ENGINE ROOM SIMULATOR COURSE

I. INTRODUCTION

This course is essentially a practical one, composed of a series exercises structured around the operation of a ship's machinery installation and carried out in conjunction with an engine room simulator delivered by Kongsberg Maritime Simulation Systems AS.

I.1 System Configuration

To achieve the objective of the course, that is "To provide adequate knowledge and necessary skills to operate, supervise and monitor the safe operation and control of ship's machinery installation in accordance with provisions of Section A-III/1, A-VIII/2 of the STCW95 Code," the simulator system is similar to those of actual marine diesel engine plant. A high-performance computer with mathematical model that represents the dynamic real-time computerized simulation of the diesel engine plant makes the exercises near reality experience.

II FAMILIARIZATION

II.1 Engine Room Simulator Course Arrangement - The simulator is installed in the following rooms;

II.1.1 Instructor Room – The room adjacent where the instructor monitors the trainees and troubles during simulation are introduced.

II.1.2 Student/Operator Room – Corresponds with the room where the graphic screen of local operator station LCD's display units are installed for checking and local operation of machineries and valves.


Instructor Station


Student Station

Figure 1. Student / Operator Station

II.2 Engine Room Simulator Course Monitoring System (TEC- Neptune) –
The TEC (Training, Evaluation and Control) instructor system is an excellent tool to efficiently prepare, control and evaluate students on a predefined task. The system is built up by scenarios used during an exercise to monitor the student training progress.

II.2.1 Keyboard Section-
The functions are grouped according to function type and assigned to keys with the purpose of achieving the best user friendliness. The keyboard has some keys, which are already marked with an appropriate text: Home, Page Up, and Page Down.

Present Windows layout:

Keyboard Key	**TEC Function**
F1	Run simulation
F2	Freeze simulation
F3	Stop, end simulation
F4	Snapshot
F5	Operating Condition
F6	Scenario
F7	Recall picture
F8	Alarm log
F9	Malfunction page directory
F10	Variable page directory
F11	Alarm list
F12	Alarm silence
Home	Picture directory
Page Down	Next picture
Page Up	Previous picture
Shift + F4	Replay / snapshot dir.
Shift + F6	Initial condition
Shift + F7	Mark picture
Shift + F8	Alarm log acknowledge
Shift + F12	Toggle window decorations
Shift Home	Picture number (mdxx)
Ctrl + P	The current display is printed on the color printer

Fig. 4 Keyboard Key TEC Function

To access functions listed in the left column in the attached table, please follow the quick reference in the right column:

Only the **Numeric buttons** and **ENTER** buttons of the keyboard are used by the student/ operator

The keyboard is used to:
- change set point of controllers
- call new model drawings
- other special functions

OPERATOR KEYPAD

Operator Keypad consists of buttons for the following purposes:

- Access of Malfunctions, Variable and Alarm list pages
- Display selection
- Alarm acknowledge
- Alarm log
- Alarm Silence

1. **Run Simulation**

   To set the simulator in Run mode, press the **Run** (F1) pushbutton on the keyboard. The mode indication in the header bar (left side) changes from *Freeze* to *Running.*
   The simulated time displayed in the header bar of the display starts incrementing.

2. **Freeze Simulation**

   To set the simulator in Freeze mode, press the **Freeze** (F2) pushbutton on the keyboard. The mode indication in the header bar (left side) changes from *Running* to *Freeze*.

   The simulated time displayed in the header bar of the display stops incrementing.

3. **Recall Picture**

   Press (F7) Button and one of the numeric keys (0-9) recall a previous marked picture.

4. **Alarm Log**

   Pressing (F8) Button shows the Alarm Log Display where you inspect and acknowledge alarms.

5. **Malfunction page directory**

   Pressing (F9) Button displays the malfunction list pages to introduce and reset malfunctions.

6. **Variable page directory**

   Pressing (F10) Button displays the variable list pages to inspect and change simulation model variables.

7. **Alarm list**

   Pressing (F11) Button displays the alarm list pages to inspect alarmed variables and acknowledge alarms.

8. **Alarm silence**
   Pressing (F12) Button silences the alarm buzzers. The alarm system activates buzzers when alarm appears.

9. **Picture directory**
   Pressing (Home) Button displays the picture directory to show an overview of the available process displays.

10. **Next picture**
    Pressing (Page down) Button displays the next picture according to the picture directory sequence.

11. **Previous picture**
    Pressing (Page up) Button displays the previous picture according to the picture directory sequence.

12. **Mark picture**
    Pressing (Shift + F7) followed by a numeric keys (0-9) to mark picture to be recalled later.

13. **Alarm log acknowledge**
    Press Button to acknowledge an alarm after pointing at the alarm with the cursor.

INSTRUCTOR KEYPAD

The instructor has one or two color graphic monitors for TEC Instructor displays and Process displays. These are used when the instructor prepares, supervises, or evaluates the training sessions.

Example of a TEC Instructor display Example of a Process display

The instructor keypad has dedicated keys for the most basic instructor functions. The Operator/Student is not allowed to operate the Instructor keys except for the Running button.

II.3 The Mouse –

The mouse is equipped with two buttons. The left button is used to open valves, start pumps etc. In addition you may activate 3D buttons (soft keys) or controllers in the various displays.

The right button is used to close valves or stop the pump.

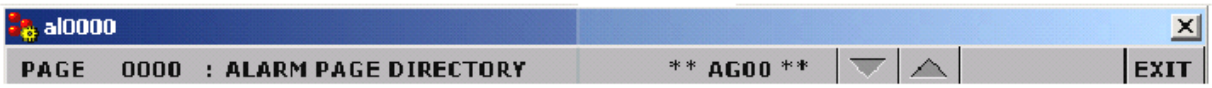
II.4 Screen Layout and Operations –

Displays and pages include some fixed basic information fields and buttons located in sections as detailed below.

II.5 Heading Bars –

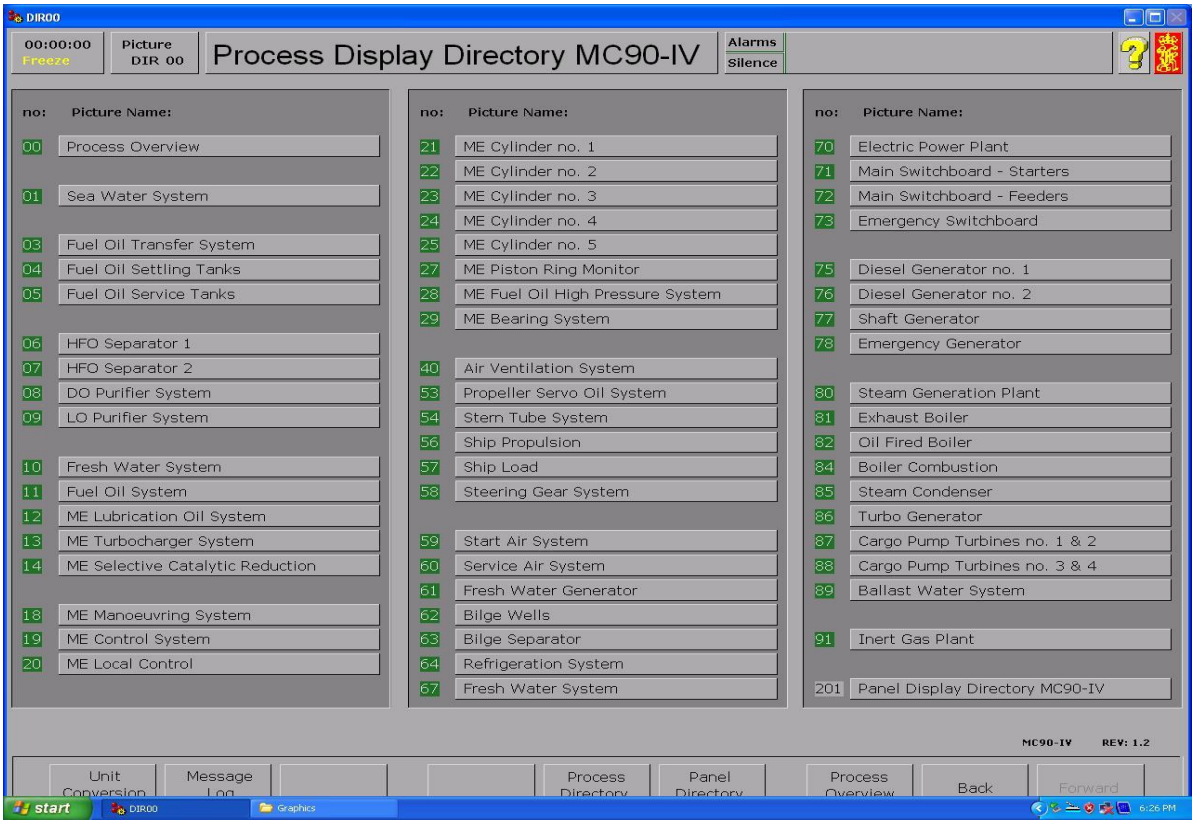
In Displays

TIME Field displaying simulator time and status (Run/Freeze).
PICTURE Field displaying the display number (ex. Picture DIR 00).
NAME Field displaying the display name (ex. Picture Directory)



On Pages

TYPE Field displaying page type. (ex a10000)
PICTURE Field displaying the page number (ex. PAGE 0000)
NAME Field displaying the page name. (ex. ALARM PAGE DIRECTORY)
DOWN Select this down arrow to display the next page in a sequence of pages.
UP Select this up arrow to display the previous page in a sequence of pages.
EXIT Select this button to remove the page.


DIR00
00:00:00
Freeze
Picture
DIR 00
Process Display Directory MC90-IV
Alarms
Silence
no: Picture Name:
00 Process Overview
01 Sea Water System
03 Fuel Oil Transfer System
04 Fuel Oil Settling Tanks
05 Fuel Oil Service Tanks
06 HFO Separator 1
07 HFO Separator 2
08 DO Purifier System
09 LO Purifier System
10 Fresh Water System
11 Fuel Oil System
12 ME Lubrication Oil System
13 ME Turbocharger System
14 ME Selective Catalytic Reduction
18 ME Manoeuvring System
19 ME Control System
20 ME Local Control
no: Picture Name:
21 ME Cylinder no. 1
22 ME Cylinder no. 2
23 ME Cylinder no. 3
24 ME Cylinder no. 4
25 ME Cylinder no. 5
27 ME Piston Ring Monitor
28 ME Fuel Oil High Pressure System
29 ME Bearing System
40 Air Ventilation System
53 Propeller Servo Oil System
54 Stern Tube System
56 Ship Propulsion
57 Ship Load
58 Steering Gear System
59 Start Air System
60 Service Air System
61 Fresh Water Generator
62 Bilge Wells
63 Bilge Separator
64 Refrigeration System
67 Fresh Water System
no: Picture Name:
70 Electric Power Plant
71 Main Switchboard - Starters
72 Main Switchboard - Feeders
73 Emergency Switchboard
75 Diesel Generator no. 1
76 Diesel Generator no. 2
77 Shaft Generator
78 Emergency Generator
80 Steam Generation Plant
81 Exhaust Boiler
82 Oil Fired Boiler
84 Boiler Combustion
85 Steam Condenser
86 Turbo Generator
87 Cargo Pump Turbines no. 1 & 2
88 Cargo Pump Turbines no. 3 & 4
89 Ballast Water System
91 Inert Gas Plant
201 Panel Display Directory MC90-IV
MC90-IV REV: 1.2
Unit Conversion
Message Log
Process Directory
Panel Directory
Process Overview
Back
Forward
start
DIR00
Graphics
6:26 PM

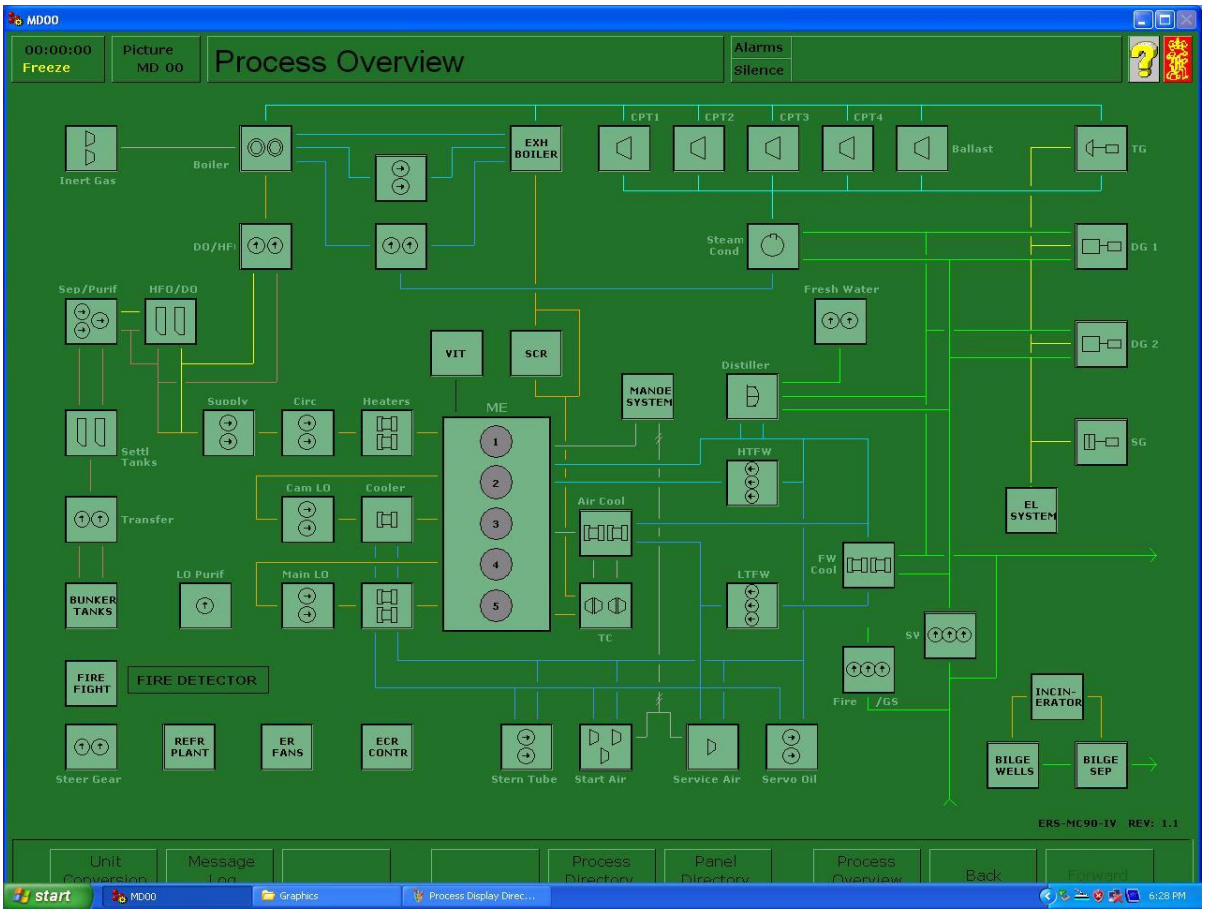

MD00
00:00:00
Freeze
Picture
MD 00
Process Overview
Alarms
Silence
CPT1
CPT2
CPT3
CPT4
Ballast
TG
Inert Gas
Boiler
EXH BOILER
DO/HF
Steam Cond
DG 1
Sep/Purif
HFO/DO
Fresh Water
DG 2
VIT
SCR
Distiller
MANOE SYSTEM
Supply
Circ
Heaters
ME
Settl Tanks
SG
HTFW
Cam LO
Cooler
Air Cool
EL SYSTEM
Transfer
FW Cool
LO Purif
Main LO
LTFW
BUNKER TANKS
TC
SV
FIRE FIGHT
FIRE DETECTOR
Fire /GS
INCIN-ERATOR
REFR PLANT
ER FANS
ECR CONTR
BILGE WELLS
BILGE SEP
Steer Gear
Stern Tube
Start Air
Service Air
Servo Oil
ERS-MC90-IV REV: 1.1
Unit Conversion
Message Log
Process Directory
Panel Directory
Process Overview
Back
Forward
start
MD00
Graphics
Process Display Direc...
6:28 PM

Fig. 2 Description of legends

II.6 Color Table – Standard color used for the piping diagrams in the local operator station presented to the monitor system.

Fresh water (low and high temperature)	Blue
Sea Water	Green
Diesel Oil	Yellow
Fuel oil	Brown
Lubrication oil	Light brown
Start and service air	Grey
Steam	Light blue

Fig.1 Color codes for pipelines

II.6.1 Abbreviated Process Diagrams meaning: **(Description of Legends)**

Temperature	T	Frequency	F
Flow	G	Electrical Power	E
Pressure	P	Valve	V
RPM	N	Level	L
Power	Q	Miscellaneous Variable	X
Ampere	I	Water or other undesirable contamination index variable	Z
Voltage	U	Viscosity	W

III. WATCHKEEPING

III.1 General Precautions in Watchkeeping at Sea

III.1.1 While at sea, control the operation of all machinery in the engine room at all times, and pay attention to the temperature, vibration, pressure, etc.

III.1.2 Familiarize yourself with the main engine, auxiliary machinery, piping system, ship's structure, and equipment method of communication so that you may be prepared to take proper measures to cope with marine accidents such as engine troubles, fire and flooding.

III.1.3 During the duty watch, do not leave the engine room without permission. When required to do so, obtain permission from chief engineer or first engineer.

III.1.4 Always be prepared to respond to the orders from the bridge and instructions of the chief engineer.

III.1.5 If you find any abnormal condition or trouble of the main engine, generator, or major auxiliary machinery, which requires switching or stopping of such machinery, report the fact to the watch officer for main engine trouble and to the chief or first engineer.

III.1.6 Pay attention to the ventilation, air circulation and lighting.

III.1.7 When taking over the watch should go to the engine room fifteen minutes before relieving the person on watch and obtain necessary information for watch transfer.

a) Check the Main engine r.p.m. temperature, pressure, sound arid vibration of each point and utilization of electric power, auxiliary machinery for abnormal conditions, and hand them over to the person in charge of the next watch.

b) Condition of tanks in use, fuel oil tanks, bilge's, tanks, and other tanks.

c) Contents of maintenance and repair being provided in the engine room.

d) Messages and orders from the chief engineer.

e) Make entries in the daily log accurately and carefully.

Describe as precisely as possible, as it will be used as a reference in the future. Enter trouble shooting actions, if taken, in the column for remarks.

III.1.8 When sailing in heavy weather, the duty engineer should make inspection rounds through the engine room in cooperation with the duty rating, preparing for possible sudden over speed of the main engine.

a) The have the rating on watch ready to render cooperation to the engineer on duty who will be posted in the engine control room or local control handle attending over speed.

b) Dirt of the fuel oil tank accumulated in the bottom tank cause a problem, if agitated by the ship's motion and sucked into the fuel oil pump, pay special attention to clogging of the strainers for the FO and LO pumps and purifier-related FO and LO lines.

c) Air is likely to mix in fuel oil lines and cooling water lines, which requires caution.

d) Relevant tanks (expansion tank or head tank) should be properly filled to prevent overflows.

e) The bearing of the main engine are subject to overheat due to large fluctuation in speed. Pay attention to the temperature and oil pressure in each part, and also touch by hand.

f) Check the bilge water condition and dispose of it as necessary.

III.2 Main Check-points During Inspection Rounds While on Watch Main Engine System Checkpoints:

III.2.1 Check the level of cooling water expansion tanks for the main engine, diesel generator and reefer containers.

III.2.2 Check the level of LO head tank (which is usually full) for the turbocharger, and the flow of LO through the sight glass.

III.2.3 Check the fuel valve cooling water inspection tank for leakage.

III.2.4 Check the differential pressure gauges of backwash filter and if excessive clean the strainer.

III.2.5 Inspect the various valves on the main engine upper cylinder cover, visually and by touch.

a. Fuel Valves: injection sound from high pressure pipes, temperature and leakage of cooling water, and presence of FO leakage.
b. Exhaust Valve; operating condition of the valves, lubricating condition, gas leakage, gas leaking sound, smell, cooling water temperature, and exhaust gas temperature.

c. Starting Valve: Check the temperature of the starting air pipe by touch. If it is too hot, the valve is leaking.
d. Safety valve: check for gas leakage from the exhaust port.
e. Indicator valve: Check for gas leakage. If leaking, cover with blank sheet or cap.

III.2.6 Generally inspect the cylinder cover for gas leakage or normal noise, leakage from lubricator oil pipes, and section subjected to vibrations and parts which are tightened.

III.2.7 Turbocharger; check the suction filter manometer (mmAHg), sound and vibration of the blower and turbine sides, LO inlet and outlet temperatures, LO leakage.

III.2.8 Main Engine Air Cooler, adjust the outlet air temperature between 45˚C to 50˚C; check the differential pressure between the inlet and outlet, seawater inlet and outlet temperatures, and leakage (check the controller position of opening).

III.2.9 Main engine governor, pay attention to the movement, and reading of the load indicator. Check for leaks, loose link mechanism or any abnormal condition.

III.2.10 Local gauge board: Check each pressure gauge, control oil pressure, and return pressure.

III.2.11 Pressure gauges at the engine room middle stage; Check emergency control air pressure and starting air pressure.

III.2.12 Cylinder Oil lubricator, check the lubricating condition, motor revolution, and inlet pressure of the hydraulic motor.

III.2.13 Main FO Pump, Check leakage and any abnormal condition around the FO pump, and FO and steam leakage from FO heating pipes.

III.2.13 Lubricate moving parts such as the fuel oil linkages, etc.

III.2.14 Main engine bearing LO pressure.

III.2.14 LO Backwash Filter: Check the pressure difference between inlet and outlet, and leakage.

III.2.15 Check the temperature of the crank case of all cylinders and gear case of the main engine. Check cooling fresh water for normal flow, and cylinders for abnormal noise.

III.2.16 Trust bearing: Check bearing temperatures forward/aft, and for abnormal noise or heating.

III.2.17 Intermediate bearing: Check the oil level, lubricating condition and temperature.

III.2.18 Shaft horse power indicator: Check the oil level and forward /aft temperature.

III.2.19 Shaft slip ring carbon: Check the operating condition and wear.

III.2.20 Stern tube

a. Maintain and adjust the stem tube LO pump outlet pressure.
b. Check sea water temperature at the inlet and outlet of stem tubs LO cooler and leakage and other abnormal condition.

c. Check the oil level of the stern tube LO sump tank, and supply oil as necessary.
d. Check the stern tube oil sight glass, and oil baths forward seal. Also inspect the head tank it should be overflowing.
e. Check the stern tube sealing system, the after seal tube oil head tank level, stern tube inlet pressure, forward seal return lube oil temperature, stern tube return tube oil temperature, forward tube seal inlet leakage and other abnormal condition.

III.2.21 Lube oil, sea water and fresh water coolers for the main engine, check the temperature of the cooling sea water, lube oil inlet and outlet, and fresh water inlet and outlet. Check for leakage and other abnormal conditions.

III.3 Generator System Check Points

Visually check the local instrument panel of the diesel generator: Tachometer; lube oil rocker arm, booster air, jacket cooling water, fuel oil and nozzle cooling oil pressures.

a. Check the governor oil level, supplement as required.
b. Clean the fuel oil, lube oil notch wire strainer by back wash.
c. Clean the strainers by manually turning.
d. Check the fuel oil pump of each cylinder for operating conditions, leakage and other abnormal conditions.
e. Check the lube oil sump tank level and supplement as required.
f. Check the level of lube oil leak collecting tank and fuel oil pump lubricating oil tank level.
g. Check the temperature of lube oil at each outlet of bearing.
h. Check the turbocharger L.O. pressure and for abnormal noise.
i. Check the direct driven pump for leakage, vibration and other abnormal conditions, and oil as required.
j. Check the valve operating mechanism located at the cylinder cover for lubrication, and leakage of gas, cooling water, and fuel oil.
k. Take the temperature of each cooling water cylinder and exhaust gas.
l. Check the inlet and outlet temperatures of lube oil, fresh water and sea water coolers and for leakage and other abnormal conditions.
m. Check the operating condition of each controller, and drain off the condensation from the air of reducing valves.
n. Check the bearing of lube oil flow at the site.
o. Check the standby generator and peripheral equipment for any abnormal condition.

III.4 Turbo Generator Check Points

a. Observe the turbine casing temperature, and check for noise with a probe.

b. Check the pressure of sealing steam, first stage steam, and governor oil.
c. Check the oil cylinder lift scale and governor load limited notch.
d. Check the lube oil sump tank and governor oil level.
e. Turn the relevant strainers manually.
f. Check the generator cooler for LO leakage, and LO flow through the sight glass.
g. Observe the reading of the vibrometer.
h. Check the position of opening of low pressure steam intake control valve, and low pressure piston valve.
i. Set the sealing steam pressure and check its reading.
j. Check the turbo generator steam control valve tar leakage and other abnormal conditions.
k. Check the turbo generator steam damping valve for leakage and other abnormal condition.
l. Check the vacuum, water level condensate temperature of T/G service main condenser and so on for any abnormal condition.
m. Check the inlet and outlet-pressure of T /G service condenser condensate pump and vacuum pump, and for leakage, heating and other abnormal conditions.

III.5 Boiler System Check Points

III.5.1 Check the pressure measured by the main pressure gauge, water level, and the condition of burner/s.

III.5.2 Check the burner control panel to see whether each indicator lamp is normal, and conduct a lamp test.

III.5.3 Boiler burning pump unit

a) Check the indication of the thermal control and the actual temperature.
b) Check the heater oil pressure and adjust as required.
c) Check the strainers for leakage and other abnormal conditions.

III.5.4 Boiler water level controller

III.5.5 Check the indication of the controller and the valve opening position.

III.5.6 Drain the reducing valve of water and check for abnormal conditions.

III.5.7 Boiler surroundings

a) Check the boiler-mounted valves for leakage.
b) Check that there is no oil in the cascade inspection tank.
c) Check the drain cooler fresh water level, drain outlet temperature, etc. for any abnormal conditions.

III.5.8 Check the boiler and, waste oil incinerator for any causes that may lead to fire.

III.6 Fuel oil. & Lube oil, Purifier system check points

III.6.1 Check the temperature and leakage from the heavy liquid side. (Take care when blowing).

III.6.2 Check the gear case oil level.

III.6.3 Check the oil flow rate and adjust as necessary.

III.6.4 Check vibration and operating condition.

III.6.5 Check the oil heater temperature and for leakage and other abnormal condition.

III.6.6 Blow the purifier operating water tank and check its level.

III.6.7 Check the purifier service pump for leakage and other abnormal condition.

III.7 Main/auxiliary air compressor system checkpoints

III.7.1 Check the cylinder oil level and supplement as required.

III.7.2 Check the crankcase oil level and supplement as required.

III.7.3 Check the V -bell tension and cooling water pump.

III.7.4 Check the compressor and motor for overheating, vibration and noise.

III.7.5 Check the cooling water temperature, position of valve opening, and for leakage of the cooler and any other abnormal conditions.

III.8 Refrigerating system (air conditioner, ship's provision stores, dehydrator)

III.8.1 Check the refrigerant level in the receiver.

III.8.2 Check the crankcase oil level.

III.8.3 Check the compressors and motors for overheating, vibration, V -belt tension and other abnormal conditions.

III.8.4 Check the electric load current.

III.8.5 Check whether the suction and discharge pressures show specified values. In the case of provision chambers, take the temperature of fish, frozen, and vegetable chambers and lobby, and check the frosting condition over the evaporator in each chamber.

III.9 Steering gear system check points

III.9.1 Lube oil tank level

III.9.2 Oil temperature

III.9.3 Lube oil tank leakage and other abnormal conditions

III.9.4 Lubrication of each section

III.9.5 Lubrication of rudder carrier and supply of grease pot (add as required).

III.9.6 Color (red /green) of the line filter (green; normal)

III.9.7 Pump discharge pressure

III.9.8 Check for leakage, vibration, overheating, noise, and other abnormal conditions

III.9.9 Motor load current and heating

III.9.10 Check the pump unit for leakage and other abnormal conditions

III.9.11 Lube oil reserve tank level and abnormal condition

III.9.12 Check the steering room for any fire hazards

III.10 Fresh water generator

Check the following items:

III.10.1Vacuum pressure

III.10.2Reading of the salinometer

III.10.3Flushing condition, feed water pressure

III.10.4Water generating rate (adjust as necessary)

III.10.5 Whether the cooling water and heating temperature are normal

III.10.6 Operating conditions of the ejector and distillate pump

III.10.7 Leakage and other abnormal conditions

III.10.11Condensate water level

III.11 Exhaust gas economizer and surroundings

III.11.1Check the seal air pressure

III.11.2Check the draft gage and/or exhaust gas temperature difference

III.11.3Check for leakage of gas, steam, and feed water, and other abnormality

III.12 Fuel oil tank and other tanks

III.12.1Check the level service tanks and drain water. Check temperature of oil in the tank, indication of the controller, and the position of valve opening.

III.12.2 Check the lube oil of each settling tank and drain water. Check temperature inside tanks, indication of controller, and position of valve opening.

III.12.3 Check the lube oil storage tank, settling tank, and cylinder oil tank for leakage and other abnormal conditions.

III.12.4 Check the level of the drinking water, fresh water pressure tank/pump.

III.12.5 Adjust the fresh water tank pressure, and check for any abnormal conditions.

III.12.6 Check the oil level of the sludge, waste oil and leaks tanks, and properly dispose of them as required

III.12.7 Check the level of the bilge tank, primary tank and cofferdam.

III.12.8 Check the waste oil indicator, place where materials are stored and each store rooms for any fire hazards and abnormal condition.

III.12.9 Check the condition of the engine room and its bilge's wells, and dispose of bilge water as required.

III.12.10 Check the inlet and outlet temperature of the calorifier and motor for any abnormal condition.

III.12.11Manually drain the main air reservoirs of water.

III.12.12 Drain the air pressure reducing valve header of water.

III.12.13 Lubricate the FO and LO transfer pumps and check for leakage from glands.

III.13 General Precautions during Watch in Port

III.13.1 During a watch in port, pay special attention to the safe operation of auxiliary machinery. If any abnormal conditions are found, immediately report to the engineer on watch and take proper corrective action.

III.13.2 Accurately make entries on the Chief Engineer's log. Especially accurate records of tank soundings taken at noon are required.

III.13.3 During the watch in port, ensure to make periodical rounds to inspect the same check points of machinery as in the watch in sea.

III.13.4 When in port, as there maybe shore repairers on board for repair maintenance of machinery, ensure to understand the content of the work and check the results.

III.13.5 When any ship's equipment or consumable stores are presented to the repairer for the repair work, report to the chief or first engineer and keep a record.

III.13.6 If hot work is conducted make strict inspections to avoid fire hazards.

III.13.7 Maintain the engine room shipshape and check the location and contents of repair work.

III.13.8 Provide assistance for loading ship's equipment and consumable.

III.13.9 When bunker is supplied, make rounds for oil spills in cooperation with a person or the supplier's side.

III.13.10 Never allow unnecessary visitors in the engine room. Take care for the security purpose of the ship by meticulously checking fire, the bilge condition and sea valves to prevent flooding, theft, etc.

IV. SAFE PRACTICES AND OPERATIONAL PROCEDURES – When working in the engine room either during watch keeping or maintenance operations, safe working practices must always be observed. In operating machineries, a checklist should be available in the ECR and at the machine side.

IV.1 Safe working practices - Enumerated below are some of the general safe working practices that must be observed and followed at all times:

a) Regulation requires every dangerous part of a ship' machinery to be securely guarded unless it so positioned or constructed that it is as safe as if were securely guarded or is otherwise safeguarded.
b) All steam pipes, exhaust pipes and fittings which by their location and temperature present hazard, should be adequately lagged or otherwise

shielded. The insulation of heated surfaces should be properly maintained, particularly in the vicinity of the oil systems.

c) The source of any oil leakage should be located and repaired as soon as possible.

d) Waste oil should not be allowed to accumulate in the bilges or on tank tops. Any leakage of fuel, lubricating and hydraulic oil should be disposed in accordance with MARPOL at the earliest opportunity. Tank tops and bilges should be painted with light color and kept clean and illuminated in the vicinity of the pressure oil pipes so that leaks may be readily located.

e) Great caution is required when filling any settling or other oil tank to prevent oil overflowing, especially in an engine room where exhaust pipes or other hot surfaces are directly below. Manholes and other openings in the tanks should always be secured so that, should that tank be overfilled, the oil is directed to a safe place through the overflow arrangements.

f) Particular care should be taken when filling tanks which have their sounding pipes located in the machinery spaces to ensure that weighted cocks are closed. In no case should a weighted cock on fuel or lubricating oil tank sounding pipe secured in the open position.

g) Engine room bilges should at all times be kept clear of rubbish and other substances so that mud boxes are not blocked and the bilges may be readily and easily pumped.

h) A notice should be displayed at each boiler setting out operation instructions. Information provided by the manufacturer of the oil burning equipment should be displayed in the boiler room.

i) Personnel using hydraulic and pneumatic equipment should be fully conversant with the proper procedures for its safe operation. Operating instructions should be followed at all times.

j) Operators should ensure that the system operating pressure shown on the pressure gauge is at the level recommended.

k) The equipment should not be operated if it is in any way faulty, with components that are not designed for use with the equipment, or when safety device is missing, incorrectly adjusted or defective.

l) Prior to a hydraulic system being activated and when it is being closed down, the recommended checks should be made to ensure that there are no pockets of air or trapped pressure in the system and that there are no external leaks.

m) Before any repair or maintenance is commenced, care should be taken to ensure that all measures and precautions necessary for the safety of those concerned have been taken.

n) No maintenance work or repair which might affect the supply of water to the fire main or sprinkler system should be started with out the prior permission of the Master and Chief Engineer.

o) Before machinery is serviced or repaired, measures should be taken to prevent turning or inadvertent starting may occur with automatic or remote control systems.

p) Electrically operated machinery should be isolated from the power supply.

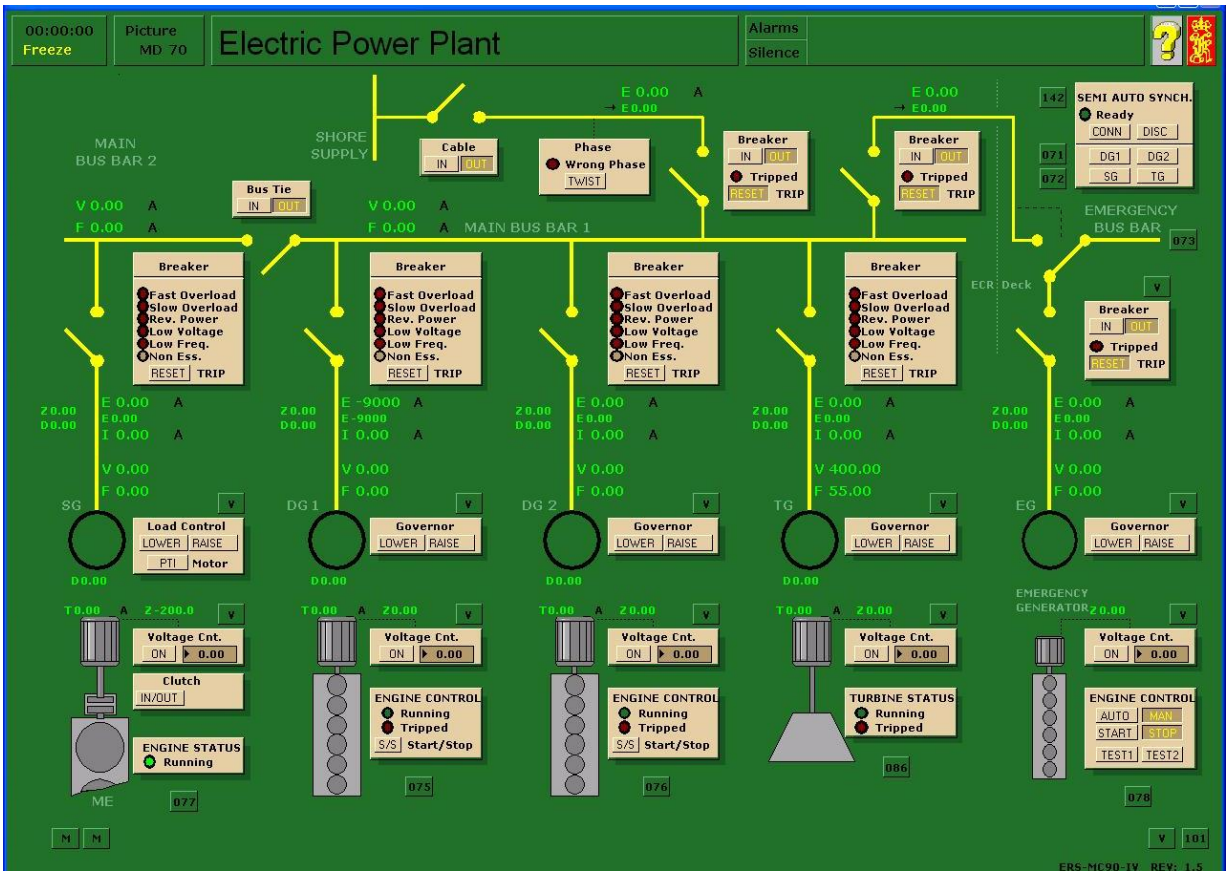
q) Steam operated machinery should have both steam and exhaust valves securely closed and, where possible, the valves locked or tied shut or some means employed to indicate that the valves should not be opened. The same care should be done when working with pressurized systems.

r) Post warning signs at or near the controls giving warning that the machinery should not be used.

IV.2 Operational Procedures – When starting a system, always have in mind that engine room systems are in some way interconnected to each other. Always pay attention to other systems as it may be affected by your current activities.

In lining up a system (like S.W. cooling system), open all valves from sea chest to overboard valve but ensuring that the pump's discharge valve should be opened last.

Also consider that starting pumps depends upon the type of pump being used. For centrifugal pump, crack-open the discharge valve before starting and then gradually fully open the valve. For positive displacement and axial flow type of pump, discharge valves should be fully open prior starting the pump.



v. ELECTRICAL POWER PLANT

Description

The functions and information in this picture are similar to the functions and information normally found on a real main switchboard on board when it comes to controlling of generators and their prime movers.

The ship's electric power is generated by these engines:

- two diesel engine driven synchronous generators – DG1 and DG2
- one turbine driven generator.
- one propeller shaft driven synchronous generator, with power take in facility.
- one emergency generator

It is and distributed via these devices:

- one main switchboard, divided into two main 440V bus bars
- one 220v bus bar
- one emergency bus bar
- one 220v emergency bus bar

The ship's electric distribution is grouped into 3 separate bus bar sections:

- Main Bus bar 1 is powered by the diesel generators and turbo generator. The shore connection is also connected to this bar. All the electrical main consumers and the emergency bus bar are fed from this section.

- Main Bus bar 2 is powered by the shaft generator. It is normally isolated from the bus bar 1 by a bus tie breaker. The consumers connected to bus bar 2 are (the bow thruster and the heavy deck machinery) all insensitive to frequency/voltage variations and hence are suitable for shaft generator supply.

- Some specially selected consumers are connected to the third bus bar section, the Emergency Bus Bar. Normally the bus tie breaker separating bus bar 1 and emergency bus bar is closed.

In black-out conditions the bus bar breaker opens, the emergency generator starts and, when ready the generator is automatically connected to the emergency bus bar.

The Load of electric motors is generally not modeled in detail. The total electric load can be computed by adding the rated power of all the running motors and then correcting this sum with respect to the present line voltage/frequency.

The typical current increase during the starting phase of an asynchronous motor is modeled.

Some of the pumps are modeled in more detail. These can be operated at variable speed. The electrical load is computed from hydraulic load based on pump characteristics and operational conditions.

Some electric loads have no influence apart from that of the power generating system, like general consumers (lighting, heating, etc.) specified by the instructor.

A static frequency converter is included. When active, it will convert the bus bar frequency to a frequency specified by the converter's set point. The speed of the variable speed pumps will follow the output frequency. No variation in the electric slip is modeled, so pump speed is strictly proportional to frequency.

The cable from shore can only be connected in port (no speed). The ship speed should be kept to zero by "STOP SHIP" function (mooring condition).

At cable connection, the electric phase will be chosen at random. The phase sequence is indicated by a rotating light wheel. Clockwise rotation is correct. Pressing on "WRONG PHASE" light simulates a corrective phase change.

For a smooth transfer, shore power can be synchronized to the ship's electric net by adjusting the speed/phase of the ship generators before the generators are finally disconnected.

The frequency and the load sharing between the generators are given through the joint effect of the speed governors. By using the lower/raise switches on the Load Control, the desired load sharing and network frequency can be obtained.

Due to the difference in the torque characteristics of the generators, it will not be possible to keep the same load sharing over the whole power range (except by manual readjustment or by control action from the Power Chief System).

The bus bar voltage and reactive load sharing between generators can be adjusted by trimming the generator magnetization.

All main generators are protected by a circuit breaker. The main circuit breakers connecting each generator to the electric bus bar are disconnected automatically for the following reasons:

- Connection shock
- Overload current (Fast Overload / Slow Overload)
- Reverse power
- Low voltage
- Low frequency
- Bus bar shock

The settings of the above are easily accessed on the breaker itself. The breaker also sets the level at which the preferential trips operate; this function does not trip the circuit breaker. Whichever trip has activated is indicated and

can be reset from the circuit breaker. The emergency generator cannot be synchronized and the settings are accessed via variables.

The reverse current protection takes place if the generator's prime mover (diesel engine or steam turbine) is shut down. The generator will then function as an electric motor driving the steam turbine or diesel engine, if it is not disconnected.

"Bus bar shock" is most likely caused by a very rough connection to one of the other generators.

Semi Synchronizing is a manual synchronizing to main bus. By selecting the generator to be connected by pressing the corresponding button and then manually adjust voltage and frequency until synchronization (READY lamp is lit), the generator is ready to connect.

Connecting the generator to main bus is carried out by the CONNECT button. (Generator to be connected has to be selected and READY lamp must be lit).

Each generator is excited by an AVR based on a PI controller. Changing the excitation setting alters the controller base setting.

Each main generator has indication for rotor phase (between current and voltage), current angle, power factor, and reactive power.

Normal operating modes.

Emergency generator on AUTO at all times.

In port
- Diesel generators supplying power as required, normally one is sufficient.

Maneuvering

Fixed pitch operation
- Both diesel generators supplying all electrical power.

Variable pitch operation
- Both diesel generators supplying main bus
- Bus tie open
- Shaft generator supplying power to bow thruster.

Sea passage
- Turbine generator supplying all power
- Shaft generator in PTI

Turbine out of action
- Shaft generator supplying all power.

IA *SUPPLY SHORE POWER*

Bus bar 1 is supplied from shore connection via the shore cable and the shore connection circuit breaker. The maximum electric load obtained via the shore connection is 280 kW. At cable connection, the electric phase will be chosen at random. A rotating light-wheel indicates the phase sequence. Clockwise rotation is correct. Pressing the "WRONG PHASE" button simulates a corrective phase change and the shore connection can be set.

Related systems required to be in operation: NONE

OPERATIONAL PROCEDURE FOR SHORE POWER CONNECTION (MD 70)

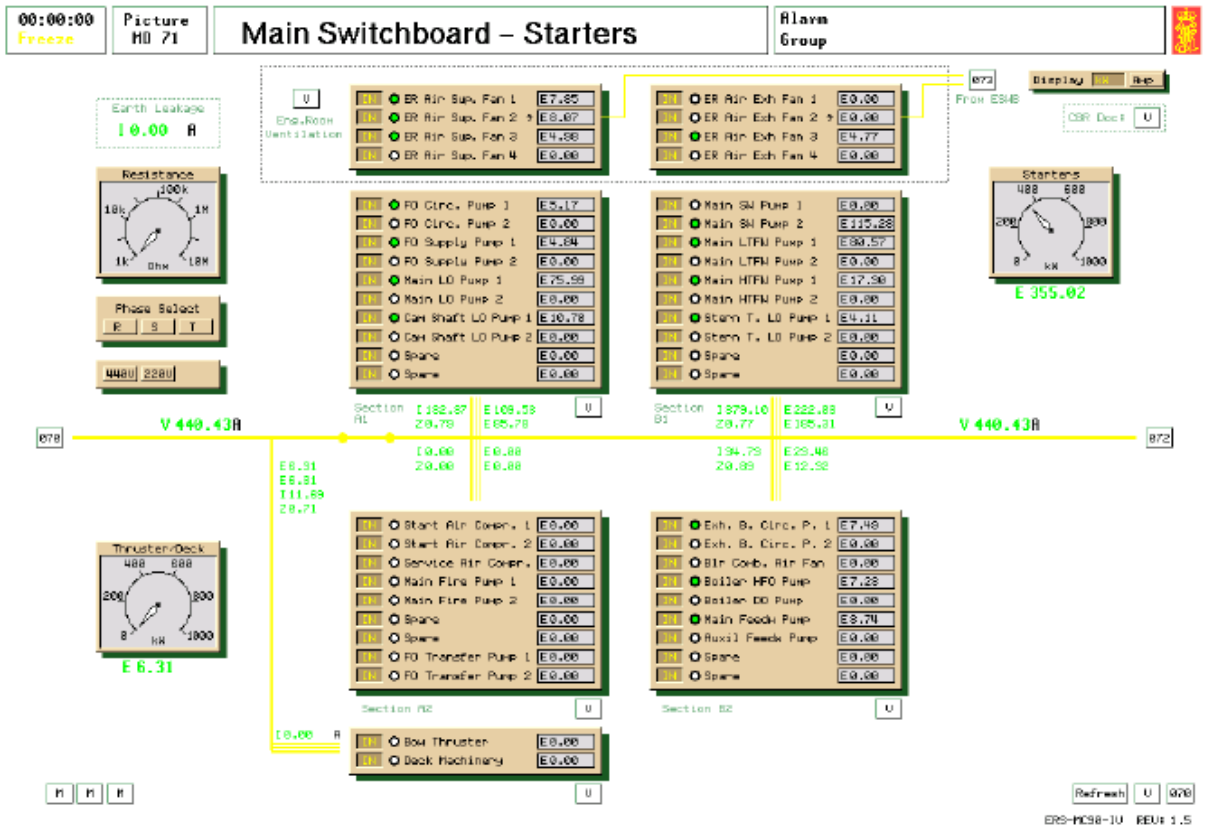
Preparations before supply shore power

- 1.Select picture Model Diagram No. 70. "Electric Power Plant".
- 2.Ensure all generators ACB, emergency bus bar and bus tie disconnected.
- 3.Press "IN" button on Shore Cable Panel to connect incoming cable.
- 4.Check phase rotation, if Wrong Phase press "TWIST" button.
- 5.If the breaker will be tripped, press button RESET
  (TRIPPED lamp on shore BREAKER Panel lit)

Starting Procedure:

MANUAL Mode

- 1.Press button "IN" to close shore circuit breaker supply for main bus 1.
- 2.ESB connect switch Breaker "IN".
- 3.ESB Bus Tie Control press "AUTO" "IN" (MD73).
- 4.All Switchboard Power Supply press Button "IN" (Confirm):
  Main Switchboard Starters (MD 71)
  Main Switchboard Feeders (MD 72)
  Emergency Switchboard (MD 73)



VI. MAIN SWITCHBOARD STARTER SECTION

General

The starters are grouped into four main sections. Deck machinery and bow thruster are supplied via a bus tie.

Each starter group has indication for current, active power, reactive power, and power factor. Starters indicated with an asterisk are supplied from elsewhere and are not included in the calculations for the starter group.

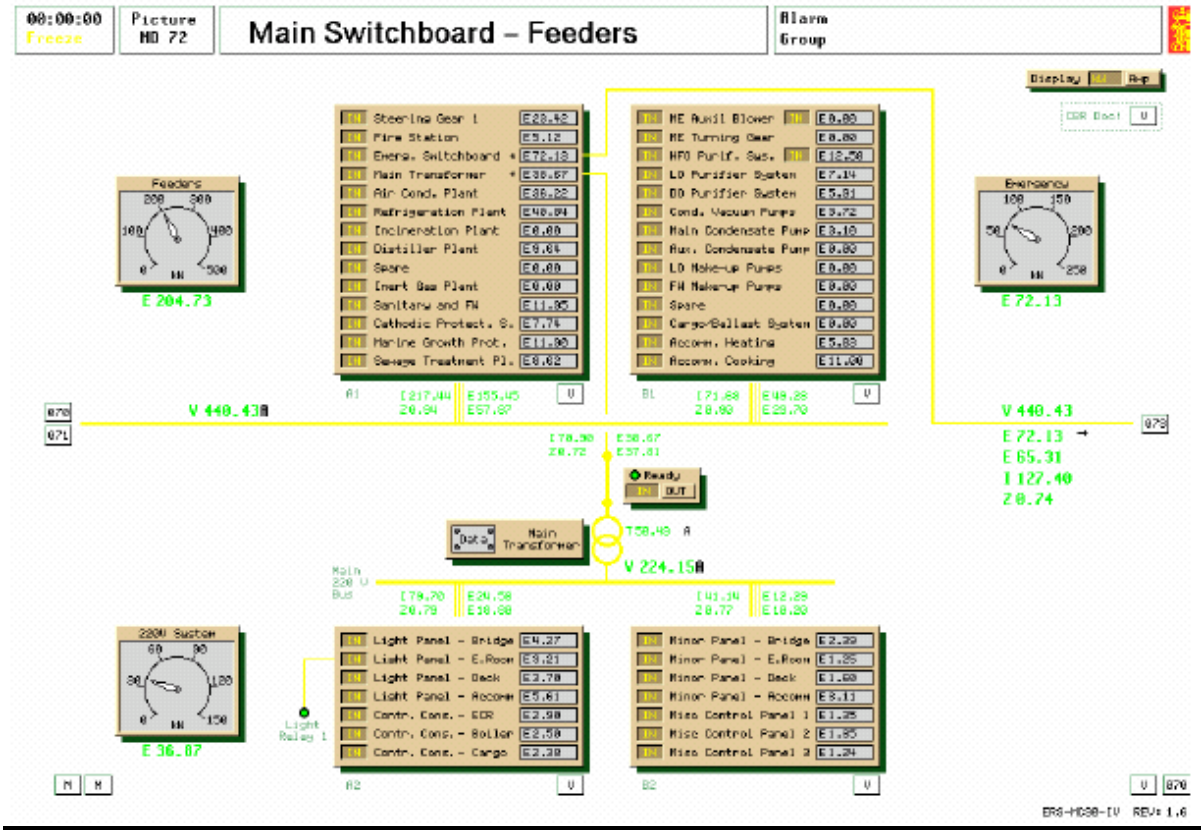
The breakers are operated by pressing the **IN** button. Pressing **IN** again will open the breaker. The green indicator shows if the machinery is running.

The display value of the breakers may be changed from active power to current. Total Earth Leakage current is constantly monitored. Earth fault finding is available by selecting 440v or 220v distribution system and switching between phases.

In case of overload of available supply the breakers can be grouped for non - essentials to automatically disconnect. Non-essentials must be circuits not required for the safe operation of the vessel.

Note: The Main bus bar is divided into two separate main bus bars 1 and 2. In Sea Operation Both the Shaft Generator and Turbo Generator have the

capacity to serve the power demand during normal running. In Standby Operation (maneuvering), it is recommended to connect an extra generator to avoid black out due to heavy changes in load from Bow thruster and Deck machinery.



VI. MAIN SWITCHBOARD-FEEDER SECTION

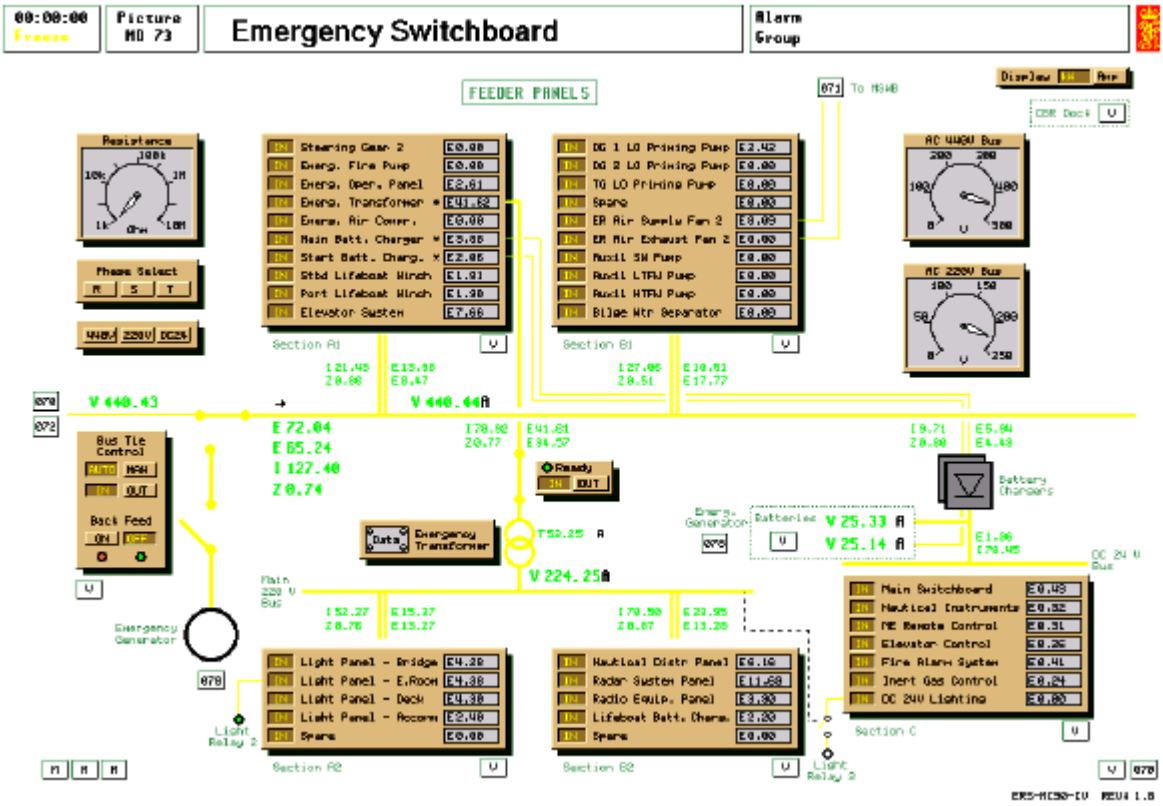
General

The feeders are grouped into four main sections. The 220v sections are fed from the main bus via a circuit breaker and transformer.

Each feeder group has indication for current, active power, reactive power and power factor. Feeders indicated with an asterisk are supplied from elsewhere and are not included in the calculations for the feeder group.

The breakers are operated by pressing the **IN** button. Pressing **IN** again will open the breaker. The display value of the breakers may be changed from active power to current.

In case of overload of available supply the breakers can be grouped for non-essentials to automatically disconnect. Non-essentials must be circuits not required for the safe operation of the vessel.



VII EMERGENCY SWITCHBOARD

General

The emergency switchboard supplies circuits necessary for the safety of the vessel. These include communications, navigation lights, fire alarm, and fire and flood control.

The feeders are grouped into four main sections. Two 440v sections and two 220v sections supplied via a circuit breaker and transformer.

Each feeder group has indication for current, active power, reactive power, and power factor. Feeders indicated with an asterisk are supplied from elsewhere and are not included in the calculations of the feeder group.

The breakers are operated by pressing the **IN** button. Pressing **IN** again will open the breaker.

The display value of the breakers may be changed from active power to current.

Earth fault finding is available by selecting 440v, 220v or 24v dc distribution system, and switching the resistance meter between phases.

The feeder circuit breakers can be individually grouped by setting the function variable to one of eight settings.
1 OL trip only
2 OL trip and auto pump restart
3 OL trip and zero volts disconnection
4 OL trip and zero volts trip

The settings can be found on the CBR Doc variables. The emergency switchboard supplies are all essential and should not be connected to non-essential trips.

Battery chargers via the 440v emergency bus supply the emergency batteries. There are two sets of batteries, one for starting the emergency generator and one for the main 24v supply. Terminal voltage of each battery is displayed.

The 220v bus bar is supplied from bus bar 1 via a circuit breaker and transformer.

The emergency switchboard supplies the emergency 220v bus bar via a circuit breaker and transformer. Two battery chargers supply emergency batteries, one for starting battery and one for emergency supplies.

The bus bars can also be supplied via a shore connection link that has the ability to alter phase rotation to ensure that motors turn in the correct direction.

The status of all prime movers is indicated, with the diesel generators having a remote start available.

VI.1 Emergency Generator Back Feed Mode

The Emergency Switch Board (ESWB) and the Main Switch Board (MSWB) can be connected in two different ways.

Normal Mode

The Emergency Switch Board is connected to the Main Switch Board by a selection switch. If there is voltage on the Main Switch Board the position is kept in “MSWB.” When the switch is deactivated by loss of main voltage or by emergency generator “test 2” override, the switch takes default position, “Emergency Generator.” The selection switch functions as a safe guard against
overloading the Emergency Generator by mechanically isolating it from the main bus.

Optional Mode

If it is required that the Emergency Generator in critical situations also should be able to feed the main bus system, the selection switch must be exchanged with a bus-tie breaker with associated bus-tie control logics. In addition, the

Emergency Generator must be permanently wired for connection to the emergency bus bar.

Changing from Normal to Optional Mode is done by setting the parameter MVP7005.C06136 to 1 ,see also MD70/73. The Optional Mode is denoted "Back Feed Permit (USCG) Mode"

OPERATIONAL PROCEDURE FOR EMERGENCY GENERATOR (IN CASE OF USING)

The emergency generator can be set to either AUTO or MAN mode. It is normally kept in AUTO. Test 1 starts the generator; test 2 connects the breaker while disconnecting the emergency bus bar from the main bus bar. In AUTO mode if power is lost (**Black Out**) to the emergency bus bar the emergency generator starts and connects automatically. Reconnecting the emergency bus bar to a live main bus bar automatically stops the emergency generator.

The emergency generator is arranged for automatic start and connection to the emergency switchboard in the event of failure of normal supply from bus bar 1 (**Black Out**).

In the event of low voltage at bus bar 1 the following sequence will take place, provided that the emergency generator is in AUTO:

1. The emergency generator is started
2. The emergency tie-line breaker is opened
3. The emergency generator is connected to the emergency bus bar.

and when the voltage at bus bar 1 is re-established the sequence is…

1. The emergency generator circuit breaker is disconnected
2. The emergency tie-line breaker is closed
3. The emergency generator stops after a few minutes of idling.

II.1 PREPARATION

Related systems required to be in operation: NONE

- 1. Select picture Model Diagram No. 70. "Electric Power Plant".
- 2. Ensure battery voltage is correct. MD73.V72691.
- 3. The Emergency Generator can also be started and connected on the main switchboard's "Emergency Generator" section.

Starting Procedure:

MANUAL MODE FOR STARTING EMERGENCY GENERATOR (MD 70):

- 1. Press "START" button on Engine Control Panel.
- 2. Turn on voltage control and adjust to 440v.

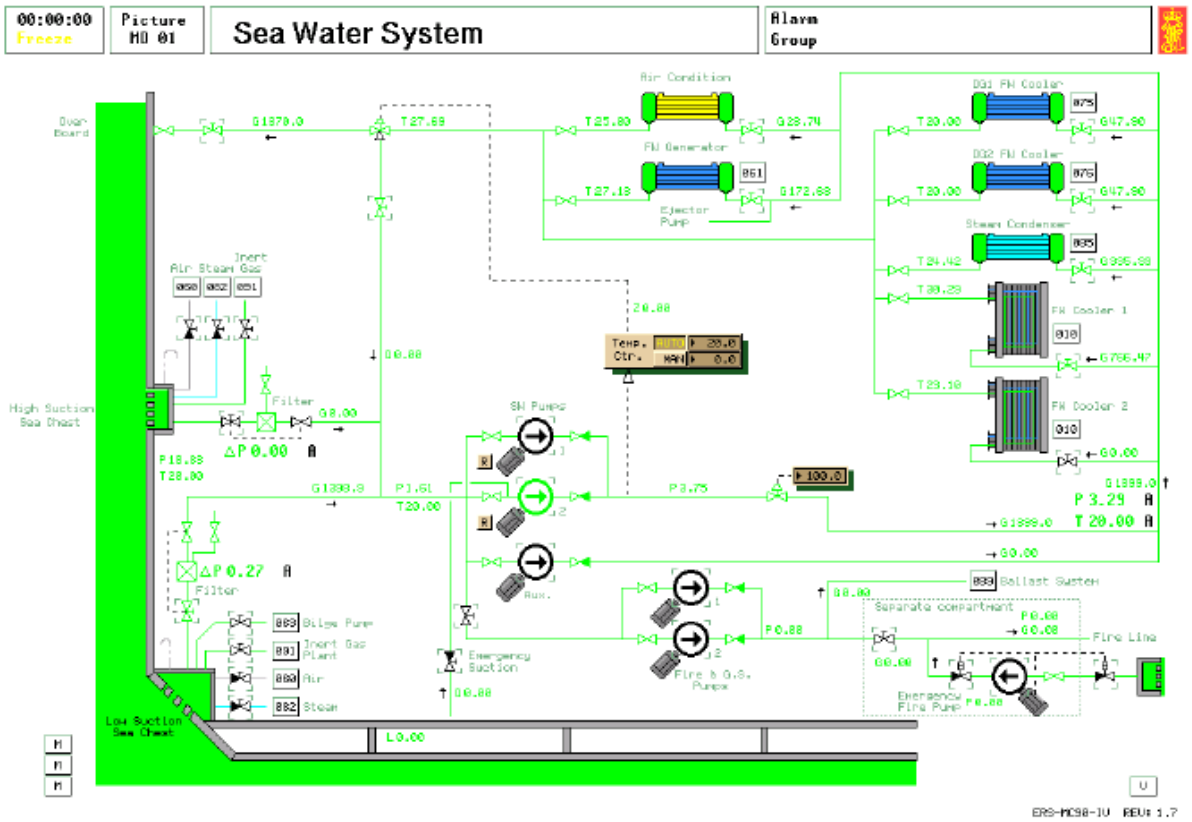
- 3. Use governor control to give 60Hz output.
- 4. Press button “IN” to connect emergency generator breaker.
- 5. If shore power is connected, disconnect it by pressing the “OUT” button on the shore BREAKER Panel
  Trip main bus breaker connection to emergency bus.

ENGAGE BREAKERS ON EMERGENCY SWITCHBOARD (MD 73)

- 6. Press the “IN” button to operate the breakers.
- 7. Pressing “IN” again will open the breaker.

AUTO MODE FOR STARTING EMERGENCY GENERATOR

1. The generator is normally in AUTO, voltage control on, circuit breaker open.
2. In case of “Black out” (supply is lost to the emergency switchboard) the generator will automatically start and close the circuit breaker supplying the emergency bus.
3. The main bus will be isolated due to the connection circuit breaker opening on low voltage.
4. When the emergency bus is again supplied from the main bus, connection circuit breaker closed, the emergency generator will automatically stop, and open the circuit breaker.



IV. SEA WATER SYSTEM (MD01)

IV.1 DESCRIPTION

Seawater is pumped by two electrically driven SW pumps from sea chests through the seawater filter. The flow from the pumps goes to five coolers, which are connected in parallel:
- Fresh Water Cooler 1
- Fresh Water Cooler 2
- Steam Condenser
- DG1 Fresh water cooler
- DG2 Fresh water cooler
- Fresh Water Generator
- Air Conditioning

During cargo operations there will be an increasing load on the steam condenser. To meet the additional need for cooling water, the system is equipped with an auxiliary pump.

Seawater is taken from either a high suction sea chest via a strainer when the vessel is loaded or a low suction sea chest when the vessel is in ballast. In order to avoid too low seawater temperatures at the cooler inlets a controllable re-circulation valve is used to circulate water from the overboard line back to the common seawater suction line. A standard PID controller controls the re-circulation valve. The re-circulation line is smaller and has higher flow resistance than the overboard line. The total seawater flow will therefore be reduced in the

re-circulation line. The control valve has a pneumatic actuator. The standard valve actuator can be changed with a motor driven actuator.

The motor control interface is modeled as follows:

- 100 % controller signal gives full opening speed
- 50 % controller signal gives zero speed
- 0 % controller signal gives full closing speed

Studies comparing the dynamic behavior of the standard actuator system with the motor actuator system are recommended.

Two fire and General Service pumps are provided which can service the fire main or the ballast system. They take suction from the main seawater service pump suction line.

No 2 main SW pump can be used as emergency bilge pump. A separate pipe is provided for this operation.

The emergency fire pump has a separate suction from its own sea chest.

The sea water system has an emergency suction main SW valve.

The air condition is ready for use when the following criteria are fulfilled:

- Valve to air-condition SW cooler is open.
- The differential pressure (difference between the inlet SW pressure to coolers and the SW pressure outside the hull (mWC) is more than 0.5 bar.

OPERATIONAL PROCEDURE FOR THE SEAWATER SYSTEM:

Required systems to be in operation: Shore Power, Emergency Generator or an Auxiliary Generator connected to the emergency switchboard.

PREPARATIONS

- 1. Select picture Model Diagram 01 ***SEA WATER SYSTEM***.
- 2. Press to open High or Low Sea Chest suction valve.
- 3.Press to open one of three seawater pumps ”suction valves” from sea chests
- 4.Press to open inlet valves to coolers (DG #1 FW Cooler, FW Cooler #1 and Air -condition)
- 5. Delivery valves of cooler are normally open. Confirm.
- 6. Press to open Overboard valve of Sea Water line.
- 7. Press to open re-circulating valve.
- 8. Select temperature controller button of 3-way valve MANUAL to AUTO Pos. (Temperature should be slightly above seawater ambient temperature.)

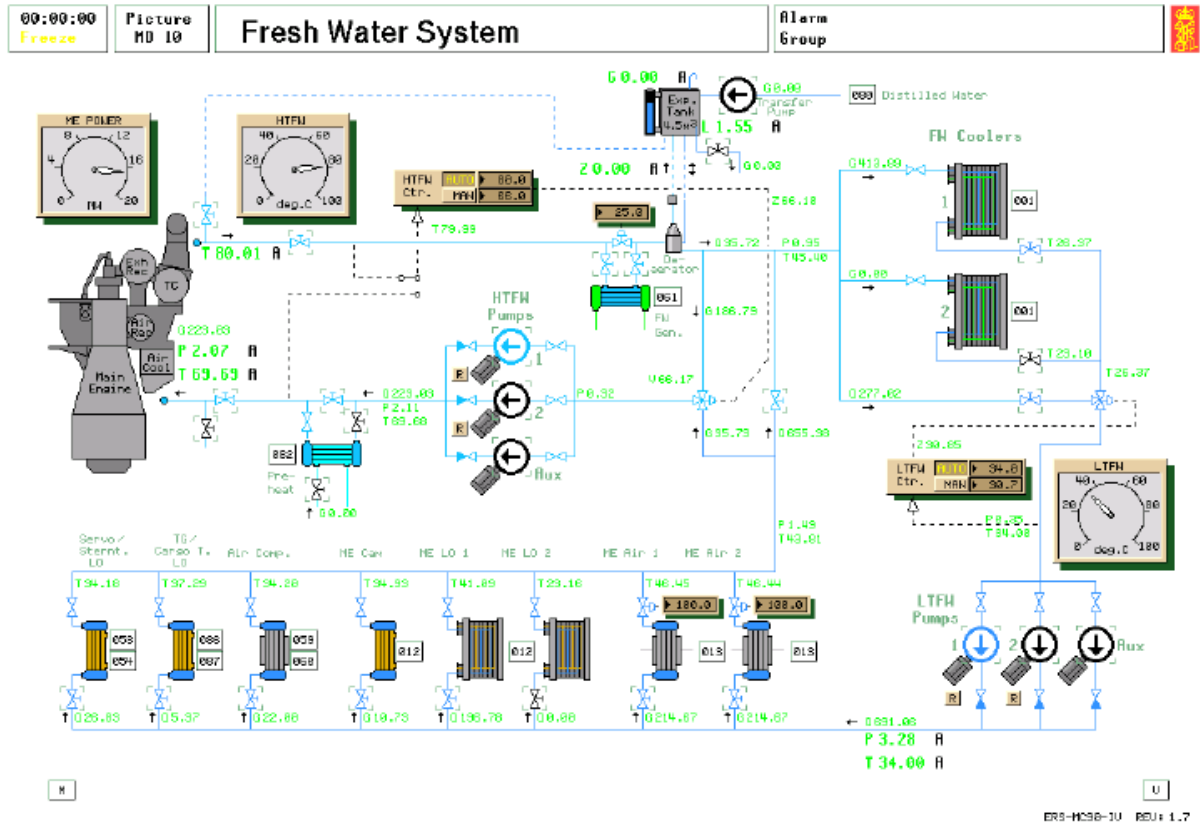
STARTING PROCEDURE:

MANUAL MODE:

- 1. Start Aux. Sea water pump if power is supplied by emergency generator because it is connected to emergency bus bar.
- 2. Note that if the Main Bus Bar supplied power, you can use the main seawater pump and always use no.1 pump.
- 3. Using the left button on the mouse can start seawater Pump.

AUTO MODE:

- 1. Note that this mode is only available when Diesel Generator power is in used.
- 2. Select the Picture “Power Chief-Pump/Compressor Control (MD 102)
- 3. Press the AUTO button on the Seawater Pumps Panel;
- 4. If the pump in service stops, the “Standby” pump will start only if the AUTO Mode is selected:
- 5. If in emergency situation, emergency suction can be used to empty engine room bilges with seawater pump or fire pump;
- 6. Emergency suction also from cargo holds and sludge tank. Open emergency suction and overboard from pumps and start pump.



X. FRESH WATER COOLING SYSTEM

General

The fresh water cooling system is separated in two subsystems:
- Low Temperature System
- High Temperature System

The Low Temperature Fresh Water (LTFW) system cools all auxiliary equipment, such as the following:

- two start-air compressors
- service air compressors
- lub.oil system for turbo-generator and cargo pump turbines
- stern tube and propeller servo oil system
- main engine air cooling system
- cooling of the oil in the camshaft and main engine lub.oil system. The temperature sensor can be moved from the outlet to the inlet of ME from variable page.

The LTFW pumps (normally only one in operation), pump the fresh water through the above mentioned coolers. The FW system is cooled by the SW system. The effect of cavitations is modeled for the LTFW pumps. The auxiliary LTFW pump is mainly used when in harbor or during blackout.

The fresh water temperature in the LTFW system is controlled by a PID controller, which actuates a three-way mixing valve, placed after the two fresh water coolers. This controller can be operated in manual or auto mode. The temperature before the LTFW pumps gives the controller input signal.

From the LT/HT junction, some of the LTFW is led directly to the FW coolers, while some is led to the HTFW loop.

The High Temperature fresh water cools the cylinder liners of the main engine. Some of the excessive heat is used for heating the fresh water generator. The fresh water through the main engine is driven by two main and one auxiliary HTFW pumps, of which only one of the main pumps is normally in operation. The auxiliary pump is provided for use in port. If the HTFW pumps stop, a small
cooling medium flow will still be present as long as one of the LTFW pumps is running. If the main engine has been stopped for a long period of time, it is required to heat the HTFW with the pre-heater, which is supplied with steam.

The venting valve in HTFW line after cylinders should always be open. Its purpose is to keep a small amount of water flowing from the cylinders to the expansion tank in order to release entrapped air in HTFW system. The system is indicative only.

The effect of cavitations is modeled for the HTFW pumps. The auxiliary HTFW pump is mainly used when in harbor or during blackout.

The HTFW system is controlled by a PID controller, which operates a three way mixing valve, mixing hot water from main engine outlet with cold water from the LT/HT junction. The temperature sensor may be moved from the outlet to the inlet of ME.

If the FW of the main engine outlet is at boiling point, fresh water evaporation is simulated. The resulting low water level in the expansion tank leads to low pressure in the fresh water system. The HTFW pumps are especially liable to cavitate under these low pressure conditions, causing a reduction in ME cooling.

The static pressure in the fresh water system is given by the water level in the fresh water expansion tank. There is a small constant consumption of fresh water due to leakage and evaporation. The expansion tank must be filled periodically. In bad weather, unsteady expansion tank level is simulated, and false alarms may arise.

Actuator type can be changed from variable page.

OPERATIONAL PROCEDURE FOR FRESH WATER COOLING SYSTEM:

Related systems to be in operation: Main bus bar to be active.
Main sea water system

PREPARATIONS:

- 1. Select picture Seawater System (MD 01) and ensure that valves are opened to one cooler;
- 2. Select picture Fresh Water System (MD 10) then ensure that valves are opened before and after HTFW pumps:
- 3. Open valves before and after LTFW pumps;
- 4. Open valves before and after desired coolers/condensers such as the following:
  - Propeller Servo Oil Coolers / Stern Tube Coolers
  - Turbo Generator / Cargo Turbines LO Coolers
  - Air Compressor Coolers
  - Camshaft LO Coolers
  - Main Engine LO Coolers
  - Main Engine T/C Air Coolers
- 5. Refill expansion tank if needed by starting FW Transfer pump until sufficient level is obtained;
- 6. If Fresh Water coolant is cold when filling, risk of overflowing when water is heating must be observed;
- 7. The Fresh Water pumps can also be started from Power Chief Panel pump section;

Note: Only valves with drawn handles can be opened; generally, coolers can be closed off with inlet valves. When inlet valves are closed, cooler is sealed off for cleaning attempt. Where two coolers are placed under one symbol, check with respective pictures to ensure that valves are actually opened.

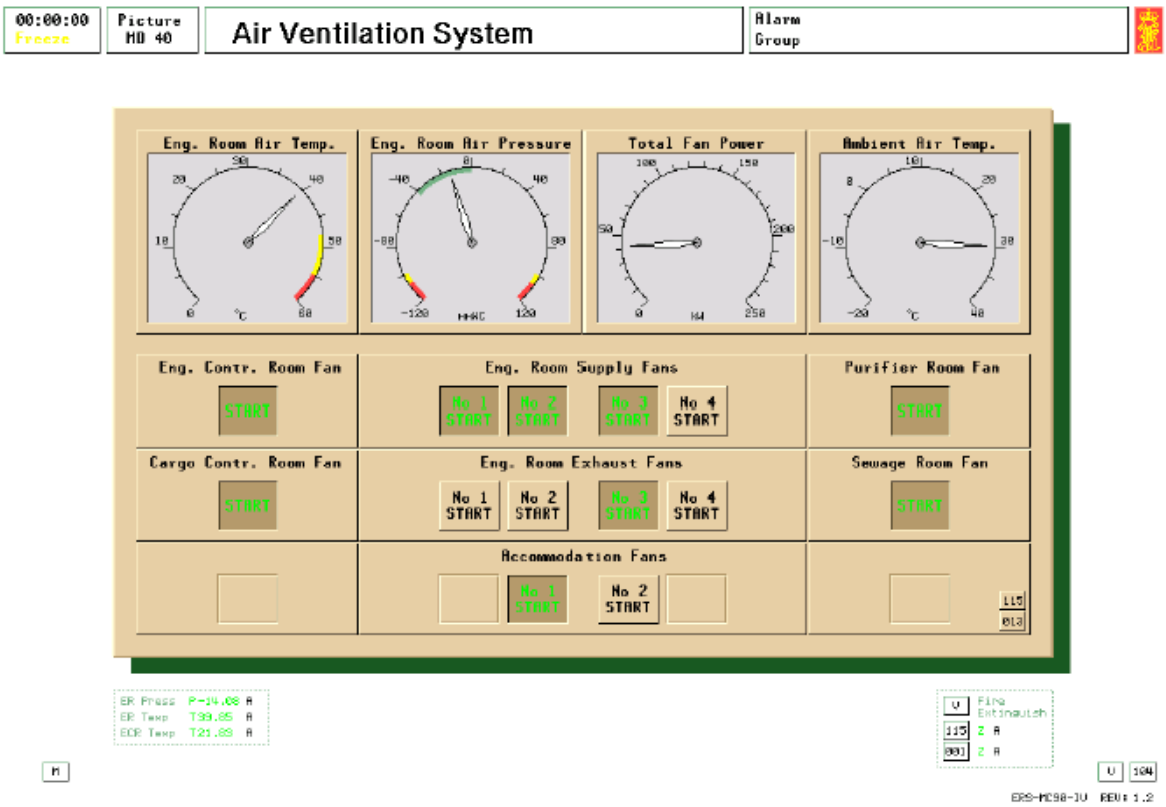
STARTING PROCEDURE:

MANUAL MODE:

- 1. Set HTFW and LTFW controller in Manual.
- 2. Start selected fresh water pumps (as a general rule, always use # 1 pump), one for High Temp. (80°C, as guide only) and Low Temp. (35°C, as guide only).
- 3. If starting circulation from “cold ship” status, heat the water with steam heater by opening valve on heater (Insufficient pre-heating of the main engine before starting may cause misalignment of the main bearings and fresh water leaking).
- 4. Circulate with Aux. Pump until Main Engine is sufficiently hot to be started;
- 5. Set flow controllers for T/C air coolers Main Engine to desired flow;
- 6. Observe scavenging air temperature after main engine start to avoid condensation if temperature drops below dew point;
- 7. The expansion tank level should be checked periodically.

AUTO MODE:

- 1. Preparation as in MANUAL.
- 2. Select Auto on controller after setting temperature to a suitable value;
- 3. Select picture MD 102; “Power Chief/Pump Compressor control and press AUTO for HTFW and LTFW pumps. Aux. Pumps are not part of standby start panel;
- 4. Close steam pre-heater after engine start;
- 5. During stay in Port, Aux. Pump is sufficient to use for cooling.



XI. AIR VENTILLATION SYSTEM

General

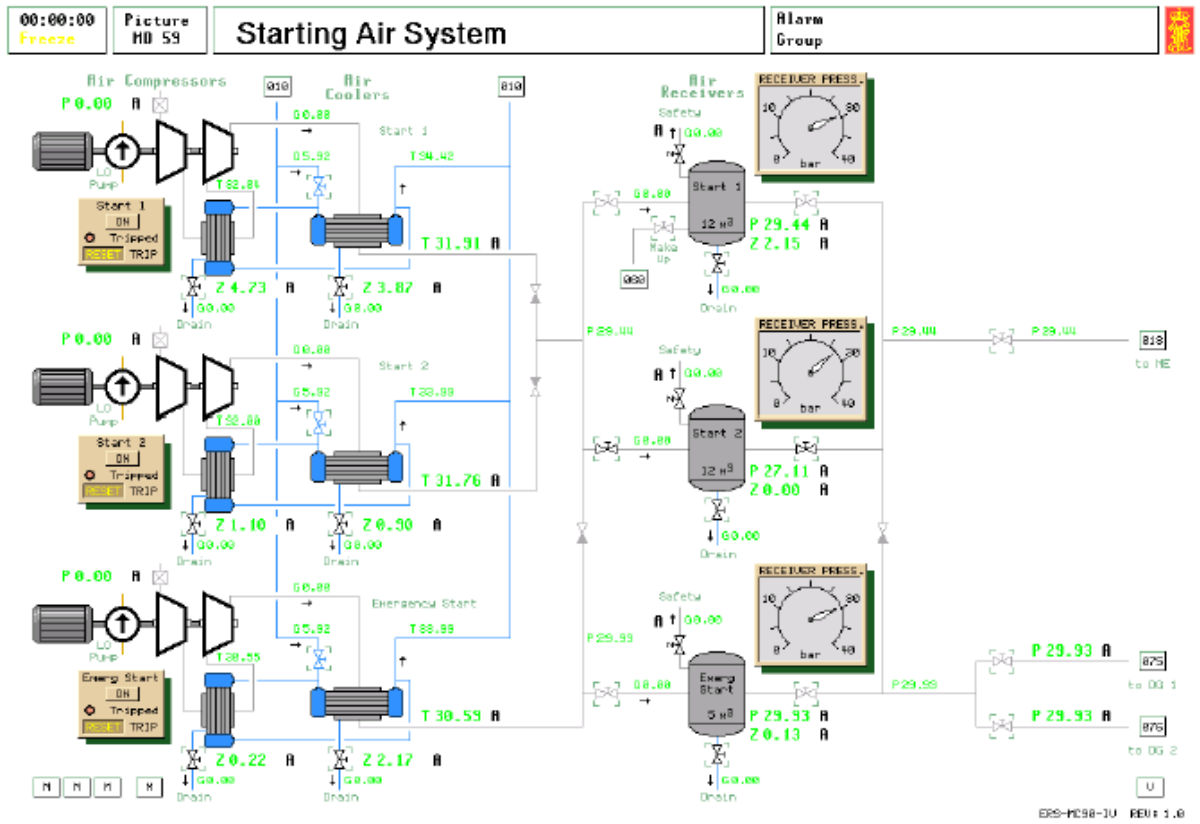
The ventilation system consists of four supply fans and four extractor fans for the main engine room. Control room and Cargo Control room all have supply fans. The Purifier room and Sewage room have exhaust fans. Accommodation fans are also started from this panel. The panel gives indication of Engine Room and ambient temperature as well as air pressure within the Engine room.

The air pressure in the engine room space will vary depending on which fans are running and also on whether the main engine and diesel generators are running. Insufficient air supply will lead to the engine room temperature rising. Indication is also given of fire detection in the Engine room and Deck areas.

Should the Emergency Shut Off be operated or the CO2 cabinet door be opened then the Engine room supply and exhaust fans will be stopped.

OPERATIONAL PROCEDURE FOR AIR VENTILATION SYSTEM (MD40):

- **Start fans (MD40)**
  Press Start Button to start the fans.



XII. STARTING AIR COMPRESSOR

DESCRIPTION

The purpose of the start air is to provide starting air to the diesel engines and ensure that first start is available should all power to the vessel be lost.

The compressed air system consists of two start air compressors, one emergency air compressor, two start air receivers, and one emergency start air receiver.

All compressors start and stop automatically according to need by the compressor control system included in the Power Chief system if the compressor

is in AUTO position. The emergency compressor is supplied from the emergency switchboard

Each air compressor is monitored by an independent, local safety system.
The air compressors will trip at these levels:

	Start air comp.	Emergency air comp.
Disch. air temp.	> 110°C	> 110°C
Lub oil press.	< 0.75 bar	< 0.75 bar

All compressors are cooled by LTFW. Trip condition is indicated by a red alarm light on the compressor panel.

The starting air compressors are normally operated with one compressor selected as Master. This is achieved at the Power Chief panel. Master cut in and cut out setting can be set on variable page 7020.

The start air receivers can be operated in parallel, or one of the receivers can be pressurized and kept shut off the other as a standby receiver. The main and the auxiliary diesel engines are supplied by separate air lines and stop valves from one or both of the air receivers. There is a non-return valve in the connection from the main start air to the auxiliary start air to ensure that the emergency start air receiver only supplies the auxiliary engines.

The safety valves for the start air and service air receivers open at approximately 32 bar respectively. The settings of the safety valves can be changed from the variable page.

The air receivers and the air coolers will gradually fill with water, depending on compressed air production and air humidity. The receivers and coolers must be manually drained regularly. Much water in the start air receivers will reduce starting capacity.

If the service air compressor fails, make-up air can be taken from the #1 start air receiver. The air make-up valve is usually left open for safety reasons. If the service air compressor trips, service, and control air pressure is not lost, but supplied through the starting air receivers. This may prevent a serious situation like a shut down of the main engine in narrow waters. Carefully consider if or when to close the service air make-up valve.

- The basic “start air leakage” is set to give 2-3 compressor starts per hour. The air flow delivered from the start air or emergency air compressor is dependent on the discharge (receiver) pressure.
- The start air consumed during a main engine start depends on start duration and engine speed. The diesel generators draw an equal amount of air for each start.
- All main control valves included in the ship machinery are assumed to be air operated. As the control air pressure is reduced, these devices will be slower and the effective actuator time constants are increased.

- Various control loop problems may develop at low control pressure. Some of the loops will be slow and stable, others conditionally unstable (unstable in an intermediate range).

OPERATIONAL PROCEDURES FOR STARTING AIR COMPRESSORS:

Required systems to be in operation: Main Seawater and Low Temp.

PREPARATIONS

- 1. Select picture Model Diagram 10: "Freshwater system"
- 2. Check that HTFW system and LTFW system are operation and that the valve to air compressor coolers is open.
- 3. Select picture Model Diagram 59: "Start Air System".
- 4. The Starting Air Compressor can also be started from the "Power Chief"(MD102). Panel's compression section (if diesel generator/s is running and connected).
- 5. When starting from shore power or emergency generator, you can only use Starting Air Compressor # 2.
- 6. Open fresh water inlet valve(s) to start air cooler(s).
- 7. Open drain valve(s) from start air cooler(s).
- 8. Open air inlet valve(s) to start air receiver(s).
- 9. Open air outlet valve(s) from start air receiver(s).
- 10. Operate drain valve(s) from start air receiver(s) to ensure no water is present.

STARTING PROCEDURE:

MANUAL MODE:

- 1. If the selected compressor is tripped (TRIPPED lamp lit) press RESET button on the compressor panel.
- 2. Start the compressor by pressing button "ON".
- 3. Check to ensure that all drain valves are closed;

AUTO MODE:

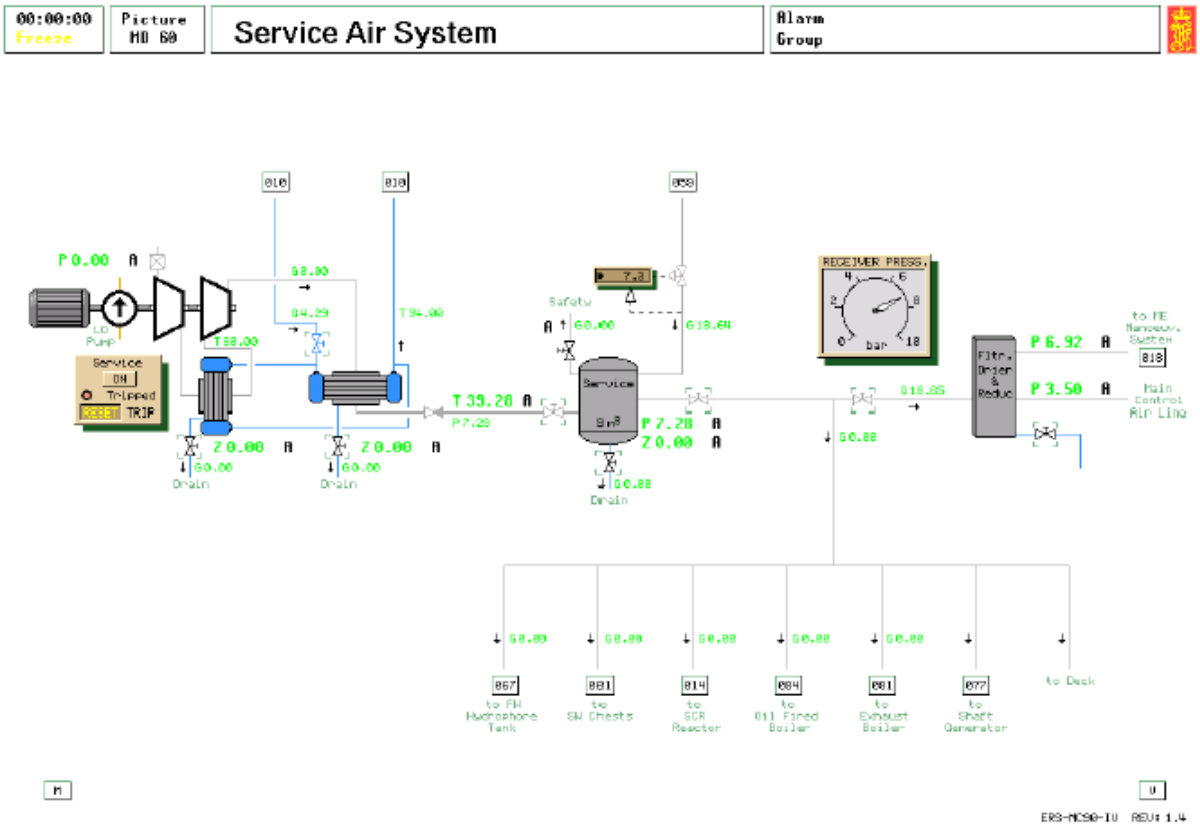
- 1. Check to ensure that all drain valves are closed
- 2. Select picture Model Diagram 102
- 3. Select AUTO mode on the "Power Chief" panel. Select the desired Master compressor. The compressors will then start and stop according to the limits given.
- 4. When pressure in air vessel increases open-air supply valve(s) to selected consumer(s).

Note: When a compressor is started manually it is not stopped automatically by a pressure control.

NORMAL OPERATION

1. Normally all start air vessels are pressurized and in operation.

2. Both of the start air compressors are in AUTO mode with one selected as Master.
3. Emergency start air compressor in manual mode with emergency air receiver supplied from main compressors.
4. Air receivers and air coolers must be drained regularly.



XIII. SERVICE AIR COMPRESSOR

DESCRIPTION

The purpose of the service air compressor system is to provide air to the control equipment and control valves in the engine room, and for General consumption purposes in engine room and at deck.

The compressed air system consists of one service air compressor, one service air receiver and a filter drier/reducer assembly for maneuvering system air and control air.

The compressor starts and stops automatically according to need by the compressor control system included in the Power Chief system if the compressor is in AUTO position.

The service air compressor is monitored by an independent, local safety system. The air compressors will trip at these levels:

Service air comp.

Disch. air temp.	> 100oC
Lub oil press.	< 0.75 bar

The compressor is cooled by LT fresh water. High air outlet temperature is indicated by a red alarm light on the compressor panel.

The safety valve for the service air receiver opens at approximately 8.5 bar. The settings of the safety valve can be changed from the variable page.

The air receivers and the air coolers will gradually fill with water, depending on compressed air production and air humidity. The receivers and coolers must be manually drained regularly. Much water in the service air receiver will reduce the operating capacity.

The air to the maneuvering system and control equipment is filtered and dried and pressure reduced by a pressure reduction valve (part of the filter/drier assembly).

The maneuvering air pressure is delivered at a different pressure than the main control air pressure.

If the service air compressor fails, make-up air can be taken from the #1 start air receiver. An air reduction control valve closes the make-up gradually at increasing service air pressure. The valve is pressure controlled, with an opening set point set slightly lower than the auto start set point of the service air compressor.

The air make-up valve is usually left open for safety reasons. If the service air compressor trips, service, and control air pressure is not lost, but supplied through the starting air receivers. This may prevent a serious situation like a shut down of the main engine in narrow waters.

Under certain conditions, starting air compressors "produces" a considerable amount of water. The starting air may also contain a small amount of oil. This will gradually reduce the efficiency of the air dryer/cooler and is therefore not desirable. By keeping the service air compressor in service, carry over of dirty air from the starting air compressors to the control air system is prevented.
Carefully consider if or when to close the service air make-up valve.

OPERATIONAL PROCEDURE STARTING SERVICE AIR COMPRESSOR:
Required systems to be in operation: Main Seawater and Low Temp.

PREPARATIONS

- 1. Select picture Model Diagram 10: “Freshwater system”
- 2. Check that HTFW and LTFW systems are in operation and the valve to air compressor coolers is open.
- 3. Select picture Model Diagram 60: “Service Air system.”
- 4. Open fresh water inlet valve to service air cooler.
- 5. Open drain valve from service air cooler.

- 6. Open air inlet valve to service air receiver.
- 7. Operate drain valve from service air receiver to remove any water present.
- 8. Open air outlet valve from service air receiver.
- 9. Open air inlet valve to service air filter and dryer.
- 10. Operate drain valve from service air dryer to remove any water.

STARTING PROCEDURE:

MANUAL MODE:

- 1. If the compressor is tripped (TRIPPED lamp lit), press RESET button on the compressor panel.
- 2. Start the compressor by pressing button ON.
- 3. Close service air make-up valve from start air receiver no. 1
- 4. Check to ensure that all drain valves are closed.
- 5. Select AUTO mode on the Power Chief panel. The compressor will then starts and stop according to the limits given. These limits are adjustable from the variable page 7020.

Note: When a compressor is started manually, it is not stopped automatically by a pressure control.

AUTO MODE:

- 1. Close drain valves.
- 2. Select picture MD 102. “Power Chief Pump / Compressor Control” ;
- 3. Press Auto on the Service air Compressor Panel;
- 4. The service air compressor is normally operated in AUTO mode
- 5. The stop valve for the make-up line is normally open.
- 6. Check that the set point of the make-up valve is slightly below the set point of the service air compressor.
- 7. Drain air receiver, air cooler, and filter drier regularly.

MODEL PARTICULARS:

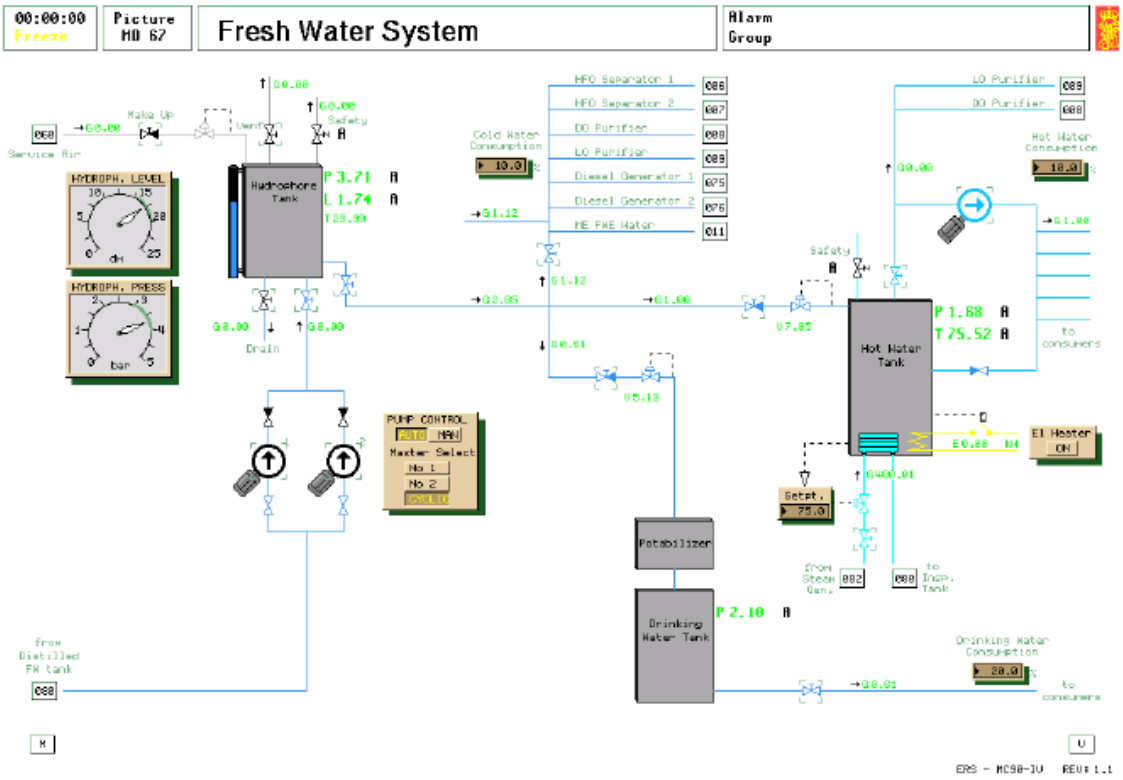
- The air flow delivered from the service air compressor is dependent on the discharge (receiver) pressure.

- All main control valves included in the ship machinery are assumed to be air operated. As the control air pressure is reduced, these devices will be slower and the effective actuator time constants are increased.

- Various control loop problems may develop at low control pressure. Some of the loops will be slow and stable, others conditionally unstable (unstable in an intermediate range).

- The service air compressor in this system is often called an "instrument air compressor" and is usually of the "oil free" type. In addition, there is often a "working air compressor" supplying consumers not including delicate instrument systems.

- Much water in the service air receiver will lead to problems with the oil viscosity controller. If the intermediate air cooler is not drained regularly, it will gradually fill with water and overheat.



XIV. FRESH WATER HYDROPHORE SYSTEM

General

Fresh Water Hydrophore System, MD67, consists of a pressurized hydrophore tank with necessary pumps and valves, a drinking water tank and a hot water tank. The capacity of the system is approx. 10 t/h of cold water, hot water and drinking water, supplied to different users. The hydrophore tank volume is 3.0 m³, pressure is kept between 3 and 4 bar.

The system interfaces to the following subsystems:

Purifiers: MD06/07/08/09.
Main engine: MD11.
Diesel generators: MD76\5/76.
Distilled water: MD80.
Steam System: MD82.
Compressed air system: MD60.

OPERATIONAL PROCEDURE FOR FW HYDROPHORE SYSTEM (MD67):

PREPARATION

- Main bus bar to be active.

STARTING PROCEDURE

MANUAL MODE:

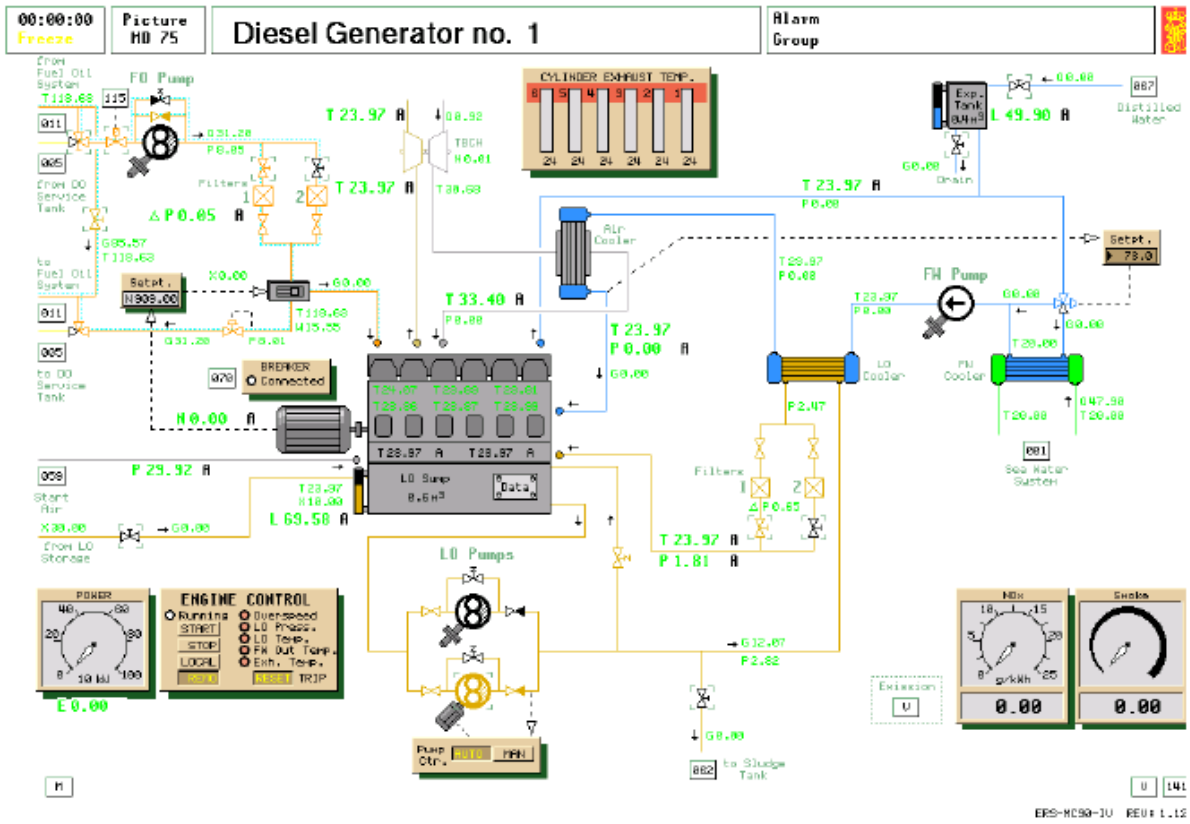
- 1. Open valve(s) from distilled FW tank 1(2).
- 2. Set pump control to MAN.
- 3. Start pump.
- 4. Open for service air if necessary.
- 5. Set temperature controller (steam or electric) to suitable value.
- 6. Start hot water circulation pump.
- 7. Open valves to consumers.

AUTO MODE

- 1. Open valves and set temp controllers as in manual.
- 2. Set pump control to AUTO.
- 3. Select, which pump to be the master pump.

CYCLIC MODE

- 1. Set pump control to AUTO.
- 2. Press the button CYCLIC.



XV. DIESEL GENERATORS

General

The ship is equipped with two 900kW/850kVA/440V/60Hz/900 rpm synchronous main generators. Each generator is driven by a turbocharged, four-stroke, 6-cylinder auxiliary diesel engine (DG1and DG2).

The auxiliary diesel engines are equipped with separate, integrated systems for cooling water and lubrication oil. The diesel engines are designed for both diesel and heavy fuel oil operation (700 cSt).

In order to prevent carbonizing and heavy smoke emission during low load, the fresh water cooling system is arranged in such a way that the scavenge air is heated during low load.

Description

The engine is equipped with a shaft driven fuel oil pump. The pump takes suction either from the fuel oil supply system or direct from the diesel oil service tank. Shifting between diesel oil and fuel oil is carried out by means of the double 3-way valve, shifting both supply and return direction.

The piping from Fuel supply system (MD11) to the diesel generators (MD75/76) can be heated by steam tracing and is also kept hot by fuel recirculation at each generator. To keep the fuel injection pumps hot, a non-return fuel circulation valve is mounted in parallel with the fuel pump, also a pressure control valve in the fuel return line is included. The fuel quality at injection pumps is indicated. For a safe start the viscosity at injection pumps should not be higher than 17-18 cSt. If a change-over is made from HFO to DO while the engine is running, there will be a short loss of power, but the engine will keep running. A change-over to HFO while the engine is running on DO will cause misfiring/engine stop due to too low temperatures of the metal part in the fuel feeder line and injection pumps. The fuel oil pump discharges to the high pressure pump header through a duplex filter. Surplus oil is returned to the diesel oil service tank or the fuel oil service tank depending on the position of the double 3-way valve.

An electrically operated shut-off valve on the suction side of the fuel oil pump shuts off the fuel oil supply in case of an emergency. The valve is controlled from the Remote Emergency Operating Panel.

The lubrication system is equipped with an electrical oil pump and a shaft driven main lubrication oil pump. The electrical pump serves as a pre-lubrication oil pump and as a standby oil pump in case of break down of the shaft driven main pump. The pumps take suction from the diesel engine lubricating oil sump and discharge through a freshwater cooled oil cooler and a duplex filter. The oil sump can be refilled from the lubricating oil storage and the oil can be drained to the sludge tank by using the electrical oil pump.

The electrical oil pump can be operated in manual or in automatic mode.

Seawater for fresh water temperature cooling is provided by the vessel's main sea water system.

A shaft driven fresh water circulating pump circulates fresh cooling water through the lubricating oil cooler, the scavenging air cooler/heater, cylinder jackets, and the fresh water cooler. The temperature is controlled by a simple proportional controller, controlling the temperature at inlet cylinder jackets.

The governor (rpm controller) settings are available in a pop-up window with the following variables:

- Speed-droop (speed controller droop setting): Default setting = 60%, which represents a speed droop approx. 3%, or 1.8Hz. 100 % = approx. 5% speed droop.
- Speed set point (basic speed at unloaded engine): Default setting = 909 rpm.
- Load limit (speed controller max. Output limit): Default setting for the "maximum fuel lever position" = 100%.
- Compensation lever (speed controller gain): Default setting for the proportional gain is set to 65.
- Compensation valve (speed controller integral time): Default setting = 20 sec.

-The governor response at different settings can be studied by means of the pop-up TREND window.

NOTE! Frequency regulation stops when the Engine is overloaded (when alarm is activated).

The FW temperature controller is a proportional gain controller with BIAS setting. BIAS default setting is 50%, which means that 50% is added. (Deviation * P-Gain) + BIAS = Output.

The pre-lubrication pump: Interval lubrication with default setting: 8 seconds on and 20 seconds off. The pre-lubrication pump will stop when the diesel starts, if lubrication oil pump control is set to AUTO, and start when the diesel engine stops.

The Engine Control Panel has the following functions and indications:
- Selection of local/remote control of engine
- Start/stop of engine
- Trip indications
- Reset of trip

Safety System

The diesel engines are equipped with a separate, independent safety system acting as a back-up system to the safety system of the Power Chief. The system monitors the engine condition by binary sensors and includes the following adjustable parameters:

Parameter Normal setting

Over speed 112%
Low Lub Oil Pressure 1,0 bar
High Lub Oil Temp. 85◦C
High fresh water Temp. 96◦C
High Exhaust Temp. 700◦C

If one of the parameters is exceeded, the diesel engine will shut down and a trip alarm is given. A lamp at the local panel indicates the trip condition. To restart the engine, the cause must be found and corrected and the safety system must be reset by pushing the RESET button. The trip limits can be inspected and changed from the variable page 7615.

STARTING PROCEDURE FOR THE FIRST DIESEL GENERATOR

In normal operation the generator is in standby mode with AUTO and priority selected on the POWER CHIEF, while in AUTO mode the generator must be prepared ready to start.

Required system to be in operation:
- Emergency bus bar active
- Start air Compressors with minimum of 15 bar (218 psi) pressure on the starting air line and DG air supply valve open.
- Sufficient level in the fuel oil service tanks

PREPARATION

- 1. Check the level in the fresh cooling water expansion tank and refill if necessary.
- 2. Check that the fresh water temperature controller is working and in AUTO – normal set point is 75-80°C (Depending on engine type).
- 3. Ensure seawater valve to cooler is open pump, MD01, and seawater flow is normal.
- 4. Check level in lubricating oil sump tank, (min 40%) – refill from storage tank if necessary.
- 5. Line up lubrication oil system. Normally one filter is in operation and one filter is cleaned and on standby.
- 6. Ensure that lubrication oil valve to the sludge tank is closed.
- 7. Start the electrically driven lubricating oil pump (pre-lubrication oil pump), and check that the oil pressure is increasing.
- 8. Set the electrical lubricating oil pump in AUTO mode by pressing the AUTO button on the PUMP. CTR. panel.
- 9. Check water level in the fuel oil service tanks and drain if necessary.
- 10. Ensure that fuel oil supply valve from diesel oil service tank; MD05, and fuel oil system, MD11, to generator engine are open.
- 11. Open fuel oil inlet valve to fuel oil pump.
- 12. Open fuel oil valve before fuel oil filters. Normally one filter is in operation and one filter is cleaned and on standby.
- 13. Check the position of the fuel oil supply 3-way valve.
- 14. Open start air valves, MD59. Start air must be at least 15 bar (218 psi) on the starting air line.
- 15. If any of the alarm lamps (red) at the local panel are lit, press the RESET button.

STARTING

MANUAL MODE:

- 1. Select picture MD 70: “Electric Power Plant” (The engine can only be started from the Power Chief Panel, if in REMOTE mode).
- 2. Ensure that the “Magnetization” button is switched ON; (Excitation)
- 3. Start the engine from the local panel by pressing the START button.
- 4. When engine is running, stop Lubricating oil priming pump and set to AUTO.
- 5. Adjust the Frequency (if necessary) by pressing the buttons RAISE/LOWER on the LOAD CONTROL Panel until the reading of the frequency is slightly above 60 Hertz:
- 6. Ensure that the voltage produce by the generator is within the range of 440 Volts to 450 Volts;

- 7. Adjust voltage produced by changing the set values on the magnetization Panel;
- 8. If TRIPPED, RESET the BREAKER Panel by pressing the button RESET on the BREAKER Panel.
- 9. The generator can now be connected to the main bus using the Synchroscope panel, MD142, or Electric Power Plant panel, MD70.
- 10. To use the POWER CHIEF the generator must be switched to Remote.
- 11. Modern engines are normally operating on Blended or Heavy Fuel Oil. On the Fuel/Blended oil engines, Diesel is only used to prepare the engine for repair (overhaul) or when steam is not available.
- 12. When steam is available and sufficient temperature on the HFO, changing to HFO is carried out by opening the HFO supply valves (MD 05) and changing position on the three way valve (MD 75-76).

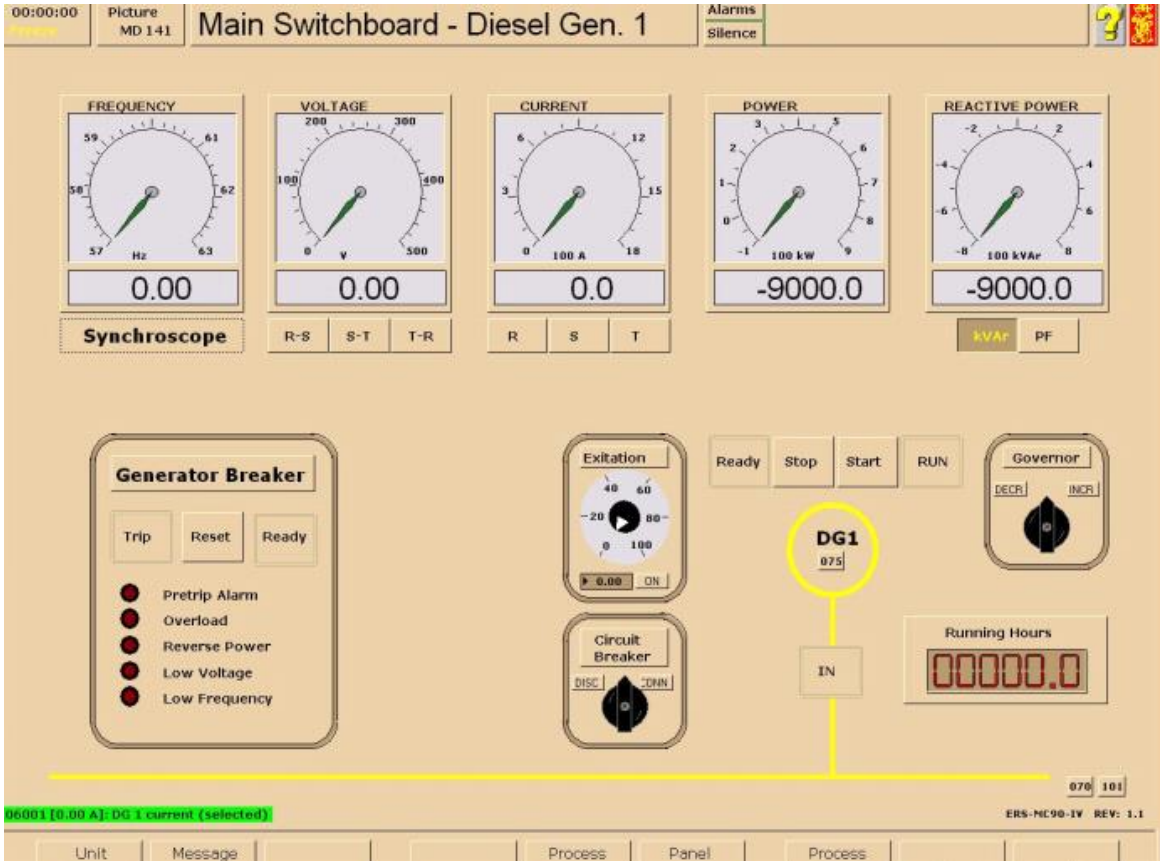
Note: D/G air run or turning with indicator valves open usually done before continuous operation to eliminate the moisture and acid formation inside cylinder chamber.

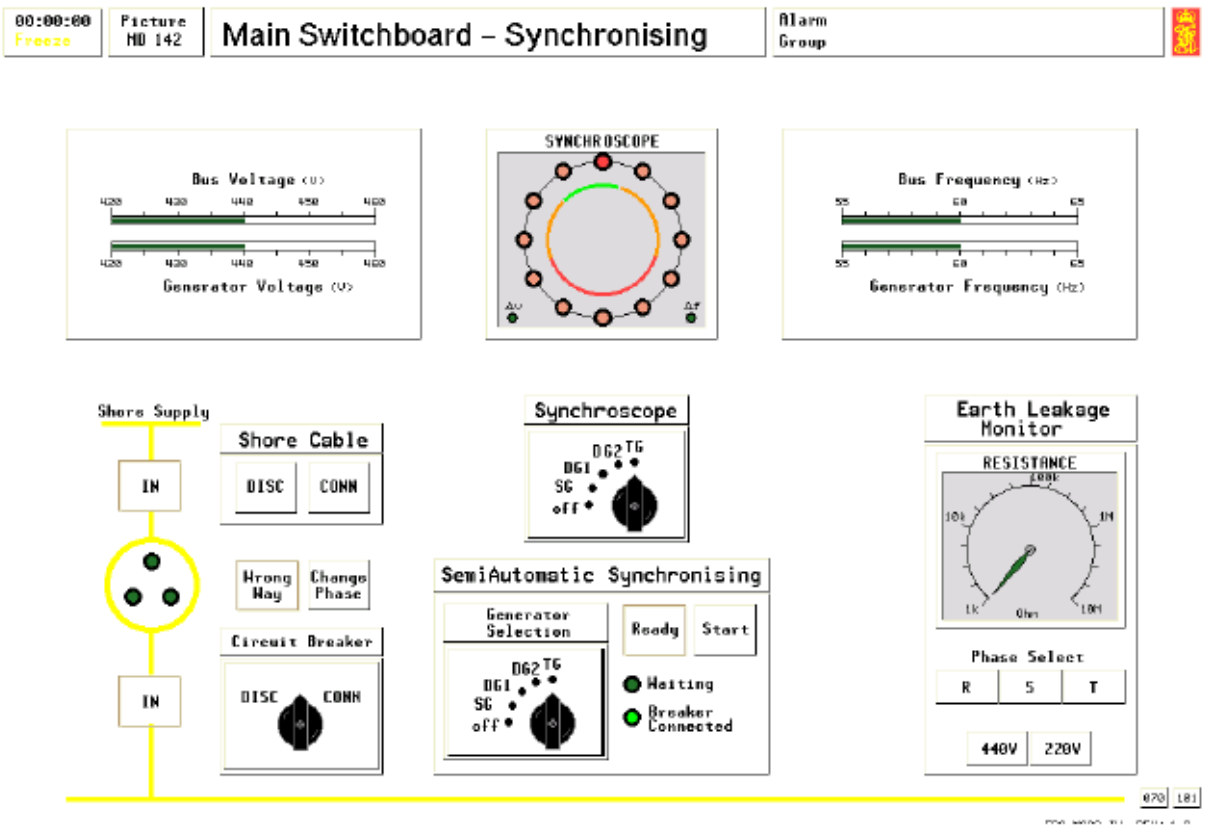
SEMI-AUTO MODE:

- 1. For Semi-automatic connection to the Main bus bar; press DG1 on the SEMI AUTO SYNCH MD 142;
- 2. As soon as the Ready light indicator of the SEMI AUTO SYNCH Panel is lit, press the button CONNECT;
- 3. Readjust the frequency if necessary;

AUTO/STANDBY MODE:

- This is only permitted when at least one generator is connected


00:00:00
Picture MD 141
Main Switchboard - Diesel Gen. 1
Alarms
Silence
FREQUENCY
VOLTAGE
CURRENT
POWER
REACTIVE POWER
0.00
0.00
0.0
-9000.0
-9000.0
Synchroscope
R-S
S-T
T-R
R
S
T
kVAr
PF
Generator Breaker
Trip
Reset
Ready
Pretrip Alarm
Overload
Reverse Power
Low Voltage
Low Frequency
Exitation
Circuit Breaker
DISC
CONN
Ready
Stop
Start
RUN
DG1
IN
Governor
DECR
INCR
Running Hours
00000.0
06001 [0.00 A]: DG 1 current (selected)
Unit
Message
Process
Panel
Process


00:00:00
Freeze
Picture MD 142
Main Switchboard – Synchronising
Alarm Group
Bus Voltage (V)
Generator Voltage (V)
SYNCHROSCOPE
Bus Frequency (Hz)
Generator Frequency (Hz)
Shore Supply
IN
Shore Cable
DISC
CONN
Wrong Way
Change Phase
Circuit Breaker
DISC
CONN
IN
Synchroscope
DG2 TG
DG1
SG
off
SemiAutomatic Synchronising
Generator Selection
DG2 TG
DG1
SG
off
Ready
Start
Waiting
Breaker Connected
Earth Leakage Monitor
RESISTANCE
Phase Select
R
S
T
440V
220V

XVI. SYNCHROSCOPE

General

The synchroscope panel is used for manual connection of the generators to the bus bar. The panel consists of selector switches for each generator, up/down control for excitation and frequency and connect/disconnect buttons for the main circuit breakers. Selecting a generator automatically connects the excitation, governor, and breaker controls to that generator. The panel indicates the voltage and frequency of the bus and of the selected generator. A synchroscope indicates the phase relationship between main bus and selected generator. There is also an indicator to show that the selected generator is connected to the main bus.

1. Connection

- 1. The incoming generator must be running and not in AUTO on MD101.
- 2. Select incoming generator, voltage and frequency can be compared with bus.
- 3. Adjust excitation if necessary to give equal voltages.
- 4. Adjust governor control so that incoming generator is slightly faster than bus frequency.
- 5. Synchroscope indicator should be turning slowly in a clockwise direction.
- 6. Connect breaker when the top synchroscope indicator is lit. The breaker connected light will show that the generator is now connected to the bus.
- 7. Increase the governor speed to give the incoming generator some load.
- 8. To manually share the load equally use the governor controls on MD70 or on each generator page MD140/141/143/144.

2. Disconnection

- 1. Ensure generator to be disconnected is not in AUTO on MD101
- 2. Use governor controls on MD70 or on each generator to reduce the load on outgoing generator to zero.
- 3. Select outgoing generator.
- 4. Disconnect, breaker connected light goes out.

STARTING PROCEDURE FOR THE SECOND DIESEL GENERATOR

In normal operation the generator is in standby mode with AUTO and priority selected on the POWER CHIEF. While in AUTO mode the generator must be prepared ready to start.

Required system to be in operation: **-** start air compressors, within minimum of 15 bar (218 psi) pressure on the starting air line and D/G air supply valve open. Sufficient level in the FO Service tanks, Operation as an isolated system is not available

1. Preparation

- 1. Select picture (MD 76): Diesel Generator No.2;

- 2. Check level in the fresh cooling water expansion tank and refill if necessary.
- 3. Check that the fresh water temperature controller is working and in AUTO – normal set point is 75-80°C
- 4. Ensure seawater valve to cooler is open pump, MD01, and seawater flow is normal.
- 5. Check level in lubricating oil sump tank, (min 40%) – refill from storage tank if necessary.
- 6. Line up lubrication oil system. Normally one filter is in operation and one filter is cleaned and on standby.
- 7. Ensure that lubrication oil valve to the sludge tank is closed.
- 8. Start the electrically driven lubricating oil pump (pre-lubrication oil pump), and check that the oil pressure is increasing.
- 9. Set the electrical lubricating oil pump in AUTO mode by pressing the AUTO button on the PUMP. CTR. panel.
- 10. Check water level in the fuel oil service tanks and drain if necessary.
- 11.Ensure that fuel oil supply valve from diesel oil service tank; MD05, and fuel oil system, MD11, to generator engine are open.
- 12. Open fuel oil inlet valve to fuel oil pump.
- 13. Open fuel oil valve before fuel oil filters. Normally one filter is in operation and one filter is cleaned and on standby.
- 14. Check the position of the fuel oil supply 3-way valve.
- 15. Open start air valves, MD59. Start air must be at least 15 bar (218 psi) on the starting airline.
- 16.If any of the alarm lamps (red) at the local panel are lit, press the RESET button.
- 17. Start the engine from the local panel by pressing the START button.

1. Starting

MANUAL MODE:

- 1. If the starting air pressure is above 15 bar (218 psi) , the engine is ready to be started.
- 2. Press Start. Button on the Engine Control Panel if in Local Mode.
- 3. May be started both from MD 76 MD 101 and MD 142 when in remote mode.

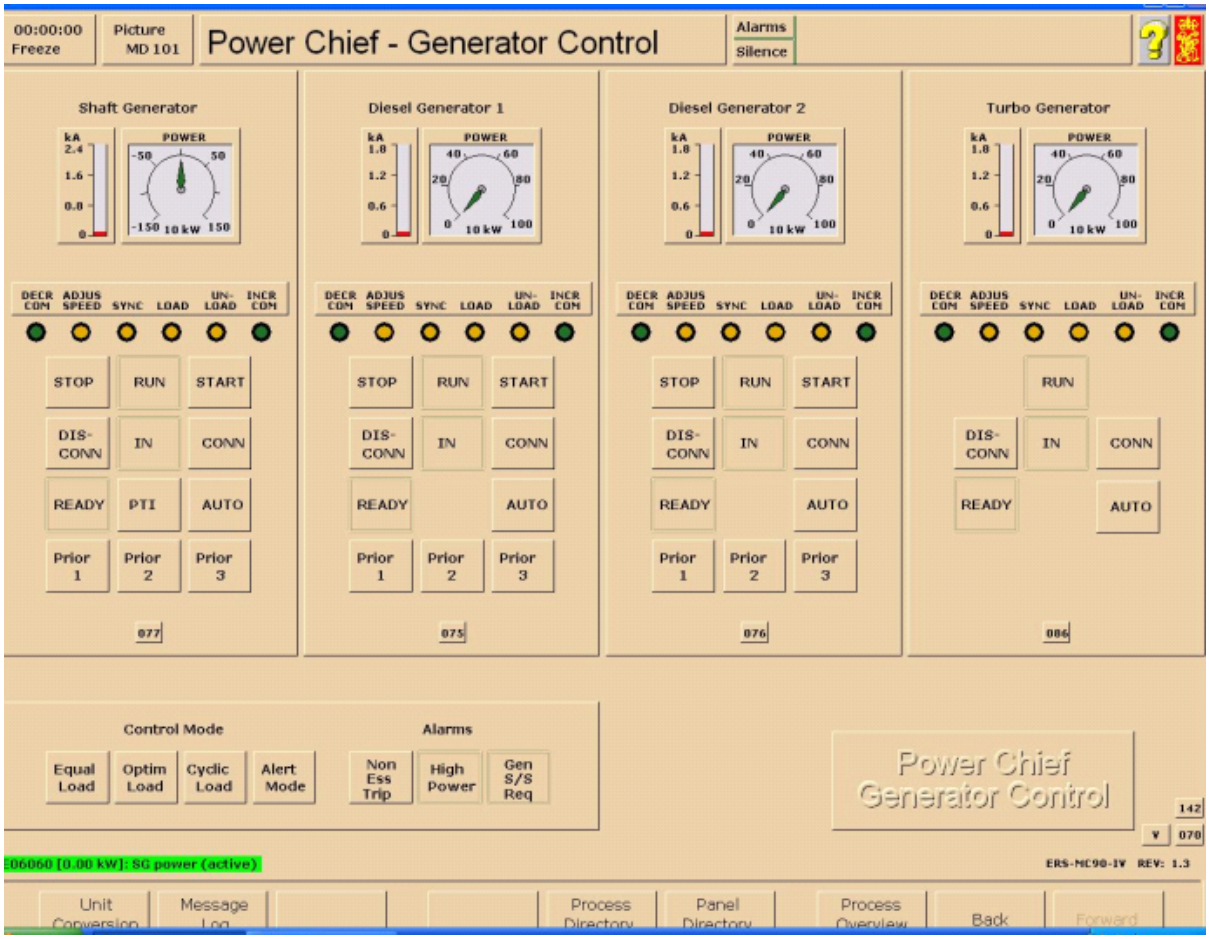
SEMI-AUTO SYNCHRONIZING:

- 1. Select picture MD 142: “Main Switchboard - Synchronizing” (The engine may also be started from this model diagram, if in REMOTE mode).
- 2. Locate the Panels of the Started engine MD 70;
- 3. Check if the button “On” on the Main Panel is active (ON).
- 4. If not then press the said button.
- 5. Press the button RESET on the BREAKER Panel if necessary.
- 6. Press button D/G 2 on the SEMI AUTO SYNCHRO Panel:

- 7. Adjust voltage and frequency until ready lamp is lit;
- 8. Press connect button;
- 9. If the breaker is not connecting, fine adjustment of frequency and voltage may
  be necessary until breaker connects.

AUTO MODE:

- Please refer to connecting the second diesel generator on MD 101 “Power Chief/Generator Control”.



XVII. POWER CHIEF- GENERATOR CONTROL

Automatic Power Management

1. There are 2 Generators. After completion of starting preparations, connect the first generator manually as described. Press buttons AUTO and PRIORITY 1 for this generator set.
2. After preparing of second generator, the READY signal will be lit on Power Chief panel.
   Press buttons AUTO and PRIORITY 2 for this generator.
3. Select required control mode.

4. Second generator will automatically start, take load, and stop according to the electrical consumption and the selected control mode.

AUTO Puts the diesel generator into auto mode provided the following:
- READY lamp is lit. See the conditions related to the READY lamp.
- In this mode, the Power Chief will take care of starting and stopping, connecting and disconnecting and load sharing of the generators.
- If the lamp is flashing, the Auto mode is cancelled because of The READY condition is no longer met.

READY Conditions related to the READY lamp:
- Engine Control in REMOTE
- LO Priming Pump in AUTO
- All trip RESETs
- Voltage Control ON

PRIORITIES:

PRIOR 1 Lamp push-button to select highest priority, that is first in and last out.

PRIOR 2 Lamp push-button to select medium priority, which is later in and earlier out than number 1.

PRIOR 3 Lamp push-button to select medium priority, which is later in and earlier out than number 2.

Shaft generator - Remote control functions

START Starts the Synchronous condenser

STOP Stops the synchronous condenser.

READY Indicates that the shaft generator clutch is engaged

CONN Manual, remote connection of the generator breaker.
- To manually connect an engaged shaft generator via the power management system, switch off the **AUTO** and activate the **CONNECT** button. The power management system will automatically synchronize and connect the shaft generator to the bus bar.

DISCONN Manual, remote disconnection of the generator breaker.
- To manually disconnect a shaft generator via the power management system switch off the **AUTO** and activate the **DISCONNECT** button. The system will automatically reduce the load and disconnect.

RUN Lamp indicating that the Synchronous condenser is running.

IN Lamp indicating that the generator breaker is connected.

AUTO Puts the generator into auto mode provided these conditions:
- READY and RUN lamps are lit.
- In this mode, the Power Chief will take care of connecting and disconnecting and load sharing of the generator.
- If the lamp is flashing, the Auto mode is cancelled because of the READY conditions is no longer met.

PTI Selects Motor mode for the generator. Breaker must be Connected before PTI can be selected.

Turbo Generator:

- When the steam pressure produced in the exhaust boiler is higher than 8 bar, start the turbo-generator manually and adjust load from the main switchboard. When steam conditions are stable, transfer to AUTO.

- The boiler combustion control should be prepared and in AUTO mode, ready for automatic start up of burners. The Burner Management load setting selection should be “LOW.” The essence of the turbo-generator is to utilize excess energy (waste heat) in main engine exhaust gases. Therefore, T/G is mainly run when waste heat is to be recovered.

Control modes

- Desired load sharing is selected by pressing the buttons on the CONTROL MODE Panel.
- CONTROL MODE selects various automated Power Management functions.
  -] Equal load
  -] Optimal load
  -] Cyclic load
  -] Alert Mode

Equal load (symmetrical load sharing)

- Is normally selected when safety is the most important issue (during maneuvering, loading, discharging etc.).
- Balances load evenly between generators, when two or more are running in parallel.

NOTE!
In the first place, the prime mover speed controller carries out the main control of the load sharing, while the Power Chief carries out the fine adjustment.

The settings for start and stop load can be read and changed at variable page.

Optimal load (asymmetrical load sharing)

- Provides maximum fuel economy (Highest priority takes “max load” while lower priority takes the rest of the load).
- Is selected for economy, usually during sea voyages
- Diesel(s) is running at max. Load;
- First priority takes “max load” while second priority takes the rest of the load

The settings for start and stop load can be read and changed at Variable Page.

Cyclic load

- Is selected when it is necessary to run more than one diesel on low power.
- This mode will cycle the load between the engines in such way that one of the diesels is running at max. Load while the other diesel handles the remaining load and thereby prevents carbonizing of the cylinders, valves etc.

The cycling period can be read and changed at Variable Page.

Alert Mode

- Alert mode is selected when the automatic stopping of a generator is undesirable. Alert mode can be used with equal load, optimum load and cyclic mode.
- When ALERT MODE is selected the automatic disconnection and stopping of generators is inhibited. This mode is used when a large excess capacity is required, i.e. maneuvering, or when sudden large power surges may occur, i.e. when using the bow thruster.

Frequency Control

NON ESSENTIAL LOAD TRIP

- Flashes when alternators have been overloaded and non-essentials are tripped. Reset function by clicking on button.

HIGH POWER

- Flashes when generator set reaches upper limit. To reset/acknowledge alarm click flashing button.

GENERATOR START / STOP REQUEST

- Flashing button indicates upper load limit is near for running set. If in automatic mode, next generator set is started and connected automatically, or disconnected, and stopped depending on requirements.

OPERATIONAL PROCEDURE FOR POWER CHIEF – GEN. CONTROL

1. Preparations:

- 1. Diesel generators to be ready and in alarm free condition.
- 2. Valves for fuel and lub. Oil, etc. must be opened and ready for use when starting diesel generators (Ready lamp is lit);

Starting Procedure:

2. MANUAL mode

- 1. Push START button for the respective generator engine.
- 2. When running light appears, generator is ready for connection to main bus bar.
- 3. Push CONNECT to connect generator to main bus bar.
- 4. If emergency generator is running it will automatically disconnect and stop.
- 5. Shore power must be manually disconnected.

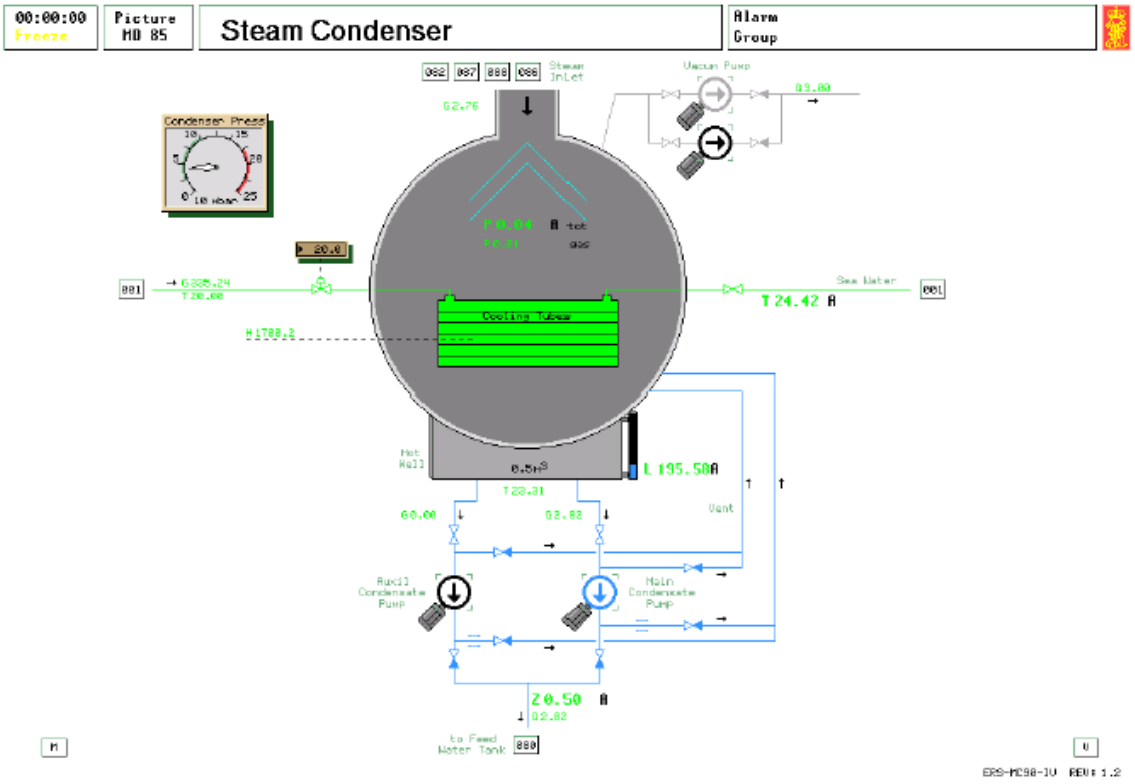
Note: On an actual plant, generators have to be synchronized before connecting to a live switchboard. This feature is not modeled here, and therefore generators can be connected indiscriminately. When connecting a generator to shore power, proper frequency must be observed. More often than not, shore power frequencies are 50 hertz, while ship power is 60 hertz.

- 6. Starting and connecting second diesel generator as described for the first one, also without synchronization;
- 7. After connection of generator(s), voltage and frequency must be checked.
- 8. Select picture MD 70: " Electric Power Plant" and adjust frequency if necessary by using the RAISE and LOWER buttons while observing load sharing.
- 9. Voltage is adjusted with the MAGN (Magnetization);
- 10.Click inside numeric values then enter new values and press ENTER;
- 11.Keep adjusting until frequency is slightly 60 Hertz and voltage slightly above 440 V;

Note: On an actual ship adjusting frequency and load sharing is a continuous task unless switchboard is automated. When load changes, so do bus bar values.

AUTO Standby Mode

- 1. Press button REMOTE on the Engine Control Panel;
- 2. Select picture MD 101: Power Chief- Gen. Control
- 3. Locate Diesel Generator panels and check that the READY indication (the diesel engine must be in remote mode and possible alarms must be acknowledge);



XVI. STEAM CONDENSER

General

The steam condenser is used to cool the exhausting steam from the
- Dump valve on MD82
- Turbo generator on MD86
- Cargo pump turbines on MD87 and 88
- Ballast pump turbine on MD89

The Steam condenser is seawater cooled with a flow adjusting valve on the inlet. This can be utilized when optimizing the operation of the plant.

To improve plant performance, the condenser is operated in vacuum conditions. The vacuum is created and maintained by the two vacuum pumps, of which only one is required at one time. The pressure in the condenser shell can be regarded as composed by two components; vapor pressure and pressure from non condensable gases. The vapor pressure depends on the total steam flow to the condenser, the sea water flow, and the sea water temperature. When the vacuum pump is stopped, the gas pressure will gradually increase and the total pressure slowly moves towards atmospheric pressure.

The air leakage increases strongly if the sealing steam on the turbo alternator

is not pressurized. The outlet valves of the cargo turbines should be closed when not in operation to stop air leakage from cargo turbine glands.

Condensate from the condenser is held in the hotwell, beneath the condenser tubes. Extraction from this hotwell is provided by the condensate pumps. A main condensate pump is provided for low duty and an auxiliary pump for high load duties although during periods of ultra high load both may be required to maintain the condensate level in the condenser. The pumps are modeled as “cavitation” pumps and the delivery increases strongly with hot well level. A separate level control system is therefore not required.

OPERATIONAL PROCEDURE FOR STEAM CONDENSER

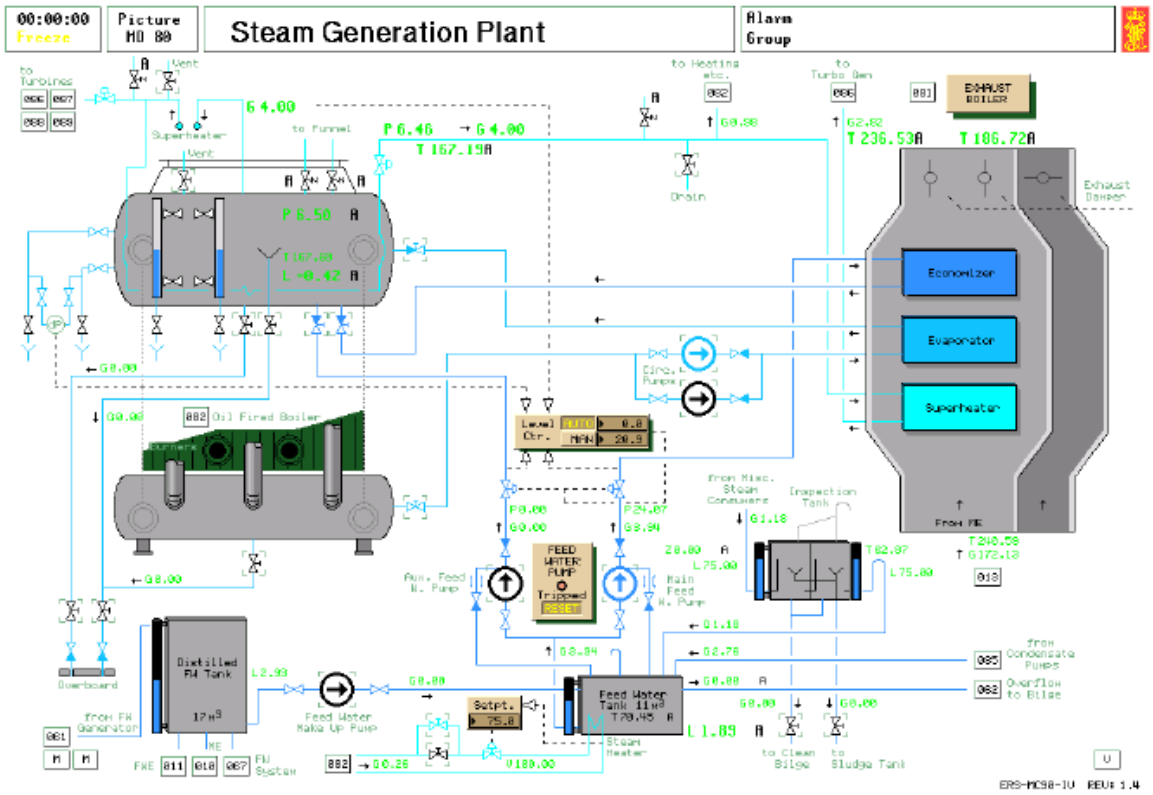
RELATED SYSTEMS TO BE IN OPERATION: **MAIN BUS BAR TO BE ACTIVE**

PREPARATIONS:

- 1. Select picture MD 01: “ Seawater system and ensure that there is seawater cooling opened to condense; Flow controller adjusted to suitable value;
- 2. Select picture MD 85: “Steam Condenser”;

STARTING PROCEDURE:

- 3. Start vacuum pump and wait until high pressure alarm in condenser is off;
- 4. Start one condensate pump;
- 5. Vacuum pressure must be kept constant low by regulating seawater flow with controller.



XIX. STEAM GENERATION PLANT

Description:

The system is designed to operate in two distinctive modes:

a) Cargo pumping (in port use)
The oil fired boiler operates at a steam pressure of 16 or 7 bar (high or low setting). Steam is supplied to the four cargo pump turbines, and ballast pump turbine, with a total output capacity of 40 tons/hour.

b) Turbo generator operation (at sea use)
When the ME is running, the waste heat in the exhaust gas is used to generate steam, between 7 and 9 bars. The minimum pressure of 7 bars can be maintained by automatic operation of the oil fired boiler if required, whilst the exhaust damper control will limit the maximum pressure to 12 bars.

There is an oil fired (OF) water-tube boiler for port and pumping duties, and an exhaust gas boiler (EGB) for steam supply at sea.

To simplify the model drawing, the steam generator is presented as a separate unit. Often, this is built together with the oil-fired boiler as a secondary drum placed over the primary drum (double pressure drum).

Steam from the oil-fired boiler's primary system is condensed to water in the steam generator and flows by gravity back to the primary drum.

Water in the steam generator (secondary steam drum) flows by forced circulation to the evaporator section of the exhaust boiler and a mixture of water and steam returns to the secondary steam drum.

The primary water system is hermetically sealed, and normally there is no consumption of primary water. If however, the primary steam pressure gets so high that the safety valves opens or a water leakage occurs, the primary drum level will decrease.

Refilling of primary water can be achieved by starting the primary make-up pump and opening the make-up valve.

Feed water for the OF boiler is supplied via the economizer section of the EGB at all times. Water from the OF Boiler water drum is circulated through the EGB Evaporator section before being returned to the OF boiler steam drum.

Saturated steam is passed through the superheated section of the EGB to supply the Turbo-alternator at sea.

There are two feed pumps (Main and Auxiliary) drawing from the feed tank which can be topped up by the Make-up feed pump from the Distilled Water tank. The auxiliary Feed water pump is used only for high steam production (cargo pumping), as it has approximately 5 times the capacity of the main feed water pump.

Condensate returns directly to the Feed tank but other returns are via an observation tank to prevent oil contamination. The screen will display the oil content within the inspection tank to indicate oil contamination of the condensate returns.

The water level in the secondary drum is controlled by a PID level controller, driving the two feed water control valves in parallel from a common I/P converter.

Both feed water pumps trip at high-high secondary drum water levels to protect steam consumers from "water strike" caused by water in the outlet steam.

The heat transfer in the exhaust boiler is controlled by exhaust dampers which by-pass some of the exhaust from the main engine. The exhaust damper position is automatically set by a PID controller thus controlling the secondary steam pressure.

The condensate from heating and miscellaneous service application returns to a condensate filter/inspection tank and then flows back to the feed water tank.

The condensate from the condenser is pumped directly to the feed water tank.

When the oil-fired boiler is in operation, there will be constant water consumption due to the burners atomizing steam flow. Open drain/vent valves blowing safety valves and steam and condensate leakage all reduce the water content in the feed water tank.

Refill is taken from the distilled water tank. Note that consumption of FW in the distilled FW tank is not modeled.

The feed water tank and the filter/inspection tank are modeled with heat loss to the surroundings. They will therefore gradually cool down if the inlet flows are stopped.

The temperature of the condensate entering the inspection tank is assumed to have a constant value (80°C).

If the oil-fired boiler or exhaust boilers are dirty they must be cleaned ("soot blowing"). Secondary steam is used to soot blow the oil-fired boiler and service air soot blows the exhaust boiler.

The exhaust boiler soot blowing equipment represents a very heavy load on the service air system when in operation.

OPERATIONAL PROCEDURE FOR STEAM GENERATION PLANT

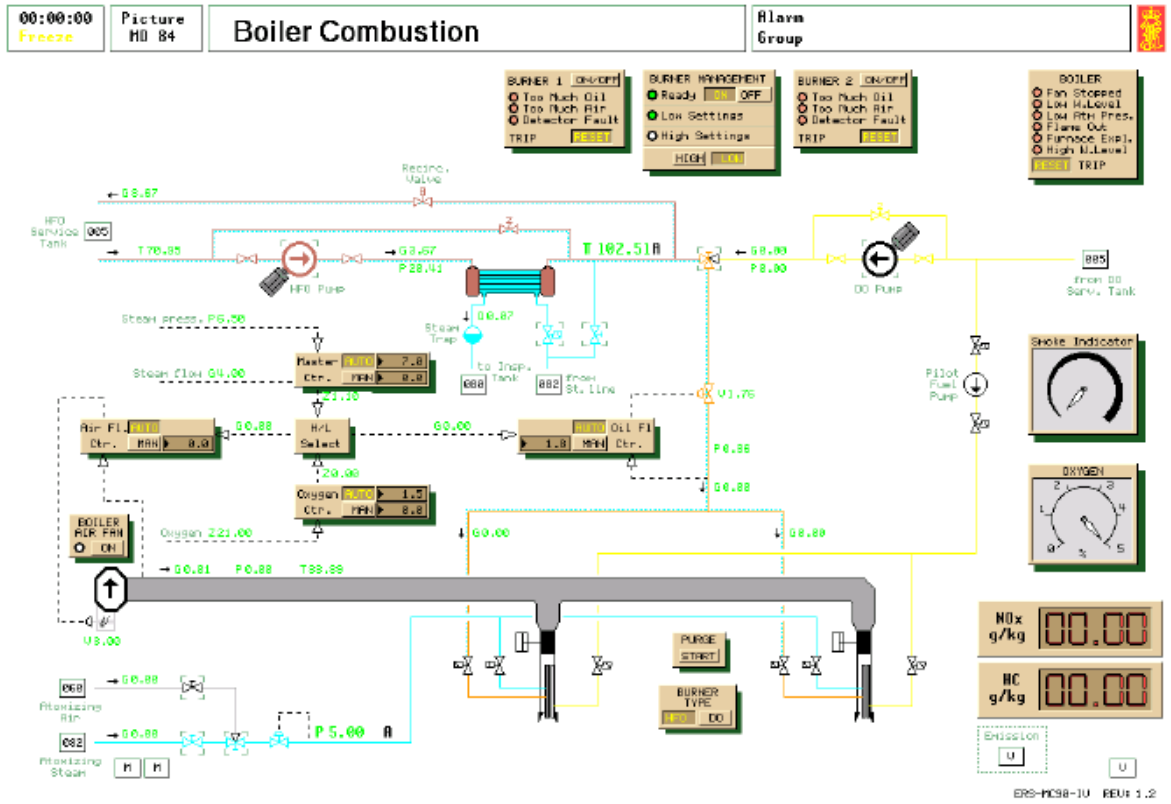
Related system required to be in operation: Main bus bar should be active

PREPARATIONS:

- 1. Check Seawater system and ensure that the seawater cooling for the condenser is opened. Flow controller should be adjusted to a suitable value;
- 2. Line up the stream condenser. Start vacuum pump, and wait until high pressure alarm within the condenser is off.
- 3. Start main condensate pump to transfer condensate from hot well to feed water tank.
- 4. Proceed to the Steam Generation Plant then ensure sufficient level in feed water tank or else refill the said tank by starting the feed water pump.
- 5. Check level at primary drum and ensure that the level is sufficient or with in normal limits. The primary drum can be refilled by starting the primary make up pump after opening the primary feed water stop valve.
- 6. Note that when refilling a cold boiler, water will expand when heated. Do not overfill the boiler when it is cold.
- 7. If the primary or secondary drum has too high water level, water can be drained by opening the primary drain valve.

STARTING PROCEDURE:

- 8. Start feed water pump, RESET if tripped, then set level controller to AUTO
- 9. Start circulation pump to exhaust evaporator;
- 10. Open steam generator vent valve.



XX. BOILER COMBUSTION

DESCRIPTION:

The boiler has two registers fitted in the roof which can burn either diesel oil or heavy fuel oil, the burner being changed to suit.

Each fuel system has it's own supply pump and the HFO system is fitted with a steam heater to condition the oil for combustion and a steam tracing system to assist in keeping the oil flowing. Atomizing steam, or air, is provided to improve the combustion of the fuel. A diesel oil pilot burner is provided to ensure light-up of the main burner.

Air as well as steam for atomization is provided, selection being made by change-over valve. Neither of which are allowed to operate when the DO burner is in use.

A burner management system is provided which operates the boiler at 8 bar on the low setting and 16 bar on the high setting.

A safety system cuts off the fuel oil supply to the boiler by closing the trip valve under the following conditions:

- stopped combustion air fan
- low steam drum water level
- low steam atomizing pressure
- no flame indication, both burners
- no purge operation
- incorrect nozzle fitted
- high water level

The combustion control system consists of a master controller, two slave controllers, and also an oxygen controller. It has three main objectives:

- to control the oil flow to the boiler to keep the steam pressure as close to the pressure set-point as possible.
- to supply the correct amount of air relative to oil at any time to ensure efficient and safe combustion.
- to supply the correct amount of air to allow the inert gas system to operate at low oxygen levels

The master controller generates a signal to a “high/low” select logic box. This computes the set-points for the desired oil and air flow for the slave controllers. The master controller is a PID acting controller with feed forward from steam flow out of steam drum and feedback from the steam pressure.

The slave controllers are fully acting PID controllers. They must be set in manual mode during start-up.

The function of the “high/low” select logic is to ensure that air command increases before oil command at load increase and that oil command is reduced before air command at load reduction. This is a standard logic block found in most boiler control schemes, and will prevent excess smoke during load changes.

Before the start-up of the boiler the furnace must be air purged. The purging period is set long enough to change the air volume in the furnace about 4 times in accordance with classification society’s safety requirements.

The automatic lighting sequence is as follows:

- air register is opened to allow the boiler to be purged
- the pilot oil pump is started
- electric spark ignitor turned on
- the pilot oil valve is opened and the pilot flame should ignite (a small flame is displayed)
- main oil shut off valve opened
- atomizing air/steam valve is opened (when in HFL operation)

If the flame detector does not see flame within approximately 6 seconds, the oil shut off valve and the air register are closed. The boiler will trip and will

need to be manually reset. When the burner is in operation, the flame will be "blown out" if there is too much air compared to oil (alarm code will be too much air), and it will be difficult to ignite if there is too much oil compared to air (alarm code will be too much oil).

Burner Management

The boiler system includes a simple but efficient burner control system. It starts and stops burner no 2 (slave burner) according to need. It is in function only if burner no 1 (base burner) is on.

The slave burner is started if the secondary steam pressure is under low limit and is stopped if the pressure is over high limit.

To avoid burner cycling (frequent start and stop of burners caused by the mutual influence between combustion control and burner management), there is a time delay between start and stop.

It is recommended to try several values of pressure limits and time delays to demonstrate its effect on the overall combustion control performance.

If a burner fault occurs, the burner is shut down and the "BURNER ON" light is flashing. The cause of a burner fault is found by inspecting the trip code:

- too much oil during ignition
- too much air during ignition
- unstable flame caused by lack of oil
- unstable flame caused by lack of air
- flame detector failure

The heavy fuel oil is taken from the common HFO service tank and heated in a fuel oil heater. Normal operating temperature is 90°C. If the heavy fuel oil gets colder than 80°C, the smoke content will increase because of poor oil atomization. The burners will require more excess air for safe combustion.

Atomizing steam is supplied from the steam system on MD82, and atomizing air is supplied from the service air system on MD60. Both mediums pass through a pressure reduction valve. At atomizing pressures lower than 3 bar the burners must be fired on diesel oil.

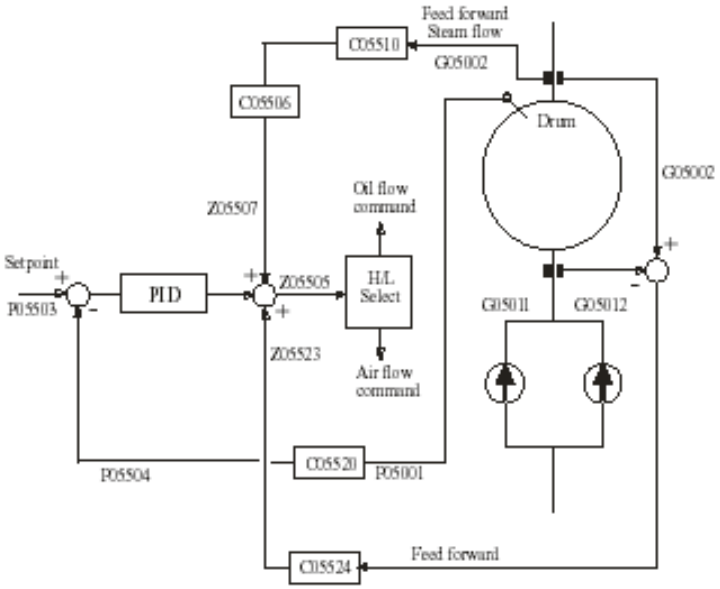
The diesel oil is taken from the common DO service tank and is pumped into the boiler's fuel oil line by a separate DO pump. Criteria to be fulfilled before Burner management are ready to be put in AUTO. These can be checked by clicking the tracker ball on the burner management icon.

- HFO selected (valve)
- HFO pump running
- HFO heater valve open
- Air fan running
- Atomizing steam valve open

- Burner trip reset (no trip)
- All 4 controllers in AUTO
- HFO temp > 80 ° C

Note that the boiler fan and HFO pump are automatically started at reduced ME power, i.e., the exhaust boiler is not sufficient to maintain the steam pressure. When the exhaust boiler is maintaining the steam pressure at increased ME power (oil fired boiler is stopped), the fan and HFO pump must be stopped manually.

Oil Fired Boiler Master Controller



The feed forward signal to master controller:

Steam flow out (G05002*C05510) and:

(Steam flow out - feed water flow in) * constant =
(G05002-(G05011+G05012) * C05524

All feed forward signals are individually adjustable. Can be switched off by setting the C-variable to zero (0).

OPERATIONAL PROCEDURE FOR BOILER COMBUSTION

Required systems to be in operation:

- Main bus bar should be active
- Seawater cooling system must be active
- Air compressor should be active
- Note that there has to be a sufficient control air to the operation of boiler fan flap

STARTING PROCEDURE IN THE CASE OF COLD FIRING:

- MD80; check the boiler water level is within normal working limits.
- MD 82; open V05103 (Drum vent) and V05652 (Superheater Vent).
- MD 05; Open V00367 (DO to boiler), V00327 (HO to Boiler) and V00328 (HO Service Tank shutoff valve)
- MD 84; Start the DO pump (R05634), change over V05654 (HFO/DO c/o Valve) to DO, select DO Burner (X05702)
- MD84; Start the FD Fan (R05635).
- MD84; Set the four controllers to manual, the master at 7, the fuel flow and oxygen controllers at 10.
- MD84; the air flow should be set at 100 and the purge cycle initiated. When the purge cycle is complete, (the purge indication releases) change the air flow controller value to 10.
- MD84; Reset any boiler trip, and press burner 1 on/off button.
- MD84; Pilot fuel pump should start and pilot flame appear at burner followed after a few seconds by the main flame.
- MD84. Pressure should now be raised according to standard boiler practice according to the scenario conditions selected. The following sequence will bring the boiler on-line within one hour:
- MD84; Decrease the airflow controller to 1 and decrease the fuel controller value to 4. Allowing the burner to fire continuously, go to MD82.
- MD 82; when steam drum temp > 105o C (drum pressure over = 0.23bar) shut drum vent (V05103)
- MD82; open V05378 (steam line drain).
- MD82; Fully (100%) open main shut off Valve (V05108)
- MD 84; Open V05653 (Boiler FO heater shut off valve) and V05668 (Boiler steam tracing valve),
- MD84; Start the HFO Pump (R05633).
- MD84; Open V05640 (Atomizing steam valve).
- MD 80; when the main steam line pressure rises to 1.0, shut steam line drain (V05378).
- MD80; when the level in the steam drum drops below -10, open Boiler Main feed valve (V04807), put Feed controller in MAN and start the Main feed pump (R05630). Adjust the MAN output to 10%.
- MD80; Raise the water level to + 75 and stop the pump. Monitor the water level and repeat this operation as necessary when the level drops below – 75.
- MD 84; when the boiler pressure reaches 8 bar the “low atomizing steam pressure’ and ‘HFO low temp’ alarms should reset. When alarms have reset, switch No 1 burner off at on/off button.
- MD84; Change over HFO/DO c/o Valve (V0654) to HFO and the Burner type to HFO.
- MD84; Put airflow, Fuel flow and oxygen controllers in AUTO and then finally put the Master controller in AUTO.
- MD84; Reset the boiler Trip - Burner management “ready” light should illuminate, so now switch it on.
- MD84; Stop D.O. pump, as the boiler is now operating in HFO mode.
- MD 80; The Main feed pump (R05630) should now be started and left running.

- The boiler will now operate in automatic mode at either the low setting (for 8 bar operation at sea), or the high setting (for 13 bar operation for cargo operations)

Oil Fired Boiler Level Control

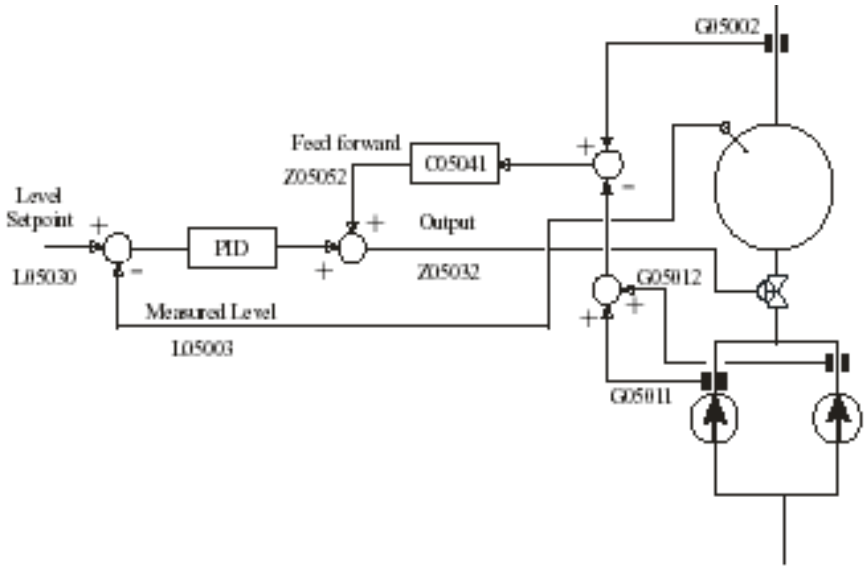
The performance of the water control loop is largely dependent on whether the main or the auxiliary feed water pump/control valve is in operation and on valve and pump characteristics. When the water is supplied through the auxiliary line there will be no preheating of the water and a drop in steam pressure will occur if the cold feed water flow increases rapidly. A reduction in steam pressure tends to increase the feed water flow even more, due to the increased differential pressure across the feed valve.

There is therefore a mutual disturbing interaction between the combustion control and the water level control system. The water flow influences the steam pressure and the steam pressure the water flow.

The “three-point” level control includes the feed forward signal from the difference between steam flow (outlet steam drum) and feed water flow (total). This control reduces the sensitivity to the disturbance set up by varying steam pressure and to conditions like mismatched control valve (flow characteristic/hysteresis) or oversized feed water pump.

It is of vital importance that the steam pressure is steady when the level controller is adjusted. It is therefore recommended that the master combustion controller is set to MANUAL during level control trimming. This “breaks” the mutual interaction between pressure and level control.

Oil Fired Level Controller



Feed forward:
Z05052 = (steam flow out - feed water flow in) * C05041

The feed forward signal is switched off when setting C05041 to zero (0).

OPERATIONAL PROCEDURE IN THE CASE OF NORMAL FIRING:

Related systems required to be in operation:

- **Main bus bar should be active**
- **Seawater cooling system must be active**
- **Air compressor system must be active**
- **Note that there has to be a sufficient control air to the operation of boiler fan flap.**

STARTING PROCEDURE:

- 1. Note that the Boiler Combustion can also be controlled from the boiler control console.
- 2. Check HFO and DO service tanks and open HFO and DO supply valves to boiler;
- 3. Switch on the Boiler Air Fan;
- 4. Reset any tripped functions on the boiler panel and burner panel;
- 5. Set all controllers to MANUAL and the Burner Type should be in DO;
- 6. Set Air flow controller to maximum them press Purge START button;
- 7. When purging is finished, start DO pump and select Do on the 3-way valve by clicking on the diesel line with the mouse right button.
- 8. Set the desired values on Air flow controller and Oil flow controller then wait until fan flap or damper has positioned according to set value.
- 9. Start one burner by pressing the Burner On/Off button.
- 10. If for any number of reasons the burner fails to ignite, purge again and repeat the procedure.
- 11. Adjust air and oil to obtain burning with as little smoke as possible,

and as little oxygen content as possible.

- 12. When you have steam pressure, commence heating fuel oil by heating tanks. See service tank instruction.
- 13. When pressure rises, star 2nd burner and adjust air/oil again. Keeping a boiler within limits when operating manually is a continuous task.
- 14. When required steam pressure is achieved, switch controllers to AUTO

AUTO MODE:

- 15. When burner controls are switched to AUTO, adjust master controller, airflow controller, and oxygen controller if necessary to maintain correct readings.

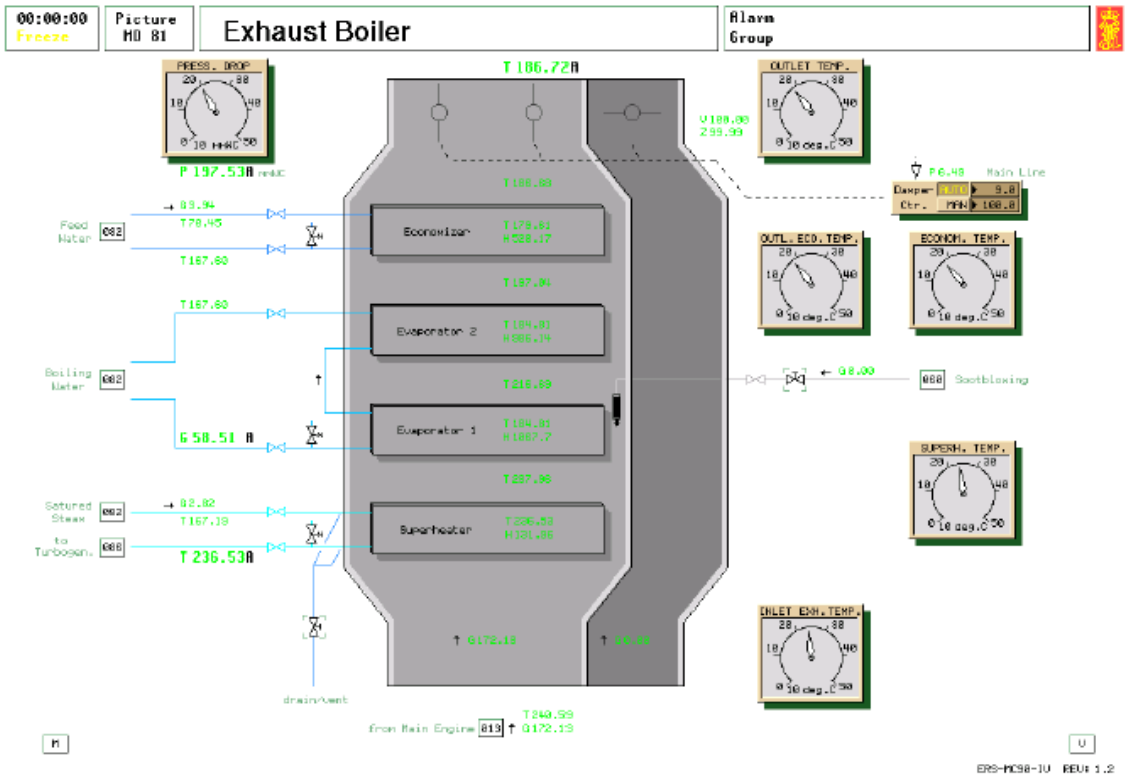
Changing to Heavy Fuel Oil:

Sufficient preheating of HFO is essential;

- 16. Start HFO pump;
- 17. Check if temperature desired is reached
- 18. Check that all requirements for burner management are satisfied except for the HFO Select valve.
- 19. Shut down boiler burner by pressing the On/Off button;
- 20. Change over to HFO by switching the 3-way valve to HFO. (Press right button of the MOUSE)
- 21. Ensure that there is steam in steam atomization line.
- 22. Switch burner type from DO to HFO;

Burner Management:

- 23. Select the load setting that corresponds to mode of operation: “High
- 24. Setting” is required for Cargo Pump turbine operation, else “Low Setting” is used.
- 25. In high setting, the steam pressure will be controlled at 13 bar. The exhaust boiler and the TG are assumed inactive;
- 26. In low setting, the steam pressure will float according to TG load. The oil fired boiler will start if pressure drops less than 8 bar;
- 27. When the green button at the Burner Management panel is lit, this indicates that the boiler is already ready for Auto Burner Management;
- 28. Press the “ON” button at the Burner Management Panel; Burner Management will now start and stop burners automatically when required.



XXI. EXHAUST BOILER

General

The Exhaust Gas Boiler consists of two ducts through which the exhaust gases from the main engine passes. One duct contains four banks of heat exchanger tubes, the other is plain to bypass the heat exchangers. Dampers control of the exhaust gas flow path, and the damper position is regulating by the PID controller from a steam pressure input.

The top bank of tubes is the economiser section where the feedwater passes through the tubes counter to the gas flow.

The next two banks are the evaporation section and the water from the oil fired boiler water drum enters the lower header of the lower bank and passes parallel to the gas flow collecting heat. The steam/water emulsion leaves via the upper header of the upper bank and returns to the steam drum of the oil fired boiler.

The lower bank of tubes is the superheater section where the saturated steam from the oil fired boiler passes in via the upper header of the bank and counter to the gas flow to out of the lower header to the turbo-alternator. The superheater is fitted with a combined vent and drain valve.

There is a Sootblower fitted for cleaning purposes which uses air as the operating medium from the air receivers on MD60.

OPERATIONAL PROCEDURE ON EXHAUST BOILER

Related system required to be in operation:

- Main engine to be running.
- Oil fired boiler to be operating.
- Heating: Running of circulating pumps with oil fired boiler running

PREPARATIONS:

- 1. Drain off water in super heater before opening steam pressure;

STARTING PROCEDURE:

MANUAL MODE:

- 2. Damper control in MANUAL with by-pass positioned open;
- 3. When Main Engine is running and oil fired boiler to be stopped. Gradually open damper flap valves to exhaust boiler.

AUTO MODE:

- 4. When oil fired boiler stops (in AUTO), and pressure increases in secondary drum steam pressure, switch damper controller to AUTO;
- 5. Stop boiler fan and FO supply pump;

NOTE:
Boiler fan and FO pump will start automatically at decreased ME Power (if burner management is active);

When in operation, daily soot blowing of smoke uptake must be done. Ensure air valves are opened before attempting to soot blow.

- 6. Bleed off water from super heater until dry saturated steam is the only content in super heater.

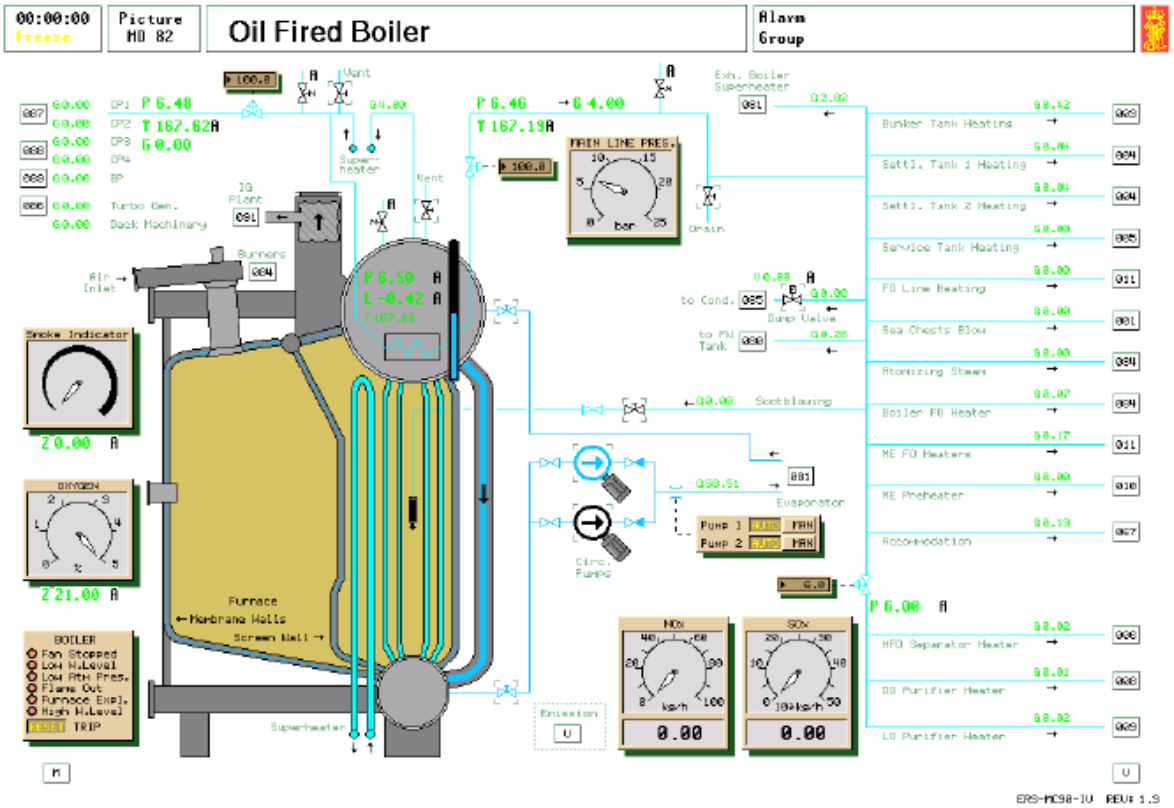
The Economizer section will be put into operation once the OF Boiler main feed system is in use.

The Evaporator section is started up once the OF Boiler Feed system is in use by the following:

1. Opening V04804 Boiler Circ pump outlet valve and V04805 Boiler circ pump inlet valve
2. Starting one of the two circulating pumps (R05380/1) on MD80 or MD82
3. Place the circulating pumps on auto on MD82 to provide standby operation.

When the Main Engine is Full Away (at Sea) the Superheater section can be put into operation by performing these actions:

1. Opening the superheater drains (V05374)
2. Starting the turbo alternator (see MD86) and either running up the Turbo generator or if it is in use, removing the electrical load before changing over to supply through the EGB, shutting the drain valves and restoring the load.



XXII.1 OIL FIRED BOILER

General

This has two oil fired burners fitted in the roof of the boiler. The furnace is of membrane wall construction except where the single bank of inverted U-tubes forming the superheated. The super heater is protected from the main flames by a screen row of tubes from the water drum to a header leading to the steam drum. After the super heater is a bank of generating tubes running between the two drums.

Connecting the steam and water drums are unheated down comers to promote circulation.

A de-super heater is fitted within the steam drum to provide saturated steam flow for the heating loads shown on this screen. This will ensure that there is a positive flow of steam through the super heater at all times, and should prevent excessive super heater metal temperatures that could lead to super heater failure.

A steam driven soot blower unit is fitted within the generating tube bank to ensure that the heating surfaces are kept clean.

Saturated steam from the drum supplies heating services in port and heating services and EGB super heater at sea. Superheated steam supplies the

Cargo/Ballast pumps (MD87/88), Turbo alternator (MD86), and Deck machinery.

A vent is provided on the steam drum to vent air from the boiler during start-up, and to ensure that the steam drum does not allow a vacuum to form during shut-down periods.

To provide a lower heat source to the separators and purifiers, a pressure reducing valve is fitted. This valve should ensure that the steam temperature within these supplies is moderate, and below 160°C.

A steam dumping facility is provided. When it is activated, the steam is dumped directly to the condenser, thus avoiding loss of feed water that would occur should the boiler safety valves lift. A flashing light and alarm indicates that dumping is activated. Steam dumping starts at approximately 17 bar.

OPERATIONAL PROCEDURE FOR OIL FIRED BOILER:

Related system to be in operation:
- **Main bus bar should be active**
- **Boiler fan must have sufficient power, since start of fan generates a heavy load.**
- **DO tanks and HFO tanks to have sufficient level**

PREPARATIONS:

- 1. The oil fired boiler can be controlled from the boiler control console;
- 2. See instruction "Steam Generation Plant" before operating "Steam Generator Boiler Combustion";

Starting Procedure:

- 3. For actual firing of boiler see Boiler combustion;
- 4. Check water level and refill if necessary;
- 5. Reset any tripped functions if there are any;
- 6. Drain superheater until dry saturated steam after the boiler start;

SOOTBLOWING:

- 7. Once daily when in operation, ensure that air is opened before sootblowing;

XXII.1 BOILER EMISSION

A full survey of the simulated flue gas composition is displayed on model variable page MVP8206.

PM, particulate matter in flue gas, or "smoke" is indicated on a relative scale ranging from 0-100 %.

All other components are presented as mass flows, kg/h, or as specific mass ratios, g/kg fuel.

NOx represents the sum of nitrogen dioxide (NO2) and nitrogen monoxide (NO).

SOx represent all sulphur components, mainly sulphur dioxide (SO2) and some sulphur trioxide (SO3).

HC and CO, hydrocarbons and carbon monoxide, represent all residual unburned fuel components in the flue gas.

The computation of the flue gas composition is based on empirical constants and functions. The results must be regarded as indicative only.

Comments on flue gas emission

NOx generation increases with temperature and excess oxygen in furnace. Unevenly distributed air/fuel creates high local temperatures in the combustion zone and gives higher overall NOx values.

In the simulator the NOx can be seen to increase with boiler load (furnace temperature) and oxygen surplus in furnace (oxygen controller setting).
Atomizing steam to the burner cools the flame and reduces the NOx formation somewhat.

NOx reduction can generally be accomplished by:

- operating as close to stoichiometric combustion condition as possible.
- operating with homogenous, well-mixed fuel/air mixtures throughout the combustion zone
- operating through a two-stage combustion process to reduce peak flame temperatures:

stage one: a fuel rich zone with lack of air ,

stage two: a lean burning zone with some extra air added to complete combustion. This staged combustion reduces average flame temperatures and NOx generation

The simulator offers three methods for demonstrating reduced NOx emissions:

Flue gas recirculation – FGR

In a given marine boiler with limited space available, the easiest way of reducing NOx is probably through flue gas recirculation. A flue gas duct from the stack to the air combustion air fan inlet is needed, sometimes separate flue gas recirculation fans are required.

In the FGR example recirculation rate of 15 % is assumed, giving a NOx reduction of approximately 30 %.

Tangentially fired boiler – TFB

Such boilers require much space, and this pose a challenge to marine applications.

The boiler design offers good air/fuel mixing by cyclone action. Its well-mixed, homogenous combustion zone enables furnace operation at very low excess air values (down to 0.5 %).

The TFB example is assuming an “over-fire” air supply to obtain a two-stage combustion with fuel rich burning in stage 1 (in the lower boiler part) and air rich afterburning at reduced temperatures in stage 2 (upper boiler part).

Selective Catalytic Reduction – SCR

Effective NOx reductions can be achieved by a post treatment of the flue gas by adding ammonia (NH3) to the flue gas stream in a fixed bed catalyst vessel. The flue gas temperature level must be right, typically between 300 and 400 dgrC. The catalyst promotes a reaction between NOx and NH3 to form nitrogen and water. NOx reductions as high as 90% are achievable. Careful design of inlet mixing grid and control of the NH3 dosage is necessary to keep ammonia emission (“NH3-slip”) to an acceptable level. The ammonia concentration in the flue gas should not be higher than a few ppm.

The ammonia requirement is in the order of 0.50 kg NH3 per kg NOx reduced. Cleaning the flue gas of the simulator boiler would thus require an ammonia consumption of approximately 25 kg/h at high boiler load (fuel flow 3 ton/h).

Comment on CO/HC emission

The content of carbon monoxide (CO) and unburned hydrocarbons (HC) in the flue gas increase with decreasing excess air. When air-to-fuel ratios approach stoichiometric values both CO and HC emission increase dramatically. Tangentially fired boilers allow operation at a lower air-to-fuel ratio without excessive CO/HC/smoke, giving high boiler efficiency and reduced NOx values.

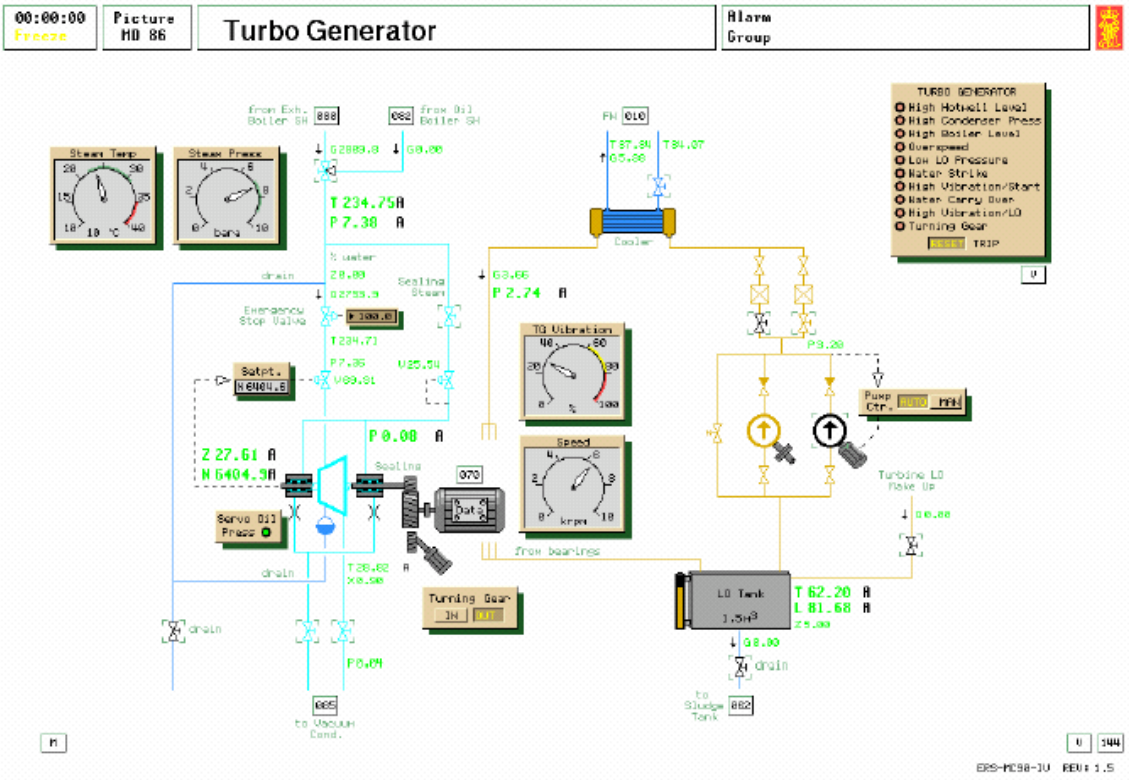
SOx generation

The SOx generation depends on the sulphur content in the fuel. In the simulator, the sulphur content in the HFO and DO fuel can be seen and changed on the fuel oil data page MVP1129. Default setting is 3.5 % sulphur in HFO and 0.5 sulphur in DO.

The slight increase in the SOx reading at high excess air settings is due to the fact that more SO3 is formed at high oxygen concentrations.

The SOx is not affected by the NOx counteracting measures described earlier. The most efficient practical way of reducing sulphurous emission in

maritime applications seems to be removing sulphur from the fuel oil in the refinery by chemical processing.



XXIII. TURBO GENERATOR

General

A 1.5MW turbo-generator is fitted for use at sea with steam supply from the exhaust gas boiler. In port it can also be supplied from the oil fired boiler on the low setting. There is a change-over valve fitted in the inlet line.
The turbo-generator is fed with superheated steam from the exhaust boiler. The exhaust fired boiler produces steam of 12 bar and superheated to approx. 290°C.

The turbine is modeled realistically with torque dependent on steam flow, inlet steam pressure/temperature and condenser vacuum. The throttle valve is controlled by a speed governor. The speed can be remotely adjusted by lower/raise signals from the electric switch board, or the manual set-point adjustment at the throttle valve.

When the turbo-generator is shut down, a gradual collection of water in the steam line/turbine casing is modeled. Before start of cold turbo-generator the main steam line and turbine casing must be drained of water.

If the turbo-generator is started with much water present in the steam line, “water strike” will occur. This can severely damage the turbine rotor and is indicated by a turbine trip.

The Turbo generator is modeled with engine driven LO pump as well as an electric pump drawing from a LO tank and discharging to the Turbo alternator via a fresh water cooled cooler. Two filters are provided to allow one set to be used and the other set on standby.

Water ingress into the lubricating oil sump is modeled. Hence the turbo-generator lube oil tank should be drained off regularly and replenished with new oil. Very low/high lube oil temperature or very high water content will reduce the lubrication ability of the oil and cause rotor instability and possible turbine trip (high vibration trip).

Sealing steam for the glands is provided from the main inlet line, via a pressure reducing valve. The sealing steam drains exhaust to the main condenser.

The turbo-generator is protected by a separate safety system, and trip signal is given on the following conditions:
- high condenser hotwell water level
- high condenser pressure (low vacuum)
- high boiler water level
- turbo-generator overspeed
- low lub oil pressure
- rotor water strike
- high vibration (due to cold start)
- high rotor vibration (due to poor lubrication)
- turning gear engaged

All trips must be manually reset before the turbo-alternator can be started.

OPERATIONAL PROCEDURES FOR TURBO GENERATOR

RELATED SYSTEMS TO BE IN OPERATION: **- STEAM GENERATION PLANT**
- STEAM CONDENSER

PREPARATIONS BEFORE STARTING:

When steam is available at 7bar either from the oil fired boiler or the exhaust gas boiler do the following:

- 1. Select picture MD 01; Open seawater to steam condenser (V00673)
- 2. Select picture MD 85; Start Main Condensate pump R 04721 and No. 1 vacuum pump R 04720
  Note: vacuum must be established and the condenser drained empty by starting the vacuum pump and main condensate pump
- 3. Select picture MD 86; Set V04608 (T/G select valve) to oil fuel boiler
- 4. Select picture MD86; Open the following valves:

  • Steam line drain (V04657),
  • Sealing steam outlet (V04655),

- Turbo generator outlet to main condenser (V04660),
  Note: If the cargo turbines are out of operation, their exhaust valves should be closed to avoid extra air leakage into the condenser.
- LO Filter No 1 (V04668)
- LO cooling water shutoff valve (V04661)
- Sealing steam valve (V04656)
  Note: It is not possible to obtain sufficient vacuum if the sealing steam has not been opened, because of air leakage to shaft sealing.

- 5. Select picture MD86; Check the level and water content of the turbo generator. Drain and refresh as required.
- 6. Select picture MD86; Start LO pump and set pump controller to “AUTO”.
- 7. MD86; Engage the turning gear for about 1 minute. On disconnection reset the turbine trip.

STARTING PROCEDURE:

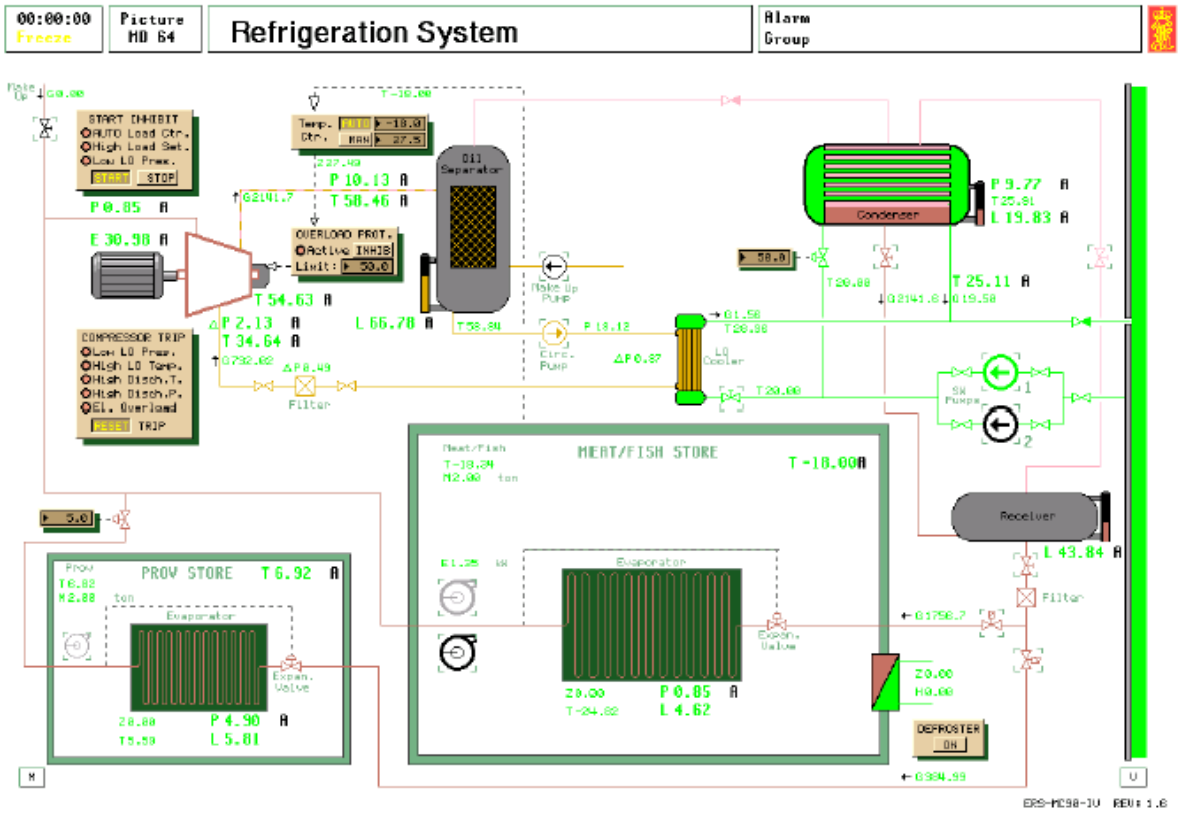
- 8. Press ON button (TG Start/Stop control oil);
- 9. Select picture MD86; Slowly open the turbo generator emergency stop valve (V04652) to 15% (approximately 1200 R.P.M).
- 10. Select picture MD86; The Turbo generator should start to roll slowly. Let the turbine rotate for 2 minutes at this speed.
- 11. Select picture MD86; Continue to open the valve very slowly, up to 40% over 5 minutes (approximately 4000 R.P.M).
- 12. Select picture MD86; Once the machine is up to speed (6400 rev/min) the emergency stop valve should be opened to 100% then close 1 turn valve (not simulated) and steam line drain (V04657) closed.
- 13. Select picture MD86; Monitor all temperatures and pressures to ensure no alarms are active. The turbo generator can now be put on electrical supply.

It is important that the turbine is started slowly. This is to reduce thermal tension during start up. If the turbine speed is taken up too fast, high vibration will occur and the turbine will trip.

STOP PROCEDURE:

- 1. MD70; Ensure the turbo alternator is not supplying electrical load. If so open the circuit breaker using the procedure within the electrical section.
- 2. MD86; Slowly close the emergency stop valve (V04652) to 20% open over 3 minutes. This will remove instability within the steam supply system.
- 3. MD86; Open the steam line drain (V04657)
- 4. MD86; Trip the turbo generator by pressing the ON button.
  This will close the throttle valve.
- 5. MD86; Ensure the electrical driven lubricating pump has started. If not place it in manual and start the pump.
- 6. MD86; After the turbo-alternator has cooled down (leave for 10 minutes), close the following valves:

- steam line drain (V04657),
- Sealing steam outlet (V04655),
- turbo generator outlet to main condenser (V04660),
- LO Filter No 1 (V04668)
- LO cooling water shutoff valve (V04661)
- Sealing steam valve (V04656)



XXIV. REFRIGERATION SYSTEM

Description:

The refrigeration plant is based on R22 and consists of the following main components:
- Electrically driven screw compressor
- Compressor lubrication oil recovery system
- Sea water cooled condenser
- Refrigerant liquid receiver
- Evaporators (2)

Nominal capacities are as follows:

Cooling capacity: 110 kW at - 18°C/30°C
Screw compressor motor: 50kW (67hp)
Refrigerant flow: 0.6 kg/sec
Sea water cooling flow: 20 t/h

The plant comprises following compartments:

One Meat/Fish compartment (-18°C) including:
- One 4 kW air fan for cooling down
- One 1.5 kW air fan for normal operation
- One evaporator with dry expansion
- Evaporator electrical defrost device

One provision store compartment for perishable goods (+5°C) including:
- One air fan
- One evaporator with dry expansion
- One evaporator pressure controller

The compressor is lubricated and cooled by oil and refrigerant gases. The lubrication oil is separated from the compressed refrigerant gas in the oil separator. The bottom part of the separator serves as an oil reservoir. If the oil level is less than 20% full, new oil must be added.

A substantial part of the compressor heat is transferred to the cooling oil in the compressor screw, and the oil must be cooled. This is done by sea water in the lubricating oil cooler.

The electric compressor motor load varies according to compressor condition, suction pressure, and discharge pressure and gas flow. Electric overload will occur if the load is higher than a pre-set adjustable limit.

The effective (internal) compression ratio and thus the compressor capacity of the screw compressor is adjusted by means of a suction slide valve. A PID controller, controlled by the Meat/Fish store temperature, positions it.

The sea water flow to the condenser is supplied by two sea water pumps. Normally just one is in operation, while the other is standby. The sea water flow can be adjusted by a throttle valve at the condenser inlet. Normally 50% valve setting is used, giving a flow of approx. 20 ton/h.

The condensed refrigerant flows by gravity to the liquid receiver. The valve called "vapor valve" is for pressure equalizing between condenser and the liquid receiver vessel. If it is closed, the draining of the condenser will be obstructed.

Heat loss to surroundings is dependent on ambient temperature. At steady state condition this is the only heat load modeled, in addition to the air circulation power dissipation. To enable more versatile steady state operations, an extra heat load can be activated. This "extra load" can be interpreted as a secondary brine system cooled by the circulating air. The load setting represents the rate of flow circulation on the brine side. The additional heat flow is computed as being proportional to load setting and to the

difference between the brine temperature (= 0°C) and refrigerated air temperature.

Start Inhibit functions:
- AUTO selected : X06615 = 1
- High controller setting : Z06616 > 26%
- Low lubricating oil Pressure : P06571 < 0.75 bar

OPERATIONAL PROCEDURE FOR REFRIGERATION SYSTEM

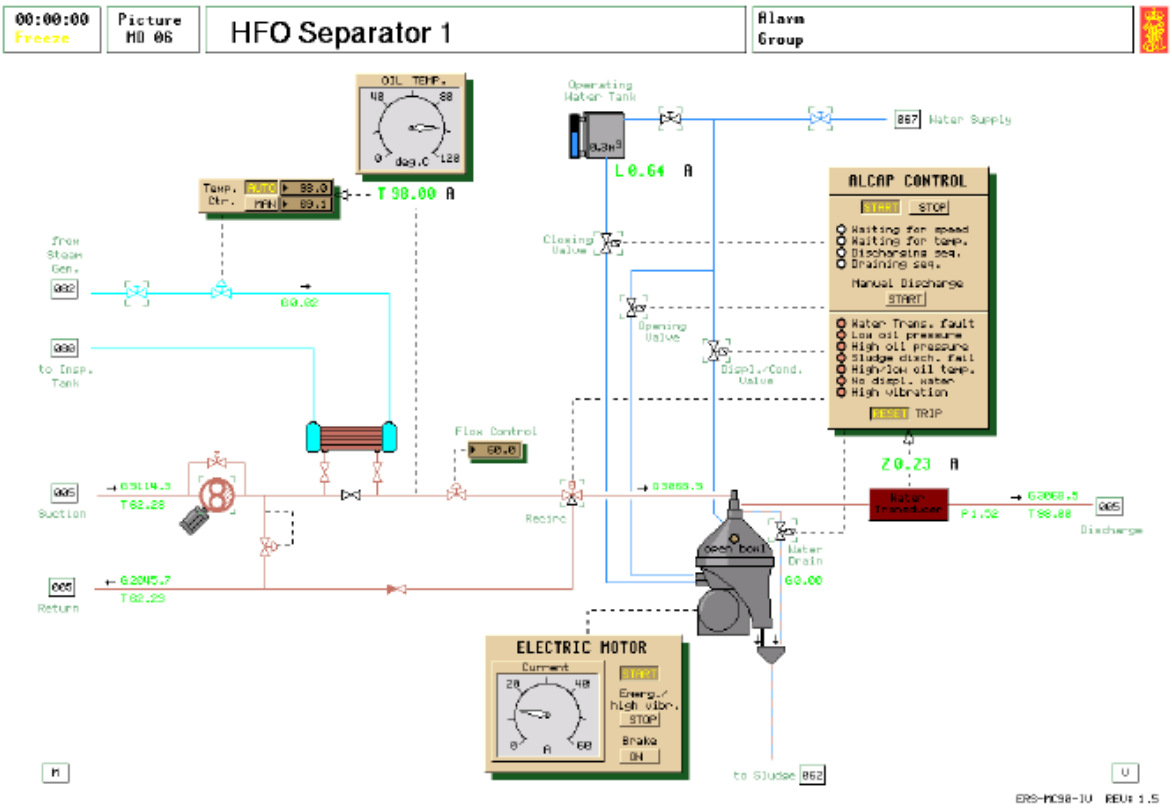
STARTING PROCEDURE:

MANUAL MODE:

- 1. Select picture MD 64: “Refrigeration System”
- 2. Open valves in the lubrication oil system
- 3. Check and, if necessary, refill the lubrication oil by means of the make-up pump.
- 4. Open vapor valve between compressor and condenser.
- 5. Open vapor and liquid valves between the condenser and receiver.
- 6. Open sea water cooling valves to lubrication oil cooler and condenser and start sea water pump.
- 7. Condenser regulator (cooling water control valve) must be set to a suitable level to maintain appropriate condensation pressure. (As refrigerant used is R22, but R12 can be selected in variables list);
- 8. Reset the trip functions if any present and start the compressor.
- 9. Start forced draft fans in compartments.
- 10. Open the liquid valves from receiver to evaporators.
- 11. Gradually increase compressor capacity manually checking the compressor electric power consumption during cooling down.
- 12. Set temperature control into MAN and adjust capacity control slide valve to 10%, (otherwise compressor will trip on overload).
- 13. Refill refrigerant by opening make up valve if necessary.

AUTO MODE:

- 1. Preparation as in manual mode;
- 2. Set temperature control to less than 10% before compressor start and adjust capacity control slide valve to 10%, (Compressor will overload also in auto mode unless the compressor is started with low load);
- 3. Set temperature controller into AUTO when temperature in Meat/Fish store is below –10°C.
- 4. Normal temperature in Meat/Fish store is -18°C.
- 5. When Meat/Fish store temperature approaches -18°C change to 1.5 kW fan.
- 6. Adjust Provision store evap. capacity regulator to maintain Provision store temperature at 5°C.



XXV. HFO SEPARATOR SYSTEM

General

The purpose of the HFO separator system is to supply the main engine and the diesel generators with fuel oil, free from impurities and water to the highest degree.

Description

There are two HFO separators of the "ALCAP" type. The two HFO separators take suction from the settling tanks and the service tank and discharge to the HFO service tank.

Operation Mode

Pumping up service tank:
One separator taking suction from the selected HFO settling tank and discharge to the HFO service tank.

Re-circulating service tank:
One separator takes suction from the HFO service tank and discharge to the HFO service tank.

Each separator is provided with a separate electrical driven feed pump with constant displacement. The flow to the separator is controlled by means of

an adjustable flow control valve. The excess flow from the feed pump is returned to the HFO settling tank or to the HFO service tank.

Each feed pump/separator has a capacity, which is 10% above maximum total HFO consumption

Each separator is provided with an operation water gravity tank.

During operation, there is a constant consumption of operating water and the operating water gravity tank must be manually refilled on low alarm.

The oily water sludge and the drain from the shooting are collected in the sludge tank.

A steam heated pre-heater heats the heavy fuel oil before it is led to the separator bowl. A PID controller controlling a control valve at the pre-heater steam inlet controls the temperature.

ALCAP Operating Principle

The oil to be cleaned is continuously fed to the separator. Separated sludge and water accumulate at the periphery of the bowl.

Normally a sludge discharge takes place at specific time intervals, but if the water contamination is high, an earlier discharge may be initiated.

When separated water reaches the disk stack, some water escapes with the cleaned oil. The increase in water content is sensed by a water transducer installed in the clean oil outlet.

When the water content in the cleaned oil reaches a specific “trigger level,” the control program will initiate an automatic discharge of the water in the bowl.

The water is discharged with the sludge through the sludge ports at the periphery of the bowl.

If the water contamination is so high that the “trigger” level is reached within 15 minutes (adjustable) after the last sludge discharge, the water drain opens. The valves remain open for a specific time after the water content has passed the “trigger” level on its way down.

If the water content in the cleaned oil does not decrease below the “trigger” level within 2 minutes after a sludge discharge or a water discharge through the water drain valve, there will be an alarm, and the inlet oil valve will close.

On the ALCAP control panel there are indications of the following alarms:
-Water Transducer Failure
-Sludge Discharge Failure
-High Oil Pressure

-Low Oil Pressure
-High/Low Oil Temperature
-No Displ. Water
-High Vibration

Water transducer failure alarm is activated if the transducer is measuring less than 0.05% water content in the outlet oil. Since it is not possible to measure a water content below this value in this separator system, this limit is used to indicate a fault condition of the transducer. On board, this failure could be loose connections, faulty oscillator unit, etc. This malfunction is set by the instructor in the malfunction page M0603. After repair of transducer, we have to reset the ALCAP before it is possible to start the separator.

High oil outlet pressure alarm is indicated when oil pressure out is more than 1.9 bar.

Low oil outlet pressure alarm is indicated when oil pressure out is less than 1.45 bar.

When we have open for free flow, we have to reset the ALCAP before start.

High/Low oil temperature alarm is activated if the oil temperature differs more than 5% from set point. This malfunction can be triggered from the malfunction page M0604 (Heater failure) or by changing set points directly on the heater controller when the controller is set to manual operation.

When the oil temp is within 5% from set point we have to reset the ALCAP before start.

No displ. water alarm is activated when the ALCAP control system tries to fill water but there is no water supply caused of a shut water supply valve. When we have open for water supply we have to reset the ALCAP before start.

High vibration alarm is activated when we have high vibration in the separator bowl. When this alarm is activated, the separator will be emptied, the ALCAP control system will be shut down, the oil will be recirculated (three way valve will close against separator) and the electrical motor will stop. This malfunction is set from the malfunction page M0602. After repair attempt, we have to reset the ALCAP before start.

Sludge discharge failure alarm is activated if the separator is not able to empty the separator for water and sludge. The ALCAP control system will directly try a new sludge/discharge sequence. If the water transducer still measures to high water content in the oil, the separator will be emptied, the ALCAP control system is shut down and the oil will be recirculated. This malfunction is set from the malfunction page. After the repair attempt, we have to reset the ALCAP before start.

OPERATIONAL PROCEDURE FOR HFO SEPARATOR SYSTEM:

Related systems required to be in operation: Main bus bar and Boiler running with normal steam pressure.

-] Normally one HFO purifier is in service and one HFO purifier is standby. The HFO purifier in service take suction from one of the settling tanks and discharge to the service tank.
-] The flow through the HFO purifier in service should always be adjusted according to the current HFO consumption in order to optimize the purification at all times.

PREPARATION:

- 1. Open outlet valve from selected HFO settling tank.
- 2. Open HFO SEP oil inlet valve to separator.
- 3. Open HFO SEP oil outlet valve to HFO service tank.
- 4. Open HFO SEP HEATER STEAM shut off valve.
- 5. Open valve for displacement water.
- 6. Drain settling tank.

STARTING PROCEDURE:

- 7. Start HFO SEP feed pump. Adjust desired flow.
- 8. Set temperature controller to AUTO and adjust set point to 98°C.
- 9. Check that the purifier brake is not engaged.
- 10 Start electric motor of the purifier.
- 11. Wait for purifier speed to stabilize. Observe the am-meter and “waiting for speed” indication on ALCAP control panel.
- 12. Put the ALCAP control into operation by pressing the start button on the control panel.

When correct oil temperature (observe indication on the ALCAP control panel), the three-way valve will open for delivery to the separator.

- 13. Observe and adjust flow after separator.

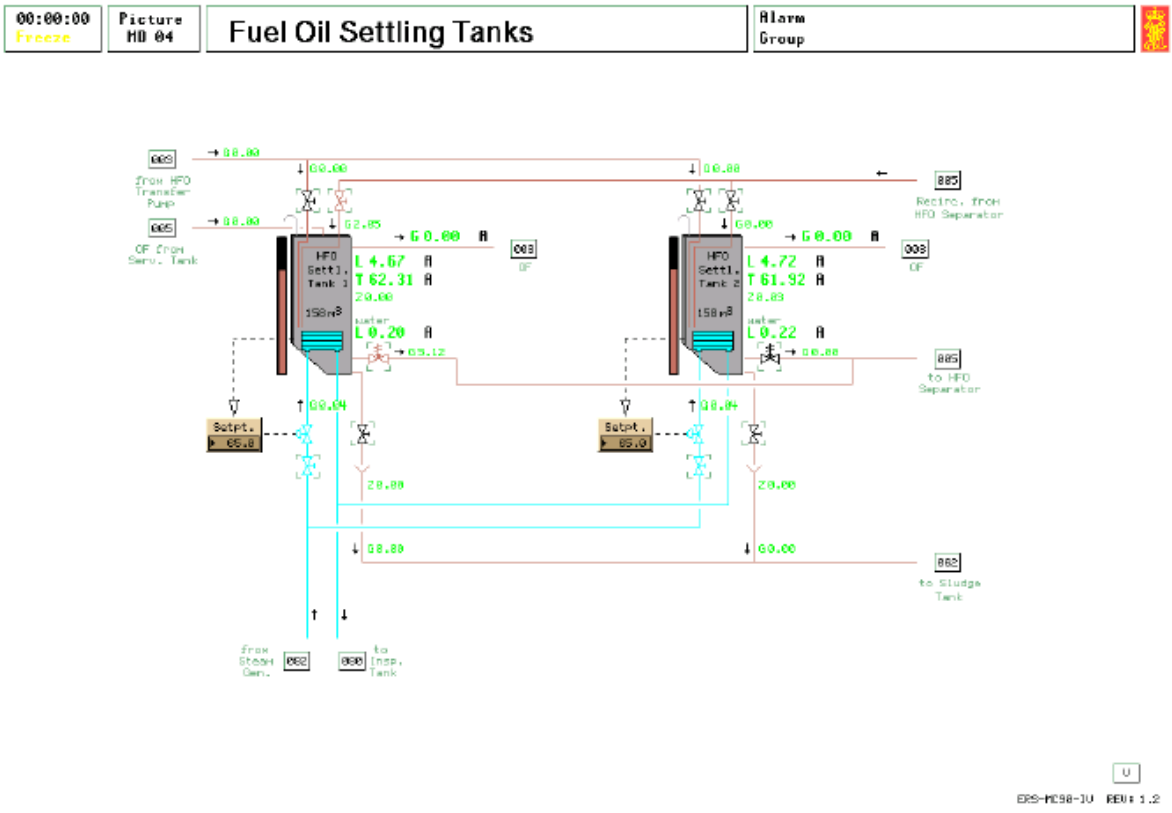
STOPPING PROCEDURE:

- 1. Perform a manual discharge
- 2. When discharge sequence has finished, push the stop button on the ALCAP control panel.
- 3. Stop the purifier
- 4. Stop the feed pump
- 5. If high vibration occurs stop the purifier and engage the brake immediately.

Model particulars

- The purifier is modeled with an automatic dirt build up within the bowl. After each shooting sequence, the bowl is cleaned. If the dirt cumulative exceeds an upper limit, the cleaning efficiency will be reduced. The purifier therefore must be shot regularly.
- The instructor can adjust the rate of dirt build up.
- The cleaning efficiency and a contamination index at the separator outlet is computed and displayed.

  The amount of water separated is dependent of the water content in the settling tank



XXVI. FUEL OIL SETTLING TANKS

DESCRIPTION:

Fuel oil settling tanks comprises two identical HFO Settling tanks no. 1 and no. 2.
Both tanks are filled from the oil transfer system by the HFO transfer pumps taking suction from either the bunker tanks or the fuel oil spill tank. The filling line at each settling tank is provided with a shut-off valve.

By means of shut-off valves (quick-release, remote controlled shutoff valves) at the outlet from each HFO Settling tank and associated piping system, provision

is made to have the HFO separators to take suction from one or both settling tanks.

Bulk water settled in the settling tanks can be drained from the bottom of the tank to the sludge tank via a drain valve.

The purpose of the HFO settling tanks is to do the following:
- Settle bulk water and sludge
- Act as buffer tank for the HFO separator system
- Supply the HFO separators with fuel oil of an almost constant temperature

MODEL PARTICULAR:

If the temperature of the oil in the settling tank cools below a certain limit (40°C), it will be difficult for the purifier feed pump to transport the oil.

The process of water precipitation in the settling tanks is properly modeled so that the water in the oil from the bunker tank will gradually fall towards the tank bottom by force of gravity. The water content in the oil from the bunker tank can be adjusted.

If the collected water is not discharged regularly, HFO purifier problems will finally be experienced (such as excess water to sludge tank).

In order to simulate visual inspection of the water/oil mixture, oil/water interface level is presented on screen at each tank.

The fuel oil quality (heat value, viscosity and density) in the settling tanks is set manually by the instructor. These values will influence the separator system, the fuel oil service system (viscosity and heating demands) and the operation of the diesel engines (mass flow, fuel oil pump index, exhaust temperatures and the output from the diesel engines).

Studies of how the fuel oil quality influences on the main engine (governor response) are recommended.

The water content in the oil from the bunker tank can be adjusted from the variable page.

If local engine room panels are used in the simulator configuration:

The drain valves can be opened at the local panel. In order to simulate visual inspection of the water/oil mixture, use is made of the panel light of the valve. A steady light indicates that the valve is open and water is flowing. A flashing light indicates that the valve is open and mostly oil is flowing. Note that the flashing light function is available only when Local Panel is used for operating the fuel oil settling tanks, in the engine room.

STEAM HEATING

The service tanks are equipped with steam heaters. The temperature is controlled by simple P-controllers, positioning the steam control valves according to tank temperature and temperature set point. The temperature in the service tanks will normally be maintained at a temperature corresponding to the normal discharge temperature from the separator. All HFO supply and return lines are steam traced supplied from the steam reduction valve - refer to the FO service system.

MISCELLANEOUS

Overflow from the settling tanks is led to the Spill Oil tank. Each HFO settling tank has a return line with shut-off valve for excess oil from the HFO separator feed pumps.

The HFO service tank has return pipes from venting tank, fuel oil service system, and boiler burner system and from the diesel generators.

The diesel oil service tank has return pipe from the diesel generators.
Overflow from the service tanks goes to settling tank number 1.

The service tanks are provided with drain valves and the drain are led to the Spill Oil tank.

The diesel oil storage tank is provided with a drain valve and the drain is led to the sludge tank.

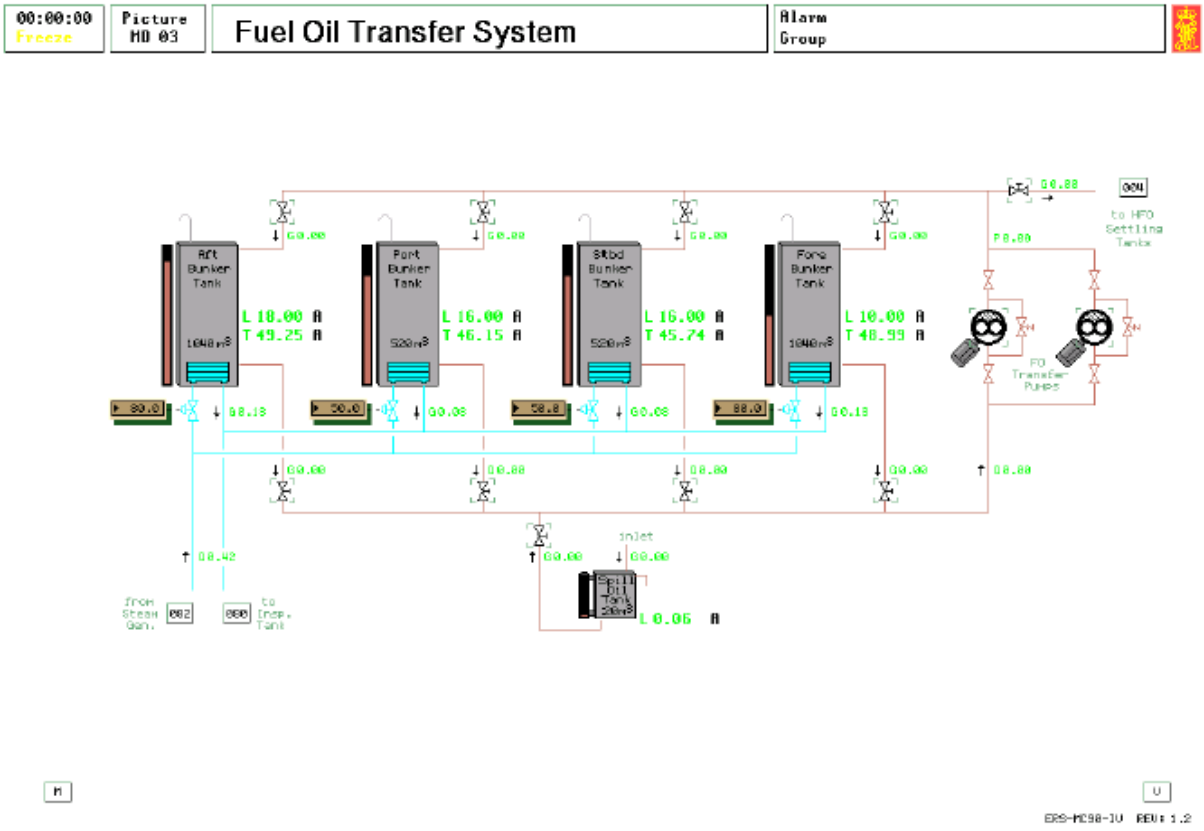
The service tanks and the diesel oil storage tank are provided with shut off valves (quick-release, remote controlled shut-off valves) at the tank outlet.

OPERARATION PROCEDURE FOR HFO SETTLING TANKS:
Required systems to be in operation: Steam system for heating oil
Preparations before starting heating: Sufficient level in tanks

STARTING PROCEDURE:

MANUAL MODE:

- 1. Select Model Diagram 04: “FO Settling Tanks”;
- 2. Select one tank to be in service;
- 3. From this tank open outlet valve to HFO Separator;
- 4. Open recirculation valve into tank from HFO Separator;
- 5. Open the heating supply valve to the heating coils and set the desired temperature from the controller.
- 6. HFO requires temperatures above 40°C for efficient pumping.
- 7. Drain water from tanks periodically or when alarms activate at 0.8m;
- 8. Water content can be read in % from the picture diagram.



XXVII. FUEL OIL TRANSFER SYSTEM

DESCRIPTION

The heavy fuel oil transfer system includes four bunker tanks, one spill oil tank, a transfer pump, and necessary piping.

The transfer pump can suck oil from any of the bunker tanks or the spill oil tank and discharge it to the settling tanks or back to the bunker tanks.

The bunker tanks are heated by steam. The heat transfer is proportional to the steam pressure which is set by manually controlled throttle valves. If the heating is turned off, the bunker tank temperature will slowly cool down towards ambient (SW) temperature. The flow resistance in the heavy fuel oil lines is dependent on temperature. The resistance increases at temperatures below 60°C (140°F); below 20°C (68°F) no flow is possible.

The spill oil tank input comes from the following tanks:

- ***over flow:***

- HFO settling tank 1
- HFO settling tank 2
- DO service tank
- HFO service tank overflows to settling tank No 1

- ***drain flow:***

- Mixing tank
- HFO Service tank
- DO Service tank

ENGINE ROOM FIRE

If high alarm in the spill oil tank is disregarded and the tank starts to overflow, engine room fire is likely to (will) develop. The fire can be extinguished after the following actions have been taken:

- ✓ The fuel oil tank quick closing valves shut
- ✓ The fuel oil pumps stopped
- ✓ The engine room ventilation fans stopped.
- ✓ The main engine stopped.
- ✓ The sea water fire line made operational.

A. DO TRANSFERRING FROM DO STORAGE TANK TO DO SERVICE TANK

OPERATIONAL PROCEDURE:

Required systems to be in operation: Main bus bar must be active
Steam system running
DO/HFO Purifier(s) running

- ❑ 1. Select picture Model Diagram 05: “FO Service Tanks”
- ❑ 2. Open diesel oil suction valve from DO storage tank to DO purifier;
- ❑ 3. Open diesel oil suction valve from DO service tank to DO purifier;
- ❑ 4. Close diesel oil suction valve to DO service tank from DO purifier;

B. TRANSFERRING OF HFO:

OPERATIONAL PROCEDURE:

Required systems to be in operation: Main bus bar must be active
Boiler running with normal steam pressure
HFO Separator running

HFO TRANSFERRING FROM HFO SETTLING TANKS TO HFO SERVICE TANK

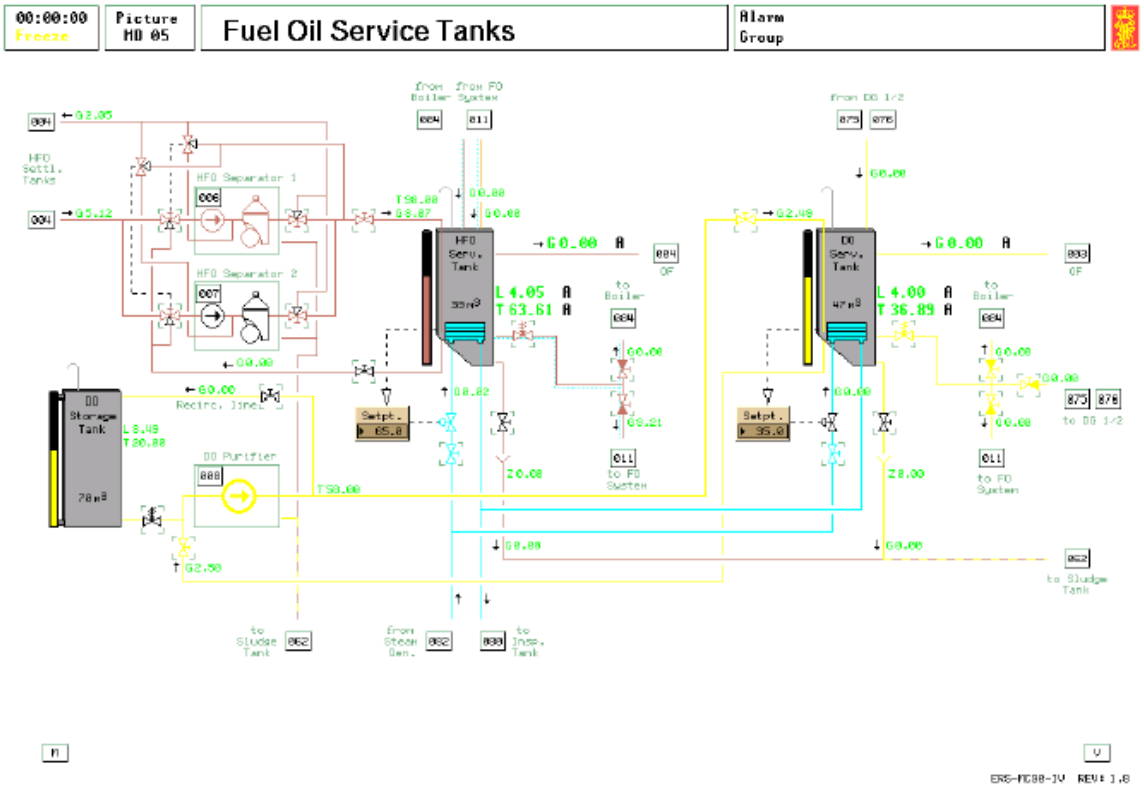
- ❑ 1. Select picture Model Diagram 04: “FO Settling Tanks”
- ❑ 2. Open fuel outlet valve from HFO settling tank to HFO separator;
- ❑ 3. Select picture Model Diagram 05: “FO Service Tanks”;
- ❑ 4. Open fuel oil separator suction valve (Settling Tank Shut Off Valves) from HFO settling tanks;
- ❑ 5. Close fuel oil separator suction valve from HFO service tank;
- ❑ 6. Open fuel oil discharge valve from separator to HFO service tank;
- ❑ 7. Close fuel oil discharge valve (MD 03: FO Transfer System) to HFO settling tanks;
- ❑ 8. Always open valves from HFO settling tank before closing valves on HFO service tank.

HFO TRANSFERRING FROM BUNKER TANKS TO SETTLING TANKS

OPERATIONAL PROCEDURE:

- 1. Co-ordinate with the deck department before attempting to transfer fuel oil.
- 2. Select picture Model Diagram 04: “FO Settling Tanks”
- 3. Open transfer inlet to selected settling tank from HFO Transfer pump;
- 4. Select picture Model Diagram 03: “FO Transfer system”
- 5. Open FO discharge valve to settling tank;
- 6. Open suction valve from selected bunker tank;
- 7. Start FO transfer pump;
- 8. Observe that transfer of oil between bunker tanks is possible;
- 9. Ensure that Bunker Tank FO filling valves are closed when transferring to settling tanks;

NOTE: On actual ships, oil is pre-heated only on bunker tanks in present “use”. Prolonged heating when oil is not consumed are both waste of energy and also opens possibility for polymerization of oil.



XXVIII. FUEL OIL SERVICE TANKS

DESCRIPTION:

The HFO Service Tank supplies clean heavy fuel to the engine fuel oil system (both ME & Auxiliary Engines) and the boiler. It is filled via the HFO

Separators system, taking suction from the HFO settling tanks. The separator (s) can also take fuel oil from HFO service tank for recirculation, as well as recirculation of the settling tanks. The DO service tank supplies the Main Engine, the boiler, and the auxiliary engines. Light fuel from DO storage tank is transferred to the DO service tank by the DO purifier.

The service tanks are equipped with steam heaters. The heat effect is proportional to the steam flow, which depends on the control valve position and the steam pressure. The temperature of the service tanks depends on steam heating, loss to surroundings and temperature of inlet flow from purifier and return flows. The fuel oil viscosity in the service tanks is computed.

Drain or overflow from the service tanks goes to the spill oil tank. The HFO service tank has return pipes from boiler and from mixer tank inlet.

The temperature of the fuel in the tanks is controlled by simple P-controllers, positioning the steam control valves according to tank temperature and set point.

Fuel oil service tanks comprise the fuel oil service tank, the diesel oil storage tank, the diesel oil service tank, and the separator systems for fuel oil and for diesel oil.

The **fuel oil service tanks** store and preheat the cleaned fuel oil.
The HFO service tank supplies fuel oil to these systems:
- Fuel oil service system.
- Boiler burner system.

The **diesel oil service tank** supplies diesel oil to the following:
- Fuel oil service system.
- Diesel generators
- Boiler burner system (when operated on diesel oil).

HFO separator 1 and 2 fills the HFO service tank.
Both HFO separators can take suction from these tanks:
- HFO Settling tanks.
- HFO service tank.

Both **HFO separators** discharge to these tanks:
- HFO service tank.
- HFO settling tanks

The fuel oil service tanks store and preheat the cleaned fuel oil. Only one HFO separator would normally be in use

The **HFO service tank** supplies fuel oil to these systems:
- Fuel oil service system.
- Boiler burner system.

The diesel oil service tank supplies diesel oil to these systems:
- Fuel oil service system.
- Diesel generators
- Boiler burner system (when operated on diesel oil).

MODEL PARTICULARS

The heat effect is proportional to the steam flow, which depends on the control valve position and the steam pressure. The temperature of the service tanks depends on steam heating, loss to surroundings and temperature of inlet flow from purifier and return flows. The fuel oil viscosity in the service tanks is computed.

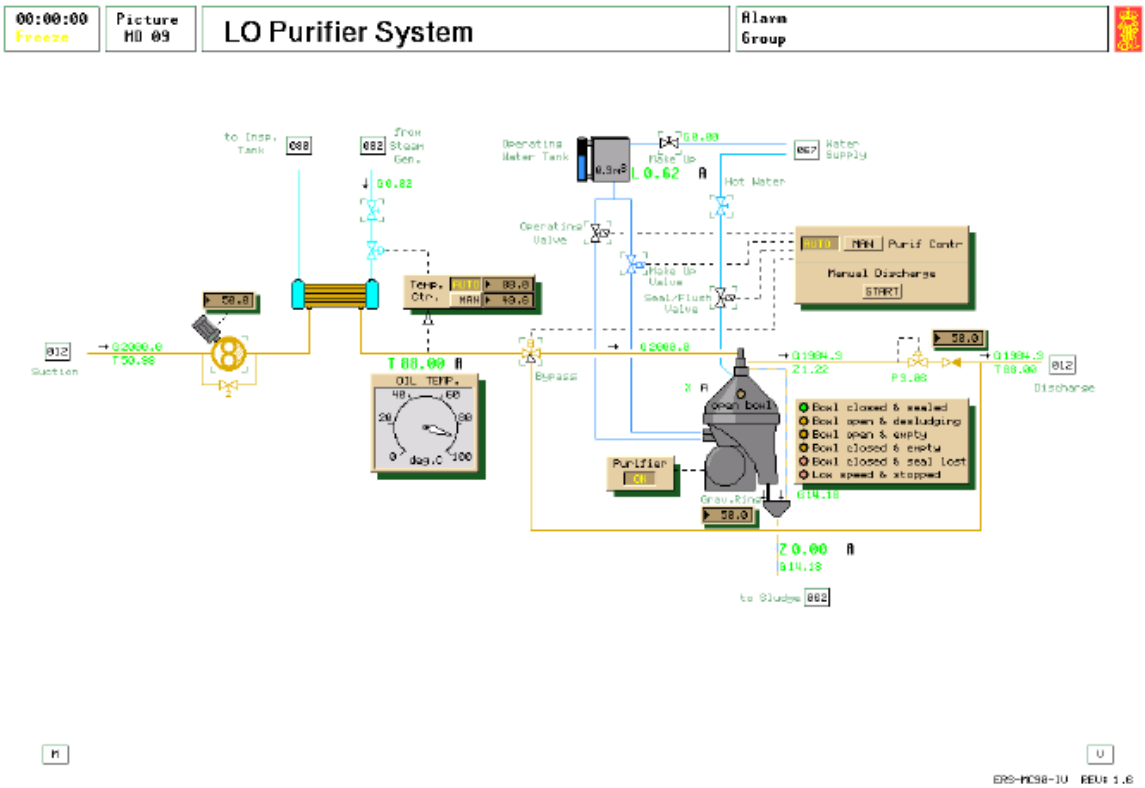
OPERATIONAL PROCEDURE FOR HFO SERVICE TANKS

Required system to be in operation: - Shore Power, Emergency Generator or an Auxiliary Generator connected to the switch board;
- Boiler system with sufficient steam pressure.

STARTING PROCEDURE

MANUAL MODE:

- 1. Select Model Diagram 03: “FO Service Tanks”;
- 2. Picture contains HFO Service Tank, DO Service Tank and DO Service Tank;
- 3. Filling with each tank with either PURIFIER systems or purified feed pumps in by-pass;
- 4. When switching tanks, always open inlet/outlet valves to “new” tanks before closing respectively on “old” tank.
- 5. To operate purifiers, see separate instructions for HFO Separators and DO purifier
- 6. To use tanks or HFO pump, oil must have sufficient temperature.
- 7. Check steam heating line at MD 82 “Oil Fired Boiler” to ensure supply of Steam for Tank heating;
- 8. At MD 03: FO Service Tanks, open steam valves to heating coils in tank bottom and set the temperature from the controller.
- 9. HFO service tank temperature controller to be set at 60° C.
- 10. DO service tank to be set at 35°C.
- 11. Settling tank temperature to be set 65°C as a guide.
- 12. HFO requires temperatures above 20°C to be pumped.
- 13. Drain water from tanks periodically.
- 14. At high water level, the Data Chief will activate the alarm system.
- 15. Water content can be read in %.



XXIX. LUBRICATION OIL PURIFIER SYSTEM

General

The lubricating oil purifier cleans lubricating oil taken from the sump tank (drain tank) from one of the main engines and discharges it to engine sump tanks.

Description

There is one lubricating oil separator. The lubricating oil separator takes suction from one end of the main engine drain tank and discharges it back to the other end of the drain tank.

The separator is provided with a separate electrical driven displacement feed pump with adjustable speed.

The separator is provided with an operation water gravity tank. During operation, there is a constant consumption of operating water and the operating water gravity tank must be manually refilled on low alarm.

The oily water sludge and the drain from the shooting are collected in the sludge tank.

A steam-heated pre-heater may heat the oil before it is led to the separator

bowl. The temperature is controlled by a PID controller controlling a control valve at the pre-heater steam inlet.

OPERATIONAL PROCEDURE FOR LUB. OIL PURIFYING SYSTEM

Related system to be in operation:
- Bus bar active
- Boiler running with normal pressure

PREPARATION

- 1. Select the lubrication oil system of one of the main engines.
- 2. Open outlet valve from selected lubrication oil drain tank.
- 3. Open inlet valve to selected lubrication oil drain tank
- 4. Start purifiers feed pump. Adjust desired flow (when starting less than 20%).
- 5. Set temperature controller in auto and adjust set point to 85°C.
- 6. Start purifier by pushing the ON button.
- 7. Fill operating water tank if necessary.
- 8. Open make up water valve (Hot water for bowl content displacement)

STARTING PROCEDURE:

MANUAL MODE:

After the purifier has reached full speed and this purifier controller is in manual, open the make-up valve and wait until mimic reads BOWL CLOSED AND EMPTY

- 9. Open seal/flush valve for 15 seconds to ensure proper water seal in bowl.
- 10. When mimic reads BOWL CLOSED AND SEALED, open oil flow to purifier by clicking open on three way recirculation valve towards purifier. The supplied oil must have sufficient temperature.
- 11. Start purifying process with gravity ring less than 50 % of full scale.
- 12. Adjust gravity ring to maximum value without losing water seal and adjust oil flow gradually to 100 %.

3. Ejection cycle:

- 13. Close re-circulation valve by pointing to valve flange facing purifier and click the close button. (Right tracker ball button).
- 14. After lost seal appears, open seal/flush valve for 5 seconds to empty bowl. Close make-up valve.
- 15. Open operating valve for 5 seconds, mimic reads BOWL OPEN DESLUDGING and BOWL OPEN, EMPTY.
- 16. Close operating valve. Wait 15 seconds. Open make-up valve,
- 17. When indicator reads BOWL CLOSED&EMPTY open seal/flush valve until mimic reads BOWL CLOSED AND SEALED
- 18. When BOWL CLOSED AND SEALED appears, open recirculation valve towards purifier.
- 19. When operating valves, indicating lamps must be observed to prevent rushing the procedure of starting cycle/ejection cycle.

AUTO MODE:

- Press purifier on button, press start and switch to auto.

ADJUSTING GRAVITY RING

- The efficiency of the purifier is dependent on the gravity ring setting and the feed flow. Low feed flow and large gravity ring result in better purification while small gravity ring increases the maximum flow admitted before broken water seal is likely to occur.
- The cleaning must always be optimized according to the current flow through purifier.

The gravity ring is slowly maximized until oil is observed in the sludge flow.

- When oil is observed the sludge flow, decrease the gravity diameter a few percent until there is no oil in the sludge flow.

Model particulars

The oil discharge pressure will build up to normal value when the separation process starts functioning properly.

The oily water sludge and the drain from the shooting is collected in a sludge tank common for all purifiers.

At loss of water seal, the oil/water will drain through sludge line to sludge tank. The oil discharge pressure will be low and the central alarm system will be activated.

The purifier is modulated with an automatic dirt build up within the bowl. After each ejection cycle, the bowl is cleaned. If the dirt cumulated exceeds an upper limit, lost water seal will occur. The purifier therefore must be cleaned regularly. The instructor can adjust the rate of dirt build up.

If the oil inlet temperature drops under a given limit or increases above a given limit, the normal separation process is disturbed, resulting in lost water seal. If the flow resistance of the discharge line is too high, the water seal will break.

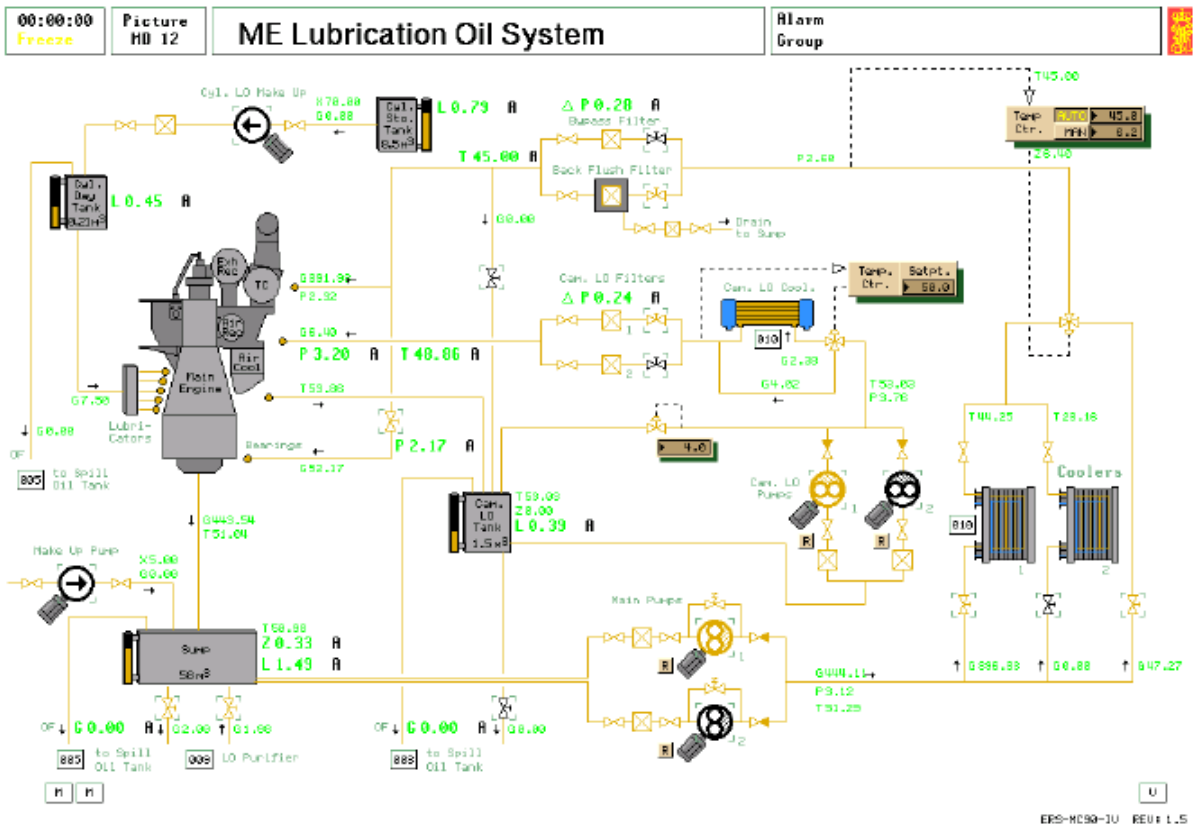
If the oil temperature reaches a critical low limit, the purifier will stop due to motor overload.

There is a constant consumption of operating water and the operating water tank must be manually refilled on low alarm or before.

The efficiency of the purifier is dependent on the gravity ring setting and the feed flow. Low feed flow and large gravity ring result in better purification

while small gravity ring increases the maximum flow admitted before broken water seal is likely to occur.

The cleaning procedure described will be done automatically at regular intervals by the Power Chief central monitoring system if the selector switch on the local purifier panel is in AUTO position



XXX. ME LUBRICATION OIL SYSTEM

General

The lubrication oil from the main engine sump is collected in a sump tank below the engine.

The LO pumps are protected by a pressure relief valve which opens when the pressure rises over a preset value. These valves are not modeled in detail and are not available from the variable list.

The service tank oil can also be cleaned in a LO purifier.

New oil is supplied by a make-up pump with flow directly to the sump tank.

The lubrication oil is cooled in two LT fresh water cooled LO coolers and is then passed through an automatic backflush filter or a standby conventional filter before it enters the main engine. The LO temperature is controlled by a PI controller, which regulates a by-pass valve for the LO coolers.

The LO filters must be checked regularly to avoid pressure/flow reduction.

The sump tank oil level will gradually decrease due to oil consumption and possible drain/sludge discharge from the purifier.

The level is unstable in poor weather and if the level is low, there may be false alarms/shut downs.

If the purifier is operated with “broken” water seal, oil is continuously discharged to the sludge tank, and there is a risk of emptying the LO well completely. The oil pressure after the pumps will be reduced towards zero as the LO sump well runs dry.

The oil temperature in the sump tank is affected by the return oil flow/ temperature from the main engine, the oil flow/temperature from the purifier and the heat loss to the surroundings. If all inlet flows stop, the temperature will gradually approach ambient air temperature. Low oil temperature gives reduced flow at main engine.

Cylinder Lubrication

A simple cylinder lubrication model is included. There will be a steady consumption of cylinder oil, dependent on main engine speed.

The cylinder LO tank must be refilled periodically. At low cylinder LO tank level there will be ME slow down/shut down.

Cam Lubrication

The lubrication oil from the main engine cam shaft is collected in a cam shaft LO tank.

The LO pressure is controlled after the two cam LO pumps by a pressure control valve with return flow to the cam LO tank.

Cam LO tank make-up is taken from the LO inlet main engine line. Discharge of the tank is directly to the spill oil tank.

The cam lubrication oil is cooled by a LT fresh water cooled LO cooler and is then passing a double filter before it enters the main engine. The LO temperature is controlled by a P controller, which regulates a by-pass valve for the cam LO cooler.

The LO filters must be cleaned regularly to avoid pressure/flow reduction.

OPERATIONAL PROCEDURE FOR ME LUBRICATING OIL SYSTEM

Related systems to be in operation: - Bus bar active
- Main Engine Cooling water system in operation

START UP L.O. FOR MAIN ENGINE

- Ensure main engine sump has sufficient oil.
- Set temperature controller to AUTO and 45°C
- Ensure suction and delivery valves on both main lube oil pumps are open
- Ensure one cooler has inlet and outlet valves open
- Ensure inlet and outlet valves to back flush filter are open
- Ensure main bearing supply valve is open.
- Start one of the main lube oil pumps in manual wait until the lube oil pressure has risen to about 3 bar then in pump/compressor Auto chief page set pump control to auto. It should only be necessary for one pump to be running with the other in standby.
- Ensure oil is flowing to piston cooling and main bearings at correct temp.

START UP OF CAMSHAFT SYSTEM

- Set temp. control to 50°C and AUTO
- Cam lube oil tank has about 1.5 m3 in it(topped up from main system)
- Set cam lube oil pressure to 4 bars.
- Check one filter in use and suction and delivery valves on both pumps open.
- One pump started manually then switched to AUTO when pressure reaches about 3.7 bar.

START UP FOR CYLINDER L.O. SYSTEM

- Ensure day tank has about 0.25m3 in it
- Check all relevant valves are open
- The flow will vary with engine speed.

SYSTEM SHUTDOWN

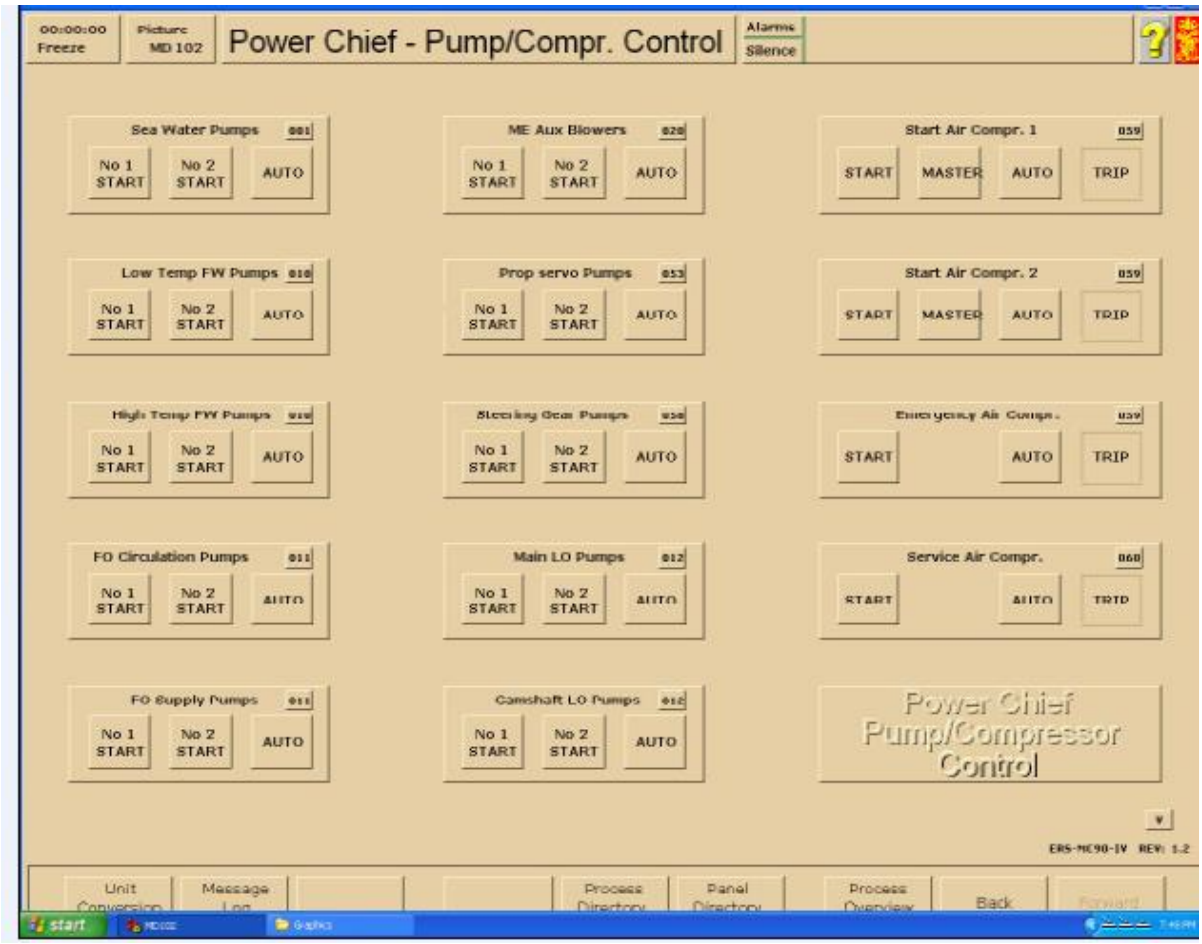
When engine has stopped at Finished with Engines wait for approx. 30 mins to ensure engine has cooled down and stop all lube oil pumps. Sump temperature in port is normally maintained by continually running the lube oil purifier.

Model particulars

- The sump tank oil level will gradually decrease due to oil consumption and possible drain/sludge discharge from the purifier. The level is unstable in poor weather and if the level is low, there may be alarms/shut downs.

- If the purifier is operated with "broken" water seal, much oil is continuously discharged to the sludge tank and there is a risk of emptying the lubrication oil well completely. The oil pressure after the pumps will be reduced towards zero as the lubrication oil service well runs dry.

- The return oil flow/temperature from the main engine, the oil flow/temperature from the purifier and the heat loss to the surroundings affect the oil temperature in the service tank. If all inlet flows stop, the temperature will gradually approach ambient air temperature. Low oil temperature gives reduced pressure at main engine.



XXXI. POWER CHIEF- PUMP AND COMPRESSOR CONTROL

General

The Power Chief – Pump and Compressor Control manages automatic and manual remote operation of the compressors and pumps.

All pumps can be started and stopped locally from the engine room independently of the AUTO/MANUAL.

If the automatic control is not active (AUTO lamp button is not lit) the pumps may be started and stopped manually from the panel.

In AUTO mode the pumps and compressors are automatically started and stopped by the control functions including the following:

- Standby start at low pressure
- Auto stop at high pressure
- Restart after black-out
- Power check (start inhibit at “High Power”) on generators
- Cyclic operation of units

If there has been a disturbance in the AUTO system, for instance, a local start/stop or an alarm has occurred, the auto lamp and the start lamp start flashing.

Each Main Engine pump with standby function may be set in auto cycle mode. In this mode the pump in service is automatically changed between pump no 1 and no 2.

The functions can be set on or off and the time period can be changed from variable page 7022.

When pressure drops below the "standby start limits", the standby unit is started automatically. Most of the low-pressure alarms are subject to "Automatic alarm blocking".

The standby start function will be blocked as well during the same period of time. The standby limits can be viewed and changed from variable page7021.

Both Main Engine auxiliary blowers will operate together in AUTO.

Each main air compressor can be selected as MASTER. The selected compressor will then starts and stop at higher pressures than the non-selected compressor.

OPERATIONAL PROCEDURE FOR POWER CHIEF PUMP/COMPRESSOR CONTROL:

Related system to be in operation: Main bus bar active

PREPARATIONS:

- 1. Select respective system picture for pumps and compressor and prepare for start of components;
- 2. Valves and operating conditions must be with in operating specifications;

STARTING PROCEDURE:

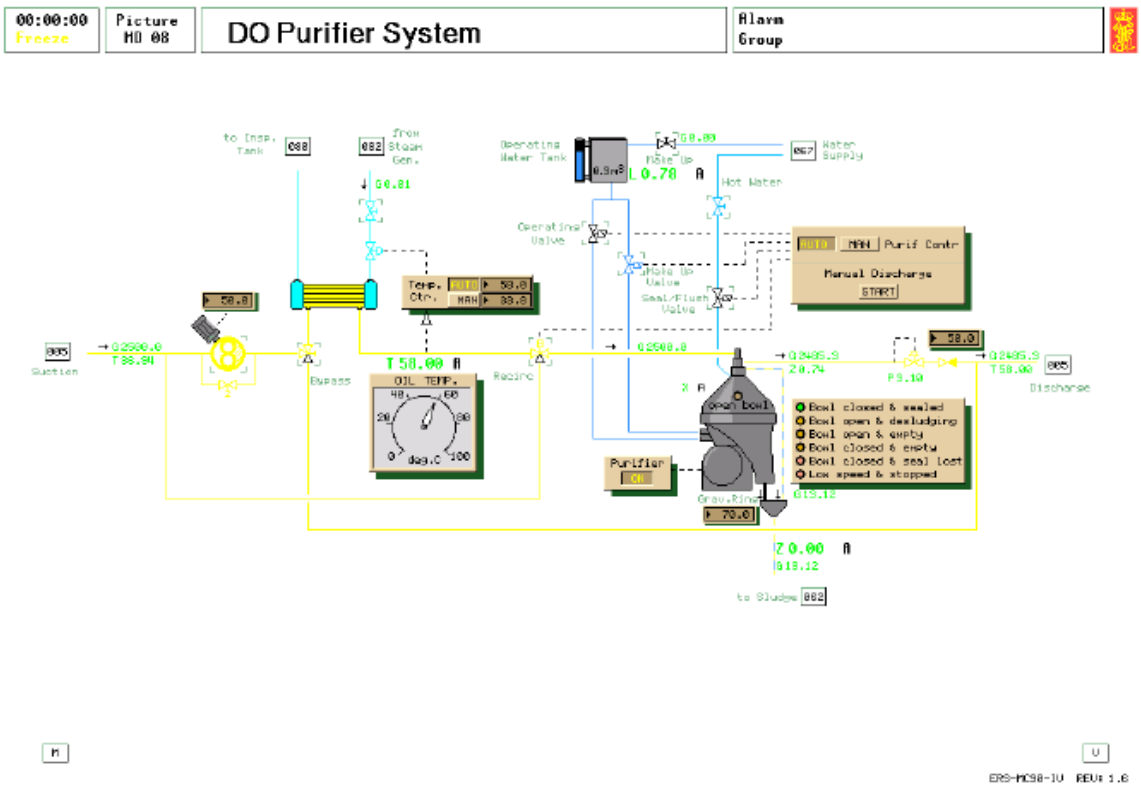
MANUAL MODE:

- 1. Push START button;
- 2. When steady light, pump/compressor is running;
- 3. Pushing button on running pump/compressor will stop the pump/ compressor, and the light will be extinguished.

AUTO MODE:

- 1. Preparations as in manual mode;
- 2. When first pump/compressor is running, push button AUTO;
- 3. Changing pumps/compressors in AUTO, push AUTO;
- 4. Start selected pump/compressor and stop running pump/compressor;
- 5. Push button AUTO;

NOTE: If an object has developed faults, or attempting to run objects without f.e.x. opening valves, standby pump/compressors will start
indicated by flashing start button. To remedy the condition, stop object. Locate problem and “repair”. After a repair attempt or rectification and set to running condition, follow normal AUTO procedure.



XXXIII. DIESEL OIL SEPARATOR SYSTEM

General

The purpose of the diesel oil separator system is to supply the main engine and the diesel generators with diesel oil, free from impurities and water.

Description

There is one diesel oil separator. The diesel oil separator takes suction from the diesel oil storage tank and discharges it to the diesel oil service tank.

The separator is provided with a separate electrical driven displacement feed pump with adjustable speed.

By means of a 3-way changeover valve located before the pre-heater, the feed pump may discharge directly to the service tank, bypassing the separator.

The separator is provided with an operation water gravity tank.

During operation, there is a constant consumption of operating water and the operating water gravity tank must be manually refilled on low alarm.

The oily water sludge and the drain from the shooting are collected in the sludge tank.

A steam-heated pre-heater may heat the diesel oil before it is led to the separator bowl. The temperature is controlled by a PID controller controlling a control valve at the pre-heater steam inlet.

Operation procedure

Normal operation:

a) The separator feed pump take suction from the diesel oil storage tank and discharge to the diesel oil service tank via the diesel oil separator.
b) The separator feed pump take suction from the diesel oil service tank and discharge to the diesel oil service tank via the diesel oil separator.

Emergency operation:

The separator feed pump takes suction from the diesel oil storage tank and discharges it directly to the diesel oil service tank.

1. Preparation

1.1 Open outlet valve from diesel oil storage tank. Open inlet valve to diesel oil service tanks.
1.2 Start purifiers feed pump. Adjust desired flow by using the variable delivery supply pump (when starting less than 20%).
1.3 Set temperature controller in auto and adjust set point to 60°C.
Start purifier by pushing the ON button.
1.4 Fill operating water tank if necessary.
1.5 Open make up water valve (Hot water for bowl content displacement).

Starting procedure

2. **MANUAL mode**:

After purifier has reached full speed, and the purifier controller is in manual, open make-up valve and wait until mimic reads BOWL CLOSED AND EMPTY
2.1 Open seal/flush valve for 15 seconds to ensure proper water seal in bowl.
2.2 When mimic reads BOWL CLOSED AND SEALED, open oil flow to purifier by clicking open on three way recirculation valve towards purifier. The supplied oil must have sufficient temperature.
2.3 Start purifying process with gravity ring less than 50 % of full scale.
2.4 Adjust gravity ring to maximum value without loosing water seal and adjust oil flow gradually to 100 %.

3. Ejection cycle:

3.1 Close re-circulation valve by pointing to valve flange facing purifier and click the close button. (Right tracker ball button).
3.2 After lost seal appears, open seal/flush valve for 5 seconds to empty bowl. Close make-up valve.

3.3 Open operating valve for 5 seconds, mimic reads BOWL OPEN DESLUDGING, and BOWL OPEN, EMPTY.
3.4 Close operating valve. Wait 15 seconds. Open make-up valve,
3.5 When indicator reads BOWL CLOSED & EMPTY; open seal/flush valve until mimic reads BOWL CLOSED AND SEALED
3.6 When BOWL CLOSED AND SEALED appears, open recirculation valve towards purifier.
3.7 When operating valves, indicating lamps must be observed to prevent rushing the procedure of starting cycle/ejection cycle.

4. AUTO mode

4.1 Press purifier on button, press start and switch to auto.

5. Re-purification of diesel oil service tank:

5.1 Open fuel oil purifier suction valve from diesel oil service tank.
5.2 Close fuel oil purifier suction valve from diesel oil settling tanks.
5.3 Open fuel oil discharge valve from purifier to diesel oil service tank.
5.4 Close fuel oil discharge valve to diesel oil storage tank.
5.5 Always open valves on diesel oil service tank before closing valve on diesel oil storage tank.

6. Adjusting gravity ring:

6.1 The efficiency of the purifier is dependent on the gravity ring setting and the feed flow. Low feed flow and large gravity ring result in better purification while small gravity ring increases the maximum flow admitted before broken water seal is likely to occur.
6.2 The cleaning must always be optimized according to the current flow through purifier.
6.3 The gravity ring is slowly maximized until oil is observed in the sludge flow.
6.4 When oil is observed the sludge flow, decrease the gravity diameter a few percent until there is no more oil in the sludge flow.

Model particulars

The oil discharge pressure will build up to normal value when the separation process starts functioning properly. The oily water sludge and the drain from the shooting is collected in a sludge tank common to all purifiers. At loss of water seal, the oil/water will drain through sludge line to the sludge tank. The oil discharge pressure will be low and the central alarm system will be activated.

The purifier is modulated with an automatic dirt build up within the bowl. After each ejection cycle, the bowl is cleaned. If the dirt cumulated exceeds an upper limit, lost water seal will occur. The purifier therefore must be cleaned regularly.
The instructor can adjust the rate of dirt build up.

If the oil inlet temperature drops under a given limit or increases above a given limit, the normal separation process is disturbed, resulting in lost water seal. If the flow resistance of the discharge line is too high, the water seal will break.

If the oil temperature reaches a critical low limit, the purifier will stop due to motor overload.

There is a constant consumption of operating water and the operating water tank must be manually refilled on low alarm or before.

The efficiency of the purifier is dependent on the gravity ring setting and the feed flow. Low feed flow and large gravity ring result in better purification while small gravity ring increases the maximum flow admitted before broken water seal is likely to occur.

The cleaning procedure described will be done automatically at regular intervals by the Power Chief central monitoring system if the selector switch on the local purifier panel is in AUTO position

OPERATIONAL PROCEDURE:
Related systems to be in operation: - Main bus bar active
- Boiler running with normal pressure

Preparations Before Starting:

1. Select picture MD 03: "FO Service Tanks";
2. Open DO Purifier suction valve from DO Storage tank;
3. Open DO Purifier discharge valve to DO Service tank;
4. Select picture MD 08: "DO Purifier System;"
5. Start DO Purifier feed pump;
6. Adjust desired FO feed flow (when starting less than 10%);
7. Set temp. controller in AUTO and adjust set point to 60 C;
8. Start purifier by pushing purifier button ON;
9. Fill operating water tank if necessary.

Starting Procedure:

MANUAL Mode:

10. After purifier has reached full revolutions, and purifier controller is in the manual;
11. Open make-up valve and wait until mimic reads CLOSED BOWLSEALING;
12. Open seal/flush valve for 15 seconds to ensure proper water seal in bowl after mimic reads CLOSED BOWL SEALING;
13. When mimic reads CLOSED BOWL SEALED, open oil flow to purifier by clicking open on three-way recirculation valve towards the purifier;

14. Oil must have sufficient temperature ;
15. Start purifying process with gravity less than 20% of full scale;
16. Adjust gravity ring to maximum value without losing water seal and adjust oil flow gradually to 100%

Ejection Cycle;

17. Close re-circulation valve by pointing to valve flange facing purifier click the close button (right tracker ball button);
18. After lost seal appears, open seal/flush valve for 5 seconds to empty bowl;
19. Close DO Purifier make-up valve;
20. Open operating valve for 5 seconds, mimic reads OPEN BOWL DISCHARGE and OPEN BOWL EMPTY;

21. Close operating water valve;
22. Wait for 15 seconds then open DO Purifier make-up valve, mimic reads CLOSED BOWL SEALING;
23. When CLOSED BOWL SEALING appears, open seal/flush valve until mimic reads CLOSED BOWL SEALED;
24. When CLOSED VALVE SEALED appears, open re-circulation valve towards purifier;
25. All the while operating valves, indicating lamps must be observed to prevent rushing the procedure of

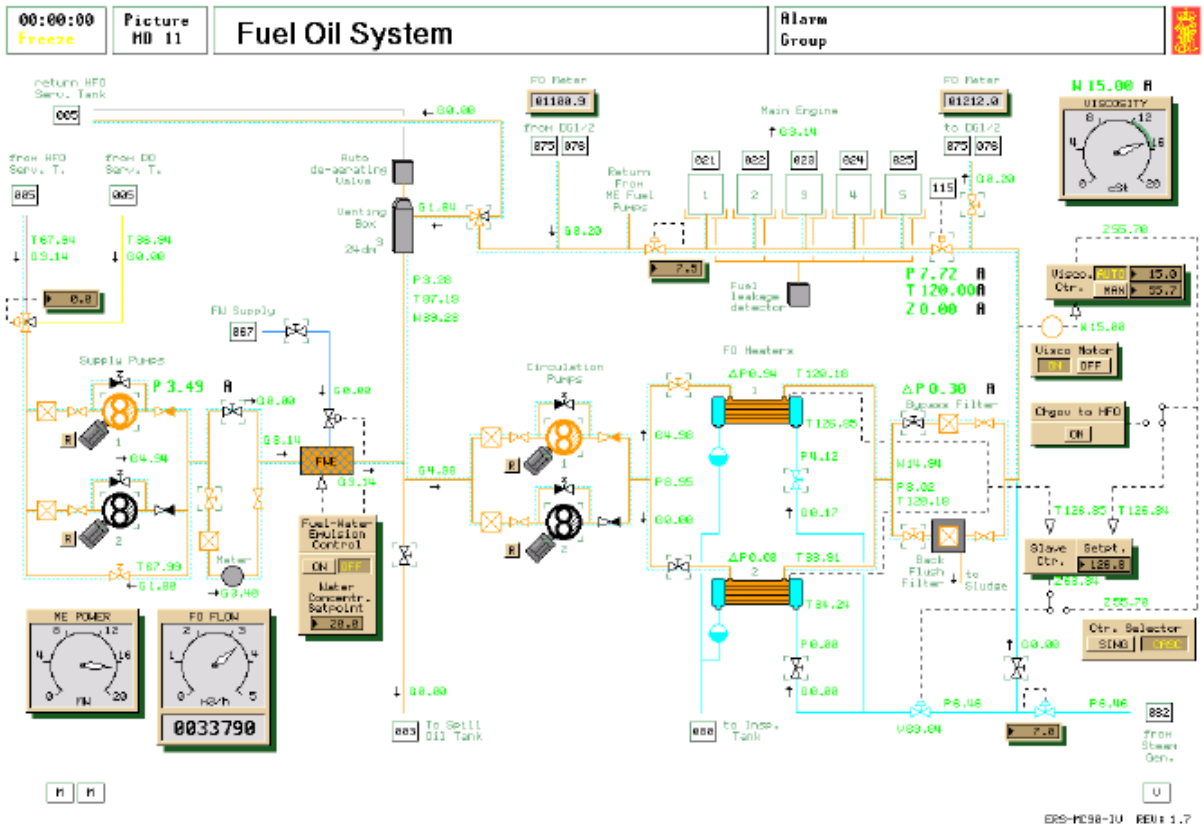
Starting Cycle/Ejection Cycle

AUTO Mode:

26. Preparation as in MANUAL Mode;
27. When purifier has reached full speed, push AUTO button on purifier control panel;

Re-purification of DO Service Tank:

28. Select picture MD 03: "FO Service Tanks";
29. Open Fuel Oil Purifier suction valve from DO service tank;
30. Close FO Purifier suction valve from DO Storage Tank;
31. Open FO Purifier Discharge Valve to FO Service Tank;
32. Close fuel oil discharge valve to DO Storage Tank;
33. Always open valves on DO service tank before closing valves on Do Storage tank.



XXXV. FUEL OIL SYSTEM

General

The purpose of the fuel oil service system is to preheat the fuel oil to correct injection viscosity, to fine-filter the fuel oil and to supply the main engines and the diesel generators with a continuous flow of fuel oil at a correct pressure.

All engines are running at the same viscosity and intended to operate on heavy fuel oil at all times, full power, maneuvering and in port.

Operation on diesel oil is only recommended during abnormal conditions and during major overhaul of the fuel oil system. The system is capable of preparing heavy fuel oil with a viscosity of 700 cSt. at 50°C and arranged as a pressurized fuel oil system in order to prevent foaming and high-pressure fuel oil pump cavitation.

Description

Two supply pumps take suction from the heavy fuel oil service tanks or from the diesel oil service tank through an adjustable 3-way mixing valve. The supply line from each service tank is equipped with none-return valves in order to prevent confluence.

The supply pumps discharge to the venting tank at a pressure of approx. 4 bar(g). The total amount of fuel oil supplied to the venting tank. is measured by a flow meter (totalizer) equipped with a by-pass valve.

The capacity of each supply pump exceeds the max. consumption of the main engines and the diesel engines.

The venting box can be drained to the spill oil tank through a drain valve.

Situated between the fuel oil meter is a ***Fuel-Water Emulsion Control Unit***

Which is designed for emulsification of the fuel to reduce the NOx values in the exhaust gas from the engines. One very important thing to remember when adding water to the fuel is that to maintain the same engine power, the fuel link must increase. Therefore all the parameters or limits depending on the fuel link position must be adjusted (with the same relative values as the actual water fraction)

Two fuel oil circulation pumps take suction from the venting box and/or the fuel oil supply pumps and discharge to the fuel oil circulating line, supplying fuel oil to the injection system of the main engines, and of the diesel generators. The circulating line is equipped with two steam heated fuel oil heaters, one back flush fuel oil filter and one bypass filter. The capacity of each heater is sufficient for the max consumption for the main engines and the diesel engines.

There is a facility to run the diesel generators on gas oil with the main engine on heavy.

The capacity of each circulating pump exceeds the max consumption of the main engines and the diesel engines.

Excess fuel is normally returned to the venting box. Provision is also made to return the fuel oil to the service tanks through a 3-way changeover valve.

An adjustable (5-10 bar) back-pressure valve maintains a constant pressure in the circulation line.

The fuel oil line to the main engines is equipped with an emergency shut off valve for remote control (outside engine room).

Steam for heating of the venting box and all fuel oil lines (steam tracing) is supplied through an adjustable (0-10 bar) steam reduction valve. Steam for fuel oil heaters and steam tracing can be shut off by stop valves.

Fuel oil viscosity control

The viscosity controller positions the steam valve of the fuel oil heater directly

(single PID loop), or indirectly by adjusting the set point of a separate slave controller (cascade control).

The feedback signal to the slave controller is the mean tube metal temperature of the fuel oil heaters (High Selected).

At low load, it may prove to be necessary to stabilize the controller by reducing the steam supply to the fuel oil heaters.

This controller can be configured in cascade. A controller connected this way will be more stable and less sensitive to supply steam pressure than with a direct connected PID control.

Operation procedure

1. Preparation and starting at diesel oil

Supply system

1.1 Set 3-way valve into diesel oil position (100% for pure diesel oil).
1.2 Ensure sufficient level in diesel oil service tank and drain the tank.
1.3 Line up system from diesel oil service tank to venting tank – by pass valve for fuel oil flow meter normally to be closed.
1.4 Close venting box drain valve.
1.5 Start one of the supply pumps manually and check the discharge pressure and flow.

Circulation system

2.1 Open valves to one of the fuel oil heaters and the back flush filter.
2.2 Check that the main engine fuel oil emergency shut off valve is open
2.3 Open fuel oil shut off valves for both main engines and the supply valve for the diesel generators
2.4 Return line valve pressure controller must be set to 7-8 bars.
2.5 Check that the 3-way valve in the return line is set to return to venting tank.
2.6 Set fuel oil viscosity controller into Manual
2.7 Check that the valves for steam supply to fuel oil heaters and steam tracing is closed

Start one fuel oil booster pump manually and check discharge pressure and flow

2.8.1 Select auto standby for supply pumps and for booster pumps at the Power Chief – Pump Control panel.

NOTE: If steam system is not shut off effectively by closing the stop and control valves of the steam system, there is a risk of heating the diesel oil. Too high temperature of the diesel oil may cause poor lubrication of high-pressure

pump's plunger and of fuel oil nozzle needle valve due to low viscosity. This again may cause piston or needle valve to seize.

If there is no fuel oil consumption from the fuel oil supply system the supply pumps must be stopped in order to avoid damage of the pump due to high temperature.

3. Changing from diesel oil to heavy fuel oil.

3.1 HFO purifier to be in operation
3.2 Ensure sufficient level in the HFO service tank and proper temperature in order to get a suitable oil viscosity.
3.3 Drain the tank
3.4 Line up the system from HFO service tank to 3-way mixing valve.
3.5 Open steam valves to selected FO heater.
3.6 Open steam valve for steam tracing.
3.7 Set steam line pressure controller to desired setting. (5-8 bars) and check steam pressure.
3.8 Set viscosity controller into Auto and set point at 11-15 cSt
3.9 Gradually change value of 3-way mixing valve to pure HFO while checking that the controller keeps the viscosity within appropriate limits.

Quicker change-over can be obtained with return to service tank open. This, however, may cause needle valves to seize in fuel injectors.

4. Changing from heavy fuel to diesel oil

4.1 Slowly reduce the temperature on HFO by adjusting the viscosity controller manually.
4.2 When temperature drops, gradually mix in diesel oil by adjusting the 3-way mixing valve
4.3 Observe the rate of temperature reduction. Too quick temperature drop can cause fuel oil high-pressure pump's plungers to seize due to plunger-liner contraction/reduced lubrication.

Note: If for some reason the venting box must be drained, the three-way valve can return the fuel oil to the settling tank(s).

With main engine running, best result in viscosity control is obtained with controllers in CASCADE, VISCOSITY CONTROLLER in AUTO.

The diesel engines are usually stopped and started with HFO in fuel lines. Diesel oil is used if engines are to be stopped for a prolonged period (dry-docking) or when conducting major overhauls to fuel system. If ambient temperature is extremely low, or if steam system is out of commission, change to diesel oil before stopping or empty lines by changing to diesel oil and re-circulating oil back to HFO service tank.

Quicker change-over can be obtained with return to service tank open. This, however, may cause needle valves to seize in fuel injectors.

5. Changing from heavy fuel to diesel oil
5.1 Slowly reduce the temperature on HFO by adjusting the viscosity controller manually.
5.2 When temperature drops, gradually mix in diesel oil by adjusting the 3-way mixing valve
5.3 Observe the rate of temperature reduction. Too quick temperature drop can cause fuel oil high-pressure pump's plungers to seize due to plunger-liner contraction/reduced lubrication.

Model particulars

If the plant is shut down with no heating, the oil in the venting tank will cool down because of heat loss to surroundings. The oil viscosity in the venting tank is computed depending on temperature and possible dilution by diesel oil.

If a water leakage in the service tank heater has occurred, it will collect in the vent tank and disturb the running of the diesel engines. The venting tank can be drained or emptied to the Spill Oil tank.

If the viscosity at the booster pump inlet is high, the fuel oil booster pump discharge pressure will decrease.

The oil viscosity in the circulating line is computed, depending on temperature and possible dilution by diesel oil.

The flow resistance in fuel oil heaters and filters is dependent on viscosity. A pressure drop in fuel oil filters and fuel oil heater results in a correspondingly drop of fuel oil pressure at the DG's and ME's high-pressure pumps.

Above a viscosity of approximately 600 cSt the oil is beyond the pumping limit.

If the rate of temperature reduction/rise when changing from HFO to diesel oil is too high, some of the HP injection plungers might stick due to plunger liner contraction/reduced lubrication.

The oil delivery from the booster pumps is reduced if the suction pressure drops below a certain limit.

Fuel oil gassing

If the fuel oil temperature after the fuel oil heaters rises higher than the fuels boiling temperature, "gassing" of the oil is simulated. Fuel oil gassing causes the following effects:
- The running of the main engine is disturbed.
- The signal from the viscosity meter becomes very noisy.
- Normally HFO gassing develops above 135C and for DO above 80C

adjustable

Fuel oil quality

Fuel oil quality (heating value, density, and viscosity) can be set from variable page 1129.

OPERATIONAL PROCEDURE:

Main Engine Fuel Oil System:

Related system to be in operation: - Bus bar active
- Heating system
= steam pressure for heating when using HFO
= Oil can be circulated by opening 3-way valve return to service tank

Preparation before Starting:

1. Select diesel oil operation on 3-way mixing valve;
2. Click on window with center trackerball button and enter 100 % for pure diesel and 0% for HFO operation;
3. Make sure that the valve are opened and oil is flowing to booster pumps from HFO and DO service tanks;

Starting Procedure:

MANUAL: Mode:

4. The ME fuel oil pumps can also be started from the "Power Chief" panel's pump section;
5. Close bypass valve on fuel oil flow mater;
6. Close drain valve from ventilation tank;
7. Open valves into one of FO Heaters;
8. Open valve to one filter;
9. Open valve to main engine high pressure fuel pumps;
10. Viscosity controller in MANUAL;
11. Fuel oil back pressure controller set to less than 10 bar (above 10 Bar prevents recirculation of oil in fuel injectors since they close above 12 barG);
12. Three way return valve set with return to ventilation tank;
13. Click open on desired flow direction with left tracker ball button;
14. Start one fuel oil booster pump.

AUTO Mode:

15. Select Power Chief pump control panel and set pumps in AUTO;
16. Select AUTO on viscosity controller panel;

NOTE: Viscosity controller can be varied from SINGLE to CASCADE MODE. Varying flow/temperature conditions may need different settings

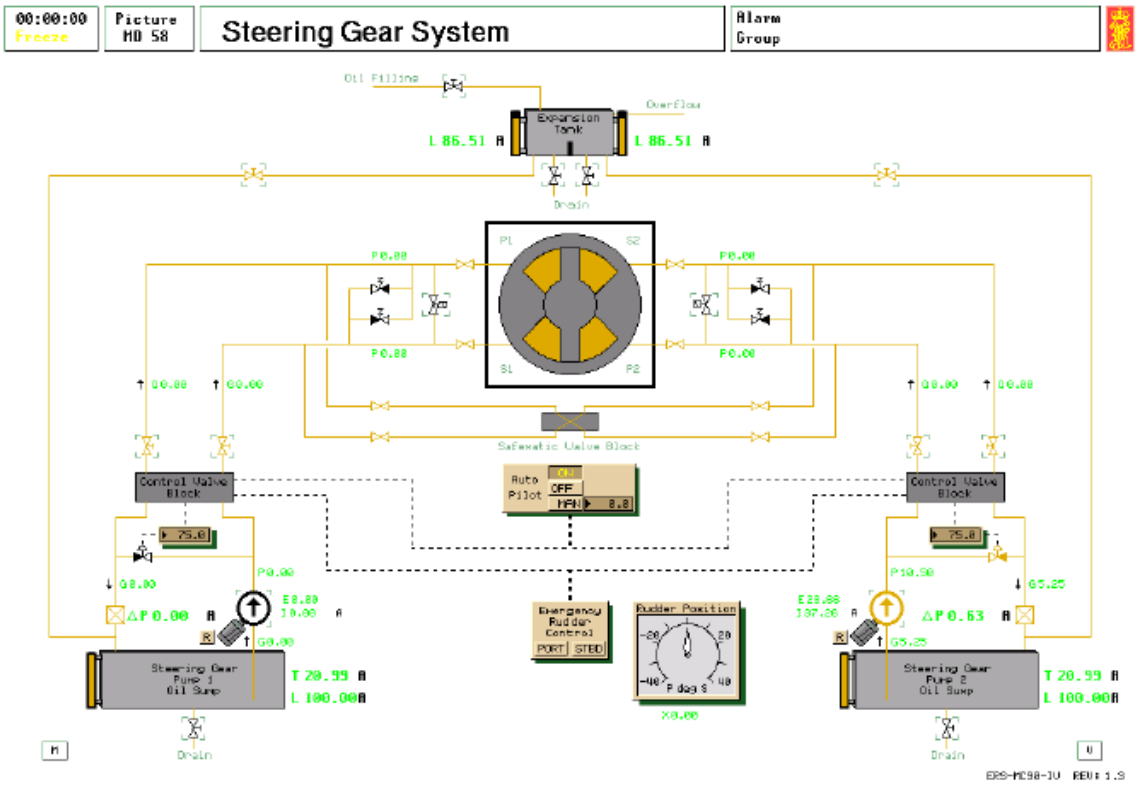
When using CASCADE control, remember to set slave controller set point to less temperature than viscosity settings would reflect.

Depending largely on viscosity index chart, consult this from for setting with emphasis on actual oil quality.

17. Open steam valves to FO Heaters;
18. Open Steam valve to steam tracing lines;
19. Steam line pressure controller to desired setting (8 bar);
20. Ensure steam consumer valve is opened;
21. Gradually change value in 3-way mixing valve to pure HFO;
22. Quicker change-over can be obtained with return to service tank opened;
23. This, however, may cause needle valves to stick in fuel injectors;

Changing from HFO to DO:

24. Lower temperature on HFO by settling on viscosity controller;
25. When temperature drops, gradually mix in diesel oil;
26. All the while, observing that the change-over is not too rapid;
27. This can also cause needles in fuel injectors to stick.



XXXV. STEERING GEAR SYSTEM

General

The steering gear system comprises:

- one hydraulic steering gear of the rotary vane type,
- two identical hydraulic systems. Each system includes:
  - one steering gear pump Unit
  - one control valve block assembly
  - necessary measuring, indication and alarm facilities for pressure, temperature, level and flow
  - necessary control and safety equipment
- one expansion tank common to both hydraulic systems
- emergency steering control equipment
- rudder angle indication

The steering gear is able to change the rudder position from 35 deg. to –30 within 48 sec. with one pump and 24 sec. with two pumps, independent of ship speed. The increased demand of thrust on the rudder at higher ship speed is taken care of by increased pump pressure.

The steering gear system is of the “IMO model” with the functionality required according to Classification Societies for gas carriers and oil tankers above 100000 tons.

Hydraulic system description

The steering gear itself is operated by two open type, low pressure hydraulic systems.

Each hydraulic system is supplied from a steering gear pump Unit (Power Pack) comprising the following:
- oil tank with a bottom drain valve
- steering gear pump of the fixed displacement type
- return line oil filter
- level indication
- equipment for monitoring of temperature, pressure and level

Additionally each system is equipped with the following:
- One adjustable system pressure-relief control valve controlling the maximum discharge pressure from the steering gear pump. Default setting is 75 bar. Above this pressure, the hydraulic oil will be by-passed back to the oil suction tank.
- one shock-relief control valve block with two adjustable relief control valves protecting the steering gear and the hydraulic system against pressure shocks when braking the rudder movement
- stop valves for manual isolating of the system
- one manual operated stop valve for by-pass of the pressure relief shock valves

The oil tank is connected to the bottom of the expansion tank, common to both hydraulic systems and normally the oil tank is full (100% level).

Each system is provided with the following alarms and safety functions:

- **LOW LEVEL - STEERING GEAR UNIT TANK**
- **LOW LEVEL STOP - STEERING GEAR PUMP**
- **OIL FILTER HIGH DIFFERENTIAL PRESSURE**
- **HIGH OIL TEMPERATURE**

Steering gear pump no 1 and the belonging controls are supplied from bus bar 1.

Steering gear pump no 2 and the belonging controls are supplied from Emergency bus bar.

Emergency steering may be carried out, in case of system communication failure with the bridge.

Control system description

The steering gear control system is of the on-off type (3-point control). The electrical controlled directional-control valve integrated in each of the

control valve blocks controls the rudder angle. The control valve block also includes over center- and flow control valves, necessary for mechanical and hydraulic safety and control.

Normal control (Follow up control)

The directional-control valve receive its control signals from the automatic rudder control system, having its set point either from the auto pilot or from the manual rudder control located both locally and at the bridge steering console

At deviations between the actual rudder position and the desired rudder position, a port or starboard signal is given to the electrical directional-control valve. The control valve changes its position and hydraulic oil is led in an out of the respective chambers at the steering gear, shifting the rudder angle towards the desired position as long as the deviation exists.

Emergency control (Non follow up control)

The directional-control valve can be manually controlled by means of the emergency control buttons fitted both at the bridge steering console and locally at the control valve.

Automatic separation control system (Safematic system)

According to international regulations, the steering gear system of larger ships must be provided with automatic separation of the two hydraulic systems, in case of a large oil leakage at one of the systems.

Both steering gear systems are connected to the common expansion tank.

A major oil leak at one of the systems will lead to a decrease of the oil level in the expansion tank and a “LOW LEVEL ALARM - EXPANSION TANK” is activated.

If the oil level continues to decrease both steering gear pumps receives a START command resulting in a start of the standby steering gear pump.

If the expansion tank oil level is still decreasing it will reach the level where the expansion tank is split up into two chambers by an internal partition plate. Each steering gear system is now supplied from its own expansion tank chamber and the decrease in oil level will only take place in the chamber connected to the defective system. A low level switch in the chamber in question stops the
respective steering gear pump and shifts the safematic control valve block into a position where:
- the two system are separated from each other
- the steering gear chambers connected to the defective system are by-passed (short-circuited)

After the separation the defective system will be shut down (pump stops, control valve block will close)

NOTE
In this condition, the steering gear torque is reduced and the ship's speed must immediately be reduced to 7 knot and the rudder angle must not exceed 15°.

The separation system can be tested by draining the expansion tank.

The systems can also be separated manually by means of the safematic valve block and the by-pass valves.

Operation procedure

1. **Preparation**
1.1 Check content in hydraulic oil tanks, refill if necessary.
1.2 Check that steering gear and expansion tank shut off valves are open.
1.3 Check that Safematic valve block valve is open.
1.4 Start steering gear pump(s) locally or remotely from control room or bridge. Testing of steering gear should be carried out before leaving port. This is normally carried out from the bridge.

2. **Pumps**
2.1 During normal operation at sea only one pump is in operation
2.2 During manoeuvre and in congested waters two pumps must be in operation.
2.3 Starting and stopping of the pumps can be carried out locally or remote via the Power Chief - Pump Control system or from the bridge steering consoles.

3. Drain and oil filling
3.1 Oil and water drainage from the steering gear systems can take place from the following:
3.1.1 The bottom of each chamber in the common expansion tank
3.1.2 The button of each steering gear pump unit tank
3.2 Oil filling is done via the filling valve fitted at the expansion tank.

4. Rudder commands
4.1 Rudder command can be set manually on the autopilot.
4.2 To set specific rudder commands, select MAN and enter numeric values in %.
4.3 Autopilot can be set to specified course commands at bridge steering console.
4.4 Select ON and enter course.
4.5 Servo speed is dependent on servo oil pressure.
4.6 In bad weather, two pumps can be run to obtain quicker servo response to auto pilot.
4.7 To use the emergency steering select OFF on the autopilot.
4.8 Emergency control can be operated locally or from the bridge console.

Note that if a failure of automatic control of by-pass and safematic valves should occur, these valves have to be operated locally.

Model particulars

For studies of mutual influence between the steering gear and autopilot the autopilot is made available in the mimic diagram 58.

When the leakage fault is identified and “repaired,” the valves have to be manually put back to normal position.

Rudder command can be set manually on AUTO PILOT to study effects of sudden large variations on rudder.

Servo speed is dependent on servo oil pressure.

As long as the directional-control valve is activated, the discharge pressure is a function of the pressure drop in the control valves and system piping and at the rudder torque, and the maximum pressure is limited by the set point of the pressure-relief control valve. When the directional-control valve is **not** activated, the system pressure relief control valve is relieved, and the pump pressure decreases to a very low value (5-10 bar - caused by the very short piping around the pump unit and the return line filter).

If the rudder command causes the rudder angle to shift to one of the extreme positions, the steering gear vane is limited by the steering gear body at 35° and the pressure will increase to set point of system pressure-relief control valve (normally 75 bar). If this condition remains for a prolonged period, the oil temperature will rise. At temperature level above approx. 65°C decomposing of
the oil and pump wear will increase exponentially and end with a break down of the pump.

OPERATIONAL PROCEDURE:

Related system to be in operation: - Bus bar to be active

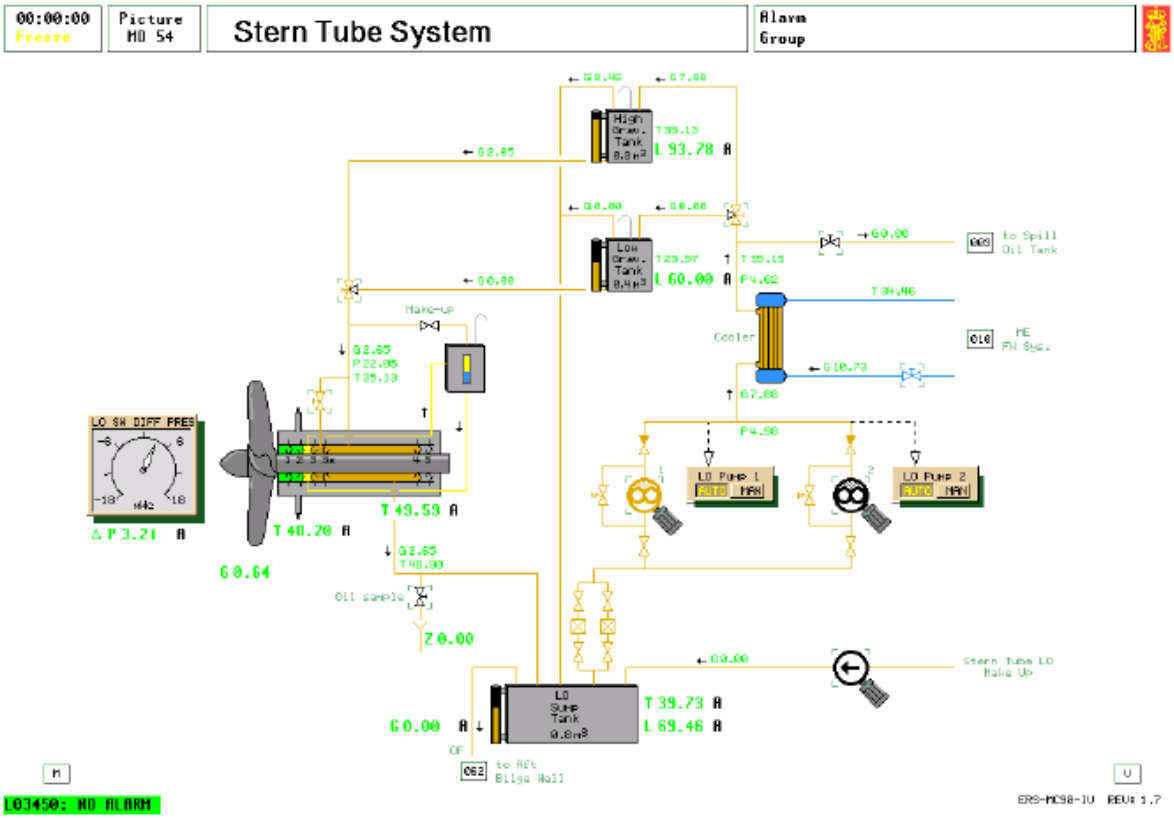
Preparation before Starting:

1. Check content in Hydraulic oil tanks and refill if necessary:
2. Check that steering gear shut-off valves are open;
3. Check that Safematic valve block valve is open (Position is from variable page);

Starting Procedure:

1. Start steering gear pump(s) locally (by pointing and clicking on pump symbol using the left tracker-ball button) or remotely from control room or bridge (by pressing the buttons);
2. Testing of steering gear should be carried out before leaving port;
3. This is normally carried out from the bridge;

4. Emergency steering to be carried by pressing the port/starboard buttons, remotely from bridge, or locally by manually controlling the control valve block position;
5. Note that if a failure of automatic control of by-pass and safematic valves should occur, these valves have to be operated locally and by hand.



XXXVII. STERN TUBE SYSTEM

General

The stern tube bearings are lubricated by two separate gravity LO tanks, one high and one low gravity. These are selectable and should be chosen according to vessel draft.

Description

The oil is pumped from the stern tube sump tank to the selected gravity tank, from where it flows to the stern tube bearings by gravity.

The gravity tank is automatically filled by one of the lubricating oil pumps and surplus oil is continuously drained to the sump tank through an overflow pipe.

The oil is cooled as it is pumped to the gravity tank. The heat exchanger is LT fresh water cooled.

If the running pump fails to maintain the level in the gravity tank the standby pump will start at low level in the gravity tank provided that the pump is in Auto mode. The low-level limit can be adjusted from the variable page.

Stopping of pumps has to be carried out manually.

Refilling of the lubricating oil sump tank is carried out by starting the make-up pump.

The oil can be transferred to the spill oil tank in case of contamination.

The stern tube has a fwd seal oil system that can be topped up from the gravity feed line.

Operation procedure

1.1 Ensure cooling water to Stern Tube cooler.
1.2 Refill lubricating oil sump tank if necessary.
1.3 Select required gravity tank using 3-way valve in filling line.
1.4 Select correct gravity feed to stern tube.
1.5 Start the lubricating oil pump in manual.
1.6 When one pump is started, set the other pump in Auto.
1.7 If the running pump is unable to maintain the level in the gravity tank, the standby pump starts automatically.
1.8 Check level of oil in sealing tank, fill from make-up valve. Drain water if required.
1.9 Stop of pumps to be carried out manually

OPERATIONAL PROCEDURE:

Related system to be in operation: - Main bus bar to be active

Low fresh water cooling system to be active

Preparation before Starting:

1. Ensure that LTFW system is opened t oLO cooler;

2. Refill circulation tank (sump tank) when needed by running make-up pump;

3. Upper or lower gravity tank must be selected depending on ship draught;

4. Selection of tank based upon differential pressure between sea water (outside ship) and LO pressure;

5. Remember to change both inlet and outlet 3-way valve;

Starting Procedure:

MANUAL Mode:

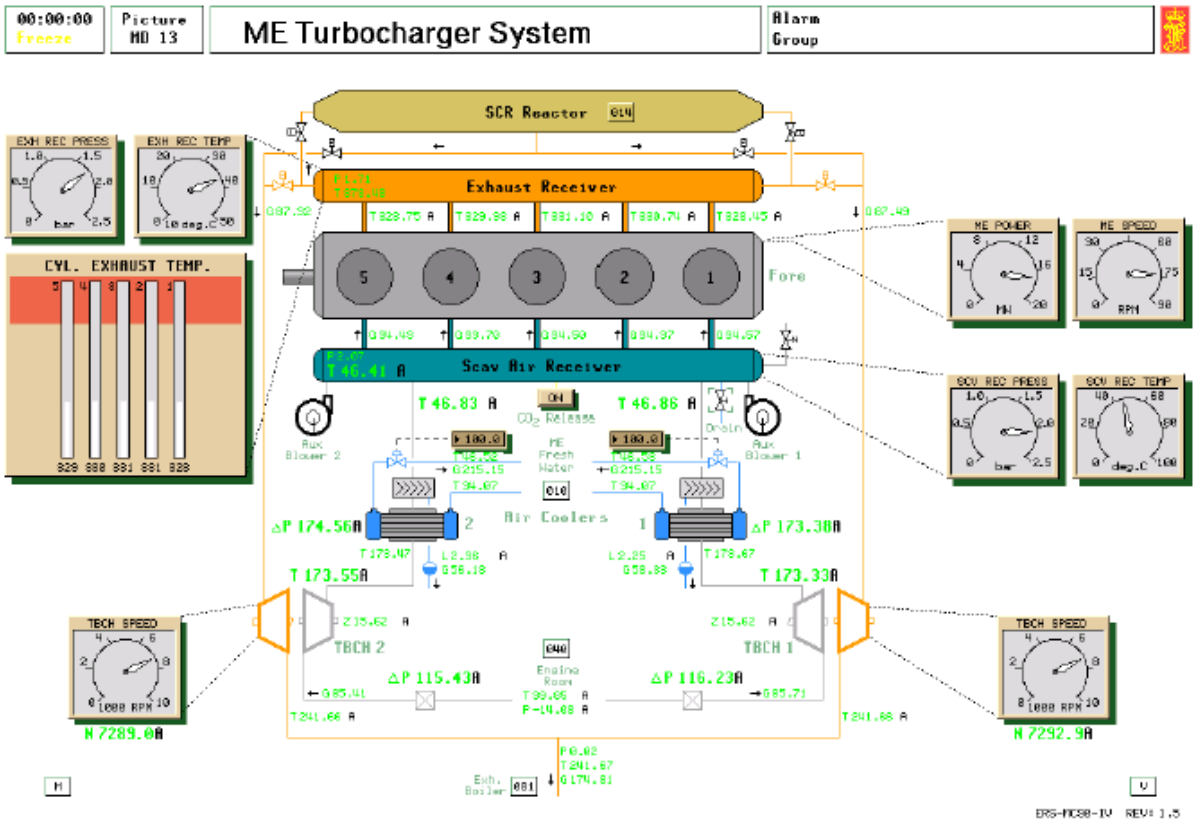
1. Start LO Pump in MANUAL Mode;

AUTO MODE:

2. After first pump is started, select other pump in AUTO Mode;

3. The standby pump will start automatically if the running pump is not able is not able to maintain the level in the gravity tank;

4. Stopping of the pump can be carried out manually.



XXXVIII. ME TURBOCHARGER SYSTEM

General

The main engine is supercharged by two constant pressure turbochargers. The turbo-charged air is cooled in a fresh water-cooled air cooler before entering the main engine.

To improve part load operation of the turbocharger system, slide valves are fitted at the outlet of the exhaust gas receiver. If automatic control of the auxiliary blowers is selected on MD20 or MD102 then during part load operation of the engine only one slide valve (into No1 turbocharger) will be open, but as the engine power increases, this will cause the other slide valve (into No2 turbocharger) will open. This will allow full engine power to be produced.

The air cooler must be kept clean to enable it to provide a sufficient amount of cool air to the engine. Hot air will lead to high exhaust temperatures, greater heat losses and increased specific fuel oil consumption.

After the air leaves the air coolers, it enters the demister units that are fitted to reduce the water content of the air. Water is drained off the demister units via the water trap, where the level and flow of the drained water can be noted from the screen display.

Dirty turbo-charger air filters throttle the scavenging airflow and will result in reduced engine performance.

The exhaust gas from the main engine cylinders enters the common exhaust gas receiver. From this receiver, the exhaust gas can either flow direct into waste heat exhaust gas boiler or via the Selective Catalytic Reduction (SCR) Receiver before entering the Exhaust Gas Boiler.

The exhaust boiler must be kept clean. High back pressure reduces scavenging air flow and engine efficiency, especially at high power.

The turbo-charger model is composed of two separate units, a centrifugal air compressor and a single stage gas turbine.

Major variables influencing the compressor torque:
- discharge pressure (air receiver)
- suction pressure (air filter differential pressure)
- air inlet temperature (density)
- compressor speed

Major turbine torque variables:
- exhaust receiver pressure
- exhaust receiver temperature
- back pressure (exhaust boiler differential pressure)
- turbine speed

The turbocharger speed is computed on the basis of the torque balance differential equation shared by the turbine and the compressor model units.

Operation procedure

1. Line up the system by opening the fresh water cooling throttle valves to air

coolers 1 and 2.

2. Ensure the scavenge air receiver drain is closed
3. Check that the SCR Reactor is isolated at engine start-up
4. Check that the Aux. Blowers 1 and 2 are running. These are operated from MD20 or MD102. Preset values for start/stop of aux. blower is respectively 0.2 bar and 0.4 bar. Slide valves can be changed to auto or manual from variable page 1301. Limits for open/close of second slide valve is available from variable page 1301, preset values are low limit = 0.4 bar and high limit = 1.5 bar.

   Note: Differential pressure across cooler and air inlet filter should be checked regularly.

OPERATIONAL PROCEDURE:

Related system to be in operation: - LTFW cooling system

Starting Procedure:

Valves from exhaust gas receiver to turbo-chargers must be opened before attempting to start engine, or when blowing through with starting air prior to start.

MANUAL Mode:

1. Select picture MD 13: "ME Turbo-Charger System";

2. Open valve for LTFW to air coolers, with setting of flow;

3. While running engine, care must be taken not to cool air below dew point in order to avoid water droplets in scavenging air resulting in high cylinder wear. (Sulphuric corrosion and loss of cylinder lubrication.);

4. Check the Slide valve controller is set to Manual (Variable Page 1301);

5. Open Slide Valves;

6. Close Waste Heat Recovery valve;

AUTO Mode:

1. After start of engine, set Slide Valve Controller to AUTO (Variable Page 1301);

2. The Slide Valves will open/close depending on exhaust gas flow.

NOTE: When running full power on main engine, fuel tanks can be heated by

Waste Heat Recovery system. Open valves and consult Waste Heat Picture (MD 65) for operation.

XXXVIII.1 MAIN ENGINE AND MAIN ENGINE SYSTEMS

XXXVIII.1.2 Main Engine

The propulsion machinery is based on one MAN B&W 5L90MC, low speed, 5 cylinder configuration, 2-stroke, turbocharged, reversible diesel engine. The main engine is coupled to a propeller shaft with both fixed pitch propeller and controllable pitch propeller (selectable by the instructor). Also a shaft generator is attached to the main engine.

Main engine data:

- Cyl Bore 900 mm
- Piston Stroke 2900 mm
- Number of Cylinders 5
- Number of Air Coolers 2
- Number of Turbo Chargers 2
- Continuous Service Rating ME 17.4 MW
- Corresponding Engine Speed 74 rpm
- Mean Indicated Pressure 13.0 Bar
- Scavenge Air Pressure 2.1 Bar
- Turbine Speed 8000 rpm
- Number of Prop. Blades 5
- Propeller Pitch 0.9 P/D
- Specific Fuel Oil Consumption 168 g/kwh

Model particulars

The main engine model ("cylinder model") is a comprehensive, semi-empirical software program module, where the result of the combustion process is calculated. Important variables are:

- Mean indicated cylinder pressures
- Mean effective cylinder pressures
- Total shaft torque
- Exhaust temperatures
- Total heat to liners (FW)
- Total heat to pistons (FW)
- Total heat to bearings (LO)

The result is dependent on several variables and the most influential ones are the following:

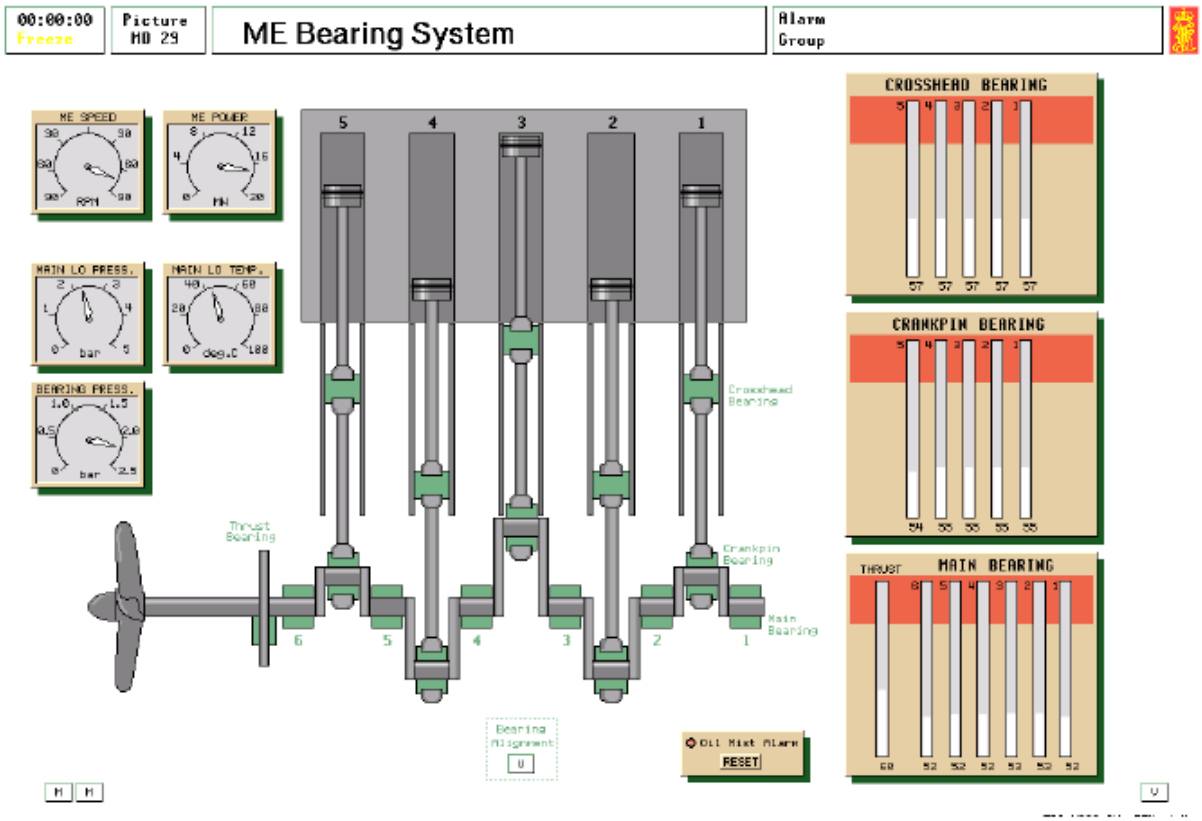
- Engine speed
- Injected amount of fuel
- Fuel heat value/viscosity
- Scavenging air pressure

- Lubricating oil inlet flow/temperature
- Jacket water inlet flow/temperature
- Mean liner metal temperature

The overall shaft torque is computed from the mean cylinder pressures. The torque balance differential equation between the propeller (water) torque and the shaft (engine) torque is then solved by integration to give the engine speed.

If the cooling water flow is reduced or cooling water pumps are stopped, the cooling effect of the fresh water is drastically reduced and the liner/exhaust temperatures will be very high. If the engine is operated without lubrication, the mechanical friction increases the piston and bearing temperatures will increase. Eventually piston seizure and bearings damage will occur. Long operation at extreme high exhaust temperatures will cause damage to the exhaust valves.

Stop of the main engine caused by physical damage on the engine is indicated by "ME damage", and may result from the following:
- Exhaust valve breakdown
- Piston breakdown
- Cylinder liner breakdown
- Bearing breakdown
- Fire damage



XXXIX. ME BEARINGS

General

The screen provides the operator with a clear display of all bearing temperatures within the engine, as well as the main parameters that affect bearing load, such as main engine speed, engine power, and the lubricating oil supply.

The bearing temperature depends on the cylinder power, the lubricating oil flow and temperature, and ambient temperature.

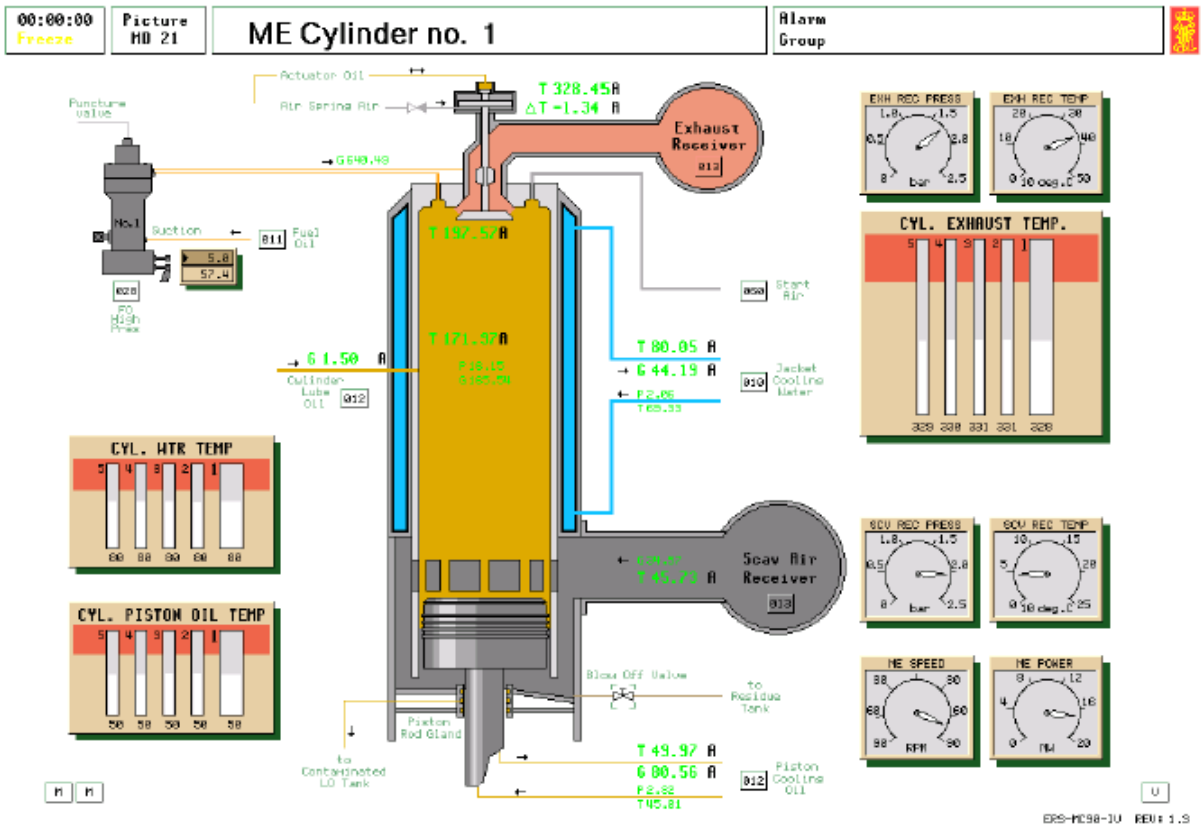
The shaft friction includes static friction as well as speed dependent friction.

Comparisons between the various bearings can be easily made, and should a bearing temperature increase above 80°C, then the indicating bar will change to red to aid identification. At the same time the bearing concerned will also change color to red.

The screen will also display the presence of oil mist within the crankcase, as well as which units are affected. Should oil mist be detected, then the engine protection system will activate, and an engine slow down will occur.

The MAN B&W procedures for reaction to an oil mist alarm, or other alarms that could lead to the oil mist situation are the following:

1. Reduce engine power/pitch down to slow-down level, if this is not an automatic function. This will drastically reduce the load on the engine bearings, and hence the production of oil mist.
2. Contact bridge, and ask to STOP engine. If the vessel is in a confined area, it may not be possible to stop the vessel. Hence the engine would continue on **minimal power**.
3. When stop order is received, stop the engine and close the fuel supply to the engine by stopping the booster pumps. This will **reduce** the oil mist in the crankcase as the engine cools.
4. Switch off the auxiliary blowers.
5. Open engine room casing. This will reduce the pressure rise in the engine room should the crankcase relief devices operate
6. Personnel to vacate engine room. This is for the personnel safety of the engine room staff should flames issue from the relief valves. It may be prudent to have a minimal staff in the control room to monitor the situation, and to maintain the main services, but under no circumstances should personnel operate on the exhaust of the engine.
7. Prepare firefighting equipment. A safety precaution against outbreaks of fire in the engine room, from any flames issuing from the crankcase relief doors.
8. **Do not open the crankcase until after at least 20 minutes.** You must allow time for the oil mist to cool and fully condense. It is also recommended that the oil mist detector alarm level should reset, which indicates that the oil mist levels are well below the Lower Explosive Limit. Obviously no naked flames should be used on the initial entry.
9. Stop all lube oil pumps. To allow personnel entry into the crankcase.
10. Isolate the starting air, and engage the turning gear.
11. Open the crankcase doors, and inspect the following areas for overheating:
    - Main and bottom end bearings
    - Thrust bearing
    - Crosshead bearings
    - Piston rods
    - Stuffing boxes
    - Chains
    - Vibration dampers
    - Moment compensators
    - Telescopic pipes
    - Cracked piston crown, allowing oil mist to enter crankcase via cooling oil return
    - Overheated diaphragm, from a scavenge fire
12. Overheating can be identified by
    - Melted or squeezed white metal from the bearings
    - Discoloration of the crankcase paint in the vicinity
    - Burnt or carbonized oil deposits
    - Excessive bearing clearances
    - Excessive oil flow from a bearing



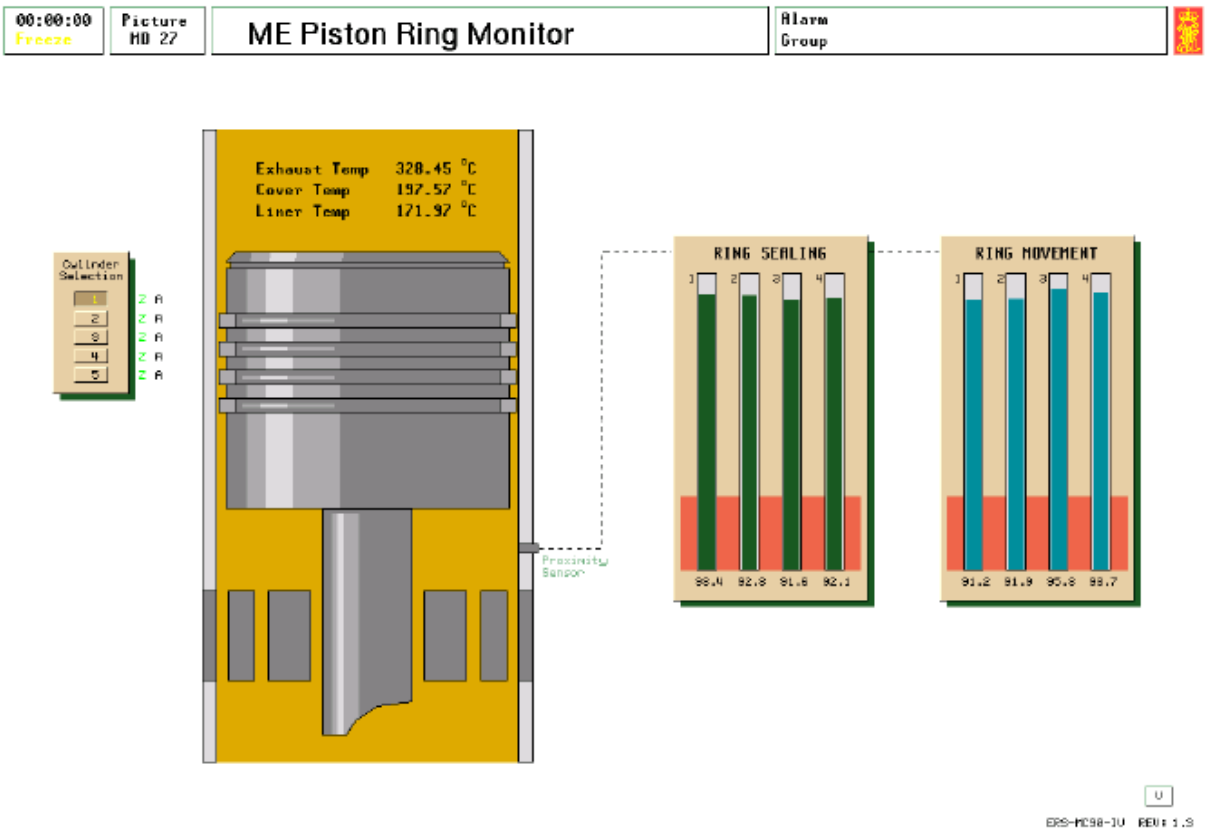
XL. ME CYLINDERS

General

The five screens are indications only of the various parameters present. The following indications are present:

- Cylinder exhaust temperature, and deviation from the average exhaust temperature.
- Cylinder water temperature and deviation from the average water temperature.
- Cylinder piston oil temperature and deviation from the average piston oil temperature.
- Exhaust receiver pressure and temperature gauges.
- Cylinder exhaust temperature ball chart illustrating each cylinder.
- Scavenge receiver pressure and temperature gauges.
- Piston oil cooling temperature and flow indications
- Main engine speed and power gauges.
- Cylinder oil flow
- Fuel pump rack and VIT setting

A blow down valve to drain the contents of the scavenge receiver is provided on each cylinder screen. This valve should opened twice daily.



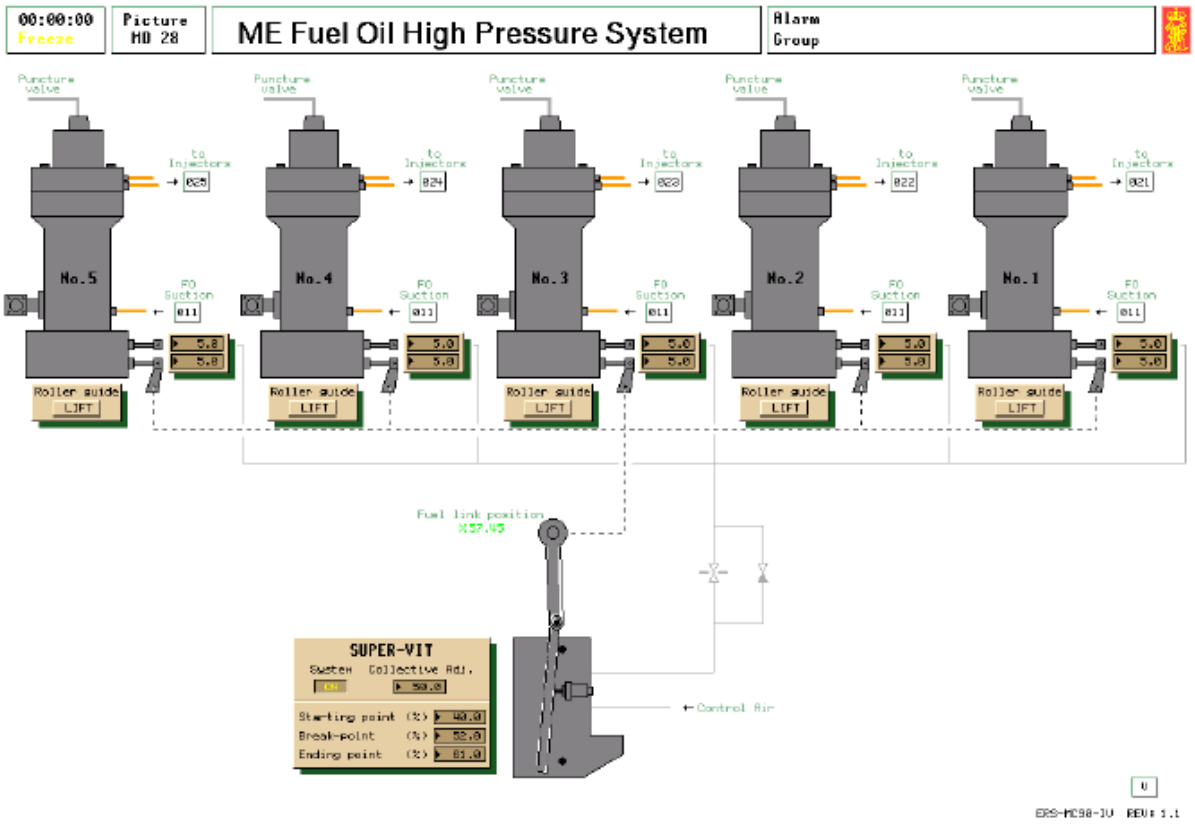
XLI. ME PISTON RING MONITOR

General

The screen provides an indication of the piston ring condition within each cylinder. Two bar charts are provided for each cylinder. The cylinder can be selected. It provides a display for each piston ring for sealing and movement.

Under normal circumstances the ring sealing and movement will be high. Should the ring wear increase then the ring sealing will reduce, whereas should the cylinder lubrication be reduced, then the ring movement will reduce.

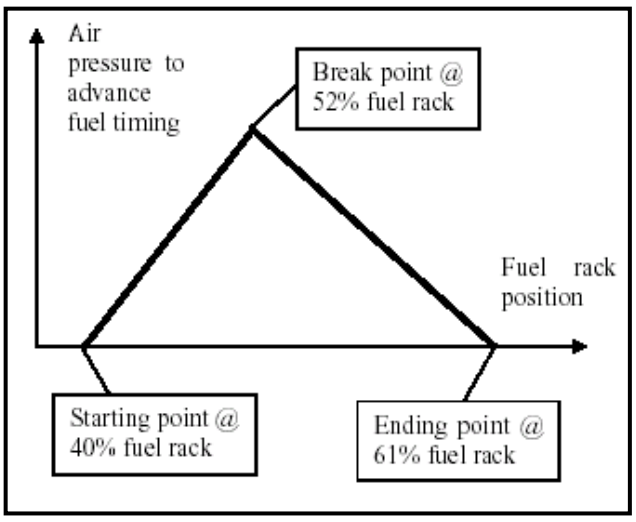
When the ring sealing and movement reduces below an acceptable level, then an alarm will be activated.



XLII. ME FUEL OIL HIGH PRESSURE SYSTEM

General

The screen indicates the Variable Injection Timing (VIT) system for the engine. VIT will advance the fuel timing to raise the combustion pressure at engine loads below 100%, and hence improve the fuel efficiency. The start and finish of the fuel advancement can be adjusted over the range of the engine, by means of the starting and ending point.



To adjust the timing of the fuel pumps, three options are available:

a) The individual adjustment at the upper control lever (to compensate for the wear within the fuel pump the timing would be advanced. 1mm reduction in the fuel pump setting is approximately 0.8° advancement.)

b) The collective adjustment input (to compensate for the quality of the supplied fuel. Reducing the collective setting by 10% would advance all fuel pumps by 0.8°)

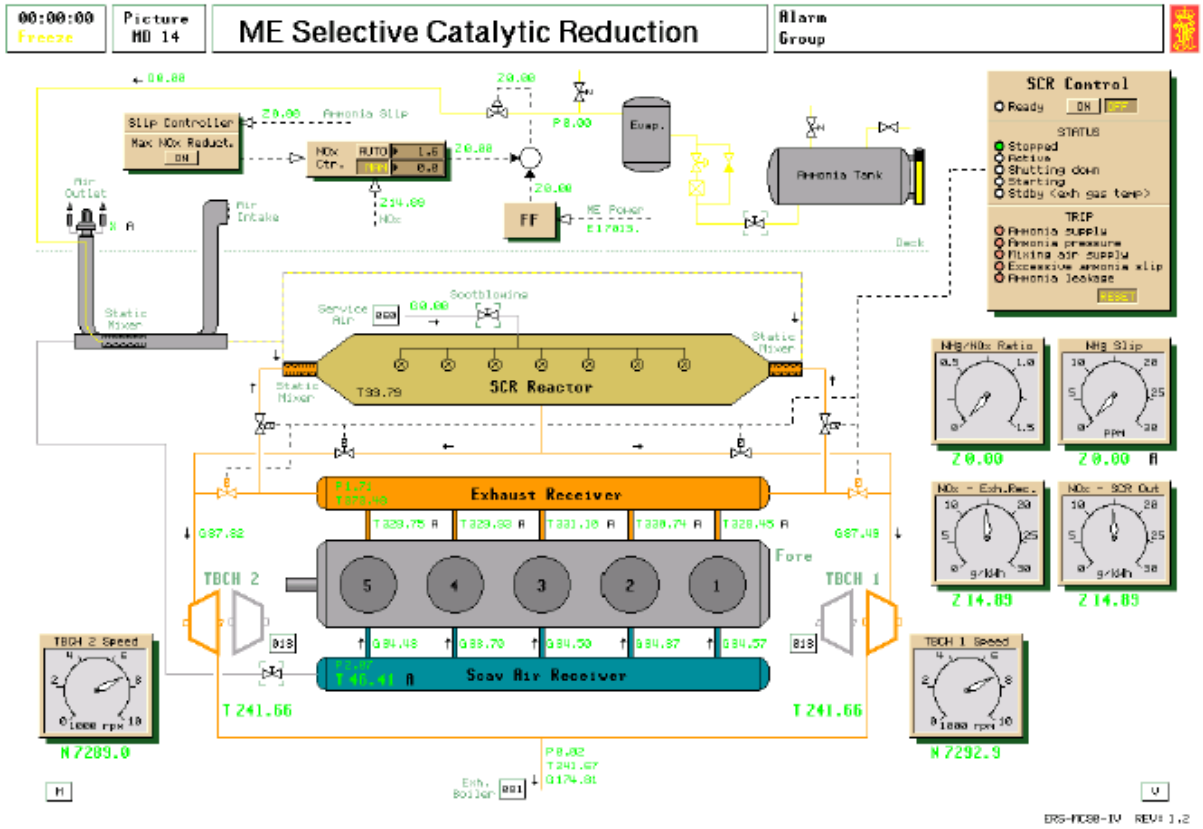
c) The variable adjustment due to fuel rack position (to increase the fuel efficiency of the engine. Dependant upon the start, break and end points, with default settings of 40, 52 and 61% to achieve actual engine characteristics)

The actual VIT advancement applied to each fuel pump is displayed beside the upper fuel pump control lever and is the summation of the above three options.

Hence each individual fuel pump can be adjusted to provide the optimum fuel timing with regard to fuel type and quality and engine load. Excess fuel timing advancement should be avoided as this will cause these likely problems:

a) Increase the maximum combustion pressure, and hence cylinder and bearing loading
b) Affect the ability of the engine to start effectively

Following adjustments to the VIT system the operator should monitor the combustion pressure over the complete engine load range, especially from 50 – 100% load using the Cylinder Indication screen MD120.



XLIII. ME SELECTIVE CATALYTIC REDUCTION

General

The Selective Catalytic Reduction unit is provided to reduce the environmental impact of the diesel engine by minimizing the Nitrogen Oxides (NOx) emitted from the main engine exhaust stream.

The SCR unit is used to treat the exhaust before it enters the turbocharger. Ammonia is added to the gas stream, and the mixture then passes through a special catalyst at a temperature between 300 and 400oC. Within the SCR Reactor the hot exhaust gases that contain NOx gases are mixed with the ammonia stream. This reduces the NOx to N2 and H2O, as detailed:

$$4NO + 4NH_3 + O_2 = 4N_2 + 6H_2O$$

$$6NO_2 + 8NH_3 = 7N_2 + 12H_2O$$

If the temperature of reaction is too high (above 490°C), the ammonia burns and does not react, and at low temperatures (below 250°C), the reaction rate is low and the catalyst can be damaged.

The quantity of ammonia added is pre-programmed into the controlling processor. This provides the base control, with a feed back link provided

by the NOx measurement taken from the exhaust stream. Using the feedback link alone would produce inaccurate control due to the sluggish nature of the reaction process; hence, a feed forward signal from the main engine actual power is used to modify the controller output.

The Slip controller will adjust the NOx controller set point down with the specified rate when the slip is below the slip set point (default 3ppm), and up when the slip is above. This “optimal” mode will be turned off if the NOx controller is not in auto, or if the control state is not “active”, and it has to be manually switched on again. The SCR slip controller controls the rate at which the ammonia flow is changed. Within the pop-up window, these settings can be adjusted, with the default setting of increase 0.02 g/kWh/sec, and decrease 0.01 g/kWh/sec.

The quantity of ammonia which can be added is limited, as excess amounts produce "ammonia slip", by which neat ammonia leaves with the exhaust stream. Thus both ammonia and NOx levels are recorded in the exhaust stream, and levels of 10ppm and 5g/kWh expected values. These values are reduced from the engine cylinder exhaust NOx level in the region of 20 g/kWh.

The ammonia is supplied as pressurized water free ammonia feed. The process units are contained within a safety area, as ammonia is combustible. Thus lines are double walled, and leak detection and appropriate venting of the storage and process areas must take place.

Operation procedure

1. Line up the system by opening the scavenge air valve to the air/ammonia static mixer.
2. Open the outlet valve from the ammonia tank so that the ammonia vapour pressure rises.
3. Input 5 g/kWh as the set value for the NOx controller, and place the controller in AUTO.
4. When the SCR control ready light is lit, then the SCR control can be selected
5. This will allow the automatic valves to change the exhaust gas flow into the SCR Reactor

The SCR control panel indicates the status of the system, with the following indications:

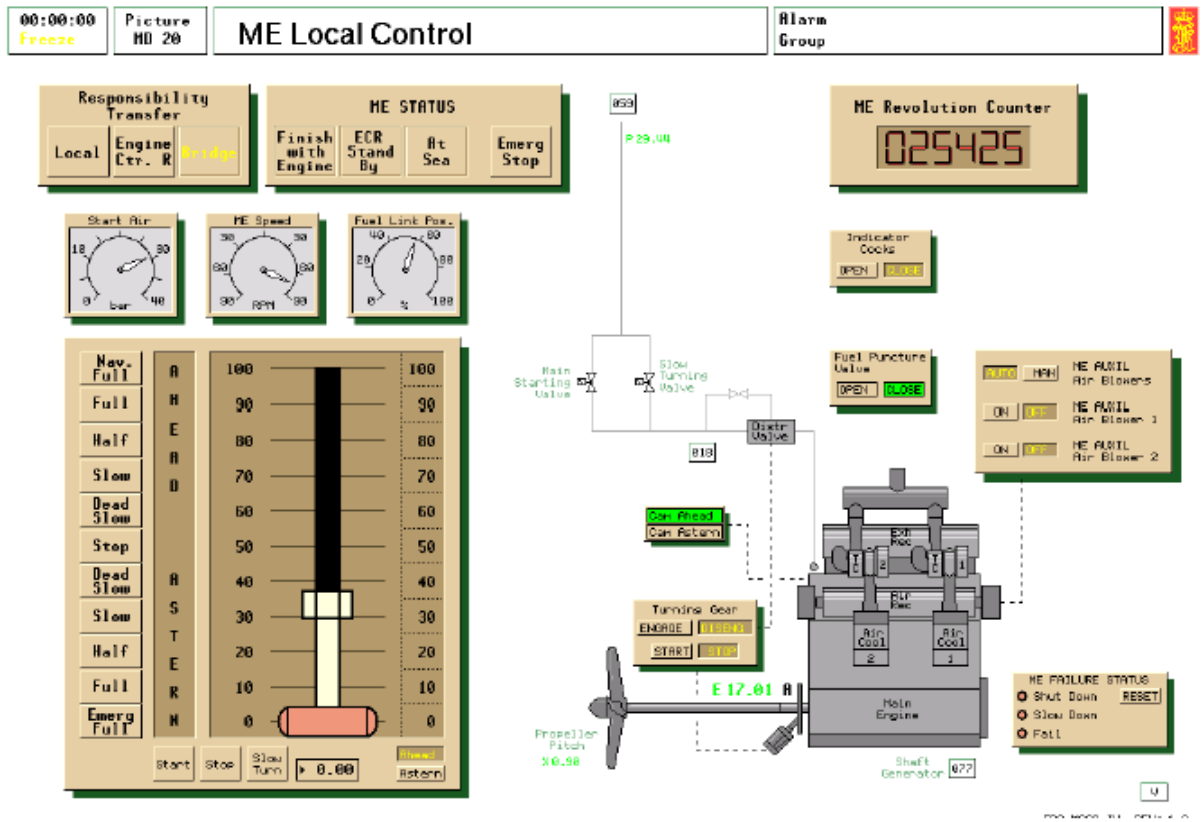
- Stopped. When the system is non-operational
- Active. The system is operational, hence the SCR Reactor bypass exhaust valves are closed and all the exhaust gas flow is directed through the reactor, and the ammonia inlet to the static mixer is open.
- Shutting Down. The system is changing from active to stopped, by changing the exhaust gas flow path from the exhaust receiver direct to the turbochargers. Note that during the shut down period (15 second default setting), both the bypass and direct flow paths are open to prevent a sudden

change in the turbocharger operation parameters and to allow the reactor to gradually cool down.

- Starting. The system is changing from stopped to active, by directing the exhaust gas flow from the exhaust receiver to the SCR Reactor. During the starting period (default 30 seconds) the SCR bypass and inlet /outlet valves are open to allow a gradual heating up of the reactor, and prevent a possible turbocharger surge by rapid change to the turbocharger turbine speed.
- Standby (exh gas temp). When the control system is selected ON, the exhaust temperature must be within pre-set temperatures to enable the system to start. These temperatures are adjustable, and the default settings are low limit 250 °C or high limit 490 °C.

The system will cease to operate if a trip is active. This will occur if any of the following occurs:

- Ammonia supply. When the ammonia supply is insufficient due to a low level in the ammonia tank, then the system will trip.
- Ammonia pressure. When the ammonia pressure is above 2.5 bar, then the system will trip.
- Mixing air supply. When the scavenge air flow into the static is low, then the system will trip.
- Excessive ammonia slip. When the quantity of ammonia input to the reactor is excessive, then the level of ammonia within the exhaust stream rises. This slip of the ammonia is measured, and when this reaches 60ppm for over 30 seconds, the system will trip.
- Ammonia leakage. As ammonia can produce a flammable and/or explosive mixture with air, any leakage in the deck housing containing the ammonia system is monitored and will cause the system to trip.



XLIV. ME LOCAL CONTROL

General

Local control of the main engine is provided to enable operation and control of the main engine should a defect or malfunction of the main control or maneuvering system occur.

In Local control the automatic thermal load programme, main governor functions, and slow down protection is overridden.

The local control panel contains the following operating functions:

- Local fuel control lever. This is directly connected to the fuel linkage. The fuel control lever can be moved by either a direct input, or by selecting a fixed step on the right of the fuel control lever.
- Emergency telegraph. This is automatically linked with the Bridge telegraph when the local control is selected by both the Bridge and Local Control stations.
- Indicator cocks. These can be opened or closed. The cocks would be opened during engine shut down, and closed when the engine is started.
- Auxiliary Blowers. These can be stopped or started in manual control, as well

as being placed in automatic control for blower stop and start via the pressure switch on the scavenge air manifold.
- Turning gear engage and disengage. Once the turning gear is engaged, it can be started to turn the engine before the engine is started. This will ensure that no water has collected within the main engine cylinders. NB The indicator cocks should be opened whilst the turning gear is operating.

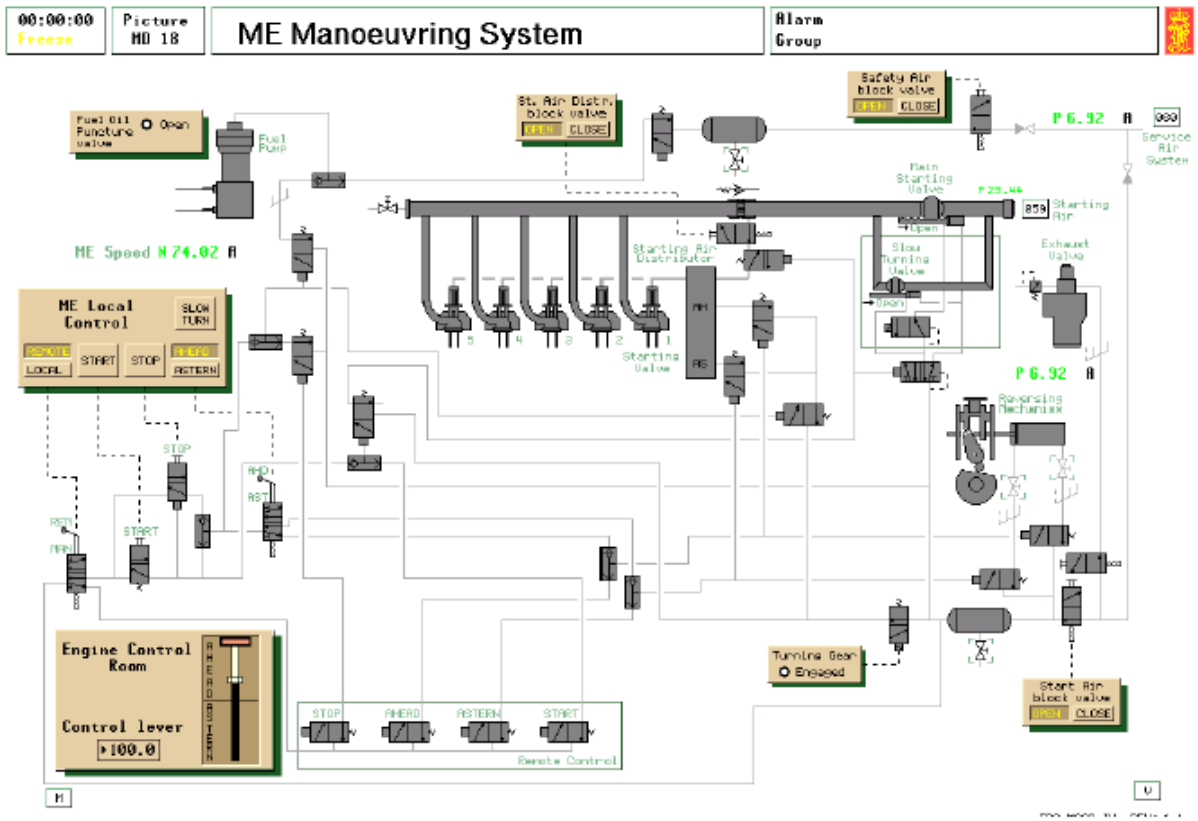
There are status indicators for the following:

- Fuel Puncture valve. The stop command for the engine will open the puncture valves. When the engine is running normally the puncture valves will be closed.
- Camshaft position. This indicates whether the camshaft is in the ahead or astern position.
- ME Failure status. This indicates locally whether there is a shut down, slow down or failure present. All three main engine protection system can be reset at this local panel.

Starting procedure of the main engine at the Local Panel

1. The local control is selected at either the Engine Control Room or Bridge. This will cause the local station indicator to flash.
2. The command is accepted at the local control panel. This will cause the local station indicator to remain lit.
3. The Bridge should select ECR Standby to indicate that engine operations are required.
4. The turning gear should be disengaged.
5. The Indicators Cocks should be closed.
6. The maneuvering system should be prepared (Ref #### on MD18)
7. The ME Failure status should be checked, and any failure reset. If the failure can not be reset then the ECR panel should be consulted on MD104.
8. The auxiliary blowers should be placed on automatic, and the auxiliary blowers should start.
9. The Emergency telegraph should be observed, and any command from the Bridge acknowledged.
10. The fuel lever should be moved away from the stop position to fulfill the Bridge request. The puncture valve will automatically close.

NB Before starting the engine after prolonged stop, always “blow through” engine with starting air with indicator cocks open.



XLV. ME MANEUVERING SYSTEM

General

This drawing illustrates the components required to start, stop, and reverse the main engine. The process diagram shows the main inputs from the local control and engine control room that starts the engine.

Before the engine can be started in any selected control position, the following valve position should be set:

1. The safety air block valve 16 should be open. This valve supplies the air to the fuel pump puncture valves should an engine safety trip be activated.
2. The starting air distributor block valve 127 should be open. This valve supplies the pilot air to open the individual cylinder starting valves.
3. The starting air block valve 1 should be open. This valve supplies the control air to the maneuvering system.
4. The turning gear valve 115 should be disengaged. This supplies the control air to valve 33 and hence would block the start sequence if engaged.
5. The pressure of the service air supply should be checked to be above 6.5 bar
6. The pressure of the starting air supply should be checked to be above 25 bar.

Engine START operation in local control

1. To control the engine system at the engine side control, the local control is selected at the ME Local Control station. This will cause valve 100 to pressurize valves 101 and 102.
2. Once in local control, the engine can be started, stopped, and reversed at the local control panel.
3. To start the engine the start button is pressed which will activate valve 101. This action will activate valves 33, 25, and 117.
4. When 33 is activated, both valves 26 and 27 will operate. Valve 26 will supply the starting air distributor with pilot or starting air valve operating air. Valve 27 will cause valve Main starting valve to open pressurizing the starting air manifold with high pressure 30 bar starting air.
5. When 25 is activated, the fuel pump puncture valves are pressurized to ensure that fuel is not admitted during the air start admission period.
6. When 117 is activated, control air is admitted to valves 14 and 15. The selection of which valve 14 or 15 then admits air to activate the starting air distributor to the ahead or astern position is determined by the selection of ahead or astern at the ME Local Control station. Once the starting air distributor is in the end position or ahead or astern that the starting air distributor will allow the control air admitted via valve 26 to the correct cylinder starting valve that will cause the engine to rotate in the desired direction.
7. The engine speed will now increase due to the admission of the starting air. Once sufficient engine rotational speed has been reached (above 20 rpm CHECK), then the start button is pressed once again to release the start command. Releasing the start command will vent the valves 33, 25 and 117.
8. The speed of the engine would now be regulated by the position of the fuel control lever on MD20.

Engine STOP operation in local control

1. To control the engine system at the engine side control, the local control is selected at the ME Local Control station. This will cause valve 100 to pressurize valves 101 and 102.
2. Once in local control, the engine can be started, stopped, and reversed at the local control panel.
3. To stop the engine the stop button is pressed which will activate valve 102. This action will activate valves 25 and 117.
4. When 25 is activated, the fuel pump puncture valves are pressurized to stop the fuel pump admitting any more fuel and hence the engine will stop.
5. When 117 is pressurized; the starting air distributor is pushed to the ahead or astern position (as dictated by valve 105), but the engine will not start as valves 26 and 27 are not energized.

Engine AHEAD operation in local control

1. To control the engine system at the engine side control, the local control is selected at the ME Local Control station. This will cause valve 100 to pressurize valves 101 and 102.
2. Once in local control, the engine can be started, stopped and reversed at the local control panel.
3. To start the engine in the AHEAD direction, then the Ahead button is pressed which will cause valve 105 to pressurize the Ahead signal line. This will in turn activate valves 14 and 10.
4. When 14 is activated; the starting distributor will be moved to the ahead position when the start signal is activated.
5. When 10 is activated, the fuel pump reversing mechanism on all five fuel pumps will be moved to the ahead position, once the engine starts to move in the ahead position.
6. The selection of the ahead position is maintained whilst the engine is running. If the engine is to be operated in the astern direction, then the engine should be stopped first.

Engine ASTERN operation in local control

1. To control the engine system at the engine side control, the local control is selected at the ME Local Control station. This will cause valve 100 to pressurize valves 101 and 102.
2. Once in local control, the engine can be started, stopped, and reversed at the local control panel.
3. To start the engine in the ASTERN direction, then the Astern button is pressed which will cause valve 105 to pressurize the Astern signal line. This will in turn activate valves 15 and 11.
4. When 15 is activated, the starting distributor will be moved to the astern position when the start signal is activated.
5. When 11 is activated, the fuel pump reversing mechanism on all five fuel pumps will be moved to the astern position, once the engine starts to move in the astern position.
6. The selection of the astern position should be maintained whilst the engine is running. If the engine is to be operated in the ahead direction, then the engine should be stopped first.

Engine AHEAD START operation in remote control (Bridge or Engine control room)

1. To control the engine system at one of the remote positions, i.e., Bridge or Engine control room, the remote control is selected at the ME Local Control station. The new control station position will then be determined by the selection of either Bridge or Engine Ctr. Room on screens MD104 or MD110.This will cause valve 100 to block the air supply to valves 101 and 102.
2. Once in remote control, the engine can be started, stopped and reversed by operation of the single control lever.

3. To start the engine, the fuel lever is moved away from the stop position in the ahead direction, which will activate valves 86 and 90.
4. When 86 is activated, both valves 14 and 10 will operate. Both valves will ensure that the starting air distributor and fuel pump reversing mechanism are in the required ahead direction.
5. When 90 is activated, and then valve 33 is activated. This will allow valves 26 and 27 to be activated. Valve 26 will supply the starting air distributor with pilot or starting air valve operating air. Valve 27 will cause valve Main starting valve to open pressurizing the starting air manifold with high pressure 30 bar starting air.
6. Note the fuel pump puncture valves are still pressurized via valves 84, 38, and 25. This signal is only reached when the start level RPM is reached, about 20 rev/min.
7. The engine speed will now increase due to the admission of the starting air. Once sufficient engine rotational speed has been reached (start level RPM), then valves 84 and 90 are released and, following a small time delay, valve 86. This will vent the valves 14, 10, 33, 26, 27, 33, 38, 25 and 117.
8. The speed of the engine would now be regulated by the position of the fuel control lever on either MD104 or MD110.

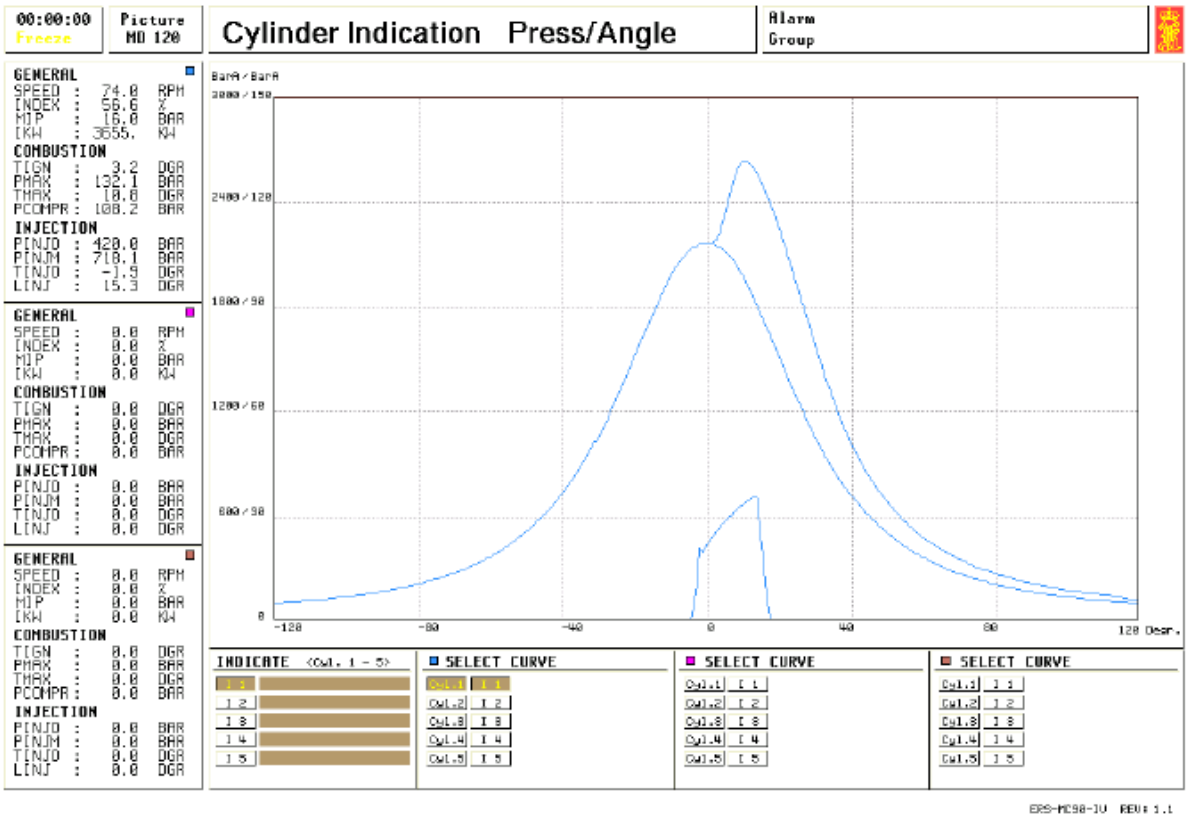
Engine STOP operation in remote control

1. To control the engine in remote control, the regulating lever is placed at zero. This will cause valve 84 to pressurize valve 38, which in turn will activate valve 25.
2. When 25 is activated, the fuel pump puncture valves are pressurized to stop the fuel pump admitting any more fuel and hence the engine will stop.
3. Valve 117 is also pressurized, so that upon starting the starting air distributor will quickly move to the desired position.
4. The stop signal on valve 84 is only released when the regulating lever is moved above the start position and the engine has started.

Slow turn operation

This engine is fitted with a slow turn arrangement that will slowly turn the engine when started. This arrangement would be manually selected when the engine has been stopped for over 30 minutes to prevent any possible cylinder damage from water leaking into the cylinder liner.

1. When the slow turn button is pressed then the valve 28 is activated. Any subsequent start sequence will only allow the small slow turning valve to open and block the opening of the man starting valve.
2. When the engine has rotated by at least one complete revolution, then the slow turn button is pressed once again to release valve 28 and hence allow the main starting air valve to open, and the engine speed should now increase to reach the start level RPM.



XLVI. CYLINDER INDICATIONS

IV.3.13.1 Press/Angle

General

The cylinder indicator is used as a teaching aid and investigative system to enable regular monitoring of the engine cylinders to be undertaken. Faults within the combustion system can be located and cleared using the malfunction editor function.

There are four different displays that can be selected to indicate the cylinder pressure conditions, namely pressure/angle (also called a draw card or out of phase diagram), pressure/volume (also called a power card, or in-phase diagram), the weak spring diagram, and the delta pressure/angle diagram. Each diagram can be used to illustrate differing combustion traits.

The pressure/angle diagram would be used for the following:
• Display the compression pressure curve, for comparisons with the other cylinders, to indicate cylinder sealing efficiency
• Display the approximate timing of the fuel ignition
• Display the fuel pressure trace (using the alternate pressure measurements of
0-3000bar.

To enable the cylinder indicator to measure the combustion

pressure, the following actions are required:

1. Select one of the field button (I1 to I5) in the INDICATE column
2. Type in your identifying comments in the INDICATE field to aid future fault identification.
3. Select the same field button (I1 to I5) in the SELECT CURVE column. Either the blue, magenta, or brown curve can be selected.
4. Select the cylinder 1 to 5 that you wish to be measured.

To measure and compare the same cylinder after a period of operation, or when a malfunction is present, using cylinder 2 as an example:

1. Carry out the tasks 1 to 3 above using the blue curve column and I2.
2. Select cylinder 2 to measure.
3. Select another field button (not chosen in point 1 such as I3) in the Indicate column.
4. Type in your identifying comments in the Indicate field.
5. Select I3 in Select Curve of the magenta column.
6. Select cylinder 2 to measure the combustion parameters of cylinder 2 again.

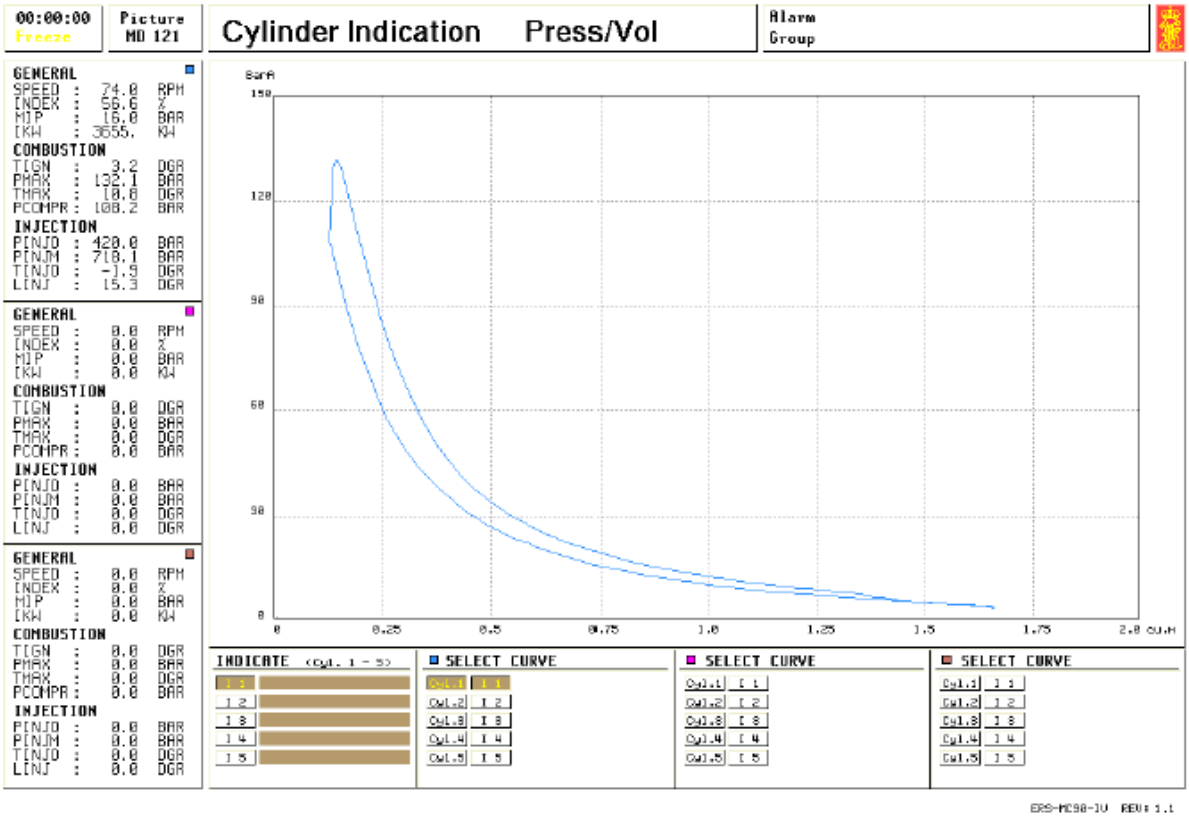
The following parameters are displayed in the numeric data display, in the instant when the cylinder indicator is taken and once a cylinder is selected together with the two indicate (I) buttons:

Speed - This is the engine speed (N).
Index - his is a measure of the fuel index
MIP - This is the Mean Indicated Pressure (MIP) measured in bar. This pressure is the equivalent pressure that acts on the piston throughout its vertical power stroke.
IkW - This is the Indicated Power of the cylinder, and is calculated from
MIP × piston working of volume × N
T_{IGN} - This is the timing of the ignition. The time between the T_{INJO} and T_{IGN} indicates the ignition delay present for that cycle. Increasing ignition delays will cause increased P_{MAX} and large delta pressure/angle (δP/δá)
P_{MAX} - This is the maximum pressure present during the working cycle. This will be affected by the quantity and timing of the fuel admission.
T_{MAX} - This is the position of the maximum temperature during the working cycle.
P_{COMPR} - This is the pressure due to compression alone after the compression stroke. It provides valuable information to the efficiency of the compression stroke, and the sealing efficiency of the piston rings, liner, and cylinder cover valves.
P_{INJO} - This is the fuel pressure when the fuel injector opens. It provides useful information that the fuel injector is correctly adjusted.
P_{INJM} - This is the maximum fuel pressure generated by the fuel pump. This indicates the internal sealing properties of the pump, and whether internal wear is present.

TINJO - This is the timing of the fuel injection. The fuel pump timing will change when the VIT operation is selected on MD28, but it should be similar for all fuel pumps.

LINJ - This is the length of the fuel injection period, and is dependant on the setting of the fuel control lever.

On the lower part of the diagram, the button Zoom can be used to zoom the diagram in horizontal direction to 300%. The button Spread is used to move overlaying curves apart vertically.



XLVII. PRESS/VOLUME

General

The pressure/volume diagram displays the classical p~V diagram used in thermodynamic calculations to measure the power produced within a cylinder. The x–axis displays the swept volume of the piston.

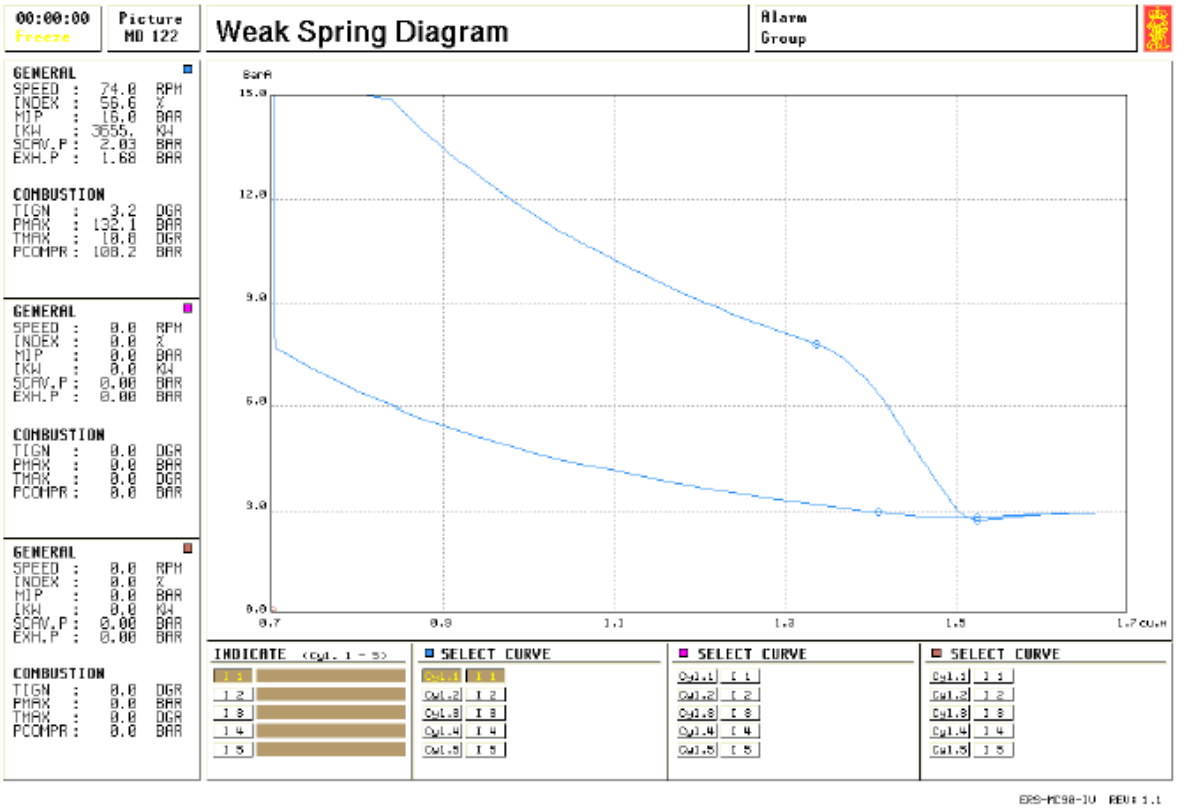
The pressure/volume diagram would be used for the following functions:

- Display the classical power diagram, where the area within the diagram equates to the power developed by that power stroke.
- Display the maximum pressure
- Display the expansion curve and thus indicating whether there is slow burning fuel or afterburning of the cylinder combustion products present.

To enable the pressure indicator to measure, the same procedure is required as for any of the cylinder indication screens. Once one screen has been activated, ALL screens will indicate the same numerical information on the left side of the screen display, although the graphical information will change.

To enable the cylinder indicator to measure the combustion pressure, the following actions are required:

1. Select one of the field button (I1 to I5) in the INDICATE column
2. Type in your identifying comments in the INDICATE field to aid future fault identification.
3. Select the same field button (I1 to I5) in the SELECT CURVE column. Either the blue, magenta, or brown curve can be selected.
4. Select the cylinder 1 to 5 that you wish to be measured.



XLVIII. WEAK SPRING DIAGRAM

General

The weak spring diagram displays the scavenging process of the cylinder. The graphical display identifies the position of the opening of the exhaust valve, the opening and closing of the scavenge ports (same point before and after bottom dead centre), and the closing of the exhaust valve.

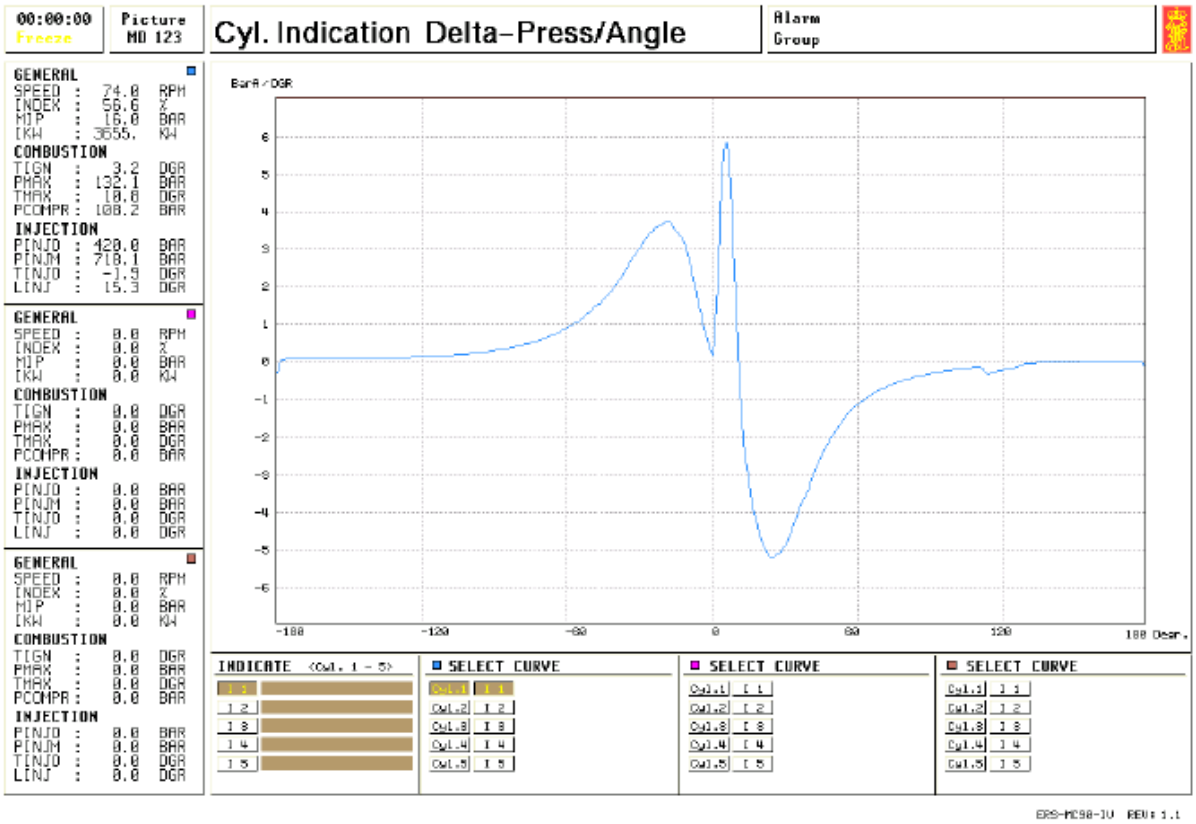
The weak spring diagram would be used for the following:

- Display the effects of fouled scavenge ports
- Display the effects of a leaking exhaust valve

To improve the display two zoom buttons are present at the base of the screen.

Zoom 1 This enlarges the pressure scale from 0-15bar to 0-6 bar

Zoom 2 The enlarges the scale to 1.0 to 3.5 bar, and displays the actual pressure within the exhaust and scavenge manifolds as dotted horizontal lines.



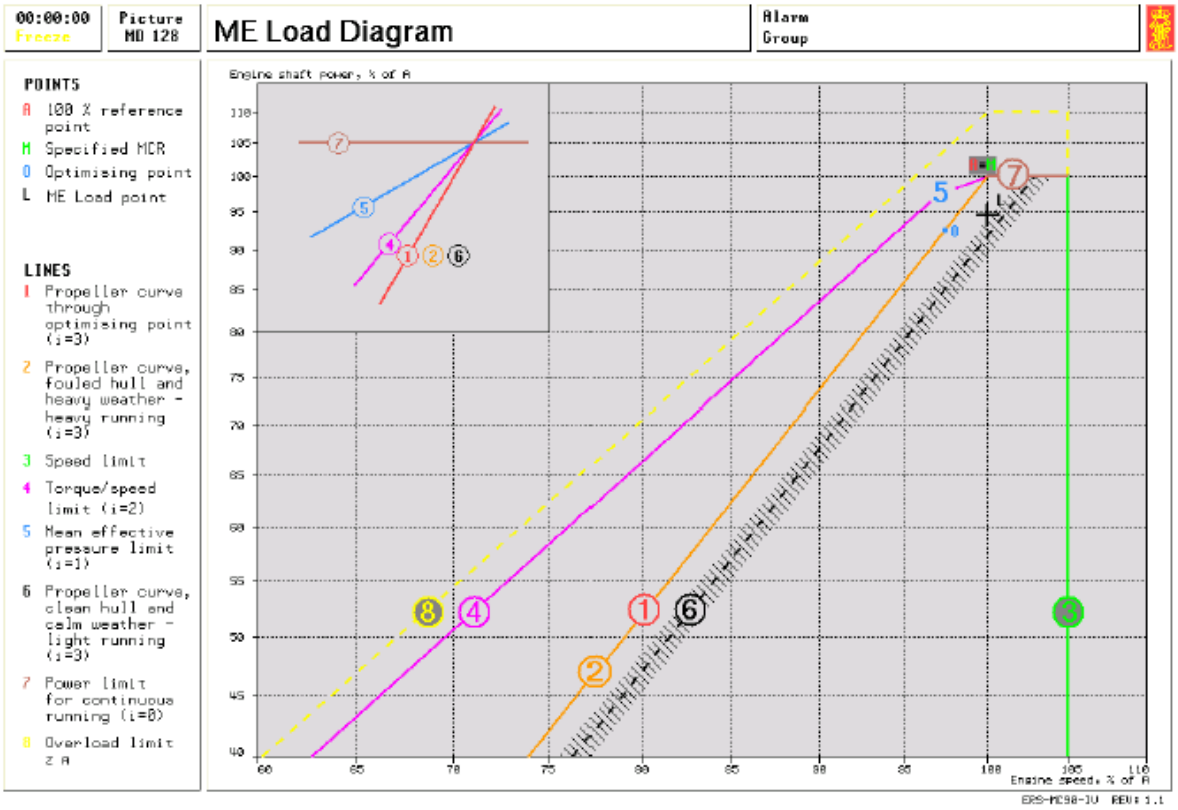
XLIX. DELTA-PRESS/ANGLE

General

The delta pressure/angle or pressure derivative graph is used to provide additional information about the combustion process by displaying the rate at which the pressure changes within the combustion chamber.

The delta pressure/angle diagram would be used for the following:

- Display the point when fuel ignition occurs
- Measure the maximum rate of pressure rise within the cylinder, to prevent shock loading damage to the piston rings and crosshead bearings.



L. Load Diagram

General

The load diagram is used to provide a graphical representation of the engine power and speed at any given time of the engine operation.

Logarithmic scales are used for both power and speed, so that the relationship PáN³ between them for a fixed pitch propeller installation can be shown as a straight line. The load diagram also provides valuable information about the limitations of engine operation. Normally the engine would be expected to operate within the limits of line 1-7 and 100% speed, but during shallow water operations, heavy weather, and during load-up periods, then operation within lines 4-5-7-3 are permissible.

These specific lines are the following:

Line 4 This represents the limit of thermal loading that should be placed on the engine. Should the engine operate to the left of this line, then there is insufficient air for combustion, and hence this will impose a limitation of the torque the engine can produce at a given speed.

Line 5 This represents the maximum mean effective pressure the engine can produce under continuous operation.

Line 7 This represents the maximum power the engine can produce under continuous conditions (100% of Maximum Continuous Rating (MCR))

Line 3 This represents the maximum acceptable speed under continuous operation (105% of the given speed for that engine)

Line 8. This represents an overload condition of the engine. The engine is designed to be able to operate for 1 hour in 12 between the lines 4 and 8, but in moderately heavy weather, engine overload would easily occur when operating close to line 4 due the varying load imposed on the engine.

Within this normal operating range, the lines of 1, 2 and 6 represent the relationship of $PáN^3$, thus reflect the expected operation of the engine for various conditions.

Line 1 represents the expected operation of the engine with the shaft alternator operating. This line passes through the optimization point of the propeller/engine st-up, where the maximum fuel efficiency of the engine will occur.

Line 2 represents the operation of the engine when the shaft alternator is not operating. This will reduce the power output of the engine, whilst it still delivers the expected speed.

Line 6 represents the light running operations of the engine. It is at this condition that the engine/propeller would be expected to operate at sea trials. However, once delivered the expected fouling of the hull, propeller and engine, combined with realistic weather and wind condition will dictate that for a given speed output a higher power output is required. By illustrating the original clean
set-up of the engine, then the engineer can quickly see how much deterioration has occurred, and hence decide when cleaning of the hull, propeller and engine is required. Note that operation with increasing hull fouling will cause the engine to operate in an overload condition, i.e., to the left of line 8.

The other points to note on this diagram are the following:

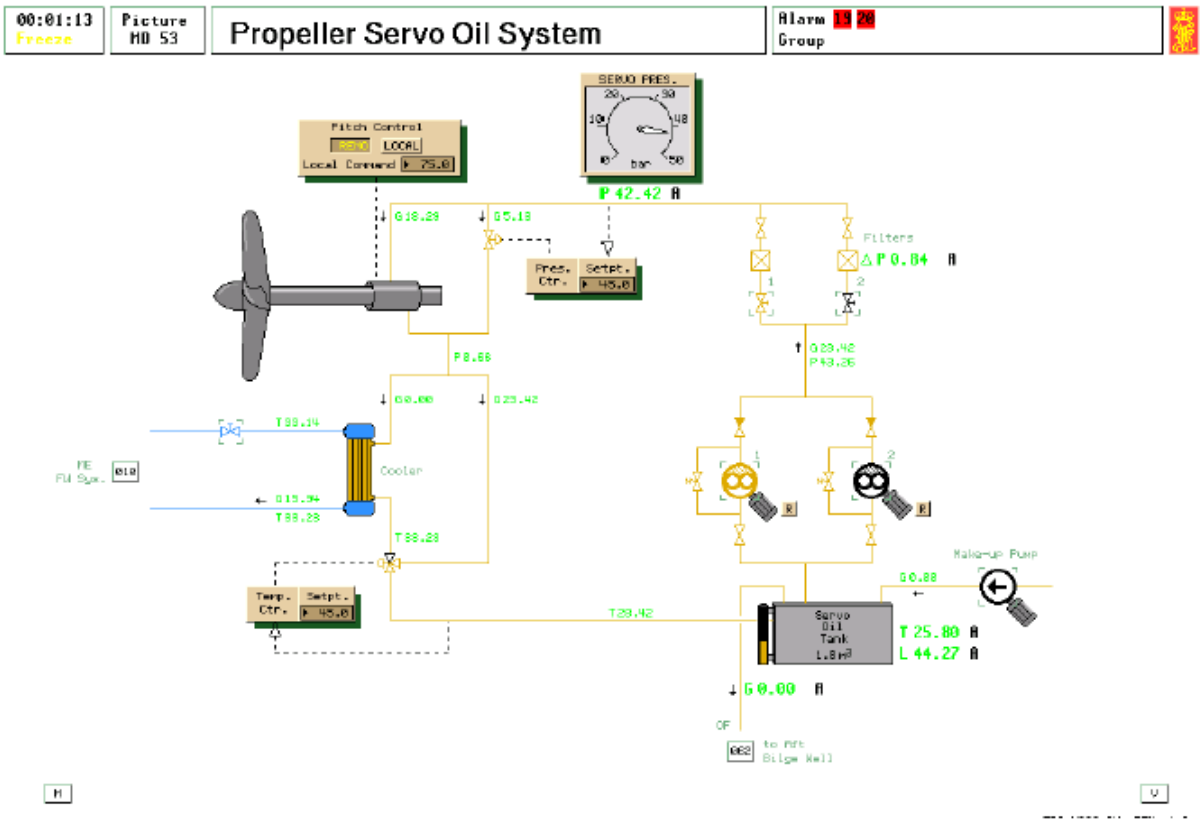
Point A – this represents the intersection between the expected operation line 6 and the maximum power line 7.

Point M – this represents the maximum continuous rating (MCR) of the engine as specified by the engine manufacturer, thus for this engine this will be 16MW at 74 rev/min.

The load diagram can be used to determine the following:

- When the engine is overloaded due to environmental conditions. Note this does not need to occur when the engine is developing excess power, as most damage occurs when operating to the left of line 8.

- The effectiveness of the load limiters. They should prevent operation to the left of line 4. If the engine was initially loaded on line 2 then when the engine is loaded up, the speed~power relationship will leave this line and move closer to line 4, especially if the shaft alternator is operating. The load limiter parameters must be adjusted if the engine load diagram indicates operation to the left of line 4 during load-up conditions. This will extend the time taken for the engine and vessel to speed up, but should prevent premature damage to the cylinder combustion components.



LI. PROPELLER AND STEERING GEAR SYSTEMS

LI.1 Propeller Servo Oil System

General

The propeller pitch servo is operated by high-pressure hydraulic oil supplied by two electrically driven pumps. Usually, only one pump is used with the other in standby mode.

The pitch control is dependent on hydraulic pressure. At low oil pressure, the maximum rate of pitch change is reduced correspondingly. If the oil is cold, the pitch servo acts more slowly.

Description

High pressure oil is delivered to the pitch servo. The pressure is controlled by by-passing oil through the pressure control valve, using a P-controller. Default pressure is 45 bar.

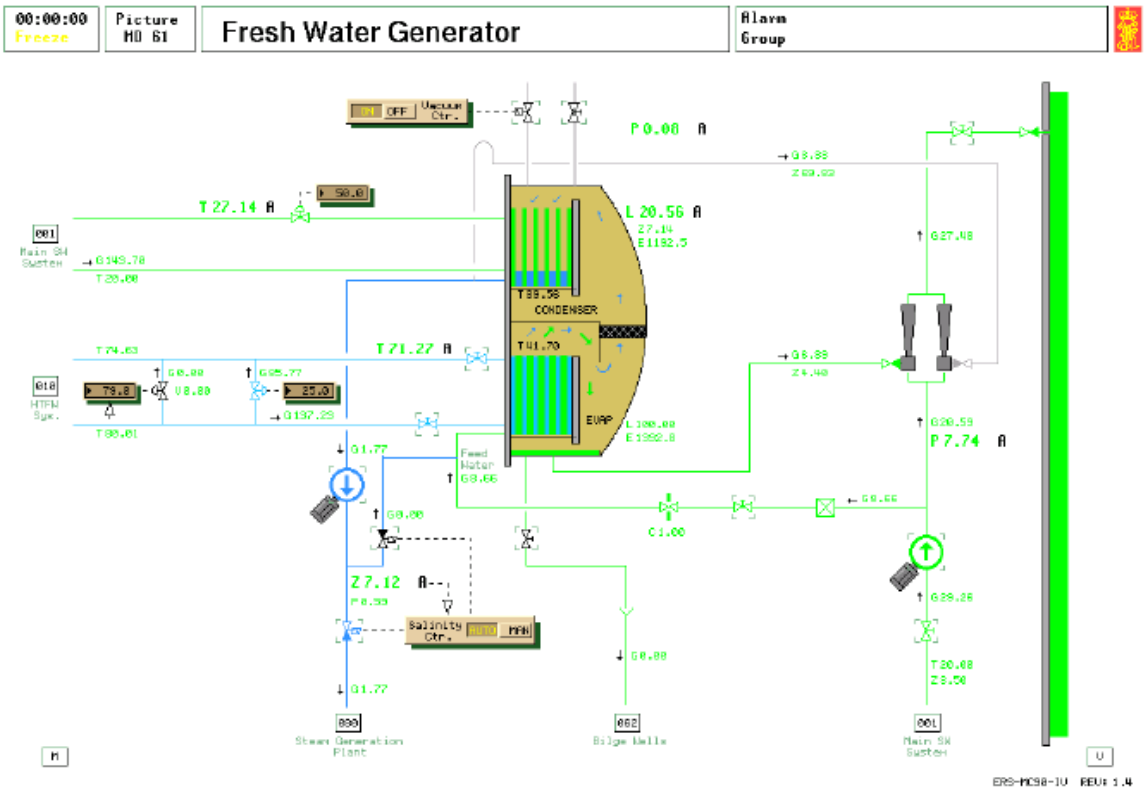
The return oil is cooled by LT fresh water and is controlled to be 45°C, again using a P-controller. The oil drains to the servo oil tank.

When pitch control is set to Local control, the pitch command is set in the numeric window in % of pitch range.

Operation procedure

1. Starting procedure:

1.1 Main engine sea water system and LT fresh water system must be in service.
1.2 Open fresh water inlet valve to servo lubricating oil cooler.
1.3 Open selected filter inlet valve.
1.4 Check level in Servo oil tank.
1.5 Select Local or Remote pitch control.
1.6 Start the lubricating oil pump locally or from the Power Chief Pump Control panel.
1.7 Put the lubricating oil pumps into AUTO mode from the Pump and Compressor Panel.



LII. FRESH WATER GENERATOR

General

Very huge waste heat sources may be utilized when connecting a fresh water generator to the main engine jacket cooling water system. Normally this temperature is 65-70°C (149 - 158°F). The function is as follows:

An automatic bypass valve is mounted in the HTFW supply line to the evaporator. It is normally closed, but at engine outlet temperatures lower than normal, it opens. This function prevents the evaporator from over-cooling the engine at low engine power, when the heat generation in the engine is insufficient for full evaporator production.

A controlled amount of sea water is fed into the evaporator where it is heated by the HTFW. The fresh water generator operates under vacuum conditions in order to reduce the evaporation temperature.

The vacuum, and thus the evaporation temperature, must be controlled to reduce the scale formation in the sea water side of the evaporator.

The vacuum allows the utilization of low temperature heating sources. The vapors generated pass through a fine mesh, to prevent salt water carryover, to the condenser.

The condenser is cooled by sea water so the vapor condenses into fresh water. The fresh water falls by gravity to the bottom of the condenser and is led to the suction of the fresh water pump.

The condition of the fresh water is monitored by a salinometer, and if the salinity is high, the condensate is recirculated to the evaporator.

Description

The evaporator is made up by heat exchangers of the plate type. The evaporator heating is supplied from the main engine HTFW circuit by controlling a bypass valve. The ejector pump is supplied from the main sea water system. The maximum evaporator capacity is 30 ton/24 hours at sea water temperature 32oC. The distillate water is led to the distilled fresh water tank via an ultra violet sterilization unit.

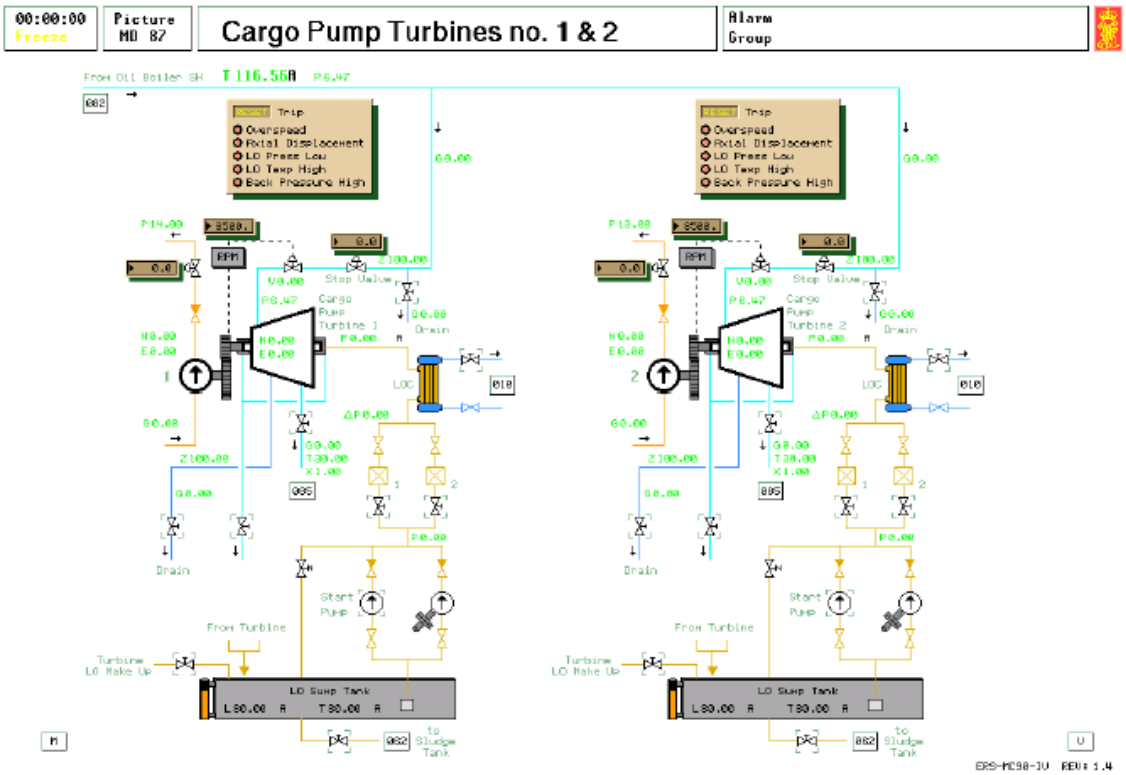
Operation procedure

1. **Preparation**

1.1 Set salinity controller to MAN.
1.2 Close evaporator drain valve.
1.3 Close vacuum breaker valve.
1.4 Check that fresh water by-pass valve is fully open.
1.5 Check that fresh water inlet and outlet valves from main engine system to generator are closed.
1.6 Close sea water feed valve from ejector pump
1.7 Open valve for sea water supply to ejector pump from main sea water system.
1.8 Open sea water valve for condenser (V00674, MD01)
1.9 Open sea water overboard valve from ejectors.

2. **Starting procedure:**

2.1 Start ejector pump, and check pressure and flow.
2.2 Open sea water flow to condenser, adjusting valve, gradually to 100 %.
2.3 Open sea water feed valve to evaporator.
2.4 Wait for the total pressure in the generator to drop to approximately 0.10 bar. (1.5 psia).
2.5 Open evaporator heating outlet shut off valve (to HTFW system).
2.6 Open evaporator heating inlet shut off valve (from HTFW system).
2.7 Close evaporator heating by-pass valve gradually while checking that the generator pressure does not exceed 0.1 bar.
2.8 Activate the automatic vacuum control valve by pressing ON at Vacuum Ctr. panel.
2.9 When distilled fresh water is visible in sight glass, open distillate re-circulation valve and start the distillate pump.
2.10 When salinity control is below alarm limit, activate salinity control by pressing AUTO at Salinity Ctr. panel



LIII. CARGO PUMP TURBINES

General

Four Turbine driven Main Cargo Pumps are modeled. The cargo turbines should be run only when the oil-fired boiler is in operation. The steam will be superheated at 13 bar and approx. 410°C.
All turbines exhaust into the main condenser, held in vacuum conditions.

There is an electric driven LO start pump and engine driven LO pump fitted to each machine, each discharging to the turbine via fresh water cooled cooler. Two sets of filters are provided. One set will be operational, whilst the other is used as standby.

The turbine speed is selectable and both the pump discharge pressure and the discharge Valve opening can be set according to load/rate of flow required.

There is modeled a simple safety system for the cargo turbines (common for all turbines), and cargo turbine trip is given on the following conditions:
- Overspeed
- rotor axial displacement (by water strike)
- LO pressure low
- LO temperature high
- high condenser pressure

Pressing the reset button resets the trip.
Note that the cargo pump turbines are less sensitive to low condenser vacuum than the turbo-generator. It is recommended not to operate the turbo alternator during cargo pumping operations.

Cargo pump operation (procedure will use the start for No. 1 turbine)

1. MD87; Open the following valves
   - Line drain valve
   - Casing drain valve
   - Gland steam outlet valve
   - Exhaust shut off valve to condenser
   - Lube Oil Filter inlet Valve
   - LO Cooler freshwater Valve
2. MD87; The manual Lube Oil pump is now started.
3. MD87; The steam stop valve is now opened from 1 upwards slowly as the turbine begins to run up to speed. Increase to a value of 20 over 5 minutes.
4. MD87; When the rotor speed reaches 3500 rev/min, the steam stop valve can be opened fully and the two drain valves closed.
5. MD87; The speed value of the turbine can be increased as required up to 6000 rev/min (NB 6177 rpm equates to about 1500 rpm of pump speed.)
6. MD82; Monitor the boiler level and steam pressure during the load up of the cargo pump.
7. MD80; Change over feed pumps to operate the aux feed water pump
8. MD85; Change over the condensate pumps to operate the aux condensate pump
9. MD87. The pump discharge valve can be opened to load up the pump.
10. MD87; The pump back pressure can be adjusted on the '*Variable Page'* to set the loading on the pump. This will modeled the static back pressure at the ship's manifold. A low back pressure can overload the turbine, whereas a high back pressure will prevent cargo pumping.

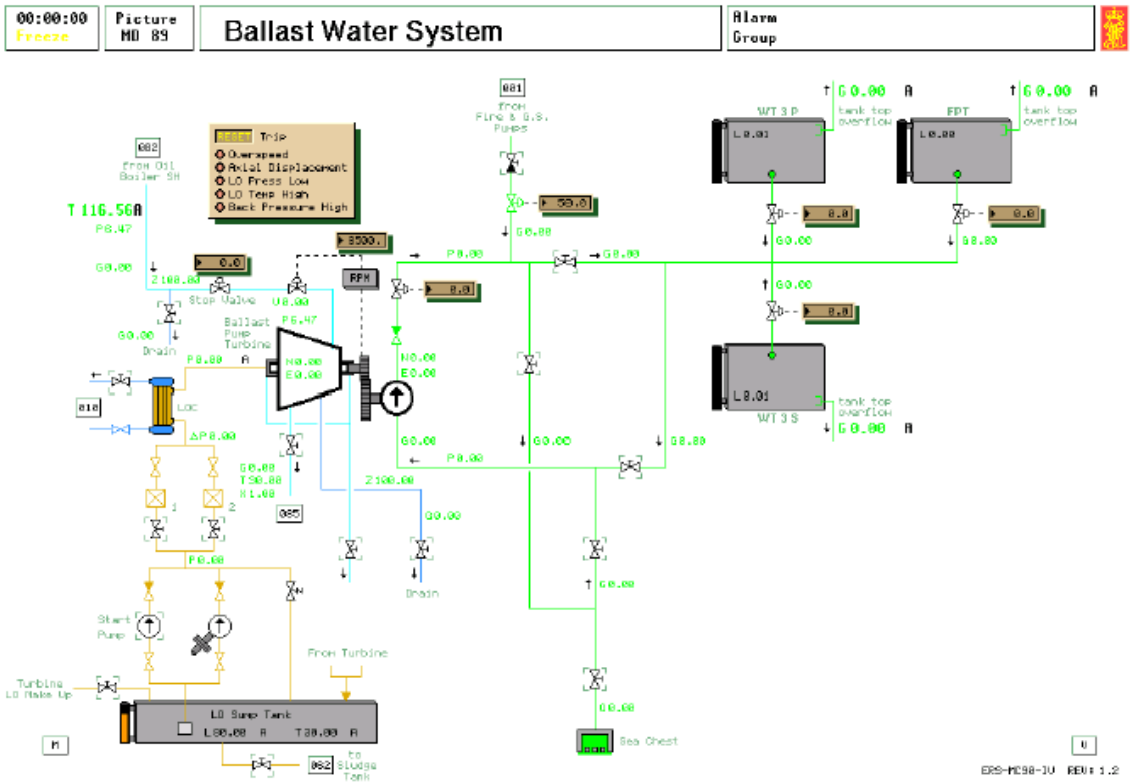
    When one cargo turbine has been started, a small pause should be made before start of the next turbine to permit the boiler system to recover from the shock caused by the sudden steam load increase. With all turbines in operation, careful attention should be paid to the boiler system, which is now working at its ultimate capacity limits.

Cargo pump operation (procedure will stop No. 1 turbine)

1. MD87; Gradually close the cargo pump outlet valve to halt cargo pumping operations
2. MD87; Once cargo pumping has stopped, close the steam stop valve slowly to 0%
3. MD87; Start the manual lube oil pump
4. MD87; Open the following valves
   - Line drain valve
   - Casing drain valve
5. MD87; Close the following valves after 5 minutes

- Line drain valve
- Casing drain valve
- Gland steam outlet valve
- Exhaust shut off valve to condenser
- Lube Oil Filter inlet Valve
- LO Cooler freshwater Valve

6. MD87; Stop manual Lube Oil pump.
7. MD80/85; If all cargo operations are halted, change over to the main boiler feed pump on MD80, and the main condense pump on MD85.



LIV. BALLAST WATER SYSTEM

General

One turbine driven ballast pump is modeled. The ballast turbine should be run only when the oil-fired boiler is in operation. The turbine exhaust into the main condenser, held at vacuum conditions.

There is an electric driven LO start pump and engine driven LO pump fitted, each discharging to the turbine via fresh water cooled cooler. Two sets of filters are provided. One set will be operational, while the other used as standby.

The turbine speed is selectable and the pump discharge pressure and the

discharge Valve opening can be set according to load/rate of flow required.

There is modeled a simple safety system for the ballast turbine, and turbine trip is given on the following conditions:
- Overspeed
- rotor axial displacement (by water strike)
- LO pressure low
- LO temperature high
- high condenser pressure

Pressing the reset button resets the trip.

Ballast pump operation (START)

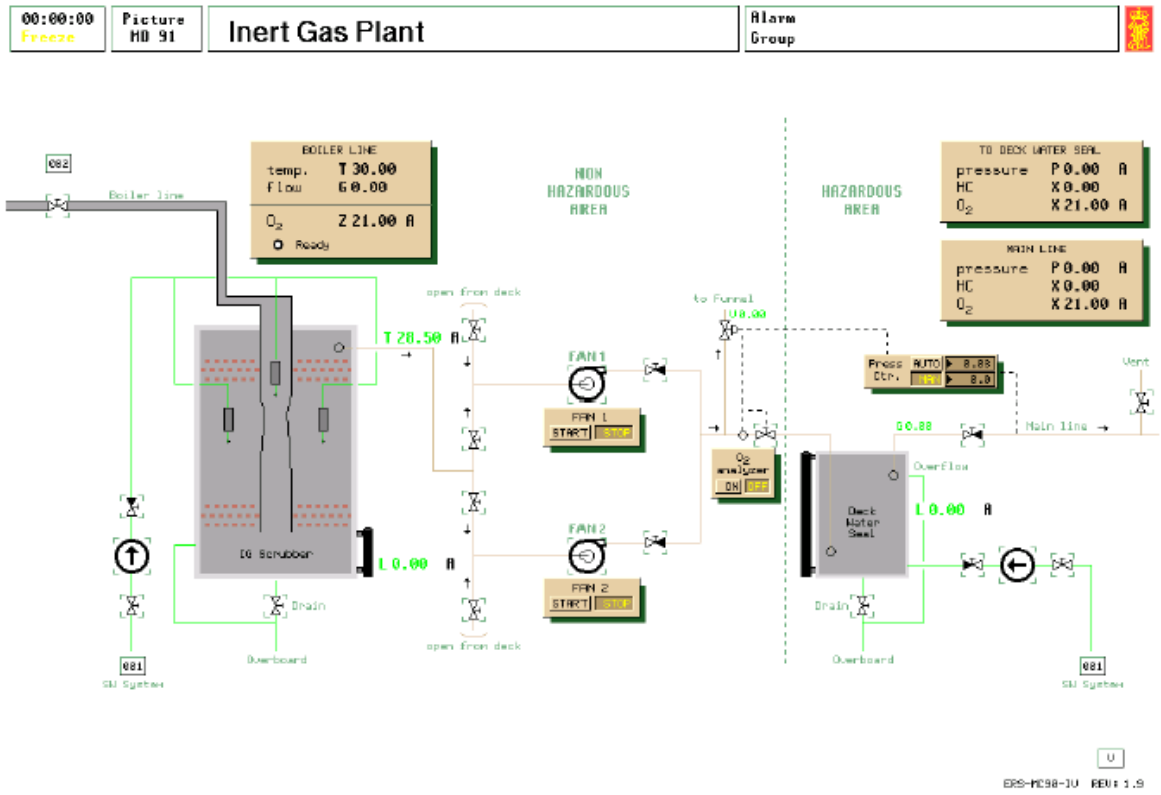
1. MD89; Open the following valves
   - Line drain valve
   - Casing drain valve
   - Gland steam outlet valve
   - Exhaust shut off valve to condenser
   - Lube Oil Filter inlet Valve
   - LO Cooler freshwater Valve
2. MD89; The manual Lube Oil pump is now started.
3. MD89; The steam stop valve is now opened from 1 upwards slowly as the turbine begins to run up to speed. Increase to a value of 20 over 5 minutes.
4. MD89; When the rotor speed reaches 3500 rev/min, the steam stop valve can be opened fully and the two drain valves closed.
5. MD89; The speed value of the turbine can be increased as required up to 6000 rev/min (NB 6177 rpm equates to about 1500 rpm of pump speed.)
6. MD82; Monitor the boiler level and steam pressure during the load up of the ballast pump.
7. MD89; The pump is set to fill or discharge the ballast tanks are required. Note that the opening on the ballast tanks can be selected to ensure that the ballast tank is filled or emptied at the required rate. This will control the vessel's trim and list
8. MD89. The pump discharge valve can be opened to load up the pump.

Ballast pump operation (STOP)

1. MD89; Gradually close the ballast pump outlet valve.
2. MD89; Close all the ballast system valves
3. MD89; Once ballast pumping has stopped, close the steam stop valve slowly to 0%
4. MD89; Start the manual lube oil pump
5. MD89; Open the following valves
   - Line drain valve
   - Casing drain valve
6. MD89; Close the following valves after 5 minutes
   - Line drain valve
   - Casing drain valve
   - Gland steam outlet valve

- Exhaust shut off valve to condenser
- Lube Oil Filter inlet Valve

7. LO Cooler freshwater Valve
8. MD89; Stop manual Lube Oil pump.



LV. INERT GAS PLANT

General

The system is modeled with an oil fired boiler where flue gas is taken from the uptake and directed through the scrubber, fans, and deck water seal to the main inert gas deck line. The capacity of the inert gas plant is approximately 40,000 m3/hour, provided sufficient flue gas is available from the boiler.

The scrubber tower has a dedicated seawater supply pump. This pump would operate at all times when the scrubber unit is used. The scrubber washes and cools the flue gas in order to reduce soot and SO2 content. The outlet of the scrubber feeds the suction of the inert gas fans. Only one fan is required to be operated at any time.

The inert gas then passes through and oxygen analyzer and associated controls before entering the deck seal. The deck seal provides one of the two non-return valves that are mandatory in inert gas systems, to isolate the engine room from the hazardous deck area. The deck seal water level is maintained by a dedicated sea water pump. The pump is only operated when the deck level falls. A reduction in deck seal level is modeled, and is

dictated by the carry over of the deck seal water during inert gas system operation. Inert gas passes through the non-return deck shut-off valve into the deck main.

The oxygen content will vary with the boiler load, and the setting of the oxygen controller within the boiler combustion on MD84. In order to avoid inert gas exceeding 5% O2 entering the cargo tanks, the gas supply valve will trip and vent the flue gas to the funnel.

Another valve controlling the mainline pressure will also regulate the main line deck pressure to the tanks by venting to the funnel.

For cargo tank ventilation with fresh air, the system can be used by opening inert gas suction from the deck rather than the scrubber supply.

Operation (Start-up of system)

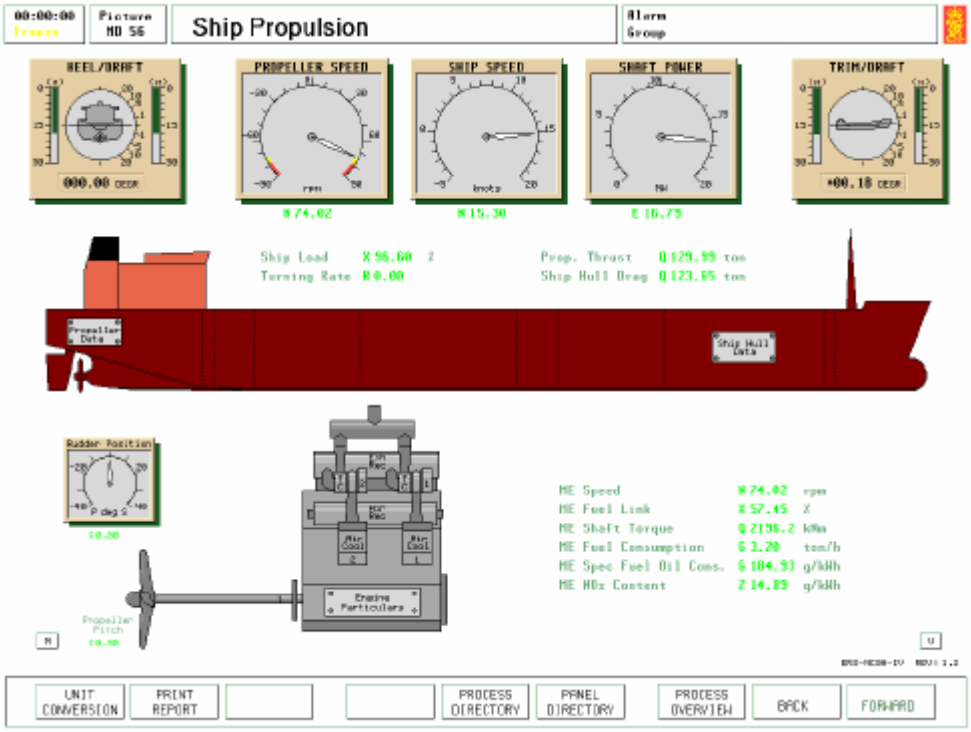
1. MD01; Ensure the sea water inlet valve on either the high or low suction is open.
2. MD91; Open the scrubber tower sea water valves and start the pump to establish a seawater flow through the scrubber tower.
   Ensure the scrubber tower drain is closed
3. MD91; Ensure the inert gas fans fresh air suction valves from deck are closed
4. MD91; Check the level of the deck seal. If low, then open the valves and start the pump to fill the deck seal with seawater.
   Stop the pump and shut the valves when the level reaches 0.5m.
5. MD84; Check that the boiler is firing under stable load, and with an oxygen controller setting of 3.0%
6. MD91 Open the Shut-off Valve on the flue gas from the boiler supply line.
7. MD91; Switch on the Oxygen analyzer and put the Pressure Controller on Manual. Input a Value of 100 to open the flow only to the funnel.
8. MD91; Open selected fan suction from scrubber tower, and discharge valve and start fan.
9. MD91; Open the vent on the deck main
10. MD91; When the Oxygen reading from the boiler line is below 4%, open the deck isolating valve.
11. MD91; Switch the Pressure Controller to AUTO, with a setting of 0.03bar.
12. MD91; Once the oxygen level has stabilized within the main line, close the vent on the deck main, and open the supply to the cargo tanks
13. MD91; Monitor and maintain the deck water seal level as required by starting the deck seal pump.

Note the flow of inert gas to the cargo tanks is a function of the cargo discharge rate (from the cargo oil pumps) and the inert gas pressure.

Operation (Clean air ventilation of cargo tanks)

1. MD01; Ensure the sea water inlet valve on either the high or low suction is open.

2. MD91; Close the outlet gas valves from the scrubber tower
3. MD91; Check the level of the deck seal. If low, then open the valves and start the pump to fill the deck seal with seawater.
   Stop the pump and shut the valves when the level reaches 0.5m.
4. MD91; Open selected fan suction from the deck, open discharge valve and start fan.
5. MD91; Open the vent on the deck main
6. MD91; Switch the Pressure Controller to AUTO, with a setting of 0.03bar.
7. MD91; Once the oxygen level has stabilized to over 20% within the main line, close the vent on the deck main, and open the supply to the cargo tanks
8. MD91; Monitor and maintain the deck water seal level as required by starting the deck seal pump.



LVI. SIMULATOR & SHIP MODEL PARTICULARS

LVI.1 Propeller and Ship Model Characteristics

The propeller characteristic is realistically modulated. The propeller torque and thrust depend on ship speed, propeller revolution, and propeller pitch and rudder deflection. The hull resistance is set for a typical VLCC. It is made dependent on ship speed, ship draft, heel and trim, depth of water, weather condition (wave/wind) and the hull's degree of fouling.

The basic ship speed response-constant is correctly modulated in dependence of load condition. By using the "Ship Dynamics" from the Operating Condition picture, the instructor can change the apparent speed response to save time:

- 1 times true response

- 2 times true response
- 4 times true response

The steady state thrust or the time scale does not influence propulsion power!

The hull model includes dynamic description of the ship's movement ahead, its speed and rate of turn, its yawing, rolling, and pitching etc. The hull drag force includes water resistance due to waves, wind, and ice. The weather condition sets the General level of wave disturbance. The wind force is specified by mean wind speed and wind direction.

The ice resistance is composed of one steady and one dynamic component. If the ship gets stuck in the ice, "ice breaking" can be tried. Reverse the ship some ship lengths and then ram with full power towards the ice edge.

The influence of the weather condition, set by the instructor, is modulated in three ways:
- The waves' effect on the propeller is simulated by adding the hydrodynamic propeller torque random disturbances (low pass filtered, white noise). The rpm will vary somewhat and the Auto Chief system will be disturbed in its speed controlling function.
- The pitch and roll movement of the ship is simulated by adding the liquid level
in the following tanks:
- Fresh water expansion tank
- ME lubrication oil sump tank
- ME rocker arm lubrication oil tanks
- DG1 & 2 sump lubrication oil tanks
- HFO service tanks
- DO service tank
- Engine room bilge well

The breaking effect of the waves on the ship speed is simulated by increasing the propulsion resistance. The ship speed will drop and the main engines will thus be heavier loaded.

The water depth can be specified and the "shallow water" effect demonstrated. The effect is noticeable only if the depth is less than 2-3 times ship draft.

A Bow Thruster can be operated from the bridge (Instructor's Station). The thruster pitch is adjustable. Note that the bow thruster force will decrease at increasing speed ahead and at full speed the bow thruster will have no influence.

LVI.2 Ship Load

All tanks are assumed prismatic in form (tank masses proportional to level). The following main tanks are included:
- FO settling tanks

- FO service tanks
- Spill oil tank
- FO bunker tanks
- DO storage tank
- Lubrication oil tanks

Storage tanks are modeled as masses entered by the instructor, and set the boundaries for the simulated systems.

Ballast tanks are represented on this ship as followed:

- 2 x 1 Ballast wing tank
- 1 Fore peak tank

The load in cargo tanks can be altered by the operator or the instructor from Variable Page 5702, Ship Load Condition.

Ship Load override

The instructor can override the actual calculated load of the ship by changing the "SHIP LOAD" parameters from page 9002, "Sim Control; External Conditions:"

X07015	0(M)= load set by hull program 1(P)= load set by "potentiometer"X06317 at the same page (pot meter input) 2(F)= full loaded ship (100% dwt) 3(E)= light ship (20% dwt)

LVI.3 Ambient Temperatures

The ambient sea water and air temperature is adjustable through the variable page 9002 "SIM CONTROL; External Conditions". The sea water temperature effects the operational condition of all FW, lubricating oil and air coolers. Changes in the sea water temperature will over time impact the temperature in various tanks, on condition they were left without heating.

The air temperature in the engine room depends on the total power from the main auxiliary engines, ambient air temperature, and the number of engine room ventilation fans in operation. In case an engine room fire is simulated, the temperature will increase rapidly. The air temperature in the engine room also effects the scavenging air temperature of the diesel engines.

A simple model of the engine control room (ECR) air conditioning system is included. If the air conditioning system is turned off or has failed, the engine control room temperature will gradually approach machinery space temperature. Fire in the engine room will lead to an overload of the air conditioning system and will finally fail.

LVII. AUTO PULSAR SYSTEM

Description

To facilitate easy test of controller performance in various systems, the auto pulsar system is included. The auto pulsar enables auto-change of set point in intervals. The engine room systems with auto pulsar functionality vary with the simulator model but are found under the SIM CONTROL variable pages.

The following settings are typical for a low speed engine model:

Sea water temp control: Default = 20 degC Auto pulsar = 16 degC
Low temp fresh water temp control: Default = 34 degC Auto pulsar = 30 degC
High temp fresh water temp control: Default = 80 degC Auto pulsar = 75 degC
Lubrication oil temp control: Default = 45 degC Auto pulsar = 41 degC
Main engine command: Default = 100 % Auto pulsar = 70 %
FO Viscosity control: Default = 15 cSt Auto pulsar = 12 cSt
Boiler level control: Default = 0 mm Auto pulsar = -50mm
Boiler pressure control: Default = 16 bar Auto pulsar = 15 bar

Operation

Select SIM CONTROL variable page.
Set Pulsar system active (1).
Set one or more of available systems to auto pulsar active (1).
Observe that controller instantly changes set-point and the counter starts counting down from default time setting (seconds).
To switch off auto pulsar, type 0.

The following settings in seconds are typical for the low speed models:

Sea water temp control: Default = 180 seconds ON/180 seconds OFF
Low temp fresh water temp control: Default = 180 seconds ON/180 seconds OFF
High temp fresh water temp control: Default = 180 seconds ON/180 seconds OFF
Lubrication oil temp control: Default = 120 seconds ON/120 seconds OFF
Main engine command: Default = 300 seconds ON/300 seconds OFF
FO Viscosity control: Default = 120 seconds ON/120 seconds OFF
Boiler level control: Default = 300 seconds ON/300 seconds OFF
Boiler pressure control: Default = 240 seconds ON/240 seconds OFF

Useful Info

Changing ON and OFF time is done by typing desired time as a negative value.

Note that some simulator models may have counter range 0-99, this means that any number is multiplied by 10 to get the time in seconds (setting 12 is equal to 120 seconds).

LVIII. BILGE SYSTEM AND BILGE SEPARATOR

Pollution prevention

To reduce pollution of the world's coasts and waters by the shipping industry, a great number of laws, regulations and penalties have been established and are being enforced. These include regulations set forth by the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the
Protocol of 1978 (MARPOL 73/78 Annex I), the Federal Water Pollution Control Act of 1970 (FWPCA), and the Oil Pollution Act of 1990 (OPA 90).

Of greatest interest aboard the training ship are the regulations concerning the pumping of machinery space bilge. The law, as established by MARPOL 73/78 ANNEX I, for ships of four hundred gross tons and above, defines permissible discharge of oil or oily waste from machinery space bilge and fuel oil tank ballast water, as follows:

1. When the vessel is anywhere within a "Special Area" which includes the entire Mediterranean Sea, Black Sea, Baltic Sea, Red Sea, and Gulf Areas; *No Discharge* is permitted, except when:

1. The vessel is underway, and
2. The ship is operating an oil content monitor, oil separating or filtering device which will automatically stop discharging when the oil contend of the effluent exceeds 15 parts per million (ppm), and
3. The oil content of the effluent without dilution does not exceed 15 ppm.

2. Outside of the "Special Areas," and more than 12 nautical miles from land, the requirements are the similar to the ones above except that the oil content of the effluent discharge is relaxed to 100 ppm. In addition, discharge is permitted when the vessel is not underway, if the oil content of the effluent does not exceed 15 ppm.
3. Outside of the "Special Areas," and less than 12 nautical miles from land, *No Discharge* is permitted except when the oil content of the effluent without dilution does not exceed 15 ppm.

The MARPOL regulations are more restrictive for oil tankers, and slightly more flexible for vessels of less than 400 gross tons. Before pumping bilge on your license, make sure you understand the law.

It is no longer legal anywhere in the world to pump machinery space bilge directly overboard without going through some kind of oil content monitor that will automatically stop the discharge when the legal limits are exceeded!

In addition, U.S. laws prohibit any discharge which forms a sheen, sludge, film, or emulsion in U.S. territorial seas. Such seas are defined by the navigable waters, including river systems and tributaries or into or upon waters of the contiguous zone. The Department of Justice may prosecute an unlawful discharge or act in Federal District Court. Penalties set down by OPA 90 and the FWPCA are generally up to $25,000 per day of violation or $1,000 per barrel discharged. The master of the ship must immediately notify the nearest Coast Guard of an unlawful discharge and proceed in the clean up. Gross negligence or wilful misconduct could cause penalty costs to triple.

MARPOL regulations also require every vessel to maintain an *Oil Record Book*, where a permanent record of almost every handling of oil or oil waste is maintained.

For non-tank vessels, the following operations must be recorded in the oil record book:

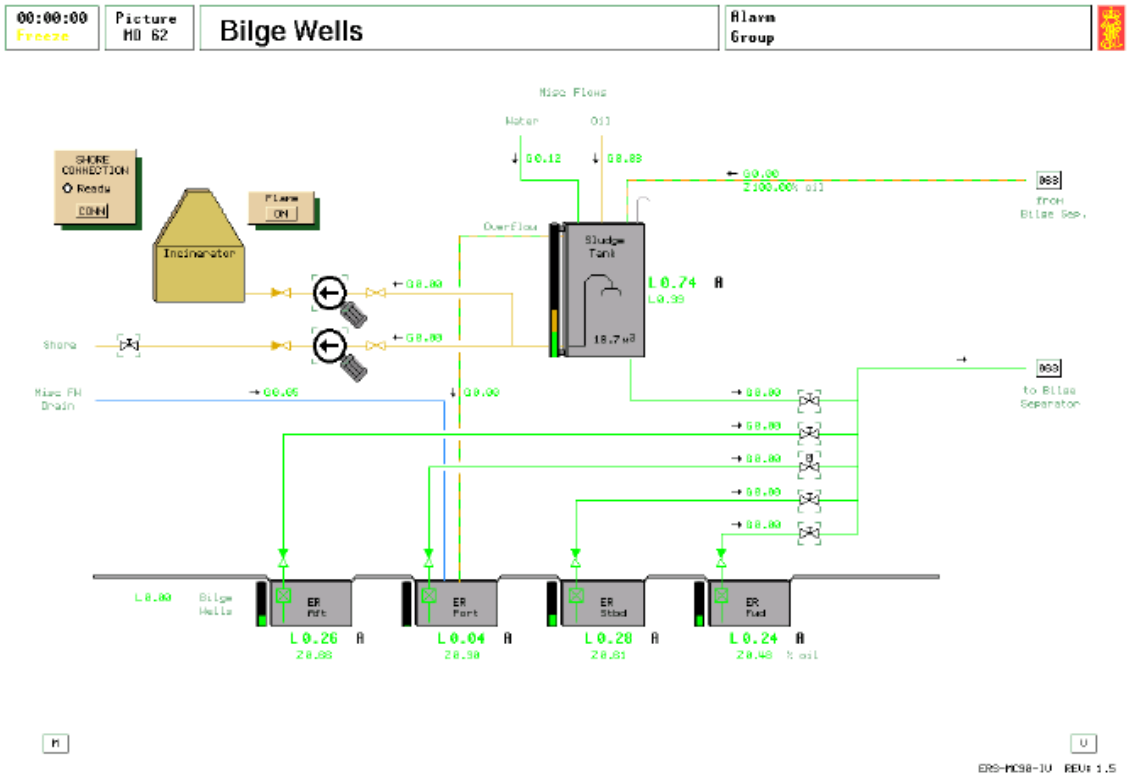
- Ballasting or cleaning of oil fuel tanks.
- Discharge of dirty ballast or cleaning water from oil fuel tanks
- Collection and disposal of oil residues (sludge)
- Automatic and Non-automatic discharge overboard or disposal otherwise of bilge water which has accumulated in machinery spaces.
- Condition of oil discharge monitoring and control system (failures and repairs)
- Accidental or other exceptional discharge of oil
- Bunkering of fuel or bulk lubricating oil
- Additional operational procedures and General remarks

The FWPCA and OPA 90 established additional regulations regarding the transfer of oil to or from a vessel. They state that no person may perform oil transfer operations unless he holds a valid license authorizing service on such vessels as a master, mate, or engineer, and has full knowledge of current oil transfer procedures that are maintained aboard that vessel.

During vessel-to-vessel transfers, each tank vessel with a capacity of 250 or more barrels of cargo oil must have a means that enables continuous two way communication between the person in charge of the transfer of operations on both vessels.

There must be an emergency means on board to enable a person in charge of an oil transfer operation to stop the flow of oil to a facility, another vessel or within the vessel. This may be by the means of the pump control, quick acting power actuated valve or an operating procedure. There must be adequate and protected lighting in areas of oil transfer operation.

It is your responsibility as a marine engineer to know, understand, and obey the law.



LVIX. Bilge Wells

General

Bilge well description
The following Engine Room bilge wells are included:
- Aft
- Fwd Port
- Fwd Stbd
- Centre

A sludge tank and an incinerator are also part of the bilge system. The bilge pump can take suction from any of the four bilge wells, or from the sludge tank, and discharge it to the bilge separator.

The Fwd Port engine room bilge well, in addition, receives possible overflow from the sludge tank and miscellaneous fresh water leakage/overflow from the engine room systems.

The bilge wells cascade into one another as the bilge fills and overflows.

When the separator is in automatic operation, it works on the Fwd Port bilge well. If the bilge separator is on for an excessive time, an alarm will sound to indicate that there is a serious leakage.

Sludge tank

The sludge tank receives drain from the following sources:
- HFO purifier sludge
- DO purifier sludge
- LO purifier sludge
- HFO settling tank 1 drain
- HFO settling tank 2 drain

The total water and oil input flows are summed up and displayed as two separate variables (oil, water) for convenience.

Oily return flow from the bilge water separator also enters the sludge tank. Sludge can be discharged from the sludge tank to the incinerator or to a shore reception facility.

Incinerator

The incinerator takes suction from the oil (top) part of the sludge tank by means of a float device. To initiate incinerator operation, start the pump and ignite the burner. If the pump light begins to flash, this flashing indicates automatic stop of the pump.

Auto stop can be caused by:
- No oil in the sludge tank
- Time out for burner ignition

Flashing burner light indicates that the burner is ready for ignition.

Operation.

1. Incinerator operation

1.1 Note amount of oil in sludge tank
1.2 Open valve from sludge tank to burner pump.
1.3 Open valve to incinerator.
1.4 Start incinerator by pushing flame ON.
1.5 Incinerator will automatically stop at low level in sludge tank.
1.6 Note and record amount of sludge incinerated.

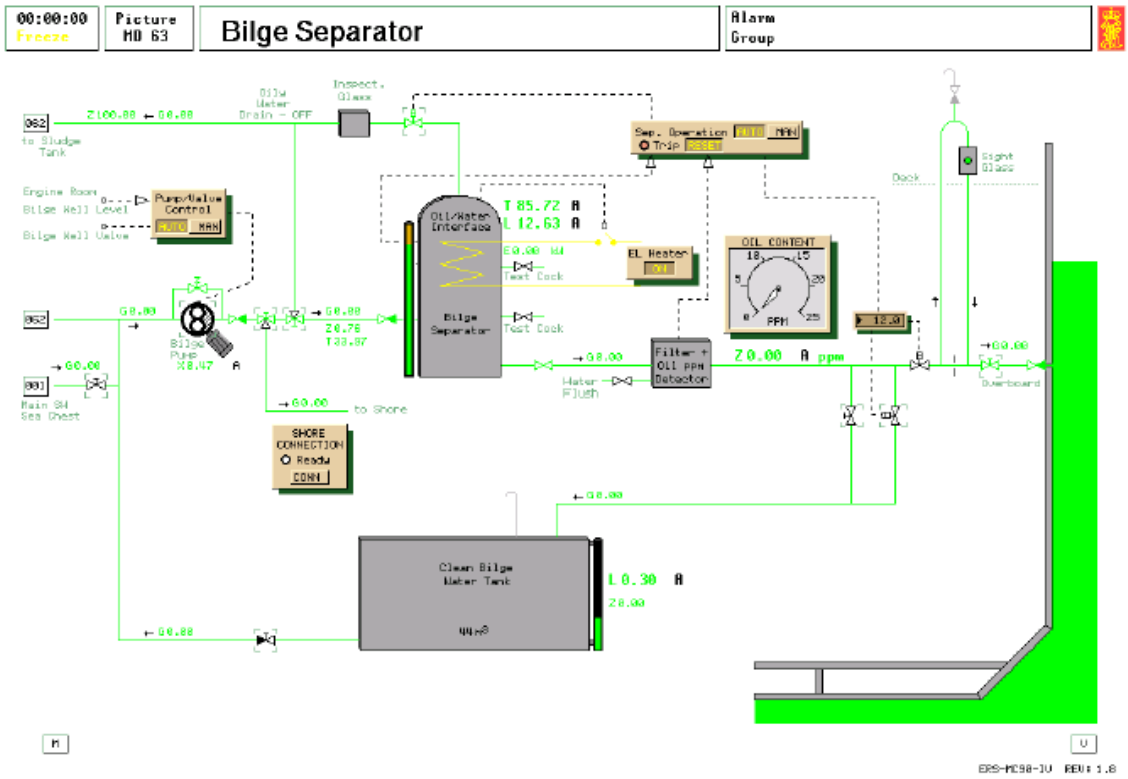
NOTE. The incinerator should only be used during sea passage.

2. Sludge to shore

2.1 Check that shore connection has been established.
2.2 Note amount of sludge in tank.
2.3 Open valve for discharge sludge ashore.
2.4 Start shore pump
2.5 Close discharge valve before removing the shore connection.

2.6 Note and record amount of sludge discharged.

NOTE: Before discharge to shore remote stop of the shore pump from deck location must be tested.



LX. BILGE SEPARATOR

General

The separator is provided to eliminate engine room bilge water in accordance with current pollution prevention regulations by discharging water containing no more than 15 ppm of oil overboard.

The bilge separator separates oily water taken from the sludge tank or from the bilge wells. Clean water is pumped overboard or to the clean water bilge tank, while the oil is returned to the sludge tank.

The unit consists of a tank divided into several zones by internal baffles. A positive displacement bilge pump supplies unprocessed oil/water downstream into the separator and simultaneously discharge treated water out of the tank.

As the oil/water mixture flows through the tank, oil droplets are attracted to the coalescer beads while water is repelled under the influence of gravity and heat. Water passes around the beads but oil temporarily attaches to them. Oil droplets accumulate on the beads, until they become large enough to break away and float to the top of the tank.

Meanwhile, the treated water is discharged from the bottom of the tank, through the oil content monitor and then either overboard or to the Clean Bilge Tank, depending on residual oil content. Effluent will only be discharged overboard when its oil content is less than 15 ppm.

Eventually the oil layer at the top of the tank increases sufficiently to trip a sensor which causes the separator drain solenoid to open. The accumulated oil is forced out through the oil discharge valve to the sludge tank.

If the separator is operated in “AUTO” mode, the following functions are automatic:

- The overboard valve is closed and the re-circulation valve opened if the ppm limit in the overboard water is above a pre-set limit.
- If the oil/water interface sensor detects low level (much oil), the sludge valve is opened.
- The bilge separator pump may be started/stopped automatically according to the bilge well level. This function is dependent on suction from the engine room bilge well.

A flashing AUTO light indicates functional failure. The cause can be high oil content (low-low oil/water interface level) or low separator temperature. The separator pump will then be stopped, the sludge valve opened, and the overboard and re-circulation valves closed.

The heating power is turned on/off according to temperature, by a thermostatic switch as long as the main switch is on. This switch works independently of the AUTO mode.

Operation procedure

1. Preparation of bilge separator

1.1 START electric heating of bilge separator and set separator operation in MANUAL
1.2 Set the separator into AUTO mode when sufficient temperature (50°C)
1.3 Check the setting of the ppm detector.

2. Automatic or manual operation of the separator

2.1 Normally the separator is operated in AUTO. In Auto the valves for bilge over board, bilge re-circulation to clean bilge tank and sludge drain from separator to sludge tank are automatic controlled.

3. Daily service bilge from engine rooms.

3.1 Check oil content in bilge well.
3.2 Open suction valve from bilge well.

3.3 Open valves through separator.
3.4 Check that over board valve is closed.
3.5 Open discharge valve to clean bilge tank..
3.6 Check that bilge separator is in Auto.
3.7 Start bilge pump in manual.

If bilge has high oil content open 3-way valve before bilge separator and discharge directly to sludge tank.
3.8 Let the oily water mixture separate in sludge tank before emptying water to clean bilge tank.

4. Automatic bilge from engine room bilge well.

4.1 If AUTO bilge control is active, the bilge suction valve from the engine bilge and the bilge pump will be activated according to the level in the bilge.
4.2 If the bilge pump is ON for more than 20% (adjustable) of the OFF time an alarm is activated. Immediate action must be taken.

5. Emptying clean bilge tank.

5.1 Check and note down time and ship's position.
5.2 Check that bilge separator is ready.
5.3 Open suction valve from clean bilge tank
5.4 Open discharge over board
5.5 Check that bilge separator is in Auto.
5.6 Start bilge pump
5.7 Observe PPM-meter to avoid pumping oil overboard
5.8 Check and not down time and ship's position when finished.

6 Stopping Bilge Separator

6.1 Ensure operation is in manual mode.
6.2 Close bilge suction valve and open sea suction to flush separator.
6.3 Manually open Sludge valve to remove recovered oil.
6.4 Stop pump and close sea suction and overboard valves.

7 Bilge to shore

7.1 Check that shore connection has been established.
7.2 Note amount of bilge water in tank.
7.3 Open valves for bilge tank and discharge bilge ashore.
7.4 Start bilge pump
7.5 Close all valves before removing the shore connection.
7.6 Note and record amount of bilge discharged.

NOTE: Before discharge to shore remote stop of the bilge pump from deck location must be tested.

Model particulars

- A small amount of oil and water is constantly leaking into the bilge wells (from unspecified sources).
- The content of the sludge tank is assumed to separate immediately into oil and water.
- The settling process in the separator vessel is modeled to be dependent on settling time, inlet flow oil content, temperature and position of oil/water interface level.
- Shore connection can only be activated if ship is in “mooring condition” (VP 9200, X07005=1)

LXI. SHAFT GENERATOR/MOTOR

General

The shaft generator/motor system consists of the following main components:
- Control system
- Static converter
- Shaft generator/motor
- Synchronous condenser
- Smoothing reactor

The power from the shaft of the main engine drives the shaft generator via a gear and a clutch. The clutch is driven by control air and will not operate if the control air is missing. The clutch will not engage if the inlet shaft speed is above 300rpm.

The Shaft Generator can supply the ship’s network with electrical energy when SG is running above 200rpm. Between 200 and 400rpm the load is limited to half, above 400rpm maximum power is available.

The synchronous condenser controls voltage and frequency. Frequency is determined by condenser speed, voltage by a standard AVC.

A load controller controls power flow through the static converter by timing rectifying thyristors, it also controls the excitation of the shaft generator.

The shaft generator is designed for continuous parallel operation with conventional auxiliary generators and exhaust gas turbo generator sets.

The control panel supplies auxiliary power for the excitation converter and cooling fan. The SG cannot operate if auxiliary power is lost. The synchronous condenser is started from the control cabinet. When starting the SC, considerable power is drawn from the main distribution supply.

The shaft generator can be used as a motor in Power Take In mode. This enables excess available electrical power to be used to supplement the main engine to give greater shaft output. In PTI mode, the motor can either use

the available electrical capacity or the maximum consumption can be manually selected. The maximum load on the motor will always leave a reserve of 300kW.

Operation Procedure

Normal operation involves engaging the clutch at standby in order that the generator may be used on passage.

During maneuvering electrical power is supplied from the diesel generators.

When the vessel is on passage the turbine generator is used in parallel with the shaft generator.

If there is available electrical capacity from the turbine generator then the shaft generator may be used in PTI mode to increase efficiency.

In case of main engine reduced power or if extra shaft power is required the shaft generator can be used in PTI mode with the diesel generators.

1. **Starting shaft generator**

1.1 Ensure auxiliary power on and cooling fan is running.
1.2 Check that enough reserve power is available to start synchronous condenser, about 150kW.
1.3 Start synchronous condenser.
1.4 Open air valve to clutch.
1.5 Ensure input shaft speed below 300 rpm and connect clutch in local control. When clutch has engaged change to remote control.

2. **Generator Mode**

2.1 Normal mode is generator mode as indicated on the control panel.
2.2 The generator can be connected manually or automatically from the Power Chief panel in the normal manner.

3. Power Take In

3.1 To use PTI the generator breaker must first be connected in the normal manner.
3.2 PTI can be selected locally or from the Power Chief panel.
3.3 In PTI mode, select either Available Mode to use all available power (300kW will be in reserve) or select Setting Mode where the motor power can be set up to a maximum of 300Kw in reserve.
3.4 To change to PTI select Generator Mode.

4. **Stopping**

4.1 It is normal to leave the clutch engaged when the main engine is running otherwise; in order to engage clutch, the engine would have to be slowed down.

4.2 If the generator is not required, disconnect circuit breaker in the normal manner.

4.3 The synchronous generator may now be stopped.

4.4 If maintenance is to be carried out, it will be necessary to turn off the auxiliary power, disengage the clutch, and close the air valve to the clutch.