100W x 2

There are six embedded PT100 temperature probes in the secondaries, three active and three spare. The heaters are thermostatically controlled with the thrmostat being set at 10^{O}C.

This transformer is located in load center room No.4, this is located on the 4th deck, port side between frames 90 and 100.

Illustration 3.2a General Arrangement of HV Switchboard *(Authors notes: To be completed once photographs are available)*

3.2 MAIN SWITCHBOARDS AND DISTRIBUTION

Manufacturer	KTE
Model	KHMS-25A
Type	Dead front self supporting
Rated voltage	7.2kV
Service voltage	6.6kV
Rated busbar current	1250A
Fault level voltage	Sym. rms 25kA for 3 secs Asym. 63kA
Control voltage	110Vdc

No.1 6.6kV Switchboard Panel Designations

Panel	Bus	Function
1	No.1	No.1 bus GPT panel
2		No.2 Propulsion transformer
3		No.1 HV main transformer
4		No.1 shore power incomer (stbd)
5		No. interconnection bus - 1 to bus - 3
6		No.1 diesel generator
7	No.2	Bus tie and synchro
8		Bus riser and No.2 bus GPT
9		No.2 diesel generator
10		No.2 interconnection bus - 2 to bus-4
11		No.2 HV main transformer
12		Bow thruster
13		No.1 I/O panel, PMS work station

No.2 6.6kV Switchboard Panel Designations

Panel	Bus	Function
1	No.3	No.3 bus GPT panel
2		Stern thruster
3		No.3 HV main transformer
4		No.3 interconnection bus - 3 to bus - 1
5		No.3 diesel generator
6	No.4	Bus tie and synchro
7		Bus riser and No.4 bus GPT
8		No.4 diesel generator
9		No.4 interconnection bus - 4 to bus - 2
10		No.2 shore power incomer (port)
11		No.4 HV main transformer
12		No.1 propulsion transformer
13		No.2 I/O panel, PMS work station

The locations of the HV switchboards are as follows:

- No.1 HV switchboard - HV room no.1, 4th deck engine room, starboard side, between frames 70 - 90.
- No.2 HV switchboard - HV room no.2, 4th deck engine room, starboard side, between frames 51 - 70.

No.1 440V switchboard panel designation

Panel	Function
A	No.1 group atarter panel
B.1	No.1 440V feeder panel
B.2	No.1 440V feeder panel
C	Shore power incomer (stbd)
D	No.1 incomer panel
E	Bustie and emergency switcboard interconnect panel
F	No.2 incomer panel
G	Interconnect IC1 panel
H.1	No.2 440V feeder panel
H.2	No.2 440V feeder panel
I	No.2 group starter panel

No.2 440V switchboard panel designation

Panel	Function
A.1	No.3 group starter panel
A.2	No.3 group starter panel
A.3	No.3 group starter panel
B	No.3 440V feeder panel
C	Interconnect IC2 panel
D	No.3 incomer panel
E	Bustie and emergency switchboard interconnect panel
F	No.4 incomer panel
G	Shore connection panel (port)
H.1	No.4 440V feeder panel
H.2	No.4 440V feeder panel
I	No.4 Group starter panel

No.1 440V switchboard is located in the No.1 engine control room on the engine room 4th deck, port side, between frames 70 - 90.

No.2 440V switchboard is located in the No.2 engine control room on the engine room 4th deck, port side, between frames 51 - 70.

The locations of the power panels are as follows:
Load center room No.1 (4th dk, stbd side, between frames 123 - 132):

- No.1 emergency 440V load center panel
- No.1 emergency 120V load center panel

Load center room No.2 (4th dk, port side, between frames 123 - 129):

- No.1 440V load center panel
- No.1 120V load center panel
- No.2 440V load center panel
- No.2 120V load center panel
- No.1 120V receptacle distribution board

Load center room No.3 (4th dk, port centerline, between frames 90 - 96):

- No.2 emergency 440V load center panel
- No.2 emergency 120V load center panel

Load center room No.4 (4th dk, port side, between frames 90 - 99):

- No.3 440V load center panel
- No.3 120V load center panel
- No.2 120V receptacle distribution board

Load center room No.5 (3rd dk, stbd side, between frames 58 - 70):

- No.4 440V load center panel
- No.4 120V load center panel
- No.3 120V receptacle distribution board

Load center room No.6 (2nd dk, stbd side, between frames 66 - 70):

- No.3 emergency 440V load center panel
- No.3 emergency 120V load center panel

AHU room No.3 (3rd dk, center line, between frames 134 - 153):

- No.1 240/120V laundry distribution board

AHU room No.7 (3rd dk, center line, between frames 88 - 103):

- No.2 240/120V laundry distribution board.

AHU room No.9 (5th level, center line, between frames 86 - 111.

- No.3 240/120V laundry distribution board

Local Group Starter Panels (LGSP)

LGSP	Location	Prim. Source	Sec. Source
1	Aux. machine room No.1	No.2 LCP	
2	Aux. machine room No.2	No.2 LCP	
3	Aux. machine room No.3	No.3 LCP	
4	Aux. machine. room No.4	No.3 LCP	
5	No.1 engine room floor	No.1 LVMSB	ESBD
6	No.2 engine room floor	No.2 LVMSB	ESBD
7	Motor room No.1	No.2 LVMSB	ESBD
8	Frequency converter room No.2	No.1 LVMSB	ESBD
9	Steering gear room	No.2 LVMSB	
10	Bosun's store	No.2 LCP	ESBD
11	Load center room. No.5	No.4 LCP	
12	Acc. main deck. AHU room 5	No.2 LCP	
13	Acc. level 2 AHU room 8	No.3 LCP	

Distribution Boards

There are a number of distribution boards both 440V and 120V situated around the vessel, normally near to the equipment that they service, they are as follows:

- 16 off Distribution boards (440V)
- 18 off Distribution boards (120/240V)
- 24 off Light distribution boards (120V)
- 13 off Emergency light distribution boards (120V)
- 3 off Laundry distribution boards (120/240V)
- 3 off Receptacle distribution boards (120V)
- 1 off RORO lighting control panel. (120V)

The three receptacle distribution boards are equipped with DEIF AAL-insulation monitors set to 0.1 MΩ. They are also equipped with earth indicator lamps which indicate in which phase the low insulation is present.

3.3 MAIN SWITCHBOARDS CONTROL AND OPERATION

6.6kV Main Switchboard Automatic and Manual Operations

Overview

The 6.6kV main switchboard contains panels for the following:

No.1 6.6kV Switchboard Panel Designations

Panel	Bus	Function
1	No.1	No.1 bus GPT panel
2		No.2 Propulsion transformer
3		No.1 HV main transformer
4		No.1 shore power incomer (stbd)
5		No.1 interconnection bus - 1 to bus - 3
6		No.1 diesel generator
7	No.2	Bus tie and synchro
8		Bus riser and No.2 bus GPT
9		No.2 diesel generator
10		No.2 interconnection bus - 2 to bus-4
11		No.2 HV main transformer
12		Bow thruster
13		No.1 I/O panel, PMS work station

No.2 6.6kV Switchboard Panel Designations

Panel	Bus	Function
1	No.3	No.3 bus GPT panel
2		Stern thruster
3		No.3 HV main transformer
4		No.3 interconnection bus - 3 to bus - 1
5		No.3 diesel generator
6	No.4	Bus tie and synchro
7		Bus riser and No.4 bus GPT
8		No.4 diesel generator
9		No.4 interconnection bus - 4 to bus - 2
10		No.2 shore power incomer (port)
11		No.4 HV main transformer
12		No.1 propulsion transformer
13		No.2 I/O panel, PMS work station

Operation of the main switchboard circuit-breakers can be carried out either remotely via the power management system (PMS) or locally at the switchboard. Local control of the inserted generator breaker is carried out from the 6.6kV main switchboard generator control panel.

Sepam 80 Multifunction Protection Unit

The 6.6kV main switchboard panels are each equipped with Sepam Series 80 multifunction protection units, mounted on the front of the panels.
The Sepam 80 can be used for three types of operations:

- Normal operations, such as consulting operating information, resetting the Sepam and acknowledging current alarms.
- Protection settings, such as modifying the tripping set point of an active protection function.
- Modifying Sepam parameters, such as changing the operating language or setting the internal clock.

Note: Protection settings and parameter operations require a password and should only be completed under the direction of the Chief Engineer.

Diesel Generator Protective Functions

Each diesel generator panel is equipped with a Sepam 80 (G3M) multifunction protection unit providing the following protection functions:

- Undervoltage (27).
- Directional active over-power (32P).
- Temperature monitoring (38/49T).
- Excitation loss (40).
- Stator current imbalance (46).
- Phase overcurrent (50/51).
- Neutral time overcurrent (51N)
- Voltage restrained overcurrent (51V).
- Overvoltage (59).
- Neutral directional overcurrent (67N).
- Under/over-frequency (81L/81H).
- Latching/acknowledgement (86).
- Generator differential (87G).

Bow Thruster Protective Functions

The bow thruster panel is equipped with a Sepam 80 (S1M) multifunction protection unit providing the following protection functions:

- Undervoltage (27)
- Stator current imbalance (46).
- Phase overcurrent (50/51).
- Neutral directional overcurrent (67N)..
- Latching/acknowledgement (86).

Stern Thruster Protective Function

The stern thruster panel is equipped with a Sepam 80 (S1M) multifunction protection unit providing the following protection functions:

- Synchrocheck (25)
- Thermal overload (49)
- Instantaneous overcurrent (50)
- Overload (51)
- Neutral over voltage (59N)
- Directional over current (67)
- Neutral directional over current (67N)

HV Main Transformer Protective Functions

Each HV main transformer panel is equipped with a Sepam 80 (T2M) multifunction protection unit providing the following protection functions:

- Undervoltage (27).
- Negative sequence/unbalance (46).
- Phase overcurrent (50/51).
- Neutral over current (51N)
- Neutral directional overcurrent (67N)..
- Latching/acknowledgement (86).

Bus Riser and GPT Functions

The bus riser and GPT panel is equipped with a Sepam 80 (B1M) multifunction protection unit providing the following protection functions:

- Undervoltage (27).
- Overvoltage/neutral voltage displacement (59 - 59N).

Bus Tie and Synchronising Panel Protective Functions

The bus tie and synchronising panel is equipped with a Sepam 80 (B2M) multifunction protection unit providing the following protection functions:

- Undervoltage (27).
- Phase overcurrent (50/51).
- Overvoltage/neutral voltage displacement (59/59N).
- Under/over-frequency (81L/81H).
- Latching/acknowledgement (86).

Shore Power Panel Protective Functions

The AMP shore power is equipped with a SEPAM 80 (S2M) multifunction protection unit providing the following protection functions:

- Undervoltage (27)
- Phase overcurrent (50/51).
- Overvoltage (59/59N).
- Latching/acknowledgement (86).
- Directional power (32)

Interconnecter Protective Functions

The interconnecter panel is equipped with a SEPAM 80 (S2M) multifunction protection unit providing the following protection functions:

- Undervoltage (27)
- Negative sequence/unbalance (46).
- Phase overcurrent (50/51).
- Neutral over current (51N)
- Neutral directional overcurrent (67N)..
- Latching/acknowledgement (86).

Propulsion Transformer Panel Protective Functions

The propulsion transformer panel is equipped with a SEPAM 80 (T2M) multifunction protection unit providing the following protection functions:

- Synchronizing check (25)
- Thermal overload (49)
- Instantaneous over current (50)
- Overload (51)
- Neutral over voltage (59N)
- Directional over current (67)
- Neutral directional over current (67N)

Main Generator Operational Procedures

Main Generator Engine Control Panel (ECP)

The main generator control panel (ECP) has on its front panel the following switches and indicators:

Switches;

System power switch	ON/OFF
Mode switch	LOCAL/REMOTE
Run switch	START/STOP
LED test switch	Press to test
Reset switch	Press to reset
Speed switch	INCREASE/DECREASE
Emergency STOP switch	Press to STOP

LEDs;

High crankcase overpressure	Red
High oil mist det/main bearing temp	Red
Overspeed	Red
Low lube oil pressure	Red
Load limit	Yellow
Engine running	Green
System OK	Green

There is also an interactive touch display screen.

Manual Operation

1. Local Control Available for the Diesel Generator

The diesel generator can be locally controlled at the generator engine as follows:

a) It is assumed that the diesel engine is ready to start and that the engine start conditions are normal.

b) On the generator engine control panel (ECP), select the mode selection switch to LOCAL. This will be indicated by displaying LOCAL on the mode indicator panel of the engine control panel (ECP).

c) When LOCAL is selected at the ECP any instructions from the switchboatd or PMS are inhibited.

Manual control from the ECP is now available.

2. Remote Control from the PMS Available for a Diesel Generator

The procedure for remote control of the diesel generators is as follows:

a) It is assumed that the diesel engine is ready to start and that engine start conditions are normal.

b) On the generator ECP, select the mode selection switch to REMOTE. The READY TO START indicator on the respective generator panel of the main switchboard will be illuminated.

c) Turn the generator mode selection switch (SC2) at the respective generator panel of the main switchboard to the REMOTE position.

Remote control of the generator is now available from the PMS.

3. Remote Control Available from Switchboard for the Diesel Generator

The diesel generator can be remotely controlled at the main switchboard as follows:

a) It is assumed that the diesel engine is ready to start and that the engine start conditions are normal.

b) On the ECP, select the mode selection switch to REMOTE. The READY TO START indicator on the respective generator panel of the main switchboard will be illuminated.

c) Turn the generator mode selection switch (SC2) at the respective generator panel of the main switchboard to the LOCAL position.

Remote control of the diesel generator is now possible from the main switchboard.

4. Manual Diesel Generator Engine Start - Local

The diesel generator engine can be started locally from the generator ECP. It is assumed that the diesel generator is stopped and is ready to start.

a) To start locally from the generator ECP, ensure that the generator mode switch is set to LOCAL .

b) Start the generator by pressing the START button on the ECP. The generator receives a start command and starts.

Observe the running lamp, frequency meter and voltmeter on the main switchboard.

5. Manual Diesel Generator Engine Start and Stop - Remote Switchboard

It is assumed that remote control from the relevant main switchboard diesel generator panel is available. This is described in procedure No.3. The engine is assumed to be in the stopped condition.

a) Turn the generator mode selection switch (SC2) at the respective generator panel of the main switchboard to the REMOTE position.

b) On the respective generator main switchboard panel, turn the engine control switch (SC3) to the START position, the engine receives a start command and starts. When the engine has started the switch can be released and as it is spring loaded it will return to its center position.

c) When the voltage is established, the READY TO START indicator at the respective main switchboard generator panel will be extinguished and the GENERATOR RUNNING indicator illuminated.

d) To stop the generator, turn the engine control switch (SC3) to the STOP position.

6. Diesel Generator Running - VCB Closure onto a Dead Bus - Switchboard Operation

It is assumed that remote control is available as described in procedure No.2, and that the generator engine has been started and the correct voltage established at the relevant main switchboard generator panel as described in procedure No.5.

a) Turn the VCB switch (SCT) of the relevant generator panel of the main switchboard to the CLOSE position.

b) The VCB will receive a CLOSE command and will close.

The diesel generator is now supplying the main switchboard.

7. Diesel Generator Running - Manual Parallel Running of Diesel Generator

It is assumed that remote control is available at the relevant main switchboard generator panel as described in procedure No.2, and that the generator engine has been started and the correct voltage established at the relevant main switchboard generator panel as described in procedure No.5..

a) At the main switchboard bus-tie panel turn the BUS-TIE CONTROL MODE switch (SC2) to the LOCAL positiuon

b) Turn the BUS SYNCHRONIZING selection switch (SCS) at the main switchboard bus-tie panel to the relevant incoming generator position.

c) Adjust the ENGINE SPEED control switch on the bus-tie panel of the relevant incoming generator (RAISE/LOWER) while observing the the synchroscope of the bus-tie panel, until the synchroscope is moving slowly in the clockwise direction (approximately one revolution every five to ten seconds).

d) As the synchroscope approaches the twelve o'clock position (synchronism), turn the VCB CONTROL switch (SCT) at the relevant generator main switchboard panel to the CLOSE position.

e) The VCB will receive a close command and will close.

f) As the control mode is set to LOCAL, then the generator load must be balanced manually using the RAISE/LOWER switches of the incoming generator and the bus located on the bus-tie panel.

8. Manual Load Shift and VCB Disconnection for the Diesel Generator - Switchboard Operation

It is assumed that remote control is available at the relevant main switchboard as described in procedure No.2 and that the generator controls are in MANUAL mode.

a) As the control mode is set to LOCAL, then the generator load must be shifted manually using the RAISE/LOWER switches of the incoming generators located on the bus-tie panel, switching to LOWER on the outgoing generator and RAISE on the remaining generator

b) When the load on the outgoing generator is at about 10%, turn the CIRCUIT BREAKER switch (SCT) for the outgoing generator to the OPEN position.

c) The VCB will receive an OPEN command and will open. The VCB OPENED indicator on the relevant generator main switchboard panel is illuminated.

d) The remaing load that was on the outgoing generator will be taken up by the running generator.

e) After a predetermined cooldown period, turn the ENGINE CONTROL switch (SC3) on the relevant generator main switchboard panel to the STOP position, the generator will stop.

Power Management System (PMS)

The automatic operation of the switchboards is achieved by the Power Management System (PMS), the SEPAM protection relays and the control and monitoring system (CAMS)

The main purpose of the PMS is to ensure that there is always a sufficient power reserve available for the essential services of the vessel. This is achieved by:

- Generator control and monitoring.
- Load dependent start/stop of generators.
- Preferential tripping.
- Start blocking of heavy consumers.
- Load sharing.
- Frequency control of the network.
- Blackout restart and sequential restarting.
- Power limitation of propulsion drives.
- Generator start and stop priority via HMI.
- Minimum quantity of generators on line via the HMI
- Automatic recovery of main switchboard power in the event of a system blackout. The hardwired blackout recovery logic of the emergency switchboard, starts and connects the emergency generator on detection of a blackout. The starting and stopping of the emergency generator is without the intervention of the PMS
- 6.6kV and 450V switchboard circuit breaker status. via HMI
- Manual opening and closing of 6.6kV circuit breakers. via HMI
- Manual opening and closing of LV switchboard transformer incomer and interconnector circuit breakers. via HMI
- Automatic synchronising and dead bar closing of 6.6kV bus interconnector circuit breakers via the HMI.
- 1st stage (non-emergency) shutdown and start, synchronization and load up the next stand-by generator and shutdown of the faulty unit. (1st stage shutdowns are defined by the engine supplier).
- Restart lube oil pumps upon restoration of supply after a blackout.
- Monitoring of diesel engine cylinder exhaust gas temperatures and deviation alarms

The PMS on this vessel is a stand alone system, it consists of the following units:

HMI Work stations

- WS31 - Engine control console No.1
- WS32 - Engine control console No.2
- WS33 - 6.6kV main switchboard No.1
- WS34 - 6.6kV main switchboard No.2

Control field stations

- FS01A - 6.6kV main switchboard room No.1
- FS01B - 6.6kV main switchboard room No.2

Remote I/O field stations

- FS02 - Engine control room No.1
- FS03 - Engine control room No.2

HMI Work Stations

The work stations' operating system is the Iconics® SCADA system, this provides functions as follows:

- User login with multiple privilege levels
- Alarm display, sounding and acceptance
- Historical alarms and event logging
- System health monitoring
- Power system mimics (allowing both control and monitoring)
- Signal trending

The mimics are displayed on an ISIC DuraMON G-line 24"® screen monitor, this is controlled by a GE RXi2® industrial computer, it has a Cherry® keyboard and a mouse for inputting.

The work stations are located as follows:

- WS31 - No.1 engine control room console
- WS32 - No.2 engine control room console
- WS32 - No.2 HV main switchboard room
- WS33 - No.1 HV main switchboard room

Control Field Stations

The control field stations operate in parallel with one active and one on standby shadowing and checking on the operation of the active one. Should any problems arise then the one shadowing will take over the operation of the PMS seamlessly with no interruption of operation.

The active control field station receives inputs from the the plant and issues commands to the plant via the remote I/O (RIO) fieldstations.

The control field stations are located as follows:

- FS01A - No.1 HV main switchboard room
- FS01B - No.2 HV main switchboard room

Remote I/O Field Stations

These field stations contain rails of input/output terminals, they provide an interface between the plant and the controller field stations. Communication is via I/O ethernet connections.

The remote field stations are located as follows:

- FS02 - No.1 engine control room
- FS03 - No.2 engine control room

PMS Power Supply

The PMS system shares UPS power supplies with the electrical propulsion system (EPS), these UPS are located as follows:

- UPS1 - No.1 Frequency converter room, powered from load center panel No.3, circuit number P-LCP3-36.
- UPS2 - No.2 Frequency converter room, powered from emergency switchboard 440V emergency feeder panel, circuit number P-ESB-75.

Operating the Generators from the PMS Human Machine Interface (HMI) Panel

Manual Operation

There are two ways of starting a generator manually from the PMS HMI panel, the START switch on the PMS panel and the LOAD UP soft switch on the PMS HMI screen:

a) When a start request is made via the START switch of the PMS panel, the PMS will issue a START command. The engine will start and run up to its operating speed and will run off line. The PMS takes no further action.

b) When a LOAD UP request is made at the PMS HMI panel screen, the PMS will issue a START command to the generator engine which will start and run up to its operating speed. When the rated speed is reached the PMS will issue a CLOSE command to the VCB. The generators auto synchronizer will be initiated and the speed and voltage will be adjusted to match the busbar frequency and voltage by way of digital RAISE and LOWER signals. When synchronization is achieved the auto synchronizer will enable the closure of the VCB and it will close.

Automatic Operation

For automatic operation by the PMS the following criteria have to be met.

The generator's starting condition has to be normal, ie:

a) L.O. priming pump running

b) Any generator trouble has been reset

c) The engine control panel (ECP) at the machine side has a mode switch that allows a choice between LOCAL control and REMOTE control. This switch should be set to REMOTE.

d) On the generator control panels in the 6.6kV HV main switchboard rooms, put the mode switches into the REMOTE position

Automatic Start of a DG and Connection to a Live Bus

If it is required to start a standby generator by the PMS due to load dependant start the following applies :

a) The PMS will issue a START command and the engine will start.

b) When the voltage has been established the PMS will initiate auto synchronization, when synchronization has been achieved the PMS will then issue a CLOSE command to the generator VCB and it will close.

c) The PMS will then initiate auto load sharing and the load will be shared between all the running generators

Automatic Start of a DG and Connection to a Dead Bus Due to a Blackout.

Should a blackout occur the following steps will be initiated by the PMS:

a) The PMS on receiving a blackout signal will immediately give a START command to the 1st standby generator.

b) The generator will start and run up to nominal voltage.

c) The PMS will issue a CLOSE command to the relevant VCB which will close.

d) The 6.6kV main switchboard is now under power.

Disconnection of a Generator Circuit Breaker

When a disconnect command is given by the operator, it will cause an automatic load reduction of the generator. Providing the generator is in symmetrical or asymmetrical load sharing mode, when the generator load is less than 5%, the PMS will give a signal to the switchboard to open the generator circuit breaker. If the generator stop is caused by an automatic stop request from the PMS (load dependent stop), the generator downloading and breaker opening will be performed automatically, without operator intervention.

Generator circuit breaker disconnect can be initiated by one of the following conditions:

- A disconnect request from one of the operator stations.
- A load dependent stop (if the generator is in standby)
- A stop initiated by the generator's safety system (if the generator is in standby)

For the PMS to disconnect a generator from the switchboard bus, the following criteria must be followed:

- The generator must not be in local control.
- There must be more than one generator connected to the switchboard.
- The generator's share of the load must be less than 5% of the total load.
- Internal blocking criteria (e.g. not reset after downloading timeout)

If the disconnection is the result of a command from the activation of the diesel engine safety system, the generator circuit breaker will be disconnected regardless of external or internal disconnect blocking or generator load.

If a circuit breaker OPEN feedback signal is not received within the time period of the load reduction time out, a disconnection failure alarm will be raised.

Load Dependent Start/Stop of Generators

If the load on the running generators reaches 85% of the total capacity of these running generators for more than 30 seconds, the next standby generator in line will be started by the PMS, synchronize, connect to the bus and share the load with the other generators.

If after a period of time the load on all the running generators should drop to 65% of the total capacity of the running generators minus 1 for more than 60 seconds, the PMS will transfer the load from the last generator to be started to the other generators and will disconnect it and send a STOP command to it.

DG Conn.	Start Limit	Delay	Stop Limit	Delay
1	85% of 1 gen	30 s		
2	85% of 2 gen	30 s	65% of 1 gen	60 s
3	85% of 3 gen	30 s	65% of 2 gen	60 s
4			65% of 3 gen	60 s

This functions as follows:

a) One generator is running total power available = 4053kW. Load > 85% of available power = 3445kW for 30 seconds. The PMS starts 2nd generator and puts it onto the busbars, total power available 8106kW.

b) Two generators running total power available = 8106kW. Load > 85% of available power = 6890kW for 30 seconds. The PMS starts third generator total power available = 12159kW.

c) Three generators running total power available = 12159kW. Load > 85% of available power =10335kW for 30 seconds. The PMS starts the fourth generator total power available 16212kW.

d) The load is < 65% of available power of three generators = 12159kW for 60 seconds. The PMS unloads and stops last generator to be started.

e) The load is < 65% of available power of two generators = 8106kW for 60 seconds. The PMS unloads and stops last generator to be started.

f) The load is < 65% of available power of one generator = 2634kW for 60 seconds. The PMS unloads and stops last generator to be started.

g) One generator is running total power available = 4053kW.

Preferential Tripping

For the prevention of blackout circumstances, there are two scenarios for the activation of the preferential trips:

- **Frequency** - If the frequency of the supply should fall below 57Hz for 5 secs, PT-1 will trip. If the frequency were to remain below 57Hz for a further 5 secs then PT-2 will trip.
- **Load** - If the load on the generators is 100% for 5 secs then PT-1 will trip, if the load remains at 100% for a further 5 secs then PT-2 will trip.

The following are the affected units:

PT-1

- No.1 load center panel
- No.1 to No.10 hot water calorifiers

PT-2

- Starters No.1 to 4 A/C chilled water plants
- Control panels AHU No.1 to No.5
- Control panels AHU No.7 to No.16
- Starters for chilled water pumps No.1 to No.4
- Starters for heated water pumps No.1 to No.4
- Control panels for FCU1 and 2
- Control panels for FCU4 to 10
- RPD-1
- Control panels for provision refrigeration plant compressors No.1 and No.2
- Control panel for refrigerated provision store 1/2 and lobbies
- Control panel for refrigeration system of daily room (galley)

Start Blocking of Heavy Consumers

The heavy consumers on this vessel are the bow thruster (1800kW) and stern thrusters (890kW) If the PMS receives a start request from the bow or stern thusters it will evaluate if there is sufficient spinning reserve of power to start, if there is not, then the PMS will start the next generator that is in standby and when it is on line and synchronized the PMS will then issue a start enable signal to the thruster to start.

Load Sharing

Load sharing modes can be selected individually for each generator and is based on active power (kW).

The following load sharing options are available under the PMS:

- Symmetrical load sharing.
- Asymmetrical load sharing.
- Fixed load.
- Manual load sharing.

For control of load sharing and network frequency, speed increase and decrease signals (pulses) are sent to the speed governor. Speed droop is always applied (about 5%).

Symmetrical Load Sharing

In symmetrical load sharing, each generator that is connected to the switchboard takes an equal share of the load, a small deadband of 1% of rated power is allowed, this is because not all the generators have exactly the same characteristics and this allows for slight differences in the generators.

Asymmetrical Load Sharing

Asymmetrical load sharing is used as a maintenance function to burn off carbon deposits that have accumulated during extended low load operation of the generators.

One of the generators will be selected as the master and will be loaded to 80% of the total load. The remaining load will be shared between the remaining running generators (slaves).

After 4 hours the master generator will automatically change over to the next generator.

If the load on the slave generators falls below 30% of the total load, the load on the master generator will be reduced.

The load will be shared symmetrically between the running generators if the load on the slave generators should rise above 80%.

Fixed Load

At times it is necessary to run a generator at a steady load for maintenance purposes. This is achieved by selecting fixed load mode, in this mode the selected generator runs at a fixed steady load. While the generator is in fixed load mode the other running generators take care of any rise or reduction in load.

The setpoint of the fixed load is selected by the operator, it will be maintained at this level by the PMS.

When a generator is selected for standby, it cannot be selected for fixed load mode.

Manual Load Sharing

In manual load sharing mode, the operator adjusts the load on the generator that is in manual load mode by using the raise and lower speed switches at the operator station.

The PMS has no active role in this mode.

When a generator is selected for standby, it cannot be selected for manual load mode.

Frequency Control of the Network.

The PMS maintains the steady state frequency of the common bus bar to a programmed set point, by control of the prime mover governors.

Individual generator kW loadings are calculated and compared with the actual monitored loadings. If the errors are not within a pre-defined deadband, speed raise or lower pulsed output commands are sent to the respective governor(s)

Automatic Recovery of Main Switchboard Power in the Event of a System Blackout.

The hardwired blackout recovery logic of the emergency switchboard, starts and connects the emergency generator on detection of a blackout. The starting and stopping of the emergency generator is without the intervention of the PMS.

The emergency switchboard supplies all the essential services rerquired to start the main generators, the PMS will initiate a blackout recovery sequence as follows:

a) When a blackout is detected, the PMS issues a BLACKOUT CONDITION alarm, all the 6.6kV switchboard VCBs will be tripped by under voltage trips.

b) The PMS issues a START command to the generators, the generators will run up to their nominal voltage the PMS will issue CLOSE commands to the generators. When the first generator reaches its nominal voltage its VCB will close, then when the second generator has reached its nominal voltage it will synchronize with the bus and its VCB will also close and so on. When the 6.6kV bus bar is live the PMS will issue CLOSE commands to the 6.6kV ship services transformers associated with the live bus bar, this will initiate the pre-magnetization of the transformers, and their VCBs will close. The ship service 450V ACB at the 450V switchboard will close on closure of the 6,6kV VCB and the power on the 450V switchboard will be restored.

c) With power restored to the 450V switchboard the PMS will start all the services that do not have under voltage trips that were running before the blackout.

d) If the propulsion system was running before the blackout, it will be started.

e) All the consumers that were tripped on under voltage at blackout will then be started manually until full service is restored.

Sequential Restarting

After a blackout event when power is restored, certain essential services will be restarted automatically in a sequential manner, so as not to overload the generators by too many consumers being put on line at one time.

This is known as sequential starting and is arranged as follows:

Group	Consumer
0 sec	Lighting, navigation and communication control and instrument equipment. No.1 and No.2 steering gear. Nos.1, 2, 3 and 4 main generator DE LO pumps, NDE LO pumps
5 sec	Nos. 1, 2, 3 and 4 auxiliary CSW pumps
15 sec	No.1 and No.2 bow thruster fresh water cooling pumps
20 sec	No.1 and No.2 fresh water pump for water mist system. No.1 and No.2 main fire pumps. No.1 and No.2 fire main hydrophore pump. Emergency fire pump
25 sec	No.1 motor room supp/exh fan (MR1) No.2 motor room supply fan (MR1) No.3 motor room supp/exh fan (MR2) No.4 motor room supply fan (MR2)

Generator Start and Stop Priority via HMI.

The generator start and stop priority is selected by using the human machine Interface (HMI) of the PMS display screen.

Minimum Number of Generators Online via the HMI

The minimum number of generators required foir the different modes of operation of this vessel is selected by using the HMI of the PMS display screen

Power Limitation of Propulsion Drives

The PMS has no control over the propulsion system, however the propulsion system monitors the power availability and if this reduces for whatever reason the propulsion system will reduce its power requirements by reducing the speed of the propulsion. When the power reduction is ended then the propulsion system will increase its power requirements to its normal level.

Circuit breakers controlled and monitored by PMS

- Bow thruster feeder
- Stern thruster feeder
- Diesel generators Nos.1, 2, 3 and 4 Incomers

Circuit Breakers Monitored (only) by PMS

- Propulsion Transformers No.1 and No.2 Feeders
- Emergency generator incomer
- LV switchboards to emergency switchboard
- LV shore incomers No.1 and No.2 LV switchboards
- Load center Nos1, 2, 3 and 4 feeders
- Load center Nos1, 2, 3 and 4 incomers
- Emergency load center Nos.1, 2 and 3 feeders
- Emergency load center Nos.1, 2 and 3 incomers
- AMP1 and AMP2 circuit breakers

Bus-tie Circuit Breakers Controlled and Monitored by PMS

- HV Bus 1 to HV Bus 2 Interconnector
- HV Bus 1 to HV Bus 3 Interconnector
- HV Bus 2 to HV Bus 4 Interconnector
- HV Bus 3 to HV Bus 4 Interconnector
- HV Bus 3 to HV Bus 1 Interconnector
- HV Bus 4 to HV Bus 2 Interconnector
- Nos.1, 2, 3 and 4 Main Transformer Feeders
- Nos.1, 2, 3 and 4 Main Transformer Incomers
- Incomer to AMP1 Panel (AMP1 Receiving CB)
- Incomer to AMP2 Panel (AMP2 Receiving CB)
- No.1 and No.2 LV SWBD Busties
- No.1 and No.2 LV SWBD Interconnectors

Shore Power

This vessel has two types of shore power facilities,:

- Low voltage 440V, laid up/repair mode
- High voltage 6.6kV, full complement in port mode.

440V Shore Connection (Laid up/Repair Mode)

In this mode cables from shoreside are connected to sockets in weatherproof boxes, each box contains two sockets with a total capacity of 800A (2 x 400A) and are located as follows:

- Port side, on bulkhead outside the Inergen room in the multi purpose space of level 02. This is connected to a shore connection panel in the No.2 440V low voltage switchboard
- Starboard side, on bulkhead outside the emergency generator room, in the multi purpose space of level 02. This is connected to a shore connection panel in the No.1 440V low voltage switchboard

The following monitoring instruments and lamps for the shore supply are located on the shore connection panels:

- Watt hour meter.
- Phase sequence indicator.
- Voltmeter.
- Frequency meter.
- Ammeter.
- Voltmeter/Frequency phase selection switch.
- Shore power available indicator (WHITE).
- Shore Air Circuit-Breaker (ACB) closed indicator (GREEN).

A phase sequence monitoring systems are installed on the shore connection panels. The sequence should be checked before connecting shore power to the switchboards. If the phase sequence is incorrect, the shore supply must be isolated and two supply phases changed over. The supply should then be reinstated and the phase sequence checked again.

Procedure to Connect to 440V Shore Power

The following steps should be taken for safe connection of the shore power:

a) The main switchboards should be set to manual to prevent the start of the main generators when the vessel blacks-out.

b) The breakers of the consumers of the 6.6kV switchboards should be opened, and the running generators reduced to one. All non-essential services should be isolated and the load on the 440V switchboards reduced to an absolute minimum. The sequential restart facility should also be disabled.

c) The emergency generator should be placed in MANUAL MODE at the emergency generator local control panel to prevent it starting when vessel blacks-out.

d) Before connecting any cables from shore, it should be confirmed with the shore personnel that the breaker ashore is disconnected. After checking with a meter to confirm this, the shore cables are plugged into the sockets of the relevant connection box.

e) When the cables are connected, the shore personnel should be requested to close the circuit-breaker ashore.

f) A check is then made of the voltage and the frequency. If these are correct, a check is then made of the phase sequence indication observed on the phase sequence indicator (PSI). If the phase sequence indicator shows that the phase sequence is incorrect, the shore side is requested to open the circuit-breaker ashore and change over two of the phases. The shore side is then asked to close the shore circuit-breaker. The phase sequence should now be correct. The voltage, current and frequency can be monitored from meters on the shore connection panel of the 440V low voltage switchboard.

g) After informing the vessel by PA that there will be a blackout for a few seconds, the circuit-breaker of the connected generator is opened and the vessel will black-out.

h) The shore connection circuit-breaker should now be closed.

i) The 440V low voltage switchboard is now be supplied by the shore power.

The shore supply should be closely monitored to ensure the 800A current limit is not exceeded.

There is a kilowatthour meter installed on the shore connection panel to indicate the total power consumed.

There are interlocks between the circuit breakers of the generators and the shore circuit breaker, this prevents any of the generator's VCBs from closing if the shore circuit breaker is closed and vice versa.

Procedure to Disconnect from 440V Shore Power

a) Reduce the load on the 440V low voltage main switchboards and emergency switchboard to an absolute minimum.

b) Place the emergency generator in MANUAL mode, to prevent it starting automatically when the switchboard blacks out.

c) Start and run up a 6.6kV main generator in manual mode. Check the voltage and frequency and adjust if necessary.

d) Make an announcement on the PA system that there will shortly be a blackout.

e) Open the shore connection circuit breaker in the shore connection panel, the switchboards will blackout. The interconnect circuit breaker between the 440V main switchboard and the emergency switchboard in the emergency switchboard will trip due to a dead 440V low voltage main switchboard.

f) Close the VCB of the running main generator using the relevant VCB CLOSE switch on the 6.6kV main switchboard.

g) The 6.6kV main switchboard will now be powered, the interconnect circuit breaker between the 6.6kV main switchboard and the 440V main switchboard will close automatically and the interconnect circuit breaker between the 440V low voltage switchboard and the emergency switchboard will also close automatically and will be powered by the main generator.

h) Request by radio that the shore side open their ACB, when this is confirmed to have been done, then they can be disconnected and lowered ashore.

i) Another main generator can be started and connected in automatic mode and the load shared between them. The original generator can then be unloaded and stopped and then put into auto and then standby, if more power is required it will start automatically and connect and load share, the switchboards are now back to normal.

j) Place the emergency generator back in AUTO mode.

k) Ensure that all essential loads have started automatically, if any have not they should be started manually.

6.6kV Shore Power (AMP)

There are two AMP connections one to port and one to starboard, the cable reels are located on accommodation level 02, No.1 (starboard) at frame 60 and No.2 (port) at frame 55. The cables are fed to the 6.6kv HV shore connection panel in the HV shore connection room on the starboard side No.2 deck at frame 58 - 65.

Operation of the AMP Reel (Lowering).

The following steps are taken to connect to AMP connection :

a) Ensure that the POWER ON indicator is lit (white) on the reel control panel. Ensure that REEL READY indicator is lit both on the reel control panel and on the shore power panel of the 6.6kV main switchboard (white) if not check if Q2 and Q3 are closed (inside cabinet).

b) Using the cable guide switchbox (located on the fwd frame of the reel unit), place the cable guide selector switch into the ON position, then press the LOWER push button, the cable guide will lower to its operating position, there is a limit switch so it cannot lower past its correct position. When the guide has reached its operating position and is stopped by the limit switch, place the cable guide selector switch into the OFF position

c) Using the cable reel selector switch on the pendant box (MANUAL/AUTO), place the switch into the MANUAL position and make sure the EMERGENCY STOP switch is not in the operating position.

d) Press the UP push button on the pendant box, this will lift the plugs from their stowed position the reel will only rotate a little until the up limit switch is activated..

e) With the assistance of another person to guide the plugs into the correct position on the guide, press the DOWN push button on the pendant box.

f) Make sure the plugs are placed correctly in the bottom window of the guide and that they do not snag. Keep the DOWN push button pressed until the plugs reach the required position where the shore personnel will pull the plugs and cables to the connection point. Before connection the nylon protection sleeves must be pulled back and the plug covers removed. the cables are then secured using the cable socks that are provided. The plugs are then connected into their appropriate colour coded sockets.

g) When the connections are made the cable reel selector switch is then placed into the AUTO position, this will activate a timer that will operate the reel motor for 10 seconds every 10 minutes (adjustable) this will reel in any slack that occurs due to the movement of the vessel owing to wind, tide or changes in the draft. The hydrodynamic drive system of the reel allows for the cable to unwind if any tension is applied to it so that the cable can never be over tensioned.

Operation of the AMP Reel (Raising)

The following steps are taken to disconnect from the AMP connection:

a) Ensure that the POWER ON indicator is lit (white) on the reel control panel. Ensure that REEL READY indicator is lit (white) if not check if Q2 and Q3 are closed (inside cabinet).

b) Using the cable reel selector switch on the pendant box (MANUAL/AUTO), place the switch into the MANUAL position and make sure the EMERGENCY STOP switch is not in the operating position.

c) Press the DOWN push button on the pendant box enough to slacken the cables a little. The shore can then unplug the cables from their sockets and the protective covers and sleeves are replaced on the plugs. The cable socks can then be released from their fixings

d) Press the UP button to reel in the cable. Although the plugs in their protective covers can be dragged along the wharf it is better that they be carried as the cable is reeled in.

e) Continue pressing the UP button until the upper limit is reached and the reel will stop.

f) With the assistance of a second person to guide the plugs into their stowed position press the DOWN button until they are resting lightly on the deck.

g) On the cable guide switchbox place the guide ON/OFF switch into the ON position and press the UP button until the guide is fully retracted.

h) Make sure that the plugs are in their properly stowed position.

i) On the cable guide switchbox, switch ON/OFF switch into the OFF position.

j) Place the MANUAL/AUTO switch into the OFF position

k) As an additional safety precaution the EMERGENCY STOP push button can also be operated.

When connecting to the AMP this sequence is followed.

a) Required criteria for connection
   - AMP connecting mode is set from switchboard (other generator load up is inhibited).
   - One generator remains online with minimum loading.
   - Generator VCB is switched to REMOTE.
   - AMP receiving VCB is switched to REMOTE.
   - AMP receiving VCB is available.
   - AMP VCB is closed.
   - Blackout recovery is disabled.
   - Automatic START/STOP is disabled.
   - Preferential trip is disabled.

b) Transfer to AMP1 or AMP2 button is pressed by operator on the mimic.

c) Switchboard synchroniser checks voltage, phase and frequency.

d) AMP receiving VCB is closed by PMS.

e) PMS transfers load from generator to AMP.

f) When load on generator is less than 5% the generator VCB will open.

g) When system is being supplied by AMP the generator is manually stopped.

When the AMP is disconnected this sequence is followed

a) Preconditions are checked
   - Blackout recovery disabled
   - Automatic start/stop disabled
   - Preferential Trip disabled
   - Only 1 AMP connected
   - Only 1 generator online
   - Total system load supplied by shore supply is less than the capacity of 1 generator

b) AMP disconnecting mode is set from the switchboard

c) Generator START/LOAD UP is permitted

d) Selected generator by operator is started and is run up to nominal voltage.

e) The TRANSFER button is pressed by operator on the mimic

f) PMS unloads from the AMP to the generator

g) When AMP load is less than 5% AMP receiving VCB is opened

h) Other generators are then permitted to be started connected to the switchboard and loaded.

Switchboard Electrical Interlocking

The Local-Manual synchronising of each switchboard section will only operate if all other 6.6kV Main switchboard synchronising section sync select switches are in the 'OFF' position.

General Switchboard Interlocks

- The dead bus voltage trip will prevent all feeder circuit breakers from closing onto a dead bus. This excludes generators and bus-ties/interconnectors. The bus-ties/interconnectors are only prevented from closing if both switchboards are dead
- The generator and AMP shore panel feed incoming circuit breakers are able to close onto a dead bus.
- In the event of a lockout trip the circuit breaker is prevented from closing if the fault is not cleared and lockout manually reset.
- If a generator engine is not running its circuit breaker cannot close.
- The generator circuit breakers will trip on:
  - Engine shutdown,
  - Governor major fault
  - AVR watchdog fault
  - Diode short circuit or loss of sensing,
  - Protection relay fault
  - ESD Emergency shutdown.
- The generator is only available for PMS control if the engine is in REMOTE mode and the selector switch at the generator incomer panel is switched to REMOTE and all lockout protection trips are healthy.
- The diesel engine is inhibited from starting in both remote and local modes if the generator circuit breaker is earthed or if the lockout fault has not been cleared and manually reset.
- The switchboard will trip the diesel engine and de-excite the generator on a lockout protection fault.
- Unless the thruster converter has not been precharged or the thruster transformer has not been pre-magnetised, and all CB inhibits are not healthy the thruster transformer circuit breaker cannot close. This interlock is a function of the converter.
- The thruster transformer CB trips in the event of a drive system fault or EMERGENCY STOP.
- If the feeder circuit breaker of the propulsion transformer is in the TEST position the thruster converter is inhibited from pre-charge.
- Thruster transformer and ship service transformer feeder circuit breakers trip on winding over temperature.
- It is imperative that in the event of a lockout trip, the fault must be investigated before any lockout relays are reset and before any attempt is made to close the affected circuit breaker. When multiple lockout trips occur eg, generators and bus-ties, this indicates that a fault exists on the busbar or interconnecting cable and as such must not be made live until the problem has been investigated and rectified.
- Interlocking shall prohibit closed ring operation and ensure that at least one bus section stays open.
- Interlocking is provided to allow for only momentary synchronizing of AMP shore power.

Interlocking between 6.6kV and LV Systems

The design of the system is such that all four main generators can operate at once in single island mode.

The following electrical interlocks are provided, to ensure that the system operates in a safe and reliable manner,

- In the event of a ship service transformer 6.6kV circuit breaker opening, a trip command will be sent to the downstream equipment to open the corresponding 450V circuit breaker.
- In the event of a ship service transformer 450V circuit breaker opening, a trip command will be sent to the upstream equipment to open the corresponding 6.6kV circuit breaker.

Interlocking at 450V Main and 440V Emergency Switchboard

- Interlocks are provided to ensure that one out of three breakers are opened at the 450V switchboard.
- Interlocks to ensure that the shore supply connected on 450V switchboards is not running in parallel with ship's main supply.
- Interlocks are provided to ensure that only one of the two interconnectors from the 450V switchboards to the emergency switchboard is active. To that end there is an interlock between the interconnecter at No.1 450V switchboard and No.2 450V switchboard so only one can close at one time. The interconnector circuit breakers at the Emergency Switchboard are also interlocked so that only one of them can be closed.
- Interlocks are provided to ensure that one out of three breakers, emergency generator incomer circuit breaker, or a interconnector circuit breaker from the 450V switchboard are connected at emergency switchboard at any one time.
- Interlocking is provided for 450V switchboard interconnector circuit breakers so that they may only be closed if both incomer circuit breakers on the receiving switchboard are open.

Insulation Monitoring

6.6kV HV Switchboards High Resistance Grounding (HRG) System

In ships the earthed neutral point is prohibited as if an earth fault should occur very high levels of earth fault current would make it impossible to operate with an earth fault. The HRG system is used to counter this. The HRG system uses ground protection transformers (GPT) these consist of three single phase transformers with their primaries connected in star formation to each of the phases of the bus with the neutral point earthed. The secondaries are connected in an open delta configuration with a resistor connected across the open delta connection. Each HV bus is equipped with a GPT. The Sepam protection relays are connected across these resistors.

When the system is healthy and no earth faults are present the primary voltages of the GPT are balanced and so the secondaries are at zero volts and so no current will flow. Should an earth fault occur on one of the phases this would cause a voltage to be produced in the secondaries, this will cause a current to flow which is restricted by the resistor, a corresponding current will also flow in the primaries restricted by the resistor. Across this resistor Sepam 80 protection relays are connected, These will produce a two stage trip the first stage will trip the bus-ties and the interconnecter VCBs thus isolating the busses. If the fault still persists on one of the busses the second stage will cause the respective generator VCB to trip.

Earth monitor lamps are also provided on the front panels of the GPTs, these will indicate in which phase the fault occurs.

450V Ship Service Switchboards

The 450V ship service switchboards are monitored by DEIF SIMQ Mk11 insulation meters, if the insulation should fall below the programmed level of 0.5 MΩ. an alarm will be raised to both the PMS and CAMS.
Earth lamps are provided on the incoming panels to detect on which phase the low insulation is, the phase that has caused the alarm can be determined by the use of the earth lamps. The lamp that dims or extinguishes is the one on the faulty phase. The faulty equipment has then to be isolated by opening the breaker of each piece of equipment in turn while monitoring the insulation resistance monitor meter and when the breaker of the faulty equipment is opened the meter will show high resistance. This should only be done after consultation so as not to compromise the operations of the systems.

120V Switchboards

The 120V feeders are monitored by DEIF AAL-2 insulation monitors set to 0.1 MΩ. Earth lamps are provided on the incoming panels to detect on which phase the low insulation is, the phase that has caused the alarm can be determined by the use of the earth lamps. The lamp that dims or extinguishes is the one on the faulty phase. The faulty equipment has then to be isolated by opening the breaker of each piece of equipment in turn while monitoring the insulation resistance monitor meter and when the breaker of the faulty equipment is opened the meter will show high resistance. This should only be done after consultation so as not to compromise the operations of the systems.

Load Center Panels

No.1 and No.2 load center panels are monitored by DEIF AAL-2 insulation monitors set to 0.1 MΩ. Earth lamps are provided on the incoming panels to detect on which phase the low insulation is, the phase that has caused the alarm can be determined by the use of the earth lamps. The lamp that dims or extinguishes is the one on the faulty phase. The faulty equipment has then to be isolated by opening the breaker of each piece of equipment in turn while monitoring the insulation resistance monitor meter and when the breaker of the faulty equipment is opened the meter will show high resistance. This should only be done after consultation so as not to compromise the operations of the systems.

Receptacle Distribution Boards

The three receptacle distribution boards are monitored by DEIF AAL-2 insulation monitors set to 0.1 MΩ. Earth lamps are provided on the incoming panels to detect on which phase the low insulation is, the phase that has caused the alarm can be determined by the use of the earth lamps. The lamp that dims or extinguishes is the one on the faulty phase. The faulty equipment has then to be isolated by opening the breaker of each group of receptaclest in turn while monitoring the insulation resistance monitor meter and when the breaker of the faulty equipment is opened the meter will show high resistance. This should only be done after consultation so as not to compromise the operations of the systems.

6.6kV Switchboard 110Vdc Control Voltage Uninterruptible Power Supply

So as not to lose the 6.6kV main switchboard control voltage in the event of a blackout, each 6.6kV main switchboard has a 110Vdc UPS. These will seamlessly take of the provision of the 110Vdc control voltage in the event of a power loss.

The input voltage 440Vac is transformed down to 118V, rectified and fed to the output as 110Vdc and also charges the batteries. Should the 440Vac be lost due to a blackout, the batteries would seamlessly take over the duties of the 110Vdc control voltage.

These UPS are redundant as each one supplies both switchboards and also the AMP shore power switchboards, so if one should fail the other one will take over all the control voltage duties.

The UPS specification is as follows:

Manufacturer	KTE Electric Co Ltd
Type	Dead front self supporting
Input voltage	440Vac/60hz from emerg. swbd P-ESBD-153
Output voltage	110Vdc
Rated current	50A
Charging voltage	119.7Vdc floating

Batteries

Manufacturer	SEBANG (Global Battery Co Ltd)
Type	ESP40-12
Nominal voltage	108Vdc
Capacity	40Ah

The front panel has the following controls and indicators:

- KTE-UPS-110 UPS controller panel
  - Mode switch
  - Alarm reset switch
  - Set switch
  - Enter switch
  - Up/Down switches
  - Lamp test switch
  - Battery state indicator
  - Charging/Discharging indicators
  - Setting indicator display

    - Source indicator
    - Alarm indicators
- Amp switch
- Volt switch
- Ammeter
- Voltmeter
- Insulation monitor
- Earth lamps
- Earth lamp push button switch

The batteries are contained in a compartment in the lower part of the unit.

No.1 110Vdc UPS is located in the No.1 HV main switchboard room, port bulkhead at frame 68 and No.2 110Vdc UPS is located in No.2 HV main switchboard room, port bulkhead at frame 78.

3.4 ELECTRICAL SWITCHBOARD ROOMS AND SUBSTATIONS

6.6kV High Voltage Switchboard Rooms

The locations of the HV switchboards are as follows:

HV room No.1, 4th deck engine room, starboard side, between frames 70 - 90. Contained in this room are:

- No.1 HV main switchboard
- No.1 HV main transformer
- No.2 HV main transformer
- UPS for HV main switchboard

HV room no.2, 4th deck engine room, starboard side, between frames 51 - 70 Contained in this room are:

- No.2 HV main switchboard
- No.3 HV main transformer
- No.4 HV main transformer
- UPS for HV main switchboard

6.6kV AMP shore power room, 2nd deck engine room, starboard side, between frames 58 - 66.

Contained in this room are:

- No.1 and No.2 6.6kV shore power connection panels.

440V Switchboard Room

No.1 440V switchboard is located in the No.1 engine control room on the engine room 4th deck, port side, between frames 70 - 90.

No.2 440V switchboard is located in the No.2 engine control room on the engine room 4th deck, port side, between frames 51 - 70.

Load Center Panels

Load Center Room No.1,

Located on the 4th deck, starboard side, between frames 123 - 132: Contained in this room are:

- No.1 emergency 440V load center panel
- No.1 emergency 120V load center panel
- No.1 emergency load center panel transformer
- No.2 emergency load center panel transformer

Load Center Room No.2,

Located on the 4th deck, port side, between frames 123 - 129: Contained in this room are:

- No.1 440V load center panel
- No.1 120V load center panel
- No.2 440V load center panel
- No.2 120V load center panel
- No.1 120V receptacle distribution board
- No.1 Load center panel transformer
- No.2 Load center panel transformer
- No.1 Receptacle transformer

Load Center Room No.3,

Located on the 4th deck, port centerline, between frames 90 - 96. Contained in this room are:

- No.2 emergency 440V load center panel
- No.2 emergency 120V load center panel

Load Center Room No.4,

Located on the 4th deck, port side, between frames 90 - 99. Contained in this room are:

- No.3 440V load center panel
- No.3 120V load center panel
- No.2 120V receptacle distribution board.
- No.2 Receptacle transformer
- No.1 LV main transformer
- No.2 LV main transformer

Load Center Room No.5,

Located on the 3rd deckk, starboard side, between frames 58 - 70. Contained in this room are:

- No.4 440V load center panel
- No.4 120V load center panel
- No.3 120V receptacle distribution board.

Load Center Room No.6,

Located on the 2nd deck, starboard side, between frames 66 - 70. Contained in this room are:

- No.3 emergency 440V load center panel
- No.3 emergency 120V load center panel

AHU Room No.3,

Located on the 3rd deck, center line, between frames 134 - 153. Contained in this room are:

- No.1 240/120V laundry distribution board

AHU Room No.7,

Located on the 3rd deck, center line, between frames 88 - 103. Contained in this room are:

- No.2 240/120V laundry distribution board.

AHU Room No.9,

Located on the 5th level, center line, between frames 86 - 111. Contained in this room are:

- No.3 240/120V laundry distribution board

Emergency Switchboard Room

The emergency switchboard room is located in the multi-purpose space of the engine room casing, 2nd level, starboard side between frames 51 - 64. Contained in this room are:

- Emergency switchboard
- No.1 440V/120V emergency transformer
- No.2 440V/120V emergency transformer.

3.5 ELECTRICAL SAFETY AND PERMIT TO WORK SYSTEM

High Voltage

High voltage circuits are potentially more dangerous than low or medium voltage circuits. This is not only due to the increased voltage, but also the explosion risk, and because under certain circumstances, high voltage circuits can retain a lethal charge even when switched off. In addition, dangerous potentials exist some distance from the actual live high voltage conductors, the distance being determined by the conductor voltage, and the dielectric strength of the insulating materials (including air) surrounding the conductor.

It is therefore essential that all persons who may be required to work on, or operate high voltage apparatus, are fully aware of the hazards and how to avoid the associated danger.

Personnel carrying out high voltage isolation, earthing, maintenance and inspection should have high voltage training.

High voltage apparatus is classified as any apparatus, equipment and conductors which are normally operated at a voltage exceeding 1,000V AC or 1,500V DC.

A Permit to Work system should be established onboard to issue permits to work to the authorised person in charge of work that is to be carried out on the earthed high voltage apparatus, detailing exactly what apparatus is dead, isolated from all live conductors, discharged, connected to earth, and on which it is safe to work.

A key interlocking system is provided for 6.6kV parts, where access to live electrical parts can be reached without using tools. All other parts such as generators and motors are closed, and can be opened only by skilled personnel using tools. The key interlocking system allows for safe access to high voltage equipment for maintenance and repair.

WARNING
At all times the Company's policies on high voltage safety must be adhered to and the Permit to Work system must be followed.

Permit to Work

If maintenance or inspection is required to be carried out on any high voltage equipment, a risk assessment should be conducted, and a Company Permit to Work certificate must be obtained and completed.

The Permit to Work certificate is to be signed by the Chief Engineer officer.

'Caution' and 'Danger Live' notices are to be displayed at all points where the work is being carried out, and near parts that are live or may be made live.

Prior to any work being carried out, the item of equipment or circuit is to be isolated from all sources of possible supply, earthed and tested to ensure that the circuit or equipment is dead.

Cancellation of the Permit to Work certificate must be signed by the person actually carrying out the work and the Chief Engineer officer.

Permit to Work Procedure

a) Issue the Permit to Work.

b) Place the neccesary safety notices in locations that will give a good warning to the vessel's personnel to keep away from the work area.

c) Switch off the equipment on which the Permit to Work is to be issued.

d) Isolate from all sources of supply including voltage transformers. Where physical isolation of the primary is not possible, remove secondary fuses and secure to prevent replacement.

e) Prove the circuit dead.

f) Discharge to earth (where possible through the earth switch).

g) Apply circuit mains earth and secure them to prevent removal.

h) Prove the circuit dead at the point of work to the person who is to receive the Permit to Work or sanction for test.

The named authorised person is responsible for carrying out the above steps in a safe manner.

Mechanical Key Interlocking

WARNING
The High Voltage switchboards have lethal voltages in them. All Company rules and regulations concerning working with high voltages must be adhered to at all times

Owing to the high voltages present in the 6,6kV main switchboards, stringent safety measures must be taken when ever any work or maintenance is carried out on them.

Each VCB has an earthing switch associated with it. The VCBs and the earthing switches are mechanically interlocked, this prevents the earth switch being closed when the VCB is closed and vice versa.

To Earth No.1 Bus

To earth No.1 bus the following procedure must be followed:

a) Open the VCB of the bus tie panel between busses No.1 and No.2 and rack out to the DISCONNECTED TEST position.

b) Earth the interconnection panels 5 and 4 on HV switchboard No.2 and remove keys QM1-5 and QM2-4

c) Open and rack out to the DISCONNECTED TEST position VCBs for panels 2, 3, 4 and 6.

d) On panels 2, 3, 4 and 6 apply circuit earth by closing the ES switch.

e) Remove keys from locking devices QM1-2, QM1-3, QM1-4 and QM1-6.

f) Insert all the keys into the key exchange box (KA), rotate all of the keys to the trap position.

g) Rotate and remove key STA from the key exchange box this will trap all the other keys.

h) Insert key STA into No.1 panel earthing device lock and rotate

i) Apply No.1 bus section earth by closing the ES switch.

j) The No.1 bus section and feeders are now earthed and the key STA is trapped.

k) return the bus to normal working repeat the above steps in the reverse order.

To Earth No.2 Bus

To earth No.2 bus the following procedure must be followed:

a) Open the VCB of the bus tie panel between busses No.1 and No.2 and rack out to the DISCONNECTED TEST position.

b) Earth the interconnection panels 9 and 10 on HV switchboard No.2 and remove keys QM1-10 and QM2-9

c) Open and rack out to the DISCONNECTED TEST position VCBs for panels 9, 11 and 12.

d) On panels 2, 3, 4 and 6 apply circuit earth by closing the ES switch.

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e) Remove keys from locking devices QM1-9, QM1-11, and QM1-12.

f) Insert all the keys into the key exchange box (KB), rotate all of the keys to the trap position.

g) Rotate and remove key STB from the key exchange box this will trap all the other keys.

h) Insert key STB into No.7 panel earthing device lock and rotate.

i) Apply No.2 bus section earth by closing the ES switch.

j) The No.2 bus section and feeders are now earthed and the key STB is trapped.

k) To return the bus to normal working repeat the above steps in the reverse order.

To Earth No.3 Bus

To earth No.1 bus the following procedure must be followed:

a) Open the VCB of the bus tie panel between busses No.3 and No.4 and rack out to the DISCONNECTED TEST position.

b) Earth the interconnection panels 5 and 4 on HV switchboard No.1 and remove keys QM1-5 and QM2-4

c) Open and rack out to the DISCONNECTED TEST position VCBs for panels 2, 3, and 5.

d) On panels 2, 3, and 5 apply circuit earth by closing the ES switch.

e) Remove keys from locking devices QM2-2, QM2-3 and QM2-5

f) Insert all the keys into the key exchange box (KA), rotate all of the keys to the trap position.

g) Rotate and remove key STA from the key exchange box this will trap all the other keys.

h) Insert key STA into No.1 panel earthing device lock and rotate.

i) Apply No.3 bus section earth by closing the ES switch.

j) The No.3 bus section and feeders are now earthed and the key STA is trapped.

k) To return the bus to normal working repeat the above steps in the reverse order.

To Earth No.4 Bus

To earth No.4 bus the following procedure must be followed:

a) Open the VCB of the bus tie panel between busses No.3 and No.4 and rack out to the DISCONNECTED TEST position.

b) Earth the interconnection panels 9 and 10 on HV switchboard No.1 and remove keys QM1-10 and QM2-9.

c) Open and rack out to the DISCONNECTED TEST position VCBs for panels 8, 10, 11 and 12.

d) On panels 8, 10, 11 and 12 apply circuit earth by closing the ES switch.

e) Remove keys from locking devices QM2-8, QM2-10, QM2-11 and QM2-12.

f) Insert all the keys into the key exchange box (KB), rotate all of the keys to the trap position.

g) Rotate and remove key STB from the key exchange box this will trap all the other keys.

h) Insert key STB into No.6 panel earthing device lock and rotate.

i) Apply No.4 bus section earth by closing the ES switch.

j) The No.4 bus section and feeders are now earthed and the key STB is trapped.

k) To return the bus to normal working repeat the above steps in the reverse order.

Procedure for Opening the Back Cover of the Switchboard Panels

To remove the rear cover of the switchboard follow the following procedure:

a) Make sure that the VCB is in the OPEN position.

b) Rack out the VCB to the DISCONNECT TEST position.

c) CLOSE the earth switch ES to the ON position.

d) Take the key from the front earthing switch locking device.

e) Use the key to unlock and open the rear panel.

To replace the rear cover follow the following procedure:

a) Close and lock the rear cover

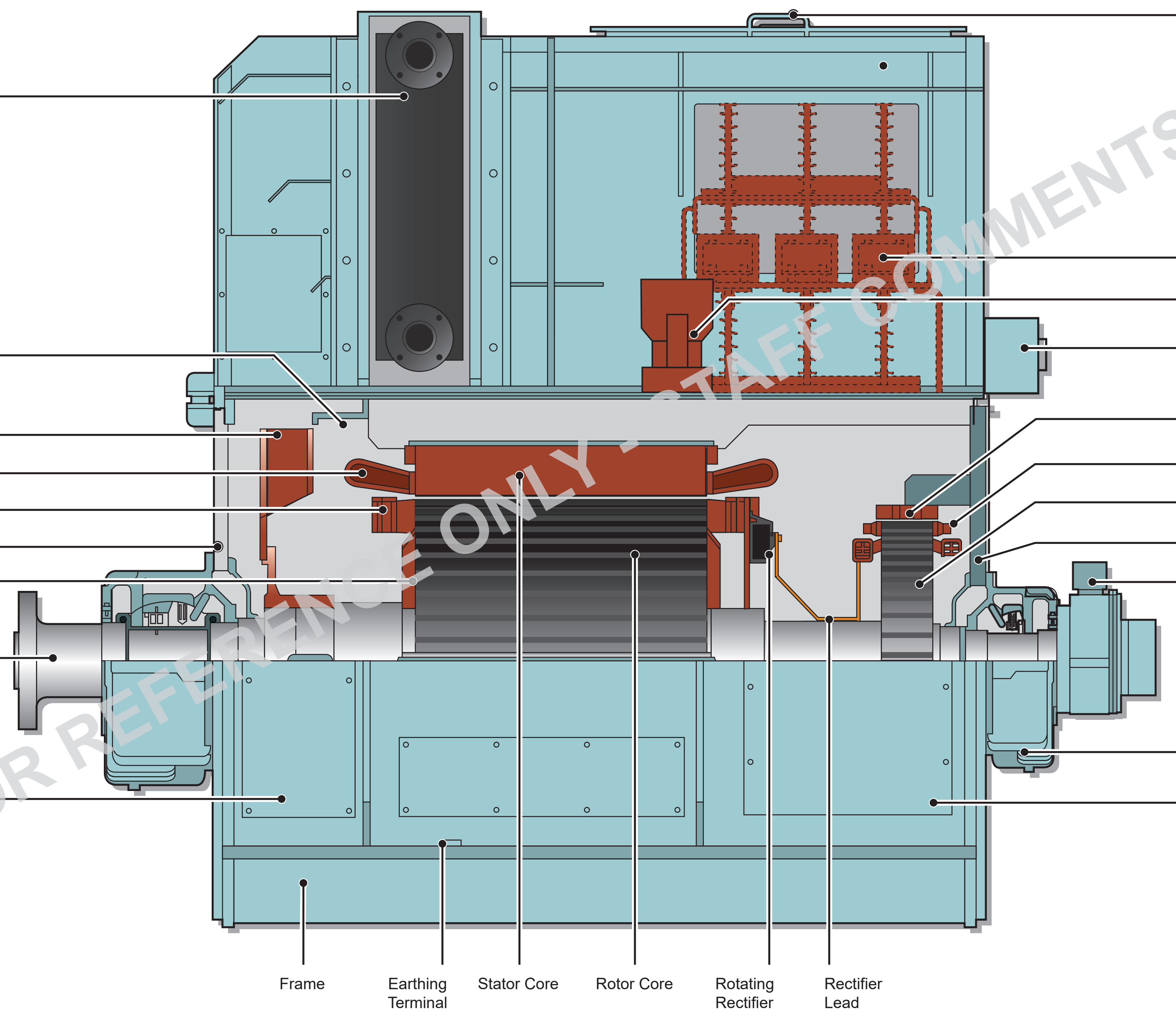
b) Take the ES key from the rear locking device.

c) Use the ES key to unlock the front earthing switch.

d) OPEN the earth switch ES to the OFF position

e) Rack in the VCB to the service position.

Illustration 3.6a Main Alternator



Hyundai HSJ9 830-10P Alternator - Simplified Arrangement

Reference Drawing: 3G-011221

3.6 MAIN ALTERNATORS

This vessel's main power generation capacity is provided by four Hyundai HSJ9 913-08P diesel alternators.

Diesel Generators

The diesel alternators have the following characteristics:

Manufacturer	Hyundai
Model	HSJ9 913-08P
Type	08 pole, cylindrical rotor, brushless. separately excited
Rated Output	5066.25kVA/4053kW
Rated Voltage	6.6kV ac
Current	443.2A
Speed	900 rpm
Frequency	60Hz
Power factor	0.8
Exitation voltage	60Vdc
Exitation current	4Adc
Bearings	D.E. sleeve bearing 250 x L200 N.D.E. insulated sleeve bearing 225 x L168.
Cooling	Air to water cooling
AVR	HDEC 2000
Protection	IP44
Insulation Class	F
Temp. Rise	B
Space Heater	120V 1000W

Location

The generators are located as follows:

No.1 and No.2 in engine room 1 in FZ3, and No.3 and No.4 in engine room 2 in FZ4.

Stator

The stator frame is of welded steel plate design, the stator core is of laminated electrical steel sheet laminations insulated from each other and clamped into a solid core, this is centred into the stator frame and locked against any radial or axial movement. The windings are of two layer coil design and are insulated to class F by integrated mica and enamel coated insulation and then impregnated with cast resin. This provides high dielectric strength and high resistance to moisture, chemicals and aggresive gases, and provides good rigidity and long operating life.

The stator windings have six PT100 temperature probes embedded in them, three active and three spare

Rotor

The rotor consists of a core made up of electrical steel laminations insulated from each other compressed between two end plates and shrink fitted onto a forged steel shaft.

The windings are placed into slots formed when the laminations were pressed out, these windings are wedged into the slots tightly and the ends of the windings are supported with glass fibre bindings.

When the winding slots were formed during the pressing of the individual laminations holes were also formed that when the laminations are clamped together form cooling ducts in the core of the rotor, this greatly enhances the cooling and circulation of the cooling air.

Bearings

This is a double bearing machine, with sleeve bearings at the D.E. and NDE, they have forced oil lubrication with oil coolers, each bearing has its own oil lubrication unit and oil cooler, the oil from the bearing is cooled in a water cooler before being returned to the bearing. This allows reliable lube oil delivery during startup/shutdown and when in turning mode. A filter is fitted to filter the oil and an alarm will be initiated if the filter differential exeeds a programmed value.

Item	Alarm
Low	0.5bar
Low/Low	0.2bar
Flow D.E	6 litres/min
Flow NDE.	2 litres/min
Pressure relief valve	6bar
Filter diff	Yes

Cooling

The cooling system consists of an internal fan attached to the rotor shaft, this circulates the air through the machine and provides cooling. In turn this air is directed to the air/water cooling unit where the air is cooled by water filled tubes, it is then redirected to the fan where the cooled air is once again recirculated.

The air to water cooler is a double tube cooler with a slotted plate fins, the water flows through the inner tube and cools the outer tube and slotted fins, the air flows through these fins and around the outer tubes and so is cooled.

Should there be a leakage between an inner tube and an outer tube the water wil flow down a small tube to a leakage detector and this will provide an alarm to the system, there are two leakage detectors for each cooling unit, right and left.

If for some reason the cooling water cannot be provided the alternator can run in emergency cooling mode, certain plates and covers are removed to provide circulation of air from outside the alternator and venting of the heated air into the surrounding atmosphere.

The cooler is fitted with a PT100 temperature probe for cooling air temperature,

Space Heater

A 1000W 120V space heater is provided, the contactor for the space heater is interlocked with the VCB of the alternator so as to de-energise the space heater when the VCB closes and to energise the space heater when the VCB opens.

Excitation

The excitation is controlled by an AVR the excitation power is supplied by a permanent magnet generator (PMG) and so it is separately excited. The excitation is supplied to an excitation generator the armature of which is attached to the rotor shaft of the main alternator. A dc voltage is applied to the stationary field windings of this excitation generator and this will cause current to flow and so set up a dc magnetic field. The armature which is attached to the rotor of the main alternator rotates within this magnetic field and an ac current is induced to flow in the rotating armature. This in turn is rectified by a six rectifier three phase rotating rectifier array. The dc current from this is passed to the main alternator's rotating field windings and this will produce an output at the terminals of the stator windings. This constitutes the three phase output of the alternator.

Any variation in the dc voltage applied to the stationary field windings of the excitation generator is reflected in the three phase ac output of the main alternator and so any variation in the output of the main alternator can be compensated for by a corresponding variation in the dc applied to the stationary field windings of the excitation generator, an increase in the dc voltage will cause an increase in the three phase ac voltage and a decrease will cause a decrease.

Automatic Voltage Regulators (AVR)

With an automatic voltage regulator (AVR) providing the dc to the stationary field windings of the excitation generator, fine control over the output of the alternator is achieved.

The AVR used is a Hyundai HDEC 2000, This AVR detects any fluctuation in the generator's output and applies correction to the excitation to offset the fluctuation and so keep the output voltage constant. As the AVR derives its power supply and thus the excitation power, from a permanent magnet generator (PMG) and not from the output of the generator via embedded auxiliary windings, the supply to the exciter is independent from the main output of the alternator, so any dips in the output voltage of the main alternator due to heavy consumers starting etc will not affect the excitation supply, so the fluctuation in the generator output can be compensated for quickly by an increase in dc volts to the excitation and so a tight control over the voltage output of the main alternator is achieved., it is therefore a separately excited system.

Each generator has an AVR No.1 and No.2 generator's AVRs are located in the No.2 GPT panel, No.1 6.6kV HV main switchboard panel No.8.

No.3 and No.4 generators AVRs are located in the No.4 GPT panel, No.2 6.6kV HV main switchboard panel No.7.

Alarms

The alternators have various alarms as follows:

Item	Alarm	Trip
Winding Temperature	120deg C	125deg C
Bearing Temperature	95degC	100deg C
Cooling Air temperature	60deg C	65deg C
CW Leakage Alarm (right and left)	ON/OFF	

3.7 ACCOMMODATION DISTRIBUTION

Illustration 3.7.1 Accommodation Distribution

(Authors notes: To be completed once photographs are available)

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3.8 ENGINE ROOM DISTRIBUTION

Illustration 3.8.1 Engine Room Distribution

(Authors notes: To be completed once photographs are available)

3.9 BATTERY AND UPS POWER SUPPLIES

Main Ship's Battery Charge and Discharge Panel

Manufacturer	KTE Electric Manufacturing Co Ltd
Type	Self supporting dead front
Supply	Main source 440V from LCP No.2
	Secondary source 440V from emerg. switchboard
System voltage	24Vdc
Output	26.7Vdc floating voltage
Current rating	60A
Control system	Automatic by silicon controlled rectifiers (SCR)

On the front panel are a number of switches and indicators:

- WL1 - Main source indicator (white)
- WL2 - Emergency source indicator (white)
- EL81P - Earth lamp positive line
- EL81N - Earth lamp negative line
- ES81 - Earth test push button
- RL - Battery disconnect alarm light (red)
- AS81 - Ammeter switch
- VS81 - Voltage switch
- MCCB1 - Main source circuit breaker
- MCCB2 - Emergency source circuit breaker
- BCM - Charger controller panel
- A81 - Ammeter
- V81 - Voltmeter
- MΩ81 - insulation monitor

Distribution

Circuit	Circuit Name	Rating
P-BS-04	Wheelhouse console distribution board	60A
P-BS-05	Training bridge console distribution board	50A
P-BS-06	No.1 engine control room console	50A
P-BS-07	No.2 engine control room console	50A
P-BS-08	No.2 AIS power supply unit	6A
P-BS-09	Gyro compass dual AC adapter	15A
P-BS-10	Magentic compass inter conn. unit	15A
P-BS-11	Magnetic compass inter conn. unit	6A
P-BS-12	Echo sounder multi-distributor	6A
P-BS-13	Speed log No.1 multi-distributor	6A
P-BS-14	Speed log No.2 multi-distributor	6A
P-BS-15	Master clock unit	6A
P-BS-16	Inmarsat FB250 power supply unit	6A
P-BS-17	Sound reception system main panel	6A
P-BS-18	Sound reception system repeater panel	6A
P-BS-19	BNWAS processor unit	6A
P-BS-20	Water tight door indicator panel in wheelhouse	6A
P-BS-21	Water tight door indicator panel in training bridge	6A
P-BS-22	Control panel for elevator	6A
P-BS-23	RP for day signalling light (starboard)	10A
P-BS-24	RP for day signalling light (port)	10A
P-BS-25	RP for day signalling light (center)	10A
P-BS-26	RP for day signalling light (starboard)	10A
P-BS-27	RP for day signalling light (port)	10A
P-BS-28	RP for day signalling light (center)	10A
P-BS-29	No.2 AIS power supply unit	6A
P-BS-30	No.1 load center panel	10A
P-BS-31	No.2 load center panel	10A
P-BS-32	No.1 emergency load center panel	10A
P-BS-33	F-JB-SD01	10A
P-BS-34	F-JB-SD02	10A
P-BS-35	Signal light control panel	10A

Insulation Monitoring

A DEIF ADL-111Q96 is used to monitor the insulation resistance of the 24VDC system, it is an insulation monitor specifically designed to monitor dc circuits it is set to 0.1MΩ.

Earth lamps are provided on the panel to detect on which line the low insulation is (positive or negative). The lamp that dims or extinguishes is the one on the faulty line. The faulty equipment has then to be isolated by opening the breaker of each feeder in turn while monitoring the insulation resistance monitor meter and when the breaker of the faulty feed is opened the meter will show high resistance. This should only be done after consultation so as not to compromise the operations of the systems.

UPS for Lighting System

There is a dedicated UPS for the lighting system onboard this vessel, the details are as follows:

Manufacturer	LUXCO Korea
Type	10kVA UPS
Capacity	10kVA
Input voltage	440Vac, 3 phase
Output vltage	120Vac, 3 phase
Batteries	
Type	ESP 200Ah - 12, Lead acid.
Capacity	12V 200Ah each battery
Number of batteries	22
Nominal voltage	264Vdc
Charging current	37A

This UPS provides power to the emergency lighting system should a blackout occur, it supplies the following emergency lighting distribution boards, these distribution boards are normally fed from the emergency load center panels, but if a blackout occurs a circuit breaker will trip on loss of power from the emergency load center panel and this will cause a contact open and disconnect the emergency load center panel inmput and at the same time it will cause another contact to close and part of the distribution boards will then be powered from the UPS.

Dist. Bd.	Location	FZ
EL01	Wheelhouse safety center group panel	02
EL02	Training bridge safety center group panel	02
EL04	Corridor level 01 at frame 135 starboard center line	02
EL05	AHU room 8 at frame 96 port side	03
EL06	Multi-purpose space at frame 47 main dk stbd side	04
EL07	AHU room 4 at frame 136 starboard center line	02
EL12	Engine room 1 4th deck at frame 84 starboard side	03
EL13	Engine room 2 4th deck at frame 59 starboard side	04

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Power Management System (PMS) and Electric Propulsion System (EPS) UPS

The PMS and the EPS share common UPSs the specification is as follows:

Manufacturer	Joyatlas GMBH
Model	Joystart Ocean 6kVA
Units	2
Capacity	6kVA
Input voltage	440Vac 3 phase
Frequency	60hz
Input current	15A
Output voltage	120Vac at 60hz
Output nominal current	50A
Supplied from	No.1 - No.3 Load center panel, circuit P-LCP-36
	No.2 - Emergency switchboard, circuit P-ESB-75

Batteries

Manufacturer	CTM
Model	CTL-12-12L
Volts per battery	12V
Charging volts	Float charging 2.275V per cell
Capacity per battery	12Ah
Number of batteries	60
Battery voltage	360V x 2 = 720V

These UPS are loacated as follows:

- No.1 in Frequency converter room No.1
- No.2 in Frequency converter room No.2

CAMS UPS

There are a total of six UPS for the CAMS system they are all of the same model and are located as follows:

- Nos.1 & 2 are located in the No.1 engine control console in engine room No.1
- Nos.3 & 4 are located in the No.2 engine control console in engine room No.2.
- No.5 is located in the wheelhouse console
- No.6 is located in the training bridge console.

The specification is as follows:

Manufacturer	EATON
Model	9SX 3000
Units	6
Input voltage	120V.
Frequency	50/60hz auto-sensing
Input current	24A
Capacity	3000VA

Batteries

Type	Sealed lead acid, VRLA
Voltage	96Vdc, 8 x 12V 9Ah

VDU and Alarm Printer UPS

This UPS is located in No.1 engine room console, its specification is as follows:

Manufacturer	EATON
Model	9SX 1000
Input voltage	120Vac
Frequency	50/60hz auto-sensing
Input current	9A
Capacity	1000VA

Batteries

Type	Sealed lead acid, VRLA
Voltage	36Vdc, 3 x 12V 9Ah

Navigation Light UPS

There are two navigation light UPS, one in the wheelhouse console and one in the training bridge console. The specification is as follows:

Manufacturer	EATON
Model	9PX 1500
Input voltage	120V
Frequency	50/60hz auto-sensing
Input current	10A
Capacity	1500VA

Batteries

Type	Sealed lead acid, VRLA
Voltage	72Vdc, 2 x 6 x 12V 9Ah

These will supply the navigation light control boards should a blackout occur.

Illustration 3.10a Emergency Switchboard *(Authors notes: To be completed once photographs are available)*

3.10 EMERGENCY SWITCHBOARD

Manufacturer:	KTE
Type:	Low voltage, metal-clad
Short circuit fault level	440V bus, sym. 60kA,Asym. 132kA
	120V bus, sym. 50kA, asym. 105kA

The emergency switchboard consists of the following panels :

Panel	Function
A	Emergency generator and bus tie panel
B	440V Feeder panel
C	220V Feeder panel

The emergency switchboard supplies all the loads necessary to start up a main generator should a loss of power occur (blackout). It will also supply the vessel's essential circuits in an emergency situation when the main supply is not available.

Normally, power is supplied from the LV main switchboards to the emergency switchboard via interconnectors.

If a failure should occur in the normal supply then the emergency generator will start automatically and connect directly to the emergency switchboard. Interlocks are in place to prevent the emergency generator from starting and running in parallel with a main generator.

The emergency generator is normally kept in standby mode. The emergency generator may be started for testing and maintenance purposes manually locally and manually at the emergency switchboard. Manual operation may be required in the event of an automatic control circuit failure.

Local manual starting and control of the emergency generator diesel engine is carried out from the engine side local control panel LCP.

Emergency Generator Operating Procedures

The vessel is equipped with one diesel-driven emergency generator. Under normal conditions, the emergency switchboard is supplied from the LV main switchboards. In the event of failure of the normal supply, the emergency generator will start automatically and connect to the emergency switchboard. Interlocks are provided which prevent the emergency generator running in parallel with any of the main diesel-driven generators.

The following procedures are related to the above:

1. Local Manual Control of Emergency Generator From Engine Control Panel (ECP)

a) It is assumed that the emergency generator interlocks are normal and the engine is ready to start.

b) The emergency switchboard mode switch NORMAL/MANUAL/TEST is set to MANUAL

c) The Mode switch on the generator engine local control panel is set to the LOCAL position.

Manual control of the emergency generator is now available.

2. Manual Control of the Emergency Generator From the Emergency Switchboard

a) It is assumed that the emergency generator interlocks are normal and the engine is ready to start.

b) The emergency switchboard mode switch NORMAL/MANUAL/TEST is set to MANUAL

c) The mode selection switch on the generator engine local control panel is set to the MANUAL position.

Manual control of the emergency generator is now available from the emergency switchboard.

3. Automatic Control of the Emergency Generator

a) It is assumed that the emergency generator interlocks are normal, the engine is ready to start.

b) The mode selection switch on the generator engine local control panel is set to the AUTOMATIC position.

c) The emergency switchboard generator panel mode switch NORMAL/MANUAL/TEST is set to NORMAL.

Automatic control of the emergency generator is now available from the CAMS.

4. Automatic Operation: Emergency Generator Start and Connection onto Dead Bus

a) It is assumed that the emergency generator interlocks are normal, the engine is ready to start.

b) The mode selection switch on the generator engine local control panel is set to the AUTOMATIC position.

c) The emergency switchboard generator panel mode switch NORMAL/MANUAL/TEST is set to NORMAL.

d) The main switchboard bus tie breaker opens due to a zero volt situation (blackout).

e) When the emergency switchboard bus voltage drops to zero, the emergency generator engine receives a start command and starts via its electric starter. If the engine fails to start, a start fail alarm is activated.

f) When voltage is established, a check is made to confirm that the emergency switchboard bus voltage is still zero. If this is the case, the emergency generator ACB closes. The emergency generator ACB CLOSED lamp is illuminated. The emergency generator now feeds the emergency switchboard. If the second check on the emergency switchboard reveals normal power has been restored, the emergency generator will run idle until it is stopped manually.

Note: The emergency generator ACB will close within 42 seconds of the blackout being detected.

5. Emergency Generator Engine Test and ACB Closure Without Blackout

The emergency switchboard is being supplied by the main switchboard.

a) The emergency switchboard generator panel mode switch NORMAL/MANUAL/TEST is set to TEST.

b) The emergency generator receives a start command and starts. Once the generator is running, a check is made that a voltage has been established.

c) The incoming ACB will OPEN and the emergency generator ACB will close.

The emergency switchboard is now supplied by the emergency generator.

6. Manual Changeover Back to Main Supply on Emergency Switchboard

It is assumed that the emergency switchboard is supplied from the emergency generator.

a) The emergency switchboard mode switch NORMAL/MANUAL/TEST is set to NORMAL

b) The emergency generator ACB will OPEN and the emergency generator will receive a STOP signal.

c) The incomer ACB will receive a CLOSE command and will close. The emergency switchboard is supplied from the LV main switchboard.

d) Allow the emergency generator to run off-load for a brief cooldown period.

e) Stop the emergency generator by pressing the STOP pushbutton on the selected emergency generator control position.

3.11 EMERGENCY ALTERNATOR

Alternator

Type:	LSA 50.2 L7/4P
Configuration:	4 salient poles, separately excited, brushless, single bearing NDE
Voltage:	450V
Current:	1,443A
Speed	1,800rpm
Overspeed:	2,070 rpm
Output:	900kW/1,125kVA
Frequency :	60Hz
Power factor:	0.8
Overload capacity:	110%
Excitation:	Separately exited by PMG
AVR:	D350
Bearing NDE	6320 2RS/C3
Cooling system:	Air cooling
Insulation:	Class H
Temperature rise:	Class F
Protection	IP23
Space heater:	120V, 500W

Location

The emergency generator is located in the emergency generator room in the engine casing 2nd level, starboard side in FZ4 between frames 50 and 64.

Description

The emergency alternator is of the separately excited brushless type of conventional design. The stator core being of stamped electrical steel plates insulated on both sides by inorganic resin and clamped together, the whole is mounted in a welded steel frame that provides good rigidity and low vibration. The stator windings are double layer lap wound with 2/3 pitch. The rotor is a 4 salient pole rotor, the cores of the poles being made of electrical steel stampings clamped together with inorganic resin for insulation. The rotor is supported at the none drive end by a high speed low maintenance anti friction ball bearing (6320 2RS/C3).

Excitation is provided by a D350 automatic voltage regulator, the supply for the automatic voltage regulator is provided by a permanent magnet generator this is attached to the main rotor at the none drive end. This therefore is a separately excited alternator. The emergency generator is normally kept in AUTOMATIC mode, this allows automatic starting in the event of a blackout.

Excitation

The excitation system is of the separately excited type. It comprises of an automatic voltage regulator, which samples the output of the alternator and adjusts the excitation accordingly to keep the output as constant as possible. The power supply for the automatic voltage regulator and thus the excitation is provided by a permanent magnet generator. The permanent magnet generator is attached to the none drive end of the rotor shaft. This delivers a steady voltage independant of the main alternator output windings.

The automatic voltage regulator D350 feeds a steady current to the exciter's stationary winding. This induces a three phase current in the windings of the rotating excitation armature, this output of the excitation armature feeds a three phase revolving rectifier bridge (made up of 6 rectifiers), this in turn supplies a dc current to the rotating field windings of the rotor. The rotating field windings produce a rotating field, this rotating field induces currents into the three main stator windings. The three phases of current induced into the stator windings constitute the output of the alternator.

As the supply to the automatic voltage regulator is not derived from the output of the alternator, therefore any variations of the output due to switching of heavy loads will not effect the supply to the automatic voltage regulator and so a tight control over the output can be maintained.

Space Heater

A space heater of 120V/500W is provided, this is interlocked with the emergency generator. The space heater is thus switched off when the emergency generator is running, when the emergency generator stops the space heater will automatically switch on again.

Emergency Generator Battery Charger

Charger

Manufacturer:	Newmar
Type:	PT-24-20U
Supply:	AC110 – 240V, 50/60Hz
Output:	DC 24V at 20A

Batteries

Manufacturer	Interstate
Model	M-8D-MHD
Type	Maintenance free sealed lead acid
Number	2 x 12V - 24V 220Ah/20hrs
Cold cranking amps	1125A
Cranking amps	1405A

Under normal circumstances, the control panel is supplied directly from the battery charger output with the batteries being charged simultaneously, if there should be an interruption in the output of this power supply, the batteries would seamlessly take over supplying the engine control panel. When the emergency generator is running, it will supply the control panel via a tapping on its stator winding, this powers an independent power supply.

Engine Control Panel (ECP)

The ECP is an Auto Maksin C Command Elite Plus, this consists of a customer interface box (CIB) which is mounted on the generator set skid. There is a power ON/OFF switch and an EMEGENCY STOP switch mounted on the front panel of the CIB, mouted in the upper part of the front panel is a DCU 410E engine control unit (ECU). The ECU provides all the functions of operating the emergency generator..

Manufacturer	AutoMaksin
Model	C-Command Elite Plus

The C-Command Elite Plus control panel consists of the following units:

- DCU 410E, engine control unit (ECU)
- SDU-410, Safety unit (shut down unit SDU)
- RIO-410, Remote input/output unit (RIO)

The DCU 410E has a color touch screen, this is divided up into three section. At the top is a status bar, this indicated the present status of the generator and any alarms that are extant. The central part is the main screen area. At the bottom of the screen is soft button bar, the soft buttons will have different function depending upon which display has been selected, for example, the MODE soft button will bring up a mode selection screen and the mode of operation can be chosen from there.

The generator engine START and STOP switches can be either latched or unlatched, when latched all that is needed is a single push of the soft switch to start or stop the engine, in the unlatched position the START and STOP switches have to be held down until the engine either starts or stops (it is more usual to have the Start and Stop switches unlatched).

Starting the Generator Engine

The normal method of stating is by electrical starting, three attempts are made and if this fails it will attempt to start with the hydraulic starter.

Insulation Monitoring

As the emergency switchboard's insulation monitor a DEIF SIMQ MkII set to 0.5 MΩ is connected on the emergency generator side of the generator ACB, it will only be operational when the emergency generator is running and connected to the emergency switchboard.

Therefore, if a low resistance alarm is raised when the bus tie between the 450V main switchboard and the emergency switchboard is closed an alarm raised on the insulation resistance monitor of the 450V main switchboard and will not distinguish if the fault lies in the main switchboard or the emergency switchboard. To determine which has the fault the circuit breaker to the emergency switchboard in the 450V main switchboard must be opened. If the fault indication persists, the fault is in the 450V main switchboard, if the fault indication disappears the fault is in the emergency switchboard.

The 120V feeder panel also has a DIEF SIMQ MkII insulation monitor set to 0.5 MΩ.

The No.1 emergency load center panel 120V feeder is equipped with a DEIF AAL-2 insulation monitor set to 0.1 MΩ.

Alarms

Function	Warning	Alarm	Trip
Overspeed		2070rpm	yes
Low F.O pressure	4.8 bar	3.7 bar	
Low L.O.Pressure	3 bar		
High L.O. Temperature	120^{O}C		
Low coolant water pressure	0.7 bar	0.0 bar	
High jacket water temperature	100^{O}C		

3.12 CATHODIC PROTECTION SYSTEM

Manufacturer:	Wilson Walton
Model	Aquamatic 4

Introduction

The vessel is provided with an Impressed Current Cathodic Protection (ICCP) system. This system works as a method of corrosion prevention, automatically controlling the electrochemical corrosion of the ship's hull structure below the waterline. The metals making up the ship's hull below the waterline are vulnerable to the effect of electrolytic corrosion. Electrolytic corrosion can be compared to a simple battery cell, consisting of two plates in an electrolyte. If these two plates are connected electrically, one of them will waste away through electrolytic action. Sea water acts as an electrolyte, so when two metal plates are immersed in it, one of the metals will act as the anode and will waste away, this is known as galvanic corrosion.

Which metal that acts as the anode and which metal that acts as the cathode depend on their relative positions in the electro-chemical series, steel acts as an anode to copper, or any alloy of copper. The magnitude of the electric current generated in the corrosion cell, and the rate of wastage of the anode depends upon which metals are involved and the concentration of the electrolyte.

This vessel is fitted with an ICCP system. This method of corrosion protection automatically controls electro-chemical corrosion of the ship's hull structure below the waterline by forcing the steel of the hull to be at a more negative potential than the surrounding sea water.

This is achieved by introducing a current that acts in opposition to the galvanic corrosion current by using electrodes attached to the vessel's hull providing a source of DC current. This DC current needs to be adjusted so as to provide the correct flow of current, not too little as this will leave the vessel's hull under-protected and not too much as this will over-protect the hull. To this end, reference anodes are fitted, these detect the potential difference at the hull/sea water interface and the power supply adjusts the current output accordingly. This is the basis of ICCP. For vessels above a certain size, two systems are normally fitted, a forward system and an aft system.

Fresh Water Operation

The resistivity of fresh water is approximately 1,000ohm/cm, significantly higher than that of sea water (25-50ohm/cm). The output voltage will automatically increase to maximum to compensate for this. The system will return the hull to the optimum protection level when the vessel returns to sea water.

System

Power Unit

Type:	200A computer controlled
Input:	440V, 60Hz, 3-phase
Output current:	200A
Output voltage:	36V
Supplied from	LGSP5 (sec 2), engine room No.1 port center line at frame 89
Location:	Motor room No.1, 4th deck, stbd center line, at frame 39

Electrodes

Anodes:	2 x circular max rated at 36VDC - 100A
Material:	Titanium/Urethane
Reference cells:	2 x zinc

Electrical Installation

The power supply unit is connected to two anodes one to port and one to starboard (2 x 100A and two zinc reference electrodes, port and starboard, There is a remote monitoring unit in the engine control room No.1 at frame 85

System Operation

Protection is achieved by passing a low voltage DC current between the hull metal and anodes which have been insulated from the hull, but are in contact with the sea water. The DC current is controlled by the ICCP system's controller power unit. The electrical potential of the hull is maintained more negative than the anodes, ie, cathodic. In this condition, corrosion is minimised. Careful control is necessary over the flow of impressed current, which will vary with a number of factors including:

- Ship's speed.
- Salinity of sea water.
- Temperature of the sea water.
- The condition of the hull paintwork.

The zinc reference electrodes tend to maintain a steady hull to reference electrode potential of approximately 400 to 600 mV in normal sea water, the hull being positive with respect to the reference electrode. To provide the optimum amount of protection, the potential between hull and reference electrode must be maintained at approximately 220mV.

If the potential of the hull is made too negative with respect to the anode, damage to the paint can occur through electrolytic action or through the forming of hydrogen gas between hull steel and the paint. The system on this vessel controls the impressed electrical current automatically to ensure optimum protection. The control unit's transformer steps down the 440V supply to a low voltage high current AC this is then rectified which produces a low voltage highly controlled DC current. The difference between the hull to reference electrode potential and the set point is amplified. A signal corresponding to this difference is applied to the control circuits of the output thyristors. This causes a corresponding variation in the DC output from the thyristors and the DC protection current is adjusted to the value necessary to provide optimum cathodic protection. The positive output is connected to the anodes and the negative is connected to the ship's hull. Once it is switched on it operates automatically and needs no other intervention. Sufficient current is impressed via the anodes to reduce the potential of the hull to seawater interface to an optimum level of between 125 and 250mV.

The amount of current supplied, and hence the degree of protection provided, ia monitored via of a vacuum flourescent display on the remote control unit located in the engine control room No.1 in the forward part at frame 85. The following readouts are provided:

- Cell 1 - Displays hull potential in millivolts measured by cell No.1.
- Cell 2 - Displays hull potential in millivolts measured by cell No.2.
- Shaft 1 - Displays propeller shaft potential in millivolts. Range of operation is 0mV to 250mV.
- Output Volts - Displays the output voltage in VDC. This relates to the total output voltage applied to the hull mounted anodes with respect to the hull.
- Anode 1 Amps - Displays the output current for each anode in amperes DC. This relates to the individual amount of current each anode supplies to the hull.
- Anode 2 Amps - Displays the output current for each anode in amperes DC. This relates to the individual amount of current each anode supplies to the hull.

The display provides the state of the system's operation, and also the general condition of the immersed hull.. It should be noted, however, that a correct interpretation must include an analysis of the present display readings collectively, and ideally, the present readings should be compared to recorded readings of past performance in order to complete the picture. Thus, it is advisable to maintain a daily record of the system's operation.

The reference cell potentials indicate the electrical potential of the outer hull. One terminal of the display's input is connected directly to the hull; the other terminal is connected to a zinc electrode fixed to but insulated from the outer hull. When this zinc/steel assembly is immersed in an electrolyte (such as sea water), a galvanic potential is created. The magnitude of this potential, measured by the computer, varies according to several parameters:

- Amount of exposed steel area
- Vessel draft
- Condition of external coating
- Conductive properties of the electrolyte (seawater)
- Miscellaneous factors.
    - Composition of the steel (on a molecular level)
    - Vessel speed
    - Temperature
    - Availability of oxygen

Utilizing anodes fabricated of inert metals such as titanium, an electrical current is forced or "impressed" through the electrolyte, forming an electrical field on the surface of the immersed steel. As more current is impressed, the steel becomes more cathodic. By controlling the amount of current supplied in such a way as to exactly match the variable amount of current required to maintain an arbitrary hull-potential, any desired degree of cathodic protection may be obtained simply by choosing the corresponding potential value.

Extensive research indicates that the most desirable potential level is about 200mV (with respect to zinc.)

Controls

Most ICCP system controls and indicators are located on the front panel of the Remote Administration Display (RAD) cabinet. The ON-OFF POWER switch located in the upper left-hand corner of the power supply will energize the system by switching on the AC input power, or secure the system by switching off the AC input power.

The auto/manual mode switch and manual output adjust potentiometer are located inside the power unit on the control board AQ-CCB-300A. This switch is normally left in the "AUTO" position. Manual Mode is rarely used and generally reserved for testing.

When Power is Applied

Upon application of power, the system will go into a self test and self calibration cycle. The display will indicate, "Survey Network" then "Self Testing - Please Wait."

The following components are tested during the self test cycle:

- Network
- Controller
- Switcher (power supply)
- Individual anodes
- Individual reference electrodes (cells)
- Propeller shaft ground assemblies

At the conclusion of the power-up self test and calibration cycles, the system will regulate output as required to protect the external submerged hull structure. The display will default to the "Summary Display" mode at the conclusion of the self test and calibration cycle.

Summary Display Mode

The Summary Display is the default display mode which will be present most of the time. This display will summarize the status of each zone on the network (a zone will usually consist of one switcher and its anodes and cells). The top line of the display will always indicate the name of the zone to which the summary information pertains. The bottom line will reveal two key areas of performance:

1. System Operational Status
2. Hull Protection Status

System Operational Status messages pertain to the functional capability of the ICCP equipment. If all equipment produces proper test results, the following message will appear: "System Working OK." If any component has failed the diagnostics, the display will indicate "Fault Detected." This fault message is followed by the specific fault detected, often with brief instructions to assist in correcting the fault condition.

NORMAL display:

- SYSTEM SYSTEM WORKING OK

FAULT display:

- SYSTEM FAULT DETECTED

followed by

- ANODE 1 OPEN CIRCUIT - CHECK ANODE FUSE AND ANODE CABLE SPLICE

Log Report Display Mode

Daily log readings are obtained by pressing the "DATA SELECT" button. The Data Select button located in the upper right-hand corner will enable the following system readings to be displayed sequentially:

- Cell 1
- Cell 2
- Shaft 1
- Output Volts
- Anode 1 Amps
- Anode 2 Amps

Function Display Mode

Special functions are available by pressing and holding the "DATA SELECT" button for two seconds.

These functions are typically used only by service personnel and are not normally accessed at other times.
The available functions are as follows:

- Service Mode
- Normal Mode
- Preview Results
- Self-Test
- Version

ICCP Log

There is a log that must have the readings from the control panel entered every day, this is sent off to the manufacturer at the end of each month to be analysed.

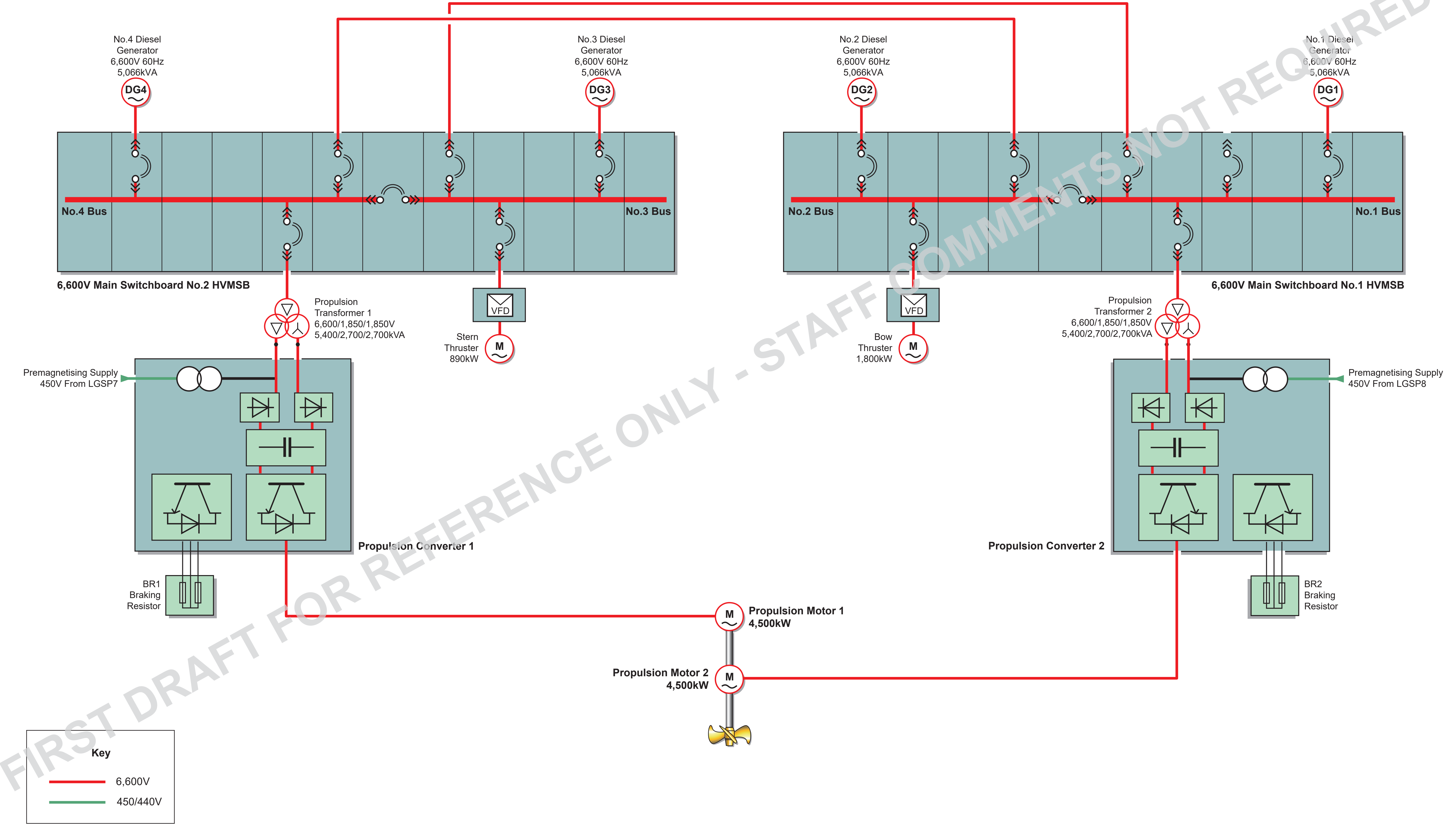
Rudder and Shaft Earth Bonding

Due to the fact that the rudder and the propeller shaft is insulated from the rest of the vessel by grease with respect to the rudder and by a film of lubrication oil with respect to the propeller shaft, these have to be earthed to the vessel's hull separately:

- Rudder: This is achieved by using an earthing strap from the rudder head to a point on the interior of the vessel's hull (usually the deckhead above the rudder stock).
- Propeller Shaft: The propeller shaft is earthed using an earthing slip ring and brush assembly. The brush is made of high density silver graphite, the slip ring is made of a silver alloy which is clamped to the shaft. This has to be kept clean so that there is always a good contact between the brushes and the slip ring, and thus a good connection. The brushes are connected to an adjacent stud so as to provide a good earth.

The reading displayed on the meter when the vessel is stopped will be 0mV, when the shaft is running it should be >80mV. When the recorded value falls to <80mV the slip ring should be cleaned. There is a section on the log sheet for a weekly entry of shaft earthing readings.

Illustration 4.1a Propulsion Overview



Reference Drawing: NSMV-321-B607 Sht 1 Rev. 4

4.1 PROPULSION CONTROL

Propulsion Introduction

The vessel is fitted with two propulsion systems, the main propulsion system and the thruster systems. The main propulsion system consists of a fixed pitch propeller driven by two electric variable speed induction motors. The two motors are mounted in tandem on the propeller shaft and coupled directly to the propulsion shaft without gearing.

The electric plant is designed according to the power station principle, meaning that under normal conditions the switchboard works as a common bus bar system. The main propulsion transformers, as well as thruster motors and distribution transformers, are connected to this bus bar.

Each propulsion electric motor system consists of the following equipment:

- A propulsion transformer fed from the 6.6kV main switchboard.
- A premagnetisation transformer fed from the 440V switchboard.
- A synchro-converter providing the variable freqency motor supply from the fixed frequency mains supply.
- One AC synchronous induction propulsion motor.
- Two independent remote control systems with redundant active/standby configuration.

The 6,600V 60Hz network supply is lowered down to 1,850V by the propulsion transformers and this is the supply to the MV7306 propulsion converters. There is one propulsion transformer with two secondary windings, providing two 1,850V supplies to each converter; this provides a 12-pulse input to the rectifier section of the converter, reducing harmonic distortion.

The converters rectify the 1,850V AC supply to a DC level and this is then inverted to an AC supply with the required frequency for supply to the propulsion motors.

The propulsion plant is designed so that the propeller speed can be precisely controlled to allow maximum efficiency and manoeuvrability. The synchro-converter propulsion drives are designed to provide four-quadrant operation with reversal of torque and direction with continuous speed control from 0 to 100% of rated speed.

The propulsion system can be operated using both or one converter/transformer-motor subsystem. The propeller speed will be limited by the available power when using one subsystem. With both subsystems in operation, the propulsion will remain in operation in the event of a failure of one subsystem.

The operation of the propulsion system is interlocked with the auxiliaries of the shaft line equipment. There is also a dedicated propulsion operating mode for navigation during heavy seas.

The control system has automatic propulsion torque limitation functions to prevent an overload of the diesel generators and possible black-out. The propulsion system is interfaced with the Power Management System (PMS) to regulate propulsion power in accordance with the power plant capacity. The propulsion control system is also interfaced with the Control and Automation System (CAMS).

Control Introduction

This is a single screw vessel fitted with two identical propulsion motor systems, the following descriptions apply to both No.1 and No.2 systems.

The propulsion can be operated with two or only one converter/transformer/motors in operation.

During normal operation, the two separate converters and control systems constantly communicate via redundant ethernet optic fibre networks and conventional wire ethernet networks, this is mainly to provide balanced load for the two propulsion motors.

The basic concept of this electric propulsion system is to compare a speed reference (speed demand) from one of the control station speed levers (or transmitter dial at the local control stations) and compare it to the existing speed of the propulsion motor(s). If the speed reference is different from the measured speed, then adjustments are made to the speed of the propulsion motors to bring the motor speed in line with the speed setting of the control levers. This is achieved by the speed regulator generating a torque set point that corresponds to the propulsion torque required to increase or decrease the speed of the motor to the required value.

Propulsion Control Stations

The propulsion system can be controlled from any one of the following control stations around the vessel. Each control station has its own priority:

Local control panels (level 3).

- Propulsion converter 1 room (LOC1).
- Propulsion converter 2 room (LOC2).

Engine control rooms (level 2).

- Engine control room1 (ECR1).
- Engine control room 2 (ECR2).

Wheelhouse and bridge wings (level 1).

- Wheelhouse bridge (WH).
- Port wing (PWG).
- Starboard wing (SWG).

Training bridge (TRN) (level 1).

There is a telegraph system fitted with a panel at each remote control station to provide the transmission of speed and direction orders in the event of an emergency or failure of the control system.

The control stations communicate with the propulsion system and each other via duplicated optical fibre ethernet loops. These operate in tandem and so provide redundancy. If there is a failure of one, the other will carry on communication without interruption. The control stations act as the interface between the operator and the propulsion system, each control station having a speed setting lever for each propulsion system (port and starboard).

There are also TFT touch screen displays at each control station and these provide the functions for the following:

- Control of the auxiliaries and their sequential starting.
- Control station position selection/changeover.
- Propulsion mode selection/switching.
- Power sequence stop/start.
- Propulsion speed setpoint control.
- Propulsion safeties override (if allowed).
- Alarm and fault handling (acknowledge, reset, etc).
- Alarm, shutdown, slowdown status display.
- Propulsion system status/measurement display/indicators.

The speed setting levers have electrically-driven motorised shafts and are connected by the redundant ethernet optic fibre loop. When the active control station lever is moved, the others will follow the movement and so there is no need to align the lever when a control station is changed over.

Remote Control

The remote control management is carried out in the Propulsion Power Controller (PPC). Only one remote control station can be in control of both propulsion converter/motor subsystems at one time and is classified as the 'active' station. The converter local control stations (LOC1/LOC2) control stations are managed in the same way as the other stations, although they are not connected on the remote network. This allows local station availability in case of failure of the remote network and also that the control station switch-over process is identical irrespective of the control station.

The LOC1/LOC2 stations provide system control in 'standalone' operating mode utilising directly connections to the converter.

Emergency Control Modes

In the case of a complete remote control system failure, the propulsion can be operated at the converter LOC1/2 panels in Local Emergency mode using the

Local emergency Operation Panel. In this case the emergency telegraph system would be utilised.

Change of Remote Control Station

At each control panel there are ‘CONTROL HERE’ and ‘TRANSFER ACKN’ buttons to take control of propulsion operation or to acknowledge a control request from another control location. When control is requested to be transferred to another station, a buzzer is activated at both stations until the transfer is completed or cancelled.

There are different levels of control priority between the remote control stations and these priorities will define the procedure for taking control. There is no restriction regarding control transfers. The Priority level, from lowest (1) to highest (3) is shown in the control priority illustration:

Take Control with Acknowledgment - Low to High Priority

In the event of a ‘Take Control’ request from the higher priority station, control is immediately transferred from the lower priority active station. Control transfer acknowledgment is required on the former active station to mute the transfer buzzers.

Take Control Via Request - High to Low Priority

In the event of a ‘Take Control’ request from the lower priority station, control transfer acknowledgment is required at the active station before control is transferred to the lower priority station.

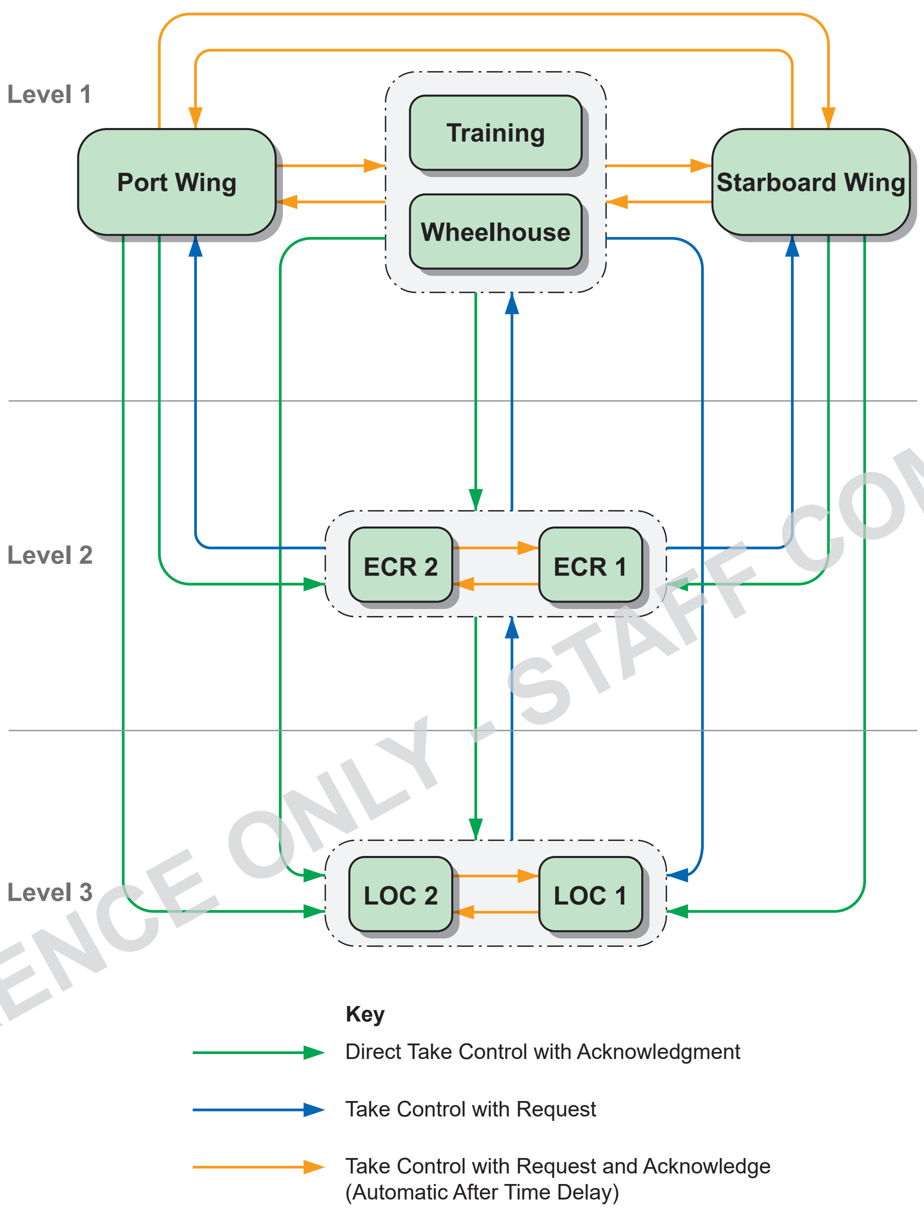
Take Control with Request and Acknowledgment - Automatic

In the event of a ‘Take Control’ request from a same priority station, control is transferred with request and acknowledgment. If no acknowledgment is received from the active station, control is automatically transferred after a time delay. A control transfer to a same or lower priority station is only possible when the speed lever of the destination station is aligned with the current speed setpoint to avoid a speed step. When a control transfer is requested to a higher priority station, it is carried out immediately irrespective of speed lever matching.

The remote control station ECR1 is the default control station. In the event of a system startup, remote control is initialised at this station.

In the event of a fault at an active station, the system activates the buzzers at all healthy stations and control can be taken at any healthy station regardless the transfer functions.

Illustration 4.1b Propulsion Control Priority



Operating Modes - Lever Mode

Lever mode is available at any active remote control panel. When set to this mode, the panel speed lever considered as the ‘Master’ lever and its position sets the propulsion speed set point. This mode is the system default and failsafe mode, ie, if another speed control system fails, control returns to lever mode. All system levers are motorised and will follow the current speed reference, allowing a seamless speed setting changeover when changing control stations. The ‘Lever’ indication is shown at all control stations when this mode is active.

There is a ‘fine’ setting which provides precise speed adjustment (to one rpm).

Operating Modes - Speed Mode

Speed mode is the default mode to control the propulsion motors. Motor speed is controlled according to the speed setpoint set by the operator from the active remote control station. Speed control mode is automatically selected at the system startup, when the power control mode is cancelled or in the case of a crash stop. The remote control panels will display the option to select or deselect speed control mode and current speed mode status.

Operating Modes - Power Mode

Power mode allows control of the motors via motor power setting instead of speed. This avoids any large power variations which may affect the generating plant. This mode can be used at high speeds or during heavy sea conditions.

The selected speed setpoint at the active remote control station is converted by the motor control (PECe) into a power setpoint.

When permitted, power mode is selected either automatically by the propulsion system (PPC) when in open sea conditions (speed measurement >66 rpm - 60% of the rated speed) or manually when the operator selects power mode at the active remote control panel. The operator can also select manual or automatic selection of the power mode.

Power mode is cancelled and speed mode automatically selected when power mode is manually unselected by the operator at the active panel. This is also carried out automatically by the by propulsion system (PPC) in the following cases:

- Permanent permissives are not satisfied.
- The speed setpoint is set to below 55 RPM (50 % of rated speed). If the operator wants to decelerate quickly and it is more efficient to control the motor speed.
- Speed measurement <55 RPM for 30 seconds (50% of rated speed).

Power mode selection status is displayed at all the remote control panels.

Starting the Propulsion System

The initial conditions for starting the system are:

- The LOCAL/REMOTE switches on the propulsion transformer panels of the HV main switchboard must be in the REMOTE position.
- The main switchboard CBs must be ready to close, ie, the CB CLOSE AVAILABLE indicators must be illuminated.
    - Propulsion transformer 1, HVMSB2 panel 12.
    - Propulsion transformer 2, HVMSB1 panel 2.

- There must be sufficient generators running to provide enough power for the vessel's normal network consumers and for the propulsion system.

When these conditions are met, the converter drives can be started.

Starting Sequences

There are two starting sequences, the auxiliaries starting sequence and the power starting sequence. The auxiliaries starting sequence must be completed successfully before the power starting sequence can be enabled.

Auxiliary Starting Sequence

The auxiliary starting sequence ensures that the system cooling facilities are started and feedback received that they are operating satisfactorily.

Auxiliary start orders are given by the operator from the selected propulsion remote control panel. The PPC controls the starting sequence as two separate sequences (System 1 and system 2). When a starting order signal is given, the auxiliaries will start in a timed sequence so as not to overload the system:

a) The auxiliaries start request is initiated by pressing the AUX ON button.

b) The converter cooling pumps are started.

c) After a delay of two seconds, the propulsion transformer fans are started.

d) After another delay of two seconds, the propulsion motor fans are started.

e) After a further delay of five seconds, an 'Auxiliaries Started' indication is displayed.

To stop the auxiliaries, the operator presses the AUX OFF button. The auxiliaries will run for a specific time delay (30 minutes - adjustable) to ensure adequate cooling of the different components. The power sequence must be turned off prior to auxiliaries stopping (permissive).

After the above delay, only auxiliaries designated 'essential auxiliaries' will remain in operation. These are one converter pump and one transformer fan and will remain in operation as long as the main switchboard CB is closed.

Auxiliaries - Blackout and Emergency Stop

In the event of a blackout and subsequent recovery sequence, all auxiliaries which were previously running are restarted automatically. The master speed lever is set back automatically to the zero position and the other levers follow via the electric shaft facility. To restore the propulsion, the operator must press the 'Power START' command at the active control station to restart the propulsion motor.

In the case of a propulsion emergency stop, the motor jacking pumps supplied from the emergency network will remain in operation. All the other auxiliaries are stopped for safety reasons.

Auxiliaries - Motor Jacking Pumps

The propulsion motor bearing oil jacking pumps are not controlled as part of the auxiliaries sequence. They are separate to ensure protection of the shaft line which could be damaged by shaft rotation by wake effect. The stopping of these pumps is possible only at the pump local control panels.

Power Starting Sequence

The power starting sequence is the switching on of power to the system, so the propulsion motor is ready to rotate. The power starting order is given by the operator from a propulsion remote panel by pressing the START button.

In certain specific circumstances, the operator can bypass some permissives and override specific faults to enable the power sequence to be started,

The following conditions must be met before the power sequence can be completed:

- The auxiliary starting sequence must have been completed successfully.
- There must be sufficient reserve generated power (two generators connected).
- There must be no alarms/warnings active.
- The bearing jacking systems must be in operation (both motors).
- The shaft line must be free to turn, ie, turning gear disengaged, shaft lock disengaged.
- The speed set point is 0 rpm.
- The propulsion converters are ready.

If all of these conditions are met, then the power starting sequence can begin when a start power request is initiated:

a) The pre-magnetising contactors are closed and the pre-magnetisation of the propulsion transformers and pre-charging of the converter DC filter capacitors takes place.

b) A close request is sent to the main switchboard propulsion transformer circuit-breakers.

c) The pre-magnetising transformer contactors open.

d) The motor speed is referenced and the motor starts and accelerates to the speed setpoint.

Crash Stop Manoeuvre

If the propulsion system is operating in the ahead direction and a full astern is given by setting the speed lever to the FULL ASTERN position, this condition will initiate the crash stop manoeuvre as follows.

a) The speed signal from the control station lever requests a reverse rotation and/or crash-stop manoeuvre.

b) Motor torque decreases following the maximal torque ramp (1pu/s). The speed regulator follows the speed ramp.

c) When the torque is zero, it is maintained at zero and the propeller shaft is in a free wheeling phase (the speed regulator is inhibited).

d) Due to the resisting torque on the propeller, the shaft line speed is reduced down to its trailing speed.

e) The motor torque is inverted when the speed is equal to a speed threshold. This is the braking phase in regeneration mode. Negative power (negative torque, positive speed) is dissipated via the braking resistor.

f) Torque is then limited by the converter torque curve and the braking limitations.

g) The motor frequency is held to 1.5Hz.

h) As soon as the motor can provide an acceleration torque sufficient for the propeller resistive torque, the control system starts the rotation reversing sequence. The motor speed continues to decelerate

i) The propeller reaches zero speed and is then driven in the astern direction. The negative forcing torque is still applied and the motor speed becomes negative. The motor power is positive and the speed increases in the astern direction according to the speed ramp. The negative torque is limited in the astern direction.

The propulsion system exits crash stop mode when one of the following conditions are fulfilled:

- The motor speed is negative (ie, shaft line in astern direction).
- The speed lever is put in the ahead direction (positive speed setpoint).

Local Control Station Keypads

This facility allows the operator to operate the drive in the event of failure of the whole remote control system, ie, no speed lever operation and no control panels. It also allows the reading and resetting of the present fault or faults. It displays the converter main measurements. It is designed as a maintenance and control tool for service engineers and trained technicians. It allows the propulsion system to run with a minimum of security conditions, these are those that only concern the drive itself. Other conditions such as the auxiliaries of the transformers and motors must be operated manually.

The keypad is connected to the propulsion main controller PECe via a RS232 modbus, the keypad being the master.

The Emergency Telegraph

In the event of a major failure in the propulsion control system, an emergency telegraph system has been provided. This is a completely independent system with an independent power supply.

The emergency telegraph system is equipped with a pointer telegraph at the converters and a communication system to indicate orders from the wheelhouse to the selected control station. The system allows an operator located at the bridge (wheelhouse, training, port or starboard wings) to send the speed and direction orders to another operator located in the ECR1/2 or converter rooms.

The ECR1/2 or converter operator uses the LOC1, LOC2, ECR1 or ECR2 remote control stations, or the converter's LOP to set the speed setpoint to the propulsion.

The emergency telegraph system is made up of the following:

- Master telegraph units located in the wheelhouse, training, port and starboard wing locations.
- Slave telegraph units located in the ECR1, ECR2, LOCAL 1 and LOCAL 2 rooms.

The Emergency Stop System

Hard-wired emergency stop buttons are located at each control station. There are also emergency stop buttons on each of the converter cabinets; these emergency stop switches stop both drives. The pressing of an emergency stop pushbutton will have the following results:

- A propulsion motor stopping sequence will be initiated.
- The propulsion transformer circuit-breakers will be tripped.
- The propulsion auxiliaries will be stopped with the exception of the motor bearing jacking pumps, these can be stopped manually at their local control panel, if required.

These actions are accomplished by the use of hard-wired connections to the emergency stop relay and then the circuit-breakers. A monitoring system is provided in case of a line fault and this will raise an alarm in the ICAS.

Each of the emergency stop pushbuttons has three contacts, two of the contacts are hard-wired to the emergency stop relay of each converter (these are used to trip the circuit-breakers of the propulsion transformers). The third contact is connected to the control panel I/O and will raise an alarm to indicate which emergency stop pushbutton has been activated.

Alarms and Faults Functions

The propulsion control system detects and manages any faults. The faults can be detected by each PECe or the process PLC controllers depending on the location of the fault. When a fault occurs, an alert with different programmed effects is generated, according to the type and severity of the fault - in increasing order of priority:

- Warning.
- Torque limitation.
- Speed limitation.
- Motor stopping (alarm)
- Motor stopping and network CB tripping (alarm).

When a fault occurs, the notification is displayed individually on the alarms mimic and at the control station panels.

Audible Alarms

At local stations, any alarm is signalled by buzzer, if the station is selected. At ECR stations, any alarm is signalled by buzzer even if the station is not selected. At the wheelhouse, training and wings stations, only following alarms are signalled, if the station is selected for control:

- Propulsion alarms - critical.
- Propulsion alarms - with propulsion limitations.
- Propulsion alarms - related to remote control function.

The audible signal is stopped when the alarm is reset or the operator presses the 'SILENCE BUZZER' button at the active panelor at the ECR station. Each station has its own silence button which will mute its own buzzer.

The fault reset button is always available at the local and ECR stations, even when the station is not selected for control.

Fault Memory Function

When a failure is detected, the fault memory is set inside the controller (PPC or PECe, depending on the fault) and an alarm is raised on the HMI. The fault memory must be reset manually to remove the effect. The reset is effective only if the failure (fault cause) has been repaired/cleared. HMI alarms have their own acknowledgement via the HMI and is dedicated to HMI alarm management only. An alert disappears on the HMI supervision when it has been acknowledged and when the fault is reset.

The propulsion control system has self-check facilities and can detect failures of its components, raise an alarm and carry out the appropriate actions.

The PECe and PPC controllers have a monitoring function that checks if the controller's tasks have been carried out correctly. When a critical task fails, the drive is tripped. When a non-critical task fails, a warning is raised.

Propulsion Shutdown Override

In order to maintain propulsion for critical operations, such as when manoeuvring, specific propulsion effects can be overridden by the operator. Alarm management is carried out so that a sensor failure does not jeopardise the system. This is mainly achieved by monitoring the consistency of the sensor signals delivered (PT100 probes and 4/20mA open circuit detection, etc) and also comparing the measurements and data from other sensors.

The 'SHUTDOWN OVERRIDE' function allows the operator to inhibit the safeties of some predefined faults which would otherwise result in a propulsion converter shutdown. This is to keep the propulsion running even if some damage could occur to equipment. These faults are mainly related to the temperatures of the motor/transformer windings and the motor bearings.

In the event of a shutdown override, the function is active for both propulsion sub systems.

A temperature fault is usually raised as a 'high' alarm, possibly followed by a 'high-high' alarm that would normally result in a converter shutdown. To inhibit the shutdown, the high-high alarm must be overridden before it occurs The Operator is warned at the remote control station panel that it is possible to activate the shutdown override mode. It is then the operator's responsibility to manually activate the override mode.

All the alarms that can be overridden are configured as 'shutdown overridable'. Consult the manufacturer's Fault and Effect matrix documentation for the in-depth list and guide to alarms and faults.

WARNING
While the SHUTDOWN OVERRIDE mode is active, all of the 'shutdown overridable' alarms are overridden and a converter shutdown will not be carried out when these alarms are raised.

In the above case, an alert with same wording as the alarm, but prefixed 'INHIB' in red, is raised but will only have a warning effect. A specific warning 'New Shutdown Fault Inhibited' is also raised.

WARNING
Damage to the equipment could occur if an alarm is overridden.

When activated, the control system will repeatedly remind the operator that the override mode is activated by flashing the background of the 'SHUTDOWN OVERRIDE' button for a few seconds, every 5 minutes.

To exit the override mode, the operator must deactivate it manually.
There is one 'SHUTDOWN OVERRIDE' button at each remote control panel. When a shutdown override mode can be activated, the background of the 'SHUTDOWN OVERRIDE' button flashes on the active remote control station panel.

To activate the shutdown override mode, the operator must press the 'SHUTDOWN OVERRIDE' button. The button background is the illuminated.

To deactivate the shutdown override mode, the operator must press the 'SHUTDOWN OVERRIDE' button again and the button background will be turned off at all the remote control station panels.

Slowdown Override function

The 'SLOWDOWN OVERRIDE' function operates in a similar way to the shutdown override and is fitted to allow the operator to inhibit the safeties of some predefined faults which would result in a propulsion limitation of torque or speed. Again, the slowdown override function, when activated, is engaged for both the propulsion sub systems.
All the alarms that can be overridden are configured as 'slowdown overridable'. Consult the manufacturer's Fault and Effect matrix documentation for the in-depth list and guide to alarms and faults.

Power Start Permissives Bypass

At propulsion system starting, when the power sequence is started, it is possible to bypass some start permissives which may be missing if the propulsion is urgently required. the operator has to manually activate actions on the remote control panel, provided the operator has checked the reasons for the alerts. The use of the 'BYPASS' buttons enable the 'POWER START' buttons to be actioned for a few seconds only. The bypass is automatically cancelled after each power start. The operator can bypass the following start permissives:

- 'No alert having warning effect'.
- 'Shaft line free'. In the event of a communication fault or turning gear sensor fault the operator must manually check the turning gear is actually disengaged.
- 'Enough power to start'. In the event of a communication fault, the operator must manually check that sufficient generating capacity is available.

Operation in Downgraded Mode

Jacking Pumps - PPC or I/O Rack Loss

If both redundant PPCs or remote I/O racks are lost, both pumps in each jacking unit will operate by default. The PPC only requests the standby pump to stop.

In the case of a failure of the jacking unit (failure of both pumps or failure of the piping), the shaft line speed should be operated, (until the jacking is repaired, above the speed threshold (55 rpm) where the oil film to lift the rotor shaft in the bearing is self-created. If slowing down has to be carried out before stopping the propulsion, the propulsion should slowdown from 55 rpm to zero rpm in less than 15 minutes before stopping the propulsion. After this, the shaft line should not rotate to preserve the bearing journal.

During blackout, both pumps are sent start requests but only the pump supplied by the emergency network will start and therefore becomes the normal pump. The standby pump (main network supply) will not start. At the end of the blackout, the normal pump remains running and the standby one is stopped.

In the case of an emergency stop, the jacking pumps remain in operation. All other auxiliaries are stopped for safety reasons.

I/O Rack Failure

In the event of system failures, the propulsion system may continue to operate in 'downgraded mode'. The level of operation in this mode will depend on the specific fault and may consist of warmings, limitations or a shutdown.

The loss of an I/O rack may occur due to an ethernet disconnection or a loss of supply. In this case, this will generate a fault to indicate which rack is faulty. Each I/O rack has watch dog monitoring and in the case of failure, all outputs/Inputs are reset. The logic is defined to keep the safety of the vessel in case of failure and the final action could be a warning, a limitation or a shutdown, dependent on the fault and its location. For example, if there is a fault on the critical converter I/O rack, the outcome will be a shutdown and trip of the converter. For details of specific racks and the outcome of a fault, consult the relevant manufacturer's documentation.

Remote Control Station Failure

The possible faults at a remote control station broadly fall into three groups:

- Loss of supply or loss of ethernet switch.
- Loss of remote control panel.
- Loss of remote control IO Rack.

If the station was in control at the time of failure, the station will not be operational. The speed setpoint is set at the moment of failure and an alert signal is sent to the other stations requesting the operator to take control. The emergency stops are hard-wired so will remain active but without indication.

Network Failure

The main networks utilise optical ethernet loops and each device is connected by a network switch unit. Each network switch monitors the operation of the optical fibre links on both sides of the switch. In the case of failure, an alarm is generated and sent to the control system through the remote I/O rack. Information is displayed on HMI system to provide the status of all switches. In case of link failure between two switches, both are displayed in failure. If one link is lost, a warning is displayed on the HMI but there is no effect on the propulsion. If there is a loss of several links or switches, communication is with the I/O rack and the effects will be as per I/O rack failure.

PPC and PECe Failure

The PPC units have built-in redundancy, therefore a single PPC failure has no effect on propulsion. If both PPC units are faulty, both the converter/motors are tripped (the operator can still use the converter LOP in standalone mode). In case of one PECe failure, the associated converter-motor is tripped and the other system will remain operational (single motor operation).

Propulsion Speed - Settings

The propeller motor shaft line cannot rotate between -20 and +20 rpm for an extended or permanent time period. This low speed range is only briefly allowed in transient conditions. The propulsion motors do not have any barred speeds when the jacking units are able to operate. Speed regulation starts as soon as the propulsion is started and the speed setpoint is different from 0 rpm with a dead band of 20 rpm (+/- 18% of the rated speed). The propeller speed is controlled over its entire speed range. If operating with the speed above the 18% threshold and the operator setting the speed lever to 0 rpm, the speed is controlled down to 0 rpm, then the speed control is locked and the torque is released. The shaft line is then free wheeling.

When a speed setpoint is set at the active control station, acceleration and deceleration is carried out using three preset ramps as follows:

Acceleration	Deceleration
0 rpm to 38 rpm	110 rpm to 62 rpm
38 rpm to 62 rpm	62 rpm to 38 rpm
62 rpm to 110 rpm	38 rpm to 0 rpm

A further faster deceleration set of ramps are used in the case of a crash stop.

Supervision Computer and Human Machine Interface (HMI)

This supervision computer supervises the propulsion system processes. The operating parameters of the propulsion system are input by the supervision computer and its HMI. There are actually three supervision computers all communicating via an ethernet network and also with the propulsion process controllers by the same method. The HMI computers are designated as workstations (WS1/2/3) as follows:

- WS1 Engine control Room 1.
- WS2 Engine control Room 2.
- WS3 Frequency Converter 2.

The main functions of the supervision computers are as follows:

- Propulsion monitoring and control.
- Alarm management.
- Recording of events.
- Recording trends.

The basic display screen has four areas, the top banner, bottom banner, right banner and mimic area.

Top Banner

The top banner displays an alarm window, it displays the last three alarms, the type of alarm is also indicated (critical and non-critical status). The colour of the alarm message indicates the status as follows:

Alarm Level	Present - Not Acknowledged	Present Acknowledged	Cleared - Not Acknowledged
1 Non-critical	Yellow blinking	Yellow steady	White and grey blinking
2 Critical fault	Red blinking	Red steady	White and grey blinking

The Bottom Banner

The bottom banner displays data such as sequence status and set point values for both shaft lines.

Propulsion Status Display

The colour tags change colour depending upon the status. The interpretation of the colour tags are as follows:

CVT (converter status):

- BLUE: Communication out of service.
- YELLOW: Alarm.
- AMBER: Limitation.
- RED: Stop.
- GREEN: ON.

Master:

- GREEN: Master.
- GREY: Slave.

Power (power status):

- GREEN: ON.
- GREY: OFF.
- GREEN blinking: Sequence in progress.

Ready:

- GREEN: Initial condition OK.
- GREY: Otherwise.

Aux. (auxiliary status):

- GREEN: ON.
- GREY: OFF.
- GREEN blinking: Sequence in progress.

Propulsion Data Display

Indicates the active control station and mode of speed reference:

- Local Local control station (LOC1/2).
- ECR Engine control room (ECR1/2).
- WH Wheelhouse.
- PWG Port bridge wing.
- SWG Starboard bridge wing.
- TRN Training bridge.

Mode of Speed Reference Section

This indicates the mode of reference for speed regulation:

- LEV (lever).
- Stand-alone.
- Fine setting.
- Combined lever + power.
- Fine setting + power.
- Lever + pressure.
- Fine setting + pressure.

Other Indications:

- Speed: Speed measurement in rpm.
- Ref: Speed reference in rpm.
- Power: Power measurement in kW.
- Torque: Torque measurement in %.
- Limit by propulsion: Limitation by propulsion in %.
- Limit by PLS: Limitation by PLS in %.

Right Banner Section

The right banner section provides access to the following:

- MIMICS: This is a mimic browser providing access to the available mimics.
- PREVIOUS: This provides access to previous mimics.
- TRENDS: Gives direct access to trends mimic.
- ALARMS: Gives direct access to alarms mimics.
- EVENTS: Gives direct access to the events mimics.
- SYSTEM: Gives access to the system utilities.
- PRINT: Prints the contents of the screen.

The right banner also displays the time, date, vessel name, the workstation ID and the logged-in user. In the mimic display screens (where mimic is of one shaft line system), there will be an icon of an open door usually at the top centre of the screen, this gives access to the other shaft line when this touch screen button is pressed.

Pop-Up Displays

In the mimic displays where an object such as a propulsion transformer is shown in relief, this is a touch screen switch that gives access to a pop-up display that gives information about the subject.

4.2 PROPULSION LIMITATION SYSTEM

The propulsion system has a comprehensive safety and protection system. This protects the power network and the propulsion system itself from any consequences of irregularities in the system operation. These protection functions are as follows:

- Anti-Overload Limitation (AOLL).
- Anti-Blackout Limitation (ABOL).

Anti-Overload Limitation

The process controller manages this function and receives the following inputs:

- Generator circuit-breaker status.
- Bus-tie circuit-breakers status.
- Current generator operating mode.
- System power measurements.
- Maximum power available from each generator.
- Any tripping intentions that might occur.

These inputs are continuously processed by the process controller to provide limitations or other actions as follows.

Propulsion Limitation by Active Power Overload (PMAX)

The active power measurement of the most heavily loaded generator is taken as a basis for this function. If this measurement becomes higher than the threshold set point (a percentage of the generators rated power), the propulsion torque is limited automatically. This threshold set point is adjustable using the supervision computer (the default value of this set point is 85%, but the minimum value is 60%). The limitation is proportional to measured power set point. This function is active as long as the propulsion is ON and the shaft speed is greater than 20%. A generator is considered to be in service if the circuit-breaker is connected.

Propulsion Limitation by Reactive Power Overload (QMAX)

The reactive power measurement of the most heavily loaded generator is taken as the basis for this function. If this measurement becomes higher than 100%, the propulsion torque is limited automatically. The limitation is proportional to measured power set point. This function is active as long as the propulsion is ON. A generator is considered to be in service if the circuit-breaker is connected. This system response to the activation of this function is 100msec, in addition to any time delay caused by the generator power transducers.

Propulsion Limitation by Reactive Power Overload

The reactive power of the highest loaded DG is monitored by this function. When this measurement is higher than 100%, the propulsion torque is automatically limited. The propulsion limitation applied is proportional to the difference (measurement – setpoint). This function is active when the propulsion power sequence is on. A DG is considered as in service when it is connected (CB closed).

Generator Load Modes

Under normal operation, the connected generators operate under balanced load sharing in 'Load Sharing Mode'. However, it may occasionally be necessary to reduce the load on one generator for operational purposes.

If a DG is set to DERATING mode, the rated power of the DG has been decreased but the DG is still managed in load sharing with the other DGs by the PMS. The limitation system considers this new rating as the P MAX threshold for that DG while it is derated. The PMS sends a 'DG in derating mode' signal to the limitation system.

If a DG is set to FIXED LOAD mode, it is managed with its own power load limit which is different from the limit of the other DGs working in load sharing. The PMS sends a 'DG in fixed load mode' signal to the limitation system.

A DG operating in FIXED LOAD mode can also operate in DERATING mode. In this case, PLS considers the new rate d power of the DG.

Anti-Blackout Limitation

This function is designed to prevent blackouts by monitoring the network frequency and voltage levels as follows:

Minimum frequency limitation: The frequency of the main network is checked continuously, if this frequency falls below a certain level of 97.5% of the rated frequency (58.5Hz), this indicates that the connected generators are overloaded (active power). To prevent a blackout, a signal is sent to immediately reduce the power requirements of the propulsion system and an automatic torque reduction takes place.

Network voltage limitation: The voltage of the main network is checked continuously, if the voltage falls below a certain level of 90% of the rated voltage (5,940V, this indicates that the connected generators are overloaded (reactive power). To prevent a blackout, a signal is sent to immediately reduce the power requirements of the propulsion system and an automatic torque reduction takes place.

Displayed Information

The following is displayed on the supervision computer HMI screen:

- The active power of each generator.
- The reactive power of each generator.
- The status of each circuit-breaker.
- Propulsion limitation system set points, measurements and limitations.
- Indication of either Pmax or Qmax limitation.

Torque Limitation

Torque limitation is also applied to protect the system equipment from possible damage through excessive mechanical loading. The propulsion limitation system functions as torque limitation as well as other limitations as follows:

- Min/Max network frequency limitation.
- Network voltage limitation.
- Propulsion limitation system.
- Sequential limitation.
- Electro-technical limitation.
- Process limitation.

The power limitation system has the anti-overload, network frequency and voltage limitations already described and this torque limitation is calculated and applied as a factor to the current torque to reduce it.

Torque threshold limitation includes electro-technical and sequential process limitations. These limitations are predefined thresholds of the rated torque according to each item or equipment. These limitations are applied to the torque demand to limit the propulsion power consumption (or the regeneration during braking phase).

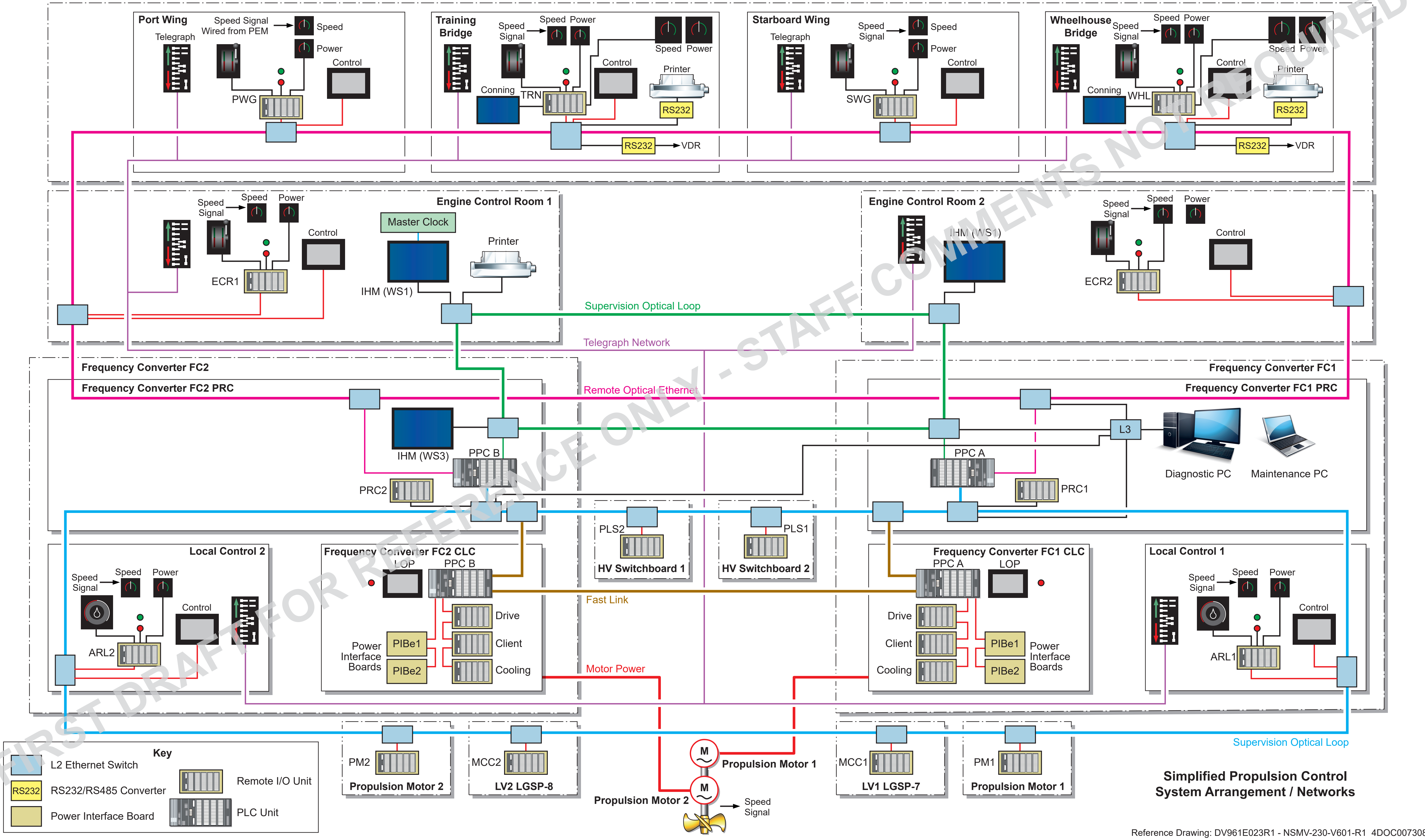
Sequential limitation protects items such as the transformers from possible overheating in the event of cooling equipment faults, etc.

Overspeed limitation is also carried out in the event of the motors overspeeding possibly due to the propeller leaving the water. This protection is applied via system software settings and also via hard signals from the motor pulse generator. The overspeed protection is triggered at three thresholds as follows:

1. 117.7 rpm (107% rated motor speed).
2. 123.2 rpm (112% rated motor speed).
3. 125.4 rpm (114% rated motor speed).

A SLOWDOWN lamp will be illuminated in the event of an active limitation that results in a motor slowdown.

Illustration 4.2a Propulsion Control System



Reference Drawing: DV961E023R1 - NSMV-230-V601-R1 4DOC0073080

4.3 PROPULSION CONTROL SYSTEM

Introduction

There are essentially two propulsion control systems controlling two converter/motor systems. These two systems receive controlling signals from the control stations and other system inputs from the propulsion controllers.

Control of the propulsion motor operation is via speed regulation according to a speed setpoint sent from the control station levers. This signal is compared to motor speed measurement calculated from electrical motor measurements, not from direct speed measurement from the encoder (pulse generator).

The speed regulator produces a torque setpoint corresponding to the propulsion torque needed to provide the required speed. The torque setpoint is converted into an active current setpoint providing motor current regulation based on vector flux control.

The propulsion control system consists mainly of the following sub-systems:

- Power Electronic Controller (PECe): providing control of the converter/ motor and anti blackout propulsion limitation. Converter control circuits and inter-connections.
- Propulsion Process PLC (PPC): Management and monitoring of equipment, propulsion operation, interlocks with shaft line equipment, anti-overload limitation, interface with supervision, interface with external systems (CAMS, VDR, etc).
- Supervision: HMI operator interface.
- Remote control: Control stations/human interface for propulsion control.
- Diagnostic/maintenance: Interface with Maintenance and diagnostic PCs and operations.
- Automation networks: network systems to interconnect with all sub-systems.
- An optic fibre ethernet loop communication system.
- An optic fibre remote control ethernet loop system. Two wire ethernet loops, running in tandem for redundancy.

These systems all connect to make up the distributed propulsion control system in such a way that each of the propulsion systems can function together in synchronisation or individually if required.

Control Stations

The control of the propulsion system is managed from eight control stations as follows:

- Propulsion converter 1 room (LOC1).
- Propulsion converter 2 room (LOC2).
- Engine control room1 (ECR1).
- Engine control room 2 (ECR2).
- Wheelhouse bridge (WH).
- Port wing (PWG).
- Starboard wing (SWG).
- Training bridge (TRN).

Each of these panels has the same facilities, but the local control panels do not use speed levers, they are fitted with speed dials for inputting speed set points. All the switching and indications of the control stations are carried out via a TFT touch screen panel, except for the emergency stop switches which are discrete switches hard-wired into the system.

There are also indicators for speed and power adjacent to the control station. In the wheelhouse and training bridge there are additional larger scale speed and power meters in the overhead consoles.

Wheelhouse Control Station

Most of the switching and indication of the propulsion control are carried out on the touch screen display panel.

There are additional meters for propeller speed and power indication in the wheelhouse console, adjacent to the control panel and further larger displays in an overhead console at the forward end of the bridge.

A single speed lever controller and emergency telegraph unit are mounted in the control station panel.

There are also EMERGENCY STOP and SILENCE BUZZER pushbuttons adjacent to the control panel, these are hard-wired into the propulsion system in case there is a breakdown in the communication between the control panel and the propulsion system.

Bridge Wing Control Station

The facilities at the bridge wings are the same as for the wheelhouse except the large overhead power and speed meters are omitted.

Training Bridge Control Station

The facilities at the training bridges are the same as for the wheelhouse.

Engine Control Room Control Stations

The engine control rooms 1 and 2 have a touch screen panel and meters for propeller speed and power indication. There is also a single speed lever controller and emergency telegraph unit mounted in the console. There are also EMERGENCY STOP and SILENCE BUZZER pushbuttons adjacent to the control panel, these are hard-wired.

The ECRs also have an HMI supervision PC workstation (WS1 and WS2) that displays the system information and parameters.

Local Control Stations

The local control stations are fitted with a speed transmitter dial in place of a speed lever.

Each local control station has its own touch screen display however, LOCAL 2 station has an HMI supervision PC workstation (WS3).

Propeller speed and power meters, EMERGENCY STOP and SILENCE BUZZER pushbuttons and emergency telegraph units are fitted.

All of the above control stations are connected together by a redundant ethernet optical fibre network and are connected to the drive converter, also by redundant optical fibre ethernet network. They are also connected by conventional ethernet networks.

Each of the speed levers is driven by an electric shaft arrangement; when one is designated the master, eg, the wheelhouse control station, all the other control station speed levers and dials will follow the position of the master allowing a seamless changeover in control location.

The Propulsion Drive Cabinets

The propulsion drive cabinets contain the equipment and systems for the supply of power to the propulsion motors. The converters take the fixed frequency network voltage and convert this to a variable voltage, variable frequency output, suitable for driving the propulsion motors at the required speed:

- Input voltage: 6.6kV
- Input frequency: 60Hz
- Output voltage: 0 ~ 3300V
- Output frequency: 15 ~ 90Hz

The drive cabinets contain the following units:

- Process unit (PRC).
- Control unit (CLC).
- Cooling unit (CCU).
- Pre-magnetising unit (PRE).

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Anything to update?

It is important that this manual is kept up to date as a live document. If you believe there are any errors or omissions in this manual, or you are aware of changes to the equipment or systems on board then please contact the publishers:

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- Diode front end (DFE).
- DC link (DCC).
- Inverter cubicle (INV).
- Inverter local control section (ILC).
- AC output cubicle (AC OUT).

For a more detailed explanation of the converter unit, refer to the propulsion converter section.

Each of the converter units has a cabinet cooling fan. The diode front end section, the DC capacitor link and the inverter section are all fitted with water cooling.

The Process Unit (PRC)

This section contains the Propulsion Process PLC (PPC). The following functions take place in the process unit:

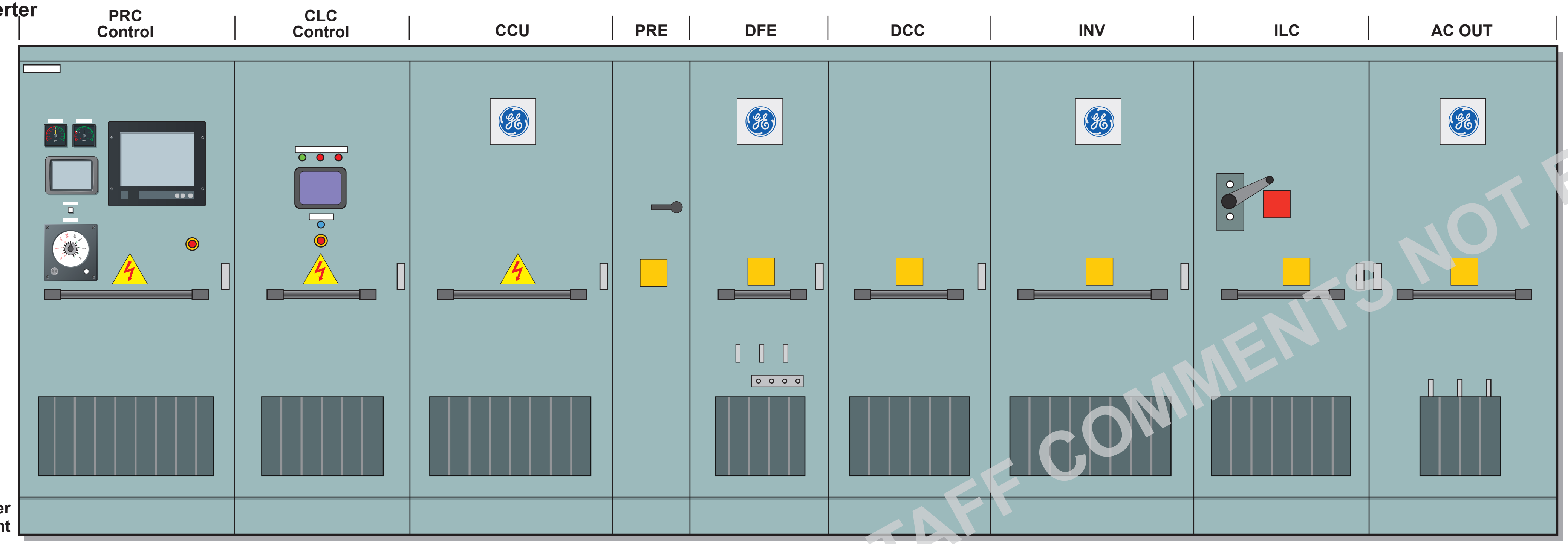
- Control of the motor drive functions.
- Drive protection settings and monitoring.
- Control of transformer and motor auxiliaries.
- Emergency stops management.
- Alarm management.
- 220V AC UPS and 220V AC distribution.
- 24V DC supply and 24V DC distribution.
- Speed measurement management.
- Speed indication management.
- Management of signals from:
  - Propulsion motor.
  - Shaft equipment.
  - Propulsion transformers.
- Sensor management.
- Communication to CAMS management.
- Communication network management.

CLC Section

This section contains the Power Electronic Controller (PECe) and the drive's Local Operating Panel (LOP). They provide control of the following functions:

- Local drive control in standalone mode.
- Power bridge I/O signals.
- Power switching ON/OFF signals.
- Speed set point management.
- Insulated Gate Bipolar Transistor (IGBT) pulse calculation.
- Anti-blackout Limitation (ABOL).
- Rough sea power regulation mode.
- Power bridge alarms and safeties monitoring.
- Power Interface Board (PIBe): Interface facility to all converter analog and digital measurements. IGBT firing and monitoring.

Illustration 4.4a Propulsion Converter



Propulsion Converter
Panel Arrangement

Key

PRC - Process Control

CLC - Converter Local Control

CCU - Converter Cooling Unit

PRE - Pre-charge Cubicle

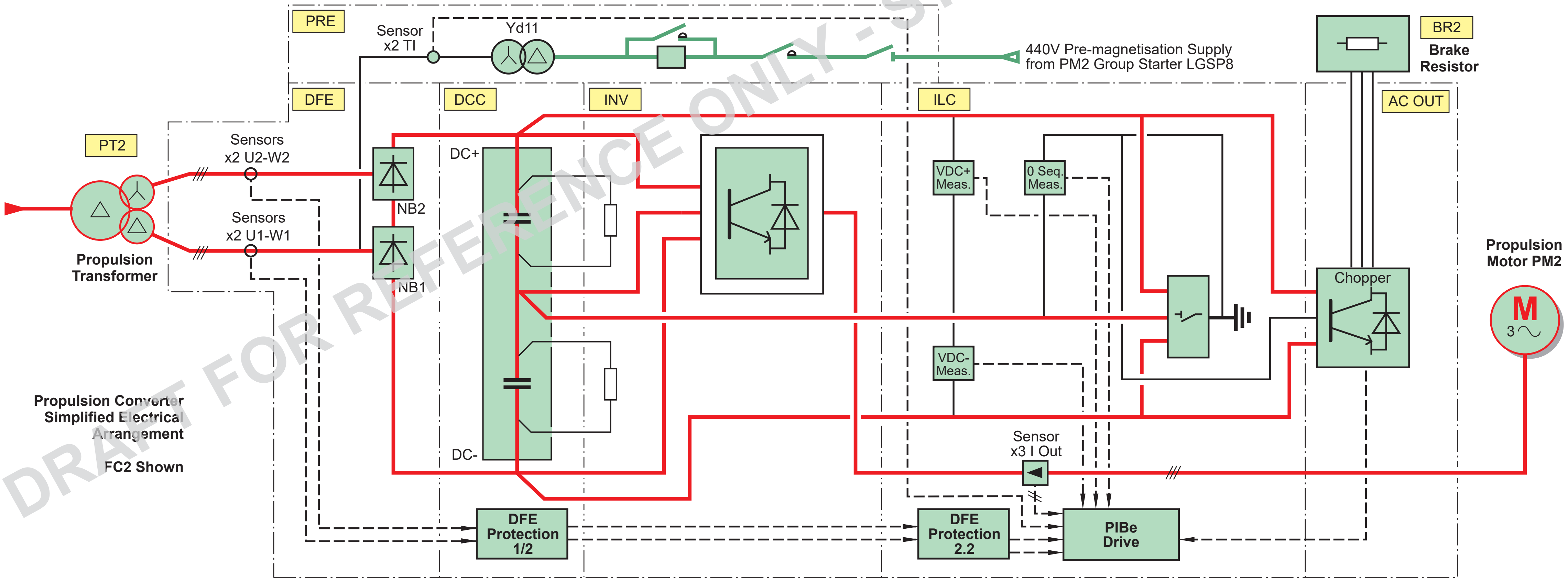
DFE - Diode Front End

DCC - DC Capacitor

INV - Inverter

ILC - Inverter Local Control

AC OUT - AC Output Section



Propulsion Converter
Simplified Electrical
Arrangement

FC2 Shown

Key

6,600/1,850V AC

440V AC

Reference Drawing: DV961E023CR2 Sht 2 / Sht 13

4.4 PROPULSION CONVERTERS

Manufacturer:	General Electric
No. of sets:	2
Model:	MV7306 DFE 12P
Rated output power:	4.75MW
Input voltage:	1,850V
Output voltage:	0 - 3,150V
Output current:	1,035A
Supply frequency:	60Hz
Output frequency:	???Hz
Protection:	IP23

Converter Location

- No.1: Frequency converter room 1, zone 4, 4th deck.
- No.2: Frequency converter room 2, zone 3, 4th deck.

Introduction

The purpose of the converter in the propulsion system is to convert the fixed voltage and frequency of the vessel's main 6,600V power network into a variable voltage and frequency that is used to drive the variable speed electric propulsion motor.

The converters (also known as a variable frequency drive) take the vessel's main AC supply, converts it to DC via rectification, then uses Pulse Width Modulation (PWM) techniques to produce a sine wave AC supply of the required frequency. This supply is applied to the propulsion motor, the voltage and frequency of the sine wave determining the torque and speed of the motor.

The converters are pulse width modulated, three level source inverters utilising press pack Insulated Gate Bipolar Transistors (IGBTs). The IGBTs are power semiconductor devices used basically as an electronic switch to regulate the output motor supply.

Converter Architecture

Each converter consists of the following sections:

- PRC: Process control section.
- CLC: Converter local control section.
- CCU: Converter cooling unit.
- PRE: Pre-charging (pre-magnetising) section.
- DFE: Diode front end section.
- DCC: DC capacitor section.
- INV: Inverter section.
- ILC: Inverter local control section.
- AC OUT: Alternating current output to motor section.

The mains power supply and motor supply cables to and from the converter are connected to their corresponding bus bars inside terminal units.

The functions of the sections of the converters are as follows:

Process Control Section - PRC

The process control cubicle contains all the control and management modules for the propulsion system. It also contains a 230V AC 1.5kVA UPS for power supply security, the UPS output goes to the CLC section for distribution. The front panel of the PRC also contains the local control panel for the propulsion unit, this includes the following:

- Speed setting dial and reply pointer.
- TFT touch screen.
- Propeller rpm meter.
- Power meter.
- Panel mounted supervision computer, with touch screen.
- Emergency stop pushbutton.
- Silence buzzer pushbutton.

The Power Electronic Controller - PECe

The propulsion motor control is based on a Power Electronic Controller Ethercat (PECe). The PECe is a distributed control system consisting of the following:

- A PECe P80i industril PC.
- A Power Interface Board Ethernet (PIBe).
- Ethernet network for communication and data acquisition.
- A Beckoff I/O low speed data acquisition unit.

The PECe PC is located inside the converter local control cubicle and it manages the following control functions of the converter:

- The speed regulation loop.
- The Anti-Blackout Limitation (ABOL) system.
- The torque regulation loop.
- The flux regulation loop.
- The current regulation loop.
- The starting sequence control.

The Power Interface Board (PIBe) is also located in the PRC and has the following functions:

- Produces the trigger pulses for the IGBTs, transmitted to the IGBTs via fibre-optic connections.
- Interfaces for all hard-wired connections required by the PECe, such as measurements and circuit-breaker status. This data is acquired in two ways:
  - Fast signals: Input and output signals such as voltage and current measurements.
  - Slow signals: Input and output signals connected via a dedicated I/O rack for other data such as circuit-breaker status and water cooling unit interface.

Propulsion Process Controller - PPC

This is an integral part of the control PC PECe and has control over the following functions:

- Starting and stopping of the system auxiliaries.
- Process fault management.
- The Propulsion Limitation System (PLS). This controls the automatic limitation of the propulsion in case of overloading of the main diesel generators.
- The management of the remote control system from the operating positions around the vessel.
- Interfaces with external system or devices such as the Integrated Control and Automation System (ICAS), the Human Machine Interface (HMI) and the Voyage Data Recorder (VDR).

To carry out these functions, the PPC requires inputs and outputs to/from different types of networks as follows:

Optic Fibre I/O Ethernet Network

This network provides communications between the PPC and the remote control positions. Due to the systems loop configuration it is fault tolerant. The propulsion system can be controlled from the eight possible remote control positions that utilise this network:

- Bridge console.
- Port bridge wing console.
- Starboard bridge wing console.
- Training bridge console
- Engine control room 1.

- Engine control room 2.
- Port local control panel.
- Starboard local control panel.

I/O Ethernet Network

This network provides for the propulsion control management and safeties:

- Motor safeties.
- Converter safeties.
- Transformer safeties.
- Auxiliaries motor control centre safeties.
- Shaft line safeties monitoring, temperature monitoring and interlocks.
- PLS data from the main switchboards.

I/O Network for Inter-Process Communication

This system provides communication between the port and starboard drives and the HMI computers. It is a redundant system using two separate ethernet networks connected and operating in tandem. If one network should fail, there would be no interruption of communication. This network also connects the maintenance computer to the system; this PC is used for:

- Configuring the IP addresses of the different components of the propulsion system (PPC, PECe, remote I/O rack, etc).
- To download software to the PPC and PECe.
- To monitor the propulsion system using analytical tools.

Converter Local Control Section - CLC

This section contains the following:

- The PECe P80i industrial PC.
- Power Interface Boards (PIBe) units (x2).
- Interconnection and interfaces between the various units of the system and also between the system and external equipment.
- Switching for the cooling system.
- The 24V DC converters to convert 230V AC from the UPS in the PRC for control and for process computer supplies.
- Cabinet heater supplies distribution.
- Cabinet fans supply distribution.
- Power supply distribution for control relays.
- Power supply distribution for network devices (switches, etc).

Converter Cooling Section - CCU

This section contains the converter cooling pumps and switching system. The cooling of the drive is achieved by a closed loop de-ionised water to fresh (raw) water heat exchanger system.

The system consists of two pumps, one normal and one standby; the normal pump will start during the auxiliaries starting sequence. The water cooling system consists of:

- Two electrically powered pumps; one in normal mode and one in standby.
- A resin de-ionising cartridge.
- An expansion vessel to compensate for changes in pressure.
- A de-ionised water to raw water heat exchanger.
- Sensors for monitoring the pressure and temperature.

De-ionised water is pumped through the cooling pipes and ducts of the high voltage sections to provide cooling. This water is then passed through a water to water heat exchanger and the heat from the de-ionised water is dissipated in the raw water. The de-ionised water is also passed on to the cooling pipes to the other HV cubicles. The temperature, pressure and the quality of the de-ionised water is monitored and the following parameters are checked:

- De-ionised water inlet temperature.
- De-ionised water outlet temperature.
- De-ionised water pressure.
- De-ionised water conductivity.
- De-ionised water flow.
- De-ionised water leakage.

Parameter	Set point	Result
De-ionised water temperature alarm	43°C	Alarm
De-ionised water temperature fault	45°C	Stop
De-ionised water pressure L	0.9 bar	Alarm
De-ionised water pressure LL	0.5 bar	Trip
De-ionised water conductivity H	1.5μS/cm	Alarm
De-ionised water conductivity HH	1.9μS/cm	Trip
De-ionised water flow	< 80% rated flow	Fault
De-ionised water leakage	No contact	Limitation

The active pump is started during the auxiliaries starting sequence. The pump is stopped approximately ten minutes after the AUXILIARIES OFF order is given; however, the pump will continue to operate as long as the main circuit-breaker is closed or the DC bus voltage has not discharged.

There is a three-way bypass valve that can regulate the flow of raw water to the heat exchanger if the inlet or outlet temperature is under a set point depending on the ambient temperature, or when the main breaker opens after a time delay, to keep the temperature of the cooling de-ionised water at an optimum level.

The conductivity check is carried out even if the unit is switched off. If a high level of conductivity is detected, a de-ionisation cycle is performed until a satisfactory level is achieved, so the cooling unit is maintained in a ready to start condition in terms of conductivity. If there is not an emergency stop in force, it will be automatically restarted.

Pre-charging Section - PRE

The pre-magnetisation (pre-charging) transformer and switchgear for the pre-magnetising of the propulsion transformer and the DC filter capacitors is located in this section.

Diode Front End Section - DFE

This section consists of the diode font end bridge. This bridge receives the output of the two secondary windings of the propulsion transformer and rectifies this to a DC voltage. The diode bridge is made up of four stacks of six diodes, one stack to each transformer secondary. The output is passed to the DC Capacitor filter circuit (DCC).

Due to the arrangement of the propulsion transformer secondaries, one star and one delta wound, the resulting phase shift is applied to the diode front end, this effectively provides a 12-pulse configuration that ensures harmful harmonics in the system are reduced.

Diode Front End Disconnection - DFED

This section houses the equipment for the disconnection and earthing of the diode front end when required.

DC Capacitor Section - DCC

This section houses the DC filter capacitor banks. These capacitors provide the DC filtering of the rectified AC to remove any residual ripple from the waveform to provide a more stable DC supply. The capacitors are water cooled. During the power sequence they are all pre-charged.

Inverter Section - INV

In the inverter section, the DC from the rectifier section via the DCC section is converted back to AC using pulse width modulation via the IGBTs; these are high power semi-conductor switches that when triggered can switch on and off extremely fast, allowing precise control of the PWM and therefore precise control over the motor speed and torque. The IGBTs are triggered by optical fibre links from the trigger circuits in the PIBe board.

Output Section - AC OUT

This section contains the connections between the output of the inverter section and the cabling to the propulsion motor.

It also contains a PIBe unit that provides the triggering pulses for the inverter IGBTs and the braking chopper IGBTs.

Propulsion Motor Braking

When the speed of a variable speed motor is reduced by reducing the frequency of the motor supply voltage, energy is fed back into the drive and so the voltage on the DC link will increase. This does not matter for small changes in motor speed, however, for large changes this could be a problem, as the feedback of large amounts of energy into the drive could cause damage.

As this converter system uses a Diode Front End (DFE) (and not an active front end), this energy cannot be fed back into the supply network (regeneration). Therefore, an alternative means of dissipating this braking energy from the motor must be utilised. This system uses a chopper unit and this is connected to the DC link, and when the voltage of the DC link rises above a certain level due to the braking energy from the motor, the chopper unit will activate and feed the excess energy to a braking resistive load - the Braking Resistor Unit (BRU). The braking resistors heat-up rapidly and this heat is then dissipated slowly.

The main component of the chopper unit are IGBTs and these can handle large amounts of energy very quickly, and so this excess energy is dissipated from the drive rapidly. The control for these IGBTs is from the PIBe unit in the AC OUT cubicle, this provides the trigger pulses for both the output IGBTs and the chopper IGBTs. The IGBTs in the chopper unit will switch the excess DC voltage to the braking resistors until such a time as the voltage on the DC link falls to a normal value.

The braking resistor units are installed forward and aft of the associated frequency converter rooms at 4th deck level. The specification of the braking resistors are as follows:

Manufacturer:	MS Resistances
Type:	B-006-014-0020-20-HE
Material:	Stainless steel alloy
Resistance:	2 x 7ohms at 45°C
Voltage:	5.5kV nominal
Insulation level:	7.2kV
Rated:	2 x 10MJ / 20 seconds every 30 minutes
Surge:	2.6MW to 0MW in 15.4 seconds

The resistors are made up of grids of stainless steel alloy and these are spot welded together in banks mounted between two end plates, supported both horizontally and vertically by porcelain insulators.

The assemblies are mounted in an enclosed cabinet that is cooled by an air to water cooling unit, the cooling air flow is by natural convection as the hot air from the resistors rises and is cooled by the air to water heat exchanger and the rise of the hot air from the resistors draws in cool air from the bottom of the enclosure. The cooling water is supplied from the propulsion auxiliary fresh water cooling system. The cooler has a water leakage detector fitted and temperature monitoring via two PT100 sensors.

A thermostatically controlled 120V 50W anti-condensation heater is also fitted in the braking resistor enclosure.

The specification of the air to water cooler is as follows:

Manufacturer:	VDL Klima
Model:	16 KDLD-261-1620-2-2
Type:	Double tubed
Water temperature:	34°C to 38°C max
Water flow:	10m^3/h
Pressure drop:	30kPa
Heat dissip. in water:	11.1kW
Heat dissip. in air:	2.25kW
Operating pressure:	6 bar

There are certain alarms associated with the braking resistor unit:

Function	Set point	Result
Air temperature H	250^{0}C	Alarm and limit regen. to 1/3
Air temperature HH	300^{0}C	Alarm and limit regen. to 0
Water leakage		Alarm

In order to avoid a large energy storage in the braking resistors, the activation of the braking resistors is managed as follows:

- If zero speed or reverse speed is requested, the activation of the braking chopper is restricted to under 40% of full speed.
- In a crash stop situation when:
  - Two motors are running, the activation of the chopper is allowed under 50% of full speed.
  - One motor running, the activation of the chopper is allowed under 45% of full speed.

In a crash stop situation, the air temperature H and HH limitations are inhibited and only an alarm will be raised.

Emergency Converter Control

Each converter is fitted with a Local emergency Operating Panel (LOP) which is directly connected to the power electronic controller PLC.

If the propulsion remote control system fails (a link failure between PPC and PECe, or all remote control stations failed), the propulsion can be operated from the actual converters in 'Standalone Mode' using the LOP. This facility is usually for maintenance viar service engineers or trained operators.

local operation allows running of the motor with the minimum security conditions (only those regarding the converter itself) and the operator must check that all conditions are fulfilled to run the equipment properly, (ie, manual start of the required auxiliaries).

At the LOP, the operator can :

- Control the cooling pumps.
- Start the converter power sequence.
- Set a speed setpoint.
- Read/reset faults.
- Read the converter main measurements.

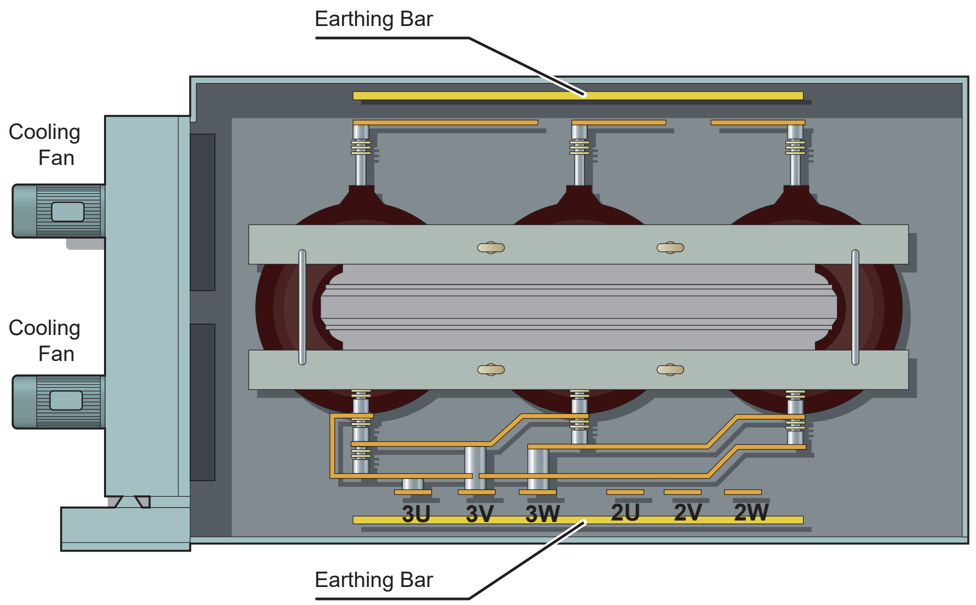
When the standalone mode is selected at the master converter, control is automatically transferred by the PPC to the LOCAL remote control station. So, when the standalone mode is released from the LOP, the control of the propulsion is at the LOCAL remote control station.

If standalone mode is selected at the slave converter, the active remote control station does not change (the slave converter receives its torque setpoint from the master converter).

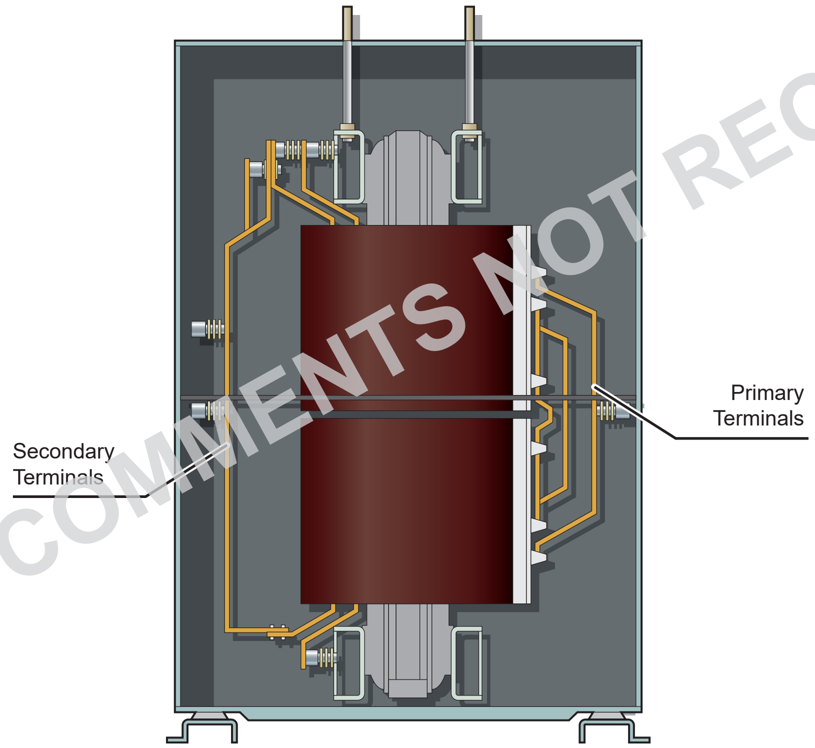
In standalone mode, the motors can only be controlled in 'Speed' mode only, there is no Power mode.

Illustration 4.5a Propulsion Transformers

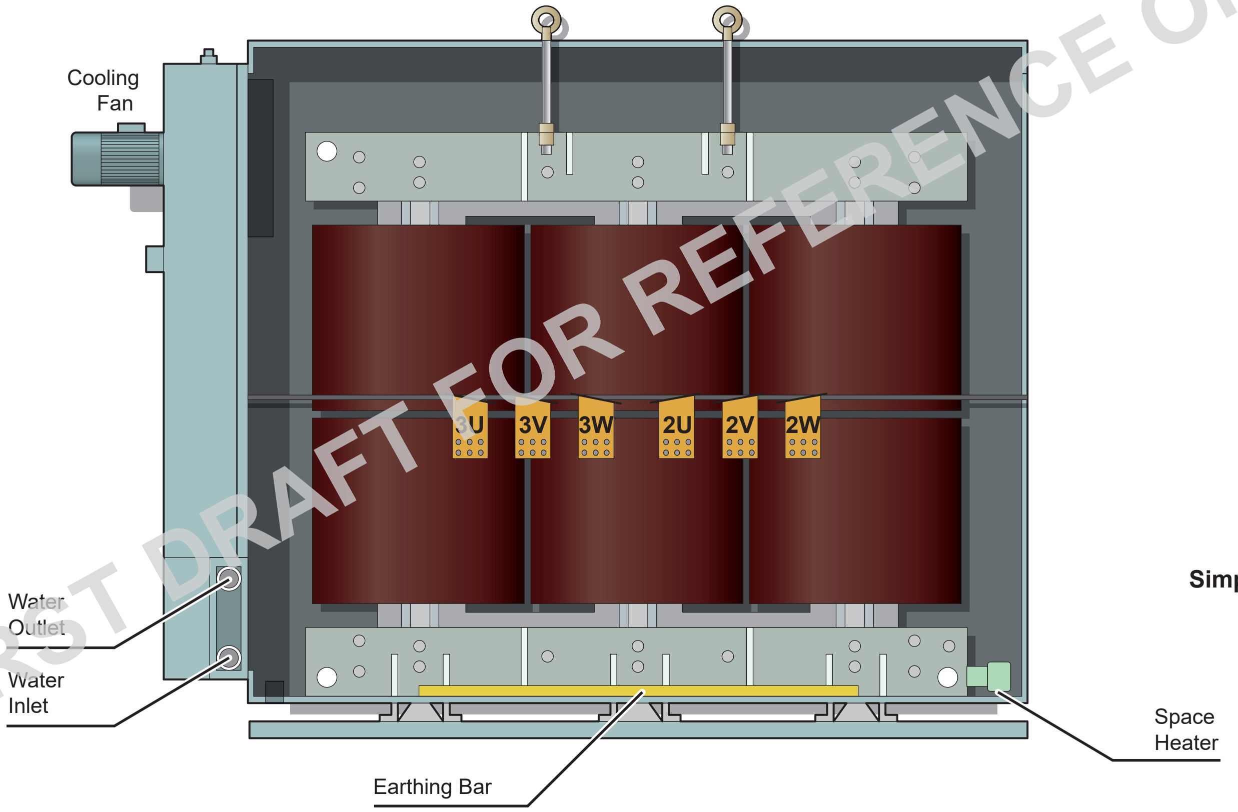
Propulsion Transformer Top View



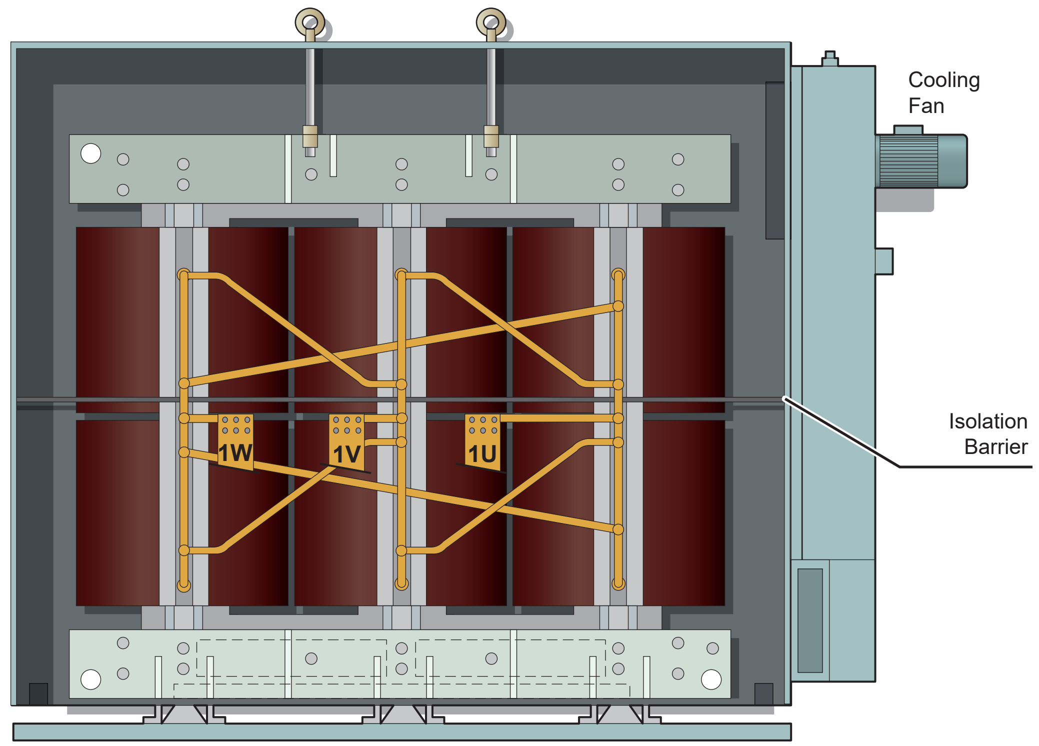
Propulsion Transformer End View



Propulsion Transformer LV Side View



Propulsion Transformer HV Side View



Propulsion Transformer Simplified Internal Arrangements

Reference Drawing: DV961E023AR0-NSMV-233-V604-R0 / SIM19-101-2-DW-GA-001 Rev 4

4.5 PROPULSION TRANSFORMERS

Specification

Manufacturer:	Sanil Electric
Model:	SMT-3H5400KMD
Type:	Cast resin
Rated primary capacity:	5,400kVA
Rated sec. capacity	2 x 2,700kVA
Rated primary voltage:	6,600V
Rated primary current:	472.4A
Rated sec. voltage:	2 x 1,850V
Rated sec. current:	2 x 842.6A
No. of units:	2
Frequency:	60Hz
Protection:	IP44
Cooling:	Forced air, fresh water AF/WF
Insulation class:	F
Weight:	11,000kg

Transformer Location

- No.1: Frequency converter room 1, zone 4, 4th deck.
- No.2: Frequency converter room 2, zone 3, 4th deck.

Introduction

There are two propulsion transformers fitted, one for each propulsion converter/motor system. They are situated in the converter rooms on the 4th deck level. Each of the propulsion motor converters is supplied by a propulsion transformer. The propulsion transformers adapt the network voltage (6,600V) to the requirements of the propulsion frequency converters (1,850V).

Each propulsion transformer is equipped with one water heat exchanger and two cooling fans. The cooling fans are started when the AUXILIARIES ON order is received. Each transformer is fitted a standstill heater to avoid any condensation when the transformer is switched off. The heaters are rated 120V, 200W and they are fully automatic and thermostatically controlled. Heater operation is interlocked with the transformer supply circuit-breakers.

The primary winding is delta connected. One secondary winding is delta connected and the other is star connected. This provides a phase shift in one of the supplies to the converter rectifier bridge which reduces harmonics.

Construction

The transformer core is made of cold rolled grain oriented electrical steel laminations insulated from each other by a thin resin coating. The laminations have overlapping joints staggered over several laminations. The cutting angles of the joints are 45º, this provides a reduction in no-load losses, no-load currents and also provides noise reduction. The resin coating also provides corrosion protection. The core is clamped into a secure metal frame.

The primary windings are of aluminium foil wound with alternate layers of insulating sheet, bonded together and heat treated. The winding is vacuum cast in resin, to provide insulation and protection from any external influences such as chemicals, chemical vapours, oil and any other contaminants, as well as providing resistance to vibration and mechanical shocks.

The secondary windings are of aluminium foil strips wound with alternate layers of insulating sheet, bonded together and heat treated. The winding is vacuum cast in resin. Copper screens are fittedbetween the HV and LV coils.

The transformer core and winding unit is enclosed in a sheet metal cabinet with the cooler and two associated cooling fans.

Infrared inspection windows are installed in the top cover of the transformers for manual temperature monitoring of the windings and cores with an infrared camera device.

Each transformer has two external junction boxes for the auxiliaries; JB1 for the space heater and auxiliary power connections and JB2 for the PT100 temperature sensor terminations.

The main primary and secondary cables enter the enclosure from the bottom.

Transformer Cooling

The following are the characteristics of the air/water cooling system:

Manufacturer:	VDL Klima
Heat dissipation cap:	55kW
Water flow:	9.5m^3/h minimum
Water inlet temp:	38°C
Water outlet temp:	43°C
Pressure drop:	25kPa
Rated water pressure:	6 bar
Test water pressure:	9 bar

The cooler coils are double tubed with removable covers and a leakage detector is fitted which will raise an alarm in the event of water leakage.

It is a closed loop cooling system, the hot air is drawn from the top of the transformer enclosure by the fans and then forced down to the bottom of the cooler unit where it is driven through the water filled tube stacks and cooled. The cooled air is then reintroduced into the bottom of the transformer enclosure. The cooling water is supplied from the propulsion auxiliary fresh water cooling system.

Premagnetising

Each propulsion transformer is provided with a 26kVA premagnetising transformer. The premagnetising transformers are energised before the main supply and will magnetise the transformer before the 6,600V supply is connected, therefore limiting the inrush current. This ensures there is no large voltage drop on the main network when the propulsion transformers are connected. The premagnetising transformers are fitted in the converter.

Alarms, Limitations and Trips

The low voltage secondary windings are equipped with PT100 temperature sensors with two active and one spare for each winding, one of the active sensors supplies an input to the CAMS system and the other supplies the propulsion control system.

There are also PT100 sensors for cooling air temperature. The settings for alarms, limitations and trips are as follows:

Function	Set Point	Alarm	Limit	Trip
Transformer winding temp. H	100°C	Y	Y	
Transformer winding temp. HH	110°C	Y		Y
Transformer fan fail		Y	Y	
Transformer water leakage		Y		
Transformer cooling air H	60°C	Y	Y	
Transformer cooling air HH	65°C	Y		Y
Cooling air flow low		Y		

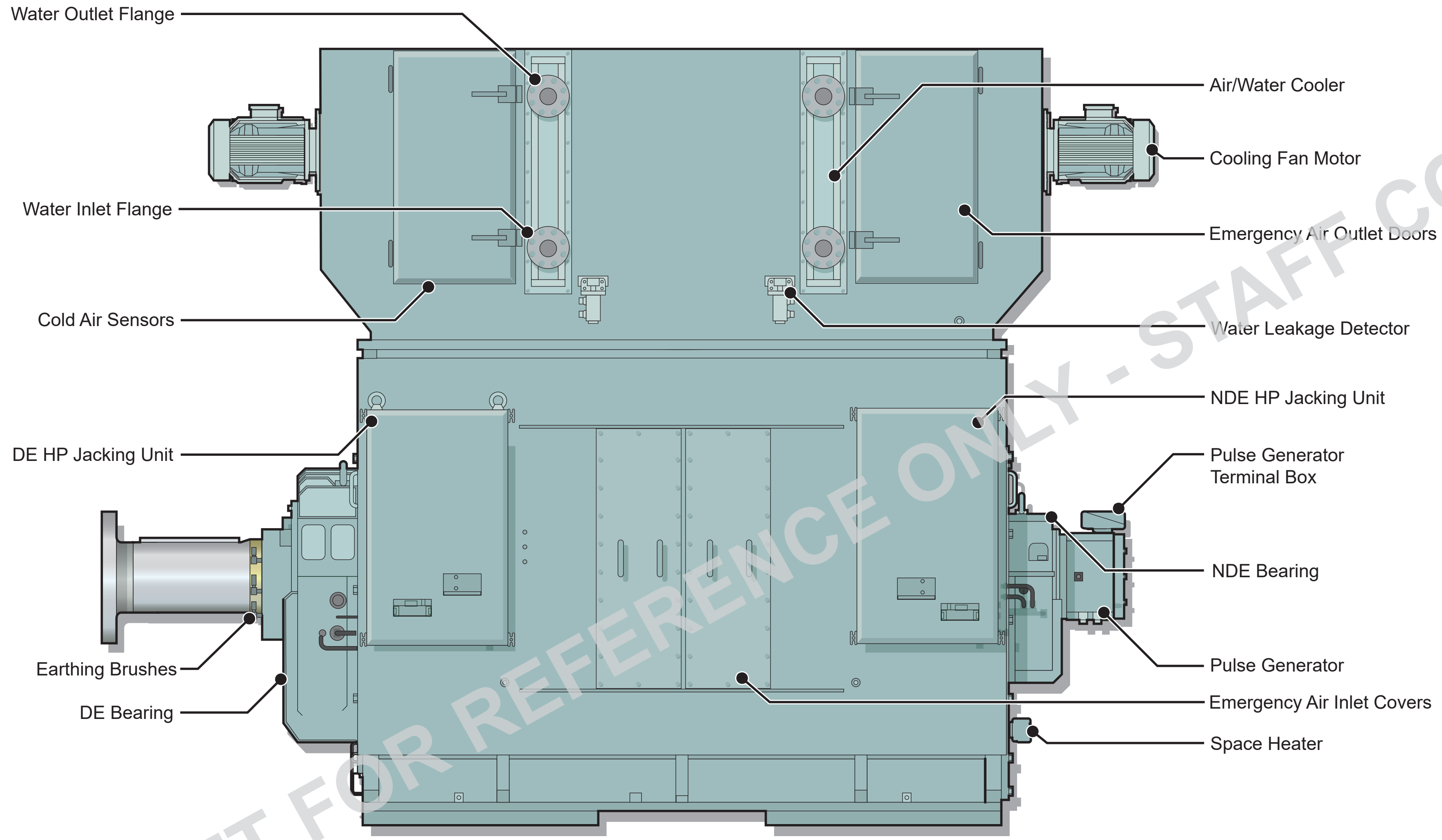
The first level alarm of the winding temperature will also initiate a propulsion limitation, the second level, a trip.

The cooling air temperature first level alarm will initiate an alarm the second level alarm will initiate a propulsion limitation.

The water leakage and the air flow detectors will initiate an alarm only.

The transformer fans are started during the converter auxiliary start sequence. Under normal operation, both fans operate at the same time, however, one fan is kept in operation for each transformer as long as the circuit-breaker is closed to dissipate the no load heat losses.

Illustration 4.6a Propulsion Motor



Propulsion Motor - Simplified Arrangement

Reference Drawing: DV961E023CR2-NSMV-233-V606-R2 E95S20A041A

4.6 PROPULSION MOTOR AND SHAFT EQUIPMENT

Propulsion Electric Motors

Manufacturer:	GE Power Conversion
Type:	AC induction
Model:	N3 HXC 1250 L/10/V
No. of sets:	2
Rated:	4,500kW
Voltage:	3,150V
Current:	1,035A
No. of Poles:	10
Speed:	0-115rpm
Weight:	57,500kg
Protection:	IP44/56

Propeller

Manufacturer:	Nakashima
Type:	5 blade fixed pitch
Model:	ABS Type 4
Material:	Ni-Al-Bronze
Diameter:	5,850mm
Weight:	18,390kg

Propulsion Shaft Bulkhead Seal

Manufacturer:	SKF
Type:	Fireproof
Model:	A60

Propulsion Shaft Thrust Bearing

Manufacturer:	Wartsila
Type:	Self-lubricated
Model:	OBSQ-F 450

Propulsion Shaft Intermediate Bearing

Manufacturer:	SKF
Type:	Self-lubricated tunnel
Model:	SLN-041-1001-000

Propulsion Shaft Stern Tube Bearing

Manufacturer:	SKF
Type:	Water-lubricated
Model:	SSB-512-0011-000

Propulsion Shaft Stern Tube Seal

Manufacturer:	SKF
Type:	Simplex compact seal 600
Model:	SC3 ZW-P

Propulsion Shaft Turning Gear

Manufacturer:	Dellner Brakes
Type:	Electric, driven gear
Model:	TF 110

Propulsion Shaft Horse Power Meter

Manufacturer:	Kyma
Type:	Strain gauge
Model:	KPM-P

Propulsion Motor Bearings

Manufacturer:	Renk
Type:	Self-lubricated sleeve with jacking
Model:	SMNFB 45-400 (DE)
	SMNFQ 35-315 (NDE)

Propulsion Motors

The two propulsion motors PM1 and PM2 are located at tank top level, PM1 located in motor room 1 and PM2 in motor room 2. They are tandem mounted driving a common propeller shaft which drives the fixed pitch propeller.

The motors are directly coupled to the propeller shaft without gearing and the motors can operate in both directions, the minimum speed of rotation in either direction is XXX rpm.

The motors and shafts are fitted with turning gear and a shaft lock. When either of these two facilities are engaged, propulsion is blocked.

Each propulsion motor is fitted with two pulse generators to accurately measure the position of the rotor. This is for starting and operating the motors. Speed monitoring is from sensors fitted to the toothed wheels on the motor shafts.

Construction

The stator core is made up of electrically insulated sheets, braced with clamping bolts and rings and mounted in the stator housing. The stator windings consists of layered coils mounted in the open slots of the stator core. The stator is connected to two terminal boxes on the stator housing. The terminal boxes contain the current bars for connecting the stator cables. The star points are also arranged in two boxes at the front of the housing.

The rotor is comprised of a forged shaft with a shrunk on rotor body. The 10 poles are screwed onto the rotor body.

Motor Bearings

The motor is equipped with self-lubricated, sleeve bearings, equipped with hydrostatic jacking pumps. There are two jacking oil pumps for the drive end bearings and two jacking oil pumps for the non-drive end bearings, normally with one operating and one in standby.

Cooling

The motors are fitted with two air-water heat exchangers providing cooled air which is forced through internal cooling openings via four 440V 9.2kW electric-motor driven fans. This air is then circulated back to the coolers. In the event of a fan/fans failing, it is still possible to operate at a reduced speed.

In the event of failure of cooling water, it is possible to operate the motor with draught ventilation. The motor is provided with emergency air openings in the cooler hood and in the stator housing. The loss of the cooling fans will cause a ‘request for reduction’ signal to be raised via the control system.

After stopping the propulsion motors, the fans will continue to operate for a 30 minute cooling down period.

Each motor is equipped with anti-condensation space heaters. There are two 120V AC 1,650W electrical heaters fitted.

The following temperature monitoring sensors are fitted:

- Embedded resistance temperature sensors in each of the stator windings. There is one in use and one spare in each stator winding.
- Monitoring of internal cold air temperature at the DE and NDE.
- Monitoring of internal hot air temperature
- Monitoring of the two coolers for cooling water leakage.
- Bearing shell temperature at DE and NDE.

If any of the parameters of the monitored points are exceeded, an alarm is raised. If exceeded further, automatic reductions in power or a shutdown.

Cooling Fan Failures

If one motor cooling fan fails, a non-critical fault alarm is raised.

If two motor cooling fans fail, one from fans 1 and 2 or one from fans 3 and 4, a non-critical fault alarm is raised.

If two motor cooling fans fail, both fan 1 and fan 2 or both fan 3 and fan 4, a critical fault alarm is raised.

If any three motor cooling fans fail, both drives are tripped.

Propeller Shaft

The propeller shaft system is made up of different sections, connecting the propulsion motors to the propeller. The sections of shaft are connected by means of seven flanged couplings secured with hydraulically tightened bolts. The sections are as follows:

- No.1 intermediate shaft.
- No.2 intermediate shaft.
- No.2 motor shaft.
- No.3 intermediate shaft.
- Thrust shaft.
- No.4 intermediate shaft.
- Propeller shaft.

The shaft is supported by eight bearings in order to preserve the alignment and prevent excessive stresses developing. Pedestal bearings are provided for the inboard part of the shaft and a sea water lubricated stern tube bearing is fitted where the shaft passes through the hull. The bearings are as follows:

- Aft stern tube bearing.
- Forward stern tube bearing.
- Thrust bearing.
- Motor 2 aft bearing.
- Motor 2 forward bearing.
- Intermediate shaft bearing.
- Motor 1 aft bearing.
- Motor 1 forward bearing.

An inboard stern tube seal is provided to prevent water from entering the hull. Where the shaft passes through the watertight bulkhead between the two propulsion motors, a bulkhead seal is fitted. A 40mm disc is fitted between the No.2 intermediate shaft and the No.2 motor shaft to enable shaft disconnection between motors/compartments.

To transmit thrust from the propeller to the hull, a thrust bearing is fitted to the shaft. The thrust bearing and shaft pedestal bearings are oil lubricated.

The shaft is provided with an electric motor-driven turning gear which is engaged and operated as required for maintenance purposes. A start blocking system prevents the electric propulsion motor from being started when the turning gear is engaged. A shaft locking system is provided to hold the shaft and prevent rotation; the turning gear can be damaged by the action of water flow on the propeller blades which will cause the propeller, and hence the shaft, to rotate. This locking system is for use in an emergency and prevents rotation of the shaft and propeller should there be a failure of any part of the system, The locking device is also interlocked with the propulsion motor operation.

All bearings have temperature monitoring utilising PT100 sensors

Propulsion Motor Bearing Jacking System

Each motor bearing system has two Lubrication Oil (LO) jacking pumps.

The motor is fitted with bearings which utilise a hydrostatic jacking system for slow speed lubrication. The bearings self-lubricate above 55rpm.When operating at slow speeds (below 55rpm) and when stopped or when ready for starting, the jacking oil pumps operate. The jacking pumps are stopped when the rotor speed reaches 65rpm and the pumps restart at 55rpm.

The bearings are monitored for oil pressure and the jacking units have monitoring for rated oil flow, low oil flow and clogged filter.

- Bearing oil sump temperatures by RTDs, DE and NDE.
- Bearing oil level monitoring by level switches, DE and NDE.
- Bearing hydrostatic oil flow by oil flow switch, DE and NDE.
- Bearing hydrostatic oil pressure by transmitters, DE and NDE.
- Bearing hydrostatic oil filter monitoring, DE and NDE.

The NDE bearing is insulated from the ship's structure to prevent excess electromotive force transient currents present in the shaft from being transmitted into the bearing. The DE bearing is not insulated. There are shaft earthing brushes fitted at the DE bearing to shunt transient currents to earth.

The propulsion motors, thrust block and shaft bearing lubrications systems are described in the lubricating oil section of this manual.

If a failure or lack of pressure should occur, the propulsion control will switch over from the active pump to the standby pump and an alarm will be raised and displayed. One of the pumps is supplied from the normal supply and the other from the normal and the emergency supplies. In case of blackout, the system switches in the pump that has the emergency feed.

Stern Tube Arrangement

Description Required

4.7 THRUSTERS

Bow Thruster

Manufacturer:	Kawasaki
Type:	Retractable, L-drive, controllable pitch
Model:	Rexpeller KST-180LC/EMR
No. of sets:	1
Propeller:	4-blade, Nickel-Aluminum Bronze (ABS Type-4)
Propeller diameter:	2,150mm
Rotation:	Clockwise (from propeller side view)
Max. propeller speed:	301 rpm

Drive Motor

Manufacturer:	Hyundai
Type:	Vertical induction motor
Model:	HIN1 505-86Y
Rated:	6,600V, 212.5A, 1,800kW
Speed:	889 rpm
No. of Poles:	8
Space Heater:	120V, 500W
Weight:	7,200kg
Protection:	IP44

Main Hydraulic Power Unit

Manufacturer:	Kawasaki KPM
Model:	
Motor:	440V, 30kW, 1,750 rpm

Retracting Hydraulic Power Unit

Manufacturer:	Kawasaki KPM
Model:	
Motor:	440V, 11kW, 1,750 rpm

The retractable bow thruster provides an athwartships or variable direction maximum thrust of 246 kN (measured in azimuth thruster mode). The bow thruster is located forward in the hull between frames 82 and 90. When in the housed position, it operates as a conventional tunnel bow thruster (tunnel thruster mode). When lowered to its position below the hull, it is then operated and controlled as a steerable azimuth thruster unit (azimuth mode).

The thruster unit (known as a 'Rexpeller') comprises a four bladed controllable pitch propeller with duct and gear case containing the propeller drive, input shaft, bevel gear and propeller shaft. The steering part consists of spur gears driven by an axial piston type hydraulic motor and swivel column. The spur gear wheel is at the upper end of the swivel coupling and the thruster unit (the propeller part and gear case) is fitted to the lower end. The propeller shaft is sealed against sea water ingress by three lip type sealing rings.

The power from the vertically mounted electric drive motor is transmitted to the propeller through a flexible coupling to the input shaft, lower bevel gears and the propeller shaft. The bearings and gears in the gear case have oil bath type lubrication.

Operation

The thruster is retracted or lowered via the vertical guides. When the thruster is retracted inside of the hull, operation is only as a tunnel thruster. Only when the thruster is extended to its fully lowered position underneath the hull bottom can the thruster be operated through 360° in azimuth thruster mode.

Note: The thruster unit can only be extended or retracted when the ships speed is lower than 3 knots.

Note: When retracted and operated in tunnel thruster mode, operation is limited to a maximum of 30 minutes.

Steering, propeller blade pitch and housing/lowering are carried out hydraulically. There are two separate thruster hydraulic pump units; the 30kw unit is for the steering and controllable pitch functions, the 11kw unit is for the retract and lower functions. These are located in the bow thruster room in zone 1. The systems have a 110 litre gravity tank located in the bow thruster room

The cylinder locking arrangements that secure the thruster in the lowered and retracted positions are pneumatically powered.

When lowered, the thruster can turn in azimuth 180° in 15 seconds. The propeller blade pitch can be moved the full 55° (from +30° to -25°) in azimuth thruster mode in approximately 35 seconds and in tunnel thruster mode in approximately 25 seconds. From the retracted position to the fully lowered position takes approximately five minutes. To retract from lowered position also takes five minutes.

The following interlocks are required to enable drive motor starting:

- Thruster function is 'Ready to Start'.
- Propeller blade pitch at zero
- Sufficient generating capacity connected.
- Main switchboard circuit-breaker closed.
- Control system power on.

Lowering and retracting is carried out from a control box at the machine side or from the remote control panel on the bridge. To lower and retract the thruster, the following interlocks apply:

- The steering angle is at the 'home' position of 270 degrees.
- The drive motor is stopped.
- The lowering/retracting pump is running and pressures normal.
- The pneumatic locking devices No.1/No.2 are normal
- The ship's speed is below 3 knots (NMEA speed input).

Remote control and operation of the bow thruster is described in the bridge manual. In the event of a failure of the normal operating and remote control system, the thruster can be operated locally by manual operation of the solenoid valves, consult the manufacturer's documentation for in-depth description.

Local Lowering Operation

From the local control panel in the bow thruster room:

a) Ensure permission is obtained from the bridge that the thruster can be lowered. Ensure ship's speed is lower than three knots.

b) Ensure that all conditions are confirmed ready, All power supplies are on and hydraulic units are operating correctly.

c) Press the REX RETRACT pushbutton.

d) Press the RELEASE locking device pushbutton. The lamp will illuminate when this is carried out.

e) Press the REX LOWER pushbutton. When lowering is complete, the AZIMUTH POSITION lamp will illuminate.

Local Retracting Operation

From the local control panel in the bow thruster room:

a) Ensure permission is obtained from the bridge that the thruster can be retracted.

b) Confirm that the locking device RELEASE lamp is illuminated.

c) Ensure that all conditions are confirmed ready, All power supplies are on and hydraulic units are operating correctly.

d) Press the REX RETRACT pushbutton.

e) When retracting is complete, press the ENGAGE locking device pushbutton. The thruster is housed.

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Anything to update?

It is important that this manual is kept up to date as a live document. If you believe there are any errors or omissions in this manual, or you are aware of changes to the equipment or systems on board then please contact the publishers:

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Cooling

The motor air cooler and the hydraulic unit oil coolers are cooled with water from the bow thruster FW cooling system. This system has a FW cooler, two FW cooling pumps and a FW expansion tank. This tank can be replenished from the distilled water system. This system must be in operation before running the bow thruster (see fresh water cooling section).

Drive Motor

The drive motor starter incorporates an auto-transformer which is used to lower the starting current. The starter is located in the bow thruster room in zone 1. If the starter cabinet is opened, the main supply circuit-breaker at the main switchboard is tripped. The bow thruster main 6,600V supply is from panel 12 of the main switchboard HM1.

The starter incorporates a touch-screen LCD display that will allow the control location to be selected LOCAL/REMOTE, Other items are available fior display, eg, system configuration, interlocks, control, running hours, etc. The motor control screen allows local control of the drive motor, thruster room fan and the hydraulic pump unit.

WARNING

Do not attempt to start the thruster motor more than three times in a 60 second period. If the motor does not start within this time, a 25 minute time delay must be observed before attempting to start the motor again.

The drive motor is fitted with stator temperature monitoring sensors and an anti-condensation space heater. The air/water cooler is also fitted with leak detection.

Stern Thruster

Manufacturer:	Kawasaki
Type:	Side thruster, controllable pitch
Model:	KT-88B3
No. of sets:	1
Propeller:	4-blade, Nickel-Aluminum Bronze (ABS Type-4)
Propeller diameter:	1,650mm
Rotation:	Clockwise (from propeller side view)

Drive Motor

Manufacturer:	Hyundai
Type:	Vertical induction motor
Model:	HLA9 630-66Y
Rated:	6,600V, 95.3A, 890kW
Speed:	1,184 rpm
No. of Poles:	6
Space Heater:	120V, 630W
Weight:	4,600kg
Protection:	IP44

Main Hydraulic Power Unit

Manufacturer:	Kawasaki KPM
Model:	25-6L8D
Motor:	440V, 5.5kW, 3,600 rpm

There is one stern thruster fitted in the hull between frames 34 and 36. This thruster is a conventional side tunnel thruster with a controllable pitch propeller. The stern thruster provides an athwartships thrust of approximately 126 kN.

Power is transmitted from the drive motor through the flexible coupling, input shaft and bevel gears to the propeller shaft which rotates the propeller in a constant direction. The bearings and gears in the gear case have oil bath type lubrication. The propeller part consists of four propeller blades, a propeller hub with a hydraulic servomotor and sliding block mechanism. Pressurised oil from the solenoid valve is fed to the hydraulic servomotor through the pipes in the propeller shaft, resulting in the reciprocal movement of the servomotor piston. This piston movement is converted into rotary movement of the blades by the sliding block mechanism.

Controlling the propeller blade pitch is carried out hydraulically from the main hydraulic pump unit. This unit is located in the stern thruster motor room in zone 4. The hydraulic systems have an 80 litre gravity tank located in the stern thruster room. This gravity tank has an automatic thermostatically controlled 2kW heater operated initially from the control panel mounted locally. The propeller blade pitch can be moved the full 40.8° (from 20.4° port to 20.4° starboard).

Control and operation of the stern thruster is described in the bridge manual. In the event of a failure of the normal operating and remote control system, the thruster can be operated locally by manual operation of the solenoid valves, consult the manufacturer's documentation for in-depth description.

Cooling

The motor is cooled using local air which is drawn in at the top of the motor enclosure and exhausted through the lower end vents.

The drive motor is fitted with stator temperature monitoring sensors and an anti-condensation space heater.

Drive Motor

The drive motor starter incorporates an auto-transformer which is used to lower the starting current. The starter is located in the frequency converter two room (FC2) room in zone 5. If the starter cabinet is opened, the main supply circuit-breaker at the main switchboard is tripped. The stern thruster main 6,600V supply is from panel 2 of the main switchboard HM2.

The starter incorporates a touch-screen LCD display that will allow the control location to be selected LOCAL/REMOTE, Other items are available fior display, eg, system configuration, interlocks, control, running hours, etc. The motor control screen allows local control of the drive motor, thruster room fan and the hydraulic pump unit.

WARNING

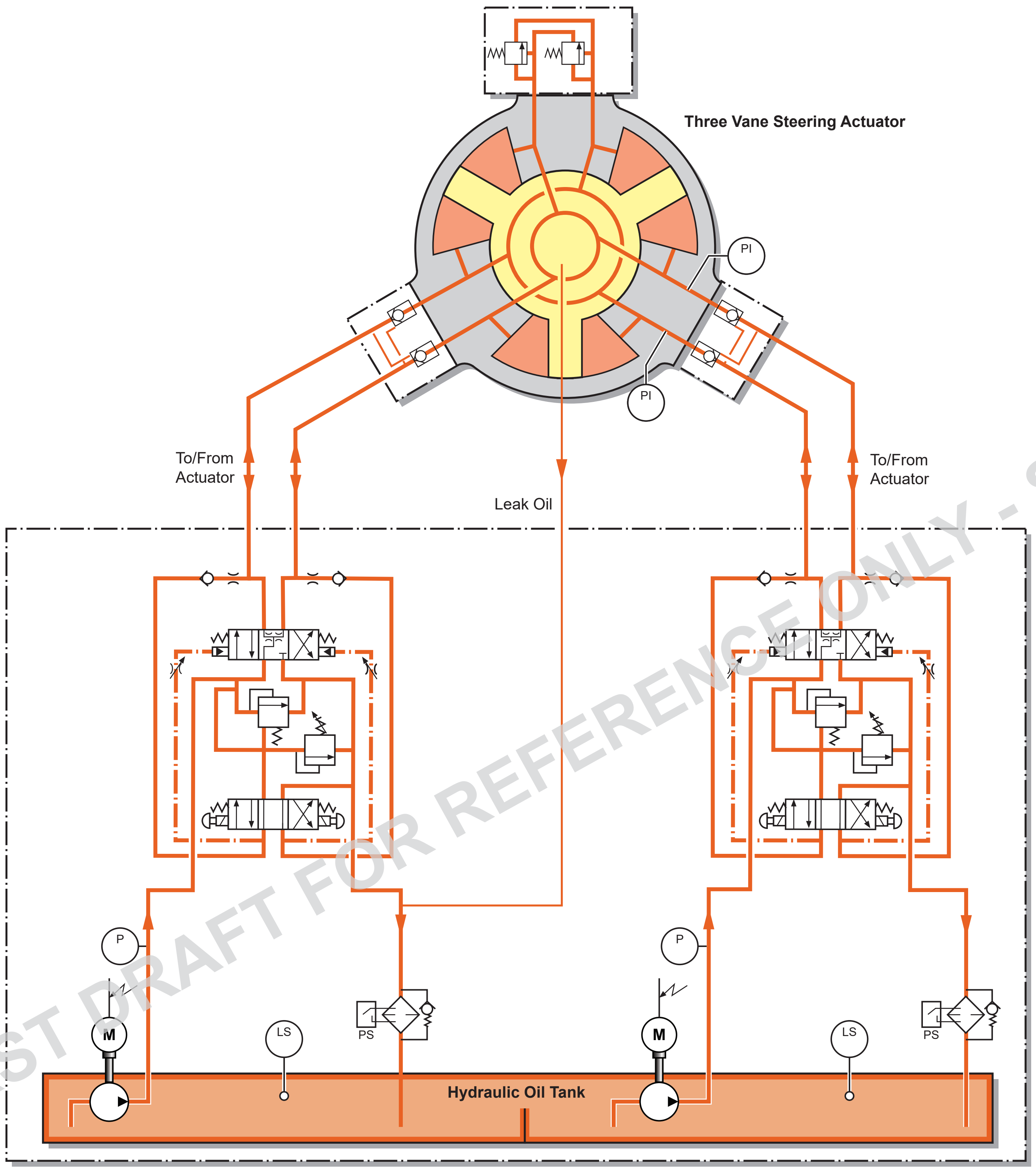
Do not attempt to start the thruster motor more than three times in a 60 second period. If the motor does not start within this time, a 25 minute time delay must be observed before attempting to start the motor again.

The following interlocks are required to enable drive motor starting:

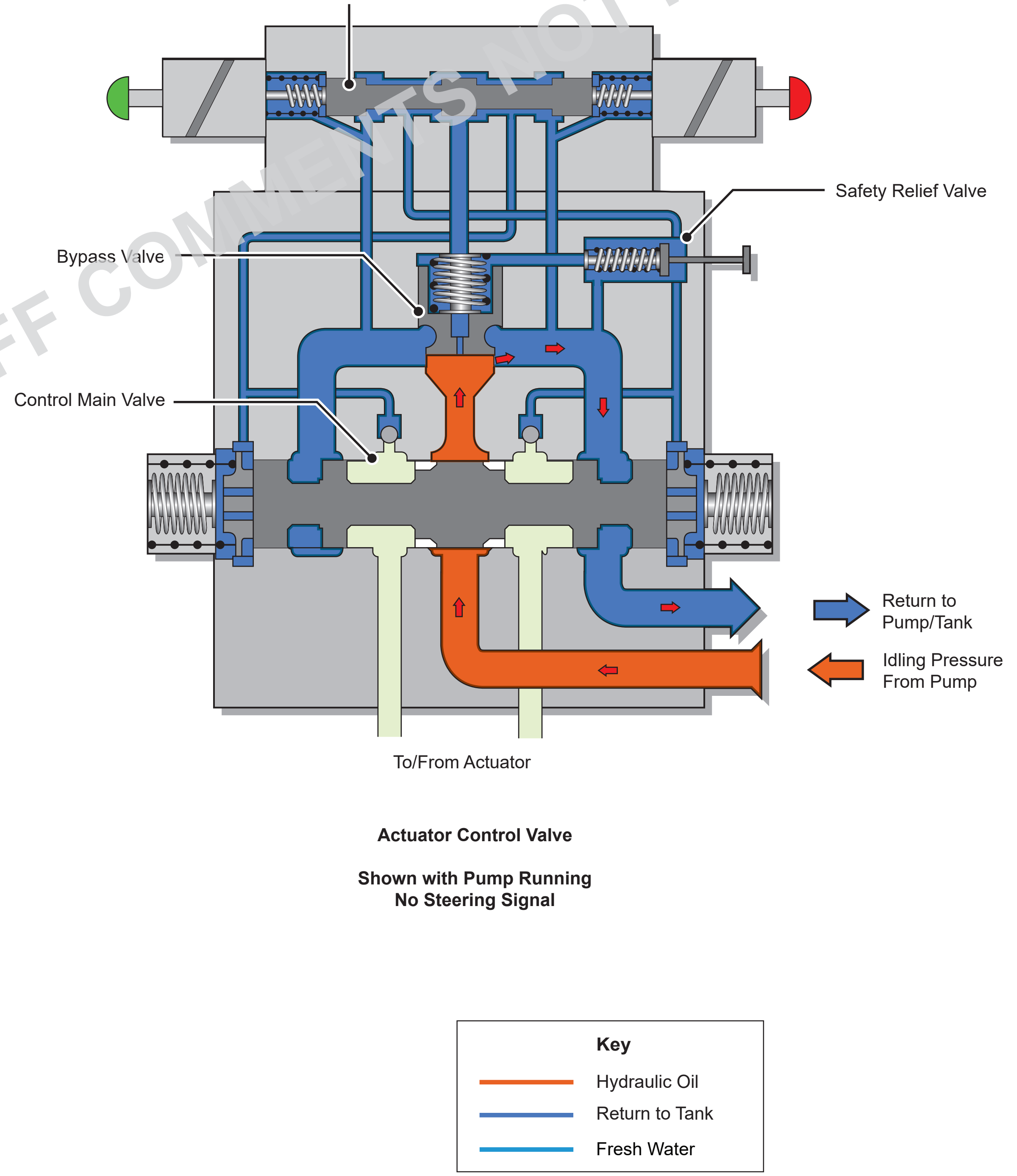
- Thruster room fan running.
- Hydraulic unit power on.
- Hydraulic unit running.
- Propeller blade pitch at zero
- Sufficient generating capacity connected.
- Main switchboard circuit-breaker closed.
- Control system power on.

The full list of system alarms and conditions are listed in the manufacturer's documentation.

Illustration 4.8a Steering Gear Hydraulic System



Steering Gear Hydraulic Circuit Diagram



Actuator Control Valve

Shown with Pump Running No Steering Signal

Reference Drawing: 403 Steering Gear 44896

4.8 STEERING GEAR

Rotary Vane Rudder Actuator

Manufacturer:	Kongsberg/Rolls-Royce
No. of sets:	1
Model:	RV 650-3
Type:	Electro-hydraulic rotary vane
Max. working torque:	644kNm
Max. working pressure:	80 bar
Max. rudder angle:	46.5°-0-46.5° (mechanical)
	45°-0-45° (electrical)
Steering time:	28 seconds with one pump unit running
(30°-0-35°)	14 seconds with two pump units running
Oil tank capacities:	Rudder actuator 130 litres
	Pump unit 600 litres
	Oil storage tank 450 litres

Power Pack

Manufacturer:	Rolls-Royce
Type:	Screw pump
Relief Valve setting	80 bar
Pump Capacity:	216 litres/min

Pump Electric Motor

Size:	160L-2
Motor rating:	21.6kW, 34A, 3x440V, 60Hz, 3,500 rpm

Introduction

There is one steering gear, located in ??? at frame xxx; The steering gear is designed to move the rudder through the required 70° with both pumps operating in 14 seconds.

The steering gear system consists of the actuator, hydraulic power unit, an electro-hydraulic control system, and the associated electrical and electronic components. Two pumps supply hydraulic power to the actuator; the pumps may be operated together or separately. At sea in open water, only one pump is normally used, but when manoeuvring or in confined water, both pumps will be operating. A single pump can supply the necessary hydraulic power to develop the specified rudder torque. The pumps are of the screw-type and operate continuously to supply oil to the control valve unit, which directs the oil flow to the appropriate side of the actuator to move the rudder as required.

Rudder Actuator

The actuator consists of a cylindrical housing and rotor; stoppers are attached inside the housing and the unit is sealed by end covers which are bolted to the housing. The rudder stock is attached to the rotor and the hydraulic force is transferred to the rudder stock/rudder by means of a frictional connection between the rotor hub and the rudder stock taper. A hydraulic nut is used to pull the rudder stock into the rotor hub. Once installed, the hydraulic nut and lock plate act as a safety device to secure the connection.

There are three vanes on the rotor, which is supported in the housing by two radial bearings, upper and lower, and a carrier bearing. The carrier bearing supports the rotor, rudder stock and the rudder. The bearings are lubricated by the hydraulic oil from the operating system.

The rudder actuator is divided into chambers by means of three stoppers, which are bolted inside the actuator housing. The rotor vanes operate inside the chambers formed by the stoppers. Oil flows into and out of the spaces formed between the vanes and stoppers via passageways in the stoppers. The passageways are connected by two distribution rings which are arranged in the correct formation for actuator operation. The distribution rings connect with the oil supply and return lines, and they are opened and blocked by means of control valves, which are located on the actuator. The control valves are operated by solenoids, which are activated by the steering signals. Internal oil leakage within the actuator is returned to one of the hydraulic power pack reservoirs, via a separate pipe.

The steering gear is normally remotely operated from the bridge. When a steering command is given, one of the solenoids is energised. The solenoid control valve will be activated according to the command signal and the rudder movement will be initiated. The hydraulic control system also incorporates an automatic lock valve. The valve locks the rudder in position until a steering command is received; the valve also protects the steering system in the event that the 'in service' hydraulic pump unit fails.

In the event that the remote control system fails, the steering gear hydraulic system can be controlled by manual operation of the actuator control valve.

Electrical limit switches are fitted to the actuator, and these operate to stop the oil supply to the steering gear actuator before the rotor vanes contact the stoppers, providing protection for the unit. The limit switches are located on top of the actuator and they may be adjusted if necessary. Care must be taken when making any adjustments, as incorrect adjustment may result in the rotor vanes contacting the stoppers.

Two potentiometer feedback units are attached to the top of the actuator and these are chain-driven by the rudder stock. The units act to provide feedback and rudder position signals for the control system. A scale is also mounted on the actuator to provide mechanical indication of the rudder's position.

The rudder stock is equipped with a stuffing box to seal the steering compartment from the sea.

Power Supplies

Electrical power is supplied to the No.1 steering gear pump from the emergency switchboard, circuit P-ESB-45.

Electrical power is supplied to the No.2 steering gear pump from the No.2 LV switchboard bus no.3, circuit P-LM2-48.

The No.1 and No.2 steering gear control systems are supplied from the No.1 and No.2 steering gear starters respectively.

The oil transfer pump is supplied from the starter for No.1 steering pump.

Hydraulic System

The rudder actuator is supplied from the hydraulic power pack. The hydraulic control valves are located on the actuator. The power pack incorporates two separate pump units and each of these comprise:

- An oil reservoir.
- Hydraulic pump.
- Control valves.
- Return oil filter.
- Oil cooler.

Two separate oil reservoirs are formed by a division plate inside the power pack tank. The division plate does not extend to the top of the tank and so allows overflow between the two reservoirs. The hydraulic pumps are submerged inside the oil reservoirs; each reservoir is equipped with a low level alarm float switch. The oil returning from the actuator also passes through a filter, which is equipped with a differential pressure alarm switch to warn when the filter cartridge requires changing.

Control Valve Unit

Each hydraulic pump delivers oil to a dedicated control valve unit which is mounted on the rudder actuator. The control valve unit acts to regulate the flow of oil from the pump to the actuator according to the steering commands. Each of the control valve units comprise:

- Solenoid operated pilot valve.
- Main control valve spool.
- Lock valve.
- Safety relief valve.
- Bypass valve.

Steering commands from the bridge are relayed to the control valve units as electrical signals which operate the solenoid valves. When there is no steering signal, the solenoid valve is held in the neutral position by locating springs. The main valve spool is therefore held in the neutral position by springs and the lock valve is kept in the closed position (by springs). With the solenoid valve and main valve spool valve in the neutral position and the lock valve closed, the pump continues to operate, but the oil is returned to the reservoir.

A steering command will energise one of the solenoids and cause the solenoid valve to move in the appropriate direction for port or starboard rudder angle. The hydraulic control oil now moves the main control valve spool. The lock valve is also opened to allow working pressure oil and return oil to flow to/from the actuator chambers. The oil return from the actuator vent chambers is directed back to the power pack oil reservoir. The rudder is moved and when the required angle is attained, the solenoid is de-energised and returned to the neutral position by the springs. This causes the main valve spool to be returned to the neutral position (by spring action) and the lock valve to close. The supply of oil to the actuator is stopped and the rudder is locked in the required position.

The purpose of the bypass valve is to return oil to the oil reservoir at the beginning of delivery to the actuator; this acts to soft start the delivery process and reduce shock in the hydraulic system. The safety relief valve acts with the bypass valve to return oil to the oil reservoir should the pressure in the hydraulic system exceed preset values.

Local Steering Gear Control

Controls are located in the port and starboard steering gear compartments, which allow the operator to control the steering actuators via electrical signals to the control valve solenoids. Cabinets in each steering compartment incorporate the various electrical systems and controls. The local steering gear control system is described below.

Emergency Steering

In the event that the remote control system fails, the steering gear hydraulic system can be controlled by the manual operation of the actuator control valves. Two levers are arranged on the control valve unit to manually operate the solenoid valve. Local control of the hydraulic pumps must be selected on the pump starter cabinets in the port and starboard steering gear compartments. Procedures for the emergency operation of the steering gear are detailed below.

> **Note:** Emergency steering is effected by the two levers which act directly on the solenoid valve. Only one hydraulic pump unit should be running when using the emergency steering control.

Lock Valve

Should the 'in service' pump unit fail and hydraulic oil pressure be lost, the lock valve will close, isolating the defective hydraulic system. The integrity of the rudder actuator is therefore maintained and steering can be continued by means of the standby pump. The standby pump unit is automatically started if the operating pump fails.

Relief Valve

In addition to the safety relief valve in the control unit, the actuator is fitted with a relief valve which opens when excess oil pressure exists in the actuator. The relief valve acts to protect the system in the event of a heavy wave hitting the rudder. The force of a wave on the rudder can generate very high hydraulic pressures in the steering gear, and the relief valve allows oil to flow from the pressure side to the vent side of the actuator vanes. The rudder will move, but this produces a feedback signal, indicating that the rudder is not in the position set at the steering control. The control system will now operate and deliver oil to the actuator in order to return the rudder to the required position.

Steering Gear Operation

The steering gear has two modes of operation:

- Follow-up (FU) steering: The rudder moves to the rudder angle set by the operator.
- Non-follow-up (NFU) steering: The rudder moves as long as the steering signal is active.

The steering gear pumps may be started from the wheelhousee, training bridge, ECR or locally from the steering gear room. Prior to leaving port, the steering gear operation should be checked and this should be observed by an engineer in the steering compartment. The results of any checks should be entered in the Engine Room Log Book.

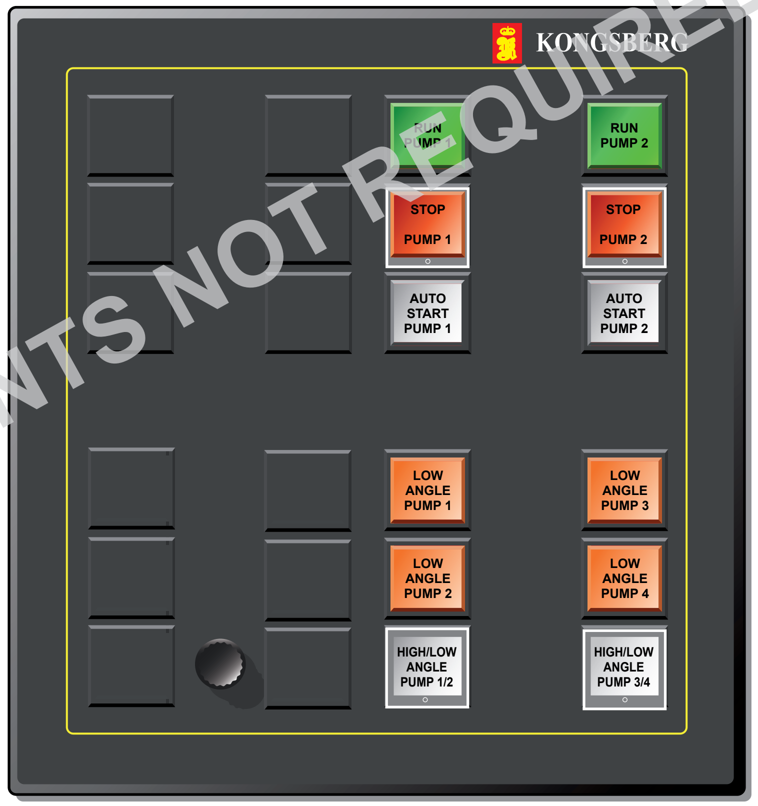
Control of the steering gear from the wheelhouse is described in the bridge operating manual.

> **Note:** The starting of the standby pump is automatic when one pump is in operation. The control system will start the standby pump when an alarm is activated on the running pump.

Control System Overview

The wheelhouse and training bridge steering gear control system consists of steering gear control, alarm and indication panels. The ECR has alarm and indication panels. The alarm panel and indication panel are fitted with separate sections for each pump unit and the alarm functions are shown on the panel illustration: The steering gear compartment has the motor starters that have a motor controller panel fitted.

Illustration 4.8b Steering Gear ECR Indication and Alarm Panels



Steering Gear ECR Indication Panel

Steering Gear ECR Alarm Panel

The motor controller panel has a control selector switch with the following positions:

- Remote control (steering from the wheelhouse/training bridge).
- Stop.
- Local control (emergency steering from the steering gear room).

Author's Note: Local Motor Controller Detail Required

The normal operating position is REMOTE CONTROL. In this position, start, stop and rudder steering commands are sent from the wheelhouse/bridge. The STOP position ensures that no unintentional start commands are received from the remote positions from the wheelhouse/training bridge during any local tests or maintenance of the steering gear.

LOCAL control is used for steering testing or for emergency operation of the valves, etc. The motor controller operates the steering gear hydraulic pump .

The 'Power Failure Control' alarm will be activated when the selector switch is set to the STOP and LOCAL positions as information to the wheelhouse/training bridge that remote control is not available.

Hydraulic Lock Alarm

Hydraulic lock occurs if the oil cannot flow to and from the actuator chambers. The hydraulic lock alarm is fitted in order to provide a warning that the control unit is locked in either the port or starboard position. The operating pump must be stopped and the standby pump started. If both pumps are operating, the pump unit in which the hydraulic lock has occurred must be stopped.

Alarm Panels

The alarm panels are equipped an alarm ACK pushbutton, a lamp TEST pushbutton and dimmer pushbuttons (+ and -). The alarm buttons have two functions, depending on whether it is pressed once or twice:

- First push: Turns off the local buzzer.
- Second push: Stops the local blinking alarm light. The lamps will show a permanent light if the alarm condition is still present. If not, the alarms will be turned off.

Interface to CAMS

The steering gears are monitored by the CAMS system, via the operator workstation STEERING GEAR mimic. The CAMS has no control over the steering gear. Alarms and rudder/pump status are shown on the mimic screen.

Communication

A talk-back station, a sound-powered telephone and an automatic telephone are installed in the steering gear rooms at the local control positions to allow commands from the bridge to be relayed to the operator. The telephone systems can be seen in the photograph of the local control cabinets.

Rudder Angle Indicator System

The rudder angle indicator must be correctly zeroed when the rudder is in the neutral/midships position. A check must be made at weekly intervals to ensure that the rudder indicators are reading correctly and the angle indicators adjusted as required. Details of the adjustment procedure are given in the manufacturer's steering gear manual and they must be followed precisely in order to ensure accuracy.

Procedure for Putting the Steering Gear into Operation

Author's Note: Ship/Company specific procedure required.

a) Check the oil level in the steering gear reservoir tanks and replenish if necessary.

b) Ensure that the main power isolator switches on the motor controller cabinets are turned ON.

c) Select the steering gear and pumps for local operation. With permission from the bridge, start one pump. Check for abnormal noises and check the system for leaks. Stop the first pump and start the second pump; repeat the checks, then stop the second pump.

e) Change steering gear and pump to REMOTE CONTROL.

f) Carry out pre-departure checks as per company instructions.

g) During pre-departure checks, the rudder must be operated from the bridge. Both pumps must be checked for operation and the rudder turned hard-over in each direction.

Note: The system must be operated remotely from the bridge when pre-departure checks are made.

Procedure for Steering Gear Operation from the Steering Gear Compartments

Author's Note: Ship/Company specific procedure required.

Emergency Control from the Steering Gear Room

Author's Note: Check below against Ship/Company specific procedure.
Should all the control systems fail (including the local NFU control system), steering capability can be maintained by manually operating the solenoid valves on the hydraulic control units. The selector switch on each of the steering gear motors starter cabinets and the local steering control cabinets should be set in the LOCAL position. The manual operating levers are then unlocked and used to control the rudder via the solenoid valves. The pump operates to turn the rudder in the required direction whilst the solenoid pushbutton is held depressed. Only one pump should be in operation for each steering gear when in emergency control.

In the event of complete failure of the steering gear control system, the steering gear must be operated in emergency manual mode from the steering gear compartment.

a) Establish communication with the bridge from the steering gear room(s).

b) At the steering motor control cabinet, change the selector switch to the LOCAL position.

Note: Operate one steering pump only.

c) At the emergency valves on the hydraulic actuator unit, remove the pin which secures the operating handles. The handles are coloured red and green for port and starboard rudder movement respectively. Using the appropriate handle, press the manual pushbutton on the solenoid valve according to the helm commands. Observe the rudder movement on the scale fitted to the actuator. Release the solenoid pushbutton when the rudder reaches the desired angle.

When the need for emergency manual steering is finished, the switch on the steering motor control cabinets must be returned to the REMOTE BRIDGE control position, and the manual control handles secured.

Note: Selecting PUMP STOP or LOCAL (EMERGENCY MODE) operation will activate the 'Power Failure Control' alarm.

5.1 MAIN MACHINERY CONTROL

5.1.1 CONTROL, ALARM AND MONITORING SYSTEM

Manufacturer: Kongsberg
Model: K-Chief 600

Introduction

The K-Chief 600 Control, Alarm and Monitoring System (CAMS) is a distributed monitoring and alarm system which covers all the important systems on board the vessel and is microprocessor-based. It is designed to provide the ship's officers with all the basic alarm and status information they require to maintain a safe and efficient operation of the machinery, including when the engine room is unmanned. The basic functions include:

- Process and system monitoring.
- Event logging and monitoring.

The main applications of CAMS to which these functions apply are:

- Alarm/event recording.
- Watch call system.
- Engine room alarm monitoring.
- Primary trend functions.

The Operator Stations (OPs) feature full color graphic displays and functional operator panels.

Ship@Web System

The Ship@Web system is a K-Chief 600 automation system under protection by a local server/firewall. The main server's role is to be the connection point with external networks requiring information from CAMS. The server will be the host for all the clients, both on the administrative network and on the external shore ship owner Local Area Network (LAN).

External access to CAMS and process LAN needs authorisation from a firewall/gateway connecting to a Virtual Private Network (VPN) solution. This provides the internal network with a high security access level for CAMS, protecting the process LAN from viruses, trojans and other threats from the administrative or external network.

Extended logging of data is included in the Ship@Web system. The data (measuring points)is be stored for one month (the Month log). Data older than one month can be stored for up to 5 years (the Year log). In the Year log, mean values are calculated for groups of measuring points. In addition, maximum and minimum values, and essential events in the data log are stored.

Description of System and Functions

CAMS is made up of standard Digital Processing Units (DPUs) communicating with the central computers through a dual redundant bus network. The DPUs contain the Input/Output (I/O) signal processing cards from the equipment being monitored.

Each OS provides the operator with standard display mimics containing information of the main and auxiliary equipment. Control of any of the DPUs is possible from the OS. The system provides for full monitoring and alarm facilities in the machinery spaces and Engine Control Rooms 1+2 (ECR1+2).

Detailed information from any DPU, such as normal readings or alarms, can be shown on the screen mimics or printed out. The presentation of the data can be a bar graph or a trend curve. The system also displays the latest alarms in each alarm group and all active alarms. Whenever a system measuring point changes, the associated DPU updates the database in each of the OSs, this ensures all the information shown on any OS is always up to date. All of the changes in the measuring points from the DPUs are logged with a time stamp and stored in the OSs for seven days and the readings can be displayed in the 'Trend' view. Any recorded alarm events are also time stamped and stored in the operator stations. They are retained for 5 years and can be displayed in the 'event history' view.

Communication Network

The OS network is a redundant LAN used for communication between the OPs, and the process area via Segment Controller Units (SCUs). Other PC-based equipment such as printers and switches are also connected to the network. The LAN is an open net using standard protocols (Ethernet, TCP/IP) that permits connection and data exchange using standard Kongsberg software.

Distributed Processing Units

The function of the DPUs is to monitor the analogue and digital sensors and to provide outputs to the different devices in the engine room. There are a number of separate DPUs in the system which meet specific control and monitoring applications.

Process Network

The process network is used for communication between the DPUs in ER1+2. Segregation of the system is by setting up autonomous segments of local systems by using a number of different DPUs. Local systems can be items such as valve control, pump control, power management, propulsion control, cargo control etc. The SCU is used as the gateway to the OS for the various segments to which the DPUs are connected. A redundant Controller Area Network (CAN) bus is used for communication between the DPUs in the process area. Power-link is a communication system for Real-Time Ethernet (RTE). The watch calling system in the accommodation, and public spaces is controlled directly from operator stations through a separate CAN bus.

Power

The CAMS normally operates on a 230V AC supply to the OSs and a 24V DC supply to the DPUs. Two Uninterruptible Power Supply (UPS) units are used and are integrated into the system to protect the equipment from supply problems. Each UPS is used to maintain a constant output voltage, and if necessary will isolate the output to a critical load. This helps to keep supply problems from reaching critical systems where they can damage hardware and software, causing the equipment to operate erratically. In the event of a blackout where the incoming mains power is lost, the energy stored in the UPS will continue to provide power to the system for 30 minutes until power can be restored. The UPS supplies also have earth fault detection equipment fitted and any earth fault will be given as a common alarm to the OS.

Operator Stations

The OSs are the main interface between the operator, and the processes being monitored. Each OS has a color monitor and a control panel connected to a desktop computer. OSs are located in ECR1 (OS1~OS3), ECR2 (OS4~OS6), wheelhouse (OS7) + safety centre (OS8). training bridge (OS9) + safety centre (OS10), Chief Engineer's office (OS11), Deck Training Officer's office (OS12), engine training spaces 1~3 (OS13~15).

Each OS comprises of a touchscreen control panel which can also be operated by a mouse, connected to a desktop computer and color monitor. The operator stations receive alarms and allow for the control and monitoring of equipment in the system. They display mimic diagrams, allow control of the watch calling system, printing of various logs and interface with the DPUs. The graphic displays are shown on the monitor of the operator stations. These displays show all or part of a system or process using standard symbols to represent the actual plant/equipment (valves, motors etc). Events such as alarms and messages are also shown on the displays. The operator panel is used to interact with the display by the use of the trackball to point and click on the symbols and menus.

The following functions are available:

- Selection and set-up of information to be monitored.
- Parameter adjustment.
- Set-up and activation of log printing.
- Alarm display selection and acknowledgement.
- Extended alarm and watch calling functions.

The following screen displays are available:

- Mimics.
- List views.
- Configuration displays.

Mimic diagrams and trend curves for the various systems can also be displayed.

Bridge Watch Extension Alarm Panel

In addition to the main OS panel on the bridge, a bridge watch extension alarm panel has also been fitted and enables the Officer Of the Watch (OOW) to monitor the machinery space alarms when ER1+ER2 are running under Unmanned Service (UMS) conditions.

The bridge watch unit indicates and accepts the transfer of watch responsibility between the bridge and the ECR, but the system prevents the bridge from taking responsibility if no engineer has been selected as the duty engineer.

The duty engineer is indicated by the illumination of the indicator for that engineer on the left-hand side of the panel. Pushbuttons allow the bridge to call the duty engineer or issue an ‘all engineers’ call if required.

Cabin Watch Extension Alarm Panels (Section 5.1.2 Refers)

When the system is selected for UMS operation, the alarms are announced in the cabin of the selected duty engineer and in the public rooms.

There are 14 watch call panels in the accommodation and on the bridge. These units are used to alert staff to any problems when ER1+ER2 is running under UMS conditions. When the bridge has supervision of the engine room watch, an alarm will be displayed on the bridge panel, and on the panel in the cabin of the duty engineer. The alarm will also be displayed on the panels in the public spaces. An audible alarm will sound in the cabin of the duty engineer and in the public spaces and can be muted by pressing the SOUND OFF button on the front of the panel; this does not acknowledge the alarm, as acknowledgement can only be done at one of the OS panels in ECR1+ECR2. If the duty engineer fails to acknowledge the alarm within a set period of time, the alarm will be repeated in all of the engineer cabins and on the bridge.

Peripheral Systems and Equipment

Engineer Safety System

The engineer safety system is part of the alarm and monitoring function of CAMS, and is more readily known as the ‘dead man’ alarm. Panels are strategically placed to assist duty personnel when operating under UMS conditions. Should the ‘dead man’ system not be reset within a predetermined time, an alarm will sound to alert staff.

Printers

The OS stations in the ECR and ship’s office/ballast control room are connected to printers for printing out alarms, events and report printing. Two printers are located in the ECR and two in the ship’s office/ballast control room.

Alarm Block (Inhibit)

Some alarms are conditional and will be inhibited when a specified condition is present. This function is accomplished by defining a signal as an inhibit source for a specified alarm or a specified group of alarms. An adjustable time delay is available to extend the inhibit situation for each signal.

This type of function is set by defining a signal as an inhibited signal for a specific alarm or group of alarms.

An adjustable time delay is available for each signal to extend the blocking facility to prevent activation of certain alarms where there is a time delay between the start of an item and the build-up of temperature or pressure.

Alarm Acknowledgement

It is possible to acknowledge alarms whilst a mimic, alarm group or alarm summary is displayed. Alarm acknowledgement is carried out by pressing the ALARM ACK button.

The SOUND OFF button is pressed to mute the buzzer; pressing the SOUND OFF button does not acknowledge the alarm.

Watch Calling Panels

The watch calling system is the ship’s extended alarm system. The system monitors the cargo, and the engine machinery alarms. Through this system, it is possible to keep the engine control room unmanned (UMS) during normal operation.

Dedicated alarm panels, which are located in various places throughout the vessel, display the alarms and information about the alarm conditions. The watch calling system is made up from a number of self-contained wall-mounted watch call panels, installed at selected locations on the vessel.

The watch calling panel is a touch screen unit, where all functions are available using the menu.

Selecting UMS Duty

On the CAMS Screen in Port

a) Click on ECR watch at the top left of the screen.

b) Select DUTY ENGINEER from the drop-down menu. The selection shows ECR.

c) Call the bridge to advise the duty engineer has been selected.

d) The engine room is now in the UMS condition with ECR watch responsibility.

On the CAMS Screen at Sea

a) Click on ECR watch at the top left of the screen.

b) Select DUTY ENGINEER from the drop-down menu. The selection shows ECR.

c) Select responsibility to BRIDGE.

d) The bridge has to accept watch responsibility.

e) The engine room is now in the UMS condition with watch responsibility to the bridge.

Selecting Manned Duty

On the CAMS Screen in Port

a) Click on ECR watch at the top left of the screen.

b) Deselect DUTY ENGINEER from the drop-down menu.

c) The engine room is now manned.

On the CAMS Screen at Sea

a) Click on ECR watch at the top left of the screen.

b) Click on ECR to give control to the engine room.

c) Deselect DUTY ENGINEER from the drop-down menu.

d) The engine room is now manned.

Note: For both of the previous cases, the bridge has to acknowledge both unmanned and manned conditions.

Command and Control System

The Command Control dialogue box shows all available control groups, and at which locations are in the control of the different groups at that moment. This dialogue is activated using the Command Control button located on the top bar.

The following command buttons are available in the dialogue:

- Take Command: Takes or requests command control over selected command group.
- Give Command: Accepts command transfer. Only command is transferred. Alarm acknowledge remains in the default location.
- Give Command and Alarms: Accepts transfer of command and alarm acknowledge to remote location.
- Deny Command: Denies request for Command Control.
- Return: Returns Command Control back to the default location.
- Override single group: Overrides single group access.
- Override All Groups: Overrides all groups access. May be used to take over control required by 'Safe Return to Port'.

If an operation is not possible, the relevant command button is greyed. Command groups have specific properties depending on location. This is identified by symbol in the dialogue. These properties are pre-defined by project and cannot be changed by the operator onboard.

Group Control Status

Symbol	Command Group Property	Description
	Default group	Default group for current location. User has access to commands and alarm acknowledge for this Command group
	Requestable	Command for this group can be requested from default location. Command transfer must be confirmed by default location. Alarm acknowledge remains in default location. Remote location receives local warnings only.
A	Requestable with alarms	Command and alarm handling for this group can be requested from default location. Command transfer must be confirmed by default location. Default location can give command only access or command with alarm acknowledge responsibility.
	Shared	Command of this group is shared between two or more locations. All items within this group can be operated simultaneously by two locations. Alarm acknowledge remains in default location. Remote location receives local warnings only.
A	Shared with alarms	Command and alarm acknowledge for this group is shared between two or more locations. All items within this group can be operated simultaneously by two locations.
	Takeable	Command of this group can be taken without confirmation from default location. Alarm acknowledge remains in default location. Remote location receives local warnings only.
A	Takeable with alarms	Command of this group can be taken without confirmation from default location. Alarm acknowledge remains in default location. Remote location receives local warnings only.
	Transfer not allowed.	Command transfer of this group is not allowed. Only emergency override may be used.

Current state of the command group is indicated by coloured spot indicator. The indication is dynamic and changes according to command group current state.

Control Group Status

Group Command State	Indication at Default Location	Indication at Non-Default Location
Group responsibility at default location	Default location holds full access to the command group	This group can be requested or taken from default location. Alternatively: This group cannot be requested or taken.
Group responsibility transfer in progress	(blinking) Group access has been requested and awaiting confirmation from default location.	(blinking) Group access has been requested and awaiting confirmation from default location.
Group responsibility at remote location	Group responsibility has been transferred and belongs to remote location.	Group responsibility has been transferred and belongs to remote location.

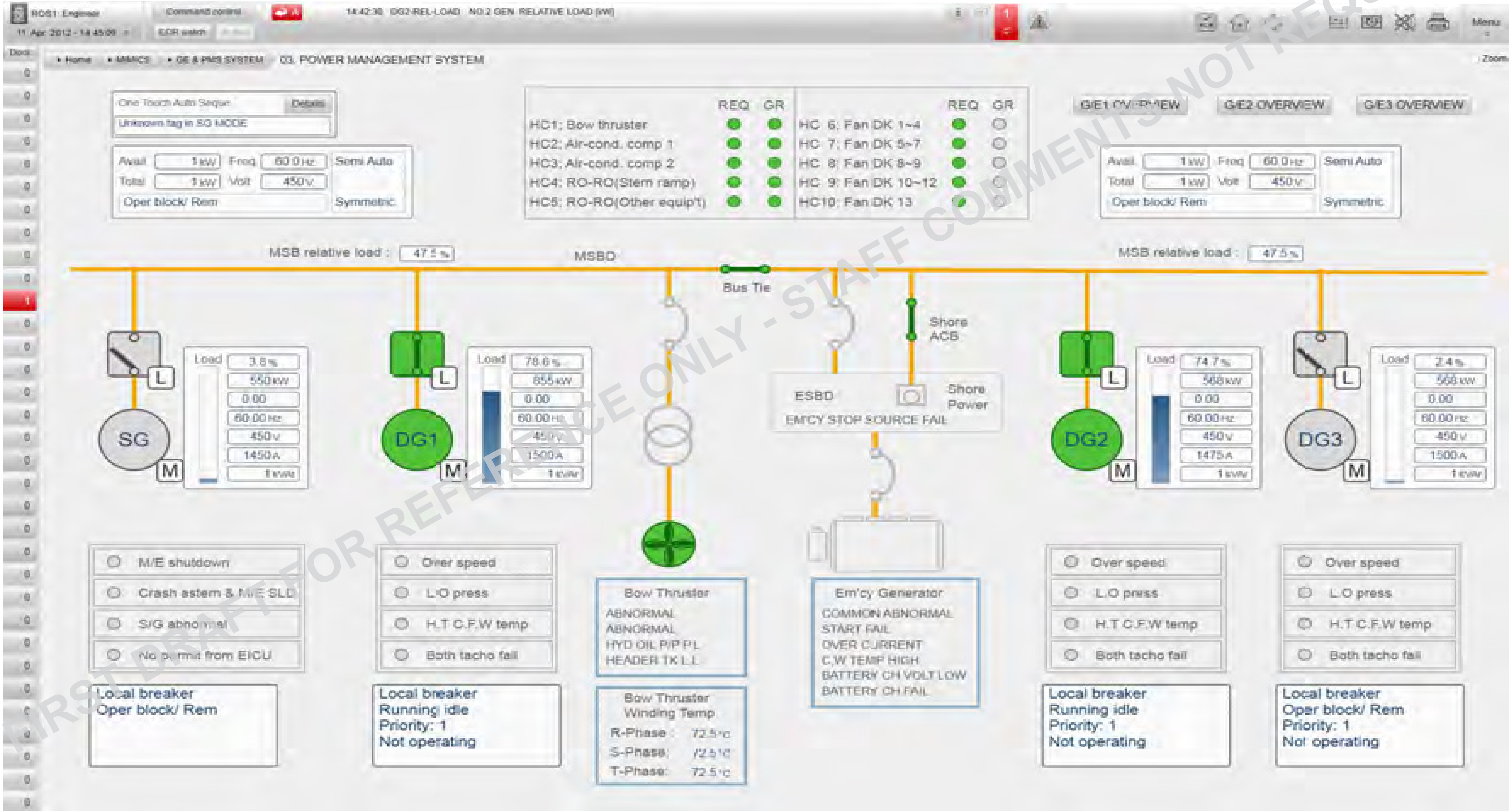
Group Control Tabs

These give the following information:

- Colour Spot: Indicates current state of the command group at current location. Indication is dynamic and can change depending on group transfer state. See 'Control Group Status' table above.
- Group Property Symbol: Indicates property of each group. This property is pre-configured and static.
- Control Group : Name of the control group.
- Control Position: Location having currently command rights of the group.
- Default Position: Location having default command and alarm acknowledge rights of the group. The system remembers the last command change for every control group.
- Last Change: in format MONTH: DAY: HOURS: MINUTES

The Control Groups tab holds two status lines, for current location, and OS at the current location.

Illustration 5.1.2a CAMS Screen Displays and Mimics *(Authors note: To be updated with clearer image)*



5.1.2 SCREEN DISPLAYS AND OPERATION

Introduction

Graphic displays are shown on each of the monitors on the OSs. These displays show all or part of a system or process using standard symbols to represent the actual plant, equipment, valves, motors etc. Events such as alarms and messages are also shown on the displays.

The OS panel is used to interact with the display and control the process which is achieved by the use of the trackball to point and click on symbols and menus.

Display Layout

The screen comprises the following main sections:

- **Top Bar.** The top bar is the component which is always visible on the screen. It cannot be hidden by any object or pop-up dialog box etc. The top bar provides the operator with full control of the system at all times, and from it the user has direct access to alarm messages, system status, interactive tools and other important system functions. It also contains the following screen buttons:
  - VIEW: Contains all commands affecting viewing properties such as display mode, palette synchronisation, brightness and contrast settings.
  - OPERATE: Contains operational modes such as mode select, command control and watch call.
  - ALARMS: Contains all alarm related functionality.
  - TAGS: Contains all the commands related to the sensors, tags and I/O modules.
  - TOOLS: Contains commands for measuring, collecting or monitoring data in a way to better interpret the situation.
  - SYSTEM: Contains commands related to the general administration of the system and support functions such as access to print, system status, help, change user etc.
- **Alarm Bar.** This is used to provide easy access to all active alarms in the system.
- **Main View Area.** This displays a combination of process, tabular, custom, trend, favourite and home views.
  - A PROCESS view is the working area for a particular system. System units and parameters can be monitored and controlled from the process view.
  - A TABULAR view is a list view which displays system values in a table format with multiple rows and columns.
  - A CUSTOM view allows the operator to customise a local working area with his preferred alarm parameters. Up to ten custom views can be populated by the operator.
  - A TREND view is used to display recorded and present data for selected alarm parameters. Trend data is logged for a 7-day period.
  - FAVOURITE view. Some process views are used over and over again, so to increase operator efficiency, up to nine views can be set as favourite views by the operator. Each view is assigned a number from 1 to 9. The ‘favourites’ bar is located at the bottom of the screen. The bar appears when the cursor hits the bottom of the screen or if the operator presses the 0 button on the control panel.
  - The HOME view is used to give the operator direct access to the complete contents of CAMS.
- **Navigation Line.** CAMS uses an interactive title line for view navigation. All of the views are available from this view navigator. The view title will be displayed, preceded by a trail showing the location of the view in the view hierarchy. Each element in the trail can be clicked to provide a pull-down menu for view navigation, this gives the operator easy access to all of the views in the system and gives the operator quick access to all views at all levels.
- **Operator Dialogs.** These are displayed in secondary windows on the screen and serve to display information to the operator and to get operator response if needed.

The illustrations provided show typical screen mimics showing the display layout for controlling and monitoring a piece of equipment or process via the OS stations. The large display area is the process display for monitoring equipment, controlling pumps, valves and process values etc. Graphics for a particular process are generally used for providing the necessary overview of the process information along with the display of critical parameters. From the overview graphics, the operator can call up a detailed process screen for any particular piece of equipment or process.

Alarms

Different colors are used on alarms to indicate the alarm’s importance. The use of colors is defined as follows:

- **High Priority (Emergency) Alarms:** These are represented by MAGENTA colored buttons. A steady magenta color means all of the alarms have been acknowledged, while a flashing magenta color means there is at least one unacknowledged alarm present.
- **Normal Priority Alarms:** These are represented by RED colored buttons. A steady red color means all of the alarms have been acknowledged, while a flashing red color means there is at least one unacknowledged alarm present.
- **Normal Priority Warnings:** These are represented by YELLOW colored buttons. A steady yellow color means all of the warnings have been acknowledged, while a flashing yellow color means there is at least one unacknowledged warning present.
- **Low Priority Warnings (Information):** These are represented by LIGHT YELLOW colored buttons. A steady yellow color means all of the information warnings have been acknowledged, while a flashing yellow color means there is at least one unacknowledged warning present.

Alarm and Warning Status

Additional information is added to the alarm and warning buttons to show the alarm status as detailed below:

- Flashing color: Alarm or warning not acknowledged.
- Steady color with a tick mark: Alarm or warning has been acknowledged.
- Flashing color with a return arrow: Alarm or warning returned.

If there are more than two unacknowledged alarms in the list, the latest alarm is shown in an extension view. The alarms are sorted by time with the newest alarm on top of the list. The number on the alarm button indicates the total number of unacknowledged alarms in the system.

Alarm Acknowledgement

Every alarm in the system must be manually acknowledged by the operator. All alarm related events are logged in the system and are available for viewing in the alarm history. The system logs all of the alarm events and retains them for a period of 5 years.

There is protection against acknowledging an alarm which appears shortly before the user presses the ACK button. In such a scenario, the user might not notice an alarm before pressing the ACK button. To protect against this, only alarms present in the system for more than 1 second can be acknowledged.

Alarms can be acknowledged in several ways. The most common methods are as follows:

- Pressing the ACK button on the trackball panel. This acknowledges all alarms visible in the alarm compartment or in the active alarms view if active alarms are currently displayed.
- Clicking on the visible alarm status button in the top bar. This acknowledges the single alarm selected.

- Using the menu button by selecting Menu > Alarms > Acknowledge.

Alarm History View

The alarm history view is used to display the following:

- Active acknowledged alarms.
- Active unacknowledged alarms.
- Acknowledged alarms returned to normal.
- Unacknowledged alarms returned to normal.
- Local time change events.

This is the main view for investigation of the history of all alarm events in the system. The view is event based, so every event has a time stamp in both local and UTC time. The alarm history view holds the last 30 days alarm entries.

Event History View

The event history view presents all digital events logged in the system, such events as:

- Alarm events: Triggered, acknowledged, returned.
- Process events: Start, stop, open, closed, connect, disconnect etc.
- Time change events.
- Tag parameter change events.
- User log-on events.

Inhibit Tags View

To avoid unnecessary alarms, some alarms are conditional and will be inhibited when a specified condition is present. The Inhibit tags view is used to display these alarms.

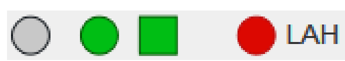
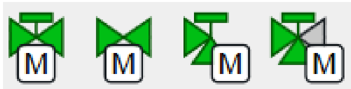
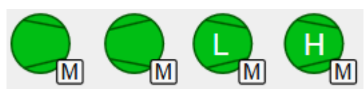
Overridden Tags View

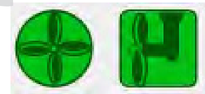
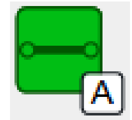
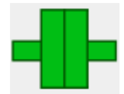
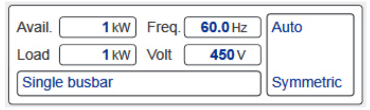
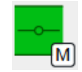
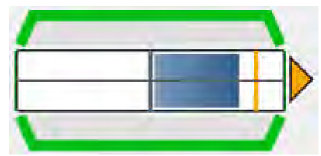
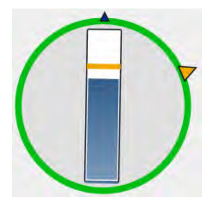
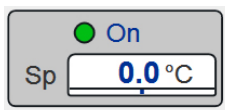
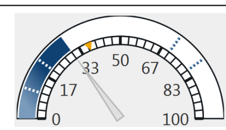
To avoid unnecessary alarms, some alarms are not checked for alarm situations. The overridden tags view is used to display these alarms. Overriden alarms are highlighted by a light blue background when the alarm tag is presented in a tabular view.

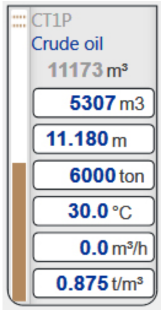
Process View Layout

The graphical process views are custom made images giving the operator easy to read information about each system and its surrounding equipment; this allows for the control of different process machinery directly from any K-Chief 600 operator station. The process view shows the interconnection of units and instrumentation used to control the process in question. A standard set of static and dynamic symbols are used to present the process.

Dynamic Equipment Symbols

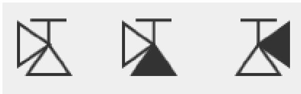
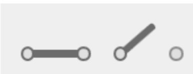
Name	Description	Symbol
Buttons	Various type of specialized buttons used to execute commands, operate timers, hotspots etc.	
Dynamic text	Symbol may indicate various process states as the text changes color dynamically.	
Values	Displays an analogue value. May contain a bar graph with alarm limits indication.	
Spots	Spots indicate the status of the process signals. They may also indicate alarm states. Spots can be circular or rectangular.	
Digital valves	Digital two-way and three-way valves.	
Analogue valves	Analogue two-way and three-way valves.	
Pumps	Symbol indicates pump in manual control (M) running in low speed (L) or high speed (H).	
Standby handlers	Used to control master-standby logic for multiple pump, compressor or fan systems.	
Fan or compressor	Symbol indicates fan or compressor in manual control (M) running in low speed (L) or high speed (H).	
Generators	Outer ring indicates diesel engine running. Inner ring indicates generator running. Symbol may have additional information label.	

Name	Description	Symbol
Motor	Indicates the running state of the motor. In this case, the motor is running and is switched to manual control.	
Thruster	Indicates running state of bow thruster.	
Breaker	Symbol for a synchronised and auxiliary breaker.	
Clutch	Clutch symbol indicates open and closed state of the clutch.	
MSB controller	Main switchboard controller symbol indicates bus bar basic settings and measured values.	
Damper	Damper symbols indicates damper position.	
Tunnel thruster	Feedback indicated by bargraph,setpoint value indicated by orange marker. Orange arrow indicate thrust. Running state shown by green border. Additional states may be indicated by text label across the symbol.	
Azimuth Thruster	Feedback and azimuth indicated by bargraph value and angle. Thrust setpoint indicated by orange marker, azimuth setpoint indicated by orange arrow. Running state shown by green border. Additional states may be indicated by text label across the symbol.	
PID controller	PID controller indicates the On/Off status and set point value.	
Gauge	The gauge symbol displays value, set point and alarm limits.	
Fire and gas symbols	Set of symbols used to indicate alarms on Fire and Gas mimic:	

Name	Description	Symbol
Tank	Tank symbol displays basic tank parameters, detailed info can be displayed using pop-up extension.	

Dynamic symbols are used for state indication and user interaction with the process items. They are distinguished by tag marks indicating their current mode. Symbols without a tag mark provide feedback only and cannot be controlled from the OS.

Static Equipment Symbols

Name	Description	Symbol
Manual valves	Valves can be two-directional or non-return.	
3-way valves	3-way valve symbols.	
Angle hand valves	Valves can be two-directional or non-return.	
Quick-closing valve	Quick-closing valve symbol.	
Safety valve	Safety valve symbol.	
Pump	Static pump symbol.	
Handpump	Static handpump symbol.	
Breaker	Static breaker in a closed and open state.	
Ejector	Ejector symbol.	
Flow meter	Flow meter symbol.	
Visco meter	Viscosity meter symbol.	

Static symbols do not change color or shape based on process events.

Auxiliary Control

Pumps

Pump Control Functions

To control the pumps, the following functions and features are available:

- Start and stop.
- Alarm reporting for a start and stop failure.
- Alarm reporting for tripping or started without commanded.
- Auto and manual control.
- Automatic time delayed restart when recovering from a blackout.
- Blocking from operation when the LOCAL switch is active or during a blackout.
- Automatic shutdown.
- Optional time stamping of every change of operation, allowing the system to record the time of starting, running and stopping.

Pump Tag Mark Description

The tag mark is located at the bottom of the symbol on the screen and indicates the following:

- M: Manual.
- A: Auto.
- L: Local.
- B: Blocked.
- T: Tripped.
- S: Shutdown.

The tag mark changes according to the changes made in the dialog box.

Pump Operating States

- Green: Pump running.
- Gray: Pump stopped.
- Gray: Pump on standby.
- Gray/Green flashing: Intermediate state.
- Red square around the symbol: Tripped/Failure.

Alarms and Events

There are some alarms that must be enabled at all times, start fail and trip alarms are among these. The following conditions will result in alarms, and the pump will be set to manual:

- Trip.
- Start failure.
- Stop failure.
- Started without commanded.

Pump Modes

The pumps can be operated in two different modes, automatic and manual.

- Auto: A unit can be automatically started and stopped.
- Manual: Only manual start and stop is possible.

Restart after blackout applies to both automatic and manual modes. The shutdown and start block functions are active both in automatic and manual modes.

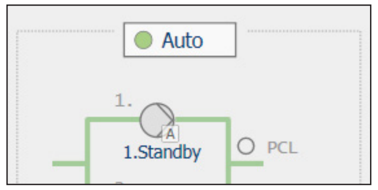
Pump Dialog Box

CAMS has a general pump dialog box. Underneath is an example of it, and a description of the function buttons.

- Clicking on the X button will close the dialog box.
- Clicking on the PIN button stops the dialog box closing. If other operations are done while the dialog box is pinned, the dialog boxes will still be displayed on the screen.
- Clicking on the >> button expands the dialog box so more information can be displayed.
- Clicking on the START button will start the equipment the dialog box is linked to.
- Clicking on the STOP button will stop the equipment the dialog box is linked to.
- Clicking on the AUTO button will switch the equipment the dialog box is linked to, to automatic operation.
- Clicking on the MANUAL button will switch the equipment the dialog box is linked to, to manual operation.
- Clicking on the RESET button will reset the equipment the dialog box is linked to.
- Clicking on the ACKNOWLEDGE button will acknowledge any alarms on the equipment the dialog box is linked to. The button will only be present in the dialog box if the controlled tag is in an alarm condition.

Procedure to Put a Pump on Standby

a) Open the display on the system and click on the Auto/Manual button depending on which mode the standby pump is in at the time.



b) A dialog box will open, similar to the one shown below.

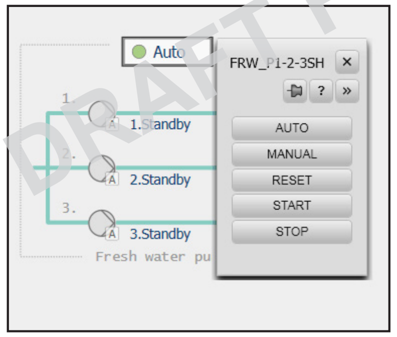
c) Click on the Auto or Manual button depending on which mode is required.

Procedure to Change a Pump's Priority

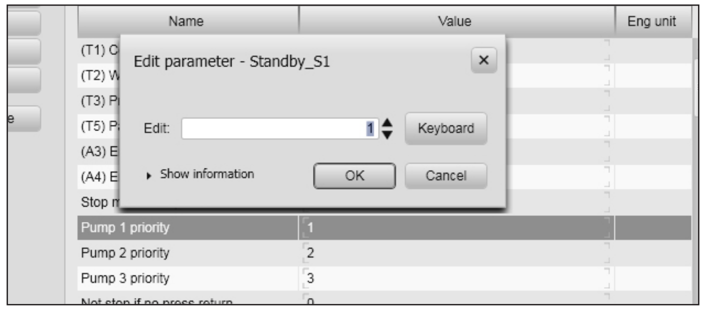
A standby pump system will often consist of two or three pumps. This procedure shows how to change the priority with three pumps.

a) Open the display showing the standby pump mimic and move the cursor over the standby pump control symbol and click on it.

b) A dialog box will open, similar to the one shown below.



c) Click on the expand button in the dialog box, then click on the tab labelled PARAMETER. Click on the line with the pump selected to open a dialog box, similar to the one shown below. This action may be password protected.



d) Change the number of the pump priority by clicking on the UP/DOWN arrows, then click the OK button. If the rest of the pumps in the system also need to have their priority changed, follow this procedure again for the remaining pumps.

Compressors and Fans

Compressor Control Functions

To control the compressors on board, the following features are available on the CAMS system:

- Priority control of the operation of the compressors in the compressed air systems and the lead/lag operation of the compressors.
- Provide automatic compressor start/stops on low/high system pressure.

Fan Control Functions

The following types of fan can be operated and controlled through the CAMS system:

- Single speed: One speed control in one direction.
- Two speed: Two speed in the same direction.
- Two directional: One speed in two directions.
- Two speed two directional: Two speed in two directions.

Compressor and Fan Tag Mark Description

The tag mark is located at the bottom of the symbol on the screen and indicates the following:

- M: Manual.
- A: Auto.
- L: Local.
- B: Blocked.
- T: Tripped.

The tag mark changes according to the changes made in the dialog box.

Compressor and Fan Operating States

- Green: Compressor/fan running.
- Gray: Compressor/fan stopped.
- Gray: Compressor/fan on standby.
- Gray/green flashing: Immediate state.
- Red square around the symbol: Tripped/Failure.

Alarms and Events

There are some alarms that must be enabled at all times. Start fail and trip alarms are among these.

The following conditions will result in alarms, and the compressor/fan will be set to manual:

- Trip.
- Start failure.
- Stop failure.
- Started without commanded.

Compressor Operating Modes

Two compressor operating modes exist, namely automatic and manual. Selecting automatic will put the compressor into automatic operation as long as the starter is not blocked or electrically isolated. The 'lead' compressor has its own start and stop limits and will start/stop in accordance with the system pressure switches. Each compressor is given a priority and each priority has its own start/stop settings. When the 'lead' compressor is running but unable to meet demand, the second priority compressor will be started if the pressure has not increased to above its start limit within a preset time.

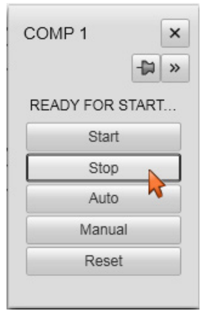
Procedure to Manually Start a Compressor

a) Open the display showing the compressor wanted, then move the cursor over the compressor symbol and click on it. A dialog box will open, similar to the one shown below.

b) Click on the START button and the compressor symbol will turn green.

Procedure to Manually Stop a Compressor

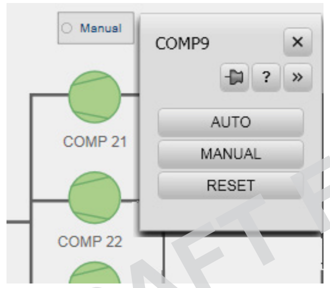
a) Open the display showing the compressor wanted, then move the cursor over the compressor symbol and click on it. A dialog box will open, similar to the one shown below.



b) Click on the STOP button and the compressor symbol will turn gray.

Procedure to Switch a Compressor to Automatic or Manual Control

a) Open the display showing the compressor wanted, then move the cursor over the compressor symbol and click on it. A dialog box will open, similar to the one shown below.



b) Click on the AUTO or MANUAL button depending on which mode is required. The compressor handler button text will change to the selected mode and the color of the circle in front of the compressor handler button will change.

Valves

Valve Control Functions

The following functions and features are available to control system valves:

- Monitoring of the controlled valve.
- Control of open/close (on/off) or analog type valves with feedback.
- Blocking a valve from opening.
- Blocking a valve from closing.
- Blocking a valve from operation (local control).
- Deviation monitoring.

Valve Tag Mark Description

The tag mark is located at the bottom of the symbol on the screen and indicates the following:

- M: Manual.
- A: Auto.
- L: Local.
- B: Blocked.
- T: Tripped.

The tag mark changes according to the changes made in the dialog box.

Valve Operating States

- Green: Valve fully open.
- Gray: Valve fully closed.
- Gray: Valve on standby.
- Gray/green flashing: Valve moving.
- Red square around the symbol: Tripped/Failure.

Alarms and Events

There following alarms are associated with system valves.

- Out of position.
- Time-out alarm.
- Signal failure.
- Operation blocked.
- Blocked from opening, not ready.

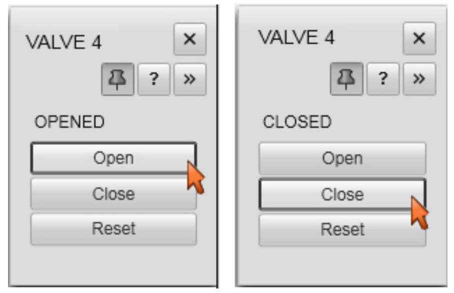
Valve Modes

System valves can be operated in two different modes, namely automatic and manual. The shutdown and start block functions are active both in automatic and manual modes. Restart after a blackout applies to both automatic and manual modes.

- **Automatic:** A valve can be automatically opened and closed by the CAMS.
- **Manual:** The valve can only be opened or closed by the operator.

Procedure to Open/Close an ON/OFF Valve

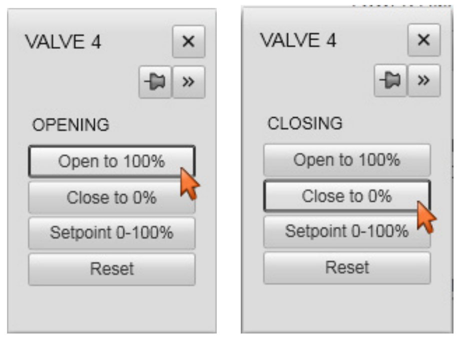
a) Open the display showing the valve wanted. Move the cursor over the valve symbol and click on it. A dialog box will open, similar to the ones shown below.



b) Click on the OPEN or CLOSE button. The valve symbol will turn green if it is being opened or gray if it is being closed.

Procedure to Fully Open/Close an Analogue Valve

a) Open the display showing the valve wanted. Move the cursor over the valve symbol and click on it. A dialog box will open, similar to the ones shown below.

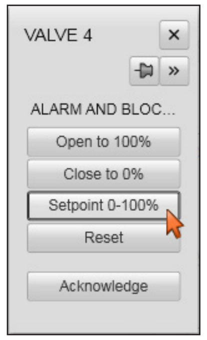


b) To open the valve, click on the OPEN TO 100% button. The valve symbol will turn green when it is fully open.

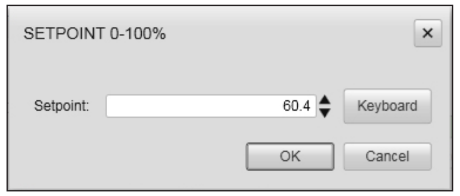
c) To close the valve, click on the CLOSE TO 0% button. The valve symbol will turn gray when it is fully closed.

Procedure to Partially Open/Close an Analogue Valve

a) Open the display showing the valve wanted. Move the cursor over the valve symbol and click on it. A dialog box will open, similar to the one shown below.



b) Click on the SETPOINT 0 - 100% button. A dialog box will open, similar to the one shown below.



c) Set the set point by using the UP or DOWN arrows, then click on the OK button. The set point can also be typed in by clicking on the keyboard button and inputting the value required at the control panel. Click on the OK button when the set point has been typed in.

Dampers

Procedure to Open/Close Dampers

a) Open the display showing the damper wanted. Move the cursor over the damper symbol and click on it. A dialog box will open, similar to the ones shown below.

b) Click on the OPEN or CLOSE button. The valve symbol will turn green if it is being opened or gray if it is being closed.

Procedure to Reset Dampers

a) Open the display showing the damper wanted. Move the cursor over the damper symbol and click on it. A dialog box will open, similar to the ones shown below.

b) Click on the RESET button.

- The red square around the damper symbol disappears.
- The symbol keeps the color it had before it tripped.

Trending

The system automatically maintains a log of all changes to all tags for the previous 7 days and stores them for use in the trend monitoring system. To display the data, the trend display is used.

Similar to the permanent system views, the TREND views are accessible from both the navigation line and the home page.

The trend view is divided into two areas:

- Tools and options area (upper part of the view).
- View area (lower part of the view).

Tools and Options Area

Active Tags

Each tag logged in the view is represented by an information field above the trend plots, showing the tag name and color representation.

For a given tag, clicking on the color symbol will highlight its trend plot in the display by using a bolder line. In addition, alarm limits for the tag are shown, if relevant.

The tag that is highlighted is easily seen by its rectangular color symbol changing form.

All plots are interpolated by default, but the operator can turn the interpolation off by right-clicking on the tag or from 'tag manager' in the trend view.

Tag Manager

The tag manager is used to select which data is to be shown by the current trend view. The tag manager dialog box is opened by clicking on the TAG MANAGER button in the upper right corner of the display.

The tag manager holds the following functionality:

- **Visible:** The tag becomes invisible in the plot area when unchecked.
- **Interpolation:** Check this box to switch if interpolation is switched ON/OFF.
- **Color:** The color representing each tag.
- **Scale:** Default, manual or automatic scale.
- **Go to Process View:** The tags having an alarm will have this button enabled. It will send the operator to the process view relevant to the alarm.
- **Name:** The short name of the tag.
- **Description:** Detailed description of the alarm tag.
- **Value:** Measured value scaled to the engineering unit.
- **Unit:** Engineering unit on the tag.

Add Tag

A new tag can be added to a 'trend view' using the ADD TAGS button inside the tag manager view.

The list of available tags may contain thousands of items. A search function has therefore been included to help the operator restrict the number of items listed. These are as follows:

- **Alarm Group:** Searches for tags belonging to a specific alarm group.
- **Tag:** Searches by tag name.
- **Description:** Search by tag description.

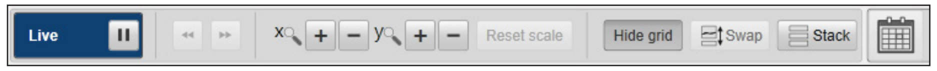
After selecting the required tag from the list, the ADD TAG button or just double-clicking the tag, places the new tag on the view. The new tag is then automatically placed at the bottom of the list. It is also possible to add tags directly from the process view. Right-clicking on the tag to be added will give the operator the option to add it to a trend view.

Remove Tag

While still working inside the 'tag manager' view, mark the tag to be removed and click the REMOVE TAG button.

Tools and Options Area – Lower Part

The lower part of the 'tools and options' area shows the following tool bar and holds the following functions:

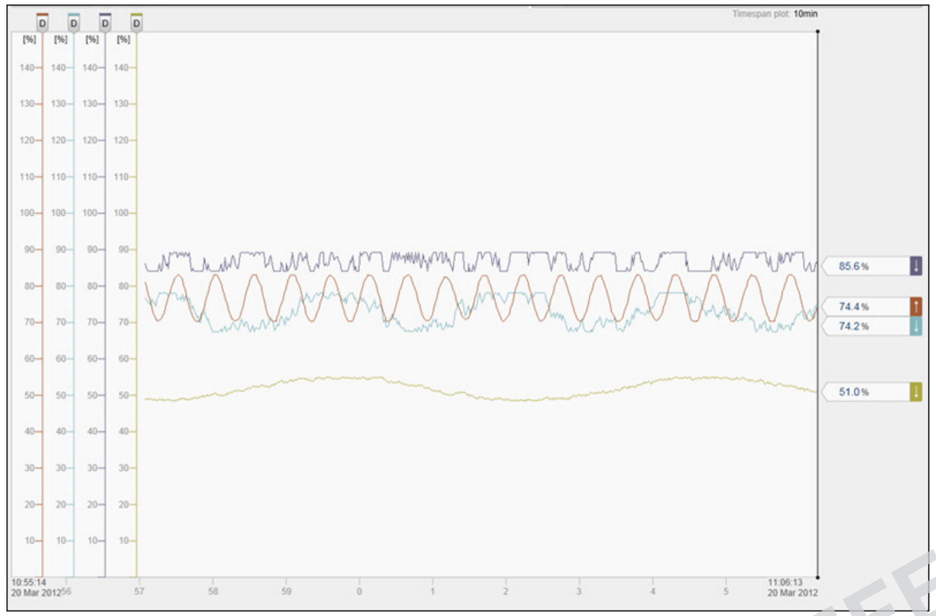


- **Live/Static View:** This selects 'live view' or a time span in the past.
- **Forward/Backward Buttons:** Moves forward and backward in time in the static view.
- **Zoom Buttons:** Pressing the X button zooms the time and pressing the Y button zooms the engineering unit span. Pressing the RESET SCALE button takes the operator back to the default scale.

- **Hide Grid:** Pressing this button shows or hides the grid from the viewing area.
- **Swap:** The analog and digital tags are presented in different windows. Pressing this button will allow the operator to swap which window is above the other.
- **Stack:** All of the tag values are plotted in separate windows.
- **Select Date/Time:** In static view, the time span can be selected from this calendar.

View Area

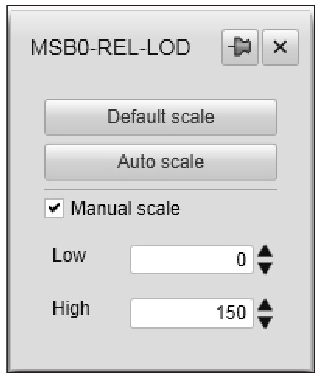
The view area is used to display the trend plots; up to 8 plots can be monitored at the same time. The plots are recognisable by each one having a unique color.



One vertical value scale is displayed for each alarm tag. The color of the scale is identical with the color of the selected plot. There are three different modes for the value scale.

- **Default mode** - In this mode, engineering high and low values are used for the value scale.
- **Auto mode** - In this mode, the value scale is automatically adjusted for the plot to fit the maximum scale range.
- **Manual mode** - In this mode, the value scale can be adjusted manually by the operator. Values can even be set to exceed engineering high and low values.

The mode for a particular scale can be edited by clicking on the relevant button. This opens the following dialog box:



The scale can be also adjusted by a trackball drag and drop. Hold the mouse over the scale and press the center button on the trackball, then move the trackball in the relevant direction to access the scale required.

5.1.3 EXTENSION ALARM SYSTEM

Manufacturer: Kongsberg
Model: WCC 600 Watch Call Panel

Introduction

The extension alarm system will alert the duty officer in the event of any monitored parameter exceeding its set value as monitored by the CAMS. The system comprises a number of self-contained, wall-mounted watch call panels that are installed at selected locations. The panels are controlled from operator stations and are used to warn the bridge and on-duty officers of alarm conditions.

The system has two main functions:

- Alarm Extension: This is a group alarm status and on-duty officer indication facility with a built-in on-duty acceptance, fault indication and test facilities.
- Officer Call: This is an individual and general calling facility for officers that can be activated from selected vessel control locations.

Watch Call Panels

There are two types of watch call panels:

- Watch bridge unit - for use on the bridge.
- Watch cabin unit - for use in cabins and public places.

The alarms will be routed to the engineer on duty as appropriate, for example, deck alarms will be routed to the chief officer when a deck system alarm is activated, and machinery alarms will be routed to the engine room duty engineer.

Panel Functions

- Indicating and accepting the transfer of machine watch responsibility to/from the bridge.
- Call the on-duty engineer at any time - cabin/public spaces.
- Self-check function with system failure indication.
- Buzzer, sound off and test function.
- Alarm summary.
- Date and time indication.

Watch Cabin Unit.

An alarm situation will be presented on the watch call unit with a buzzer sound and a visual indication. The unit will automatically switch to the Alarm Summary page and present alarm information to the user. Configuration of alarms in the system are grouped as follows:

The WCC 600 unit communicates with the main computer in CAMS system using a CAN network.

System Overview

Home Page

Cabin unit home page features:

- Indicators for duty engineers.

  In addition, the top bar and the triangle for alarm group view on the bottom part of the screen is present. These are displayed on both bridge and cabin units.

Bridge unit home page features:

- Control buttons for duty call functionality.
- Indicators for duty engineers.
- Control buttons and indicators for watch responsibility transfer and status.

Alarm Categories/Groups

The alarm group names are displayed in the bottom bar. An alarm group will flash while there are unacknowledged alarms in the group. It will turn to steady red color when all alarms in the group are acknowledged.

When an alarm condition occurs, the buzzer will sound and the alarm is indicated on the watch cabin unit. A flashing indicator will appear on the bridge unit top bar when there is a repeated alarm. The call duty engineer/officer function is available using dedicated buttons on the bridge unit.

Alarm Group View: Pressing the triangle (or bar when there is an active alarm) on the bottom part of screen opens alarm group view. Pressing the Alarms button in the top bar opens the alarm summary view.

Alarm Summary View: Within this view, the user can navigate within alarm summary and view more detailed information of the selected alarms.

Alarm Memory View: Pressing Alarms button in the top bar opens the alarm summary view. Within this view you may navigate within alarm summary and view more detailed information of selected alarms.

Settings Menu

The Settings button opens a view with the following options:

- Dimming.
- System Test.
- Configuration.
- About.

Common for the settings menu and sub-menus is that the panel exits to display the panel home page after 1 minute of no action in the menu.

Dimming Menu

This menu selection enables the user to change the screen backlight settings. A 'glider' button can be used to adjust the light, or the user can select one of two optional buttons: day or night. The night screen-saver turns off the screen when the panel is not in use or there is no alarm. If the panel is touched while the screen-saver is on, or there is an alarm condition, the screen will be turned on. The night screen-saver function is only used in the panels configured as cabin units.

To increase the backlight without using the slider button, touch the upper left and right side of the panel screen simultaneously and hold down for a few seconds while the panel gets brighter. This can be done in any of the panel views.

System Test Menu

Pressing the SYSTEM TEST button displays a test window. A 'Buzzer test' button allows the user to test the alarm sound. Pressing the button again turns the test off. The user also has the option to use the 'Sound Off' soft-button appearing in the top bar to turn the buzzer off. 

Configuration Menu

The configuration menu allows the user to carry out temporary changes to the indicators without loading new configuration settings into the panel and is therefore password protected. When pressing 'Configuration', a password screen appears, prompting the user to enter the correct password before proceeding into the menu.

The configuration menu is password protected by two user-levels: chief and administrator level. At chief level, the configuration menu contains 'Labels' and 'Screen' sub-menu. At administrator level, there is a sub-folder named 'maintenance' visible. Passwords can be obtained from the manufacturer's documentation.

About Menu

Three alternatives appear when pressing the About button:

- **Version Info:** Displays software and hardware versions.
- **Legal Info:** Displays legal considerations related to the panel.
- **Unit Status:** Displays the current watch call panel condition.

Common Function

The top field of the panel contains additional information. A digital clock is localised in the upper left field. A warning signal and a failure warning button appear if the system has an error condition.

If one or more panels are connected to 'WCC600 Load', the tool used to up-load software and configure the panels, text message MAINTENANCE will be displayed on the screen.

If a panel loses communication with the K-Chief OS system, it will give notification after three minutes. The buzzer will sound and the screen will display UNIT FAIL!. The user will be able to use the panel menus while it is disconnected. The home page and warning triangle will remain until the panel has re-established communication with the OS.

Panel Operation

Common functionality for all menus:

- Select a field to change the settings.
- Press the **X** button to return to the previous menu.
- Pressing **DONE** will return the view to the previous menu.
- The **NEXT** button allows the user to navigate through the alarms, settings etc.

Responding to Alarms

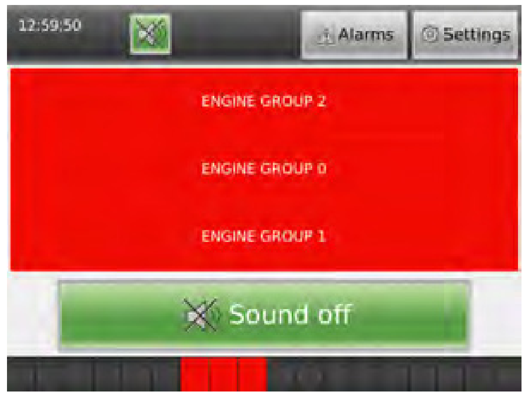
An alarm condition triggers the buzzer and alarm indication on the watch cabin unit. Do the following:

a) Press SOUND OFF.

b) Read the alarm information on the display or the text next to the indicator.

c) Take appropriate action.

d) Check the alarm disappears when the situation returns to normal.



Testing the Panel

a) Press SETTINGS, then ABOUT to check the watch call panel functionality and status. The 'Unit Status' button shows the network working status.

b) Press SETTINGS, then SYSTEM TEST to test the alarm buzzer. If the buzzer is silent, replace the panel. Otherwise, press the buzzer button again to turn the sound off.

5.1.4 PATROL CALL SYSTEM

Introduction

Engineer Safety System

The engineer patrol call system, commonly referred to as the 'dead man alarm' is an integral part of the alarm and monitoring system. The system provides a safeguard for the duty engineer when entering the engine room during periods of UMS operation. Should the engineer get into difficulties whilst alone in the engine room, the system will indicate to others that an engineer is in the engine room, but unable to operate a response button.

When entering the engine room during periods of UMS, the dead-man alarm should be switched on at the engine room entrance if it has not already been activated via the CAMS. This can be done automatically when the duty engineer has been selected.

Should the system not be reset within a predetermined time, normally 27 minutes, a pre-warning alarm sounds, allowing 3 minutes for the duty engineer to reset the system. If this is not carried out, the UMS alarm system is activated to alert the bridge and off-duty engineers.

UMS Duty

a) Once the duty engineer is selected, the dead-man alarm automatically starts.

b) If an alarm activates during the UMS condition:
- The dead-man alarm system switches on.
- After the alarm is cleared, the duty engineer presses STOP at the engine room entrance when leaving the engine room.

c) During UMS rounds, the engine room reverts to manned service, then back to UMS when the duty engineer leaves.

Note: An alarm can be acknowledged at any time from the light signal column accept button.

Note: The dead-man alarm is automatically armed when a UMS alarm is triggered.

Ilustration 5.1.4a Patrol Man Alarm Panels

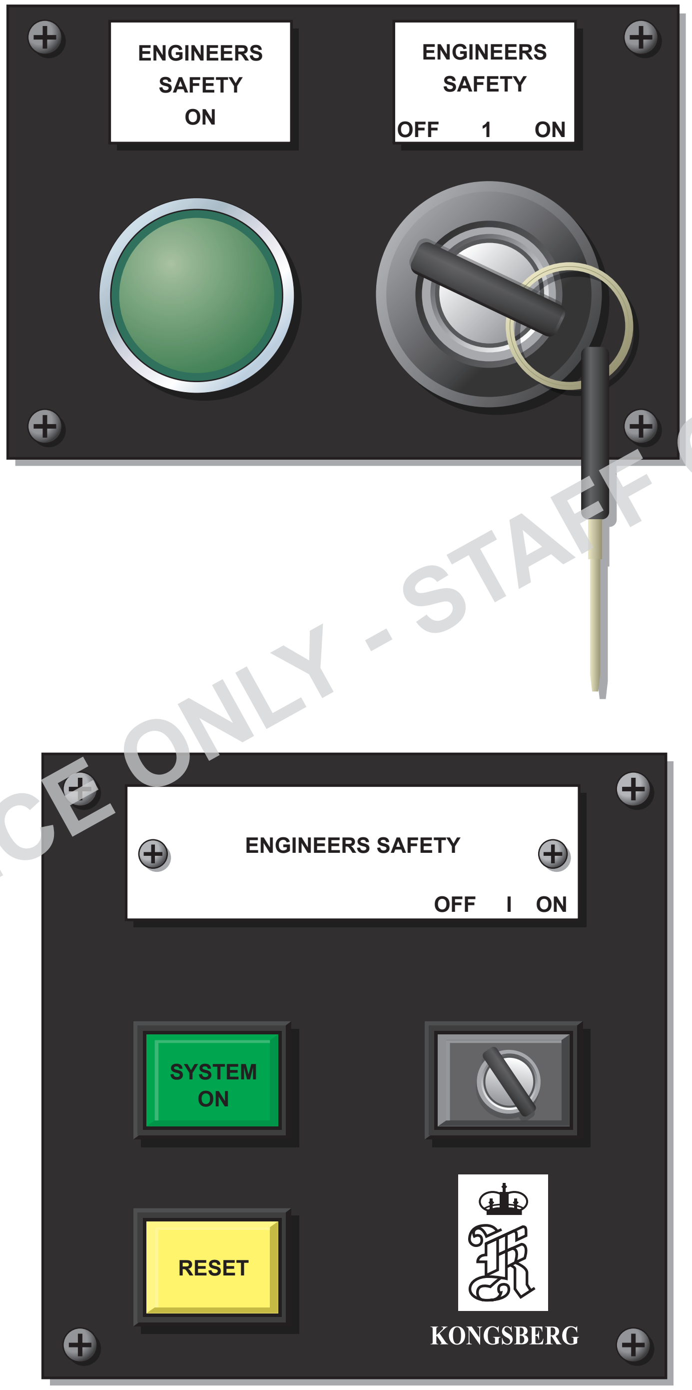
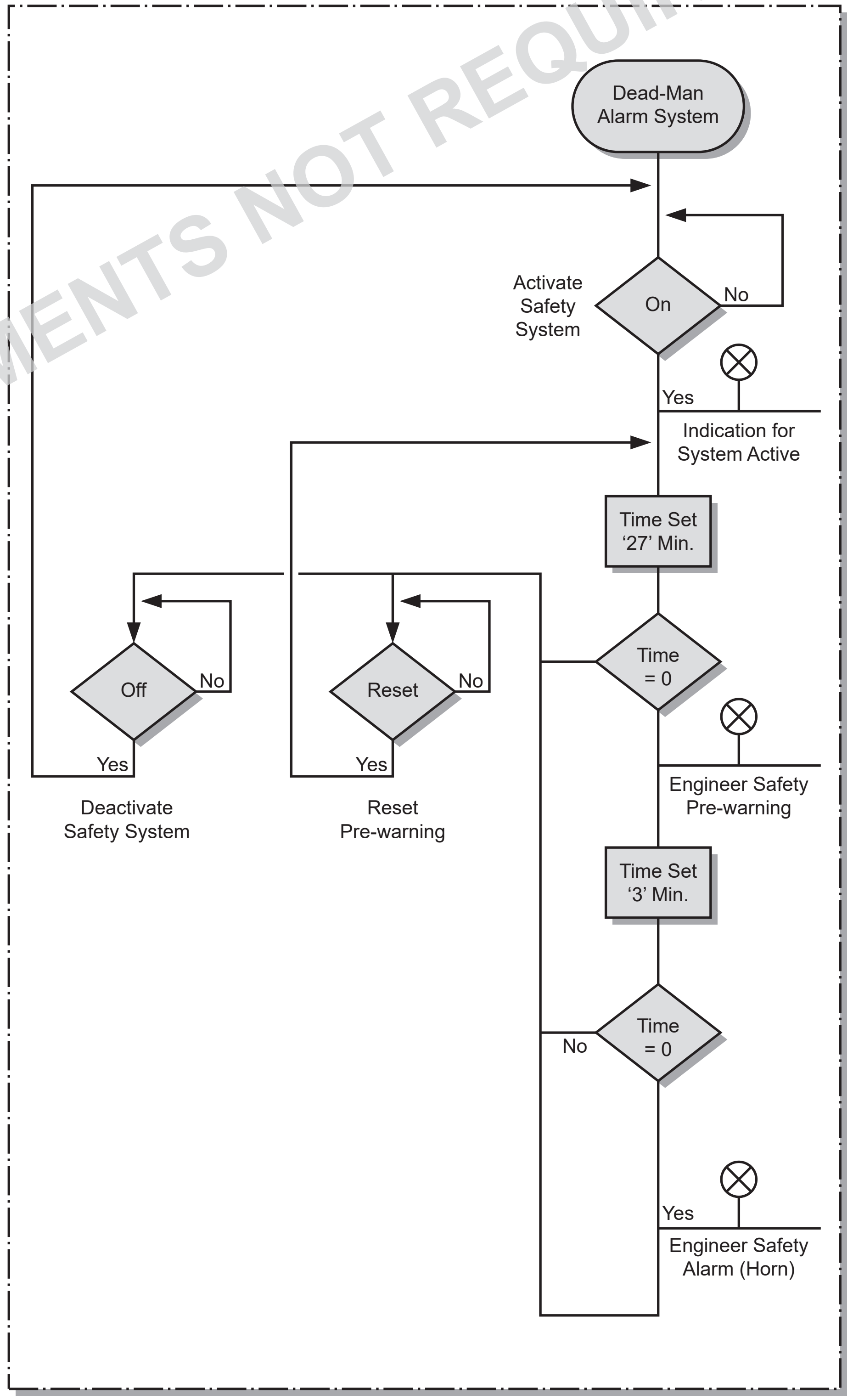


Illustration 5.1.4b Engine Room Dead-Man Alarm System



Reference Drawing: 5275564 Engineer Safety System, NSMV-436-V602/Rev 1/088

5.2 ENGINE CONTROL ROOM

5.2.1 ENGINE CONTROL ROOMS NO.1 + NO.2 OVERVIEW

Authors note: Once photographs have been obtained the ECR and ECC section will be updated with photos and illustrations where appropriate.

Introduction

The Engine Control Rooms No.1 + No.2 (ECR) are located on the fourth deck level in ER1 and ER2 where the controls are located which permit the centralised operation and supervision of the ER1+ER2 machinery. The control is primarily through the CAMS, but other control panels are also located in the room. The ECR arrangements is are shown in this section and the detailed illustration of the main operating console is as shown below.

The ECR No.1 + No.2 contain the following items of equipment:

ID No.	Equipment List ECR No.1	Equipment List ECR No.2
1	No.1 LV MSBD with GSP	No.2 LV MSBD with GSP
2	No.1 engine control console	No.2 engine control console
3	Control panel for FCU-05	Control panel for FCU-06
4	Smoke detector x 2	Smoke detector x 2
5	Receptacle double flush type x 1	Receptacle double flush type x 1
6		
7	Receptacle double flush type x 4	Receptacle double flush type x 4
8	Receptacle double flush type x 4	Receptacle double flush type x 4
9	UHF antenna, indoor	UHF antenna, indoor
10	4 port ONT x 2	4 port ONT x 2
11	WiFi access point	WiFi access point
12	PA speaker 5W x 2	PA speaker 5W x 2
13	LAN outlet box	LAN outlet box
14	White board	White board
15	Notice board	Notice board
16	Tank sounding board	Tank sounding board
17	Life jacket locker	Life jacket locker
18	4 draw filing cabinet	4 draw filing cabinet
19	Door x 3	Door x 3
20	Swivel chair x 3	Swivel chair x 3
21	Computer table x 1	Computer table x 1
22	Frames for certificates x 1	Frames for certificates x 1
23	Fire dampers local control x 2	Fire dampers local control x 2
24	Refrigerators x 1	Refrigerators x 1
25	Bookshelf x 2	Bookshelf x 2
26	Paper holder x 1	Paper holder x 1
27	No.1 fridge gas leak panel	
28	Hat and coat hook	Hat and coat hook
29	Window	Window
30	UPS panel for No.1 MGE	UPS panel for No.3 MGE
31	UPS panel for No.2 MGE	UPS panel for No.4 MGE
32	Clinometer	Clinometer
33	Fan coil unit FCU-05	Fan coil unit FCU-06
34	Portable fire extinguisher	Portable fire extinguisher
35	LED ceiling light x 9	LED ceiling light x 9
36	LED ceiling light with battery backup x 4	LED ceiling light with battery backup x 4
37	LED ceiling light x 2	LED ceiling light x 2
38	LED corner light x 6	LED corner light x 6
39	Level switch for flood detection	
40	ICCP remote panel	
41	Temp transmitter for FCU-05	Temp transmitter for FCU-06
42	No.1 PMS field station FS-02	No.2 PMS field station FS-03
43	No.2 fridge gas leak panel	

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5.2.1 ENGINE CONTROL CONSOLES NO.1 + NO.2 OVERVIEW

Introduction

Engine Control Room Console

The instruments mounted on the console includes the following principal items which are used for indication and control: ECC1 and ECC2 instrument lists are the same except for those shown in the table below.

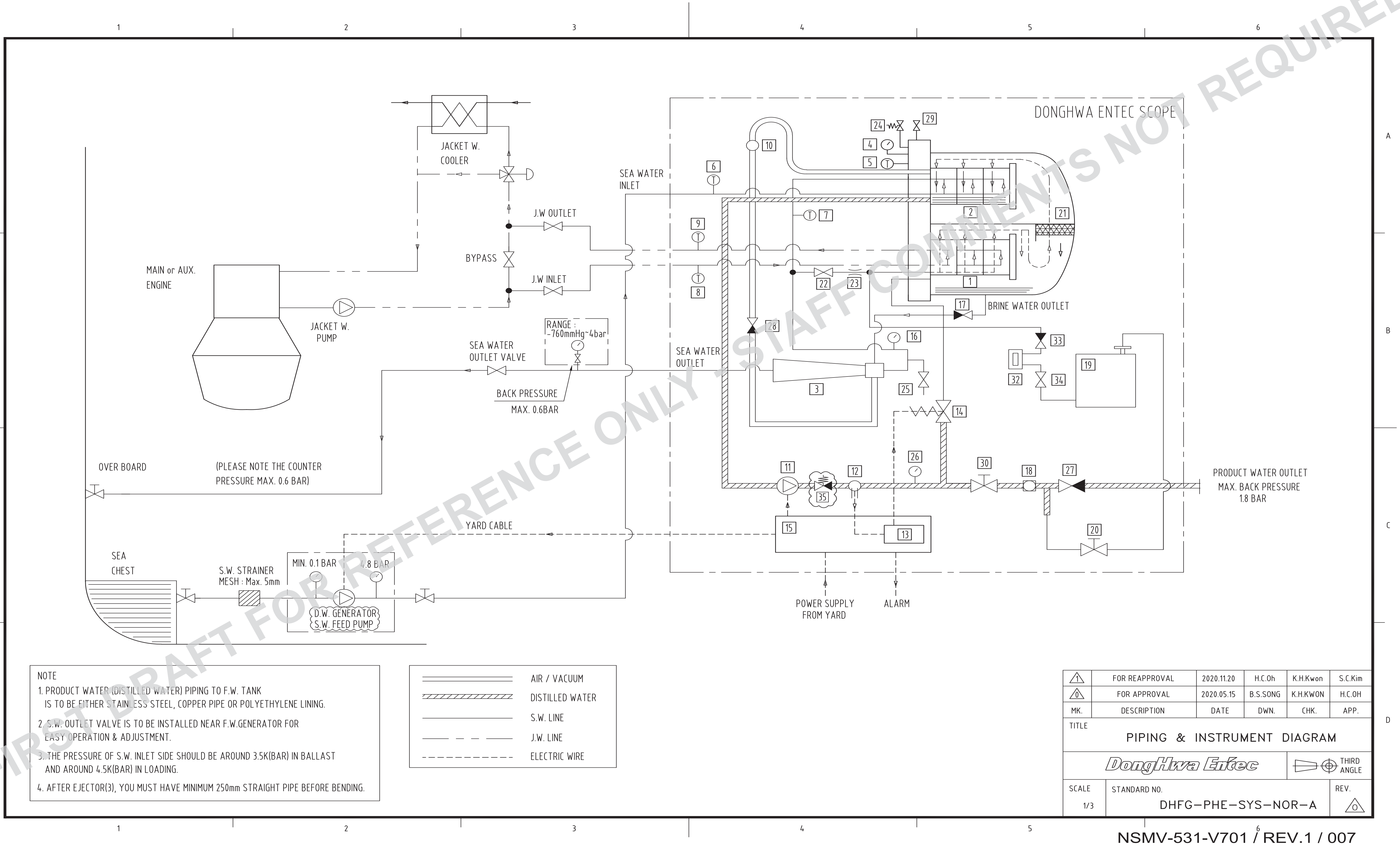
Authors note: Once photographs have been obtained the ECR and ECC section will be updated with photos and illustrations where appropriate.

ID No.	Instrument List ECC No.1	Instrument List ECC No.2
1	Propulsion system work station	Propulsion system work station
2	Propulsion touch screen	Propulsion touch screen
3	Harbour speed table	Harbour speed table
4	Silence pushbutton	Silence pushbutton
5	Propulsion No.1+2 ES PB	Propulsion No.1+2 ES PB
6	Emergency telegraph	Emergency telegraph
8	Propulsion lever	Propulsion lever
11	Speed indicator	Speed indicator
12	Power indicator	Power indicator
13	PMS monitor	PMS monitor
15	Keyboard for PMS	Keyboard for PMS
16	PCS printer	ER personnel alarm panel
17	ER personnel alarm panel	
18		Monitor 1 for CAMS OS 4
19	Monitor 1 for CAMS OS 1	Monitor 2 for CAMS OS 4
20	Monitor 2 for CAMS OS 1	Monitor 1 for CAMS OS 5
21	Monitor 1 for CAMS OS 2	Monitor 2 for CAMS OS 5
22	Monitor 2 for CAMS OS 2	Monitor 1 for CAMS OS 6
23	Monitor 1 for CAMS OS 3	Monitor 2 for CAMS OS 6
24	Monitor 2 for CAMS OS 3	Trackball for CAMS OS 4
25	Trackball for CAMS OS 1	Trackball for CAMS OS 5
26	Trackball for CAMS OS 2	Trackball for CAMS OS 6
26	Trackball for CAMS OS 3	
38	Alarm printer	
39	Data logger printer	
100	Shaft power meter	Shaft power meter
103	Manual call point	Manual call point
104	Fire detection repeater panel	Fire detection repeater panel
105	Fire detection loop list	Fire detection loop list
106	Clock	Clock

ID No.	Instrument List ECC No.1	Instrument List ECC No.2
108	CCTV monitor	CCTV monitor
109	CCTV camera controller	CCTV camera controller
111	No.1 sound powered telephone	No.1 sound powered telephone
112	No.2 sound powered telephone	No.2 sound powered telephone
113	VOIP auto exchange telephone	
114	No.1 telephone directory	
115	No.1 telephone directory	
116	UHF base station	
118	Mic + hook for UHF base station	
119	Steering gear alarm panel	Steering gear alarm panel
120	Steering gear indicator panel	Steering gear indicator panel
122	Switch panel for bow thruster	Switch panel for bow thruster
124	Touch screen for ESS	Touch screen for ESS
125	Control screen for E/R vent fans	Control screen for E/R vent fans
126	Signal light column mimic panel	Signal light column mimic panel
130	Control console power source	Control console power source
133	Stern thruster	Stern thruster
134	Stern thruster run	Stern thruster run
137	Start air comp 1+2 lead/follow	Start air comp 3+4 lead/follow
138	Start air comp 1+2 select switch	Start air comp 3+4 select switch
139	Emergency stop for No.1 MGE	Emergency stop for No.1 MGE
140	Emergency stop for No.2 MGE	Emergency stop for No.2 MGE
141	Emergency stop for No.3 MGE	Emergency stop for No.3 MGE
142	Emergency stop for No.4 MGE	Emergency stop for No.4 MGE
145	Em'cy/Auto/Main c/o switch	Em'cy/Auto/Main c/o switch
146	Patrol man call sytem switch	Patrol man call sytem switch
147	Call/Off/Patrol switch	Call/Off/Patrol switch
152	Emergency telegraph buzzer stop	Emergency telegraph buzzer stop
153	Emergency telegraph flicker stop	Emergency telegraph flicker stop
155	Rem. ind lamp for a/s comps 1+2	Rem. ind lamp for a/s comps 3+4
157	No.1 start air compressor	No.3 start air compressor
158	No.1 start air compressor run	No.3 start air compressor run
159	No.2 start air compressor	No.4 start air compressor
160	No.2 start air compressor run	No.4 start air compressor run

6.1 Water Systems

Illustration 6.1.1a Distilled Water Generator Plant *(Authors note: Illustration currently in progress)*



NSMV-531-V701 / REV.1 / 007

6.1 WATER SYSTEMS

6.1.1 FRESH WATER GENERATOR PLANT

Distilled Water Generator

Manufacturer:	DongHwa Entec
Type:	Plate
Model:	DF07/10
No. of sets:	1
Capacity:	10 ton/day

Salinometer

Manufacturer:	Donghwa Entec
Controller type:	DH-SAL-01
Cell type:	DH-SAL-01-CA
No. of sets:	1
Measurable range:	0-200ppm
Alarm point:	10ppm

Distilled Water Generator Sea Water Feed Pump

Manufacturer:	Shin Shin
Type:	Horizontal centrifugal
Model:	EHC 658
No. of sets:	1
Capacity:	$30m^3/h$ ($1,059ft^3/h$) at 4.8 bar (70psi)
Motor:	440V, 11kW(14.75hp), 3,600 rpm

Distillate Pump

Manufacturer:	Wilo
Type:	Horizontal centrifugal
Model:	DH-DIS-01
No. of sets:	1
Capacity:	$1.2m^3/h$ ($42ft^3/h$) x 3.0 bar (43.5psi)
Motor:	440V, 0.75kW(1.0hp), 3,400 rpm

Performance Criteria

Ejector inlet pressure:	3.5 bar ballast (51psi)
	4.5 bar loaded (65psi)
Ejector outlet pressure:	0.6 bar loaded (8.7psi)
Fresh water pump:	Discharge pressure 1.8 bar (26psi) max,
	0.5 bar (7.3psi) min.

Introduction

A single Distilled Water Generator (DWG) is installed on the floor, port side forward in engine room No.1. It is used to produce distilled water for engine room purposes, and has a capacity of 10 tons/day. The system utilises heat from the No.1+2 MGEs HT cooling water system to generate the water. The ejector, driven by the ejector pump, creates a vacuum in the system to lower the temperature at which evaporation of the feed water can take place. The ejector pump takes its suction from Engine Room 1(ER1) sea water crossover main. The sea water feed is introduced into the condenser section of the distilled water generator. The sea water feed evaporates at a low temperature while entering to the evaporator section due to the vacuum, by the jacket cooling water from the main engine circulating through the evaporator section. The water spray and droplets are partly removed from the vapor by the deflector mounted on top of the evaporator, and partly by a built-in demister. The separated water droplets fall back into the brine, which is extracted by the ejector pump. The resultant distillate is led to the suction of the distillate pump then transferred to the distilled water storage tank.

The water entering the evaporator section is also chemically treated to prevent the build-up of scale and foam inside the evaporator. This maintains efficiency and reduces required maintenance.

A flow meter connected to the distillate pump discharge, monitors the quantity of distilled water produced.

Fresh Water Quality

A salinometer is located on the discharge side of the distillate pump to provide continuous monitoring of the salinity of the distillate produced. If the salinity exceeds the maximum value of 10ppm, an alarm is activated and the water is automatically recirculated back into the fresh water generator separating section.

Main Components

The fresh water generator consists of the following components:

Evaporator

The evaporator consists of a plate heat exchanger which is enclosed in the lower section of the fresh water generator. The heat exchanger is supplied with feed water (sea water) and hot water from the main engine HT cooling water system.

Separator

This separates the brine from the vapour. It houses the separator baffle plate and the demister.

Condenser

The condenser is located in the upper part of the DWG and consists of a plate heat exchanger which is cooled by sea water entering the DWG. The sea water is used to cool the water vapour from the evaporator, to condense the)vapour, and preheat the feed water. The outlet pipe is branched, and used to feed the evaporator section.

Combined Brine/Air Ejector

The ejector extracts brine and incondensable gases from the separator vessel, maintaining a vacuum.

Sea Water Ejector Pump

The ejector pump is a used to provide sea water to the DWG and driving water for the ejector.

Distillate Pump

The distillate pump extracts the condensed fresh water vapour from the condenser and pumps it to the distilled water tank.

Note: The distillate pump discharge pressure should be maintained at an adequate value to ensure optimum evaporator performance.

Salinometer

The salinometer continuously checks the salinity of the water produced. If the salinity exceeds a preset value, the water is redirected back into the sea water generator evaporator section.

Chemical Dosing Pump

The feed water entering the evaporator section is treated to prevent the build-up of scale and foam inside the DWG. This aids to maximise performance and reduce maintenance requirements.

CAUTION

Instructions issued by the treatment chemical supplier regarding mixing must be strictly adhered to at all times. Protective clothing, goggles and gloves must be worn when mixing treatment chemicals.

Control Panels

Control panels for the salinometer, DWG and pumps are mounted adjacent to the DWG.

Distilled Water Generator Operation

Procedure for Starting the Distilled Water Generator

To operate the DWG, it has been assumed that the No.1+2 MGE jacket water (HT) fresh water cooling system, and MGEs are both operational. The description below assumes that all instrumentation valves are open, the control panels are switched on and the DWG sea water feed pump is being used to supply the DWG. It is assumed that all suction strainers are clear.

a) Open the sea water feed pump suction valve CW041, discharge valve CW042, and overboard valve CW045.

b) At the DWG, open the ejector inlet valve CW043 and outlet valve CW044.

c) Start the sea water feed pump, and create a minimum vacuum of approximately 92%.

d) Open the chemical treatment valve for feed water. Ensure the chemical dosing tank is at a suitable level.

e) Slowly open No.1+2 MGEs jacket water inlet valve HF005 and the outlet valve HF006; the evaporator bypass valve HF007 should be in a fully open condition at this stage, as this is used to regulate the flow of jacket water through the evaporator, and to bypass the evaporator.

f) Adjustment of the jacket water bypass valve HF0017 should be made so that the flow of jacket water through the evaporator gradually increases, and the shell temperature of the evaporator rises above 45˚C (113˚F).

The boiling temperature in the evaporator will rise, whilst the required vacuum drops to approximately 85%. This indicates that evaporation has started. After a few minutes, the boiling temperature will drop again and a normal vacuum is re-established.

g) Open the valve to the distilled water storage tank.

h) Switch on the salinometer and start the distillate pump.

i) Adjust flow rate from the distillate pump to approximately 18 litres/minute by use of the distillate pump discharge valve.

The DWG distillate pump discharges through a salinometer and a flow meter. Positioned before the flow meter is a solenoid valve. This opens when the salinometer detects too high a salinity level, recirculating the distillate pump output back into the DWG. The discharge from the pump leads to the filling valves of the distilled water tank.

Adjustment of Jacket Water Flow

To obtain the specified flow of No.1+2 MGE jacket water to the DWG, it may be necessary to adjust the bypass valve HF007 until the desired flow is achieved. For maximum output, the outlet temperature of the jacket water from the evaporator should be about *66*ºC (*151*ºC). It must be remembered that the DWG acts as a cooler for the jacket water, therefore, care must be taken to ensure that No.1+2 MGE jacket water is not under-cooled.

Adjustment of Sea Water Flow

The sea water flow is correct when the inlet pressure at the inlet to the brine/air ejector is approximately 4.5 bar (65psi) loaded, and 3.5 bar (51psi) ballast.

Stopping the Plant

a) Slowly open the DWG jacket water bypass valve HF007, and slowly close the jacket water inlet valve HF005 and outlet valve HF006.

b) When the distillate output drops below the flow sight glass, stop the distillate pump.

c) Switch off the salinometer.

d) Stop the feed water treatment dosing and close the supply valve from the feed water treatment unit.

e) Stop the sea water feed pump when the shell temperature drops below 40˚C (104˚F).

f) At the DWG, close the ejector inlet valve CW041 and outlet valve CW042.

g) Open the vacuum release valve (valve 29).

The DWG sea water circuit will need to be fresh water cleaned as required.

h) Close the sea water pump suction valve CW041, discharge valve CW042, and overboard valve CW045.

i) Close the valve to the distilled water tank.

CAUTION
All valves must be shut while the generator is out of operation, except the air release valve.

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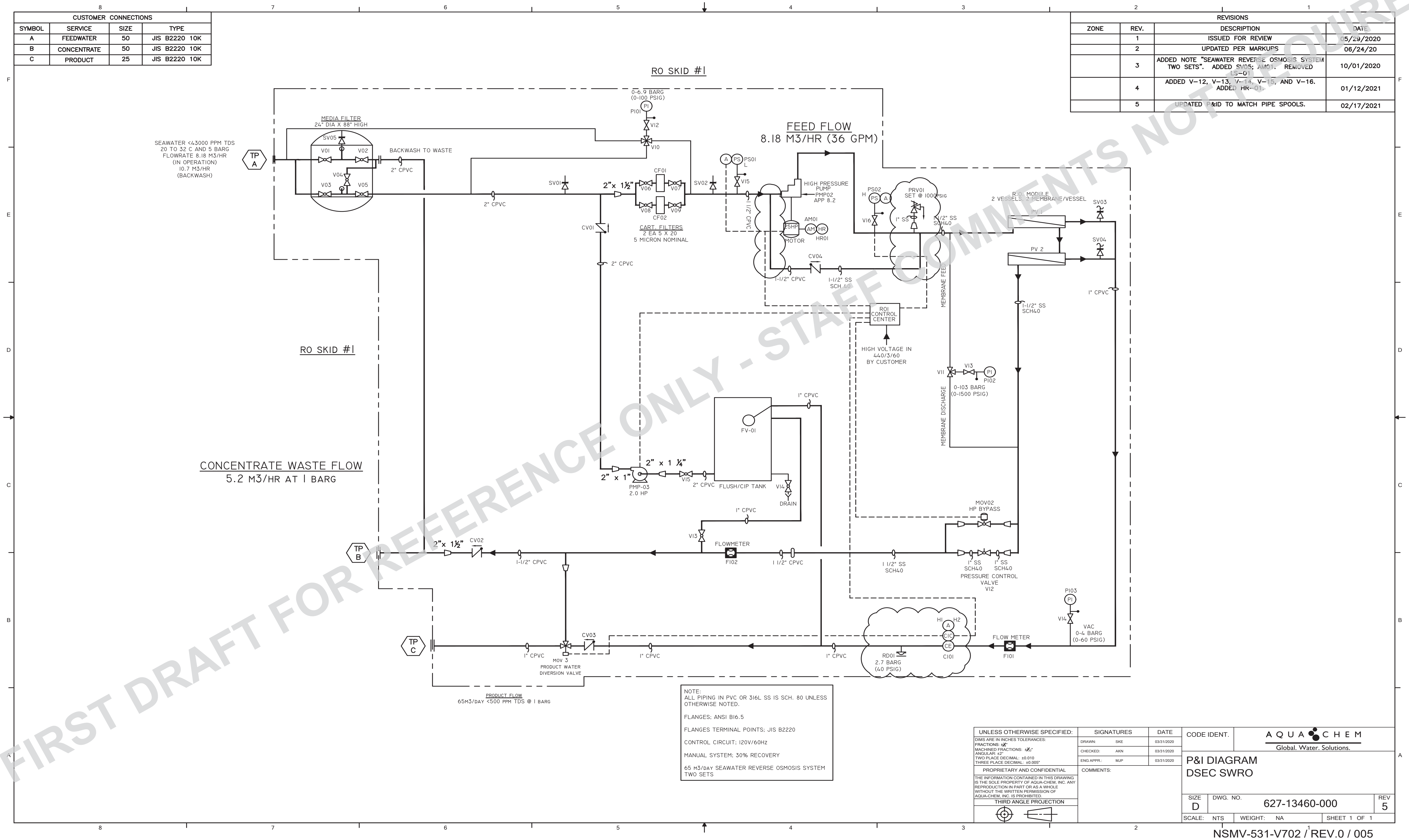
Illustration 6.1.2a Reverse Osmosis Plant *(Authors note: Illustration currently in progress)*



CUSTOMER CONNECTIONS

SYMBOL	SERVICE	SIZE	TYPE
A	FEEDWATER	50	JIS B2220 10K
B	CONCENTRATE	50	JIS B2220 10K
C	PRODUCT	25	JIS B2220 10K

REVISIONS

ZONE	REV.	DESCRIPTION	DATE
	1	ISSUED FOR REVIEW	05/29/2020
	2	UPDATED PER MARKUPS	06/24/20
	3	ADDED NOTE "SEAWATER REVERSE OSMOSIS SYSTEM TWO SETS". ADDED SV05; AM01. REMOVED LS-01	10/01/2020
	4	ADDED V-12, V-13, V-14, V-15, AND V-16. ADDED HR-01.	01/12/2021
	5	UPDATED P&ID TO MATCH PIPE SPOOLS.	02/17/2021

NOTE:
ALL PIPING IN PVC OR 316L SS IS SCH. 80 UNLESS OTHERWISE NOTED.

FLANGES; ANSI B16.5

FLANGES TERMINAL POINTS; JIS B2220

CONTROL CIRCUIT; 120V/60Hz

MANUAL SYSTEM; 30% RECOVERY

65 M3/DAY SEAWATER REVERSE OSMOSIS SYSTEM TWO SETS

UNLESS OTHERWISE SPECIFIED:	SIGNATURES		DATE
DIMS ARE IN INCHES TOLERANCES: FRACTIONS: ±1/8" MACHINED FRACTIONS: ±1/32" ANGULAR: ±2° TWO PLACE DECIMAL: ±0.010 THREE PLACE DECIMAL: ±0.005"	DRAWN:	SKE	03/31/2020
	CHECKED:	AKN	03/31/2020
	ENG APPR.:	MJP	03/31/2020
PROPRIETARY AND CONFIDENTIAL	COMMENTS:		
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF AQUA-CHEM, INC. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF AQUA-CHEM, INC. IS PROHIBITED.			
THIRD ANGLE PROJECTION			

CODE IDENT. AQUA CHEM Global. Water. Solutions.

P&I DIAGRAM
DSEC SWRO

SIZE D | DWG. NO. 627-13460-000 | REV 5
SCALE: NTS | WEIGHT: NA | SHEET 1 OF 1

NSMV-531-V702 / REV.0 / 005

6.1.2 REVERSE OSMOSIS PLANT

Reverse Osmosis Units

Manufacturer:	Aqua-Chem
Type:	Reverse osmosis
Model:	SWRO
No. of sets:	2
Capacity:	65m^3/day (64 ton/day)
Membrane housing:	4
Membrane model:	LG SW 440R

Fresh Water Generator Feed Pumps

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FGV-65D
No. of sets:	2 (1 each RO unit)
Capacity:	18m^3/h (636ft^3/h) at 4.5 bar (65psi)
Motor:	440V, 7.5kW(10hp), 3,500 rpm

High Pressure Pump

Manufacturer:	Danfoss
Type:	Plunger pump
Model:	APP8.2
No. of sets:	2 (1 each RO unit)
Capacity:	18m^3/h (636ft^3/h) at 80 barg (1,160 psi)
Motor:	440V, 18.5kW (25hp), 1,776 rpm

Flushing/Cleaning/In Place Pump

Manufacturer:	Ampco
Type:	Horizontal centrifugal
Model:	KC2 1¼ x 1
No. of sets:	2 (1 each RO unit)
Capacity:	50gpm at 20 psi
Power:	440V, 1.49kW (2hp), 3,490 rpm

Introduction

The Reverse Osmosis (RO) type fresh water generator (FWG) is designed to produce clean and purified fresh water for human consumption as well as delivering to the various utilities found throughout the vessel. The quality of the fresh water produced is in line with the World Health Organisation guidelines for drinking water.

RO is a process for reducing dissolved solids in water. This is accomplished by passing pressurized water over a semi-permeable membrane. The membrane contains numerous tiny holes that allow the water molecules to pass through. The holes are so small that they do not allow most of the dissolved solids to pass through the membrane. These solids and the remaining water (called the concentrate or brine) flow past the membrane surface, and are piped overboard. The water which goes through the membrane is called permeate, or product water.

The output of the RO plant is influenced by the following:

- Feed water temperature
- Salinity of the sea water inlet
- Applied feed pressure

Temperature of the feed water can change the output by as much as 50% in the range from nearly freezing to 95°F (35°C). Generally, product flow from RO systems will decrease by approximately 1.5% per °C decrease in feed water temperature unless pressure corrections are made. The capacity of the system therefore may vary seasonally with temperature.

The difference in salt concentration between the feed water and product water also reduces the driving force due to the difference in osmotic pressure, which must be overcome.

The rate at which water flows through the membrane is directly proportional to the driving force available. The driving force is basically the difference between the pressure on the feed water (system pressure), and product water sides of the membrane and the difference in osmotic pressure of the solutions on opposite sides of the membrane. The greater the feed pressure the greater the driving force and product flow rate will be. Increasing the pressure on the product side of the membrane decreases the driving force, therefore lowering the product flow.

The data mentioned above is monitored on a regular basis, producing a standard set of operating conditions. Any reduction in the output is usually related to the operating conditions, and will indicate the amount of fouling taking place on the membrane surfaces.

Most of the solid materials in the feed water will adhere to the membrane if not flushed from the membrane surface and vessel. Eventually, this material will so heavily coat the membrane that all flow will stop. This will result in the rapid deterioration of the membrane. There must always be sufficient concentrate flow to scour the membrane, and carry away the rejected dissolved solids. This will prevent concentrations that would allow precipitation which result in scaling of the membranes.

Reverse Osmosis Operating Parameters

The operator must be aware of the following when operating the RO unit:

- The intake of sea water to the desalination unit is only allowed outside the 5 mile zone.
- The desalination unit cannot treat sea water which is contaminated with oil or other heavy pollutants. For this reason the desalination unit must not be fed with sea water which is suspected to be contaminated by oil or other heavy pollutants. In practice this means that the desalination unit should not be operated when the ship is in a harbour or in the vicinity of a harbour. Nor should the desalination unit be operated when the sea water surrounding the ship is visually polluted, for example close to a river delta where heavy sedimentation is carried out into the sea.

Primary Components

The RO FWG system is designed to produce fresh water from sea water utilising the following primary components in process order:

Multi Media Filter

The Multi Media Filter (MMF) together with a 5 micron automatic filter is part of the pre-filtration package. The MMF comprises a tank which uses a filling of gravel, sand, and zeolite or carbon to a level of approximately 60% full. A basket is mounted at the top of the tank is to prevent washing out the zeolite or carbon during backwash. The feed water flows downstream through the MMF with a low velocity. Solids will settle, and filtering out most of the parts larger than 20 micron. The filter can be back flushed when the maximum differential pressure is reached. The back flushing is carried out with a flow of 1.4m³/h which is limited by a flow restrictor installed in the drain connection.

5-Micron Cartridge Filter

Together with the MMF there is a 5 micron cartridge filter. Both methods complete the pre-filtration package. The 5 micron cartridge pre-filter enables filtration of the system's feed water down to 5 microns for final protection of the RO membrane element. The 5 micron automatic filtration system is provided to facilitate the removal of sand and zeolite or carbon, and is used to remove smaller and unwanted suspended particles from the feed water.

High Pressure Pump

The high pressure pump is used to raise the pressure to the required RO pressure. The high pressure feed pump discharge is fitted with a high pressure protection switch unit. If the low feed pressure switch is initiated the unit will switch off automatically. Also, the pump is fitted with a pulsation damper to ensure pressure fluctuations are minimised.

On startup of the RO unit, the inlet relay will operate, then after a delay, the RO pump relay will operate. The RO unit will continue to run until a condition occurs that causes a shutdown. The can be a normal operating condition or an alarm condition. For either condition, the top line of screen 1 will display the reason for the shutdown. If the condition is due to an alarm, the alarm lamp will flash and the audible alarm will sound.

Reverse Osmosis Membrane

The RO membrane and vessel assemblies are comprised of corrosion resistant vessels, which house the spiral wound reverse osmosis membrane elements. The principle of the reverse osmosis membrane elements is to reject the salt ions present in the feed water, but to enable the potable H_2O molecules to flow through the thin membrane surface. A sufficient flow of water across the membrane surface must be continually in progress in order for the correct percentage of salt rejection to occur. Only about 5 to 10% (sea water systems, per individual membrane element) of the system feed water becomes fresh product water. The remainder becomes a concentrated brine solution which carries rejected salt ions away from the membrane element, and back to the feed water source. The proper flow of water is also essential to minimise fouling of the RO membrane element. Reducing the flow of feed water would cause the RO membrane element to recover a higher percentage of the feed water. However it should be noted that any excessive recovery would rapidly foul the membrane. In conclusion, a higher pressure will result in a higher flow of product water. The pressure in the membranes is controlled by a high pressure regulator valve.

Fresh Water Flushing Tank and Pump

Product from the RO unit fills the flushing tank at startup. Once the tank is full, product water is then directed to the FW storage tanks. At shutdown, the flushing sequence is initiated manually, then runs automatically, without further operator intervention. The backwash/flushing water enters the filter from the bottom, and flows through the bed to the top. When backwashing/flushing the MMF, the backwash water flows in reverse direction through the sand filter, the filter bed is expanded by the flow. The sediment is dragged from the filter media, and becomes suspended again in the water flow. The particles then leave the filter with the backwash water, and discharge to drain.

The freshwater flushing tank and pump are also used for chemical cleaning in place of the RO membranes.

Note: The pressure across the membrane bank is monitored by high pressure gauges with the membranes and the high pressure pump protected by low and high pressure switches. The low pressure switch protects the high pressure pump from insufficient feed water pressure. The high pressure switch protects the system and the membranes for excessive high pressures.

CAUTION

Over pressure will cause damage to the reverse membrane element and under pressure results in low product water production as well as higher salinity content in the product water. Under flow of the feed water into the reverse membrane element will cause rapid and premature fouling of the reverse membrane element as a result of higher than normal recovery (percentage of recovered water to feed water).

Conductivity Meters

Conductivity meters monitor the quality of the water being produced, and ensure that if the product quality does not meet specifications, the water is diverted to waste. These monitors need to be calibrated on a regular basis to ensure their accuracy.

Fresh Water Chlorination Unit and Rehardening Filter

The RO permeate (fresh water) has an extremely aggressive nature due to the absence of natural inhibitors such a calcium, or magnesium hardness. The pH value tends to fluctuate with a degree of instability due to the absorption of trace amounts of carbon dioxide picked up by coming into contact with air and the fact that the permeate has little buffering capacity.

To ensure the RO permeate (fresh water) required for drinking purposes is acceptable, small amounts of calcium and magnesium is added to improve taste of the product water, and avoid corrosion in the fresh water system. The fresh water is treated in a chlorinator, and a rehardening filter before being directed to the fresh water storage tanks. The dosing of the water by the chlorinator is automatic, and is set depending on the flow of the water. The chlorinator destroys bacteria and sterilises the water which is stored in the tanks. The dolomite rehardening filter produces the correct pH and imparts essential chemical salts to the fresh water, making it fit for human consumption.

Operating Parameters

The operational characteristics of the RO unit are as follows:

- The main switch is located on control box and comprises:
  - Mode ‘0’: The power to the control box is switched off.
  - Mode ‘1’: The power to the control box is switched on

The operation selection switch has two available modes to operate the RO unit which comprise the following:

- Mode 1 - STAND-BY for maintaining the unit on standby and fresh flush. In this mode the membranes are flushed with fresh water for a short period of time which will protect the membranes and the piping from corrosion during standstill. The fresh water flush will be carried out automatically.
- Mode 2 - OPERATIONAL for fresh water production and is selected to produce fresh water and operates automatically.

Alarms and their Actions

The alarms available are as follows:

- LOW PRESSURE - If the low pressure switch input becomes active for the the delay programmed in the Low Pressure Switch Delay, the unit will shutdown for a low pressure switch alarm. LO PRESSURE will show on the display, the alarm lamp will flash and the audible alarm will sound. The alarm can be reset by pressing the Alarm Silence/Reset key twice.
- HIGH PRESSURE - If the permeate TDS/Conductivity reading exceeds the limit programmed the C2 Limit Setpoint for the delay programmed in the C2 Delay Setpoint, the alarm lamp will light and the HI Cond 2 warning message will show on the display. This warning will clear when the TDS/Conductivity drops below the Setpoint. If the Shutdown warning occurs, after the time programmed in this setpoint, the RO unit will shut down and the alarm will sound. The alarm can be cleared by pressing the Alarm Silence/Reset key twice.
- CONDUCTIVITY - A high conductivity warning can be enabled by programming the conductivity limit setpoint to a value other than 0. If the warning is enabled and the conductivity is above the limit for the time programmed in the delay setpoint, the alarm lamp will light steady and the warning will be shown on screen 2.

  A high conductivity shutdown is enabled for a conductivity sensor when the shutdown delay isprogrammed to a delay greater than 0. When the limit is exceeded for the sensor for the shutdown delay,the unit will shutdown for a conductivity alarm condition. The sensor causing the alarm will be shown onscreen 1, the alarm lamp will flash and the audible alarm will sound. Pressing the Alarm Silence/Reset key twice will reset the alarm.
- AUTO RESET - If the pretreat input becomes active and stays active for 2 seconds, the unit will shut down in a pretreat lockout condition. PRETREAT will show on the display, and the unit will remain shut down as long as the pretreat input is active.
- ALARM SILENCE - When an alarm condition occurs, the audible alarm can be silenced by pressing the Alarm Silence/Reset key once. The condition is not cleared unless the key is pressed a second time. If the Alarm Silence setpoint is

programmed to 0, the alarm will remain silenced. Otherwise, the alarm will resound after this delay times out.

- BOOST PUMP CONTROL - If the Aux Mode setpoint is programmed to 1, relay 4 is programmed to operate as a boost pump control. The relay will turn on when the RO starts, and will turn off when the RO stops. If the tank low input becomes active for the time programmed in the Tank Low Delay setpoint, the RO unit will shutdown. TANK LOW will show on screen 1, the alarm lamp will flash and the audible alarm will sound. Pressing the Alarm Silence/Reset key will reset the alarm.
- MEMBRANE FLUSH - If the Flush Type setpoint is programmed to 0, flushing is disabled. If membrane flush is required, several types of flush are available. When the unit enters a flush cycle, the flush relay will activate. The flush cycle will last for the time programmed in the Flush Time setpoint.
- FLUSH MODE - The Flush Mode Setpoint can be used to control the operation of the inlet valve and RO pump during flush. Each can be independently programmed to operate during flush.

Operating Procedures

Start-Up Procedure for No.1 RO Fresh Water Generator

The start-up procedure indicates the requirements in starting the RO unit with delivery to the three potable water tanks (port, centre, and starboard). The procedure is as follows, and will be the same for No.2 FWG:

a) Ensure electrical power is available to the controls and all instrumentation is functioning correctly and there are no system faults. Confirm all alarm conditions are reset.

b) Check and fill as necessary the dosing tank with the prescribed amount of chemical solution.

c) Set the valves of the RO unit in the following position:

Sea Water Feed Pump and Overboard Valves

All valves are prefixed with ‘CW’ unless otherwise advised

Position	Description	Valve
Open	No.1 RO FWG feed pump suction valve	518
Open	No.1 RO FWG feed pump discharge valve	519
Open	No.1 RO FWG feed inlet valve	520
Open	No.1 RO FWG feed outlet valve	521
Open	No.1 RO FWG overboard valve	522

No.1 Reverse Osmosis Unit valves

Position	Description	Valve
Open	MMF tank feed water inlet valve	V01
Closed	MMF tank backwash outlet valve	V02
Closed	MMF tank backwash inlet valve	V03
Closed	MMF tank backwash rinse valve	V04
Open	MMF tank feed water outlet valve	V05
Open	Cartridge filter CF01 inlet valve	V06
Open	Cartridge filter CF01 outlet valve	V07
Closed	Cartridge filter CF02 inlet valve	V08
Closed	Cartridge filter CF02 outlet valve	V09
Set	HP pump discharge relief valve set 1,000psi	PRV01
Set	Membrane discharge/feed loop valve	V11
Set	Membrane concentrate pressure control valve	V12
Automatic	Flush/CIP tank auto filling valve from product line	FV01
Closed	Flush/CIP tank manual filling valve from membranes	V13
Closed	Flush/CIP tank drain valve	V14
Closed	Flush/CIP pump suction valve	V15
Closed	Permeate sampling valves on membrane outlets	SV03/4
Automatic	Concentrate HP bypass valve	MOV2
Automatic	Product water 3-way control valve	MOV3

Fresh Water Tanks FillingValves

All valves are prefixed with ‘HC’ unless otherwise advised

Position	Description	Valve
Open	No.1 RO FWG outlet valve	501
Open	Chlorinator and rehardening filter inlet/outlet valves	
Open	Filling valve to fresh water tank 1 port	505
Closed	Filling valve to fresh water tank 1 centre	506
Closed	Filling valve to fresh water tank 1 starboard	507

d) Confirm the emergency stops are not activated

e) Ensure instrument air is available.

f) Set the selection switch to 2-STAND-BY.

g) Set the MAIN SWITCH to ‘1’.

h) Set the selection switch to 1-OPERATION.

i) Observe that the feed valve is open.

Note: At sufficient feed pressure the high pressure pump will start to run after a predetermined (short) period.

j) Confirm that the RO unit is producing fresh water.

k) Monitor the product flow meter, FI01, and the concentrate flow meter, FI02, and the feed pressure gauge PS02.

CAUTION

The feed pressure membrane indicator PS02 must never exceed 1,000 psig.

Shutdown Procedure

Flush Mode

During shutdown the RO unit is flushed with fresh water to protect the membranes.

The freshwater flush system includes a flush/CIP tank and flush pump. Product from the RO unit fills the tank at startup through valve FV01. Once the tank is full, product water is then directed to the fresh water tanks. At shutdown, the flush sequence is initiated manually, and then runs automatically, without further operator intervention.

Manual Flushing

If flushing is enabled, this allows a flush cycle to be manually initiated by pressing the Function key, 2 and the Enter key. If flushing is already active, pressing the Function key, 2 and the Enter key will end the flush.

Procedure for Cleaning the Membranes

The membranes are cleaned by circulating the cleaning chemicals through the membranes by a flush/CIP pump from the flush/CIP tank.

Depending on the process conditions, the membranes can become fouled, which will result in an output decrease and/or a reduction in the quality of the product water, therefore the membrane cleaning procedure is to be implemented. The membrane should be cleaned in the event of the following:

- The product water flow has dropped more than 10% from initial performance.
- The salinity of the product water has increased more than 10% from the initial performance.
- The pressure difference between the feed pressure and the brine pressure has increased more than 15% from the initial performance.

The three phases in this procedure can be distinguished as follows:

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- Preparation of the cleaning chemicals.
- Cleaning of the membranes.
- Checking the results of the cleaning.

Prior to commencing the cleaning procedure the following MUST be adhered to:

- Raise a work permit and perform a risk assessment for the procedure.
- Wear the correct PPE with special attention to avoiding contact with eyes, skin and inhalation and using protective clothes, gloves and safety glasses.

CAUTION
Any spilled chemical must be removed immediately according to the instructions of the supplier.

Preparation of Cleaning Chemicals Step 1

a) Flush system with copious amounts of fresh, dechlorinated water. This step is to remove all saline water and chemicals from the system and membrane elements.

b) The RO unit and any additional prefiltration equipment such as MMF, should be flushed and sterilized prior to shutdown.

c) Close V01, V02, V03, V04 and V05 at the MMF. Open the concentrate ball valve V13 to the CIP position. Manually open MOV-2. This will allow all product and concentrate to return to the CIP tank.

Preparation of Cleaning Chemicals Step 2

a) Prepare the chemical solution, solution according to the manufacturers mixing instructions.

Cleaning Procedure Step 3

a) Start the cleaning/recirculation pump ensuring that the regulating valve is fully open, and re-circulate for forty-five (45) minutes.

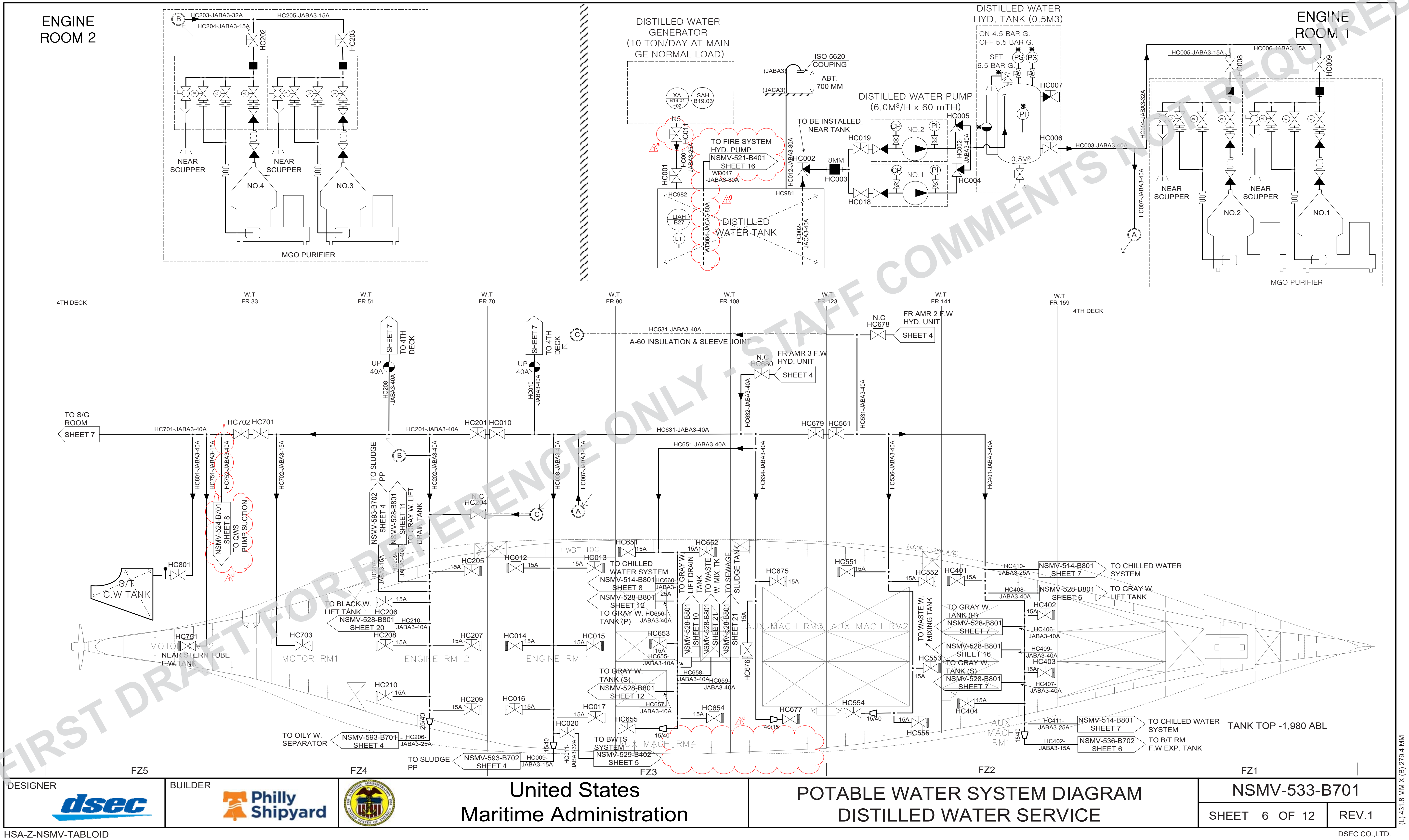
b) During recirculation, visually inspect the condition of the cleaning solution. If the solution becomes very dirty, discard the solution and mix a new batch.

c) During recirculation, the temperature of the cleaning solution will rise. Do not allow the temperature to exceed 35°C (110°F).

d) After re-circulation for 45 minutes, set the concentrate CIP 3-way valve to the service position, and pump the cleaning solution to waste.

Thr RO unit can now be returned to service.

Illustration 6.1.3a Distilled/Technical Water System *(Authors note: Illustration currently in progress)*



6.1.3 DISTILLED/TECHNICAL WATER SYSTEM

Hydrophore

Manufacturer: Samkun Century
Type: Vertical, cylindrical
Model: DT - 500
No. of sets: 1
Capacity: 500 liters

Hydrophore Distilled Water Supply Pumps

Manufacturer: Naniwa
Type: Horizontal, centrifugal
Model: SHR-40-30
No. of sets: 2
Capacity: 6m^3/h (212ft^3/h) at 6.0 bar (87psi)
Motor: 440V, 7.5kW(10hp), 3,500 rpm

- Cut-in at 4.5 bar (65psi)
- Cut-out at 5.5 bar (72.5psi)

Introduction

The distilled/technical fresh water does not require sterilizing, therefore the hydrophore pumps take direct suction from the distilled water tank, and discharge directly to the distilled water hydrophore tank. This tank supplies technical water to all of the equipment in the engine room, and outside deck areas as required.

Distilled/Technical Water System

The distilled/technical fresh water system supplies the following equipment in the machinery spaces, and outside deck areas:

- MGO purifiers operating water.
- Chilled water systems.
- Gray water lift tanks.
- Gray water tanks.
- Waste water mixing tank.
- Bow thruster room fresh water expansion tank.
- Sewage sludge tank.
- BWTS system.
- Sludge pumps priming lines.
- Gray water lift drain tanks.
- Black water lift drain tank.
- Oily water separator flushing line.
- Stern tube quality water system pump suction.
- Stern tube cooling fresh water tank.
- LT/HT expansion tanks for GEs x 4 off.
- Engine rooms No.1+2 LT fresh water expansion tanks
- Engine room distilled water service outlets.

Distilled Water Hydrophore and Pump Valves

These valves are usually left in the open position.

All valves are prefixed with 'HC' unless otherwise advised

Description	Valve
Distilled water generator outlet valve to distilled water tank	011
Distilled water tank filling valve	001
Distilled water hydrophore tank supply pumps suction valve	002
No.1 distilled water pump suction valve	018
No.1 distilled water pump discharge valve	004
No.2 distilled water pump suction valve	019
No.2 distilled water pump discharge valve	005
Distilled water hydrophore tank outlet valve to system	006
Distilled water hydrophore tank pressurizing air valve	007

Valves can be operated as necessary in accordance with the following table:

Description	Valve
No.4 MGO purifier supply valve	002
No.3 MGO purifier supply valve	003
No.2 MGO purifier supply valve	008
No.1 MGO purifier supply valve	009
Engine room 1 isolating valve at frame 70	010
Engine room 2 isolating valve at frame 70	201
Motor room 1 isolating valve at frame 33	701
Motor room 2 isolating valve at frame 33	702
Stern tube cooling water tank (blanked)	801
Stern tube water quality system pump suction valve	CW789
No.1 sludge pump priming water valve	OI041
No.3 gray water lift tank flushing valves	SN223/4/5
No.1 waste water mixing tank flushing valves	SE318/9/20
No.1 black water tank flushing valves	SE309/10/11
Oily water separator clean water supply valve	BG236
No.2 sludge pump priming water valve	OI241
BWTS fresh water cooling system supply valve	BA304
No.3 chilled water system expansion tank filling valve	023
Gray water tank (2P) flushing valves	SN251/2/3
Gray water tank (2S) flushing valves	SN254/5/6
No.1 gray water lift tank flushing valves	SN209/10/11
No.2 waste water mix tank flushing valves	SE439/40/41
No.2 black water tank flushing valves	SE430/1/2
Sewage sludge tank flushing valves	SE455/6
Gray water tank (1P) flushing valves	SN134/5/6
Gray water tank (1S) flushing valves	SN137/8/9
No.1 chilled water system expansion tank filling valve	021
No.1 gray water lift tank flushing valves	SN106/7/8
Bow thruster fresh water system expansion tank filling valve	LC413

Cross-over Valves from the Fresh Water Hydrophore Units

These valves are usually left in the closed position.

Description	Valve
No.2 auxiliary machinery room cross-over valve	678
Fresh water cross-over valve in engine room 2 at frame 70	204
No.3 auxiliary machinery room cross-over valve	660

Filling the Stern Tube Cooling Water Tank

The stern tube cooling water tank is filled with water from the distilled water storage tank as required.

a) Using the stern tube cooling water tank self-closing test valve SP773 check the level of water in the tank. This valve is positioned 1.000mm (39 inches) above the the shaft center line, and indicates the maximum water level.

b) Assess the quantity of fresh water needing to be transferred to maintain efficient cooling of the stern tube.

c) Confirm sufficient water is available in the distilled water tank then swing the spectacle blank on the supply line to the open position. When ready, open the fresh water supply valve HC800.

d) When the tank has been filled to its maximum level (checked by opening self-closing test valve SP773), close the filling valve and swing the spectacle blank to the closed position.

e) Enter the details of the transfer in the Engine Room Log Book.

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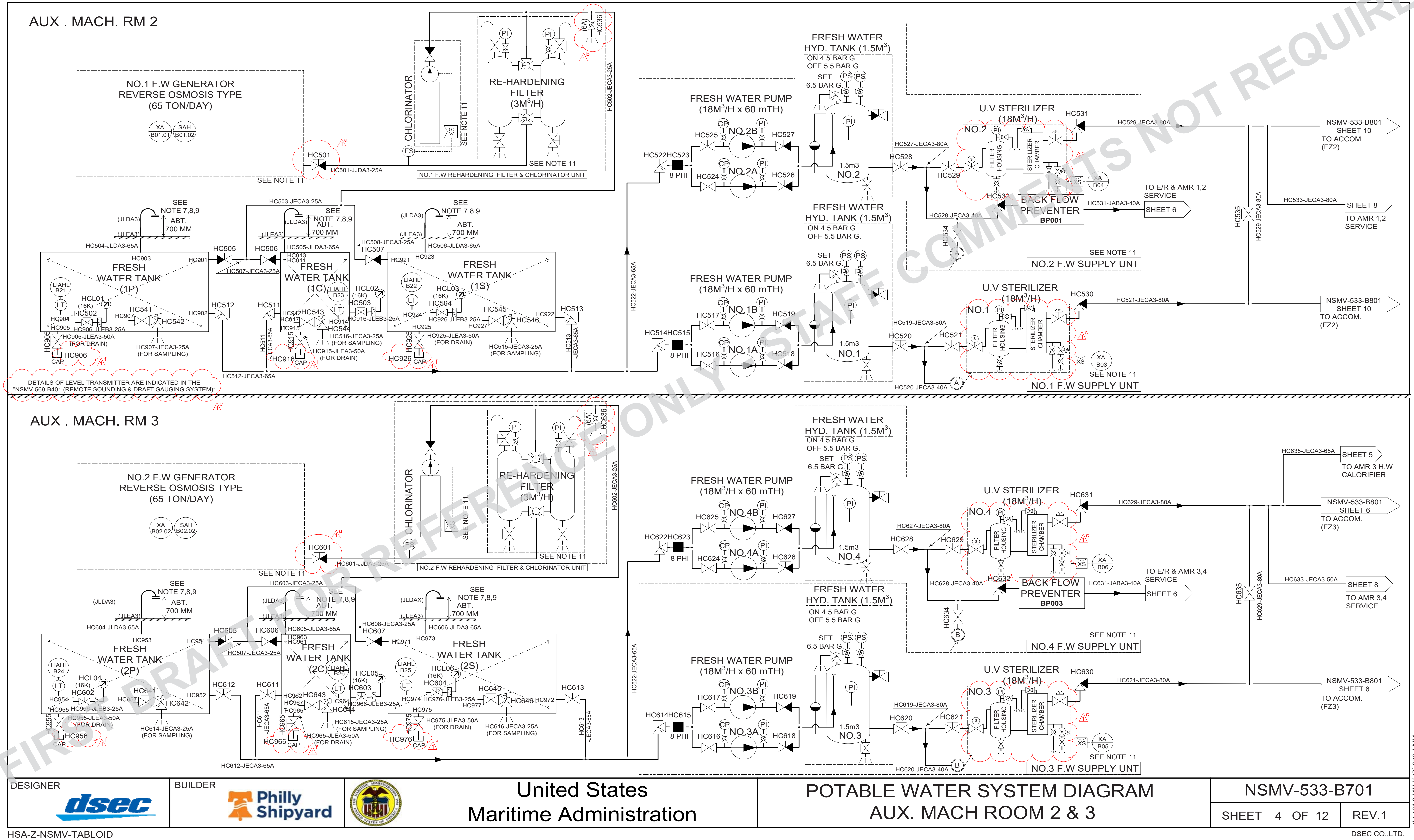
Illustration 6.1.4a Water Treatment System *(Authors note: Illustration currently in progress)*



6.1.4 WATER TREATMENT SYSTEM

Fresh Water Chlorinator

Manufacturer:	Samkun
Type:	Storage tank with dosing pump
Model:	AC-001
No. of sets:	2
Capacity:	100 litres
Dosing pump capacity:	$3m^3/h$ ($106ft^3/h$) at 3 bar

Fresh Water Rehardening Filter

Manufacturer:	Samkun
Type:	Mineral filter
Model:	REH08-03
No. of sets:	2
Capacity:	$3m^3/h$

Fresh Water Steriliser

Manufacturer:	Samkun
Type:	Ultraviolet
Model:	JSA-20
No. of sets:	4
Capacity:	$18m^3/h$ ($636ft^3/h$)
Power:	1 kW, 120VAC, 60Hz, 1ph
Lamp:	45W

Introduction

Fresh Water (FW) for domestic, potable water is stored in two sets of three storage tanks port, centre and starboard each side of the centre line in No.2 and No.3 auxiliary machinery rooms. These FW tanks have the following capacities:

- No.1 FW tank (P) $280.6m^3$
- No.1 FW tank (C) $187.0m^3$
- No.1 FW tank (S) $280.6m^3$
- No.2 FW tank (P) $215.8m^3$
- No.2 FW tank (C) $143.9m^3$
- No.2 FW tank (S) $215.8m^3$

The FW is treated in a chlorinator, and a rehardening filter before being directed to the FW storage tanks. The dosing of the water by the chlorinator is automatic, and is set depending on the flowrate of the water. The chlorinator destroys bacteria and sterilises the water before being stored in the FW tanks. The mineral rehardening filter produces the correct pH, and imparts essential chemical salts to the fresh water, making it fit for human consumption. The minerals in the rehardening filter react with the water's natural acidity to form a neutral salt, raising the pH value to between 7 and 8

FW is produced by the No.1 and 2 RO FWGs, and is pumped into the FW tanks. From these tanks, the FW is directed to:

- The FW supply system for the accommodation potable water systems.
- The AMR services system.
- Hot water calorifiers

If required, the distilled water system can be cross-connected to the FW system.

If required, the FW storage tanks can also be directly filled from a barge or shore facility using individual deck filling connections. Before filling the FW storage tanks from a barge or shore facility, the water quality must be checked to ensure that it is fit for human consumption.

CAUTION
The vessel's FW demand is produced by the RO FWGs, although it can be bunkered from a barge or shore facility. FW from a barge or shore facility may not be of the same quality as that produced on board the vessel and may not have been sterilised.

Fresh water consumers include the following:

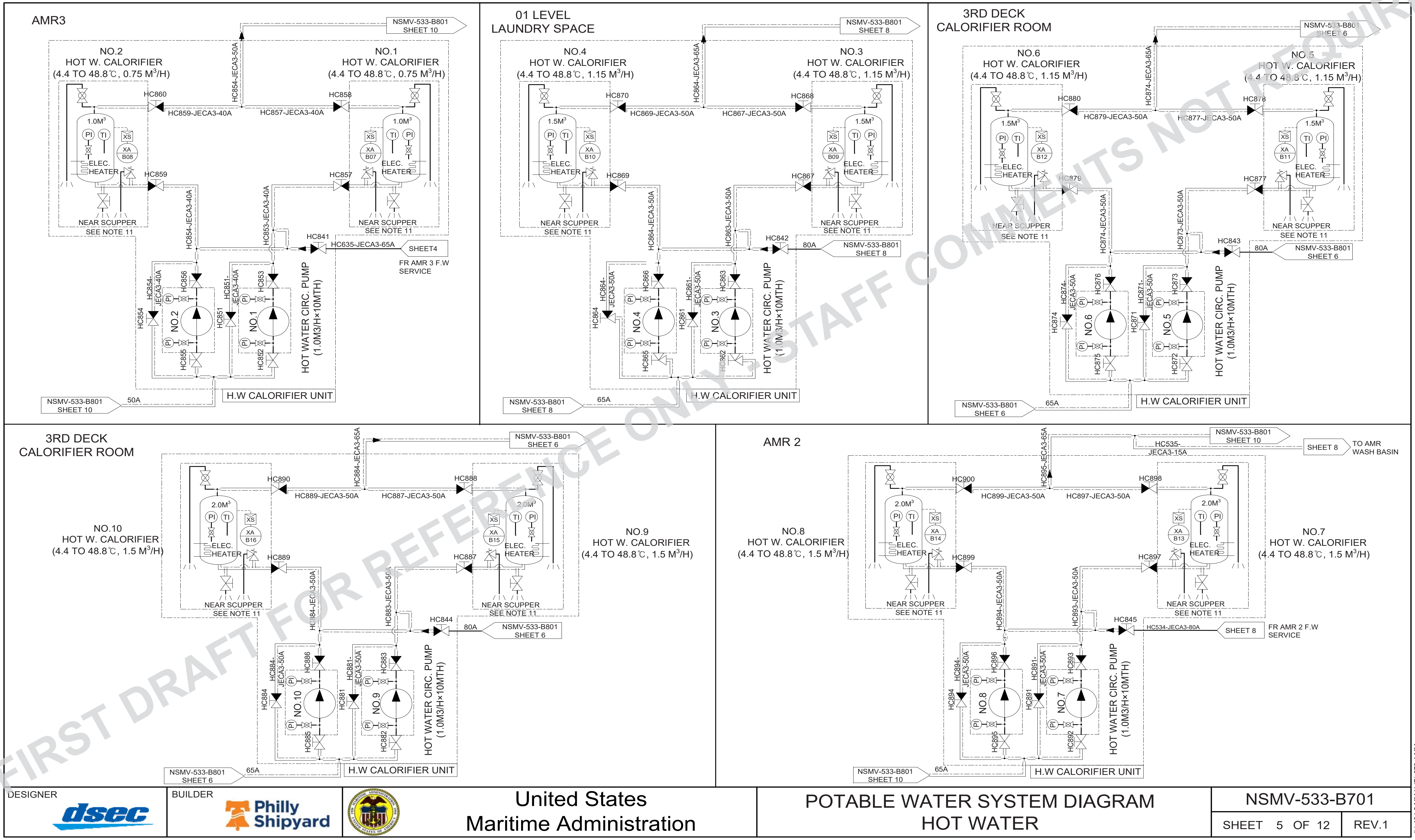
- Domestic and potable fresh water.
- Grey water tanks flushing.
- Black water tanks flushing.
- Waste water tanks flushing.

There are four FW hydrophore units, two units in No.2 auxiliary machinery room, and two units in No,3 auxiliary machinery room. All four units operate in the same manner where the FW hydrophore tank feed pumps takes suction from the FW tanks.

The duty hydrophore tank feed pump pressurises the hydrophore tank, and will start when the pressure falls to 4.5 bar (65psi), and will stop when the pressure rises to 5.5 bar (80psi). The second feed pump is available as a standby pump should the duty pump fail.

The UV steriliser uses UV light to break down micro-organisms in the fresh water, maintaining it in a sterile condition.

Illustration 6.1.5a Potable Hot Water System *(Authors note: Illustration currently in progress)*



6.1.5 HOT POTABLE WATER SYSTEM IN MACHINERY SPACES

Hot Water Circulation Pump

Manufacturer:	Naniwa
Model:	BHR-32
Type:	Horizontal, centrifugal
No. of sets:	10
Capacity:	1.0m³/h (35ft³/h) at 1.0 bar (14.5psi)
Motor:	440V, 0.4kW(0.54hp), 3,500 rpm

Calorifier No.1+2 (AMR3)

Manufacturer:	Samkun
Model:	SE-1000E
No. of sets:	2
Capacity:	1.0m³ heater 50kW 2 step+30kW emergency
Flow rate:	0.75m³/hour set temperature 60°C (140°F)

Calorifier No.3+4 (Laundry), 5+6 (3rd deck calorifier room)

Manufacturer:	Samkun
Model:	SE-1500E
No. of sets:	4
Capacity:	1.5m³ heater 77kW 2 step+30kW emergency
Flow rate:	1.15m³/h (41ft³/h) set temperature 60°C (140°F)

Calorifier No.7+8 (AMR2), 9+10 (3rd deck calorifier room)

Manufacturer:	Samkun
Model:	SE-2000E
No. of sets:	4
Capacity:	2.0m³ heater 134kW 3 step+30kW emergency
Flow rate:	1.5m³/h (53ft³/h)

Introduction

Cold potable water is also supplied to 10 calorifiers where it is heated for use in the domestic hot water system. A calorifier is a thermostatically controlled storage and heating vessel which utilises electricity to provide the heat. The electric heating element are rated between 50~ 134kW, depending on its consumer group. The calorifiers heat the water to 60°C (140°F), but thermostats on the casing can be adjusted to raise or lower this set point. From the calorifier, hot water is circulated around various hot water circuits by hot water circulating pump.

By continuously circulating the hot water in this way, wastage is kept to a minimum, with water not having to be run off to get hot water at an outlet tap or connection.

Operating the Hot Water System

Assume that No.1 FW tank (P) and No.1 FW tank (S) are to be used, with the other FW tanks being filled/in reserve.

The following procedure assumes that the fresh water hydrophore and the accommodation cold potable fresh water systems are already in use. For each Hot Water (HW) system:

a) Set all of the valves shown in the open position following table:

b) Start the hot water circulating pump.

c) Vent the air from the calorifier.

d) Start the calorifier electric heater.

No.1 and No.2 Hot Water Calorifier

Located in AMR3

Description	Valve
FW service system recirculation valve from AMR3	841
No.1 HW circulating pump bypass valve	851
No.1 HW circulating pump suction valve	852
No.1 HW circulating pump discharge valve	853
No.1 HW calorifier inlet valve	857
No.1 HW calorifier outlet valve	858
No.2 HW circulating pump bypass valve	854
No.2 HW circulating pump suction valve	855
No.2 HW circulating pump discharge valve	856
No.2 HW calorifier inlet valve	859
No.2 HW calorifier outlet valve	860

No.3 and No.4 Hot Water Calorifier

Located in 01 Laundry Space

Description	Valve
FW service system recirculation valve from accommodation sanitary supply	842
No.3 HW circulating pump bypass valve	861
No.3 HW circulating pump suction valve	862
No.3 HW circulating pump discharge valve	863
No.3 HW calorifier inlet valve	867
No.3 HW calorifier outlet valve	868
No.4 HW circulating pump bypass valve	864
No.4 HW circulating pump suction valve	865
No.4 HW circulating pump discharge valve	866
No.4 HW calorifier inlet valve	869
No.4 HW calorifier outlet valve	870

No.5 and No.6 Hot Water Calorifier

Located in 3rd Deck Calorifier Room

Description	Valve
FW service system recirculation valve from accommodation sanitary supply	843
No.5 HW circulating pump bypass valve	871
No.5 HW circulating pump suction valve	872
No.5 HW circulating pump discharge valve	873
No.5 HW calorifier inlet valve	877
No.5 HW calorifier outlet valve	878
No.6 HW circulating pump bypass valve	874
No.6 HW circulating pump suction valve	875
No.6 HW circulating pump discharge valve	876
No.6 HW calorifier inlet valve	879
No.6 HW calorifier outlet valve	880

No.7 and No.8 Hot Water Calorifier

Located in AMR2

Description	Valve
FW service system recirculation valve from AMR3	845
No.7 HW circulating pump bypass valve	891
No.7 HW circulating pump suction valve	892
No.7 HW circulating pump discharge valve	893
No.7 HW calorifier inlet valve	897
No.7 HW calorifier outlet valve	898
No.8 HW circulating pump bypass valve	894
No.8 HW circulating pump suction valve	895
No.8 HW circulating pump discharge valve	896
No.8 HW calorifier inlet valve	899
No.8 HW calorifier outlet valve	900

No.9 and No.10 Hot Water Calorifier

Located in 3rd Deck Calorifier Room

Description	Valve
FW service system recirculation valve from accommodation sanitary supply	844
No.9 HW circulating pump bypass valve	881
No.9 HW circulating pump suction valve	882
No.9 HW circulating pump discharge valve	883
No.9 HW calorifier inlet valve	887
No.9 HW calorifier outlet valve	888
No.10 HW circulating pump bypass valve	884
No.10 HW circulating pump suction valve	885
No.10 HW circulating pump discharge valve	886
No.10 HW calorifier inlet valve	889
No.10 HW calorifier outlet valve	890

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ANYTHING TO UPDATE?

It is important that this manual is kept up to date as a live document. If you believe there are any errors or omissions in this manual, or you are aware of changes to the equipment or systems on board then please contact the publishers:

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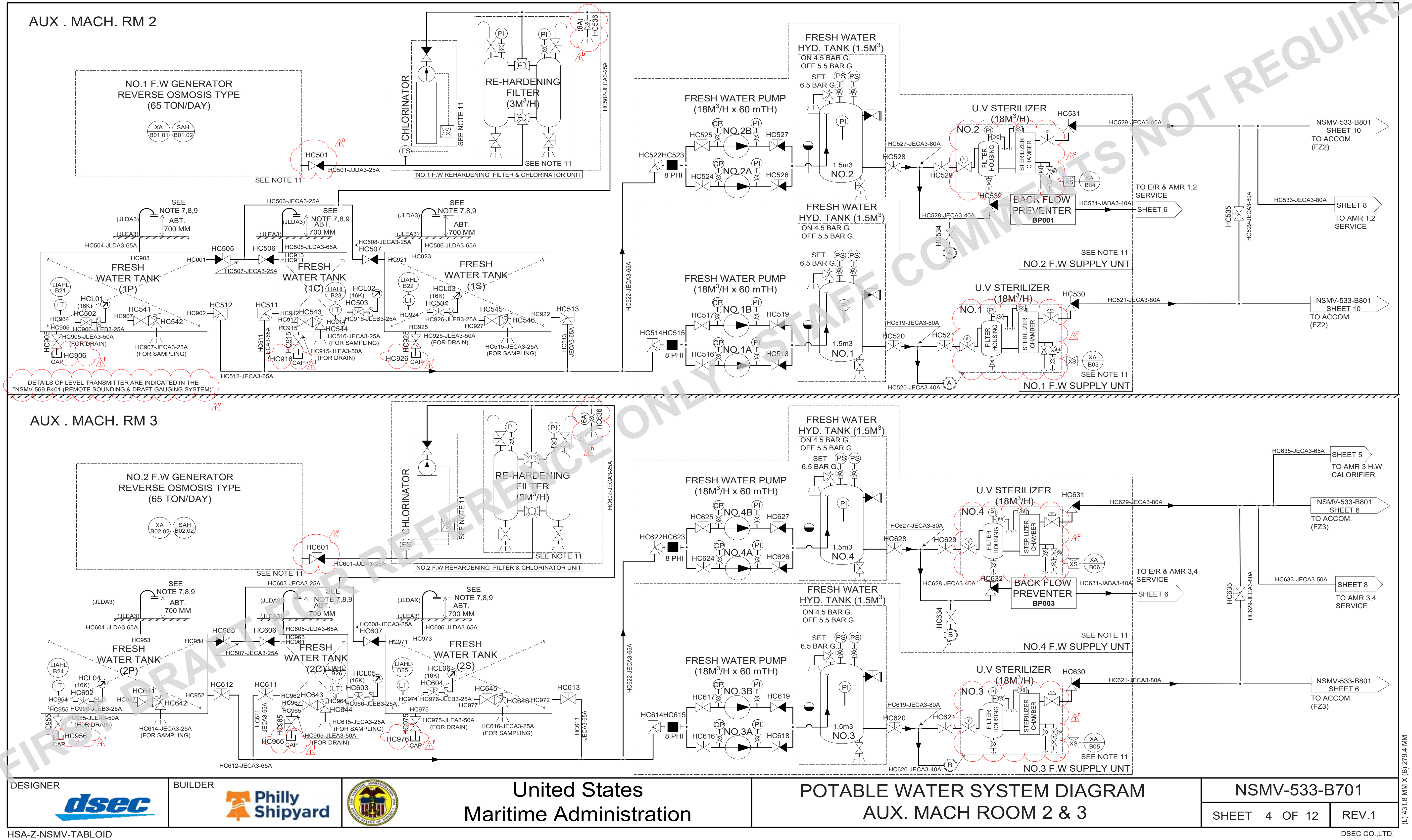
Illustration 6.1.6a Potable Hot Water System *(Authors note: Illustration currently in progress)*



6.1.6 COLD POTABLE WATER SYSTEM IN MACHINERY SPACES

Fresh Water Hydrophore Unit

Manufacturer:	Samkun
Model:	DT-500
No. of sets:	2 (2 tanks per set)
Capacity:	1.5m³
Safety valve setting:	6.5 bar (92psi)

Fresh Water Hydrophore Pumps

Manufacturer:	Naniwa
Model:	BHR-65-2
Type:	Horizontal centrifugal
No. of sets:	4 (1A+1B, 2A+2B, 3A+3B, 4A+4B)
Capacity:	18m³/h (636ft³/h) at 6 bar (87psi)
Pressure switch settings:	Pump start 5.5 bar(80psi), Pump stop 6.5 bar(92psi)
Motor:	440V, 11kW(14.75hp), 3,500 rpm

Introduction

Fresh Water (FW) for domestic, potable water is stored in two sets of three storage tanks port, centre and starboard each side of the centre line in No.2 and No.3 auxiliary machinery rooms. These FW tanks have the following capacities:

- No.1 FW tank (P) 280.6m³
- No.1 FW tank (C) 187.0m³
- No.1 FW tank (S) 280.6m³
- No.2 FW tank (P) 215.8m³
- No.2 FW tank (C) 143.9m³
- No.2 FW tank (S) 215.8m³

If required, the FW storage tanks can also be directly filled from a barge or shore facility using individual deck filling connections. Before filling the FW storage tanks from a barge or shore facility, the quality must be checked to ensure that it is fit for human consumption.

CAUTION
The majority of the vessel's FW demand is produced by the RO FWGs, although it can be bunkered from a barge or shore facility. FW from a barge or shore facility may not be of the same quality as that produced on board the vessel and may not have been sterilised.

FW is produced by the No.1 and 2 RO FWGs, and is pumped into the FW tanks. From these tanks, the FW is directed to:

- The FW supply system for the accommodation potable water systems.
- The AMR services systems.
- Hot water calorifiers

FW consumers include the following:

- Domestic, potable fresh water.
- Grey water tanks flushing.
- Black water tanks flushing.
- Waste water tanks flushing.

There are four FW hydrophore units, two units in No.2 auxiliary machinery room, and two units in No,3 auxiliary machinery room. All four units operate in the same manner where the FW hydrophore tank feed pumps takes suction from the FW tanks.

The duty hydrophore tank feed pump pressurises the hydrophore tank, and will start when the pressure falls to 4.5 bar, and will stop when the pressure rises to 5.5 bar. The second feed pump is available as a standby pump should the duty pump fail. On the hydrophore pump discharge is a UV steriliser which uses UV light to break down micro-organisms in the FW, maintaining it in a sterile condition.

Assume that No.1 FW tank (P) and No.1 FW tank (S) are to be used, with the other FW tanks being filled/in reserve.

Operating the Hydrophore System

a) Start one FW hydrophore tank feed pump on each hydrophore unit.

b) Fill the hydrophore tank with fresh water to around 75% level.

c) Stop the hydrophore pump.

d) Connect a compressed air supply line to the hydrophore tank, open the air inlet valve until the pressure is 5.5 bar.

e) Close the compressed air supply isolation valve.

f) Repeat steps b) to e) until the tank is at the correct operating pressure, with the water level at approximately 75%.

g) Switch one hydrophore pump to AUTOMATIC operation.

h) Slowly open the hydrophore outlet valve on each unit until the FW systems are pressurised.

Operating the Cold Potable Fresh Water System

The following procedure assumes that the FW hydrophore is already in use.

a) Set all of the valves shown in the open position following table:

No.1 and No.2 Hydrophore Units

Located in AMR 2

Description	Valve
No.1 hydrophore tank pumps suction valve	514
No.1 hydrophore tank pump 1A suction valve	516
No.1 hydrophore tank pump 1A discharge valve	518
No.1 hydrophore tank pump 1B suction valve	517
No.1 hydrophore tank pump 1B discharge valve	519
No.1 hydrophore tank discharge valve	520
No.1 UV sterilizer inlet valve	521
No.1 UV sterilizer outlet valve	530
No.2 hydrophore tank pumps suction valve	522
No.2 hydrophore tank pump 2A suction valve	524
No.2 hydrophore tank pump 2A discharge valve	526
No.2 hydrophore tank pump 2B suction valve	525
No.2 hydrophore tank pump 2B discharge valve	527
No.2 hydrophore tank tank discharge valve	528
No.2 UV sterilizer inlet valve	529
No.2 UV sterilizer outlet valve	531
No.1 + No.2 hydrophore pumps cross-over valve (Closed)	535
Back flow preventer BP001 inlet valve (Closed)	532
FW/DW systems cross-over valve (NC)	678

No.3 and No.4 Hydrophore Units

Located in AMR 3

Description	Valve
No.3 hydrophore tank pumps suction valve	614
No.3 hydrophore tank pump 3A suction valve	616
No.3 hydrophore tank pump 3A discharge valve	618
No.3 hydrophore tank pump 3B suction valve	617
No.3 hydrophore tank pump 3B discharge valve	619
No.3 hydrophore tank discharge valve	620
No.3 UV sterilizer inlet valve	621

Description	Valve
No.3 UV sterilizer outlet valve	630
No.4 hydrophore tank pumps suction valve	622
No.4 hydrophore tank pump 4A suction valve	624
No.4 hydrophore tank pump 4A discharge valve	626
No.4 hydrophore tank pump 4B suction valve	625
No.4 hydrophore tank pump 4B discharge valve	627
No.4 hydrophore tank tank discharge valve	628
No.4 UV sterilizer inlet valve	629
No.4 UV sterilizer outlet valve	631
No.3 + No.4 hydrophore pumps cross-over valve (Closed)	635
Back flow preventer BP003 inlet valve (Closed)	632
FW/DW systems cross-over valve (NC)	680

b) Check the UV steriliser for leaks. If there are no leaks, start the UV steriliser.

c) Check the operation of the UV steriliser lamps.

Open the drinking water outlet valves at the extreme ends of the drinking water system to allow water to flow through.

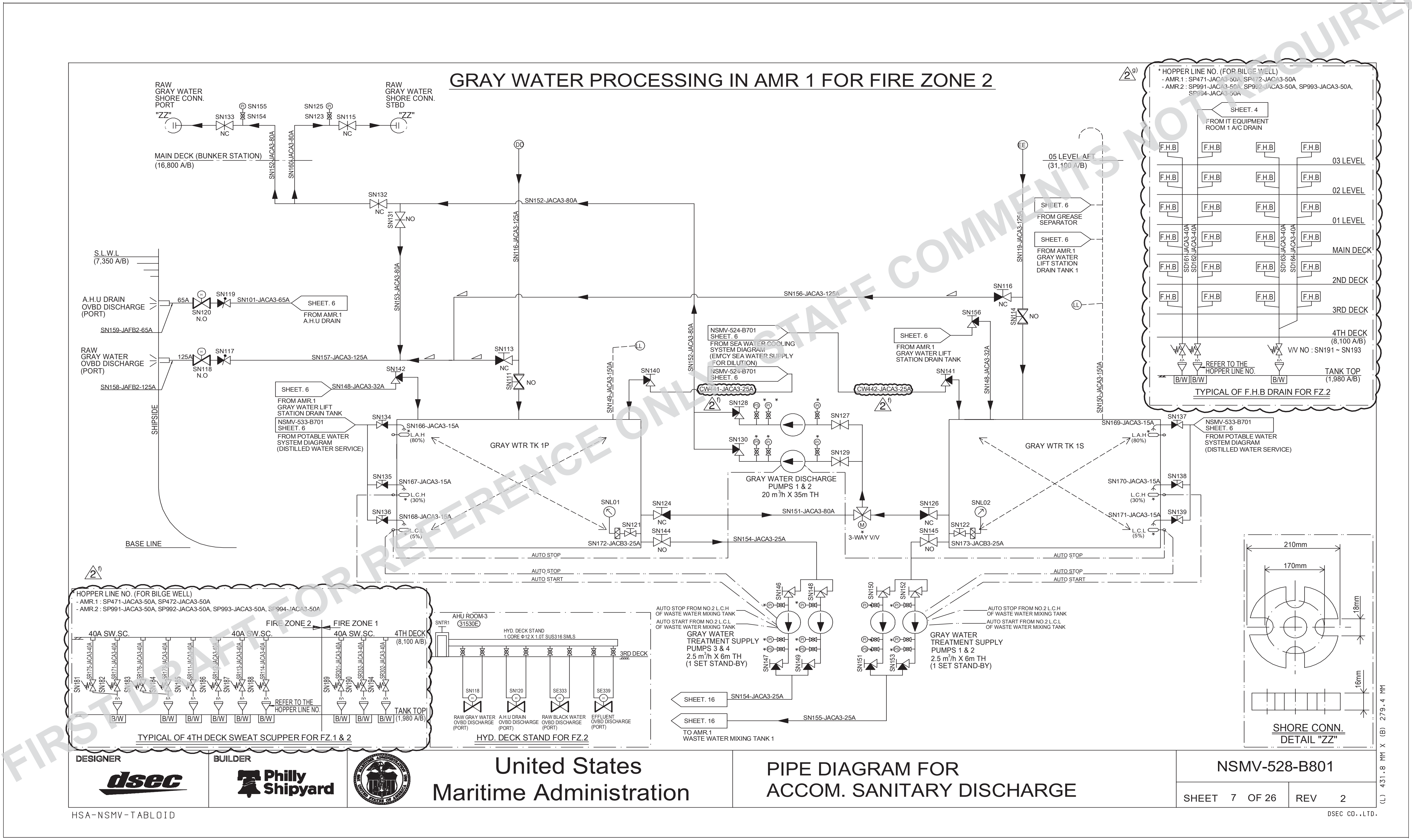
When all system water has passed through the UV steriliser, the drinking water system is ready for operation.

During operation of the drinking water system, a check must be made to make sure that the UV steriliser lamps are illuminated.

Note: Backflow preventers are fitted to No.2 and No.4 hydrophore systems to prevent back flow of DW into the FW system should the FW system act as a back up for the DW system.

6.2 Sewage Systems

Illustration 6.2.1a Grey Water System in AMR 1 *(Authors note: Illustration currently in progress)*



6.2 SEWAGE SYSTEMS

6.2.1 GRAY WATER SYSTEM

Gray Water Discharge Pumps

Manufacturer:	Winter Pumps
Type:	Horizontal centrifugal
Model:	WHA80/315
No. of sets:	2
Capacity:	20m^3/h (706ft^3/h) at 3.5 bar (51psi)
Motor:	440V, 13kW(17hp), 1,800 rpm

Gray Water Treatment Pumps

Manufacturer:	Borger
Type:	Horizontal centrifugal
Model:	AN040, BFA1/21 DN 25 in AMR1 AN040, BF21 DN 25 in AMR4
No. of sets:	8 (AMR1 x 4 + AMR4 x 4)
Capacity:	5m^3/h (177ft^3/h) at 1 bar (14.5psi)
Motor:	440V, 0.8kW(1.1hp), 1,730/208 rpm helical drive

Gray Water Lift Station Transfer Pumps

Manufacturer:	Borger
Type:	Horizontal centrifugal
Model:	AN040, BF21 DN 32
No. of sets:	3 (AMR1 x 1 + AMR4 x 1 + ER2 x 1)
Capacity:	5m^3/h (177ft^3/h) at 1.0 bar (14.5psi)
Motor:	440V, 0.8kW(1.1hp), 1,730/208 rpm helical drive

Introduction

The accommodation Gray Water (GW) system collects water from showers, baths and hand washbasins in the accommodation; this GW then falls by gravity to GW lift station drain tanks No.1 and No.2. GW from the helicopter/cargo deck, and the Ro/Ro space fall by gravity to the ER2 GW lift station No.3 The GW is then pumped out by GW transfer pumps to four GW tanks, two of which are located in AMR1, and two in AMR4.

From the GW tanks, the water may be discharged to the waste water treatment system, overboard, or ashore via the bunker stations. The GW tanks can be flushed with sea water as required. The GW tanks are pumped out by means of the GW discharge pumps. Overboard discharge of GW must be monitored. If a GW tank has to be shut down for maintenance, there is a cross-over valve which can be opened for filling the companion tank. Galley GW passes through a grease separator before entering the gray water tanks.

Each GW lift station tank is fitted with two electrically-driven, self-priming centrifugal pumps, which discharge to the GW tanks. Starting and stopping of these pumps is controlled by the float type level transmitters. The GW tanks discharge to the waste water mixing tanks.

GW from the galley areas flows via a grease separator to the sewage sludge tank. The grease trap is fitted with and electric heating element, manual cleaning facility and a bypass system fitted with valves.

The galley GW filter discharge pump operates in a similar way to the GW tank pumps. This pump takes suction from the galley grease filter, and discharges to the sewage sludge tank.

Black Water (BW) drains from the hospital flow directly to GW tank 2P, as do the laundry drains.

The GW overboard discharges are located below the water line, aft of the sea water inlet connections, thus there is no risk of contaminated sea water being brought into the ship for use in the FW generators.

Procedure to Operate the Gray Water System

Each GW lift station drain tank has dedicated inlet connections from the collecting manifold from the 4th deck. This tank is then pumped out to the GW tanks. The GW drains from the 3rd deck collecting manifold drains directly to the GW tanks.

The contents from the GW tanks is then pumped to the waste water treatment system.

a) Check that the valves to all instruments and gauges are open and that the instruments and gauges are working.

b) Check that all tank float switches are functional and have been cleaned where that facility exists.

c) Check that there is electrical power available.

d) Open all system pump suction and discharge valves.

e) Open the washing water inlet. Allow the tank to fill until the high level alarm operates. Shut off the fresh water supply. In the case of the grease separator, switch on the electric heating, and drain valves at the grease separator.

f) Check the operation of the discharge pumps; manually start each pump by turning the pump switch to the MAN position for a short period of time. Check that both pumps operate correctly, then turn the pump switch to the O (Off) position.

g) Select the discharge pumps for automatic operation by turning the pump switch to AUTO, and set one pump as the duty pump.

h) Open the GW lift station drain tanks inlet and outlet valves.

i) Open the GW tanks inlet and outlet valves.

The GW system is now in service. It should be noted that, as the GW tanks cannot be directly cross-connected to each other. However, each of the GW collecting mains can be crossed connected by opening/closing cross connection valve SD101/SD102.

Air Handling Units (AHUs) drains are led directly to overboard via hydaulically controlled overboard valves (P+S).

GWmimics provide the operator with remote access to system valves. If GW is to be discharged directly overboard, permission must be given by the bridge and discharge is only allowed in designated areas. Discharge valves to the different locations are set manually, only hydraulically operated overboard valves are operated remotely. Normally, GW is discharged to the waste water mixing tanks where it is mixed with black water before being directed to the waste water treatment system

The GW tanks may also be pumped directly ashore. This requires the line valve to the shore discharge at the bunker stations to be open. The discharge hose must be connected at the bunker station after the pipe blank has been removed, and the discharge valve must be opened.

Procedure for Pumping the Gray Water System for Onward Treatment

> **Note:** GW may only be discharged overboard when approval has been given by the officer of the watch on the bridge.

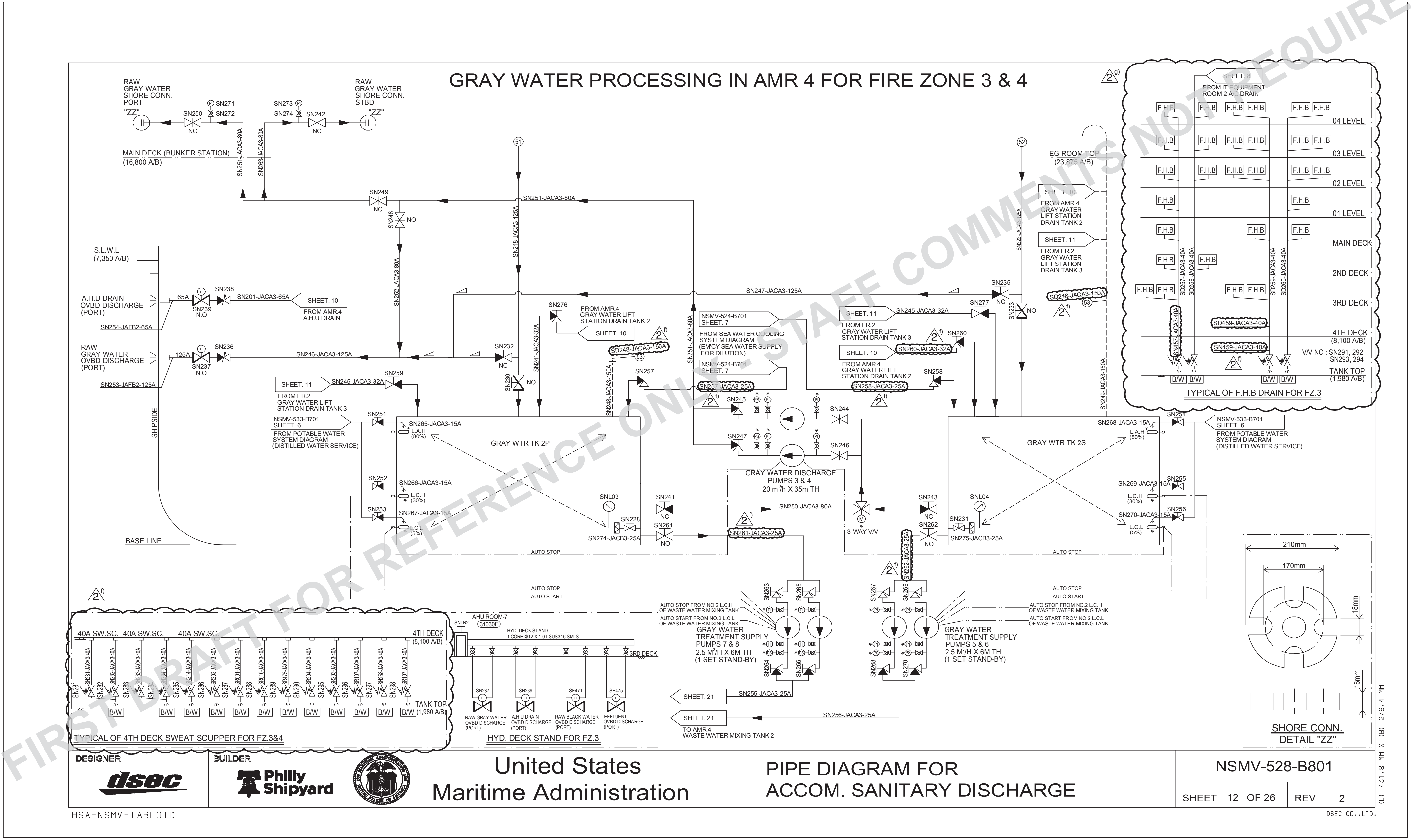
The GW lift station drain tanks are pumped out using one of the associated GW transfer pumps. The GW transfer pumps take suction from the lift station tank, and discharge into the GW tanks.

a) Check that valves to all instruments and gauges are open and that the instruments and gauges are working correctly.

b) Ensure that there is electrical power available at all relative pumps.

c) Set the valves as in the following table. Normally, GW is discharged to the waste water mixing tank before entering the

Illustration 6.2.1b Gray Water System in AMR 4 *(Authors note: Illustration currently in progress)*



waste water treatment plant and the valve table below shows the setting for this. Different pumps have different valve numbers.

Auxiliary Machinery Room 1 System

Lift Station Drain Tank No.1

All valves are prefixed SN unless otherwise shown

Position	Description	Valve
Set	3rd deck collecting manifold bypass valves	SD101/2
Open	4th deck collecting manifold inlet valves to lift station	104/5
As required	Distilled water flushing valves to lift station	106/7/8
Open	GW lift station transfer pump suction valve	109
Open	GW lift station transfer pump discharge valve	110
Open	Sewage sludge tank inlet valves from grease separator	SE450/1
Open	AHU drain valves to overboard (SN120 NO)	200/120

Gray Water Tanks 1P+1S

Position	Description	Valve
Open (NO)	GW tank 1P inlet valve from 3rd deck GW collecting manifold drains	111
Open (NO)	GW tank 1P inlet valve from No.1 GW lift station	142
As required	Distilled water flushing valves to GW tank 1P	134/5/6
Closed	Sea water flushing/diluting valve	140
Closed (NC)	GW direct overboard valve	113
Open (NO)	GW tank 1S inlet valve from 3rd deck GW collecting manifold drains	114
Open (NO)	GW tank 1S inlet valve from GW lift station	156
As required	Distilled water flushing valves to GW tank 1S	137/8/9
Closed	Sea water flushing/diluting valve	141
Closed (NC)	GW direct overboard valve	116
Closed (NO)	GW direct overboard shipside valve	118

Gray Water Discharge Pumps No.1 + No.2

These pumps are only used when pumping tank contents ashore/overboard.

Position	Description	Valve
Open	GW pumps suction valve from GW tank 1P	124
Open	GW pumps suction valve from GW tank 1S	126
Set	3-way motorized valve	
Open	No.1 GW discharge pump suction valve	127
Open	No.1 GW discharge pump discharge valve	128
Open	No.2 GW discharge pump suction valve	129
Open	No.2 GW discharge pump discharge valve	130
Open (NO)	GW line discharge valve to overboard	131
Closed (NC)	GW line discharge valve to shore manifolds	132
Closed (NC)	Raw GW shore connection valve (P)	133
Closed (NC)	Raw GW shore connection valve (S)	115

Gray Water Treatment Supply Pumps No.1 + No.2

Position	Description	Valve
Open (NO)	GW treatment supply pumps suction valve from GW tank 1S	145
Open	No.1 GW treatment supply pump suction valve	152
Open	No.1 GW treatment supply pump discharge valve	153
Open	No.2 GW treatment supply pump suction valve	150
Open	No.2 GW treatment supply pump discharge valve	131

Gray Water Treatment Supply Pumps No.3 + No.4

Position	Description	Valve
Open (NO)	GW treatment supply pumps suction valve from GW tank 1P	144
Open	No.3 GW treatment supply pump suction valve	146
Open	No.3 GW treatment supply pump discharge valve	147
Open	No.4 GW treatment supply pump suction valve	148
Open	No.4 GW treatment supply pump discharge valve	149

Auxiliary Machinery Room 4 System

Lift Station Drain Tank No.2

Position	Description	Valve
Set	3rd deck collecting manifold bypass valves	SD201/2
Open	4th deck collecting manifold inlet valves to lift station	207/8
As required	Distilled water flushing valves to lift station	209/10/11
Open	GW lift station transfer pump suction valve	212
Open	GW lift station transfer pump discharge valve	213
Open	Sewage sludge tank inlet valves from grease separator	SE450/1
Open (NO)	AHU drain valves to overboard (NO)	239

Engine Room 2 System

Lift Station Drain Tank No.3

Position	Description	Valve
As required	Helicopter/cargo deck module hook up connections	215/6
As required	Ro/Ro cargo space module hook up connections	217/8/9
As required	Distilled water flushing valves to lift station	223/4/5
Open	No.3 GW lift station transfer pump suction valve	226
Open	No.3 GW lift station transfer pump discharge valve	227
Open	No.3 GW lift station line valve	229

Gray Water Tanks 2P + 2S

Position	Description	Valve
Open (NO)	GW tank 2P inlet valve from 3rd deck GW collecting manifold drains	230
Open (NO)	GW tank 2P inlet valve from No.2 GW lift station	276
Open	GW tank 2P inlet valve from No.3 GW lift station	259
As required	Distilled water flushing valves to GW tank 1P	251/2/3
Closed	Sea water flushing/diluting valve	257
Closed (NC)	GW direct overboard valve	232
Open (NO)	GW tank 2S inlet valve from No.3 GW lift station	277
Open	GW tank 2S inlet valve from No.2 GW lift station	260
As required	Distilled water flushing valves to GW tank 1S	254/5/6
Closed	Sea water flushing/diluting valve	258
Closed (NC)	GW direct overboard valve	235
Closed (NO)	GW direct overboard shipside valve	237

Gray Water Discharge Pumps No.3 + No.4

These pumps are only used when pumping tank contents ashore/overboard

Position	Description	Valve
Open	GW pumps suction valve from GW tank 2P	251
Open	GW pumps suction valve from GW tank 2S	252
Set	3-way motorized valve	
Open	No.3 GW discharge pump suction valve	244
Open	No.3 GW discharge pump discharge valve	245
Open	No.4 GW discharge pump suction valve	246
Open	No.24 GW discharge pump discharge valve	247
Open (NO)	GW line discharge valve to overboard	248
Closed (NC)	GW line discharge valve to shore manifolds	249
Closed (NC)	Raw GW shore connection valve (P)	250
Closed (NC)	Raw GW shore connection valve (S)	251

Gray Water Treatment Supply Pumps No.5 + No.6

Position	Description	Valve
Open (NO)	GW treatment supply pumps suction valve from GW tank 2S	262
Open	No.5 GW treatment supply pump suction valve	267
Open	No.5 GW treatment supply pump discharge valve	268
Open	No.6 GW treatment supply pump suction valve	269
Open	No.6 GW treatment supply pump discharge valve	270

Gray Water Treatment Supply Pumps No.7 + No.8

Position	Description	Valve
Open (NO)	GW treatment supply pumps suction valve from GW tank 2P	261
Open	No.7 GW treatment supply pump suction valve	263
Open	No.7 GW treatment supply pump discharge valve	264
Open	No.8 GW treatment supply pump suction valve	265
Open	No.8 GW treatment supply pump discharge valve	266

d) Ensure that the GW treatment supply pumps have been set to REMOTE operation, and select the pumps for AUTO starting.

e) The pump will cut in/out on the level control in the GW tank, and in the waste water mixing tank.

CAUTION
Gray water must not be pumped overboard except in waters where the discharge is permitted. The bridge must always be consulted before any discharge of gray water.

Procedure to Discharge Gray Water Ashore

GW may be transferred ashore by the GW transfer pumps. Before any transfer takes place, agreement must be reached with the shore reception facility regarding the quantity of water to be discharged, the pumping rate, and the quality of the water. The GW transfer pumps from the individual GW tanks are used to discharge into the GW transfer line, and the valves set so that the selected bunker station to be used receives the water flow.

The shore discharge connections are situated at the bunker stations on the port and starboard sides of the ship at deck A level. There are two discharge connections at each bunker station, each having a valve; the discharge connections are fitted with a blanks.

The shore connection pipe should be connected to the shore discharge pipe at either the port or starboard bunker stations and the bunker station valve opened. The other bunker station valve must be confirmed as closed and blanked.

Auxiliary Machinery Room 1 System

Set the GW transfer valves as in the following, and assume discharge is through the port GW port shore connection.

Gray Water Discharge Pumps No.1 + No.2

These pumps are only used when pumping tank contents ashore/overboard

Position	Description	Valve
Open	GW pumps suction valve from GW tank 1P	124
Open	GW pumps suction valve from GW tank 1S	126
Set	3-way motorized valve	
Open	No.1 GW discharge pump suction valve	127
Open	No.1 GW discharge pump discharge valve	128
Open	No.2 GW discharge pump suction valve	129
Open	No.2 GW discharge pump discharge valve	130
*Closed (NO)	GW line discharge valve to overboard	131
**Open(NC)	GW line discharge valve to shore manifolds	132
**Open (NC)	Raw GW shore connection valve (P)	133
**Closed (NC)	Raw GW shore connection valve (S)	115

* Open when discharging overboard.
** Closed when discharging overboard

Auxiliary Machinery Room 4 System

Gray Water Discharge Pumps No.3 + No.4

These pumps are only used when pumping tank contents ashore/overboard

Position	Description	Valve
Open	GW pumps suction valve from GW tank 2P	251
Open	GW pumps suction valve from GW tank 2S	252
Set	3-way motorized valve	
Open	No.3 GW discharge pump suction valve	244
Open	No.3 GW discharge pump discharge valve	245
Open	No.4 GW discharge pump suction valve	246
Open	No.24 GW discharge pump discharge valve	247
*Closed (NO)	GW line discharge valve to overboard	248
**Open (NC)	GW line discharge valve to shore manifolds	249
**Open (NC)	Raw GW shore connection valve (P)	250
**Closed (NC)	Raw GW shore connection valve (S)	251

* Open when discharging overboard.
** Closed when discharging overboard

On completion of transfer, enter the transfer details in the Engine room log book.

6.2.2 BLACK WATER VACUUM UNITS

Vacuum Collection Unit

Manufacturer:	EVAC
Type:	OnlineFlex 2 FX 60
No. of sets:	2

Vacuum Collection Unit Vacuum Pump

Type:	Horizontal rotary lobe
No. of sets:	2 per unit
Capacity:	600 litre/h (2.64gpm) at -0.5 bar (-51kPa)

Black Water Discharge Pumps

Manufacturer:	Winter Pumps
Type:	Horizontal centrifugal
Model:	WHA80/315
No. of sets:	2
Capacity:	20m^3/h (706ft^3/h) at 3.5 bar (51psi)
Motor:	440V, 13kW(17.4hp), 1,800 rpm

Introduction

The Black Water (BW) collection pipes from the accommodation are connected to two separate vacuum collecting units, each unit having connections from different parts of the ship. No.1 vacuum collection unit serves Fire Zone (FZ) 1, and No.2 vacuum collection unit serves FZ 3 and 4. The outlet lines from No.1 and No.2 vacuum collection units are cross-connected which allows BW to be directed to either BW tank due to maintenance requirements.

Each vacuum collection unit has sufficient capacity for all zones it may be called upon to serve. The vacuum collection units have two vacuum pumps, for generating the vacuum, the BW collected by the unit flows by gravity to its associated BW tank. Normally, one vacuum pump is are set to operate and the second is on standby.

Automatic Operation of Sewage (Vacuum) Pumps

Manually select the pump MAN-0-AUTO switch to AUTO. The sewage pumps starting and stopping pre-set setpoints are -40kPa to -60kPa. at the vacuum manifold. When vacuum level drops to -40 kPa, the first pump starts to generate vacuum. Stopping set point of the vacuum pump is at -60 kPa. If the vacuum pump does not meet the required vacuum level within 10 seconds, the second vacuum pump will start to generate vacuum. Both pumps shall run until the stop point -60 kPa is reached. If the vacuum level drops to -20 kPa, both pumps will start immediately generating vacuum.

Manual Operation of Sewage (Vacuum) Pumps

Manual mode is a totally manual operation with no automatic operation in this mode. Manually turn all pumps MAN-0-AUTO switch to 0 and then by turning one or both pumps to MAN, the built-in vacuum generation logic is by-passed. A pump(s) selected to run in MAN mode will be operating until stopped by the operator.

Process Alarms

The control panel alarms are reset by pressing the control switch 'ALARM RESET'. The common alarm contact is open when at least one alarm is activated. If a new alarm is activated whilst common alarm contact is already open, contact first closes for 5 seconds' and then opens again to indicate, that new alarm is activated.

Purpose of the Vacuum Collection Units

The reduced pressure in the vacuum unit ensures that waste from lavatory pans flows quickly, thus ensuring rapid evacuation of the pans and associated pipework. A number of individual lavatory pans connect with a downcomer and a number of downcomers connect with a header supplying the vacuum unit. Vacuum is maintained by the duty vacuum pump. The BW is removed from the collecting unit by gravity unit to the BW tank. A BW discharge pump may also pump the black water overboard (where permitted) or ashore via the bunker stations, depending upon the setting of discharge valves.

The vacuum pumps are normally selected for AUTO operation at the local control panel, and they will operate automatically to maintain the vacuum in the collection pipes and the level in the collection tank respectively.

The collecting units, BW tanks, waste water mixing tanks, and waste water treatment plants are vented separately at the top of the funnel.

Operation of the Black Water Vacuum Collection Units

Starting the System

a) Open the shut-off valves (V003, V006, V007, V010)

b) Open valve V002

c) Check that valves V001, V005, V009 is closed.

d) Fill the unit and pipelines with water before starting the unit.

e) Turn the power on.

f) Ensure the pumps are running at the right direction.

g) Turn the operation switch/switches to AUTO.

h) Turn all switches to AUTO.

i) Press the Restart button.

Shut down

a) Close the shut-off valve (V003, V007) on the inlet lines.

b) Turn all switches to 0.

c) Turn power Off and close all the isolation valves in the outlet line.

Black Water System Line-up

Collection and transfer units are set locally for automatic operation. The vacuum unit maintains a vacuum in the collecting line. Each BW collection unit is identical and all operate in the same way.

a) Ensure that valves to all instruments and gauges are open and that the instruments and gauges are operating correctly.

b) Ensure that all accommodation lines are operational.

c) Ensure that electrical power is available at the sets.

e) If the unit has not been operated for some time, flush through the main connecting line to the vacuum ejectors and the tank system with non-potable water.

f) Set the valves as in the following table:

CAUTION
Gray water must not be pumped overboard except in waters where the discharge is permitted. The bridge must always be consulted before any discharge of gray water.

Vacuum Collecting Unit No.1 in AMR1

All valves are prefixed SE unless otherwise shown, and all valves to be open:

Description	Valve
BW collecting line isolation valves from FZ 2 main deck	301~04 360~61
BW collecting line isolation valves from FZ 2 2nd ~ 4th deck	303~05 356~359
No.1 vacuum collection unit outlet valve	306
No.1 BW tank inlet valve	307
Cross-over valve between No.1~2 BW tanks	308 (NC)
Distilled water flushing valves to No.1 BW tank	309/10/11

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Pumping No.1 BW Tank Ashore/Overboard

Black Water Discharge Pumps No.1 + No.2

These pumps are only used when pumping tank contents ashore/overboard

Position	Description	Valve
Open (NC)	No.1 BW tank suction valve	326
Open	No.1 BW discharge pump suction valve	327
Open	No.1 BW discharge pump discharge valve	328
Open	No.2 BW discharge pump suction valve	329
Open	No.2 BW discharge pump discharge valve	330
Open (NO)	BW discharge line valve	331
*Open (NO)	Raw BW overboard valve	333
**Closed (NC)	BW discharge line valve to shore manifolds	334
Closed (NC)	BW discharge pumps recirculation valve	340
**Closed (NC)	Raw BW shore connection valve (P)	346
**Closed (NC)	Raw BW shore connection valve (S)	336

* Open when discharging overboard.
** Open when discharging to shore

Vacuum Collecting Unit No.2 in AMR4

Description	Valve
BW collecting line isolation valves from FZ3~4 2nd deck	401/02/08 423/488~90
No.2 vacuum collection unit outlet valve	424
BW tank inlet valve (NO)	425
Cross-over valves between No.1~2 BW tanks	427 (NC) 428/9
Distilled water flushing valves to No.1 BW tank	430/31/32

Black Water Discharge Pumps No.3 + No.4

These pumps are only used when pumping tank contents ashore/overboard

Position	Description	Valve
Open (NC)	No.2 BW tank suction valve	463
Open	No.3 BW discharge pump suction valve	464
Open	No.3 BW discharge pump discharge valve	465
Open	No.4 BW discharge pump suction valve	466
Open	No.4 BW discharge pump discharge valve	467
Open (NO)	BW discharge line valve	469
*Open (NO)	Raw BW overboard valve	471
**Closed (NC)	BW discharge line valve to shore manifolds	472
Closed (NC)	BW discharge pumps recirculation valve	468
**Closed (NC)	Raw BW shore connection valve (P)	421
**Closed (NC)	Raw BW shore connection valve (S)	473

* Open when discharging overboard.
** Open when discharging to shore

CAUTION

Black water may only be pumped overboard in certain sea areas and restrictions must be complied with. Pumping of black water overboard must be recorded in the log book with mention of location, time and pumping rates

Ensure that each vacuum collecting unit is operational with the BW line valves to the collecting manifold open so that all associated areas are served. Cross-connection valves with the other collecting unit should be closed, and the inlet valves to the collecting unit from the collecting manifold must be open. The vacuum pump valves must be open. The BW discharge pump valves will be opened as required when pumping overboard/ashore. To prevent accidental discharges overboard/ashore, valves to the overboard discharge, and the shore connections at the bunker station must be closed.

Before a BW collecting unit is put into operation, it is necessary to check the functioning of the BW tank level switches, and level alarm. The operation of the vacuum pumps must also be checked.

The sewage BW collection systems are now ready for operation.

Operating of the Black Water Collection System

BW will be collected by the BW collecting units, and each will discharge BW by gravity into the BW tank.

Note: Lavatory pans discharge automatically when flushed. A small amount of flushing water is used to flush the bowl and to seal the outlet after flushing. All lavatory pans must be allowed flow to the collection unit without obstruction. All valves must be open when the system is in operation.

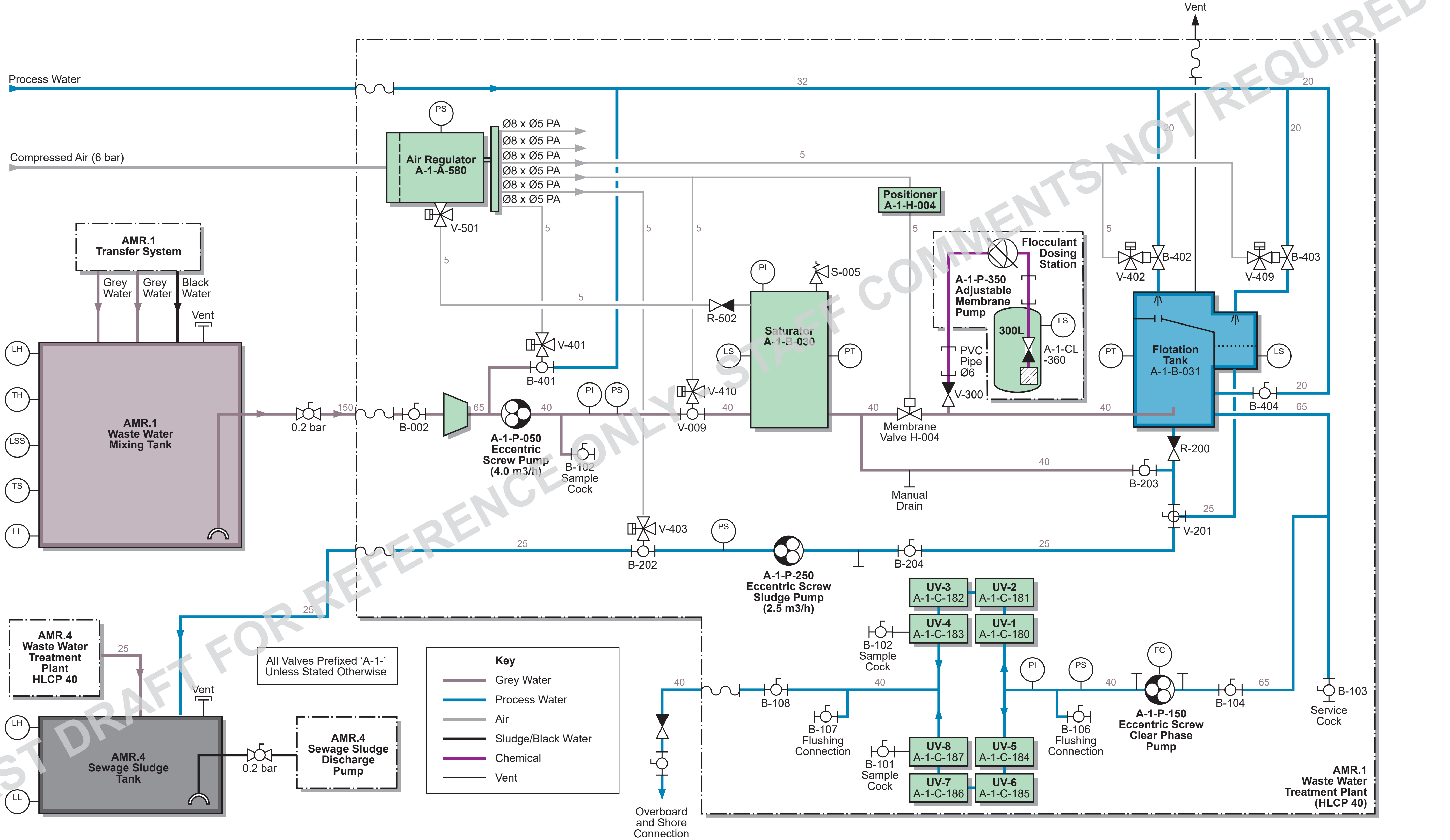
The sewage collection system will normally be monitored and operated via its local control panel, but it is necessary to check the operation of the system visually at daily intervals in order to ensure that there are no leakages.

Safe Return To Port

All personnel involved with the operation of the sewage collection and treatment plant must be conversant with the contents of Black Water Collecting System Regulations to satisfy Safe Return to Port requirements.

The BW collecting and transfer system is fitted with a number of Safe Return to Port valves which enables the system to be separated should a critical SRtP condition exist. These valves are clearly identified in AMR4 with red tags. Valves should be closed/opened as required in order to ensure that BW collection is available in the ship even with engine room compartments not functioning. Engineering staff must know the location of SRtP valves in the machinery spaces and these valves should be test opened/closed at intervals to ensure that they are able to function in the event of a SRtP condition.

Illustration 6.2.3a AMR1 Waste Water Treatment System



Reference Drawing: DV582A002R0 - NSMV-593-V801-R0 WASTE WATER TREATMENT PLANT

6.2.3 SEWAGE - BLACK WATER TREATMENT UNITS

Sewage Treatment Unit (HLCP 40)

Manufacturer:	Hamann
Type:	Dissolved air flotation (DAF)
Model:	HL-CONT Plus 40
No. sets:	2
Capacity:	96,000 litres/day
Sludge production:	2,975 litres/day
Biological loading rate:	46.5kg/d BOD

Black Water Treatment Supply Pump

Manufacturer:	Borger
Type:	Horizontal rotary lobe
Model:	AN040, BF1/21 DN 25
No. of sets:	4 (AMR1 x 2 + AMR4 x 2)
Capacity:	1.0m^3/h (35ft^3/h) at 3.5 bar (51psi)
Motor:	440V, 0.7kW(0.94hp), 1,730/129 rpm helical drive

Grey Water Treatment Supply Pump

Manufacturer:	Borger
Type:	Horizontal rotary lobe
Model:	AN040, BF1/21 DN 25
No. of sets:	4 (AMR1 x 2 + AMR4 x 2)
Capacity:	2.5m^3/h (88ft^3/h) at 3.5 bar (51psi)
Motor:	440V, 1.0kW(1.3hp), 1,730/183 rpm helical drive

Macerator Pump (A-1-Z-080)

Manufacturer:	Allweiler
Type:	Horizontal, centrifugal
Model:	ABM 10S-1
No. of sets:	2 (2 pumps/unit)
Capacity:	4m^3/hour (141ft^3/hour) at 0.6 bar (8.7psi)
Motor:	440V, 6.6kW(9hp), 1,760 rpm

Feeding Pump (A-1-P-050)

Manufacturer:	Netzsch
Type:	Horizontal, progressive cavity
Model:	Nemo NM038BY - SK20/90
No. of sets:	2 (1/unit)
Capacity:	4m^3/hour (141ft^3/hour) at 0.2 bar (3psi)
Motor:	440V, 1.75kW(2.3hp), 1,725/196 rpm gear drive

Clear Phase Pump (A-1-P-150)

Manufacturer:	Netzsch
Type:	Horizontal, progressive cavity
Model:	Nemo NM038BY - SK20F/90FU
No. of sets:	2 (1/unit)
Capacity:	4m^3/hour (141ft^3/hour) at 0.005 bar
Motor:	440V, 1.75kW(2.3hp), 1,415/190 rpm VF drive

Air Compressor (A-0-V-580)

Manufacturer:	Becker
Type:	Horizontal, rotary vane
Model:	KDT 3.60
No. of sets:	2 (1 compressor/unit)
Capacity:	63m^3/hour (2,225ft^3/hour) at 6 bar (87psi)
Motor:	440V, 2.6kW(3.5hp), 1,735 rpm

Waste Water Sludge Discharge Pump

Manufacturer:	Gianneschi
Type:	Horizontal, single screw
Model:	MV 44G
No. of sets:	2 (1/unit)
Capacity:	57 litre/minute (15.1gpm) at 0.8 bar (11.6psi)
Motor:	440V, 0.75kW(1hp), 1,750 rpm

Sludge Discharge Pump (A-1-P-250)

Manufacturer:	Winter
Type:	Horizontal, centrifugal
Model:	WHA80/315
No. of sets:	2 (1/unit)
Capacity:	3.5m^3/hour (124ft^3/hour) at 0.8 bar (11.6psi)
Motor:	440V, 13kW(17.4hp), 1,800 rpm

Dosing Pump (A-1-P-350)

Manufacturer:	Kronos
Type:	Peristaltic metering
Model:	Kronos 50
No. of sets:	2 (1/unit)
Capacity:	2 litre/hour (0.009gpm) at 3 bar (43.5psi)
Motor:	240VAC, 20W

Introduction

Creating The Sewage Mix

The sewage treatment plants process both BW and GW as a sewage mixture. This mixture is created in the sewage mixing tank from where it is pumped into the sewage treatment plant. The GW and/or BW is transferred into the sewage mixing tank to create the sewage mixture. When the filling level in the sewage mixing tank reaches a predefined level, the feeding pump of the sewage treatment plant starts to operate, and the treatment process is initiated.

Maceration

The sewage mixture from the sewage mixing tank is first run through a macerator to chop up solid and fibrous components.

TSS/COD/BOD Reduction

The sewage treatment plant separates the suspended solids (TSS), reduce the chemical (COD), and biological (BOD) oxygen demand. The sewage is enriched with air under a pressure in the saturator. After being discharged into the flotation tank through the pressure release valve, the excess air forms micro bubbles. A flocculant is added in order to let air bubbles, and suspended particles form larger flakes. These flakes float upwards, creating a sludge foam on the surface, leaving the clear phase in the lower part of the flotation tank. The sludge foam spills into the sludge compartment, which is subsequently fed into the sludge tank.

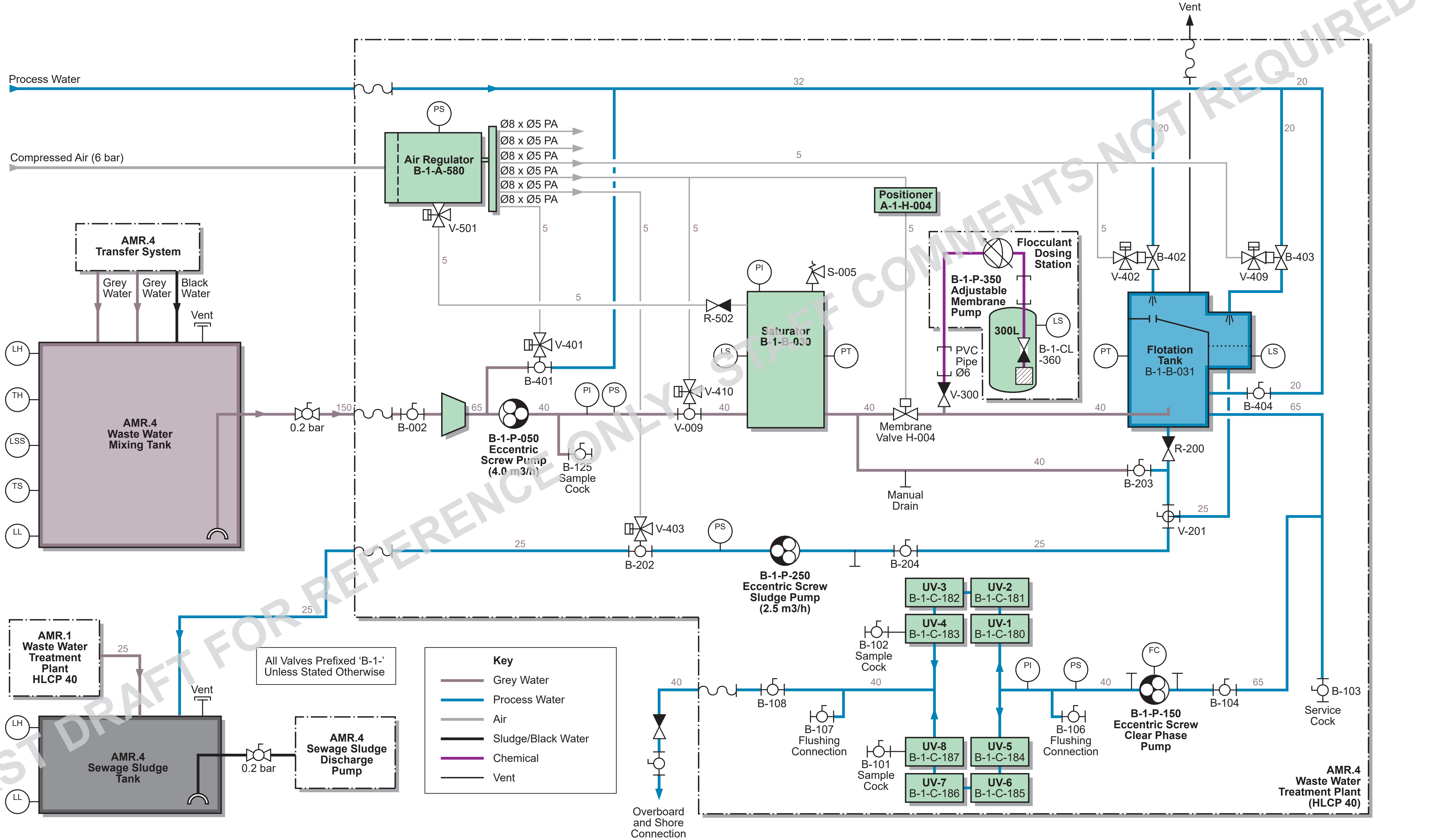
Disinfection

The largely purified sewage is finally exposed to UV radiation to degrade the DNA of bacteria and micro organisms, rendering them incapable of reproducing and causing infection. After this finishing step, the treated sewage from the sewage treatment plant is safe to be discharged overboard (if permitted).

Process Description

GW and BW is collected in holding tanks. When the filling level reaches a predefined level, the sewage treatment starts automatically. The feeding pump (A-1-P-050) starts to operate, and is protected from running dry by process water. The pump transfers raw sewage from the BW holding tank via the macerator (A-1-Z-080) to the saturator (A-1-B-030). The macerator (A-1-Z-080) in the suction line reduces the solids in the raw sewage to 1 mm pieces. The sewage is agitated with 5 bar air pressure through membrane air diffusers in BW holding tanks AMR1 and AMR4. AMR1 BW holding tank has 28 membrane diffusers, AMR4 BW holding tank has 18 membrane diffusers. The pressure sensor at the saturator (A-1-CP-062) measures this pressure in the saturator, with the required pressure in the saturator being controlled by the pressure release valve (A-1-H-004).

Illustration 6.2.3b AMR2 Waste Water Treatment System



Reference Drawing: DV582A002R0 - NSMV-593-V801-R0 WASTE WATER TREATMENT PLANT

Treatment Process

The sewage enriched with air is discharged from the saturator through the pressure release valve, and loses its pressure. The excess air forms bubbles, and a flocculant is added.

Flocculant and air bubbles connect to the suspended particles of the sewage, and form larger flakes in the flotation tank (A-1-B-031). This reduces the total density. Flakes, particles, and other impurities are lifted out by their buoyancy. This creates a sludge foam on the surface of the flotation tank, and leaves the clear phase in the lower part of the flotation tank.

The clear phase pump (A-1-P-150) operates throughout a predefined period to maintain the operation level in the flotation tank. The clear phase pump then stops. This allows fluid and sludge foam to build up in the flotation tank. The sludge foam spills over the brim of the flotation tank into the sludge compartment (A-1-CL-260).

When the sludge foam in the sludge compartment reaches the level sensor in the sludge compartment, the sludge pump (A-1-P-250) starts to run. This pump transfers the sludge from the sludge compartment to the sludge tank. The cleaning nozzle, flotation tank (A-1-A-480) in the upper area cleans the sludge compartment.

At the same time, the clear phase pump (A-1-P-150) starts to operate again to maintain the operation level. The cycle in the flotation tank begins again. The level sensor in the flotation tank prevents the clear phase pump from running dry.

The particles collected in the sump of the flotation tank can be drained manually via opening the 3-way sludge valve, (A-1-V-201).

UV Disinfection

The clear phase pump transfers the clear phase from the lower part of the flotation tank through the UV disinfection plant (A-1-C-180). The clear phase passes through the UV lamps where the UV light degrades the DNA of bacteria, and micro organisms which makes the bacteria, and micro organisms incapable of reproducing. The treated effluent is now safe to discharge overboard.

System Shutdown in Standby Mode

When the filling level of the holding tank falls below a defined stop level, the sewage treatment plant enters the standby mode:

- The macerator and the feeding pump stop.
- The clear phase pump continues to operate until the flotation tank has been drained to its stop level.
- The pressure of the saturator is released. The liquid filling level of the saturator is drained into the flotation tank.
- All pumps stop operating and the sewage treatment plant is on the standby mode.

The plant remains in the standby mode until the filling level of the holding tank reaches the start level. When the sewage treatment plant is shut down via the touch panel, the plant carries out the steps to enter the standby mode.

Note: Sewage treatment systems AMR1 and AMR4 are identical in operation.

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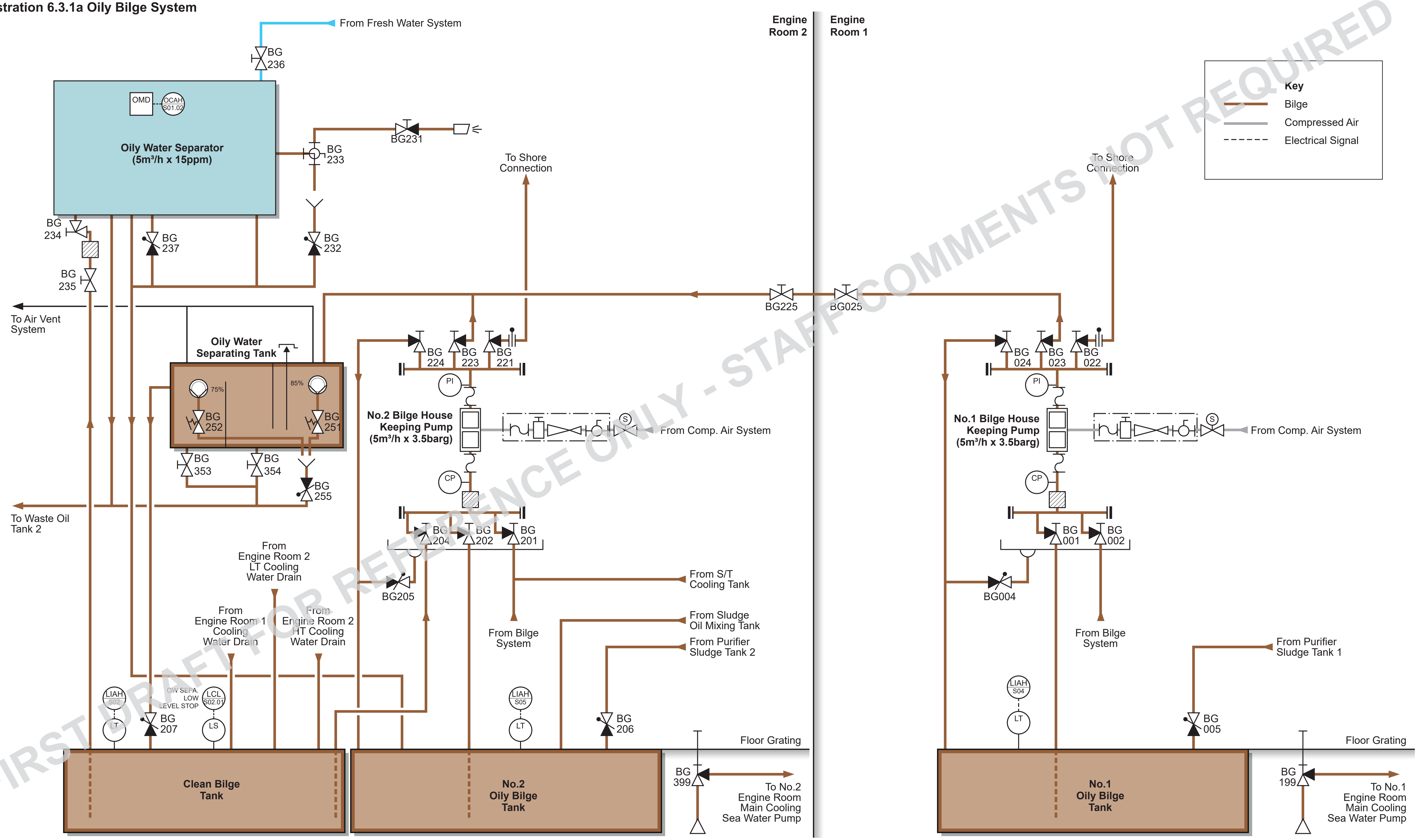
6.3 Bilge Systems

Illustration 6.3.1a Oily Bilge System



Reference Drawing: NSMV-593-B701, Rev: 01

6.3 BILGE SYSTEMS

6.3.1 ENGINE ROOM BILGE SYSTEM

Bilge House Keeping Pumps No.1+2

Manufacturer:	Wilden
Type:	Pneumatic membrane
Model:	E3AA1R110H-B-ATEX
No. of sets:	2 (1x No.1 ER + 1 x No.2 ER)
Capacity:	5m^3/h (176ft^3/h) at 3.5 bar (51psi)
Air supply:	24m^3/h (848ft^3/h) at 3.8 bar (55psi)

Bilge/Ballast Pumps No.1+2

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FEV-200D
No. of sets:	2
Capacity:	250m^3/h (8.829ft^3/h) at 2.0 bar (29psi)
Motor:	440V, 33kW(44hp), 1,750 rpm

Bilge/Auxiliary Sea Water Cooling Pumps No.1+2

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FEV-200D
No. of sets:	2
Capacity:	250/190m^3/h (8.829/6,710ft^3/h) at 2.0 bar (29psi)
Motor:	440V, 33kW(44hp), 1,750 rpm

Introduction

The engine room bilge systems ER1(Forward) and ER2 (Aft) comprise of a bilge main which connects with the various bilge wells, and void spaces in the machinery spaces. To comply to Safe Return to Port (SRtP) regulations either side of each division bulkhead has an isolation valve. These isolation valves are shown below:

- BS055*/BS054* between MR2/MR1.
- BS096*/BS095* between MR1/ER2.
- BS041**/BS040* between ER2/ER1.
- BS094*/BS093* between ER1/AMR4.
- BS024**/BS092* between AMR4/AM3.
- BS015**/BS014** between AMR3/AM2.
- BS091*/BS092** between AMR2/AM1.

Note: * = hydraulically operated valve.
Note: ** = manually operated valve.

In addition to these, the bilge main can also take its suction from the following void spaces:

- Void spaces in stern P and S.
- Void spaces under MR2 x 4.
- Void spaces under MR1 x 4.
- Void spaces 12C and 13C under ER2.
- Void spaces 11C under ER1.

The stern tube cooling water tank is fitted with a self-closing overflow valve. The outlet point in the stern tube tank is located above the shaft centre line. The valve can be quickly opened to confirm there is water in the tank for stern tube bearing cooling purposes. The stern tube cooling water tank is pumped out by No.2 bilge housekeeping pump.

The port and starboard bilge wells in the steering gear room, and port and starboard stores bilge wells are drained to the aft bilge well with self-closing drain valves.

High level alarms are fitted to the bilge wells and voids in the engine room, and to the bilge wells in the steering gear compartment. They all operate through the AMS.

The No.2 bilge housekeeping pump is used to empty the bilge wells in the ER2 bilge system, and No,1 bilge housekeeping pump is used to empty the bilge wells in the ER1 bilge system. Both of these pumps discharge into the oily water tank. These pumps can also discharge the bilge water to shore connections if required.

Oily Water Separating Tank

The oily water separating tank is used to collect the bilge water and drains from the machinery spaces, and to initially separate oil and water by two internal weirs before being treated in the oily water separator.

The tank has three compartments which are divided by two internal weir plates. The weirs allow water to flow from the bottom of the inlet section to the top of the middle section, then from the middle section to overflow to the discharge section of the tank. The oil/water mixture entering the inlet side separates, with the water passing through the bottom of the weir plate to the middle section, then overflowing to the discharge section. The water then flows from the discharge side to the clean bilge tank under the action of gravity. The oil that remains inside the oily water tank can be drained using a manually operated scum valve that allow the oil to flow to the waste oil tank. One scum valve is located on the outlet section of the tank, and one on the discharge section to drain any oil that should have entered this section. The valves should be opened in turn until all of the oil has been removed, but immediately closed as soon as water has started to flow. Each section of the tank is also fitted with a drain valve.

Waste Oil Tank No.2(P)

The waste oil tank No.2(P) has a capacity of 34.5m^3, and is used to collect the drains from the oily water separating tank, starting air and air receiver drains, and No.2 control air compressor drains. This tank is emptied by No.2 sludge pump to the incinerator sludge oil mixing tank for buring in the incinerator. Also, this pump can discharges the contents ashore when the vessel is in port via the bilge shore connection manifolds.

Clean Bilge Tank

The clean bilge tank contents are normally discharged overboard via the oily water separator. The tank is fitted with a high level alarm and indicator and a low level switch that operates to stop the oily water separator pump. If necessary, the contents of the bilge holding tank can also be pumped ashore when in port using No.2 bilge house keeping pump.

Operating Engine Room 2 (Aft) Bilge System

No.2 bilge house keeping pump is used to pump out the contents of the bilge wells in ER2, MR1, and MR2. This pump discharges to the oily water separating tank where the oil and water is separated by gravity to either the clean bilge tank or No.2 waste oil tan.

The procedure that follows has assumed the aft bilge well is to be pumped to the bilge primary tank.

a) Sound and record the level in all bilge tanks.

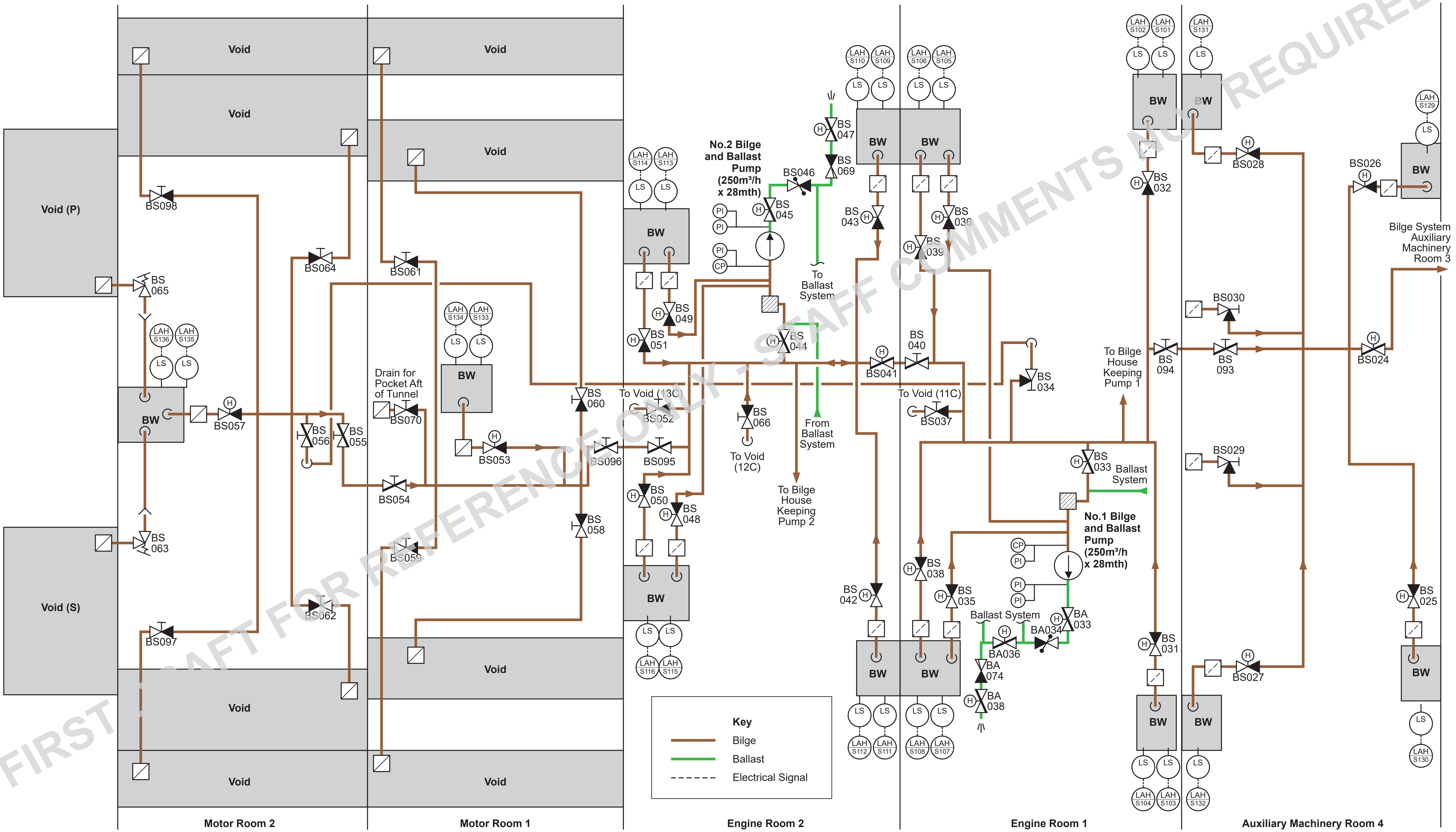
b) Ensure all of the bilge well suction strainers are clean and ready for use.

c) Check all of the instrumentation is working correctly.

d) No.2 bilge house keeping pump valves in accordance with the following table.

The valve settings have assumed the suction is being taken from the aft bilge well, but if other bilge spaces are to be pumped, the appropriate valves must be opened.

Illustration 6.3.1b ER2 Bilge System



Reference Drawing: NSMV-529-B401, Rev: 01

All valves are prefixed BS unless otherwise shown

Position	Description	Valve
Open	Pump suction valve from bilge system	201
Closed	Stern tube cooling water tanks line suction valve	SP772
Closed	No.2 oily bilge tank suction valve	202
Closed	Clean bilge tank suction valve	204
Closed	Pump discharge valve to shore connection	221
Open	Pump discharge valve to oily water separating tank	223
As required	Cross connection valves between ER2 and ER1 bilge systems	225 025
Closed	Pump discharge valve to No.2 oily bilge tank	224
Open	Aft well bilge suction valve	057
Open	Bulkhead isolation valve MR2/MR1	055/054
Open	Bulkhead isolation valve MR1/ER2	096/095
Closed	All other bilge well suction valves in this section	042/043 048~058 070
Closed	All void spaces suction valves	058~062 064

e) Start No.2 bilge house keeping pump locally, and check that the correct bilge well is being emptied. When complete, change the suction valves to pump other bilge wells or void spaces as required.

f) Following the pumping of the bilge wells or void spaces to the oily water separating tank, close all of the bilge well and void spaces suction valves.

g) Sound and record the level in the clean bilge tank and the oily bilge tank 2.

h) Check the bilge well suction strainers used are clear.

Note: The clean bilge tank, and oily bilge tank 2 are each fitted with a high level alarm and attention must be paid to the level in the tank to prevent overflowing.

i) Record the bilge pumping in the Engine Room Log Book, and Oil Record Book.

Operating Engine Room No.1 (Forward) Bilge System

No.2 (aft engine room), and No.1 (forward engine room) bilge systems are cross-connected through valves BS041/040 for discharge to the oily water separating tank, details of the this are described above.

No.1 bilge house keeping pump is used to pump out the contents of the bilge wells in ER1, AMR4, AMR3, AMR2, and AMR1. This pump discharges to the oily water separating tank where the oil and water is separated by gravity to either the clean bilge tank or No.1 waste oil tank.

The pumping procedure will be the same as that for ER2 bilge system, but using No.1 bilge housekeeping pump.

The procedure that follows has assumed ER1 port aft bilge well is to be pumped to the oily water separating tank.

Position	Description	Valve
Open	No.2 oily bilge tank suction valve	001
Open	Pump suction valve from bilge system	002
Closed	Pump discharge valve to shore connection	022
Open	Pump discharge valve to oily water separating tank	223
As required	Cross connection valves between ER2 and ER1 bilge systems	225 025
Closed	Pump discharge valve to No.1 oily bilge tank	024
Open	ER1 port aft well bilge suction valve	139
As required	Bulkhead isolation valve ER2/ER1	041/040
As required	Bulkhead isolation valve ER1/AMR4	094/093
Closed	All other bilge well suction valves in this section	038 032/031
Closed	11C void space suction valves	037

Record the bilge pumping in the Engine Room Log Book, and Oil Record Book.

Forward Bilge System

The forward bilge system includes those bilge wells located in the bow thruster room, and bosun's locker.

Bowthruster Room Bilges

This bilge system is pumped out using a fire main driven eductor rated at 10 m^3/h. This eductor discharges directly overboard via the bowthruster fresh water cooler overboard valve. To operate the system open firemain drive water valve BS088, and either bilge suction valves BS086, or BS087.

Bosun's Bilges and Chain Lockers

This bilge system is pumped out using a fire main driven eductor rated at 5 m^3/h. This eductor discharges directly overboard via the port hawse pipe via valve BS080. To operate the system open firemain drive water valve BS089, and suction valves BS083 for the port chain locker, BS082 for the bosun's store bilge well, or BS081 for the starboard chain locker.

Pumping Oily Bilge Tank No.2 to the Shore Connections

In this procedure it has been assumed the OWS has been switched off, and isolated, and No.2 ER bilge houskeeping pump is being used for this task.

The remaining bilge discharge valves should be arranged in accordance with the following table:

Position	Description	Valve
Closed	Pump suction valve from bilge main	201
Open	Pump suction valve from oily bilge tank No.2	202
Open	Pump suction valve from clean bilge tank	204
Closed	Stern tube cooling tank suction valve(and blanked)	SP772
Open	Pump discharge valve to shore connection (unblanked)	221
Closed	Pump discharge valve to oily water separating tank	223
Closed	Pump recirculation valve to oily bilge tank No.2	224
Closed	Pump discharge valve to sludge mixing tank	OI332
Open	Line discharge valve to IMO shore connections	OI340
Open	Bilge manifold shore discharge valve (P)	OI361
Closed	Bilge manifold shore discharge valve (S)	OI362

In the arrangement above it has been assumed the contents of the oily bilge tank No.2 will be discharged ashore via the port shore connection.

a) Remove the blank from the port shore connection pipe and attach the shore discharge pipe. Confirm the blank flange on the starboard shore connection manifold is fitted and secure.

b) Agree a pumping rate with the shore authorities and confirm they have capacity to receive all of the contents.

c) Start No.2 bilge housekeeping pump, and pump out oily bilge tank No.2 accordingly.

d) When the tank has been emptied, stop No.2 bilge housekeeping pump, and close all of the valves in the system.

e) When amount of oily bilge water discharged is agree by the receiver, close the port shore connection valve, disconnect the shore hose from the port side shore connection, and refit the flange blank.

f) Record the transfer in the Engine Room Log and Bilge Record Book.

CAUTION
Pumping out of oily bilge tank No.1 to shore using No.1 bilge housekeeping pump will use a similar procedure.

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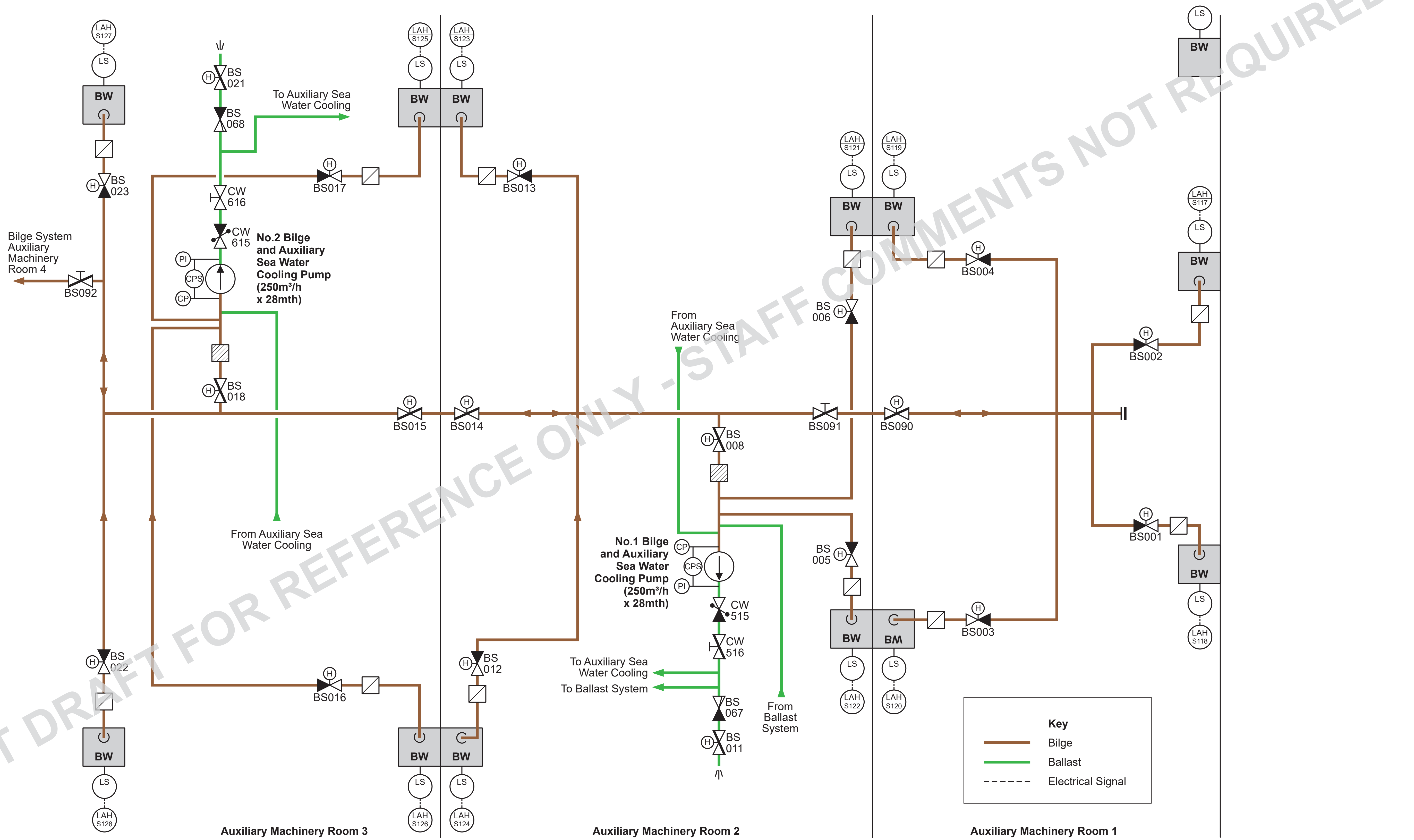
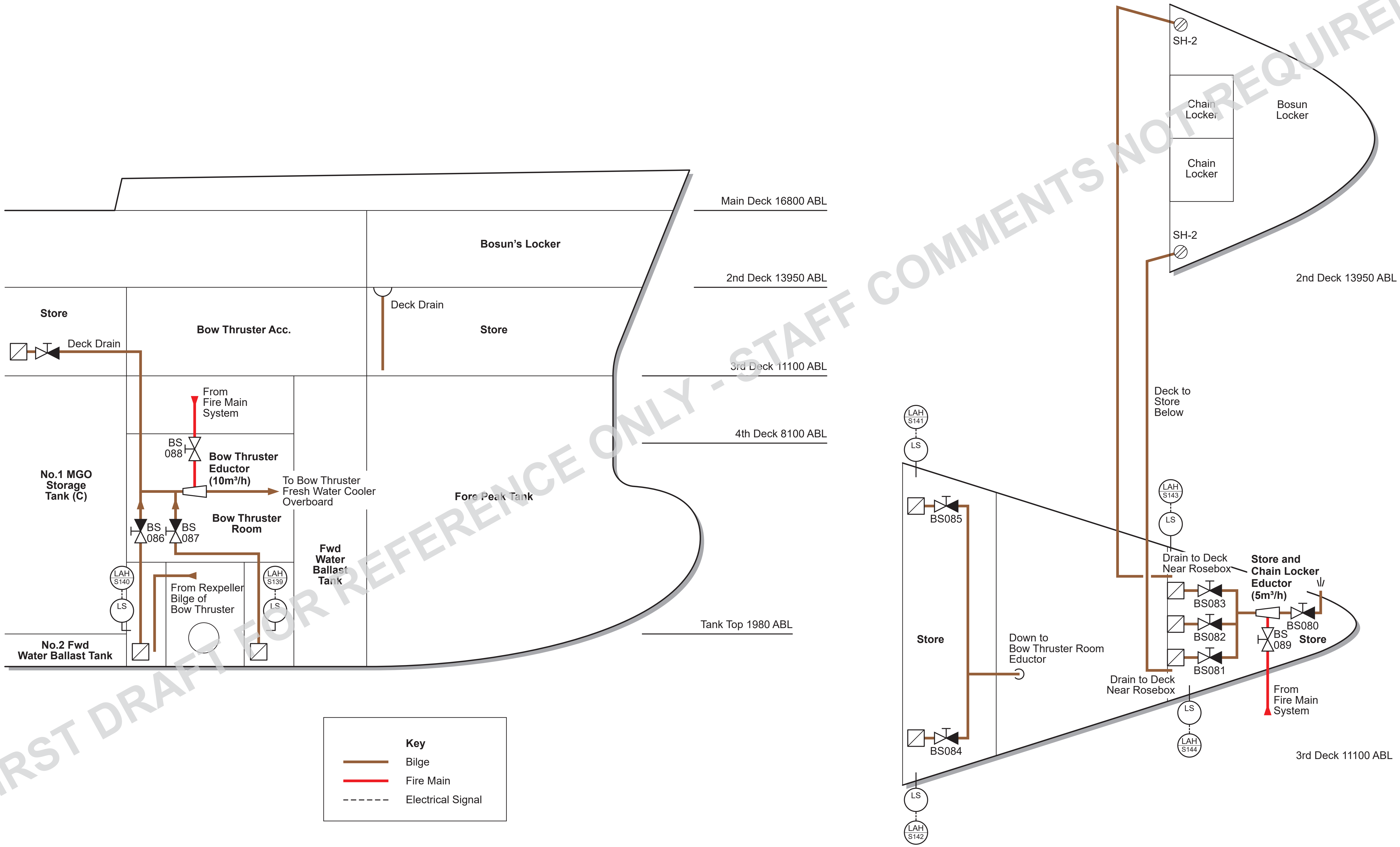
Illustration 6.3.1c ER1 Bilge System



Reference Drawing: NSMV-529-B401, Rev: 01

Illustration 6.3.1d Fwd Bilge System



Reference Drawing: NSMV-529-B401, Rev: 01

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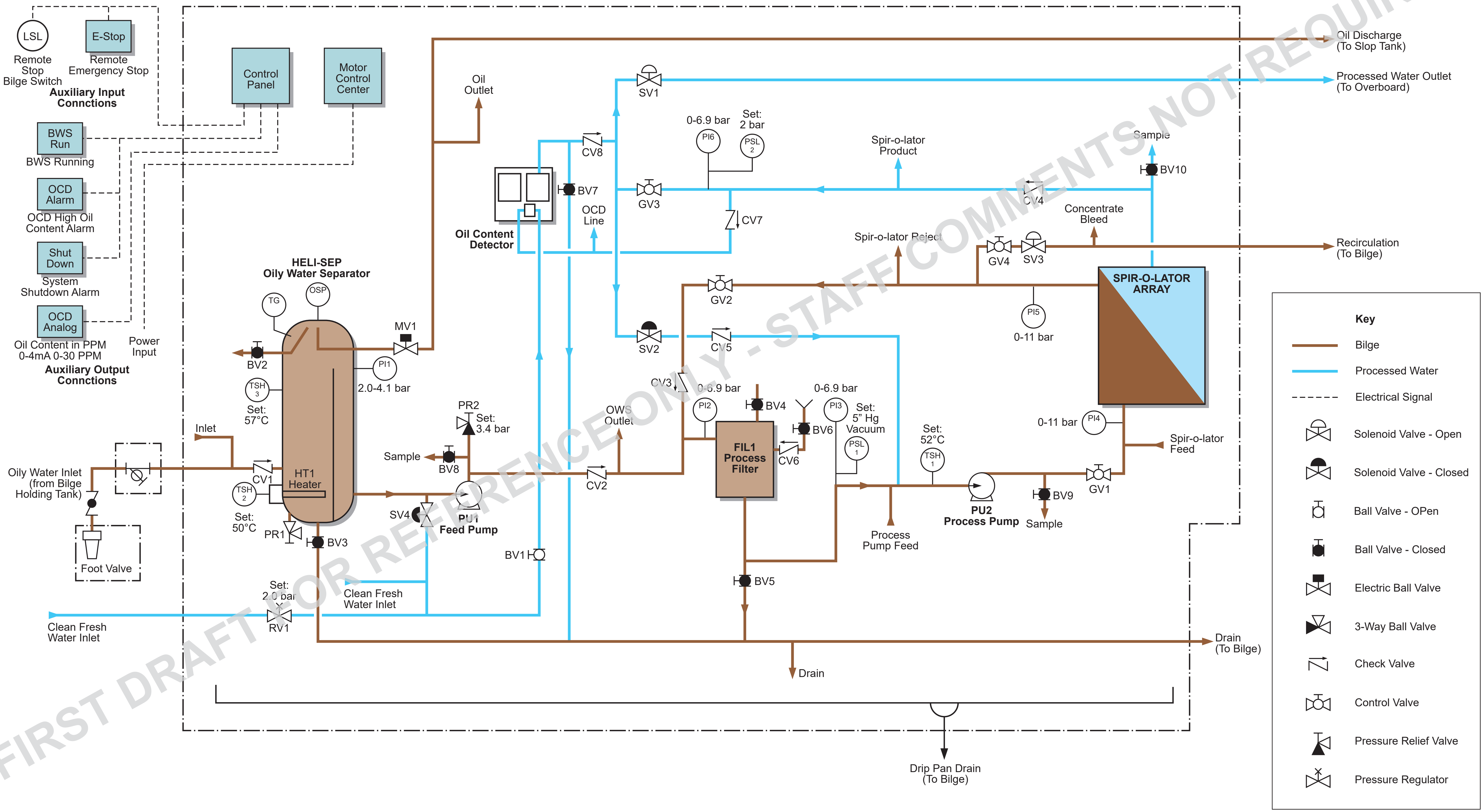
Illustration 6.3.2a Oily Water Treatment System



Reference Drawing: J657-US5051, Rev: B

6.3.2 OILY WATER TREATMENT SYSTEM

Oily Water Separator

Manufacturer:	Compass Water
Type:	Gravity separation
Model:	Ultra-Sep 5000-J657
Capacity:	$5m^3/h$ ($177ft^3/h$)
Immersion heater:	7.5kW set 50°C (122°F)

Feed Pump

Manufacturer:	XXX
Type:	Horizontal, centrifugal
Model:	XXX
No. of sets:	1
Capacity:	83.3 litres/minute (22gpm) at x.x bar
Motor:	440V, 0.75kW(1 hp), 3,450 rpm

Process Feed Pump

Manufacturer:	XXX
Type:	Horizontal, centrifugal
Model:	XXX
No. of sets:	1
Capacity:	302.8 litres/minute (80) at 1.4 bar (20 psi)
Motor:	440V, 7.5kW(10 hp), 3,450 rpm

Bilge Alarm Monitor

Manufacturer:	Rivertrace
No. of sets:	1
Alarm setting:	Alarm 1 setting ~ 5ppm Alarm 2 setting ~ 15ppm
Power:	AC 220V, 60 Hz

Introduction

The Oily Water Separator (OWS) is a two stage bilge water separation system. The first stage generates a vacuum, differential specific gravity, and a two stage coalescer for the removal of the majority of free oil, and dirt separation. The second stage uses micron filtration for removal of trace solids, and small oil droplets followed by ultra-filtration to separate, and remove emulsified oils, along with the remaining minute solids, and entrained air from bilge water. The system is designed for continuous and/or intermittent operation. After the system has been started, it is capable of automatic operation.

Stage 1

Incoming bilge water passes through a basket strainer to remove oversized solid contaminants. From there it is drawn into the first stage consisting of a coalescing OWS where the free oil droplets coalesce as they pass through the permanent matrix. This oil rises to the top of the vessel, and it is collected for discharge during the oil discharge cycle. The water is then drawn through a pack of oleophillic polishing beads, which trap the remaining fine oil droplets. These oil droplets are washed out and discharged during the oil discharge cycle.

Stage 2

Processed water from the OWS is then directed through a particulate filter, which further reduces solids contamination. This semi-treated water is then fed into the process pump; this pump increases the flow, and pressure for suitable conditions for the SPIROLATOR membranes. The SPIROLATOR membranes are oil-repellent, which prevent oil and oily-emulsions from passing through. A rejection stream is re-circulated back for re-processing.

Process Flow Description

The bilge water to be processed is drawn from the clean bilge tank by the feed pump. The bilge water then enters the OWS near the bottom of the solids sludge collecting chamber. Most of the free oil separates from the bilge water immediately due to the difference in specific gravity, and the reduced flow velocity inside the separator. The flow travels upward through the separating media matrix. This path increases contact with the separating media to improve coalescence of the free oil. The flow exits the top of the separating media matrix where the oil continues to flow upwards to the separator's oil collecting chamber due to the difference in specific gravity. The bilge water less the majority of free oil is then drawn downward by the feed pump vacuum through the polishing pack. The polishing pack coalesces any residual free oil that may be left in the water until large enough to break loose, and rise to the oil collecting chamber. When sufficient oil has collected, the oil sensing probe (OSP) creates a signal to stop the feed pump, and open the clean water inlet valve. Pressurized clean water fresh water, at 37.8ºC (100ºF) maximum enters from the bottom of the OWS, and flows upward through the polishing pack displacing the accumulated oil in the oil collection chamber (top cover of the OWS) which is discharged through the oil discharge line. After the accumulated oil has been discharged, and the OSP is again immersed in water, the OWS returns to its normal operating mode. The partially cleaned bilge water less the majority of free oils, but with some emulsified oils, is drawn through the OWS by the feed pump. The feed pump then pressurizes the bilge water for processing through the process filter before supplying the process pump with a positive suction head. The process filter removes suspended solids, and oil droplets of approximately 5 microns + from the flow.

This partially-cleaned bilge water is supplied to the process pump for processing by the SPIROLATOR membranes. The process pump increases the partially-cleaned bilge water pressure, and drives the emulsions across the surface of the membranes at a high velocity. Water, salts and detergents are forced through the membranes by pressure created by the system pumps, and operating pressure control valve, while oils and other waste larger with larger molecular weight are rejected. The portion of the semi-cleaned bilge water forced through the membranes is referred to as the processed water (clean water, oil content less than 10 ppm) while the remainder is referred to as the concentrate. The system is equipped with an oil content monitor, which continuously monitors the processed water for oil content. If the oil content exceeds the alarm set point the processed water will automatically be re-directed for re-processing. If below the alarm set point, the processed water is discharged from the system. The system is constantly being replenished by bilge water supplied by the feed pump. The concentrate with the rejected oils, and waste is fed back to inlet of the process filter, for further de-oiling and polishing before being returned to the process pump inlet for reprocessing through the membranes. This circulation loop process allows for a higher velocity flow rate across the membranes which maximizes the processed water output by minimizing fouling due to the higher velocity shearing off excess oils, and waste from the surface of the membranes. A small portion of this circulation loop is continuously bled off to the oily bilge tank, where this concentrated oils/sludge can be further coalesced before being reprocessed through the full process of the OWS. The process flow rate (system inlet rating) is equal to the OWS processed water flow (overboard) plus its circulation loop's bleed flow (return to oily bilge tank).

The OWS processed water, circulation loop, and bleed flows are factory set that can be manually checked for verification. Pressure transmitters are fitted to monitor operating conditions. A flush sequence is fitted to automatically flush the membranes with clean water periodically at each automatic shutdown of the system. A flush may be performed manually at any time. During either automatic or manual membrane flushes, the clean water is introduced to the circulation loop for a short duration of time, and pumped across the membranes by the process pump to displace the loops concentrate, and return it to the oily bilge tank where it can be reprocessed.

An electric heater is fitted to the OWS to improve the initial separation process, but the heater will only operate when the separator is filled.

Oily Water Separator Operation

After obtaining permission from the Chief Engineer, and before arrival at the destination port, the contents of the clean bilge tank are to be emptied using the OWS to make space for the stay in port. The Chief Engineer is to confirm the position of the vessel from the bridge before starting operation of the OWS. The padlock and security seals should then be attached to the overboard discharge valve on completion of the pumping operation.

When the OWS is not in use, the OWS overboard valve is to always be kept padlocked and the key is to be kept under the strict custody of the Chief Engineer. A log is to be kept when the valve is opened.

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Starting the Oily Water Separator

(Authors Note: This operation to confirm by Owners.)

Stopping the Oily Water Separator

(Authors Note: This operation to confirm by Owners.)

Pumping the Clean Bilge Tank Through the Oily Bilge Separator

a) Check with the Officer of the Watch (OOW) on the bridge that the vessel is not in restricted waters and that it is acceptable to pump bilges overboard.

b) Check with the Chief Engineer and obtain the key to unlock the overboard discharge valve.

c) Check that the OWS suction strainer is clean.

d) Open the fresh water supply valve (BG236) to the OWS.

e) Set the valves in accordance with the following table.

It has been assumed that the reclaimed oil will be discharged into No.2 oily bilge oil tank .

Position	Description	Valve
Open	OWS suction valves from clean bilge tank	BG234/5
Closed	OWS manual drain valve	BV3
Automatic	OWS oil outlet valve to No.2 oily bilge tank (NC)	MV1
Set	Clean fresh water regulating valve set 2bar(30psi)	RV1
Automatic	Clean fresh water control valve (NC)	SV4
Open	Oil content detector FW flushing valve	BV1
Closed	Oil content detector FW drain valve (NC)	BV7
Closed	Process filter manual drain valve	BV5
Closed	Process pump discharge valve	GV1
Open	Membranes outlet valve	GV3
Automatic	OWS overboard discharge control valve	SV1
Open	OWS overboard discharge non return valve	BG231
Automatic	Membranes recirculation valve (NC)	SV2
Open	Manual recirculation valve to No.2 oily bilge tank	GV4
Automatic	Recirculation valve to No.2 oily bilge tank	SV3

f) Check that all valves which are not required for operation of the OWS are closed.

g) Check that power is available to the separator control panel, then turn the power switch to the ON position.

h) Turn the oily water separator switch to the AUTO position.

- The feed pump starts.
- The process pump starts.

i) In automatic mode, the OWS will discharge oil into the oily bilge tank No.2 when the level sensing probe detects an oil level and will monitor the oil content of the discharge water.

CAUTION
In MANUAL mode, the OWS operates independently of the oil level switches and therefore will NOT automatically stop. If operating in manual mode, the system should be kept under permanent supervision.

Processed bilge water with an oil content less than 15ppm will be discharged overboard.

Processed bilge water with an oil content greater than 15ppm will automatically be discharged to the oily bilge tank No.2 until the water is clean enough to discharge overboard.

Any oil collected at the top of the bilge separator will be discharged to waste oil tank No.2.

j) Record the operation in the Engine Room Log, and Oil Record Book.

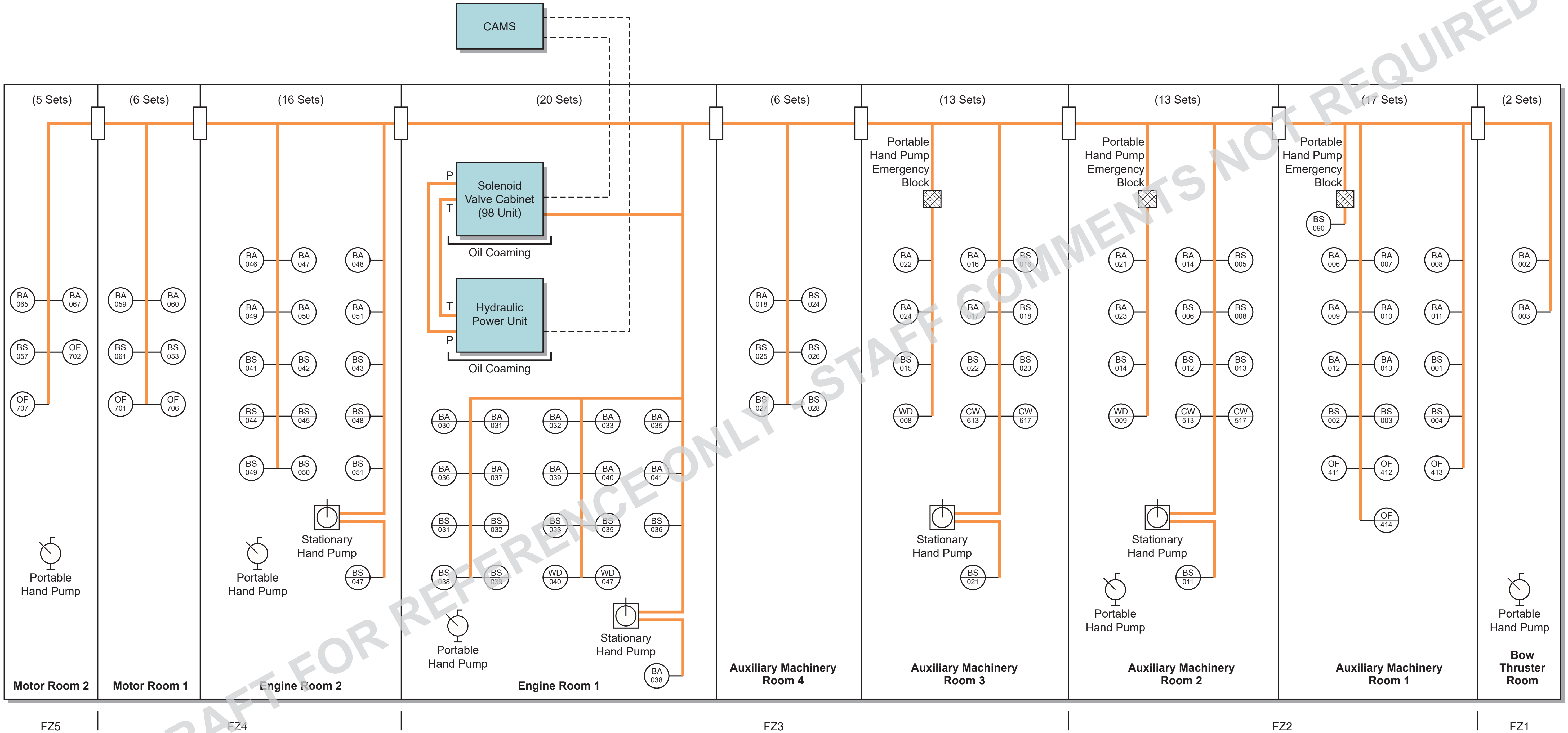
Stopping the Oily Water Separator

a) Stop the separator by pressing the STOP pushbutton. This will start an automatic flush of the membranes before shutiing down th OWS

b) Turn the main ON/OFF switch to the OFF position.

CAUTION
The oily water separator is designed to separate oil from water, not water from oil. If the bilge supply to the separator contains excessive amounts of oil it will render the equipment useless and result in unnecessary maintenance.

Illustration 6.3.3a Valve Remote Control System



Key		Abbreviations	
(orange line)	Hydraulic Oil	BA	Ballast
(dashed line)	Electrical Signal	BS	Bilge
		OF	Fuel Oil Transfer
		WD	Fire Main
		CW	Cooling Sea Water

Reference Drawing: NSMV-556-B402, Rev: 01

6.3.3 HYDRAULIC VALVE REMOTE CONTROL SYSTEM

Hydraulic Valve Remote Operating System

Hydraulic Power Pack

Manufacturer:	Damcos
Type:	Constant pressure
Tank capacity:	200 litre
Working pressure:	135 bar (1,958psi)
No. pumps:	2 x horizontal gear
Pump capacity:	9.5 litres/minute (2.5gpm)
Pump motor:	440V, 4.6kW(6hp), 1,740 rpm

Accumulator

Manufacturer:	Damcos
Type:	Bladder
No. of sets:	2
Oil capacity:	50.0 litre (11gal) at 135 bar (1,958psi)

Solenoid Valve Cabinet

Manufacturer:	Damcos
Model:	QM-type
No. of sets:	1
No. of solenoid units:	98

Portable Handpump

Manufacturer:	Damcos
Model:	K-16OU5232 complete with 5 litre reservoir
No. of sets:	5
Max. working pressure:	135 bar (1,958psi)

Stationary Handpump

Manufacturer:	Damcos
Model:	K-320-0102 complete with 5 litre reservoir
No. of sets:	4
Max. working pressure:	135 bar (1,958psi)

Introduction

The hydraulic valve remote control system enables fuel oil transfer, bilge, ballast, cooling sea water, and fire main valves to be operated from the CAMS screen displays in the ship's control centre (SCC), and the engine control room.

When the hydraulic power unit is activated, hydraulic power is available to open and close all valves connected to the system. The hydraulic oil supply to the valves works on a constant pressure principle at 135 bar (1,958psi), while the pump(s) operate in a pressure range of 145 to 165 bar (2,103 to 2,393psi) via a start/stop control system. Each pump unit has the capacity to open or close three of the largest diameter valves simultaneously from fully open to closed or vice versa within one minute at an ambient temperature of 20°C (68°F)

Pressure switch settings are as follows:

- High oil pressure alarm 170 bar (2,466psi).
- Running/standby pump stop 165 bar (2,393psi).
- Service pump start 145 bar (2,103psi).
- Standby pump start 140 bar (2,030psi).
- Low oil pressure alarm 130 bar (1,885psi).

Two accumulators are installed to store a reserve of hydraulic power in the event of failure of the pumps. They also damp out pressure fluctuations and reduce the frequency of pump starts. The accumulators have sufficient stored energy to operate three of the largest butterfly valves simultaneously from fully open to closed or vice versa.

Should there be a failure of the hydraulic power unit or loss of electrical power, the valves may be opened and closed using one emergency handpump in each machinery space, or one stationary hand pump in in ER2, ER1, AMR3, and AMR2.

The system has pressure and temperature compensating blocks, so that variations in pressure and temperature which are not produced by the controller are not allowed to activate the system. The CAMS display allows valves to be selected for opening and closing, and also indicates a valve's current position.

The hydraulic power pack unit operates 98 system valves as follows:

- Ballast system x 39.
- Bilge system x 43.
- FO transfer system x 8.
- Fire main system x 4.
- Cooling water system x 4.

There is a central hydraulic power pack located in ER1, at floor level starboard side outboard of No.1 MGE, which provides hydraulic power for operating the valves. The opening or closing of a valve is initiated by selecting the open or close option on the respective screen display. Most valves operated using this hydraulic system are the fully open or closed type, the exceptions being No.1 bilge/ballast pump discharge valve BA033, No.2 bilge/ballast pump discharge valve BS045, No.1 bilge/auxiliary seawater pump outlet valve CW517, and No.2 bilge/auxiliary seawater pump outlet valve CW617, which are of throttle type. These valves can be set between 0 and 100% open on the respective screen display.

Selecting 'Open' or 'Close' operates a solenoid valve, which directs oil from the power pack to the valve actuator and returns vent oil from the actuator in order to move the valve in the desired direction.

If there is a failure of the remote control system and the power pack is still in service, the valves may be opened and closed by manual operation of the individual solenoid valves. In an emergency, valves can be opened or closed by means of portable handpumps, five of which are provided. One pump is available in the following locations:

- MR2.
- ER2.
- ER1.
- AMR2.
- Bowthruster room.

The portable pumps attach to the emergency connections at the individual valves. Each valve has an extension pinion with a square end; a key may be attached to this pinion extension and the valve opened manually.

Four sationary handpumps for operating ships side overboard valves are at the following locations:

- ER2 for valve BS047.
- ER1 for valve BA038.
- AMR3 for valve BS021.
- AMR2 for valve BS011.

The power pack unit has 2 x 50 litre oil bladder type accumulators (the bladders are initially charged with nitrogen to 135 bar/ 1,958psi), and two electric motor-driven gear pumps which supply the system oil pressure. The oil accumulator has sufficient capacity to allow compensation for leakage from the system for about five minutes. In normal operation, one pump is selected as the duty pump, the pump operating between 145 and 165 bar (2,103 to 2,393psi). The second pump acts as a standby pump, which will cut-in automatically should the system pressure before the regulating pressure valve drop to 140 bar (2,030psi). This pump will automatically cut-out when the pressure reaches 165 bar (2,393psi).

A pump selection switch at the power pack control panel allows the pumps to be selected as duty (lead P1 - P2 etc) and standby (lag). The pump in service should be changed according to the Chief Engineer's standing orders and company procedures in order to ensure that both power pack pumps have approximately equal running hours.

The hydraulic power pack control panel has a main switch for each pump and a control location switch LOCAL/REMOTE. Each pump has a START/RUN illuminated pushbutton and a STOP pushbutton. The control panel also contains a MOTOR SPACE heater switch, and a heater status indicator light, a POWER ON indicator light, an ammeter and an hour meter. The power pack is normally operational in order that hydraulic power for actuating the valves is always available. The HPU alarm panel comprises the following alarm indicators:

- Low oil level.
- Low oil pressure.
- High oil pressure.
- High oil temperature.
- Filter clogged.
- No.1 motor overload.
- No.2 motor overload.

All system valves may be operated by the emergency handpumps, or by staionary handpumps*.

System Valves

Valve Identification	Valve
Bow Thruster Room	
Forepeak filling/suction	BA02
Forward SW ballast tank 1 filling/suction	BA03
Auxiliary Machinery Room 1	
Forward wing SW ballast tanks isolation valve	BA04
Forward SW ballast tanks isolation valve	BA06
Forward SW ballast tank 2 filling/suction	BA07
DB SW ballast tank 1C filling/suction	BA08
Forward heeling tank P filling/suction	BA09
Forward heeling tank S filling/suction	BA010
DB SW ballast tank 2C filling/suction	BA011
DB SW ballast tank 3C filling/suction	BA013
Main ballast cross-over valve	BS001
Forward AMR1 (P) bilge suction	BS002
Aft AMR1 (S) bilge suction	BS003

Valve Identification	Valve
Aft AMR1 (P) bilge suction	BS004
Bilge main isolation	BS090
MGO storage tank 2P filling/suction	OF411
MGO storage tank 2C filling/suction	OF412
MGO storage tank 1C filling/suction	OF413
MGO storage tank 2S filling/suction	OF414
Auxiliary Machinery Room 2	
Ballast redundancy isolation	BA05
DB SW ballast tank 4C filling/suction	BA014
Ballast main isolation	BA021
Ballast main isolation	BA023
Forward AMR2 (P) bilge suction	BS006
No.1 bilge/auxiliary pump suction	BS008
No.1 bilge/auxiliary pump direct overboard to sea	BS011*
Aft AMR2 (S) bilge suction	BS012
Aft AMR2 (P) bilge suction	BS013
Bilge main isolation	BS014
No.1 bilge/auxiliary pump suction	CW513
No.1 bilge/auxiliary pump discharge	CW517
Fire main isolation	WD009
Auxiliary Machinery Room 3	
Ballast main isolation	BA015
DB SW ballast tank 6C filling/suction	BA016
Ballast main isolation	BA022
Ballast main isolation	BA024
Forward AMR3 (S) direct bilge suction	BS016
Forward AMR3 (P) direct bilge suction	BS017
No.2 bilge/auxiliary pump suction	BS018
No.2 bilge/auxiliary pump direct overboard	BS021*
Aft AMR3 (S) bilge suction	BS022
Aft AMR3 (P) bilge suction	BS023
No.2 bilge/auxiliary pump suction	CW613
No.2 bilge/auxiliary pump discharge	CW617
Fire main isolation	WD008
Auxiliary Machinery Room 4	
DB SW ballast tank 8C filling/suction	BA018
Ballast main isolation	BS024
Forward AMR4 (S) bilge suction	BS025
Forward AMR4 (P) bilge suction	BS026
Aft AMR4 (S) bilge suction	BS027
Aft AMR4 (P) bilge suction	BS028

Valve Identification	Valve
Engine Room 1	
No.1 bilge/ballast pump suction from sea	BA030
No.1 bilge/ballast pump suction from WBT	BA031
No.1 bilge/ballast pump suction from WBT	BA032
No.1 bilge/ballast pump discharge	BA033
No.1 bilge/ballast pump suction from BWTS	BA035
No.1 bilge/ballast pump discharge overboard	BA036
BWTS discharge overboard	BA037
BWTS outlet	BA039
Ballast main cross-over	BA040
Ballast main cross-over	BA041
Forward ER1 (S) bilge suction	BS031
Forward ER1 (P) bilge suction	BS032
No.1 bilge/ballast pump suction	BS033
Aft ER1 (S) direct bilge suction	BS035
Aft ER1 (P) direct bilge suction	BS036
Aft ER1 (S) bilge suction	BS038*
Aft ER1 (P) bilge suction	BS039
Fire hydrophore pump SW suction	WD040
Fire hydrophore pump FW suction	WD047
Engine Room 2	
No.2 bilge/ballast pump suction from sea	BA046
No.2 bilge/ballast pump suction from WBT	BA047*
No.2 bilge/ballast pump suction from WBT	BA048
No.2 bilge/ballast pump discharge	BA049
Ballast main cross-over	BA050
Ballast main cross-over	BA051
Bilge main isolation	BS041
Forward ER2 (S) bilge suction	BS042
Forward ER2 (P) bilge suction	BS043
No.2 bilge/ballast pump suction	BS044
No.2 bilge/ballast pump discharge	BS045
No.2 bilge/ballast pump discharge overboard	BS047
Aft ER2 (S) direct bilge suction	BS048
Aft ER2 (P) direct bilge suction	BS049
Aft ER2 (S) bilge suction	BS050
Aft ER2 (P) bilge suction	BS051

Valve Identification	Valve
Motor Room 1	
SWBT 14C filling/suction	BA059
Aft heelng tank (P) filling/suction	BA060
Aft heelng tank (S) filling/suction	BA061
MR1 bilge suction	BS053
MGO storage tank 3S filling/suction	OF701
MGO storage tank 3P filling/suction	OF706
Motor Room 2	
AP tank filling/suction	BA065
SWBT 15C filling/suction	BA067
MR2 bilge suction	BS057
MGO storage tank 4S filling/suction	OF702
MGO storage tank 4P filling/suction	OF707

Operating the Hydraulic Valve Remote Operating System

a) Ensure that the oil system is fully charged, that there are no leaks evident and the oil level in the reservoir is at the normal working level. If necessary, top-up the reservoir using the correct grade of oil.

b) Check that the accumulator stop valves are in the open position, and that the drain valves are closed.

c) Turn the main switches for each motor starter to the ON position, the Power On indicator lamps for each pump should now be illuminated.

d) Turn the mode selection switch to the REMOTE position if control of the pumps is to be controlled from the CAMS screen display system.

System Checks

- Check the oil level in the power pack tank each week.
- Check for system leaks if the power pack tank level falls.

Change over the pumps as required, so that the running hours are approximately equal for each pump.

Operating Instructions

a) Open the solenoid valve box which feeds the valve to be operated.

b) Close the supply and return throttling/stop valves on the valve to be operated. Make a note of the amount of turns required to close the valves in order to return them to their correct positions when the valve is put back to normal operation. Making the isolation at this point for those tank valves which have the isolations on deck may be more expedient, as there may be problems due to the weathering effect on these deck isolating valves.

WARNING

Failure to close the above valves could result in oil flowing into the reservoir and over-pressurising it, resulting in possible injury to the operator.

Note: The solenoid valves can be operated manually by operating the pushbuttons protruding through the solenoid coils.

WARNING

Wear protective clothing including visor or goggles when operating the portable hydraulic handpumps.

Operation of Pumps and Accumulators

Pump Unit

Each pump unit has sufficient capacity to close or open 3 sets of the largest valves simultaneously within sixty (60) seconds at normal ambient temperature.

Accumulators

The total capacity of the accumulators is sufficient to compensate for oil leakage through direction control valve during leakage compensating at normal ambient temperature; or to close or open 3 sets of the largest valves simultaneously.

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Anything to update?

It is important that this manual is kept up to date as a live document. If you believe there are any errors or omissions in this manual, or you are aware of changes to the equipment or systems on board then please contact the publishers:

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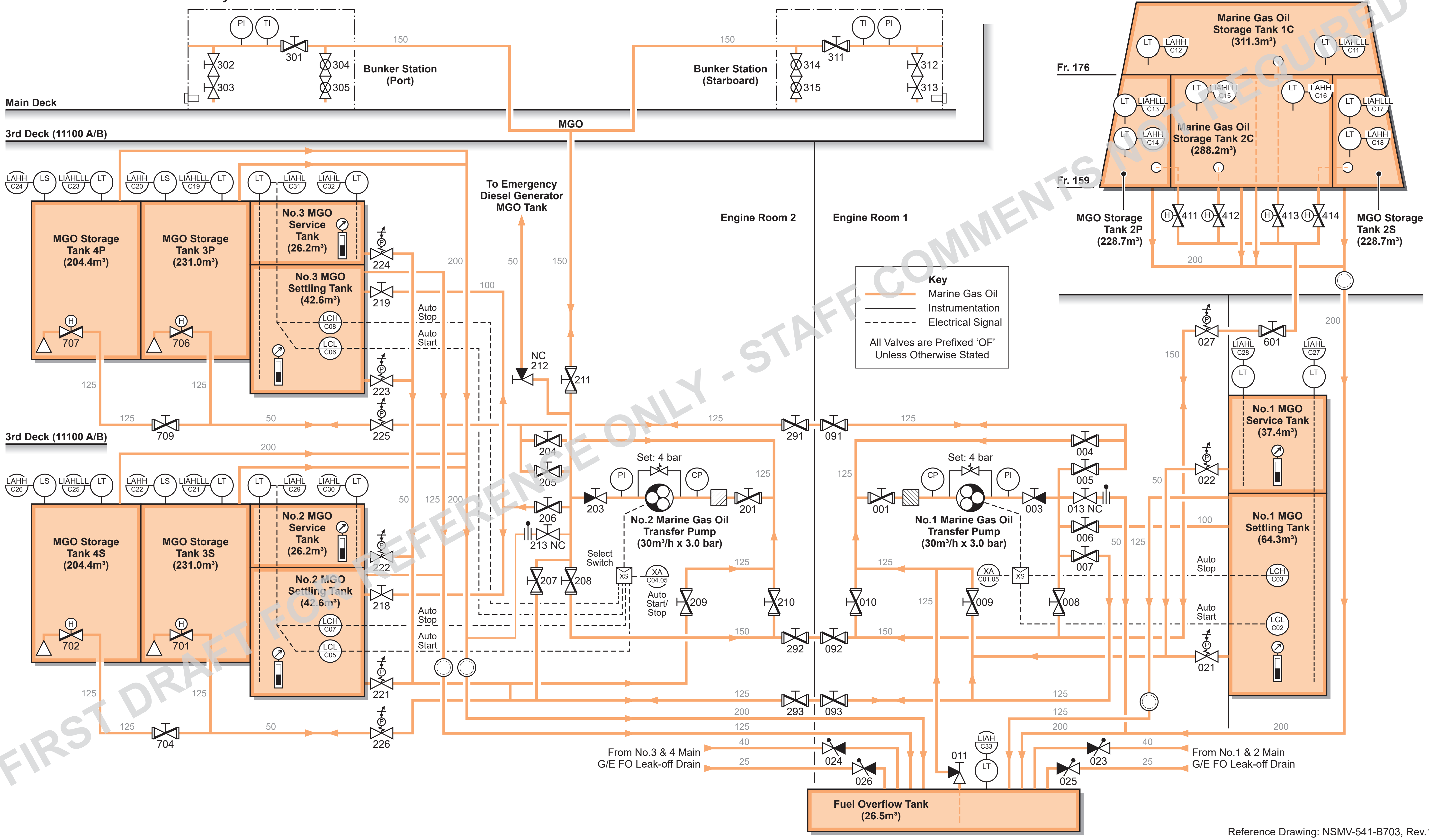
6.4 Fuel Oil and Lubricating Oil Transfer and Bunkering Systems

Illustration 6.4.1a Fuel Oil Transfer System



Reference Drawing: NSMV-541-B703, Rev.1

6.4 FUEL OIL AND LUBRICATING OIL TRANSFER AND BUNKERING SYSTEMS

6.4.1 FUEL OIL TRANSFER AND BUNKERING SYSTEM - MARINE GAS OIL

Marine Gas Oil Transfer Pump No.1 + 2

Manufacturer:	IMO
Type:	Vertical screw
Model:	ACF 080K5 NTBP 132 001
No. of sets:	2
Capacity:	30m³/h (1059ft³/h) at 3.0 bar
Motor:	440V, 8.7kW(12hp), 1,750 rpm

Introduction

Note: Refer to relevant MARPOL Regulations before receiving MGO bunkers.

Loading and Transfer of Marine Gas Oil Bunkers

CAUTION
Before any attending bunker barge comes alongside, shut off the cathodic protection equipment.

CAUTION
No diving operations are to be undertaken whilst a bunker barge is alongside.

The ordering of any bunker fuel is to be in accordance with standard company operating procedures. In addition, it is important to note that no fuel loaded on board should have a sulfur content of more than the amount that is allowed by current regulations. This limitation also applies for the sulfur content of fuel to be burnt in port or in a sulfur restricted area.

Prior to bunkering, the Chief Engineer should confirm that the specification of the fuel oil being delivered is the same as that ordered, and that the quantity being supplied is also that which was requested. The fuel log must be completed to record the quantity of that ordered and the quality of that delivered. The purpose of this procedure is to ensure that bunkers of the correct specification and agreed quantity are received on board in a safe and efficient manner which minimises the risk of pollution.

a) Prior to bunkering, the operation must be discussed with the bridge team where any matters which are likely to interfere with bunkering must be raised. All shipboard personnel must be made aware that bunkering is to take place.

b) A bunker plan should be compiled and all personnel involved in bunkering should be fully conversant with the plan contents and have a copy of the plan readily available for reference. The Chief Engineer is responsible for bunker loading operations, assisted at all times by a sufficient number of officers and ratings to ensure that the operation is carried out safely.

c) It should be established if any local regulations will apply to the bunkering operation. Complete the pre-transfer checklist and port security checklists.

d) An effective deck watch is to be maintained at all times and should include adequate supervision of both the ship and terminal operations.

e) All personnel involved should be in hand-held UHF radio contact, the radios being tested prior to the bunkering operation. Both the ship and shore are to agree on predetermined emergency procedures.

f) Fire fighting and SOPEP equipment should be readied prior to the commencement of bunkering and be readily to hand. Portable pumps should be rigged by the deck scuppers.

g) All bunker hoses are to be in good condition, and means of support to be confirmed as adequate.

h) Scuppers and save-alls (including those around bunker tank vents) should be effectively plugged. Drip trays around the bunker manifold are to be clear of anything that may block their drainage.

i) Unused bunker manifolds are to be fully secured and blanked to prevent any inadvertent leakage.

j) The bunker tank vents are to be confirmed open prior to filling the respective tank.

k) Shore or barge tanks (whichever is applicable) should be checked for water content. The barge soundings are to be checked prior to the commencement of bunkering. The Chief Engineer should also calculate the estimated finishing ullages/ soundings prior to the starting of loading.

l) Loading should start at the agreed minimum loading rate. Only upon confirmation of no leakage and fuel going only into the nominated tanks, should the loading rate be increased.

m) Where possible, new bunkers are to be segregated on board prior to use until results of the laboratory analysis have been received. The mixing of bunkers from separate deliveries is to be avoided, and wherever possible, bunkers are not to be used until a satisfactory oil analysis has been received.

n) No internal transferring of bunkers should take place during bunker loading operations unless permission has been obtained from the Chief Engineer.

o) Bunker tanks should not exceed the company stipulated maximum at any time. *90% (AUTHOR'S NOTE: Owner to confirm)* full will give an adequate reserve space for fuel oil expansion owing to temperature. It should be confirmed as to the maximum filling quantity required by the owners and/or the charterers.

p) Any bunker barges attending the vessel are to be confirmed as having been safely moored alongside by the bridge before any part of the bunker loading operation begins.

q) Level alarms fitted to bunker tanks should be tested prior to any bunker loading operations and that tank gauging systems are operational.

r) A watch for signs of leakage should be kept at the manifold during loading.

s) The maximum pressure in the bunker line should be below *4.0* bar.

t) Representative samples are to be drawn using the continuous drip method for the duration of the loading operation, and they are to be immediately dispatched for laboratory analysis. In addition, duplicate oil samples are to be taken and retained on board for at least one year. All sampling must be witnessed by a representative of the supplier and be sealed in the presence of the supplier and the receiver. Ship's copy of delivery notes are to be taken from the supplier and retained on board for a period of at least three years.

u) When the capacity of a tank being loaded approaches 80%, topping-off is to be carried out. The flow of oil to the tank in question should be reduced to half by diverting the flow of oil to another tank. In the case of the final tank, the loading rate should be reduced to the agreed minimum at least 20 minutes before the finishing ullage is reached. Endeavour to finish bunkers in the tank on the same side as the shore installation/ barge loading manifold. This will give visual, as well as verbal communication with the shore/barge operators.

CAUTION
Bunker tanks should not exceed the company or charterer agreed maximum quantity at any time.

v) The Oil Record Book and associated documentation should be updated on completion of loading, and any letters of protest issued during bunker operations to be referenced and filed.

Marine Gas Oil System

There are eight Marine Gas Oil (MGO) storage tanks, three MGO service tanks and three MGO settling tanks. The MGO is transferred from one tank to the other using the MGO transfer pumps.

The MGO storage tanks are filled from dedicated MGO bunkering lines located at the bunker manifolds on the port and starboard sides of the vessel at main deck level each side of the multi purpose space. The MGO transfer pumps are used to transfer oil from the storage tanks to the settling tanks at a rate of 30.0m^3/h and a pressure of 3.0 bar. The pumps are started and stopped automatically.

The MGO service tanks, and the MGO storage tanks overflow to the 26.5m^3 fuel overflow tank.

Marine Gas Oil Tanks (maximum filling capacity 98%)

Compartment	Volume 100% m^3	Volume 98% m^3
MGO storage tank 1C	311.3	305.0
MGO storage tank 2P	228.7	224.1
MGO storage tank 2C	288.2	282.5
MGO storage tank 2S	228.7	224.1
MGO storage tank 3P	231.0	226.3
MGO storage tank 3S	231.0	226.3
MGO storage tank 4P	204.4	200.3
MGO storage tank 4S	204.4	200.3
No.1 MGO settling tank (C)	64.3	63.0
No.1 MGO service tank (C)	37.4	36.7
No.2 MGO settling tank	42.6	41.8
No.2 MGO service tank	26.2	25.7
No.3 MGO settling tank	42.6	41.8
No.3 MGO service tank	26.2	25.7
Total MGO in storage tanks	**2166.8**	**2123.5**

The MGO storage, settling, service tanks are located as follows:

- Forward MGO storage tanks 1C, 2P, 2C, 2S between frames 159~182.
- Aft MGO storage tanks 3P, 3S, 4P, 4S between frames 13 ~ 48 aft.
- No.1 MGO settling and service tank (C) between frames 90~93.
- No.2 MGO settling and service tank (P) between frames 48~51.
- No.3 MGO settling and service tank (S) between frames 48~51.

The outlet valves from the MGO settling, and service tanks are remotely operated quick-closing valves with a collapsible bridge. They are pneumatically operated from the fire control station. After being tripped, the valve must be reset locally. Filling and transfer valves on the MGO storage tanks are operated from CAMS screen mimic

The MGO service and settling tanks are fitted with self-closing test cocks to test for the presence of, and to drain any water in these tanks. Tundishes under the self-closing test cocks drain any liquid to the sludge tank. All tanks are provided with level indication, plus remote level indication on CAMS.

Procedure to Load Marine Gas Oil Bunkers from Shore/Barge

The procedure below assumes that the MGO storage tanks are to be filled from the port bunker station manifold connection.

At the bunker loading connection to be used, remove the blank, and connect the bunker hose. Arrange a drip tray beneath the connection.

a) Ensure that the blanks on the other bunkering connections are secure and that the valves are closed. Ensure that the drain and sampling valves are closed.

b) Set the valves as in the following table:

All valves are prefixed OF unless otherwise shown.

Position	Description	Valve
Open	Port bunker manifold valve	301
As required	Port bunker manifold sample valves	304/5
Closed	Port bunker manifold drip tray drain valves	302/3
Closed	Starboard bunker manifold valve	311
Closed	Starboard bunker manifold sample valves	314/15
Closed	Starboard bunker manifold drip tray drain valves	312/13
Closed	Bunker line valve to settling tanks	206
Open	Bunker line valve to MGO tanks	211
Closed	EDG MGO tank filling valve (NC)	212
Closed	No.2 MGO transfer pump suction valve from bunker line	204
Open	MGO bunker line isolation valve	205
Closed	MGO filling valve for No.2+3 settling tanks	206
ClosedNC)	MGO drain valve to fuel overflow tank	213
Open	MGO filling/suction valve for No.3P+4P storage tanks	225
As required	No.3P MGO storage tank filling/suction valve	706
As required	No.4P MGO storage tank filling/suction valve	707
Open	MGO filling/suction isolation valve	709
Open	MGO bunker line isolation valve	207
Open	MGO filling/suction valve for No.3S+4S storage tanks	226
As required	No.3S MGO storage tank filling/suction valve	701
As required	No.4S MGO storage tank filling/suction valve	702
Open	MGO filling/suction isolation valve	704
Open	MGO bunker line isolation valve	207
Closed	MGO bulkhead isolation valves between ER2/ER1	293 093
Open	MGO line valve to forward MGO storage tanks	208
Open	MGO bulkhead isolation valves between ER2/ER1	292 092
Open	MGO filling/suction isolation valve for forward MGO storage tanks	027
Open	MGO line isolation valve to/from forward MGO storage tanks	601
As required	No.2P MGO storage tank filling/suction valve	411
As required	No.2C MGO storage tank filling/suction valve	412
As required	No.1C MGO storage tank filling/suction valve	413
As required	No.2S MGO storage tank filling/suction valve	414

c) Establish effective communication between the engine control room, and ship's office, with the bunkering barge/shore installation.

d) Signal to the barge/shore installation to commence bunkering MGO at an agreed slow rate.

e) Check the ship to barge/shore bunker flange connection and around the bunker pipeline for leaks.

f) Check that MGO is flowing into the MGO storage tanks.

g) Increase the bunker loading rate to the agreed maximum.

h) Adjust bunker valves to allow one tank to finish loading first. Always ensure another bunker tank filling valve is open before closing-in to top a tank off.

i) Signal to barge/shore installation to reduce the pumping rate to half when the final two tanks reach 80% full. Shut the loading valve on one of the two final tanks to be loaded and fill the second to last bunker tank.

j) Signal to further reduce the flow rate until the final tank is at the required level and then signal to stop.

k) The shore barge/shore installation may want to blow the bunker line with air, and clear it to the ship's tanks. In this case, leave the manifold valve, and final bunker tank filling valve open. Confirm with the barge/shore installation that all is clear to blow the line.

l) After confirming with the bunker supplier that it is safe to do so, close the manifold valve at the bunkering connection.

m) Disconnect the hose connection and replace the blank.

n) Close all the tank filling valves.

o) Take ullages all tanks, and confirm the final delivery total before releasing the bunker supplier.

p) Collect and label samples and send ashore for laboratory testing, ensuring that the MARPOL and the ship's sample are retained on board.

q) The Oil Record Book and associated documentation should be updated on completion of loading, and any letters of protest issued during bunker operations to be referenced and filed.

Transferring MGO from an Aft MGO Storage Tank to a MGO Settling Tank

This procedure assumes that MGO is to be transferred from No.3P MGO storage tank to No.3 MGO settling tank using No.2 MGO transfer pump.

a) Ensure that the transfer pump suction strainer is clean.

b) Open the suction valve at No.3P MGO storage tank.

c) Set the pump valves and the line filling valves as in the following table:

Position	Description	Valve
Open	MGO filling/suction valve for No.3P+4P storage tanks	225
Open	No.3P MGO storage tank filling/suction valve	706
Closed	No.4P MGO storage tank filling/suction valve	707
Closed	MGO filling/suction isolation valve	709
Closed	MGO bulkhead isolation valves between ER2/ER1	291 091
Open	No.2 MGO transfer pump suction from No.3P+4P storage tanks	204
Open	No.2 MGO transfer pump suction valve	201
Open	No.2 MGO transfer pump discharge valve(set 1.0 bar)	203
Open	MGO line discharge valve to No.2+3 settling tanks	206
Closed	No.2 MGO settling tank filling valve	218
Open	No.3 MGO settling tank filling valve	219

d) Start the MGO transfer pump manually and check that MGO is being pumped to No.3 MGO settling tank.

e) When the desired amount of MGO has been transferred, stop No.2 MGO transfer pump, close all valves and record the transfer in the relevant documentation.

Transferring MGO from a Forward MGO Storage Tank to an MGO Settling Tank

This procedure assumes that MGO is to be transferred from No.2P MGO storage tank to No.1 MGO settling tank using No.1 MGO transfer pump.

a) Ensure that the transfer pump suction strainer is clean.

b) Open the suction valve at No.2P MGO storage tank.

c) Set the pump valves and the line filling valves as in the following table:

Position	Description	Valve
Open	No.2P MGO storage tank filling/suction valve	411
Closed	No.2C MGO storage tank filling/suction valve	412
Closed	No.1C MGO storage tank filling/suction valve	413
Closed	No.2P MGO storage tank filling/suction valve	414
Open	MGO line isolation valve to/from forward MGO storage tanks	601
Open	MGO filling/suction isolation valve for forward MGO storage tanks	027
Closed	No.1 MGO transfer pump line suction valve from No.3S+4S storage tanks	009
Open	No.1 MGO transfer pump line suction valve from forward storage tank	010
Closed	MGO bulkhead isolation valves between ER2/ER1	293 093
Open	No.1 MGO transfer pump suction valve	001
Open	No.1 MGO transfer pump discharge valve(set 1.0 bar)	003
Open	MGO line discharge valve to No.1 settling tank	006
Closed	MGO line discharge valve to No.3S+4S storage tanks	007
Closed	No.1 MGO transfer pump discharge valve to forward MGO storage tanks	008
Closed	No.1 MGO transfer pump discharge valve for tank draining to fuel overflow tank (NC)	013

d) Start No.1 MGO transfer pump manually and check that MGO is being pumped to No.1 MGO settling tank.

e) When the desired amount of MGO has been transferred, stop No.1 MGO transfer pump, close all valves and record the transfer in the relevant documentation.

Note: MGO transfer pumps can operate in automatic operation.

(Authors Note: Owners to advise of their procedure for automatic transfer of bunkers.)

Transferring MGO from an MGO Service Tank to the Emergency Generator Fuel Tank

The MGO is transferred from the main engine MGO service system from the discharge of the MGO circulating pumps.

a) Set the pump valves and the line filling valves as in the following table:

Position	Description	Valve
Open	Emergency DG MGO service tank filling valve	OP351
Open	No.2 MGO transfer pump discharge valve to EDG MGO service tank	OF212

b) Open valve OP351, and check that MGO is being pumped to the EDG MGO fuel tank.

c) When the EDG MGO service tank reaches the required level, stop No.2 MGO transfer pump.

c) Close valves OP351, and OF212.

d) Enter the MGO transfer details in the Engine Room Log Book, and Oil Record Book.

6.4.2 TANK VENTS AND OVERFLOW SYSTEM

Introduction

All tanks are vented to atmosphere; small tanks within the machinery spaces which contain small quantities of fluid, such as independent LO tanks, are vented within their respective compartments.

The air pipes from the WB tanks, void spaces, FW tanks, and MGO storage tank are fitted with a vent head of the automatic closed type (float disc type). Air vent heads for the MGO tanks are fitted with a stainless steel fire-proof screen, and those for FW tanks are fitted with an insect-proof stainless steel wire net. The height of the air pipes above the main deck are as follows.

- 760mm on the freeboard deck
- 450mm on the superstructure deck

Sounding pipes, where fitted for double bottom tanks are terminated in the respective engine rooms or machinery spaces, and those for FO tanks and LO tanks are fitted with a self-closing cap at upper end. Oil spill coamings having a capacity of minimum one (1) barrel are fitted under or around each vent pipe head of FO tanks, and LO tanks in compliance with the USCG requirements. A drain plug is fitted at the lowest point of the coaming. Equalizing holes are fitted at the uppermost part of the sounding pipe in tanks for to be sounded. A striking plate is fitted at bottom of each sounding pipe to protect the steel plate. As a remote level measuring system of the pressure sensing type is fitted to each FW tank no sounding pipe are fitted to these tanks.

The vent lines from the MGO service and settling tanks have no-return valves fitted that drain any liquid build up to the waste oil drain tanks. No.1 MGO service/settling tanks drain to waste oil tank No.1, and No.2 MGO service/settling tanks drain to waste oil tank No.2 .

Sea chests have air venting throught holes on the shell plate instead of a venting pipe as far as practicable.

The FO overflow tank can be pumped out by No.1 MGO transfer pump. The contents of the MGO overflow tank can be pumped to No.1 MGO settling tank, or to the aft MGO storage tanks, or to the shore discharge connection at the bunker stations as required. The FO overflow tank has a high level alarm.

All clean and used LO tanks vent/overflow into a coaming around each tank. Each LO tank overflow line has a single vent which terminates in a gooseneck which then directs any overflow into a line which leads to the coaming around the tank.

The MGEs all have individual venting arrangements for their sump tanks. Each engine has two vent lines, each of those lines having two inlets. One vent is from the sump, the other is from the turbocharger. All vent lines are fitted with water traps, which overflow into nearby scuppers.

Sludge tank No.1 vent is common with waste oil tank No.1 vent, and sludge tank No.2 vent is common with waste oil tank No.2 vent

The sludge oil mixing tank vents/overflows into a drain cowl then through normally closed valve OI353 toily bilge tank No.2. The drain cowl is vented on main deck level through a air vent goose neck pipe with a screen, and drain cowl. All bilge tanks vent to the main deck

CAUTION
There is no automatic stop of any bilge/sludge transfer pump. If the pumps are allowed to run unattended and alarms are ignored, oil will eventually be spilt at some point around the vessel. This situation must not be allowed to occur, and the operation of the these pumps must be fully attended to at all times.

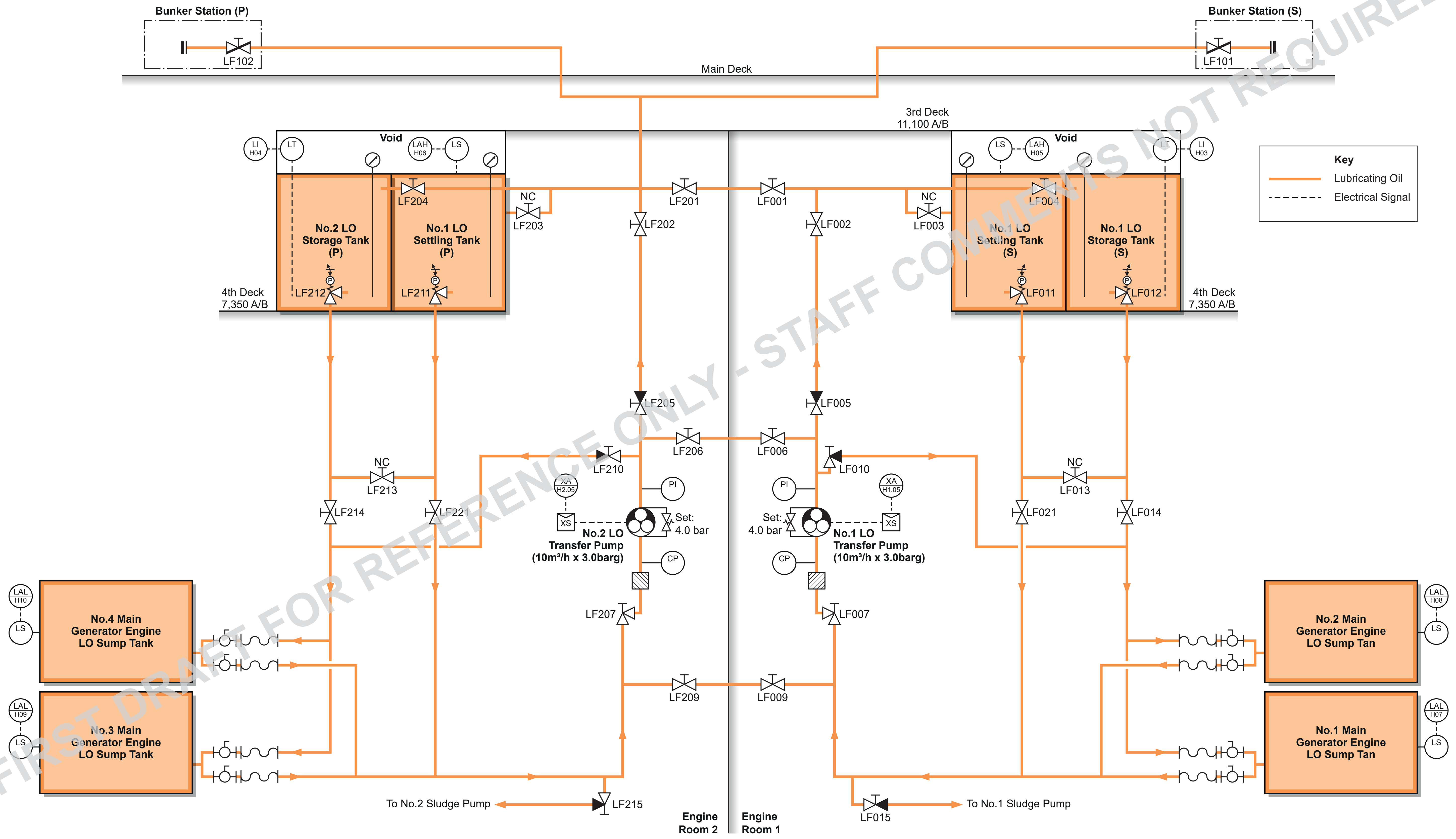
The FW tanks, and the DW water tank vent through float disc type vents on the main deck, and the FW tanks are fitted with an insect-proof stainless steel wire net. BW and forward and aft heeling tanks vent to the maindeck

The sewage forward vacuum unit vents through a vent outlet on the foremast and aft vacuum units vent through vent outlets at the funnel. The sewage treatment units vent through a combined vent outlet at the funnel. The vent outlets are fitted with flame arresters.

The black sewage treatment system has its own venting arrangements. The vents from this system are led to the funnel where they are passed into the MGEs exhaust stream.

CAUTION
Grey water must not be discharged overboard except in waters where the discharge is permitted. The bridge must always be consulted before any discharge of grey water.

Illustration 6.4.3a LO Transfer System



Reference Drawing: NSMV-543-B702, Rev: 01

6.4.3 LUBRICATING OIL FILLING AND TRANSFER SYSTEM

Lubricating Oil Transfer Pumps

Manufacturer:	Allweiler
Type:	Horizontal screw
Model:	ACG 052N7 NVBP 100 001
No. of sets:	2
Capacity:	11.7m^3/h (413ft^3/h) at 3.0 bar (43.5psi)
Motor:	440V, 4.7kW(6.3hp), 1,740 rpm

Introduction

Main diesel generator engines (MGEs) LO is stored in the following tanks:

Lub. Oil Tanks (maximum filling capacity 98%)

Compartment	Volume 100% m^3	Volume 98% m^3
LO storage tank No.1	8.1	7,9
LO storage tank No.2	8.1	7.9
LO settling tank No.1	6.1	6.0
LO settling tank No.2	6.1	6.0
Total LO in storage tanks	**28.4**	**27.8**

Each MGE sump holds 1.87 m^3 of LO.

The MGE LO storage, and settling tanks are all fitted with quick-closing valves on their outlets that can be operated remotely from the fire control station in the event of an emergency. If tripped, the valves must be manually reset before the systems can be returned to operation. The tanks are also fitted with self-closing test cocks that are used to check for the presence of water and sludge. The drains from No.1 LO storage and No.1 settling tanks lead to the No.1 waste oil tank(S) of capacity 19.8m^3. The drains from No.2 LO storage and No.2 settling tanks lead to the No.2 waste oil tank(P) of capacity 34.5m^3. The LO settling tanks have a high level alarm that operates at 80% full.

The MGE LO settling tanks allow the contents of the MGE sumps to be removed for cleaning during periods of maintenance. The cleaning involves pumping the contents of a sump up to a settling tank, and allowing it to settle over a period of time so that any water and impurities can settle out.
The LO being pumped up to the settling tanks is normally batch processed before returning to the sump from where it came. When the renovated oil is being returned to its sump, it is run down under the action of gravity.

Both of the LO storage tanks are filled via dedicated lines from filling stations on the port and starboard side bunker stations on the main deck at the side of the multi purpose space.

Both LO transfer pumps have a capacity of 11.7m^3/h (413ft^3/h) at 3.0 bar (43.5psi), and can take their suctions from any one of the following:

- No.1 LO storage tank.
- No.1 LO settling tank.
- No.2 LO storage tank.
- No.2 LO settling tank.
- No.1, 2, 3, 4 MGE LO sump tanks.

The pumps can then discharge to any one of the following:

- No.1 LO storage tank.
- No.1 LO settling tank.
- No.2 LO storage tank.
- No.2 LO settling tank.
- No.1, 2, 3, 4 MGE LO sump tanks.
- Discharge to shore.

CAUTION

Extreme care must be taken when transferring LO to ensure that oils of different grades do not become mixed or contaminated. The setting of all of the valves must be checked and re-checked prior to starting operations to ensure oil will only be pumped or separated to and from the intended source/destinations. All transfers must then be recorded in the Oil Record Book.

Loading Lubricating Oil from a Shore Station or Barge

Note: The preparation and operation procedures for loading should be followed as described in the Fuel Oil Bunkering and Transfer System section of this Manual. Precautions to be observed when loading LO are the same as for loading Marine Gas Oil. A bunker plan must be drawn up and adhered to with all loading/off loading operations recorded in the ship's oil record book.

a) Prior to loading, check that there is sufficient capacity in the receiving tank to accommodate the LO ordered.

b) Agree with the supplier the amount of LO to be supplied. Ensure that the specification of the LO to be delivered conforms to the specification of the LO ordered.

To Load Lubricating Oil Bunkers

At the LO bunker connection to be used, remove the blank, and connect the bunkering hose using a new joint. Arrange a drip tray beneath the connection. The area around the filling connection must be clean and the loading hose connected immediately to prevent the ingress of dirt. When this has been carried out, proceed as follows:

c) Ensure that the blanks on the other bunkering connection is secure, and that the manifold valve is closed.

d) Open the filling valve on the LO storage tank to be loaded (see tables below).

e) Remove the blank on the bunkering connection at the relevant bunker station. Check that the correct valves are open for the tank to be filled.

f) Establish effective communication between the bridge, engine control room, and the bunkering barge/shore station.

g) Signal to the shore installation/barge to commence pumping the confirmed LO grade at an agreed slow rate.

h) Check the ship-to-shore installation/barge connection and pipeline for leaks, and that LO is flowing into the correct storage tank and not to any other tank. Increase bunkering to the agreed maximum rate for the line.

i) As the level in the LO storage tank approaches 85%, signal to the barge/shore to reduce the flow rate until the tank has reached the required level, then signal to stop.

j) On completion of the bunkering operation, sound the tanks and agree the correct amount transferred to the vessel. Sign the LO receipt on confirmation of quantity received by supplier.

k) Leave the LO storage tank filling valve open for a time to drain the LO bunkering line back to the tank, then close the valve.

l) Close the bunker manifold valve, and disconnect the hose connection and replace the blank.

m) Ensure all the tank filling valves are closed.

n) Enter the details of the operation in the Oil Record Book.

Tank settings for loading LO are as in the table below, assuming that bunkering is from the starboard side manifold.

For each operation detailed below, it is assumed that all filling valves to other LO tanks are confirmed to be closed by the engineer overseeing the LO bunker.

MGE Lubricating Oil Storage/Settling Tanks and Loading Manifolds

All valves are prefixed LF unless otherwise shown.

Position	Description	Valve
Open	LO storage/settling tank manifold valve (S)	101
Closed	LO storage/settling tank manifold valve (P)	102
Closed	LO line valve from No.1 LO transfer pump	002
Closed	LO line valve from No.2 LO transfer pump	202
Closed	No.1 LO settling tank filling valve (P) (NC)	003
As required	No.1 LO storage tank filling valve (P)	004
Closed	No.2 LO settling tank filling valve (S) (NC)	203
As required	No.2 LO storage tank filling valve (S)	204

Transferring LO Using the LO Transfer Pumps

a) Before transferring LO, check and record the levels of oil in all the LO tanks, and confirm the tank suction and filling valves are initially closed.

b) Check the LO transfer pump suction filter is clean, and ready for use.

c) After confirming the other LO system valves are closed, open the relevant valves in accordance with the following tables:

Transferring LO using No.1 LO Transfer Pump

This procedure assumes No.1 LO transfer pump is to pump out No.1 or No.2 MGEs to No.1 LO settling tank.

Position	Description	Valve
As required	No.1 MGE LO sump suction valve	
As required	No.2 MGE LO sump suction valve	
Closed	No.1 sludge pump suction valve	015
Closed	X-connection suction valve to No.2 LO transfer pump	009
Open	No.1 LO transfer pump suction valve	007
Closed	No.1 LO transfer pump recir. valve to No.1/2 MGEs	010
Closed	X-connection discharge valve to No.2 LO transfer pump	006
Open	No.1 LO transfer pump discharge valve	005
Closed	X-connection discharge valve to No.2 LO storage +settling tanks	001
Open	No.1 LO settling tank (P) filling valve (NC)	003
Closed	No.1 LO storage tank (P) filling valve	004

Transferring LO using No.2 LO Transfer Pump

This procedure assume No.2 LO transfer pump is to pump out No.3 or No.4 MGEs to No.2 LO settling tank.

Position	Description	Valve
As required	No.3 MGE LO sump suction valve	
As required	No.4 MGE LO sump suction valve	
Closed	No.2 sludge pump suction valve	215
Closed	X-connection suction valve to No.1 LO transfer pump	209
Open	No.2 LO transfer pump suction valve	207
Closed	No.2 LO transfer pump recir. valve to No.1/2 MGEs	210
Closed	X-connection discharge valve to No.1 LO transfer pump	206
Open	No.2 LO transfer pump discharge valve	205
Closed	X-connection discharge valve to No.1 LO storage +settling tanks	201
Open	No.2 LO settling tank (S) filling valve (NC)	203
Closed	No.2 LO storage tank (S) filling valve	2 04

d) Confirm all of the other valves in the LO system are closed.

e) Start the LO transfer pump.

f) Check the oil is being correctly transferred.

g) When the required amount of oil has been transferred, stop the pump, and close all of the valves associated with the transfer operation.

h) Check and record the levels of oil in the LO tanks and record the amount transferred in the Engine Room Log.

Transferring LO by Gravity

It is possible to transfer LO under the action of gravity from the storage and settling tanks. Before any LO transfer operations are started, it must be confirmed that all of the valves associated with the transfer, and filling system are initially closed.

No.1 LO Storage Tank to MGEs No.1+2 Sumps

a) Check and record the level of oil in the No.1 LO storage tank and in No.1/2 MGE sumps, then set the valves in accordance with the following table.

MGE No.1 + No.2 LO Sumps

Position	Description	Valve
Open	No.1 LO storage tank quick-closing outlet valve	012
Closed	X-connection suction valve to No.1 LO settling tank run-down line (NC)	013
Open	No.1 LO storage tank line rundown valve	014
As required	No.1 MGE sump filling valve	
As required	No.2 MGE sump filling valve	

No.1 LO Settling Tank to MGEs No.1+2 Sumps

a) Check and record the level of oil in the No.1 LO settling tank and in No.1/2 MGE sumps, then set the valves in accordance with the following table.

MGE No.1 + No.2 LO Sumps

Position	Description	Valve
Open	No.1 LO settling tank quick-closing outlet valve	011
Closed	X-connection suction valve to No.1 LO storage tank run-down line (NC)	013
Open	No.1 LO settling tank line rundown valve	021
As required	No.1 MGE sump filling valve	
As required	No.2 MGE sump filling valve	

b) When the required amount of LO has been transferred, close all the valves associated with the operation, check and record the levels in the No.1 LO storage/settling tanks, and sump tanks. Record the amount transferred in the Engine Room Log.

No.2 LO Storage Tank to MGEs No.3+4 Sumps

a) Check and record the level of oil in the No.2 LO storage tank and in No.3/4 MGE sumps, then set the valves in accordance with the following table.

MGE No.3 + No.4 LO Sumps

Position	Description	Valve
Open	No.2 LO storage tank quick-closing outlet valve	212
Closed	X-connection suction valve to No.2 LO settling tank run-down line (NC)	213
Open	No.2 LO storage tank line rundown valve	214
As required	No.3 MGE sump filling valve	
As required	No.4 MGE sump filling valve	

No.2 LO Settling Tank to MGEs No.3+4 Sumps

a) Check and record the level of oil in the No.2 LO settling tank and in No.3/4 MGE sumps, then set the valves in accordance with the following table.

MGE No.3 + No.4 LO Sumps

Position	Description	Valve
Open	No.1 LO settling tank quick-closing outlet valve	211
Closed	X-connection suction valve to No.2 LO storage tank run-down line (NC)	213
Open	No.2 LO settling tank line rundown valve	221
As required	No.3 MGE sump filling valve	
As required	No.4 MGE sump filling valve	

b) When the required amount of LO has been transferred, close all the valves associated with the operation, check and record the levels in the No.1 LO storage/settling tanks, and sump tanks. Record the amount transferred in the Engine Room Log.

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6.4.4 LUBRICATING OIL AND FUEL OIL DRAIN SYSTEM

Sludge Pump

Manufacturer:	Allweiler
Type:	Progressing cavity
Model:	AEB1E380-1E/011P01 X 142P P5846
No. of sets:	2
Capacity:	20m^3/h (706ft^3/h) at 3.0 bar (43.5psi)
Motor:	440V, 4.7kW(6.3hp), 1,740/445 rpm geared motor

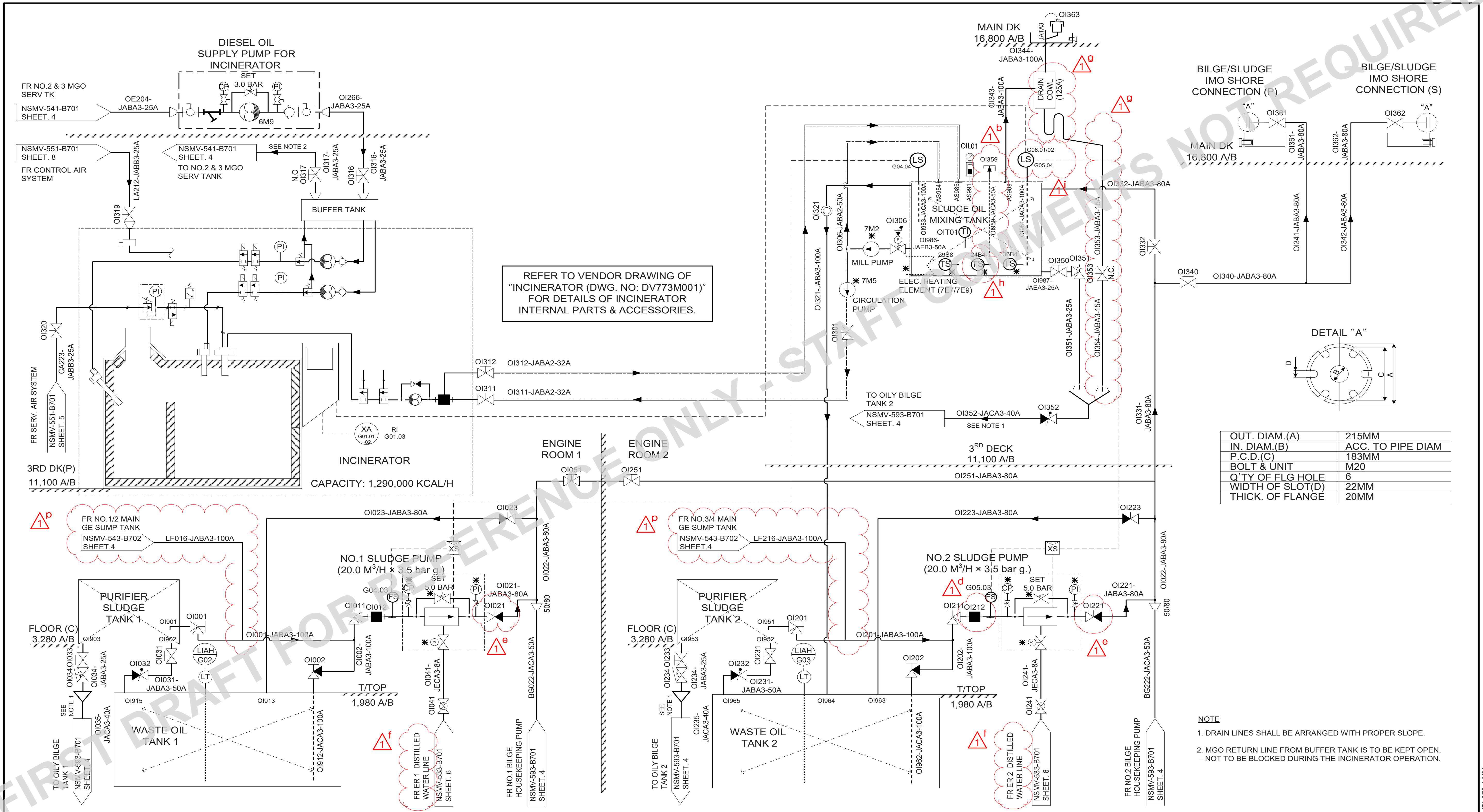
Introduction

All items of equipment and storage tanks in the engine room which contain LO or MGO are fitted with save-alls or similar devices for collecting any spilled oil, oil which leaks from glands or seals, or oil which is drained from tanks when sludging to remove water. This oil flows by means of gravity to No.1+2 waste oil tanks. Apart from non-return valves and inlet isolating valves, there are no valves in the waste oil collecting lines. Sludge/oil drain valves to the waste oil tanks must be maintained in the open position in order to ensure that the sludge/oil can flow to the tank at all times.

Each waste oil tank has a sludge pump by which the contents of the waste oil tank may be transferred to the sludge oil mixing tank, from where the sludge can be burnt in the incinerator. Alternatively, the waste oil tanks can be pumped ashore to a reception facility.

The sludge pumps must be started and stopped manually after the operator has opened the pump suction and discharge valves. The pumps are operated long enough to empty the associated waste oil tank, and it is then stopped; the pump must not be allowed to operate when it has lost suction. Waste oil tanks are fitted with high level alarms.

Illustration 6.4.5a Sludge System *(Authors note: Illustration currently in progress)*



OUT. DIAM.(A)	215MM
IN. DIAM.(B)	ACC. TO PIPE DIAM
P.C.D.(C)	183MM
BOLT & UNIT	M20
Q'TY OF FLG HOLE	6
WIDTH OF SLOT(D)	22MM
THICK. OF FLANGE	20MM

DESIGNER	BUILDER		United States Maritime Administration	WASTE OIL SYSTEM DIAGRAM -INCINERATOR WASTE OIL SYSTEM	NSMV-593-B702 SHEET 4 OF 9 REV. 1

HSA-Z-NSMV-TABLOID DSEC CO.,LTD.

6.4.5 SLUDGE SYSTEM

Sludge Pump

Manufacturer:	Allweiler
Type:	Progressing cavity
Model:	AEB1E380-1E/011P01 X 142P P5846
No. of sets:	2
Capacity:	20m^3/h (706ft^3/h) at 3.0 bar (43.5psi)
Motor:	440V, 4.7kW(6.3hp), 1,740/445 rpm geared motor

(Authors Note: Equipment and procedures to be confirmed by Owners.)

Introduction

Sludge and leak oil is collected from various locations around the machinery spaces iscollected into No.1 and No.2 waste oil tanks before treatment in the sludge mixing tank system. Each MGO separator has a sludge tank to which the separator discharges sludge. Each sludge tank drains to its respective waste oil tank by gravity. From the waste oil tanks, sludge may be pumped ashore using the associated sludge transfer pump.

Sludge from No.1 purifier sludge tank is drained to No.1 waste oil tank; sludge from No.2 purifier sludge tank is drained to No.2 waste oil tank. Sludge for treatment is taken from No.1 and No.2 waste oil tanks, and pumped to the sludge oil mixing tank where settlement takes place assisted by an electric heater in the tank. Some of the settled sludge is drained to oily bilge tank No.2. The remaining sludge is then burnt in the incinerator.

The No.1 and No.2 sludge pumps are used to pump sludge from the waste oil tanks to an approved reception facility ashore via discharges at the port and starboard bunker stations. They may also be used to pump sludge to the sludge mixing tank. After settlement the sludge can be burnt in the incinerator.

The sludge pumps are started and stopped by means of START and STOP pushbuttons, fitted locally. If sludge oil is being transferred ashore, the same precautions must be observed as when loading MGO bunkers; the SOPEP equipment must be complete, and available. Discharge of sludge oil ashore requires communication with the receiving station at all times. The ship and the receiving station must agree on the pumping rate, pumping start time, and the viscosity/temperature of the sludge oil being pumped. There are bilge/sludge oil shore discharge connections on the port and starboard sides of the ship at the bunker stations on the main deck.

Transferring Sludge

Transferring Sludge to the Sludge Oil Mixing Tank

This procedure is started manually, with the selected sludge transfer pump being started by the local pushbutton by the pump, and is stopped by the level switch in the sludge mixing tank.

a) Ensure the sludge pump suction filter is clean.

b) Ensure FW priming water is supplying the pump.

b) Set the system valves as shown in the following table which shows valve settings for the transfer of sludge from No.1 waste oil to the sludge mixing tank using No.1 sludge pump.

All valves are prefixed OI unless otherwise shown

Position	Description	Valve
Closed	No.1 purifier sludge tank suction valve	001
Open	No.1 waste oil tank suction valve	002
Open	No.1 sludge pump suction valve	011
Open	No.1 sludge pump discharge valve	021
Closed	No.1 sludge pump recirculation valve	023
Open	X-connection valves between ER1 and ER2	051 251
Open	No.1 sludge pump discharge valve to sludge mixing tank	332
Closed	No.1 sludge pump discharge valve to shore manifold	340

The procedure for pumping the contents of No.2 sludge tank to the sludge mixing tank is the same as that above, except for the setting of the tank suction valves.

Transferring Sludge Ashore

This procedure is completed manually, with the selected sludge transfer pump being started and stopped by the remote pushbuttons at the bunker station. The procedure described below assumes that No.2 sludge pump is being used to transfer sludge oil ashore via the discharge connection at the starboard bunker station. It is assumed that all tank suction valves have been checked as closed, except for those specifically mentioned:

a) Ensure that all bunkering precautions have been taken as described above.

b) Ensure the sludge pump suction filter is clean.

c) Ensure that the receiving station is aware of all conditions regarding the discharge operation, and the quantity, and quality of the sludge to be pumped.

e) Check communications between the ECR, the bunker station and the receiving station.

f) Remove the blank flange at the starboard bilge/sludge shore discharge connection, and attach the hose, ensuring that the joint is in good condition. Check that the blank flange at the port bilge/sludge shore discharge bunker station is secure and that the discharge valve is closed.

g) Set the valves as shown in the following table:

All valves are prefixed 'GDA' unless otherwise stated

Position	Description	Valve
Closed	No.2 purifier sludge tank suction valve	201
Open	No.2 waste oil tank suction valve	202
Open	No.2 sludge pump suction valve	211
Open	No.2 sludge pump discharge valve	221
Closed	No.2 sludge pump recirculation valve	023
Closed	X-connection valves between ER2 and ER1	251 051
Closed	No.2 sludge pump discharge valve to sludge mixing tank	332
Open	No.2 sludge pump discharge valve to shore manifold	340
Closed	Bilge/sludge shore connection (P)	361
Open	Bilge/sludge shore connection (S)	362

h) After final system checks and confirmation that the receiving station is ready to proceed, start No.2 sludge transfer pump at the bunker station. Start the pump by pressing the START pushbutton. Immediately test the stop facility by pressing the STOP pushbutton. When satisfied all is working correctly, start the pump again.

i) When No.2 waste oil tank reaches the low level, or the desired quantity of sludge has been transferred, stop No.2 sludge pump.

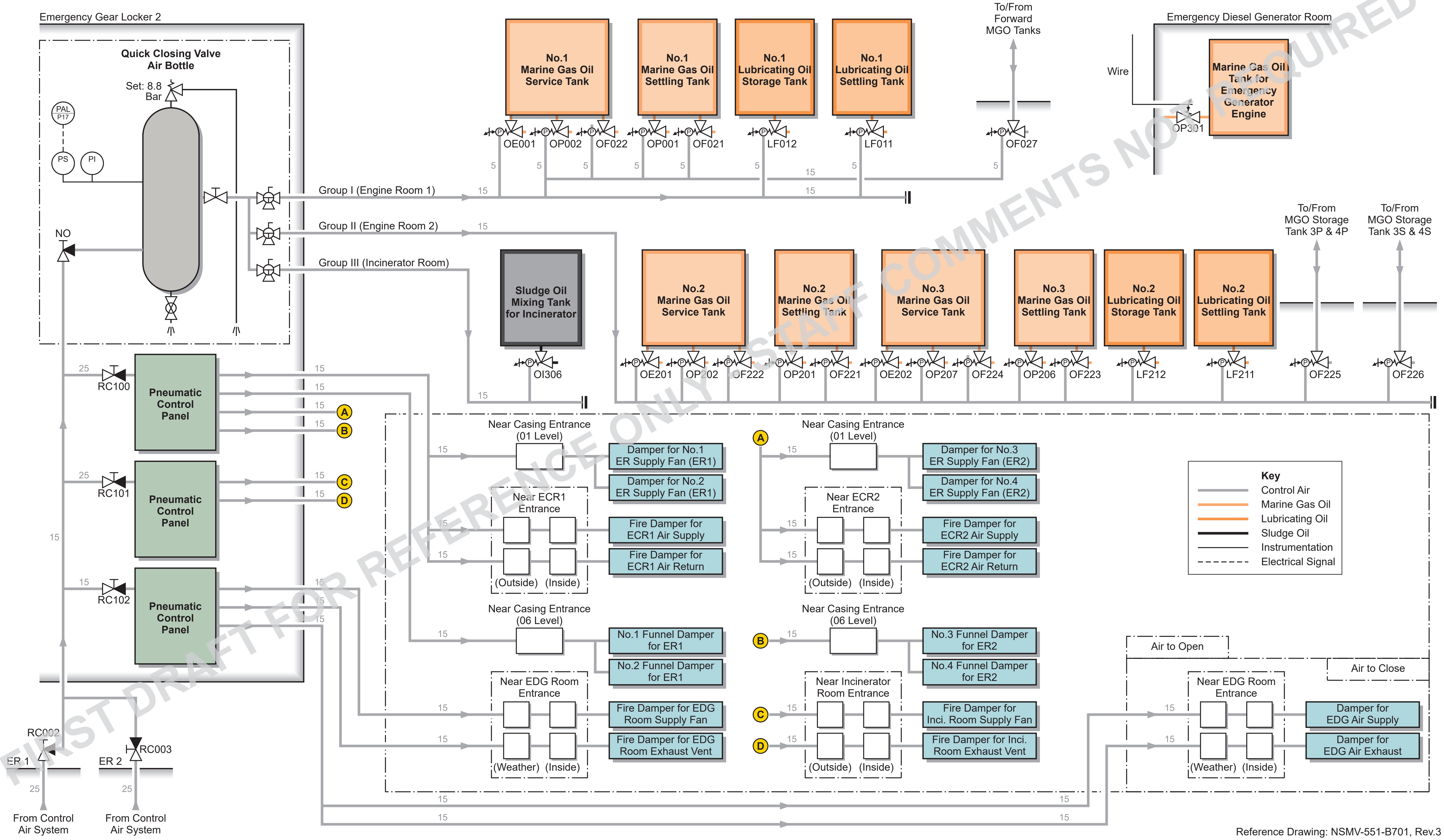
j) When the shore receiver says it is safe to do so, close all valves, allow the hose to drain, and remove the hose. Refit the blank flange at the starboard discharge connection.

k) Record the sludge transfer in the Oil Record Book.

The procedure for pumping the contents of No.1 sludge tank ashore is the same as that above, except for the setting of the tank suction valves.

> **Note:** When transferring sludge within the ship, the operator must ensure that the bunker station blanks are in place with the shore discharge valves firmly closed.

Illustration 6.4.6a Quick Closing Valve System



Reference Drawing: NSMV-551-B701, Rev.3

6.4.6 QUICK-CLOSING VALVES, FIRE DAMPER SYSTEM AND EMERGENCY STOPS

Quick Closing Valve Air Reservoirs

Manufacturer:	Poong Jin
Size:	350 liters at 8.0 bar
No. of sets:	1

Introduction

All the outlet valves from the fuel oil and lubricating oil tanks, from which oil could flow to feed a fire, are equipped with air operated quick-closing valves. They are supplied and controlled from the quick-closing valve air reservoir situated in emergency gear locker 2. The reservoir is supplied with air at a pressure of 8.0 bar from the control air system; the reservoir inlet valve from the compressed air system should be open at all times to ensure that the reservoir pressure is maintained.

The quick-closing valve air reservoir is fitted with a low pressure alarm transmitter and the pressure in the reservoir is displayed on the compressed air system CAMS mimic. The oil tank quick-closing valves' actuator lines are grouped into three systems each with a three-way operating cock.

In normal operation, the supply line to the tank valves is vented to atmosphere. When the three-way operating cock is rotated, air is supplied to pistons which collapse the bridge of each of the valves, thus causing the valves to close.

The valves are reset by venting the air supply and operating the valve handwheel in a closed direction to reset the bridge mechanism and then opening the valve in the normal way.

The emergency generator fuel oil tank is fitted with a quick-closing valve OP301 which is operated by a directly connected wire from outside the compartment.

Oil Tank Quick-Closing Valves

CAUTION

Some tanks such as small lubricating oil tanks do not have quick-closing apparatus fitted, as they are normally closed and only opened for short periods when required. It is important to ensure that these are always closed when not in use.

Air Supply Lines

Tank	Valve
Valves on air supply line Group I (ER1)	
No.1 MGO service tank outlet valve to MGEs	OE001
No.1 MGO service tank outlet valve to MGO purifiers	OP002
No.1 MGO service tank drain valve	OF022
No.1 MGO settling tank outlet valve to MGO purifiers	OP001
No.1 MGO settling tank drain valve	OF021
No.1 LO storage tank outlet valve	LF012
No.1 LO settling tank outlet valve	LF011
Forward MGO tanks filling/suction valve	OF027

Tank	Valve
Valves on air supply line Group II (ER2)	
No.2 MGO service tank outlet valve to MGEs	OE201
No.2 MGO service tank outlet valve to MGO purifiers	OP202
No.2 MGO service tank tank drain valve	OF222
No.2 MGO settling tank outlet valve to MGO purifiers	OP201
No.2 MGO settling tank drain valve	OF221
No.3 MGO service tank outlet valve to MGEs	OE202
No.3 MGO service tank valve from No.2 MGO transfer pump	OF207
No.3 MGO service tank drain valve	OF224
No.3 MGO settling tank outlet valve to MGO purifiers	OP206
No.3 MGO settling tank tank drain valve	OF223
No.2 LO storage tank outlet valve	LF212
No.2 LO settling tank outlet valve	LF211
MG storage tanks 3P + 4P filling/suction valve	OF225
MG storage tanks 3S + 4S filling/suction valve	OF226

Tank	Valve
Valves on air supply line Group III (Incinerator Room)	
Sludge oil mixing tank for incinerator	OI306

Operating the Quick-Closing Valve System

In normal operation, the supply line to the tank valves is vented to atmosphere, but when the cock is turned through 90º, compressed air is directed to the pistons which collapse the bridge of each valve, thus causing the valve to close.

The valves are reset by venting the air supply and operating the valve handwheel in a closed direction to reset the bridge mechanism, and then by opening the valve in the normal way. When the valve is fully open the locking arm can be reset by pushing the control lever on the end of the operation cylinder fully down.

Main Generator Engine Fuel Oil Inlet Quick-Closing Valves

Each MGE is fitted with fuel system quick-closing valve. This valve is for the main fuel oil supply line, which can be closed remotely.

Generator FO Isolation Valves Description	Fuel Oil
Fuel supply for No.1 generator engine	OE051
Fuel supply for No.2 generator engine	OE052
Fuel supply for No.3 generator engine	OE251
Fuel supply for No.4 generator engine	OE252

This system is supplied with air directly from the control air system, there is no air reservoir. The quick-closing valves are operated by four three-way cocks located in two cabinets one for MGE1+2, and one for MGE 3+4. *(Locations to confirm)*. Moving the operating lever for the respective MGE three-way cock to the 'emergency close' position will supply air to the top of the piston, closing the valve and stopping the fuel supply to the engine immediately. The valve will stay closed until reset manually.

To put the quick-closing valve cabinet into service for the MGEs, ensure that the supply valves LA010 for MGE1+2, and LA210 for MGE3+4 are fully open.

Ventilation Dampers

Ventilation systems in the engine room and accommodation spaces are provided with fan stops and fire dampers. Fans and ventilation systems may be stopped locally or remotely as required depending upon the nature of the outbreak.

Ventilation dampers are installed at various locations in order to shut off the flow of air which would feed a fire in a particular compartment. The dampers are to be closed in the event of a fire and ventilation fans shut off. In the event of a fire in a space where the Inergen fire suppression system is used, ventilation is automatically shut off when the system is initiated.

Air for operating these dampers is supplied by the control air system, the dampers are supplied from three master solenoid operated valve units located in the emergency gear locker No.2. Ventilation systems are grouped in order to allow any particular part of the ship to be isolated quickly. Each master valve supplies a number of individual fan dampers which are also fitted with solenoid control valves, this arrangement allows all of the dampers in the grouping to be closed at the same time, or allowing an individual fan damper to be closed when necessary.

Machinery Rooms Fire Dampers

Fire dampers operate to close the ventilation openings in the event of a fire in the engine room spaces. The dampers are kept open by air pressure supplied from the control air system. The dampers have a spring mounted in the cylinder assembly which will close the damper when the air pressure is vented. All dampers may be opened again by restoring the air flow to the damper unit.It is essential that the air supply valves are kept open in order to keep dampers in the open position for normal service. Remote operation of dampers from the emergency gear locker No.2 is arranged in three groups; these groups are indicated in the following tables. Each main group has a number of fan dampers associated within the group which can be closed independently when necessary.

Pneumatic Control Panel Supplied by Valve RC100	Control Location
Damper for No.1 ER supply fan (ER1)	Casing entrance 01
Damper for No.2 ER supply fan (ER1)	Casing entrance 01
Fire damper for ECR1 air supply	ECR1 entrance
Fire damper for ECR1 air return	ECR1 entrance
No.1 funnel fire damper for ER1	Casing entrance 06
No.2 funnel fire damper for ER1	Casing entrance 06
Damper for No.3 ER supply fan (ER2)	Casing entrance 01
Damper for No.4 ER supply fan (ER2)	Casing entrance 01
Fire damper for ECR2 air supply	ECR2 entrance
Fire damper for ECR2 air return	ECR2 entrance

Pneumatic Control Panel Supplied by Valve RC101	Damper
Fire damper for incinerator room supply fan	Incin. rm entrance
Fire damper for incinerator room exhaust fan	Incin. rm entrance

Pneumatic Control Panel Supplied by Valve RC102	Damper
Fire damper for EDG room supply fan	EDG room entrance
Fire damper for EDG room exhaust fan	EDG room entrance
Damper for EDG room supply fan	EDG room entrance
Damper for EDG room exhaust fan	EDG room entrance

Damper Operation

The damper is designed and constructed as a ‘fail close/fail open’ product (i.e. Fail close type damper is spring closes the damper blades upon loss of pneumatic or electrical supply. Fail open type damper is spring open the damper blades upon loss of pneumatic or electrical supply.)

a) The operation of the damper is controlled by a local electro-pneumatic control system. The damper controls enclosure contains the pneumatic actuator, plunger valve, solenoid valve and limit switches.

b) When the electrical supply to the solenoid valve is switched on, and the minimum air pressure is supplied to the actuator, the damper will open.

c) The damper will close, by way of actuator spring force, if there is loss of electrical power to the solenoid valve or loss of pneumatic supply. Pneumatic supply can be lost from the mains supply, or if the fusible bulb assembly is activated (i.e. bulb breaks).

d) When the fusible bulb operates, the plunger valve releases which in turn discharges air from the valve. This allows the spring return actuator to operate and close the damper.

e) The damper shall rotate anti-clockwise when opening and clockwise when closing. Direction of rotation is viewed on the drive end.

f) The limit switches shall be activated only within the last 5° of rotation of the blades when opening or closing. The blade position between fully open and fully closed can only be monitored at the enclosure, via the visual indicator.

Emergency Stops

In the event of a fire, it is essential any oil and air supply to the compartment be shut off and isolated. All machinery that could add to the fire must also be tripped and electrically isolated. The machinery involved comprises all FO pumps, hydraulic oil pumps, LO pumps and ventilation supply and exhaust fans. The various emergency stops are grouped together for ease of identification, being coded on the switchboards where the group starters are located. The coding is as follows:

List of Emergency Stops

Emergency Switchboard ES 1A

- ER1 vent fans.
- ER1 A/C.
- MR1 vent fans.
- MR1 A/C.
- FCR1 A/C.

Emergency Switchboard ES-1B

- ER2 vent fans.
- ER2 A/C.
- MR2 vent fans.
- MR2 A/C.
- FCR2 vent fans.
- FCR2 A/C.

Emergency Switchboard ES-3A

- ER1 LO pumps.
- MR1 LO pumps.
- FCR1 LO pumps.

Emergency Switchboard ES-3B

- ER2 LO pumps.
- MR2 LO pumps.
- FCR2 LO pumps.

Emergency Switchboard ES-6

- Other area fan.

Emergency Switchboard IT-1A

- ER1 vent fan.

Emergency Switchboard IT-1B

- ER2 vent fan.

Emergency Switchboard IT-4

- EDG room supply fan.

G18 AEmergency Stop Control Panel

- S1 - Engine Room Fan Start and Running (positive).
- S2 - Engine Room Fan Start and Running (reversing).
- S3 - Engine Room Fan Stop.
- H1 - SCR No.1 System Running.
- H2 - SCR No.2 System Running.
- H3 - SCR No.3 System Running.
- S4 - SCR No.1 System Stop.
- S5 - SCR No.2 System Stop.
- S6 - SCR No.3 System Stop.
- S7 - Spare.
- S8 - Spare.
- S15 - Lamp Test.

Also located in the fire control station are emergency start/stop pushbuttons for the following pumps and equipment:

- Water spray pump.
- Emergency fire pump.
- Fire pump.

The emergency fire pump can also be started and stopped from the cargo control console.

Shore Discharge Remote Stops

The shore discharge stations aft of the accommodation area, port and starboard, have control cabinets which house emergency stops for the following pumps:

- Sewage discharge pump.
- Engine bilge pump.
- Sludge pump.

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Anything to update?

It is important that this manual is kept up to date as a live document. If you believe there are any errors or omissions in this manual, or you are aware of changes to the equipment or systems on board then please contact the publishers:

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6.6 Engine Room Cranes, Hoists and Lifting Arrangements

6.6 ENGINE ROOM CRANES, HOISTS AND LIFTING ARRANGEMENTS

6.6.1 ENGINE ROOM OVERHEAD CRANES

Engine Room Cranes No.1+No.2

Manufacturer: Oriental

Type:	Trolley, normal head type, two speed
Model:	NSD-2 Ton
No. of sets:	2
Safe working load (SWL):	2 x 2.0 ton
Maximum hoist:	No.1: 7.34m, No.2: 7.56m
Rail length:	No.1: 8.05m, No.2: 9.3m
Span:	No.1: 7.6m, No.2: 8.85m
Maximum inclination:	<5° heel, <2° trim
Traversing speed (trans.):	3m/min
Traverse motor:	440V, 0.5kW(0.7hp), 1,160 rpm
Travelling speed (longit.):	3m/min
Travelling motor:	440V, 0.75kW(1hp), 1,730 rpm
Hoist speed (fast):	3.0m/min
Hoist speed (slow):	0.75m/min
Hoist motor:	440V, 2.0kW(2.7hp), 1,720 rpm
Control cable length:	No.1: 6.5m, No.2: 7.9m

Introduction

Machinery handling equipment provides facilities for lifting, transport and embarkation of machinery spares and stores. The lifting and transport requirements are satisfied by a number of different items of equipment including overhead cranes, chain hoists (blocks) with associated equipment, trolleys and pallet trucks.

Rails are fitted at locations throughout the machinery spaces in order to allow for the lifting and transport of machinery and other equipment. Hoists, chain blocks, eye bolts, wire strops, shackles etc, are colour-coded, indicating the maximum allowed loading. The Safe Working Load (SWL) must never be exceeded for any item of lifting equipment. It is the duty of the responsible person undertaking any operation requiring the use of lifting equipment to check that the equipment being used has a current certificate, that the equipment is in good condition and it is fit for purpose.

Overhead Cranes

The precautions that MUST BE taken when using the engine room overhead crane include, but will not be limited to the following:

General

- Overhead crane operation may only be carried out by competent personnel, trained to understand the hazards and risks involved with overhead crane activity.
- Personnel are, and will remain clear of the loads at all times.
- The load will not be suspended over, nor pass over personnel at any time.
- Under no circumstances may anyone ride the hook or load, injuries have occurred under these circumstances.
- Always operate the pushbuttons of the pendant with bare hands, operation wearing gloves introduces an increased risk of mis-operation.
- Never operate the crane from a remote location.
- The crane driver must always monitor the load, or the hook if the crane is being operated without a load.
- Never attempt to lift a load at an angle, center the overhead crane directly over the load before hoisting.
- Check that all lifting equipment to be used has a current test certificate, and check that the equipment is certified for the load to be lifted.
- A toolbox talk is required during which all of the team are involved.
- All personnel involved in the lifting activity are trained, competent and in possession of all required certification.
- NEVER stand or access below a suspended load.

Prior to Use

Prior to operation of the overhead crane, the person responsible for the lift MUST undertake a thorough visual inspection of the overhead crane components which include, but are not limited to, the following:

- Check the ropes for visible indication of wear, corrosion, broken strands or twist.
- Check if the rope is correctly wound upon the drum and pulley.
- Check if there are any loose or missing bolts, nuts, guards or covers.
- Check that the rated load capacity of the crane, hoist, chain, cable, slings, or other components WILL NOT be exceeded.
- Check that the hook rotates smoothly, the hook securing nut is normal and that the hook spring clip operates correctly.
- Check the weather conditions with the wheelhouse and request information regarding imminent maneuvers.

Prior to Lifting

Prior to attempting a commencement of a lift, the operation of the overhead crane under no-load condition MUST be checked:

- Check that the crane operates in the directions as indicated on the pendant pushbuttons.
    - Hoist, Lower, Long Travel (forward/aft), Traverse (port/starboard).
- Check that all hoist, lower, travel and traversing limit switches/safety devices operate correctly.
- Check that the drum brake operates correctly.
- Whilst operating the crane under no-load conditions, check for unusual noise or vibration.
- Prior to commencing any overhead crane activity, sound the warning siren to warn personnel that the crane is about to move.
- Check that the lifting device (sling, shackle etc) is sitting in the saddle of the hook.

During Lifting

- Ensure that the hoist rope does not become wrapped around the load.
- Ensure that slings, load chains and other lifting devices are securely seated on the hook and without a twist that could cause the load to swing.
- Ensure that the hoist is located directly above the load to be lifted.
    - Always lift vertically, as unnecessary force may be applied to the components of the crane when lifting at an angle.
- Check that the load is properly secured and balanced.
    - This can be checked as the load is lifted slightly and the sling is repositioned as required.
- Do not lower a load to such an extent that the rope becomes slack, as it may leave the drum groove and become damaged during hoisting, a minimum of two full turns of the rope MUST always remain on the drum.
- When changing direction of long travel or traverse, stop the movement of the crane and activate the opposite movement to stop the load swinging.

- Operate the crane movement under direction from one banks-man only, unless an emergency stop is required.

Each pair of MGEs. one pair in ER1, and one pair in ER2, has a 2.0 ton SWL capacity, electrically operated, travelling overhead gantry cranes. The hoist motor has two speeds, 3.0m/min on high speed, and 0.75m/min on low speed. The crane rails are fitted with toothed racks, and pinion drive arrangement. The gantry is fitted with a traversing toothed rack, and pinion drive arrangement which has the main hoist fitted to it.

The overhead cranes are fitted with the following safety devices:

- Hoist lowering limit.
- Hoist upper limit.
- Traversing limit (port and starboard) + clamp device.
- Travelling limit (forward and aft) + clamp device.
- Overload limit.
    - The hoist is fitted with a mechanical overload on the hoisting wire which will stop any movement if the weight on the hoist exceeds 125% of the SWL.

Note: All crane movements are protected against over-run in all directions by limit switches.

The hoist is powered by a self-braking motor driving through a reduction gear unit. This drives a drum on which the hoisting rope is wound. The motor drive shaft is fitted with a fail-safe electromagnetic disc brake.

Procedure for Operating Engine Room Overhead Cranes

a) Ensure that all lifting equipment to be used has a current test certificate and check that the equipment is certified for the load to be lifted.

b) Visually check the lifting equipment for defects, and if there is any damage, replace the item with an undamaged component; the damaged item must be sent for repair or scrapped, whichever is appropriate.

c) Firmly attach the lifting equipment to the component to be lifted, and ensure that all parts are securely attached. All bolts, screws, etc, must be fully screwed down, and no part of the screw thread must be exposed.

d) At the control power isolator panel for the overhead crane to be used, turn the power supply circuit-breaker to the ON position.

e) Release the emergency stop pushbutton on the control pendant to commence operation of the crane; the button is used to cease winching operations in an emergency.

f) Operate the lifting control as required. The following switches, pushbuttons and indicator lamps are fitted on the travelling lead controller pendant in order from top to bottom:

- Power source indication.
- Emergency Stop.
- On-Off (switch).
- Fast Up (High).
- Fast Down (High).
- Slow Up (Low).
- Slow Down (Low).
- Traverse to Left (Port).
- Traverse to Right (Starboard).
- Forward Travel.
- Aft Travel.

g) At the end of all lifting operations, the crane must be secured and the electrical isolator for the crane switched off in order to prevent inadvertent operation.

6.6.2 ENGINE ROOM HOISTS, TROLLEYS AND BEAMS

Engine Room Hoists, Trolleys

Manufacturer:	Daekyung
Types:	Plain trolley 1 ton (DPT-010) x 15
	Gear trolley 10 ton (DGT-100) x 2
	Gear trolley 5 ton (DGT-050) x 2
	Low headroom electric hoist 2 ton (DEXL-020) x 2
	Chain block 1 ton (DS-010) x 10
	Chain block 2 ton (DS-020) x 3
	Chain Block 5 Ton (Dh-050) x 1

Engine Room Beams

Beam for MGEs No.1+No.2 in ER1

No. of beams: 1 x 2.0 ton
Beam length: 9,390mm

Beam for MGEs No.3+No.4 in ER2

No. of beams: 1 x 2.0 ton
Beam length: 9,910mm

Beam for Purifiers No.1+No.2 in ER1 with plain trolley

No. of beams: 1 x 1.0 ton
Beam length: 3,750mm

Beam for Purifiers No.3+No.4 in ER2 with plain trolley

No. of beams: 1 x 1.0 ton
Beam length: 4,300mm

Beam for Engine Room Hatch Laydown Area in ER1 with plain trolley

No. of beams: 1 x 1.0 ton
Beam length: 8,100mm

Beam for Engine Room Hatch Landing Area in ER1 with plain trolley

No. of beams: 1 x 1.0 ton
Beam length: 11,900mm

Beam for Engine Room Hatch Landing Area in ER2 with plain trolley

No. of beams: 1 x 1.0 ton
Beam length: 5,950mm

Beam for Propulsion Shaft in MR1 with geared trolley 5 ton x 2 sets

No. of beams: 1 x 1.0 ton
Beam length: 6,950mm

Beam for Propulsion Shaft in MR2 with geared trolley 5 ton x 2 sets

No. of beams: 1 x 1.0 ton
Beam length: 9,320mm

Beam for Corridor (Fr90~Fr108) with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 13,000mm

Beam for Corridor (Fr96~Fr99) with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 2,500mm

Beam for Corridor (Fr108~Fr123) with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 10,400mm

Beam for General Workshop with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 9,900mm

Beam for Engine Stores with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 6,000mm

Beam for Machine Shop with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 8,950mm

Beam for Injector/Valve/Head Shop with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 3,250mm

Beam for Corridor (Fr123~Fr141) with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 12,400mm

Beam for Corridor (Fr141~Fr159) with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 12,700mm

Beam for Diesel Lab. with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 3,250mm

Beam for Side Port (S) with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 8,440mm

Beam for Side Port (P) with plain trolley

No. of beams: 1x 1.0 ton
Beam length: 8,310mm

Introduction

Engine Room Lifting Arrangements

Machinery handling requirements include facilities for lifting, transport, and embarkation of machinery spares and stores. The lifting and transport requirements are satisfied by a number of different items of equipment, including overhead cranes and chain hoists with associated equipment, trolleys and a pallet truck.

Rails are fitted at locations throughout the machinery spaces in order to allow for the lifting, and transport of machinery and other equipment. Hoists, chain blocks, eye bolts, wire strops, etc, are color-coded, indicating the maximum allowed loading. The safe working load (SWL) must never be exceeded for any item of lifting equipment. It is the duty of the engineer responsible for any operation requiring the use of lifting equipment to check that the equipment being used has a current certificate, and that the equipment is in good condition.

General Engine Room Lifting Equipment

Throughout the engine room there are rail systems with trolleys and chain blocks. These items of equipment are manually operated, and care must be taken to ensure that the equipment is operated safely and that loads are within the lifting limits of the equipment. All trolleys and chains must be secured when not in use.

Chain Blocks

The use of chain blocks is straightforward and is not explained here.

WARNING

Never use a chain block or any lifting equipment which does not display a valid current test marking.

Note: The lifting equipment in the machinery spaces all require careful attention during operation. All items of lifting equipment, including eye bolts and wire strops, must have a current test certificate, and it is essential that only equipment with a current test certificate is used. It is the responsibility of the engineering staff to ensure that lifting equipment is tested at the required intervals of time, and to ensure that this is the case, appropriate records must be maintained.

6.6.3 ENGINE ROOM SERVICE/PROVISIONS CRANE

Engine Room Service/Provisions Cranes

Manufacturer:	Oriental
Model:	FSC 50-0306
No. of sets:	2
SWL:	3 ton
Radius maximum:	6.0m
Radius minimum:	1.5m
Hoist lift:	24m
Hoisting speed:	10m/minute at rated load (by 2 layer)
Slewing speed:	0.9 rpm
Jib luffing time:	50 seconds (average up/down)
Heel/trim limits:	5°/2°
Steel wire rope:	14mm diameter, galvanised non-rotating
Motor:	440V, 19.5kW(26hp)
Power unit:	Working pressure of 250 bar (3,625psi)

Introduction

Two engine room service/provisions handling cranes are fitted, one on the port side the other on the starboard side at the after most part of deck 05 level aft. Each crane consists of a base column, slewing ring, column and gear, jib and hoisting gear, with a control platform on the side of the crane platform. All electrical, hydraulic and mechanical units required for the operation of the cranes are housed inside the crane pedestal.

The cranes are of electro-hydraulic operation with the hoisting, slewing, and jib movement being powered by the self-contained hydraulics. A single hydraulic pump supplies the hydraulic motors for these operations; with the hoisting winch gear mounted on the jib, luffing of the jib is performed by a hydraulic cylinder and slewing gear mounted on the base plate of the slewing post.

The hoisting machinery consists of a winch drum that is driven through reducing gear. The winch gear is built on a frame with hydraulic brake, motor, and flange-mounted load holding valve. There is a flange-mounted hydraulic hook stop in the top and bottom positions. All the wire sheaves are provided with double roller bearings or oil-less bearing on steel axles, fitted with grease nipples.

The hoisting, luffing, and slewing movements of the crane are steplessly controlled by three hydraulic control levers, and carried out from the control stand position. The control levers are 'spring-centred', and designed to return to the neutral position when released. For each operation of hoisting, slewing, and luffing, one operation at full speed and two operations at reduced speed.

Crane Operation

Preparations Before Operation

The space heater for the electric motor should be switched on 10 hours before using the crane. After motor heating, warm up the hydraulic pump 30 minutes before using the crane by running the the electric motor.

1) Check the oil gauge of the hoisting and slewing reduction gears, and the hydraulic power unit LO tank.
   - If the hook is at the top position it means that hoisting up limit valve is open. Therefore, keep the hoisting lever to in the 'UP' position for approximately3 minutes. Using the same method, 'Lowering' of the hook should be carried out.
   - Luffing should be carried out from maximum radius to minimum radius approximately 5 times continuously. Slewing should be carried out to both ways approximately 2 turns.
2) Apply grease to grease points.
3) Switch 'ON' at the remote push button switch, and at the. 'MCB' starter.
4) Release the hook locking devices.
5) Raise jib without load.
6) Ensure that each limit valve operates properly without load.
7) Ensure that there are no defects with electric motor, brake, and cylinder.

Operating the Crane

The crane is operated by the main control valve, located on the operations platform. All crane operations have stepless speed control from 0-maximum. Two operations can be operated at the same time at maximum load, but at a reduced speed.

Hoisting Operation : Right Lever

- Hoisting : Move the control lever to 'HOOK UP' position.
- Lowering : Move the control lever to 'HOOK DOWN' position.

Luffing Operation : Middle Lever

- Jib up : Move the control lever to 'JIB UP' position.
- Jib down : Move the control lever to 'JIB DOWN' position.

Slewing Operation : Left Lever

- Slewing to right : Move the control lever to 'CRANE RIGHT' position.
- Slewing to left : Move the control lever to 'CRANE LEFT' position.

CAUTION
Operate the control levers smoothly, as jerking levers may cause the swinging of the load especially when the load is suspended.

Emergency Stop

Emergency stop is carried out manually by using one of the following methods:

1) Pressing the 'STOP' button on the starter panel.
2) Pressing the 'STOP' button on Remote START/STOP switch.
3) Turning 'EMERGENCY STOP' valve, fitted close to control platform.

Start after Emergency Stop, Due to System Failure

The following procedure is to be adhered to:

1) 'Emergency operation instructions'.
2) Fault finding/trouble shooting to be initiated, possible findings are to be rectified prior to use of crane.
3) 'Inspection Prior to Operation' procedure to be carried out.
4) Start after emergency stops due to hazardous situations :
   - Clear the area of unauthorized personnel.
   - Carry out a normal start.

Jib Rest Valve

Jib rest valve is only used only for jib parking when the jib position is in the slewing sector area. The crane jib cannot operate luffing down to jib rest position (luffing angle 0°) in the slewing sector area. Luffing down operation in the slewing sector area will be done when the jib rest valve is closed.

After Crane Operation

After operation, park the jib on the jib rest.

1) Turn the jib to the position above of the jib rest.

2) Move control lever to the position of 'JIB DOWN' and lowering to the parked on the jib rest. This work should be carried out with no load.

3) Park the hook.

4) Lock the hook with hook lashing rope then hoist the hook slightly to protect it from moving due to pitch and roll of the ship.

5) Switch 'OFF' on the control box and the starter main circuit breaker.

Safety Features

Each of the cranes has the following safety features:

- **Load Limiting System**

  The main hydraulic circuit is protected from over-pressure by a relief valve. In addition, the hydraulic circuit is equipped with a relief valve set to activate corresponding to the crane capacity.

- **Hoisting Limit**

  The hook movement will be automatically stopped in both the upper and lower positions by limit switches on the hoisting winch.

- **Luffing Stop**

  The maximum and minimum working radii are limited by the stroke end of the luffing cylinder.

- **Load-Holding Valves**

  The winch motor, hydraulic cylinder and slewing motor are all provided with load-holding valves which will freeze the movement in case of hose rupture or other failure causing pressure drop.

- **Slewing**

  Reduced out-reach through a certain slewing sector.

- **Fail-Safe Brakes**

  Both winch motor and slewing motors are provided with fail-safe brakes, the brakes are spring operated and pressure released. The brakes will engage automatically if the control lever is in the neutral position. As the brakes are spring activated they close automatically upon failure of the hydraulic system.

- **Emergency Lowering**

  In the event of a loss of power, the winch and jib may be lowered for each crane, and slewed by means of an emergency handpump which will open the winch brake.

- **Emergency Stop**

  There is emergency stop pushbutton on the remote start/stop panel on the crane slewing pedestal and an emergency stop cock below the control levers.

WARNING
Safety devices should not be released, as there is the risk that this will cause accidents and damage to property. The crane is set up with each safety device already adjusted at its proper position, never remove it or never change the adjusting position.

6.6.4 BUNKER HOSE DAVIT

Manufacturer:	Shin Myung
Type:	Fixed jib
No. of sets:	2
SWL:	1,000kg
Working radius:	2.10m
Hoisting height:	30m
Hoisting speed at SWL:	10.0m/min (at 3 layers)
Winch type:	Air motor SMP -4P-600DR
Winch motor rating:	4.5 PS at 590 rpm
Working air pressure:	6.0 bar (87psi)
Slewing:	Slewing bar
Wire rope:	10mm diameter (19x7) x 35m non-rotating
Brake:	Mechanical

Description

There are two bunker hose davits positioned one on the port side the other on the starboard side at the after most part of the multi purpose space at main deck level, at the bunker station.

Each of the davits have a fixed jib and pedestal.

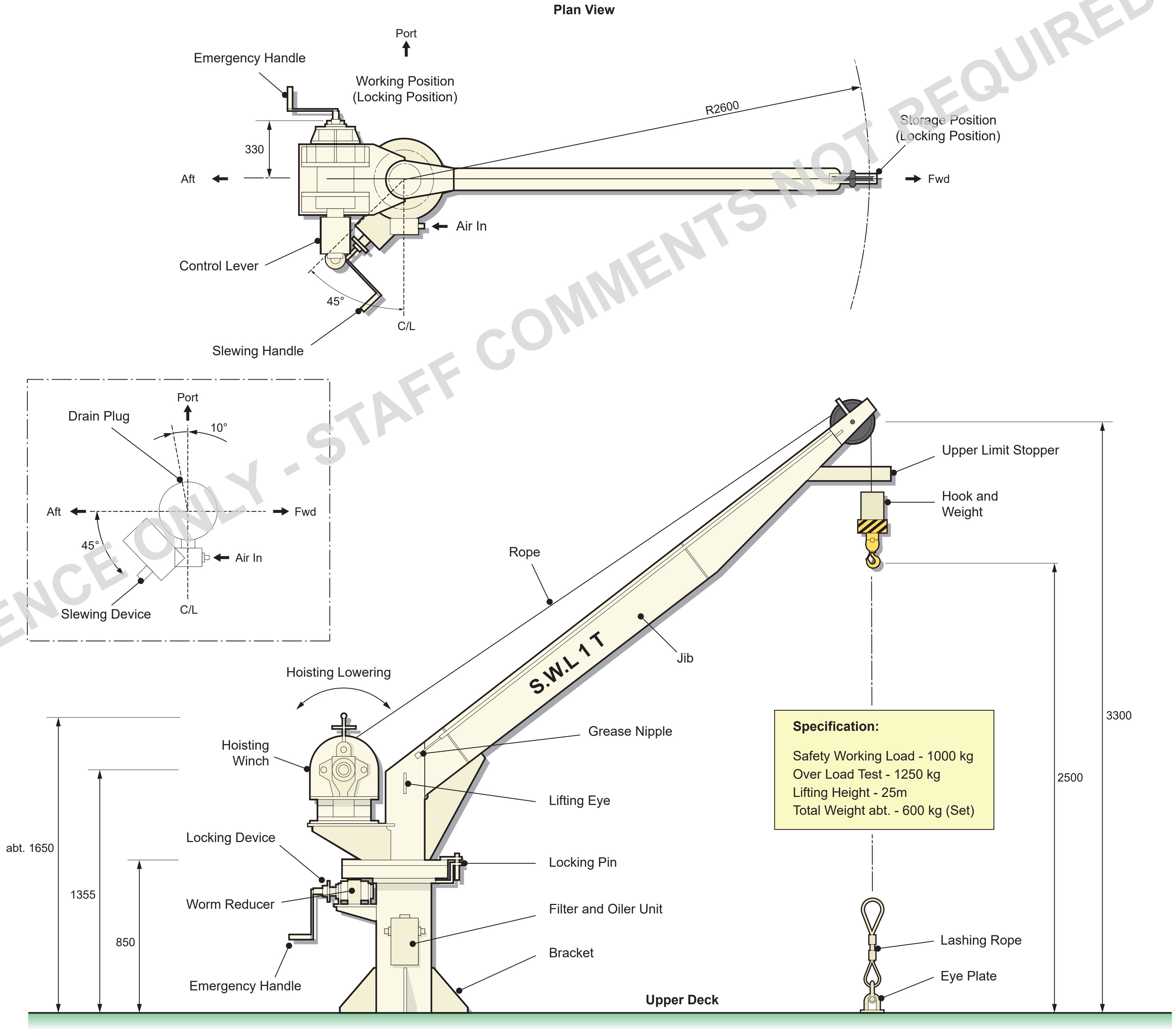
It is slewed into position by fitting a handle into the slewing gear. Two polypropylene guy ropes are fitted either side of the top of the jib to secure the jib in position.

Davit Control

Hoisting and lowering are achieved by means of an air motor mounted onto the winch drum which is operated by means of a control lever on the air motor. The davit is fitted with an oiler and air filter in preparation for the connection of an air hose from a service air outlet line on deck. The working air pressure required to hoist the maximum load is 6.0 bar.

If the air motor fails, then a cranking handle can be fitted for hoisting or lowering operation.

Illustration 6.6.4a Bunker Hose Handling Davit



Reference Drawing: SMFOD-A1T-GA

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6.7 Dry Dock Services

6.7 DRY DOCK SERVICES

Introduction

When the ship is in dry dock, many normal ship's systems will be inoperative and these services must be provided by alternative means. Dry dock operations will differ depending upon the facilities available at the dry dock, and the extent of work to be carried out. Prior to any dry docking, it is important to ensure which facilities will be available at the dry dock, and which systems the ship will be able to provide itself.

Under no circumstances should the ship provide services which might cause damage to shipboard equipment because support facilities such as cooling water, are unavailable. The shipboard equipment operated will depend upon the availability of support services and the nature of work to be undertaken in the dry dock. In certain cases it may be more convenient to have a service provided by shore facilities rather than use shipboard systems. The usual method of supplying power is by operating one of the MGEs utilising shore-side sea water cooling. However, operation of an MGE would preclude maintenance work being undertaken on that engine, and would require the fuel system, cooling system, etc, to be operated. Low load operations of the MGEs must also be avoided at the manufacturer's recommendation.

Prior to the dry docking, a work plan must be drawn up and the services to be provided by the ship must be determined. All personnel involved in the dry docking must understand which services are to be provided by the ship and which are to be provided by shore systems. Equipment for connection of services to shore facilities must be checked and positioned at the correct location before the ship enters dry dock. Personnel involved in the changeover procedure to shore services must thoroughly understand the procedures involved and the safety implications of the change, if any. Listed below are services which may be provided from ashore during dry docking, however, all services may not be used. Agreement must be reached with the shore authorities regarding supplies to the ship or quantities pumped ashore; details of quantities received and pumped must be recorded.

Fire Main

The fire main must be pressurised at all times in order to ensure that water under pressure is available in the event of a fire. Connections are available on the main deck, at the international shore connections located at the port and starboard sides aft of the multi-purpose spaces A+B.

Shore Communications

It is essential that full shore communications are available at all times during dry docking. Although VHF radio and mobile communications will be maintained, it is essential that land line telephone communications are also available. The shore telephone connection must be established as soon as the ship is in dry dock.

Electrical Power

Electrical power can be provided by operation of the ship's own MGEs. Cooling will be supplied from the shore via sea water connections *in the bunker stations*. The vessel can also be supplied with 6,600V power from ashore. Shore connections are provided through in the HV shore power room to No.1 and No.4 busties. The connections between the ship and the shore are via *five plug/socket* arrangements. The shore power system and procedures are described in the relevant section in this manual.

Compressed Air

Instrument and working air can be supplied by the working/control air compressors in association with air dryers. If necessary, the starting air compressors can supply air via the cross-connections, refer to the relevant section in this manual for details of the cross-connection procedure. These compressors, and dryers may be operated in dry dock if the LT cooling fresh water system is operational. Alternatively, a shore connection is provided, allowing these units to be shut down if required.

Steam

Steam may be required for heating purposes on board the ship. For port use there is one HVAC shore steam heater sized at 0.3 MW in MR1. For arrangements for this heater see the relevant section in this manual. Steam and condensate connections are located at the bunker stations port and starboard on the main deck.

Cooling Sea Water

(Authors Note: This section to be confirmed by Owners.)

Cooling sea water connections are available at the port and starboard bunker stations on deck, which allow sea water to be supplied to the auxiliary consumers and MGE cooling systems. The cooling sea water pumps of both systems are not operated as sea water flows through the system coolers under pressure from ashore. Sea water is discharged when the associated ship overboard discharge valve is opened, see the relevant section in this manual. The supply of sea water from ashore is lower than that provided by the ship's pumps and so the cooling load must be lower. As the ship is in dry dock, fewer items of plant will be operating and so there is unlikely to be any problem, but the outlet sea water temperature must be monitored so that it remains within acceptable limits. Cooling sea water can also be supplied to the air conditioning chillers.

Facilities must be available at the dry dock for removal of used cooling sea water. This can be discharged into the dry dock via the overboard discharges with the approval of the dry dock authorities although some form of collection arrangement will need to be provided to ensure that the water does not spread over the dry dock area. Agreement on such services must be reached with the dry dock authorities and this means that a decision must be made as to what machinery is to operate whilst the vessel is in dry dock.

Potable Water

Potable water is normally produced on board, and the fresh water tanks may contain sufficient potable water for a limited stay in dry dock. However, for a prolonged stay or if work is to be undertaken on the fresh water tanks it may be necessary to take fresh water from ashore. Shore connections are close to each potable water tank air vent. A check should be carried out on shore supplied water to ensure that it is fit for human consumption.

Effluent/Grey Water

The ship has a large effluent/GW storage capacity which will normally be emptied before the vessel enters dry dock. Provided that their use does not disturb the loading on the dry dock blocks and the ship's structure, the tanks may be used when in dry dock. The loading on the GW system will be lower when the ship is in dry dock compared with normal service, but the tanks may be filled during a prolonged stay. Connections are available at the port and starboard bunker stations for the shore discharge of effluent or GW. The GW discharge pumps are used, and the shore discharge pipe is connected to the ship's system by means of an international connection. Any pumping ashore of effluent/GW water must be with the agreement of the shore authority. Any storage in GW tanks must be clearly marked, to ensure correct later disposal. See the relevant section in this manual.

Black Water

Raw BW may be pumped ashore using the BW discharge pumps, and the BW system shore connections. There are discharge connections at the port and starboard bunker stations. Normally, such a discharge is not necessary, and if required, would be undertaken prior to entering dry dock. See the relevant section in this manual.

Oily Bilge System

The oily bilge system may be pumped ashore via connections at the port and starboard bunker stations. If required, this procedure is normally undertaken before the vessel enters dry dock, but in an emergency, the option is available to pump the oily bilges ashore using the bilge housekeeping pumps. See the relevant section in this manual.

6.5 Air Conditioning Plant Refrigeration and Ventilation Systems

6.5 AIR CONDITIONING PLANT REFRIGERATION AND VENTILATION SYSTEMS

6.5.1 AIR CONDITIONING PLANT

Chiller Units AMR 1-1 + AMR 1-2 (CH-1+2)

Manufacturer:	Carrier
Chiller unit type:	Water cooled screw
Model:	30XW-300
Refrigerant:	R134a
No. of sets:	2
Cooling capacity:	962.7kW
Heating capacity:	1,154kW
Compressor motor:	460V, xxkW, xxxxrpm VSD

Chiller Units AMR 4-3 + AMR 4-4 (CH-3+4)

Manufacturer:	Carrier
Chiller unit type:	Water cooled screw
Model:	30XW-250
Refrigerant:	R134a
No. of sets:	2
Cooling capacity:	818kW (AMR4-3), 814.5kW (AMR4-4)
Heating capacity:	974kW (AMR4-3), 970kW (AMR4-4)
Compressor motor:	460V, xxkW, xxxxrpm VSD

Air Handling Units No.01~12/14~16

Manufacturer:	Bronswerk
Type:	AHU-5000 x 1 AHU-10000 x 3 AHU-15000 x 3 AHU-20000 x 6 AHU-25000 x 2
No. of sets:	15
Fan:	1 per AHU-02/03/04/05/06/09/10/11/14/16 2 per AHU-08/12/15 3 per AHU-01/07
Fan capacity:	3,750~23,905m³/h
Motor:	440V, 5.6~45.0kW(7.5~60hp), xxxx rpm

Fan Coil Units No.01~10

Manufacturer:	Bronswerk
Type:	FCU-3000 x 2 FCU-1500 x 2 FCU-4000 x 4 FCU-8000 x1
No. of sets:	9
Fan:	1 per FCU-07~10 2 per FCU-03~6 3 per FCU-01~02
Fan capacity:	1,900~7,900m³/h
Motor:	440V, 0.2~2.4kW(0.26~3.2hp), xxxx rpm

Auxiliary Sea Water Cooling Pumps No.1, 2

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FEV-150D
No. of sets:	2
Capacity:	190m³/h(6.710ft³/h) at 2.0 bar (29psi)
Motor:	440V, 18.5kW, 1,750 rpm

Auxiliary Sea Water Cooling Pumps No.3, 4

Manufacturer:	Naniwa
Type:	Vertical centrifugal
Model:	FEV-150D
No. of sets:	2
Capacity:	190m³/h (6.710ft³/h) at 2.0 bar (29psi)
Motor:	440V, 18.5kW(25hp), 1,750 rpm

Chilled Water Pumps No.1+2 AMR1

Manufacturer:	XXX
Type:	Vertical centrifugal
No. of sets:	2
Capacity:	247m³/h(8,723ft³/h) at 4.1 bar (59.5psi)
Motor:	460V, xxkW, xxxx rpm

Chilled Water Pumps No.3+4 AMR4

Manufacturer:	XXX
Type:	Vertical centrifugal
No. of sets:	2
Capacity:	214m³/h(7,557ft³/h) at 4.1 bar (59.5psi)
Motor:	460V, xxkW, xxxx rpm

AC Hot Water Pumps No.1+2 AMR1

Manufacturer:	XXX
Type:	Vertical centrifugal
No. of sets:	2
Capacity:	73.9m³/h(2,610ft³/h) at 4.1 bar (59.5psi)
Motor:	460V, xxkW, xxxx rpm

AC Hot Water Pumps No.3+4 AMR4

Manufacturer:	XXX
Type:	Vertical centrifugal
No. of sets:	2
Capacity:	50.6m³/h(1,787ft³/h) at 4.1 bar (59.5psi)
Motor:	460V, xxkW, xxxx rpm

HVAC Water Heaters No.1+2

Manufacturer:	LHE
Type:	Plate
Model:	LT150ML-1P-29
No. of sets:	2
Heat transfer area:	14.6m²
Operating temperature:	38°C(100°F) to 53°C(127°F) glycol/water side (10% glycol) 92°C(198°F) to 70°C(158°F) fresh water side
Capacity:	Fresh water flow 84m³/h Glycol/water flow125m³/h

HVAC Shore Supply Heater

Manufacturer:	Donghwa Entec
Type:	Shell and tube
Model:	DHSH-W2104001
No. of sets:	1
Surface area:	25.5m²
Operating temperature:	147ºC(297ºF) to 147ºC(297ºF) shell side(steam) 38°C(100°F) to 52°C(126°F) glycol/water side (10% glycol)

Chilled/Hot Water Expansion Tanks

Manufacturer:	Calefactio
Type:	Vertical with removable bladder
No. of sets:	2
Capacity:	87 litre

Authors note: Items in red are not available and require information.

Introduction

The Air Conditioning (AC) installation is based upon air handling units (AHUs) which are circulated with chilled water and hot water to provide cooling and heating as required. The AHU fan blows air over the cooling/heating coils, and this chilled/warm air is distributed to the accommodation and other spaces associated with that AHU. The air circulation system incorporates fan coils in the public rooms and cabins, and so the system is one of AHUs and FCUs.

The chilled and hot water circulation systems are separate, the chilled and hot water ranges being designed to satisfy Safe Return to Port (SRtP) regulations. This means that there are effectively two separate chilled water systems and two separate hot water systems, but in each case, the separate systems are normally operated as a single combined system. Should a SRtP situation arise, the systems may be isolated on the water delivery and suction sides by means of isolating valves. AMR1 and AMR4 systems have chiller units, chilled water circulation pumps, hot water heaters, and hot water circulation pumps. Each hot and cold water circulation system has a compressed air pressurised expansion vessel.

A shore steam HVAC heater is fitted in MR1 for use when alongside a berth.

Chilled Water System

The chillers for each system cool the chilled water, the chillers being refrigeration units operating on R134a refrigerant gas. The compressed gas is cooled in the associated condenser unit which is circulated with sea water.

Chilled water is supplied to the AHUs and FCUs at a temperature of 6°C (43°F) with a designed return water temperature of 14°C (57°F). The chilled water installation is a closed system, composed a primary loop (constant flow) and a secondary loop (variable flow).

The chilled water system comprises of two subsystems; one aft in AMR1, one forward in AMR4. AMR4 subsystem serves FZ1and FZ2, and AMR1 subsystem serves FZ3, FZ4 and FZ5. Each subsystem consists of two chillers with a control panel, two chilled water pumps, piping, for their consumers including AHU, FCU, and cooling coils, and control panels. Each chiller is sized to handle 50% of the total subsystem load requirement. Each pump is sized to handle 100% of the subsystem total chilled water flow capacity. Each chiller regulates the condenser seawater valve to maintain constant chilled water supply temperature of 6°C (43°F).

Each chilled water subsystem, and pump control panel alternates each pump running/operating hours to automatically change over every 200 hours to equalise the running time of each item of equipment. The chillers have self-regulating controls.

When the chilled water subsystem starts to meet cooling demand, the lead chiller motorized isolation valve opens. When the lead isolation valve is confirmed open, the lead pump starts, as required. When the lead pump running is confirmed, the chilled water subsystem control panel delivers run permission to the lead chiller (with the fully open lead isolation valve) which will start and operate to maintain 6°C (43°F) supply water temperature. If the supply water temperature remains above 6°C (43°F) for 10 minutes, the 2nd chiller shall start for additional cooling to achieve and maintain combined subsystem supply water temperature of 6°C (43°F).

All chilled water consumer control valves are 3-way valves. All consumer control valves are of the modulating type for added system control. Each chilled water subsystem control panel has an ethernet connection to the network for communication with the touchscreen control panels, and the other HVAC local control panels.

Hot Water System

The two hot water subsystems are associated with the two chiller subsystems AMR1 and AMR4. Each subsystem consists of two hot water pumps, piping, and their consumers including AHU heating coils, and control panels. There are two heat exchangers which make use of waste heat from the MGEs jacket water, each sized for 100% of the total HVAC heating load, and one shore steam heater sized at 0.3 MW. The two hot water subsystems are each connected to both heat exchangers, and the shore steam heater. Each hot water pump is sized to handle 100% of the subsystem's total hot water flow capacity. In case of the central heating system failure, each AHU is provided with 100% electric heat as backup.

The hot water subsystem control panel alternates each pump running/operating hours to automatically change over every 200 hours to equalise the running time of each item of equipment.

When the hot water subsystem starts to meet heating demand, the consumer control valves begin to open due to space temperatures falling below specified setpoints, and the lead pump starts, as required.

All hot water user control valves are 3-way valves. All consumer control valves are of the modulating type for added system control. Each hot water system (pump) control panel has an ethernet connection to the network for communication with the touchscreen control panels, and the other HVAC local control panels.

Control and Monitoring

The systems can be selected to operate in either remote mode (touchscreen operation) or local mode (panel operation) via a toggle switch fitted on each of the AHU and FCU local control panels. Switching function between local and remote mode is not possible from CAMS. Operational modes (OFF/ON) can be selected locally at the HVAC local control touchscreen panel in Local mode, or remotely from the HVAC system touchscreen, in Remote mode.

Local Mode

The operator can start and stop the system locally at the control panel. Remote commands are overriden.

Remote Mode

Central touchscreen panels are installed on the bridge, and on the bridge braining area for remote control of all local control panels. Local commands will be overrriden. The system can only be started/stopped via remote signals from CAMS.

Control Panel Interlocks

The panels have direct interlocks between each of the pumps, and each of the chiller built-in control panels to ensure chiller only operates when a pump is running. AMR4 chilled water system chillers are interlocked with AMR4 chilled water pumps, and AMR1 chilled water chillers are interlocked with AMR1 chilled water pumps. There are no interlocks between AMR4 and AMR4 chilled water systems as they operate independently from one another.

System 'Running/On' Automatic Mode

AHU Systems

In this condition, the AHU is cooling, or heating depending on the return air temperature, and this will indicate on the local touchscreen panel which mode it is in. The AHU supply fan speed is constant. Humidification is only possible in heating mode, and is off during cooling mode.

During intermediate seasons, the AHU fans will continue operating at constant speed, and the chilled water or hot water 3-way control valves will open or close according to demand. AHU-16 may reduce airflow to and from the Multi-purpose space rooms when not occupied.

Switchover from heating to cooling will occur if:

- The return air temperature transmitter is 1°C (34°F) above the setpoint for 15 minutes. This is adjustable on the touchscreen having a range of 0 to 30 minutes.
- The heating output of PI has been 0% continuously throughout the above time.

Switchover from heating to cooling will occur if:

- The return air temperature transmitter is 1°C (34°F) below the setpoint for 15 minutes. This is adjustable on the touchscreen having a range of 0 to 30 minutes.
- The cooling output of PI has been 0% continuously throughout the above time.

The default heating mode is hot water. If the AHU is in heating mode and the temperature setpoint is not achieved after 10-15 minutes (programmable by user) then a warning is displayed at the touchscreen panel. Checking the operation of the hot water 3-way control valve, and/or the hot water circulation pump operation, and electric heating should automatically be engaged to provide heat and achieve the system setpoint. This default setting ensures that the AHU heating function is maintained if the MGE is not running such as when the ship is alongside a berth, or if there is a problem with the hot water system that requires investigation and correction. There is a button which allows manual selection of 'Electric Heating' mode if hot water will not be available.

System 'Running/On' Automatic 'Electric Heat' Mode

AHU Systems

This condition occurs if the hot water heat exchanger system has failed or has been shut down. 'Electric Heating' mode should be manually selected. The AHU supply fan speed remains constant. Humidification is only enabled in electric heating mode and is disabled during cooling mode.

Switchover from electric heating to cooling will occur if:

- The return air temperature transmitter is 1°C (34°F) above the setpoint for 15 minutes. This is adjustable on the touchscreen having a range of 0 to 30 minutes.
- The heating output of PI has been 0% continuously throughout the above time.

Chilled Water Systems

In this condition, the duty or standby pump is operating at constant speed, and one or both chillers are operating, dependent on supply water temperature.

Start-Up and Stop Sequence

AHU System Start Sequence

Step	Sequence Step Delay	Comments
Remote or Local 'System Start' command		
Delivers power to fire damper(s) and/or watertight valve(s)/damper(s)		
Control panel waits for confirmation 'fire damper(s) and/or watertight valve(s)/damper(s) open'	<120 seconds	A feedback switch delivers 'damper open' confirmation signal for each damper. If any 'damper open'confirmation not received remove power from all damper(s) and initiate alarm and start-up sequence is terminated.
Sends power and start signal to fan(s)	10 seconds	If any fan fails to start, carry out reverse sequence step by step and initiate an alarm.
System is now in 'running' mode		Fans run for 2 minutes (adjustable from touchscreen) before beginning 'control loop' operation control sequence

AHU System Stop Sequence

Step	Sequence Step Delay	Comments
Remote or Local 'System Start' command		
Removes power and start signal to fan(s)	10 seconds	
Removes power to fire damper(s)and/or watertight valve(s)/damper(s)		
Awaits closed confirmation from fire damper(s) and/or watertightvalve(s)/damper(s)	<30 seconds	A feedback switch delivers a closed confirmation signal. If closed confirmation is not received within 30 seconds, an alarm will be triggered, but system will continue to power down.

Step	Sequence Step Delay	Comments
Stops control loops for heating, cooling, and humidifying	60 seconds	
System is now in 'standby/off' mode		

FCU System Start Sequence

Step	Sequence Step Delay	Comments
Remote or Local 'System Start' command		
Delivers power to fire damper(s).		
Control panel waits for confirmation 'fire damper(s) open'.	<120 seconds	A feedback switch delivers 'damper open' confirmation signal for each damper. If any 'damper open'confirmation is not received remove power from all damper(s) and initiate alarm and start-up sequence is terminated.
Sends power and start signal to FCU(s)	10 seconds	
System is now in 'running' mode		FCU fans run for 2 minutes (adjustable from touchscreen) before beginning 'control loop' operation control sequence.

FCU System Stop Sequence

Step	Sequence Step Delay	Comments
Remote or Local 'System Stop' command		
Removes power and start signal to FCU(s)	10 seconds	
Removes power from fire damper(s)		
Awaits closed confirmation from fire damper(s)	<30 seconds	A feedback switch delivers closed confirmation signal.

Step	Sequence Step Delay	Comments
		If closed confirmation is not received within 30 seconds, an alarm will be triggered, but system will continue to power down.
Stop control loops for cooling and/or heating	60 seconds	
System is now in 'standby/off' mode		

Chilled Water System Start Sequence

Step	Sequence Step Delay	Comments
Remote or Local 'System Start' command		
Delivers power to lead motorized chiller isolation valve		
Control panel waits for confirmation 'lead isolation valve open'	<120 secs	A feedback switch delivers 'isolation valve open' confirmation signal for each damper. If any 'isolation valve open' confirmation not received, remove power from the lead isolation valve and initiate alarm. Only one isolation valve should be open per chiller.
Delivers power and start signal to lead pump		
Control panel waits for confirmation 'lead isolation valve open' and 'lead pump running'	<30 seconds	A discharge pressure delivers confirmation 'pump running'. If 'pump running' confirmation is not received, remove power from the pump, send stop signal to the pump and initiate alarm.
Sends start signal to lead chiller	10 seconds	If the lead chiller fails to start, perform reverse sequence step by step, initiate an alarm and send start signal to the other chiller.
System is now in 'running' mode		Lead chiller and lead pump run for 2 minutes (adjustable from touchscreen) before beginning 'control loop' operation control sequence.

Chilled Water System Stop Sequence

Step	Sequence Step Delay	Comments
Remote or Local 'System Stop' command		
Removes start signal to chiller(s)	10 seconds	
Removes power and start signal to pump(s)	10 seconds	
Removes power from motorized chiller isolation valve(s)		
Awaits closed confirmation from motorized chiller isolation valve(s)	<30 seconds	A feedback switch delivers closed confirmation signal. If closed confirmation is not received within 30 seconds, an alarm will be triggered, but system will continue to power down.
Stops control loops for supply water temperature	60 seconds	
System is now in 'standby/off' mode		

Hot Water System Start Sequence

Step	Sequence Step Delay	Comments
Remote or Local 'System Start' command		
Provide power and start signal to duty or standby pump		
Control Panel waits for confirmation 'pump running'	<30 seconds	A discharge pressure delivers confirmation 'pump running'. If 'pump running' confirmation is not received, remove power from the pump, send stop signal to the pump and initiate alarm.
System is now in 'running' mode		

Hot Water System Stop Sequence

Step	Sequence Step Delay	Comments
Remote or Local 'System Stop' command		
Removes power and start signals to pump(s)	10 seconds	
System is now in 'standby/off' mode		

Emergency Shutdown Sequence

For manual commands to the system to stop via control panel emergency stop push button the following shutdown sequence will occur, and the panel will be in alarm.

AHU Systems

Step	Sequence Step Delay	Comments
Remote or Local 'Emergency Stop' push button pressed		Remote=Central touchscreen and wall-mounted fire damper(s) push buttons Local=Local control panel push button
Removes power to fan(s) and local equipment	10 seconds	
Removes power from fire damper(s) and/or watertight valve(s)/damper(s)		
Disables control loops for heating, cooling, and humidifying		
System is now in 'standby/off' mode		

FCU Systems

Step	Sequence Step Delay	Comments
Remote or Local 'Emergency Stop' push button pressed		Remote=Central touchscreen and wall-mounted fire damper(s) push buttons Local=Local control panel push button
Removes power from FCUs	10 seconds	
Disables control loops for cooling and/or heating		
System is now in 'standby/off' mode		

Chilled Water Systems

Step	Sequence Step Delay	Comments
Remote or Local 'Emergency Stop' push button pressed		Remote=Central touchscreen and wall-mounted fire damper(s) push buttons Local=Local control panel push button
Removes start signal to chiller(s)	10 seconds	
Removes power from pumps	10 seconds	
Removes power from motorized chiller isolation valve(s)		
Disables control loops for temperature		
System is now in 'standby/off' mode		

Hot Water Systems

Step	Sequence Step Delay	Comments
Remote or Local 'Emergency Stop' push button pressed		Remote=Central touchscreen and wall-mounted fire damper(s) push buttons Local=Local control panel push button
Removes power from pump(s)	10 seconds	
System is now in 'standby/off' mode		

Fire Suppression Shutdown Sequence

When the local fire suppression activates the associated AHU or FCU systems to stop via an open contact switch the following shutdown sequence will occur, and the panel will be in alarm. Manual activation of the manual fire suppression emergency stop shuts down HVAC systems when the fire detector activates the alarm.

Step	Sequence Step Delay	Comments
Remote Fire Suppression switch is activated		
Removes power to fan(s), FCUs and local equipment	10 seconds	
Removes power from fire damper(s) and/ or watertight valve(s)/ damper(s)		
Disables control loops for heating, cooling and humidifying		
System is now in 'standby/off' mode		

Fire Detection Shutdown Sequence

When fire detection signal is activated, the associated AHU or FCU local control panel system will stop via an open contact switch, and the following shutdown sequence will occur, and the panel will be in alarm.

Step	Sequence Step Delay	Comments
Remote Fire Detection switch is activated		
Removes power to fan(s), and local equipment	10 seconds	
Removes power from fire damper(s), watertight valve(s)/ damper(s) and/or shut-off damper(s)		

Step	Sequence Step Delay	Comments
Disables Control Loops for heating, cooling and humidifying		
System is now in 'standby/off' mode		

Blackout Sequence

When the 440VAC power is suddenly removed from the chilled water system control panel and/or hot water system pump panel, the motorized isolation valve(s) will fail closed, and the system will shut down.

Chilled Water Systems

Each of the chillers is fitted with built-in controls. These controls self-regulate the condenser water valve open/close, the internal compressor, and the condenser pressures and temperatures to maintain supply water temperature to 6°C at any given chilled water flow rate.

Procedure for Operating the Chilled Water System

It is assumed that the forward and aft systems (chilled water loops AMR4 and AMR1) are operating independently. It is assumed that the chiller sea water systems are fully operational as described above in this manual. The chilled water pumps are associated with specific chiller units, and they will operate when these chiller units are set to operate.

The description assumes that the chilled water systems are set for cooling and each is already fully charged with water. The chilled water pressure vessel/ expansion tanks must be maintained at about ¾ full; it is assumed that the make-up water supply line valves to the pressure vessels are open.

a) Ensure that the chilled water piping system and pumps are filled and that the expansion tank is at the correct level. Check that the expansion tank outlet valve is open.

b) Check that all instrumentation valves are open and that the instruments are reading correctly.

c) Set the valves as in the following tables. The valve settings assume that all chiller units in each loop are connected to the chilled water distribution system, and available for operation.

In the tables below, the systems are set for normal summer operation with chilled water circulation.

Chilled Water System Chilled Water Pumps AMR1		
Position	**Description**	**Valve**
Open	No.1 chilled water pump suction valve	VLV105
Open	No.1 chilled water pump discharge valve	VLV107
Open	No.2 chilled water pump suction valve	VLV106
Open	No.2 chilled water pump discharge valve	VLV108
Open	Expansion tank valve	CF020
Open	Chilled water return valve from FZ 1+2	CF023
No.1+2 Chilled Water Plants (CH1+CH2) each 50% duty		
Position	**Description**	**Valve**
Open	No.1 evaporator chilled water inlet valve	CF001
Automatic	No.1 evaporator chilled water outlet valve	VLV01
Open	No.2 evaporator chilled water inlet valve	CF004
Automatic	No.2 evaporator chilled water outlet valve	VLV02
Open	Chilled water supply valve to FZ 1+2	CF022

Chilled Water System Chilled Water Pumps AMR4		
Position	**Description**	**Valve**
Open	No.3 chilled water pump suction valve	VLV109
Open	No.3 chilled water pump discharge valve	VLV111
Open	No.4 chilled water pump suction valve	VLV110
Open	No.4 chilled water pump discharge valve	VLV112
Open	Expansion tank valve	CF120
Open	Chilled water return valve from FZ 3+4+5	CF123
No.3+4 Chilled Water Plants (CH3+CH4) each 50% duty		
Position	**Description**	**Valve**
Open	No.3 evaporator chilled water inlet valve	CF101
Automatic	No.3 evaporator chilled water outlet valve	VLV03
Open	No.4 evaporator chilled water inlet valve	CF104
Automatic	No.4 evaporator chilled water outlet valve	VLV04
Open	Chilled water supply valve to FZ 3+4+5	CF122

e) Set the chilled water system valves for the AHUs and FCUs as required (normally open). The control system for the AHUs and FCUs will adjust the flow of hot and chilled water to maintain the required temperature and humidity of the air leaving the AHU/FCU.

Note: A number of final users are supplied from each branch system. At each final user location, there are supply and return valves to the local AHU/FCU and both must be opened in order to ensure a supply of chilled water.

f) Ensure that the sea water cooling system for the chiller units is operational.

g) Select the chilled water pumps for Remote operation, and at the CAMS mimic, select the required operating sequence.

h) Set the chiller units to Automatic operation, and select the sequence at the CAMS mimic. Check the operation of the chiller(s) and their associated sea water system(s).

The chilled water circulation system will start automatically and maintain the temperature of the water circulated through the heat exchangers of the AHUs in the ship. The number of pumps operating depends upon conditions. The number of chiller units operating will depend upon the cooling load and the control system will operate units as required.

j) Maintain the correct level in the expansion tank, and should be checked daily.

Chiller Shutdown

The chillers may be shut down when not required and the valves will normally be left open. However, for prolonged shutdowns, the system must be isolated and the gas pumped to the condenser. Prolonged shutdowns may be required if the vessel is operating for long periods in cold conditions or if a chiller is being repaired.

When preparing for a prolonged shutdown, the refrigerant gas is pumped to the condenser or transferred to the storage facility as applicable. Compressor gas valves are closed securely. When the compressor is shut down, its electrical system must be isolated.

Procedure for Operating the Hot Water System

The HVAC water heaters recover heat from the MGE HT cooling water systems, and uses it to provide heating for the HVAC hot water circulation system. The heat from the MGE HT cooling water heats up the glycol/water circulating through the HVAC water heater, and circulates through the AHUs, and various FCUs. Circulation of the glycol/water is carried out by hot water circulating pumps.

There are two hot water subsystems associated with the two chiller subsystems AMR1 and AMR4. Each subsystem consists of two hot water pumps, piping, and their consumers including AHU and FCU heating coils, and control panels. The two heat exchangers make use of waste heat from the MGEs jacket water, each sized for 100% of the total HVAC heating load. For port use there is one shore steam heater sized at 0.3 MW. The two hot water subsystems are each connected to both heat exchangers, and the shore steam heater. Each hot water pump is sized to handle 100% of the subsystem's total hot water flow capacity. In case of hot water heating system failure, selected AHUs are fitted with 100% electric heaters as backup.

This description assumes that the hot water systems are set for heating and each is already fully charged with glycol/water. The hot water pressure vessel/ expansion tanks must be maintained at about ¾ full.

a) Ensure that the hot water piping system and pumps are filled and that the expansion tank is at the correct level. Check that the expansion tank outlet valve is open.

b) Check that all instrumentation valves are open and that the instruments are reading correctly.

c) Set the valves as in the following tables. The valve settings assume that all hot water systems in each loop are connected to the hot water distribution system, and available for operation.

HVAC Water Heater 1		
Position	**Description**	**Valve**
Open	No.1 HVAC water heater inlet valve	HF008
Open	No.1 HVAC water heater outlet valve	HF009
Closed	No.1 HVAC water heater bypass valve	HF010
Open	Hot water return valve from AMR1	CF404
Open	Hot water supply valve to AMR1	CF402
Closed	Hot water return valve from AMR4	CF403
Closed	Hot water supply valve to AMR4	CF401

HVAC Water Heater 2		
Position	**Description**	**Valve**
Open	No.2 HVAC water heater inlet valve	HF208
Open	No.2 HVAC water heater outlet valve	HF209
Closed	No.2 HVAC water heater bypass valve	HF210
Closed	Hot water return valve from AMR1	CF408
Closed	Hot water supply valve to AMR1	CF406
Open	Hot water return valve from AMR4	CF407
Open	Hot water supply valve to AMR4	CF405

HVAC Shore Steam Heater		
Position	**Description**	**Valve**
Closed*	Steam inlet to HVAC shore steam heater	CF801
Closed**	Steam shore connection valve (S)	CF802
Closed**	Steam shore connection valve (P)	CF803
Automatic	Steam control valve	CF804
Closed	Steam control valve bypas valve (NC)	CF805
Closed*	Condensate return valve	CF902
Closed**	Condensate shore connection valve (S)	CF904
Closed**	Condensate shore connection valve (P)	CF905
Closed	Hot water return valve from AMR1	CF411
Closed	Hot water supply valve to AMR1	CF410
Open	Hot water return valve from AMR4	CF412
Open	Hot water supply valve to AMR4	CF409

Note:
* Open when shore heater is in use
** Open selected valve

ER2/ER1 FZ3/FZ4 Bulkhead Isolation Vlaves		
Position	**Description**	**Valve**
As required	Hot water supply to AMR1	CF413
As required	Hot water supply to AMR4	CF414
As required	Hot water return from AMR1	CF415
As required	Hot water return from AMR4	CF416

The hot water heating and pumping system is now set for operation.

d) Set the hot water system valves for the air handling unit supply system as required.

Note: A number of final users are supplied from each branch system. At each final user location there are supply and return valves to the local AHUs/FCUs, and both must be opened in order to ensure a supply of heated water.

d) At the CAMS Heating Water mimic, select the pumps for automatic operation and start one of the hot water circulating pumps. The other pump becomes the standby pump. (Authors note: This is to be confirmed)

e) Ensure that the waste heat recovery system is operating with heat being supplied by the MGEs which are operating. Ensure that the waste heat recovery system is circulating heated water through the heat recovery heaters. The heat recovery system heat exchangers should be operated continuously when engine cooling water is available to the waste heat recovery system.

The hot water system expansion tank water levels must be checked daily to ensure that the levels are being maintained.

6.5.2 ACCOMMODATION AIR CONDITIONING SERVICES

Introduction

Air Handling Unit System Operation

Air conditioning throughout the ship is divided into zones which correspond to the fire zones of the vessel; no air flow takes place between fire zones, as ducts do not cross zones. Within each zone there are a number of separate air conditioning stations, each with its own air handling unit (AHU) which circulate conditioned air to selected spaces. In addition, public rooms, and cabins are fitted with Fan Coil Units (FCUs) which provide extra cooling/heating as and when required at specific locations.

Each AHU is fitted with a fan which circulates air to its designated spaces. The number of air distribution lines from the fan depends upon the size of the AHU, and the spaces it serves. Extractor (return) fans discharge air from the accommodation spaces to the atmosphere, and the AHU fan draws fresh air in from outside. The air flow requirement is designed around minimum air changes per person or minimum air change required for a particular space, whichever is the greater. There are no air flows between zones as the ducts never cross over zones.

Heat Recovery Systems

The heat recovery AHUs supply a mixture of return air, drawn from the system compartments and corridors, and minimum fresh air for personnel, drawn from outside. Toilets have conditioned air transferred from other accommodation spaces such as cabins and corridors, via door grilles or undercut doors, and all air from these spaces are mechanically exhausted via the local sanitary exhaust ventilation system. Air from adjacent compartments is supplied with free-cooling ventilation and/or spot air conditioning. This air is mechanically exhausted via the local exhaust ventilation system.

Non-return dampers are installed where necessary to prevent any backflow from toilet spaces to other spaces connected to the sanitary exhaust system. The return air to fresh air ratio is maintained by balancing dampers which have been set during commissioning.

100% Fresh Air Systems

The 100% fresh air AHUs only supply fresh air, drawn from outside. Toilets shall have conditioned air transferred from other accommodation spaces such as cabins and corridors, via door grilles or undercut doors, and all air from these spaces is mechanically exhausted via the local sanitary exhaust ventilation system. All air supplied to the system compartments is naturally and/or mechanically exhausted to balance the 100% fresh air requirement. Ventilated stairwells are fitted with a fresh air supply fan, and electric duct heater for pre-heat of the fresh air during winter. Air is supplied to the lowest level of each stairwell, and all air is naturally exhausted from the top level. The electric duct heater is controlled by a wall mounted temperature transmitter located within the stairwell.

Fan Coil Unit System Operation

Fan coil units (FCU) contain a fan which draws air in from a space into the unit, then blows it over a cooling or heating coil. A chilled water coil is for cooling, and an electric heater is for heating. An FCU works by transferring heat from the air passing over the internal heat exchanger to the chilled water passing within. Cold water is supplied by a chiller unit.

Fire dampers are fitted to the ducts of this system, and are powered and controlled via the FCU control panels. There is one local fire damper control switch (push button) installed inside each room protected by fire dampers to allow manual closure of these dampers. In some cases, there may also be one local fire damper control switch installed outside a room protected by fire dampers to allow manual closure of these dampers. Generally, manual closure of the dampers from outside the room is from the FCU control panels. Each fire damper control switch is connected directly to the FCU control panel that powers its associated fire dampers.

A return air temperature transmitter mounted in the main return duct, or within the space being served sends a signal to the FCU control panel. The control panel then uses the return air/room temperature input to control the electric heating stage to provide heating to all spaces during heating mode. Alternatively, during cooling mode, the control panel uses the same return air/room temperature input to control the chilled water cooling coil valve position for each FCU to provide cooling to all spaces as required.

Heat Recovery Systems

All FCUs are heat recovery FCUs which supply a mixture of return air, drawn from the system compartments, and minimum fresh air, drawn from outside. Dependent upon available external static pressure with the FCU fan motor, minimum fresh air (unconditioned) is supplied directly to each FCU using a separate fan. The return air to fresh air ratio is maintained by the balancing dampers which have their opening positions set during commissioning.

System Descriptions

AHUs

Each AHU has its own control panel. Each control panel has an ethernet connection to the network for communication with the touchscreen panels, and other HVAC local control panels. Laundry heaters operate as required to ensure the minimum temperature of the fresh air supplied to the room is 4.3ºC (39.7ºF). The temperature setpoint is adjustable at the AHU control panel.

AHU systems are as follows:

AHU-04 and 05 System in Fire Zone 2 at 05, 04, 03, 02 Levels

AHU-04 and 05 HVAC systems supply conditioned air (including fresh air) to the accommodation spaces in F Z 2, 05 ~ 02 levels. AHU-04 and AHU-05 each deliver 50% of the required airflow to the system, and operate simultaneously. The supply ducts from each AHU are fitted with a non-return damper to prevent backflow, and short-circuiting of air between the units. Downstream of the non-return dampers, the supply ducts from each AHU is combined into a common duct which then distributes supply air to the system.

IT equipment room 1 is fitted with a split Direct Expansion (DX) system with an indoor cooling unit, and outdoor air-cooled condenser. The split system is automatic via a programmable thermostat located within the room, and operates independently from the main HVAC control system.

AHU-03 System in Fire Zone 2 at 01 Level, Main Deck

AHU-03 HVAC system supplies conditioned air (including fresh air) to the accommodation spaces in FZ 2, 01 level through the main deck. AHU-03 delivers 100% of the required airflow to the system. There is one supply duct from AHU-03 and one return duct back to AHU-03.

Class room M2A, library media room, officers lounge, crew lounge, deck training officer's office, and engine training officer's office are each fitted with an electric duct heater on the main supply air ducts to the rooms, with supply boxes and diffusers to distribute the air downstream of the heaters. Other compartments requiring reheat are fitted with cabin units.

AHU-02 System in Fire Zone 2 at 2nd Deck Mess and Food Service Areas

AHU-02 HVAC system supplies conditioned air (including fresh air) to the spaces in the FZ 2, 2nd deck mess, and food service area. AHU-02 delivers 100% of the required airflow to the system. There is only one supply duct from AHU-02 which branches into two separate ducts, one to serve the cadet mess room, one to serve the officers and crews mess rooms, and food service areas. There are two separate return ducts from these areas which combine into one common return duct to AHU-02. All heating is by heaters located within the AHU.

AHU-15 System in Fire Zone 2 at 2nd Deck Galley and Scullery

AHU-15 HVAC system supplies 100% conditioned fresh air to the spaces in the FZ 2, 2nd deck galley, and scullery area, including hoods. AHU-15 delivers 100% of the required airflow to the system. There is one supply duct from AHU-15, and no return duct as all air from the galley and scullery spaces is exhausted. Most heating is from heaters located within the AHU.

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AHU-01 System in Fire Zone 2 at 3rd Deck

AHU-01 HVAC system supplies conditioned air (including fresh air) to the accommodation spaces in FZ 2, 3rd deck. AHU-01 supplies 100% of the required airflow to the system. There is one supply duct from AHU-01, and one return duct back to AHU-01.

Each of the cadet cabins is fitted with an electric duct heater on the main supply air ducts to the rooms, with supply boxes, and diffusers to distribute the air downstream of the heaters.

AHU-11 System in Fire Zone 2 at 4th Deck Forward of Frame 141

AHU-11 HVAC system supplies conditioned air (including fresh air) to the accommodation spaces in FZ 2, 4th deck, forward of frame 141. AHU-11 supplies 100% of the required airflow to the system. There is one supply duct from AHU-11, and one return duct back to AHU-11. All heating is by heaters located within the AHU.

AHU-12 System in Fire Zone 2 at 4th Deck Aft of Frame 141

AHU-12 HVAC system supplies conditioned air (including fresh air) to the accommodation spaces in FZ 2, 4th deck, aft of frame 141. AHU-12 delivers 100% of the required airflow to the system. There is one supply duct from AHU-12, and one return duct back to AHU-12. All heating is by the heaters located within the AHU.

AHU-09 and 10 Systems in Fire Zone 3 at 05, 04, 03, 02 Levels

AHU-09 and 10 HVAC systems supply conditioned air (including fresh air) to the accommodation spaces in FZ 3, 05 ~ 02 levels. AHU-09 and AHU-10 each provides 50% of the required airflow to the system, and operate simultaneously. The supply ducts from each AHU are fitted with a non-return damper to prevent backflow, and short-circuiting of air between the units. Downstream of the non-return dampers the supply ducts from each AHU combine into a common duct which then distributes supply air to the system. Similarly, there is a common return duct back to the AHU room which is then split to return 50% of the air to each AHU.

The cadet lounges each are provided with an electric duct heater on the main supply air ducts to the rooms, with supply boxes and diffusers to distribute the air downstream of the heaters.

IT equipment room 2 is fitted with a split Direct Expansion (DX) system with an indoor cooling unit, and outdoor air-cooled condenser. The split system is automatic via a programmable thermostat located within the room, and operates independently from the main HVAC control system.

FCUs

Each FCU has its own control panel. Each control panel has an ethernet connection to the network for communication with the touchscreen panels, and the other HVAC local control panels. FCU systems are as follows: All heating is by an electric heater.

FCU-04 System for Fire Zone 1~2nd Deck, and Deck Training Area Spaces

The FCU-04 HVAC system supplies conditioned air (including fresh air) to the deck training spaces in FZ 1, 2nd deck. FCU-04 delivers 100% of the required airflow to the system. There is one supply duct from FCU-04, and one return duct back to FCU-04. No reheat is required in the individual compartments.

FCU-01 System for Fire Zone 3~2nd Deck, and Dry Provision Store 1

The FCU-01 HVAC system supplies conditioned air (including fresh air) to the dry provision store 1 in FZ 3, 2nd Deck. FCU-01 delivers 100% of the required airflow to the system. The FCU is located within the dry provision store 1 room, and has a supply ducting to distribute the air to diffusers located throughout the room and a return air intake at the FCU.

FCU-02 System for Fire Zone 3~2nd Deck, and Dry Provision Store 2

The FCU-01 HVAC system supplies conditioned air (including fresh air) to the dry provision store 2 in FZ 3, 2nd Deck. FCU-01 delivers 100% of the required airflow to the system. The FCU is located within the dry provision store 1 room, and has a supply ducting to distribute the air to diffusers located throughout the room and a return air intake at the FCU.

FCU-05 System for Fire Zone 3 – 4th Deck, ECR 1

The FCU-05 HVAC system supplies conditioned air (including fresh air) to the Engine Control Room (ECR) 1 in FZ 3, 4th deck. FCU-05 delivers 100% of the required airflow to the system. The FCU is located within the ECR 1 (due to limited fan backpressure), and has supply ducting to a ceiling diffuser and return ducting from a ceiling grille back to the FCU. This system has no heating.

FCU-07 System for Fire Zone 3 – 4th Deck, HVR 1

The FCU-07 HVAC system supplies conditioned air (including fresh air) to the High Voltage Room (HVR) 1 in Fire Zone 3, 4th deck. FCU-07 delivers 100% of the required airflow to the system. The FCU is located within the HVR 1 and has a supply outlet and a return grille on the unit. This system has no heating.

FCU-06 System for Fire Zone 4 – 4th Deck, ECR 2

The FCU-06 HVAC system supplies conditioned air (including fresh air) to the Engine Control Room (ECR) 2 in FZ 4, 4th deck. FCU-06 delivers 100% of the required airflow to the system. The FCU is located within the ECR 2 (due to limited fan backpressure), and has supply ducting to a ceiling diffuser, and return ducting from a ceiling grille back to the FCU. This system has no heating.

FCU-08 System for Fire Zone 4 – 4th Deck, HVR 2

The FCU-08 HVAC system supplies conditioned air (including fresh air) to the High Voltage Room (HVR) 2 in FZ 4, 4th deck. FCU-08 delivers 100% of the required airflow to the system. The FCU is located within the HVR 2, and has a supply outlet and a return grille on the unit. This system has no heating.

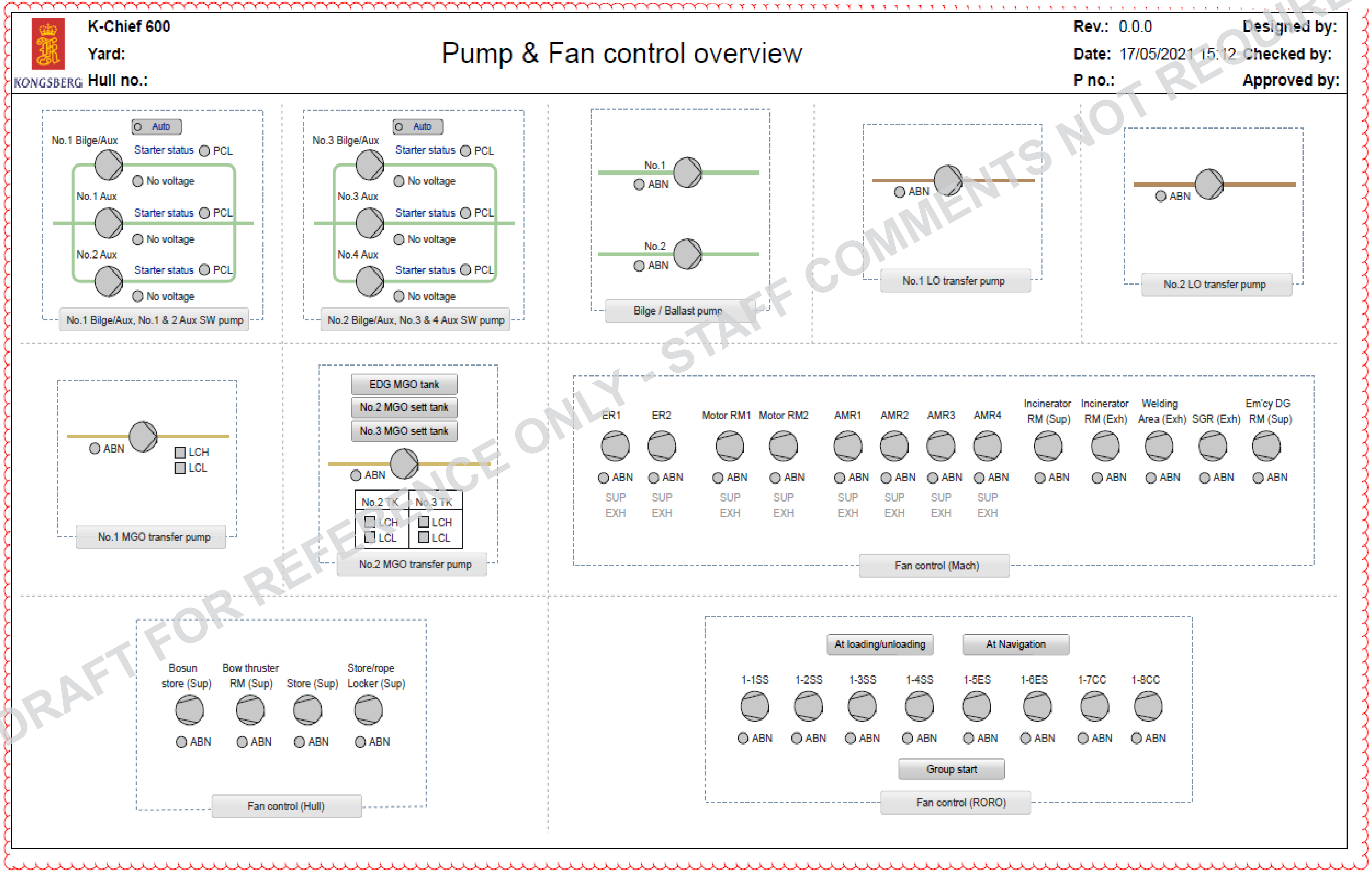
FCU-09 System for Fire Zone 4 – 4th Deck, FCR 1

The FCU-09 HVAC system supplies conditioned air (including fresh air) to the Frequency Converter Room (FCR) 1 in FZ 4, 4th deck. FCU-09 delivers 100% of the required airflow to the system. The FCU is located within the FCR 1, and has a supply outlet and a return grille on the unit. This system has no heating.

FCU-10 System for Fire Zone 5 – 4th Deck, FCR 2

The FCU-10 HVAC system supplies conditioned air (including fresh air) to the Frequency Converter Room (FCR) 2 in FZ 5, 4th deck. FCU-10 delivers 100% of the required airflow to the system. The FCU is located within the FCR 2, and has a supply outlet and a return grille on the unit. This system has no heating.

Illustration 6.5.3a CAMS Mimic for Fans



6.5.3 MACHINERY SPACE VENTILATION

Introduction

Air distribution to the machinery spaces supplies the following areas:

No.1 engine room supply fan (ER1) reversible type 69,000m³/hour:

- HV room 1.
- Passage ways x 3.
- No.1 MGE turbo charger.
- No.2 MGE turbo charger.
- Passage way between MGEs.
- Vicinity of control air compressors x 2.
- Vicinity of fire hydrophore unit.
- Vicinity of MGO purifier.
- Vicinity of service air compressor.
- Vicinity of BWTS.
- Passage way No.1 MGE forward.

No.2 engine room supply fan (ER1) reversible type 69,000m³/hour:

- ECR1.
- Passage ways x 4.
- No.2 MGE turbo charger x 2.
- Toilet.
- Vicinity of VFD panel x 2.
- Passage way MGEs aft.
- Vicinity of cooling fresh water pump.
- Vicinity of coolers x 2.
- Vicinity of start air compressors x 2.
- Passage way No.2 MGE forward.

No.3 engine room supply fan (ER2) reversible type 69,000m³/hour:

- Passage way.
- HV room 2
- Passage ways x 2.
- No.3 MGE turbo charger x 2.
- Passage way between MGEs.
- Vicinity of VFD panel x 2.
- Vicinity of cooling SW pump.
- Vicinity of coolers x 2.
- Vicinity of MGO purifier.
- Vicinity of OWS.
- Passage way No.3 MGE aft.

No.4 engine room supply fan (ER2) reversible type 69,000m³/hour:

- Toilet.
- Passage ways x 4.
- ECR2.
- No.4 MGE turbo charger x 2.
- Passage way MGEs forward.
- Vicinity of start air compressor.
- Vicinity of control air compressors x 2.
- Vicinity of air receivers.
- Vicinity of sludge pump.
- Passage way No.4 MGE aft.

No.1 motor room supply fan (MR1) reversible type 7,000m³/hour:

- Frequency converter room 1.
- Passage way.
- MR1 (S).
- MR1 (S).

No.2 motor room supply fan (MR1) non-reversible type 7,000m³/hour:

- MR1 (P).
- MR1 (P).

No.3 motor room supply fan (MR2) reversible type 7,000m³/hour:

- Frequency converter room 2.
- Passage way.
- MR2 (A).

No.4 motor room supply fan (MR2) non-reversible type 7,000m³/hour:

- MR2 (F).
- MR2 (F).

No.1 auxiliary machinery room supply fan (AMR1) reversible type 6,000m³/hour:

- AMR2 (S).
- AMR2 (S).
- AMR2 (S).

No.2 auxiliary machinery room supply fan (AMR1) non-reversible type 6,000m³/hour:

- AMR2 (P).
- AMR2 (P).
- AMR2 (P).

No.1 auxiliary machinery room supply fan (AMR2) reversible type 6,000m³/hour:

- AMR3 (P).
- AMR3 (P).
- AMR3 (P).

No.2 auxiliary machinery room supply fan (AMR2) non-reversible type 6,000m³/hour:

- AMR2 (S).
- AMR2 (S).
- AMR2 (S).

No.1 auxiliary machinery room supply fan (AMR3) reversible type 6.000m³/hour:

- AMR3 (S).
- AMR3 (S).
- AMR3 (S).

No.2 auxiliary machinery room supply fan (AMR3) reversible type 8,500m³/hour:

- AMR3 (P).

- AMR3 (P).
- AMR3 (P).

No.1 auxiliary machinery room supply fan (AMR4) reversible type 8,500m³/hour:

- AMR4 (S).
- AMR4 (S).
- AMR4 (S).

No.2 auxiliary machinery room supply fan (AMR4) non-reversible type 8,500m³/hour:

- AMR4 (P).
- AMR4 (P).
- AMR4 (P).

ECR1/2 Ventilation

This is carried out by a fan coil unit (FCU).

HV Room1/2

This is carried out by a fan coil unit (FCU).

EDG Room

This is carried out by an external fan of 2,000m³/hour.

Inergen Room

This is carried out by an external fan of 2,500m³/hour.

The ship's machinery spaces are force ventilated by means of a number of electrically-driven fans. The fans force air into the machinery spaces. All machinery spaces are fitted with ventilation fans, and the fans for each compartment are controlled separately. Fire dampers and shut-off dampers are fitted so that air flow due to natural draught may be controlled. Fire dampers and shut-off dampers are fitted in the machinery spaces.

When a start order for a fan is issued by the controller, the damper opens and that authorises the starting of the fan. If the fan does not start before expiry of the set time delay interval (typically 3 minutes), an alarm is raised. For a stop order, the fan stops, and the damper closes after a time delay. If the damper is closed whilst the fan is running, the fan will be stopped. All machinery space fans may be controlled locally or remotely from the fan control touchscreen, and each fan drives its own associated damper(s) via the fan starter. The screen mimic indicates the fan and damper status.

Most fans may be operated in Local or Remote mode; they may also be selected to operate in Automatic mode or Manual mode. In Manual mode, the air flow is set manually at the fan control panel touchscreen panel in terms of a percentage of the maximum designed air flow. When fans are operated in Automatic mode, the control system determines the air flow requirement of the space served, and adjusts the speed of the fans to obtain the correct flow. The air flow requirement is based upon pressure differential between the compartment served, and an external reference temperature; in addition, account is taken of the cooling requirement, and the number of changes of air needed. Pressure in the machinery spaces varies with the number of MGEs running, and although ER1 and ER2 are provided with combustion air fans, there will be a variation because of air flows between compartments when watertight doors are open.

Fan Starting and Stopping

Fans can be Started/Stopped and selected to Auto/Manual at the following locations:

- Fan control panels touch screens.
- Wheelhouse CAMS.
- Training bridge CAMS.
- Local starting in fan rooms.

Variable Speed Fans

The fan speed set point is defined by the PID controller which maintains the pressure in the compartment or room at the pressure selected by the operator.

Air flow requirement for comfort air depends upon the need for air change and also for cooling. Flow requirement calculations take into account the external air temperature, and so the speed of the fan may be reduced, and less energy consumed, if the external temperature allows for that. The value of the upper temperature limit may be set at the touchscreens. The minimum air flow from a fan is dictated by two factors, these being the allowed minimum speed of the fan, controlled by its inverter, and the minimum number of air changes per hour required in the compartment served.

Refer to sequence control illustrations above.

Fan Lists

Machinery Space Fans

Starting method DOL
Fan VFD control

Supply Fan	No. of Fans	Fan Capacity
No.1 engine room supply ER1	1	Reversible 69,000m³/h
No.2 engine room supply ER1	1	Non reversible 69,000m³/h
No.3 engine room supply ER2	1	Reversible 69,000m³/h
No.4 engine room supply ER2	1	Non reversible 69,000m³/h
No.1 motor room supply MR1	1	Reversible 7,000m³/h
No.2 motor room supply MR1	1	Non reversible 7,000m³/h
No.3 motor room supply MR2	1	Reversible 7,000m³/h
No.4 motor room supply MR2	1	Non reversible 7,000m³/h
AMR1 supply fan 1	1	Reversible 6,000m³/h
AMR1 supply fan 2	1	Non reversible 6,000m³/h
AMR2 supply fan 1	1	Reversible 6,000m³/h
AMR2 supply fan 2	1	Non reversible 6,000m³/h
AMR3 supply fan 1	1	Reversible 6,000m³/h
AMR3 supply fan 2	1	Non reversible 6,000m³/h
AMR4 supply fan 1	1	Reversible 8,500m³/h
AMR4 supply fan 2	1	Non reversible 8,500m³/h
Incinerator supply fan	1	2,400m³/h
Welding area exhaust fan	1	1,200m³/h
Inergen room exhaust fan	1	2,500m³/h
Steering gear room exhaust fan	1	1,000m³/h
EDG supply fan	1	2,000m³/h

Hull Outfitting Space Fans

Supply Fan	No. of Fans	Fan Capacity
Bosun's store supply	1	800m³/h
Bow thruster room supply	1	9,000m³/h
Aft store supply	1	850m³/h
Store/rope locker supply	1	850m³/h

Ro-Ro Hold Space Fans

Supply Fan	No. of Fans	Fan Capacity
RoRo space supply	1	13,800m³/h
RoRo space supply	1	13,800m³/h
RoRo space supply	1	13,800m³/h
RoRo space supply	1	13,800m³/h
RoRo space exhaust rev. supply	1	27,600/13,800m³/h
RoRo space exhaust rev. supply	1	27,600/13,800m³/h
Circulation fan	1	3,384m³/h
Circulation fan	1	3,384m³/h

Pneumatic Closing Dampers

Damper Location	No. of Dampers	Opening	
No.1 engine room supply ER1	1	Air to open	
No.2 engine room supply ER1	1	Air to open	
No.3 engine room supply ER2	1	Air to open	
No.4 engine room supply ER2	1	Air to open	
EDG supply fan (circular type)	1	**Operating Time**	
		Open	**Close**
		~ 2 sec	~ 2 sec

Electric Closing Dampers

Damper Location	No. of Dampers Safety/Ex-proof	Operating Time		Hand
		Open	Close	
RoRo space supply fan	1 safety	60 sec	3 sec	Right
RoRo space supply fan	1 safety	60 sec	3 sec	Right
RoRo space supply fan	1 safety	60 sec	3 sec	Left
RoRo space supply fan	1 safety	60 sec	3 sec	Left
RoRo space exhaust fan	1 ex-proof	60 sec	3 sec	Right
RoRo space exhaust fan	1 ex-proof	60 sec	3 sec	Left

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Anything to update?

It is important that this manual is kept up to date as a live document. If you believe there are any errors or omissions in this manual, or you are aware of changes to the equipment or systems on board then please contact the publishers:

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6.5.4 PROVISIONS REFRIGERATION SYSTEM

Manufacturer:	Bronswerk
Type:	R-407c direct expansion

Compressors

Manufacturer:	Bitzer
Type:	Semi-hermetic reciprocating, air cooled
Model:	6FE-44Y-2NU-0YM
No. of sets:	1 set of 2 compressors
Cooling capacity:	7.541kW

Condensers

Type:	Horizontal, shell and tube
Model:	Onda
No. of sets:	1 set of 2 condensers
Capacity:	99kW
Cooling water flow:	Sea water at 25.4m^3/h

Suction Accumulator

Manufacturer:	Refrigeration Research
Model:	3641
No. of sets:	1

Filter Dryer

Manufacturer:	Sporlan
Type:	Core
Model:	RCW-48
No. of sets:	1

Room Coolers

Freeze room:	-4°F (-20°C)
Chilled room:	+35.6°F (+2°C)
Lobby for freezing room:	+46.4°F (+8°C)
Lobby for daily room:	+46.4°F (+8°C)
Daily room:	+35.6°F (+2°C)

Ozone Generator

Manufacturer:	Bluezone
Capacity:	170W

Introduction

Provision Refrigeration System

The provision refrigeration system consists of one refrigeration plant having two condensing units (CDUs). The refrigeration plant has one plant control/starter panel for both CDUs, one system control panel for the freezing room, chilled room, lobby for freezing room, and lobby for the chilled room. The daily room refrigeration system has a separate control panel. One ozone generator is fitted in the chilled room. A toggle switch located on the unit is used to turn it On/Off. Once On, the unit operates continuously, independent of the rest of the system.

The chilled room is fitted with an ozone generator, which has a sterilising effect on the atmosphere of the chamber, helping to maintain the freshness of the produce stored in the chamber.

Refrigeration Plant

The refrigeration plant consists of two sea water-cooled refrigeration CDUs, one for duty, and one on standby. A plant control/starter panel is fitted on the skid to control both CDUs. Each refrigeration CDU comprises of a semi hermetic reciprocating compressor, a 2-way sea water regulating valve for head pressure control, a sea water cooled shell shell/tube condenser, an oil separator, a refrigerant receiver, suction accumulator, and safety devices.

Unit Coolers (UCs)

The provision refrigeration plant serves five refrigerated spaces, these being:

- Freezing room.
- Chilled room.
- Lobby for freezing room.
- Lobby for chilled room.
- Daily room.

The refrigeration CDUs serves a set of ceiling suspended Unit Coolers (UC). The freezing room unit coolers have electric defrost heaters, insulated and heated drain pans and heated drain lines. The remaining rooms have mechanical evaporator pressure regulating valves on the suction return line. Each UC is fitted with a thermostatic expansion valve, liquid line solenoid valve, and service isolation valves.

Refrigeration System Control Panels

There are two refrigeration system control panels in the refrigeration provision plant. One panel serves the freezing room, chilled room, lobby for freezing room, and lobby for chilled room. A separate refrigeration system control panel serves the daily room.

The touchscreen of each system control panel allows for remote start/stop of UCs. Pressing the button on the touchscreen will stop the respective room fan, and liquid line solenoid valve. Each control panel provides power to the components below. The control panel receives temperature from the refrigerated spaces, and status inputs from the CDU's.

The control panel provides outputs to the following:

- Liquid line solenoid valves in each room.
- Fans in unit coolers in each room.
- Electric defrost heaters in freezing room unit coolers.
- Drain line heater in the freezing room.
- Cooling demand signal to the duty condensing unit.
- Room temperatures to CAMS.

The control panel receives the following inputs:

- Individual alarm signals from the duty CDU.
- Alarms from the duty CDU.
- Compressor run status from the CDUs.
- Temperature transmitter readings from each room.
- Defrost 'Off' signal from each of the freezing room unit cooler.
- Heater high limit switch signal from each of the freezer room UCs.

Control Operation

Modes of Operation:

In 'Normal' mode, one CDU is in operation (duty unit), and the second unit is on standby. The system can be run in 'Pulldown' mode on either of the two system control panels if the freezing room or chilled room is at a temperature of 4°C(39°F) (adjustable on the touchscreen, default: 4°C (39°F), range: 1°C (34°F) to 10°C(50°F)) above set point for more than 30 minutes (adjustable on touchscreen, default: 30 minutes, range: 15 to 180 minutes).

In 'Pulldown' mode, the control panel allows simultaneous running of two CDUs. Before selecting the system to 'Pulldown' mode, the touchscreen on the system control panel will ask the operator to ensure that both sets of crossover liquid, and suction isolation valves on each of the CDUs are in the open position. During 'Pulldown mode', both CDUs run simultaneously to lower the room temperatures from the initial high temperature to the setpoint entered manually.

Pulldown is completed when the freezing room and chilled room is at set point +0/-1°C (+32/-30°F) for more than 60 minutes (adjustable on the touchscreen, default: 60 minutes, range: 90 to 360 minutes). the controls send a command to the standby CDU to perform a pump down.

Following the pump down step, the touchscreen will notify the operator to manually close the crossover suction, and liquid isolation valves on the standby CDU only. The operator must perform this function at the end of each pulldown cycle to prevent the risk of refrigerant charge imbalance between each CDU circuit.

Each of the two refrigeration system control panel touchscreens will display which of the two CDUs is running, either CDU1 or CDU2. When an alarm from the refrigeration plant control/starter panel is received, each refrigeration control panel de-activates all outputs except for the drain pan, and drain pipe heaters in the freezing room. Alarms of the standby unit will be ignored (alarms are displayed, but outputs to the room not affected). Each room has a temperature transmitter that transmits the temperature value to the controller of the selected refrigeration system control panel.

A request for cooling occurs when the temperature in the room is at least 1°C above the set point. When at least one room requests cooling, the system control panel sends out a cooling signal to the refrigeration plant. When no rooms are requesting cooling, no cooling signal is sent to the refrigeration plant. The system panel serving the four rooms provides separate signals for full loading (all rooms have cooling demand), and partial loading (some rooms have cooling demand) to the refrigeration plant.

When a request for cooling is identified in a room, the liquid line solenoid valves of that room UCs will open. When the request for cooling is satisfied, the liquid line solenoid valve of the that room UCs will close. When there is no request for cooling in any of the rooms, all room solenoid valves are closed, and no cooling requests are sent to refrigeration plant control/starter panel.

There is a manual option for a forced pump down at the refrigeration plant control/starter panel. When activated, a signal is sent via network from the refrigerant plant control/starter panel to each of the refrigeration system panels to close all room solenoid valves, with cooling demand signals ignored. The duty CDU will go through a normal pump down sequence. Also, there is a manual option for a service pump down at the plant control/starter panel. When activated, all room solenoid valves are forced open. Before initiating a service pump down, the the liquid line isolation valve at the CDU must be manually closed. The compressor is kept running until the refrigerant is pumped down, and stored in the condenser, completing a service pump down. The refrigeration plant control/starter panel sends out a general CDU alarm to the refrigeration system control panel.

Electric Defrost Sequence

Electric defrost is only available in the freezing room. When the system is in 'Defrost' mode, the freezing room cooling demand is ignored until the defrost sequence is completed. An authorized user can configure the defrost sequence duration, frequency, override, and stop a defrost sequence if required. Electric defrost takes place every 8 hours ('Defrost Frequency' - user adjustable; default 8 hours), or when there is a manual electric defrost made on the touchscreen. Duration of the defrost should not exceed the manual input on the control screen ('Defrost Duration' default = 15 minutes, user adjustable) or when the control panel receives the defrost termination signal, whichever comes first.

The following is the Defrost Sequence.

a) During defrost, the controls closes solenoid valves for the freezing room, and stops freezing room fans.

b) Energize defrost heaters.

c) Waits for the defrost termination fan delay switch (DTFD) to be warm enough to give a defrost termination (DT) signal or 'Defrost Duration' (manually adjustable -15 minutes default) to bypass a faulty DTFD switch - whichever comes first.

d) De-energizes the defrost heater.

e) If room has cooling demand, opens solenoid valves.

f) Waits 1 minute (user adjustable 'Fan Delay').

g) Starts room fan.

Natural Defrost

Natural defrost is available in every room except freezing room. It occurs every 24 hours or when it is manually selected. Duration is manually selected 'Natural Defrost Duration' (default=10 minutes, manually adjustable). The sequence is as follows:

a) Closes room solenoid valves.

b) Waits for defrost duration to finish.

c) If room has cooling demand, opens solenoid valves, and starts room fans.

Drain Heating

The freezing room UC is fitted with electric heat tracing underneath the drain pan surface, as well between the drain outlet of the unit cooler upto the exit point of the drain line piping out of the freezing room. Drain heating in the freezing room is always activated. The drain pan bottom surface, and drain piping is insulated. The estimated maximum power draw for the drain heating will be 500W.

Refrigeration Condensing Unit Switchover

A condensing unit switchover can be manually carried out at the plant control/starter panel. For a manual switchover, the CDU valves need to be operated manually (manual closing/opening of crossover valves).

Temperature Alarms

The following alarms are displayed on the system touchscreen control panels for each room:

- Low temperature alarm: -5°C (23°F) from setpoint.

  Action: Closes solenoid valve on the room with low temperature alarm display.

- High temperature alarm: +5°C (41°F) from setpoint.

  No action.

Alarm history and trend data is available on the touchscreen. Also, all room temperatures signals are sent to CAMS from each of the refrigeration system control panels.

Blackout and Switchover

Following a blackout, or when a manual CDU switchover is initiated, it must be confirmed on the plant control panel touchscreen that the crossover isolation valves are in the correct position before the CDU is allowed to run. This is necessary to ensure the correct valve positions before the system starts a CDU. The system panels send cooling demand signals to the plant control panel when at least one refrigerated room has a demand for active cooling. The duty CDU compressor then starts. When none of the rooms have call for cooling, the plant performs a normal pump down.

Condensing Unit Start-Up Sequence

Modes Of Operation

Modes of operation are 'Normal' mode, one CDU is in operation (duty unit), and the second unit is on standby. In 'Pulldown' mode, the control panel allows simultaneous running of two CDUs.

Parameter definitions:

- 'Low pressure delay on start-up'.
- 'Disable hot gas bypass on startup'.
- 'Low pressure (LP) switch delay compressor on'.

a) Condensing unit receives cooling demand from system panels.

b) When the LP switch closes, the start-up sequence begins.

c) If the LP switch closes within 'Low pressure delay on start-up', the system starts normally.

d) If the LP switch does not close within 'Low pressure delay on start-up', then the unit alarms 'Low pressure not reset'.

e) Compressor starts with the following :

- Both cylinder unloader solenoid valves energize (33% capacity).
- Both hot gas bypass solenoid valve, and de-superheating solenoid valves de-energized for 'Disable hot gas bypass on startup'. Following this delay the hot gas bypass system is available for capacity control.
- The LP switch is overriden for 'Low pressure switch delay compressor on', and allows the compression ratio to be established. During these 90 seconds, do not perform any capacity control (cylinder loading/unloading).

f) If the LP switch is still open after 'Low pressure switch delay compressor on', the unit alarms 'LPs not reset - post start up'.

g) If the LP switch closes within 'Low pressure switch delay compressor on', keep the compressor running based on the running command, and capacity demand.

Compressor Capacity Control

Each CDU compressor has 3 steps of unloading (0%, 33%, 66%). The CDU also has a hot gas bypass system active at all times when the CDU is running, except during startup, and pump down.

Capacity control is achieved by monitoring the suction pressure, and adjusting the capacity steps in order to maintain it at the desired loading. When the current capacity exceeds the current demand, the suction pressure will have a tendency to lower the demand. This is detected by the controls, and unloads the compressor to match demand. When the current capacity is insufficient to meet the cooling demand, the suction pressure will have a tendency to raise the demand. This is detected by the controls, and loads the compressor to match demand.

Variable Definitions

1 Suction pressure set point = 10.5 psig, dead band, +/-1 psig, default = 10.5 psig adjustable on touchscreen panel in factory mode, range 5 psig to 15 psig. If this setpoint is changed, the setpoint of the mechanical hot gas bypass, and desuperheating valves also need adjustment by a qualified service engineer.

2 Capacity step timer ramp up is adjustable on the touchscreen in factory mode, default 4 minutes, range 1 to 30 minutes.

3 Capacity step timer ramp down adjustable on screen in factory mode, default 2 minutes, range 0 to 30 minutes

Whenever a capacity step is active, the hot gas bypass valve, and desuperheating valve will mechanically regulate the suction pressure for the ranges of demand between compressor capacity steps. The capacity control allows the CDU to adjust its cooling capacity to any demand.

If the suction pressure exceeds its set point for more than the 'Capacity step timer ramp up', the next step of capacity control is engaged. If suction pressure remains below the suction pressure set point for more than the 'Capacity step timer ramp down', a step of capacity control is removed. If the current step of capacity is already 33%, then the capacity control initiates a pump down sequence.

Pump Down Sequences

There are three types of pump down sequences:

- Normal pump down.
- Service pump down.
- Standby unit pump down (completion of pull down).

Normal Pump Down

This occurs when the plant control panel is not receiving a cooling signal from the refrigeration system control panel (no load), or when there is a forced shutdown in manual mode. A 'Normal' pump down sequence is as follows:

a) Hot gas bypass solenoid valve de-energizes.

b) Desuperheating solenoid valve de-energizes.

c) Waits for LP switch to open:

d) If LP switch opens, the compressor stops, as pumpdown completed.

e) If LP switch has not opened within 3 minutes (Manually adjustable on touchscreen 'Low pressure switch delay on normal pump down', default = 3 minutes, range 0 to 15 minutes), stops the compressor, unit goes on alarm 'Failure to pump down'. An alarm signal is sent to the system control panel via network.

Service Pump Down

A service pump down occurs when the operator initiates a service pump down at the touchscreen on the plant panel. To initiate a service pump down, the CDU must be running (otherwise options will be hidden). If the duty CDU is off (no call for cooling from system panels), the system will force the CDU to run, and allow the system to stabilize before starting the service pump down sequence.

a) When a service pump down is initiated, a running verification is performed to check that the CDU is running. If the unit is not running, start unit, and allow the system to stabilize.

b) The CDU panel sends a command to the refrigeration system control panels to force all room liquid line solenoid valves to open.

c) The CDU panel de-energizes the 'King' solenoid valve, the hot gas bypass solenoid valve, and the desuperheating solenoid valve.

d) Waits for LP switch to open:

- If LP switch opens, the compressor stops, as pumpdown completed.
- If LP switch has not opened within 3 minutes (Manually adjustable on touchscreen 'Low pressure switch delay on normal pump down', default = 3 minutes, range 0 to 15 minutes), stops the compressor, unit goes on alarm 'Failure to pump down'. An alarm signal is sent to the system control panel via network.

e) A message is displayed on the plant panel touchscreen to request the operator to close the crossover isolation valve on the CDU to allow service work to be carried out.

Alarms

Standby CDU Pump Down (Completion of Pull Down)

For each CDU, the plant panel sends alarm information to the system control panel.

Alarms in Normal Mode (Single CDU Operation, 1 CDU Running, 1 CDU on Standby)

If there are alarms on the standby unit, the plant, and system panels display the alarms but takes no further action, and the system remains running with duty CDU. If there are alarms on the duty CDU, it stops, and the plant and system panels display the alarms. The alarm condition needs to be investigated and corrected, and the alarms need to be reset at the refrigeration plant panel touchscreen for the duty compressor to start. The operator may perform a manual switchover of the duty/standby CDU by manually operating the crossover valves, and entering the choice on the touchscreen if the standby CDU is available. If both CDUs have active alarms, the plant stops, and sends an alarm to the system control panels. The alarm condition needs to be investigated, and corrected. The alarms need to be reset at the control panel touchscreen to start the system.

Alarms In Pulldown (Dual CDU Operation) Mode

If one of two CDUs have active alarms, the output to that CDU is disabled, but the system is allowed to run with the active CDU. The plant and system panels displays the alarms. The alarm condition needs to be investigated, and corrected. The alarms need to be reset at the control panel touchscreen to start the stopped compressor. If both CDUs have active alarms, the plant stops, and sends alarm to the system control panels. The alarm condition needs to be investigated and corrected. The alarms need to be reset at the control panel touchscreen to start the system.

- High Pressure Switch: This alarm protects the system from a harmful HP condition such as that caused by lack of condenser water flow. This switch stops the compressor. The control panel is informed about the alarm condition. The switch requires a manual reset.
- Low Pressure Switch: This alarm protects the system from conditions that lead to LP conditions such as refrigerant leaks. This switch is also used as a control input on certain sequences such as pump down.
- Motor Protector Switch: This alarm protects the compressor windings from overheating (overloading). This switch activates an alarm. Also, a discharge gas temperature sensor is installed in compressor cylinder head.
- Differential Oil Pressure Switch: This alarm protects the system from insufficient oil flow into the compressor moving parts. This switch stops the compressor, and initiates an alarm.
- Overloads: The overloads stop the compressor, and initiates an alarm.
- E-stop Push Button: When pressed, plant stops, and goes into alarm.
- Anti-cycling: Configurable with two choices of modes for each CDU (and can be enabled or disabled as required).
  - Anti-cycling: minimum time intervals between starts is configurable between 5 to 30 minutes. Default value = 10 minutes.
  - Restart inhibitor: number of starts allowed per hour, and is configurable between 3 to 6 starts. Default value = 6.
- The plant control panel has a crankcase heater on/off indication on the touchscreen for each CDU.

Sea Water Cooling System

The CDUs are sea water cooled, the details of which are described in the Sea Water Cooling System of this manual. Below is a simplified description of this system.

Auxiliary Cooling Sea Water Pumps No.3+4 + Bilge/Auxiliary Cooling Sea Water Pumps No.2

All valves are prefixed with 'CW' unless otherwise advised

Position	Description	Valve
As required	No.2 bilge/aux. cooling sea water pump suction valve	613
As required	No.2 bilge/aux. cooling sea water pump discharge valve	616
Open	No.3 aux. cooling sea water pump suction valve	607
Open	No.3 aux.cooling sea water pump discharge valve	610
Open	No.4 aux. cooling sea water pump suction valve	608
Open	No.4 aux.cooling sea water pump discharge valve	612
Closed(NC)	Aux.cooling sea water pumps discharge valve to water mist	660
Open	Aux.cooling sea water pumps discharge valve overboard	622
Open	Aux.cooling sea water pumps discharge valve to auxiliary machinery room 4 consumers	620
Open	No.1 provisions refrigeration unit SW inlet valve	44*
Automatic	No.1 provisions refrigeration unit SW regulating valve	28*
Open	No.1 provisions refrigeration unit SW outlet valve	44*
Open	No.2 provisions refrigeration unit SW inlet valve	44*
Automatic	No.2 provisions refrigeration unit SW regulating valve	28*
Open	No.2 provisions refrigeration unit SW outlet valve	44*

Note: * = Manufacturers ID.

7.1 GARBAGE MANAGEMENT AND DISPOSAL

Garbage Compactor

Manufacturer:	Compactors Inc
Model:	TA4500SS
No. of sets:	1
Capacity:	8ft^3/h (170 liter) at 13,500 lb compaction force
Motor:	120V

Electric Plastic Waste Melter

Manufacturer:	GreenMax
Model:	M-C100
No. of sets:	1
Capacity:	220 lb/h compaction force, 100kg
Motor:	120V, 22.9kW(30.6hp)

Introduction

It is a requirement under MARPOL 73/78 Annex V to have a Garbage Management Plan on board the vessel. The plan will outline the procedures for handling, segregation, storage and subsequent disposal of the ship's generated garbage. Such a plan is to be clearly exhibited in locations used for the handling of garbage waste, and will also name the person on board responsible for the management of the plan. Warning placards should be in place about the vessel to advise the crew of what measures are in place to restrict garbage disposal into the sea and penalties involved for any breach of the rules.

The collection of garbage generated aboard the ship is based on the considerations of what can, and cannot be discarded overboard while on passage. Where possible and as space allows, receptacles are provided in the most appropriate spaces throughout the ship including the engine rooms, mess room, galley, and other living or working spaces. All crew are to be conscientious when disposing of garbage to maintain the segregation required. Strict use of the system provided will facilitate subsequent shipboard processing and, minimize the amount of garbage which must be retained, and stored aboard the ship for return to port. These receptacles should be clearly marked, and properly distinguishable by colour, graphics, shape, size and location.

Crew responsibilities should be assigned for collecting or emptying these receptacles and taking the garbage to the appropriate processing or storage location. Use of such a system facilitates subsequent shipboard processing and minimizes the amount of garbage which must be stored on board ship for return to port.

a) Plastics and Plastics Mixed with Non-Plastic Garbage

Plastic garbage must be retained aboard the ship for discharge at port reception facilities. If incinerated, then the residue, ash and plastic clinkers from plastic incinerated solid waste, should be retained onboard until a suitable shore side facility is available. When plastic garbage is not separated from other garbage, the mixture must be treated as if it were all plastic.

b) Food Waste

Some governments have regulations for controlling human, plant and animal diseases that may be carried by foreign food waste, and materials that have been associated with them (e.g. food packaging and disposable eating utensils). These regulations may demand incineration, sterilizing, or other special treatment of garbage to destroy possible pest and disease organisms. Such garbage should be kept separate from other refuse and preferable retained for disposal in port in accordance with the laws of the receiving country. Precautions must be taken to ensure that plastics contaminated by food wastes(e.g. plastic food wrappers) are not discharged at sea with other food wastes.

c) Oily and Contaminated Rags

Oily and contaminated rags, cotton waste, and such like must be kept onboard and discharged to a port reception facility or incinerated. If stored onboard. such material should be kept in a steel container fitted with a secure airtight lid, and stowed away from any hazardous areas.

d) Other Garbage

Garbage in this category includes, but is not limited to, paper products, rags, glass, metal bottles, crockery, dunnage, lining and packing materials. The vessel may find it desirable to separate dunnage, lining and packing material which will float since this material is subject to a different discharge limit than other garbage in this category. Such garbage should be kept separate from other refuse and preferably retained for subsequent disposal in port.

Garbage Record Book

It is also a requirement to maintain a record of each garbage discharge operation, this includes all discharges to sea, to reception facilities in port or to other vessels. All operations are to be recorded in a Garbage Record Book.

The details entered in the appropriate rows in the section forms are to be made in accordance with the guidelines at the front of the book Each entry is to be signed by a responsible officer. It is important that the Master obtains receipts for the amount and type of garbage landed to the shore reception facilities on each occasion garbage is landed. The amount of garbage generated on board is estimated in cubic metres, volume estimates will differ before, and after processing.

Special Areas

These are areas designated under MARPOL 73/78 which have stricter restrictions for the disposal of waste and garbage. A special area is defined in the context of the garbage regulations as a sea area which is recognised for technical reasons in relation to its ocean graphical location, ecological condition and to the type of traffic navigation through this area; the adoption of special mandatory methods for the prevention of marine pollution by garbage is required.

Annex V special areas are:

- Mediterranean Sea.
- Baltic Sea.
- Black Sea.
- Red Sea.
- Persian Gulf.
- North Sea.
- Antarctic (south of latitude 60° south).
- Wider Caribbean region (including Gulf of Mexico and Caribbean Sea).
- >3nm from the nearest land for comminuted/ground food waste (able to pass through a screen with openings no greater than 25mm).
- >12nm from the nearest land for food waste and cargo residues that are not harmful to the marine environment.
- Cleaning agents which are not harmful to the marine environment (contained in cargo hold, deck and external surfaces wash water).
- Animal carcasses (as far as possible from the nearest land and in accordance with IMO guidelines).

Inside special areas:

- >12nm from the nearest land for comminuted/ground food waste (able to pass through a screen with openings no greater than 25mm).
- >12nm for cargo residues that are not harmful to the marine environment (only if the ship is not transiting outside the special area between ports and no adequate reception facilities are available at those ports).

- Cleaning agents which are not harmful to the marine environment (contained in deck and external surfaces wash water).

Most allowable discharges are only permitted when the vessel is en route from one port to another. Discharges of any garbage from fixed or floating platforms, and from any ship alongside or within 500m of a fixed or floating platform are prohibited. For more extensive guidance on the revised MARPOL Annex V can be found in the 2012 Guidelines for the Implementation of Annex V (MEPC.219(63) adopted on 2 March 2012).

Illustration 7.1a On-board Garbage Handling

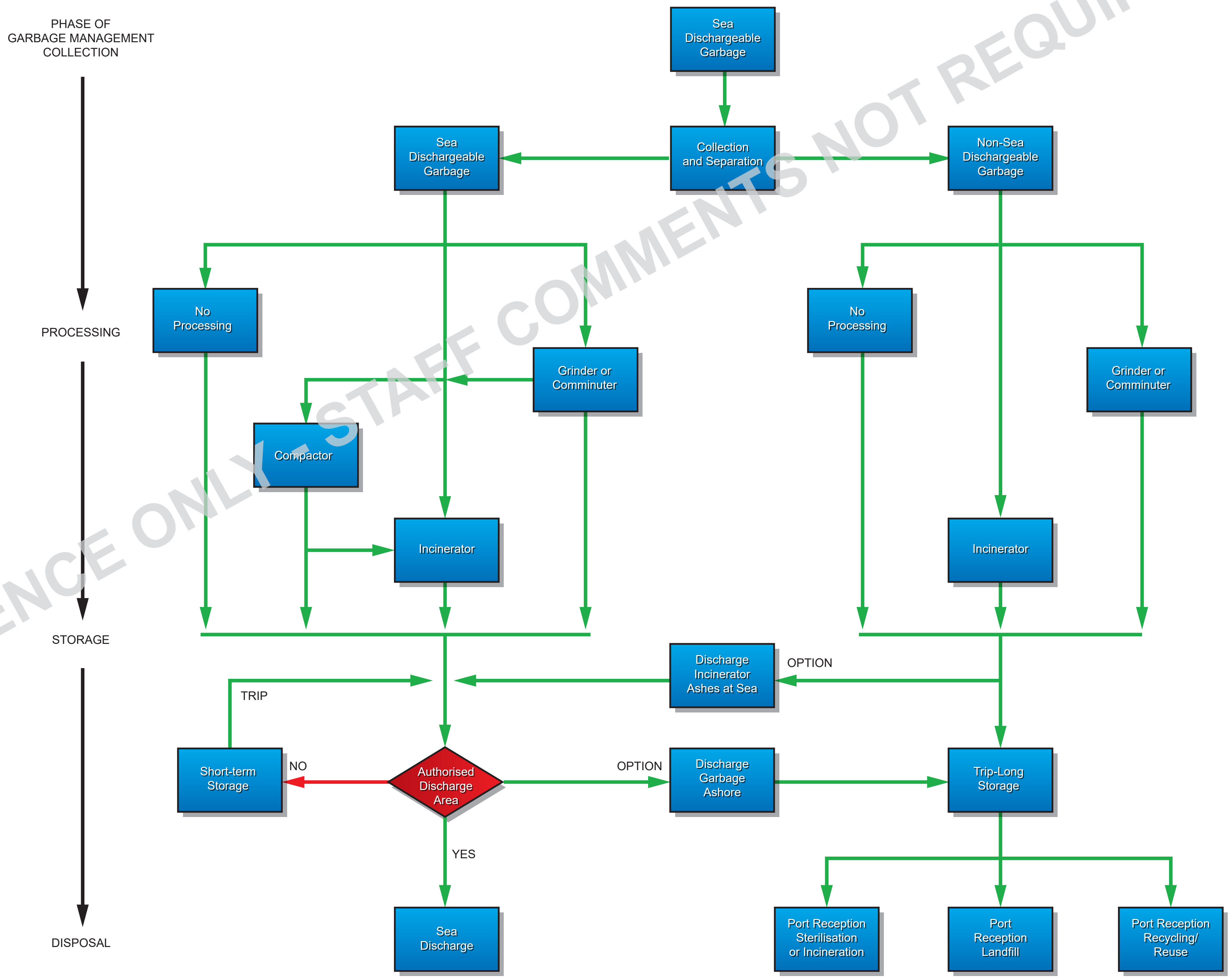
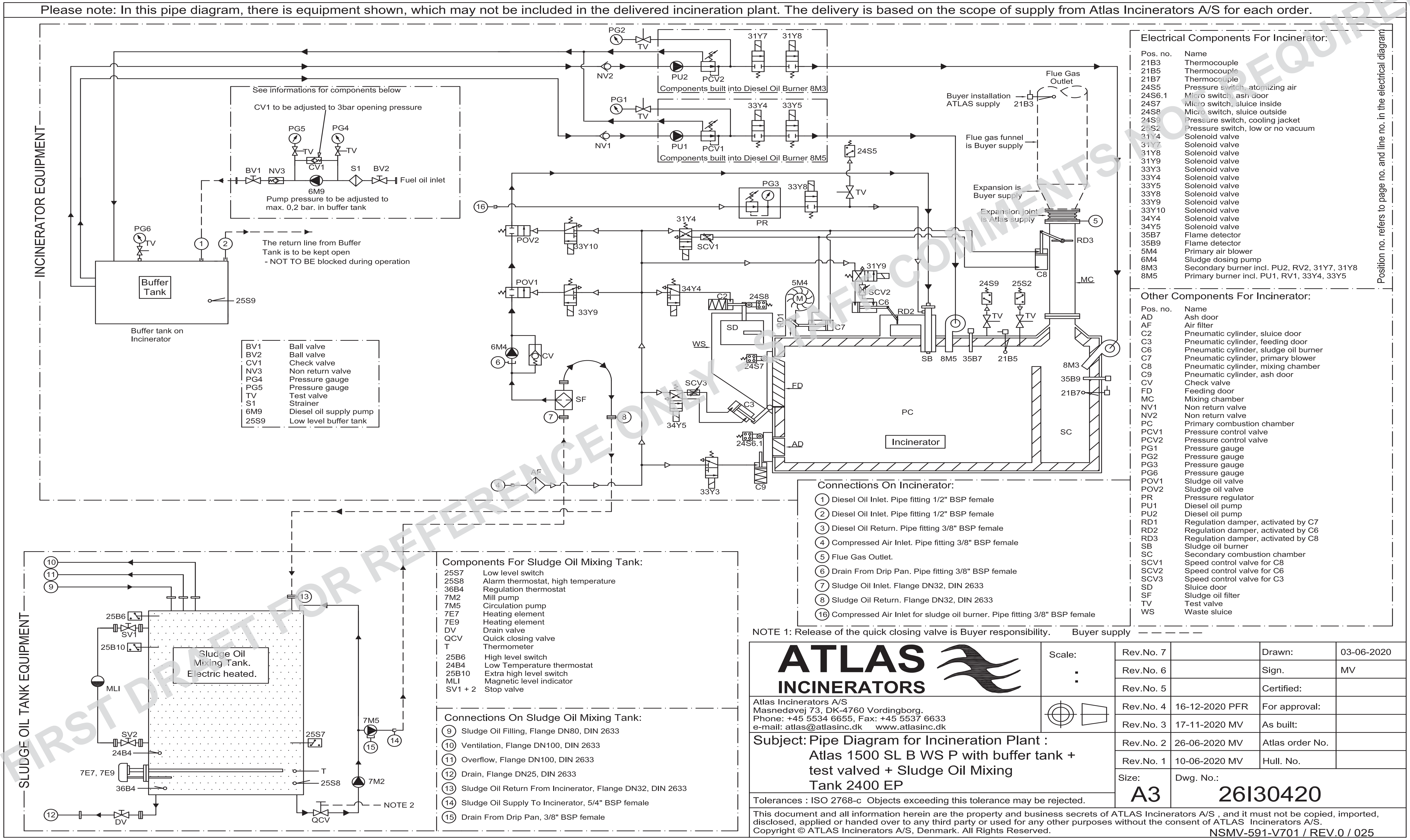


Illustration 7.2a Incinerator System *(Authors note: Illustration currently in progress)*



7.2 INCINERATOR

Incinerator

Incinerator Specification

Manufacturer:	Atlas
Type:	Solid combustible material, waste oil
Model:	1500 SL B WS P
No. of sets:	1
Calorie capacity:	1,290,000kcal/h (1,500kW)
Solid waste:	Max. 920kg/h
Liquid waste:	Max. 258kg/h
Fuel oil:	MGO (min. 2cSt at 40°C)

Sludge Dosing Pump 6M4

Type:	Progressive cavity
Model:	xxxx
No. of sets:	1
Capacity:	45~210 litres/h maximum at 2 bar
Motor:	440V, 0.3kW, 1,656 rpm, with VFD

Primary 8M5 and Secondary Burner 8M3

Type:	Automatic high pressure
No. of sets:	1
Capacity:	Primary 30.3 litres/h Secondary 22.8 ltre/h
Motor:	440V, 0.25kW

Primary Blower 5M4

Type:	High pressure, centrifugal
No. of sets:	1
Capacity:	14,800m^3/h
Motor:	440V, 11kW, 3,525 rpm

Circulation Pump 7M5

Type:	Progressive cavity
Model:	402613
No. of sets:	1
Capacity:	674 litres/h maximum at 2 bar
Motor:	440V, 0.75kW, 1,700 rpm

Mill Pump 7M2

Type:	Vertical, centrifugal
Model:	120437
No. of sets:	1
Capacity:	25,800 litre/h at 0.4 bar
Motor:	440V, 4.6kW, 3,580 rpm

Marine Gas Oil Supply Pump 6M9

Type:	Horizontal gear magnetic drive
Model:	260151
No. of sets:	1
Capacity:	107 litres/h at 17.2 bar max.
Motor:	440V, 0.44kW, 3,500 rpm

Sludge Tank Heating Element

Capacity:	5W
No. of sets:	2

Introduction

The incinerator is able to burn solid garbage waste and engine room sludge. MGO is burned in order to raise the combustion chamber to the required temperature for the combustion of solid material and sludge, MGO may also be burned to assist the total combustion when required. Although the unit is capable of burning 920kg of solid waste per hour, and 258kg of sludge per hour, care must be taken to ensure that temperature limits are not exceeded. Problems can arise when burning solid waste if the nature of the waste is not known.

The incinerator is controlled by a PLC unit, utilising a speed control unit to automatically adjust the waste oil feeding capacity. The incinerator is designed with a primary combustion chamber for burning solid material and sludge, a secondary combustion and after-burning chambers for burning uncombusted exhaust gases. The combustion chambers are equipped with MGO burners, called the primary and secondary burner respectively.

The primary combustion chamber is fitted with a charging door to admit solid material, and an ash cleaning door to allow removal of ash and slag when incineration is completed. The cleaning door is interlocked and may only be opened when the incinerator primary combustion chamber temperature is below 100°C. Flue gas from the incinerator is vented via the exhaust ducting/funnel to the atmosphere. A flue gas damper is mounted in the exhaust ducting above the incinerator. A primary blower provides forced combustion air to the primary combustion chamber, and there are also air inlet nozzles located low down in the primary combustion chamber which supplies combustion air for solid burning.

Control of the incinerator, including the temperature and pressure alarms, is from the PLC unit situated adjacent to the incinerator. A separate control panel for the sludge settling and service tank levels, and temperature alarms and milling pump start mode is also supplied.

The unit is supplied with MGO from the MGO service tank by the incinerator fuel oil pump. This pump supplies MGO under pressure to the burner unit. The sludge burner uses atomising air supplied from the general service air system. Sludge is supplied from the incinerator sludge mixing tank by means of a circulation pump. The sludge dosing pump takes suction from the circulation pump discharge line to supply the incinerator sludge burner. Any excess sludge returns to the sludge mixing tank. The mill pump is for agitation, and homogenization of the contents of the tank. Heating by two electric heating elements to the sludge mixing tank contents prior to burning sludge ensures that there is an even temperature throughout the sludge mixing tank, and that any remaining water is dispersed in the sludge charge.

The incinerator control panel consists of a main START/STOP switch, abnormal alarm indication and a touch screen panel. The touch screen of the PLC displays the temperatures in the combustion chambers and the incinerator operating conditions.

Preparing the Incinerator for Operation

a) Check that there is an electrical supply to the incinerator and that the main control panel is operational.

b) Check that there is a compressed air supply available from the general service air system.

c) Ensure that the MGO pump suction valve from the MGO service tank is open.

d) Ensure that the incinerator sludge mixing tank has been prepared for operation, and has reached a temperature of at least 60°C.

e) Ensure that all valves are in the correct operational position.

f) Check that there are no obstructions for air admission to the primary blower and the flue gas outlet.

g) Ensure that the ash and sluice doors are closed.

h) The incinerator is now ready for operation.

Operating in Sludge Mode

Before starting the incinerator, select 'SOLID & OIL' mode on the control panel display.

Step 1 Starting the Incinerator

a) Turn the Start/Stop switch to Start.

b) The primary blower starts, and runs continuously until the incinerator stops (see last step).

c) The air impeller in both primary and secondary burner starts. MGO is circulated through the burners, and back to the MGO tank.

d) Purging for 30 seconds of the primary burner (8M5), and secondary burner (8M3) starts.

e) The hours counter starts, and runs parallel with the primary blower.

Step 2 Preheating

a) After purging of the burners is completed, the secondary burner ignites, and starts burning MGO. This burner starts to heat up all combustion chambers.

Step 3 Start of Combustion

a) At 100°C in the secondary chamber, the primary burner ignites and starts burning MGO.

b) The secondary burner continues to burn.

c) Solid waste bags may be fed into the incinerator at 650 °C in the secondary chamber, ensuring clean incineration. The temperature will now rise faster.

d) At 650°C in the primary chamber, the sludge oil dosing pump will start, and the sludge oil burning starts.

e) At 652°C in the primary chamber, the air damper in the sludge oil burner will open.

When the incinerator is running, both MGO burners will ignite and burn, or shut down, according to the preset temperatures in the combustion chambers. For every restart of a burner, there is a delay of 30 seconds before ignition due to the purging time.

f) At 840°C in the primary chamber, the primary burner shuts down, as the solenoid valve in the MGO supply valve closes.

The flame detectors (35B7, 35B9) give a continuous output to the flame control circuit. In case of flame failure, the alarm will be activated after 1 second, and all oil valves will close, except the quick closing valves. The sludge burner is also controlled via the flame detector (35B7) in the primary chamber.

Step 4 Operation of the Secondary Burner

a) At 930°C in the secondary chamber, the secondary burner shuts down, as the solenoid valve in the MGO supply line closes.

b) If the temperature drops to 870°C, the secondary burner restarts, as the solenoid valve reopens.

Step 5 Stopping Combustion

a) Turn the Start/Stop switch to Stop.

b) The incinerator cooling program starts. This is part of the shutdown process.

c) The solenoid valves in the MGO supply lines for both the primary and secondary burner close.

d) The primary blower and the air impeller in both primary, and secondary burner run continuously.

Step 6 Stopping of Incinerator

a) When the temperature in the primary combustion is below 100°C, the cooling program stops.

b) The primary blower and burner air impellers stop.

All components and functions are now deactivated. However the cooling program may still repeat itself a few times. When it is completed after 4~6 hours, the main switch is turned off to shut down the power supply.

Operating in Solid Waste Mode

WARNING
Never put solid waste with a high heating (calorific) value into the combustion chamber, before the primary burner is operating and a flame is visible through the sight glass. Also, never burn more solid waste than recommended for the specific incinerator size.

Before starting the incinerator, select 'SOLID' mode on the control panel display.

Step 1 Starting the Incinerator

a) Turn the Start/Stop switch to Start.

b) The primary blower starts and runs continuously, until the incinerator stops (see last step).

c) The air impeller in both primary and secondary burner starts. MGO is circulated through the burners, and back to the MGO tank.

d) Purging for 30 seconds of primary burner (8M5) and secondary burner (8M3) starts.

e) The hours counter starts and runs parallel with the primary blower.

Step 2 Preheating

a) After purging of the burners is completed, the secondary burner ignites, and starts burning MGO. This burner starts to heat up all combustion chambers.

Step 3 Start of Combustion

a) At 100°C in the secondary chamber, the primary burner ignites and starts burning MGO.

b) The secondary burner continues to burn.

c) Solid waste bags may be fed into the incinerator at 650 °C in the secondary chamber, ensuring clean incineration. The temperature will now rise faster.

When the incinerator is running, both MGO burners will ignite and burn, or shut down, according to the preset temperatures in the combustion chambers. For every restart of a burner, there is a delay of 30 seconds before ignition due to the purging time.

The flame detectors (35B7, 35B9) continuously give an output to the flame control circuit. In case of flame failure, the alarm will be activated after 1 second, and all oil valves will close, except the quick closing valves.

Step 4 Operation of the Secondary Burner

a) At 930°C in the secondary chamber, the secondary burner shuts down, as the solenoid valve in the MGO supply line closes.

b) If the temperature drops to 870°C, the secondary burner restarts, as the solenoid valve reopens.

Step 5 Stopping Combustion

a) Turn the Start/Stop switch to Stop.

b) The incinerator cooling program starts. This is part of the shutdown process.

c) The solenoid valves in the MGO supply lines for both the primary and secondary burner close.

d) The primary blower and the air impeller in both primary, and secondary burner run continuously.

Step 6 Stopping of Incinerator

a) When the temperature in the primary combustion is below 100°C, the cooling program stops.

b) The primary blower and burner air impellers stop.

All components and functions are now deactivated. However the cooling program may still repeat itself a few times. When it is completed after 4~6 hours, the main switch is turned off to shut down the power supply.

Simultaneous Burning of Solid Waste and Sludge

If simultaneous burning of sludge and solid waste is carried out, the combustion temperature should be set to 850°C on the control panel display. For the operation to give the lowest emissions, burn sludge oil for 1 hour to heat up the incinerator. Before burning sludge oil, select ‘SOLID WASTE & SLUDGE OIL‘ mode on the control panel display.

After 1 hour, change to ‘SOLID WASTE’ mode, and feed in the garbage, and let it burn for one hour. Then change to ‘SOLID WASTE & SLUDGE OIL‘ mode, and burn the rest of the garbage together with sludge oil.

If there are large amounts of both sludge oil and solid waste to be incinerated change the mode every hour, burning sludge oil for 1 hour, then solid waste for 1 hour, and repeat as required.

Adding Solid Waste to the Incinerator

Before adding a new charge of solid waste, look through the sight glass to ensure that the incinerator is ready to receive more waste. Additional solid waste can only be added when the primary combustion chamber has cooled and the temperature interlock on the feeding door has been released. The feeding door is blocked when the primary combustion chamber temperature is above 100°C.

Care of the Primary Combustion Chamber

- Glass, bottles, and other materials which may not be burned, must not be put into the primary combustion chamber.
- Wet solid waste must not be put into the primary combustion chamber more than one hour before starting the incinerator.
- When burning oil-containing materials, such as filter cartridges, oily cotton waste, and residues from the centrifuges, do not put more than 5 litres per charge into the primary combustion chamber.
- When burning material with high calorific value with explosion-like combustion such as plastic, the maximum charge must not exceed 5.0kg.
- DO NOT overload the incinerator with waste. Ensure a maximum load per charge of 20% of the volume of the primary combustion chamber. The maximum load per charge of class II solid waste must not exceed 100kg/h.
- The feeding door must not be opened unless there is a minimum of 10mm (water gauge) vacuum in the combustion chamber as shown on the U-tube manometer.
- The flue gas uptake damper is set initially and should not be tampered with. However, excess draught can cause erratic combustion and increase the heating-up time. It may be necessary to adjust the flue damper to correct erratic combustion if it is found to be due to the air supply and not to the fuel burner.
- Removal of slag must be undertaken carefully. Do not knock or hammer on the sides of the primary combustion chamber. The main switch must be turned ON to open the door.

WARNING
DO NOT put explosive materials, closed containers or aerosols into the combustion chamber.

Alarms and Trips

The following incinerator conditions trip the incinerator or prevent it from starting and produce an alarm:

- Flue gas temperature sensor failure.
- Primary/secondary chamber temperature sensor failure.
- Primary combustion chamber low temperature - 500°C.
- Flue gas temperature high - 350°C.
- Primary/secondary chamber high temperature - 1,050°C.

- Ash door open - 100°C.
- Low negative pressure combustion air - 590Pa.
- Atomizing air pressure low - below 6~10 bar.
- Combustion air low pressure - below 18mbar.
- Primary blower failure.
- Sludge pump overload.
- Sludge pump circulating pump failure.
- Primary/secondary burner failure.
- Primary/secondary burner flame failure.
- Sluice feeding door open.
- Sluice inside door not closed - 12 seconds.
- Control power failure.
- Primary/secondary low MGO pressure.
- Sludge low pressure.
- Heating elements 1/2 overload.
- Sludge mixing tank high temperature - >80°C.
- Sludge mixing tank low temperature - 50°C.
- Sludge mixing tank high level.
- MGO tank high level.
- Sludge mixing tank low level.
- Mill pump failure.
- Sludge mixing tank mixer failure.
- PLC back-up battery low.

7.3 LAUNDRY EQUIPMENT

Introduction

Laundry equipment is fitted in the following locations on the ship:

- Cadets laundry.
- Crew laundry.
- Officers laundry.
- Ship's laundry.

Description	No.	Model	Location
Washer+dryer(stack)	77	CET9100GQ	Cadets laundry x 58 Crews laundry x 7 Officers laundry x 12
Washer extractor	3	HC040	Ship's laundry x 3
Tumble dryer	3	HC035	Ship's laundry x 3
Electric iron	8	M400	Cadets laundry x 4 Crews laundry x 2 Officers laundry x 2

7.4 ELEVATOR

Personal Elevator

Manufacturer:	Hyundai
Type:	Personal elevator
Model:	DG240
No. of sets:	1
Doors:	Landing door: hinged Car door: center opening
Capacity:	1,350kg
Speed:	45m/minute
Landings:	4
Travel height:	8.550m
Tripping speed:	63m/minute
Overspeed:	56m/minute
Motor:	440V, 6.7kW, 1,800 rpm

Introduction

There is one elevator on board the ship, and is of the single access/egress type. The elevator is powered by electrically-powered traction motor, with a central collective control system.

The speed of travel of the elevator is 45m/minute, and the speed controller controls the acceleration, and deceleration of the car between landings following predetermined, adjustable speed ramps. The lift management system is controlled through a dedicated PC which provides real-time, and historical monitoring of the elevator, which allows access to all programmable functions.

When a landing up or down pushbutton is pressed, the control system determines the direction the passengers wish to travel, and registers this information along with any other previous lift or landing calls. If the lift is already travelling in the up direction it will collect all the up calls in sequence, and the same for the down direction. In this way the elevator does not perform any unnecessary travelling, saving power, and reducing wear on the machinery.

The elevator is powered by an electrically-driven traction machine. The traction machine is an AC synchronous three-phase motor. The synchronous motor contains AC electromagnets on the stator of the motor that create a magnetic field which rotates in time with the oscillations of the line current.

The motor also has an encoder located on the motor shaft which monitors the motor speed, and provides feedback to the main inverter. In an emergency, the drive can be operated by an emergency electrical operation button in the control panel.

The motor drive shaft is fitted with a dual-circuit external spring operated shoe brake. Two separately acting brake shoes contact the brake drum via preset spring force, the brake force is set to ensure that a fully loaded car can be stopped with one brake shoe operating. The brake is released by electrically operated magnetic clamps.

The elevator is fitted with an electrical supply of 440V at 60Hz from the emergency switchboard 440V section.

The drive motor receives a variable frequency supply from the main inverter, and so varies the car speed. This means the car can accelerate and decelerate smoothly to and from landings according to predetermined speed ramps which are adjustable at the controller.

The control panel is fitted with a system of indicator lamps on its computer board which display system status and any faults which may occur. The elevator car is fitted with a load-sensing control system, this is a weighing device which will sense the loaded condition inside the car. If the elevator is 80% (or higher) loaded, but not overloaded, will bypass any landing calls until it reaches the next car initiated call stop. The unanswered landing calls are stored in the control system memory, and will be attended to in sequence, when the car is next unloaded.

The car cabin is also fitted with a fan, public address loudspeakers, normal and emergency lighting, landing and direction indicators, and a telephone.

There is an alarm pushbutton for use in an emergency. The lift car is fitted with an escape hatch in the roof, opening the hatch will stop the lift and prevent it from moving.

The elevator is fitted with an over-speed governor which will activate the jaw of the safety gear on the car, and counterweight in the event of a descending over-speed. These jaw of safety gear grip the shaft guide rails to prevent further descending movement and must be reset by raising the lift car manually, the jaw of safety gear will then retract automatically.

Elevator Power Loss

The elevator has an electro-mechanical brake which will stop the elevator automatically when the electrical power is cut off. In the event of a failure of the electrical supply, the car is stopped using stored energy. When emergency power is available, the car waits for a signal to move to the nearest landing, where the car doors open.

Emergency Stop Device

a) Detects the speed with governor or other devices, and stops the car when the car rope is cut or the car speed increases over the rated speed for some reason.

b) This device holds the rail, and is installed under the car because the car has nothing else but the rail to rely on to stop the car.

c) The progressive type of emergency stop is used to prevent injuries from the shock of the sudden stop as it activates when the car goes over the rated speed.

Operating the Elevator

a) Push the required deck button. The car will door will close after a few seconds, and the elevator will run to the selected deck. At the selected deck, the car will stop, and the car door will open.

b) Do not try and open the car door whilst the leveator is in motion.

c) If the elevator runs abnormally, or if you are locked in the car, operate the telephone in the car, and press the alarm button on the car operating panel.

d) Stay in the car until rescued which is safer than trying to escape by yourself.

e) The lift is not air tight.

Escape from the Elevator in an Emergency

a) Break the glass cover of the key box, and remove the key.

b) Unlock the car escape hatch, and push it open.

c) Escape through the escape hatch to the car top.

d) Do not close the car escape hatch, and activate the emergency stop switch on the car roof.

e) Try to evacuate through the nearest landing door as instructed on the signboard fitted on the landing door, or climb to the trunk top by using the trunk ladder to the access the lift machinery room platform, and escape through the escape door.