MACHINERY OPERATION MANUAL

LNG Steam Plant Simulator
(Version 1.4)

L-3 Communications MPRI 2006

1 PROCEDURES

1.1 DEAD SHIP TO FULL AWAY

The following procedures are suggested in order to bring the vessel from a Dead Ship Condition to Full Away. Each procedure is detailed in the section given in the right hand column. In each procedure, relevant screen display names are shown in italics e.g. *T/bines and Feed:*

1	Procedure for Manually Starting/Stopping the EDA	2.10.1.2/ 2.10.1.3
2	Procedure for Connecting the Shore Supply	2.10.2.2
3	Procedure for Preparing the EDA for Automatic Start	2.10.1.1
4	Procedure for Preparing the Main Diesel Alternator for Starting	2.10.3.1
5	Procedure for Manually Starting the Main Diesel Alternator	2.10.4.1
6	Procedure for preparing the Main D/A for Automatic Start	2.10.4.2
7	Procedure for bunkering vessel with Diesel Oil	2.6.1.1
8	Procedure for transfer of DO from bunkers to DO Settling Tank	2.6.1.2
9	Procedure for bunkering vessel with Heavy Oil	2.6.1.3
10	Procedure for transfer of HO from bunkers to HO Settling Tank	2.6.1.4
11	Procedure for Preparing the Control Air System	2.9.1.1
12	Procedure for filling the Distilled Water Tank from Shore Tank	2.3.2.1
13	Procedure for filling the De-Aerator (DFT)	2.3.2.2
14	Procedure for filling a Boiler with Water	2.3.2.3
15	Procedure for lighting a boiler using Diesel Oil	2.2.2.1
16	Procedure for Setting Boiler Controls to AUTO	2.2.2.2
17	Procedure to Prepare Drum Level Controller	2.3.2.6
18	Procedure to Start a Turbo Feed Pump	2.3.2.7
19	Procedure to prepare LP Steam Generator	2.1.6.4
20	Procedure to heat HO prior to burning	2.6.1.6
21	Procedure to change boiler fuel from Diesel to Heavy Oil	2.2.2.3
22	Procedure to prepare Steam Regulators for normal operation	2.1.6.1
23	Procedure to prepare the SW Circulation System (Speed <8 knots)	2.4.1.1
24	Procedure to produce a Vacuum	2.1.6.3
25	Procedure to prepare and run up a Turbo Alternator	2.10.8.2
26	Procedure to parallel a Turbo Alternator	2.10.8.3
27	Procedure to Load Share between 2 or more Alternators on the S/B	2.10.8.4
28	Procedure to prepare the Condensate System	2.1.6.2
29	Procedure for Preparing the Lubrication Oil System	2.7.1.1
30	Procedure to run the Main Turbines using the Telegraph/Throttle	2.1.6.6
31	Procedure to run the Distiller	2.5.1.2
32	Procedure to run the Feed Water Economisers	2.3.2.8
33	Procedure to prepare the Main SW Cooling (Speed >8 knots)	2.4.1.2
34	Procedure to Burn Gas	2.1.6.7
35	Procedure for preparing Bilge System	2.8.1.1

2 SHIP SYSTEMS

2.1 STEAM SYSTEMS

Alarms and Trips

Item	Alarm Set Point	
Port/Stbd Superheater Temperature High	1000 °F	537 °C
Port/Stbd Superheater Pressure High	900 psi	6.2 MPa
Port/Stbd Superheater Pressure Low	800 psi	5.5 MPa
Port/Stbd Desuperheater Steam Pressure Low	750 psi	5.2 MPa
Port/Stbd Drum Level High	5.00 in	+100 mm
Port/Stbd Drum Level Low	-5.00 in	+100 mm
Port/Stbd Drum Pressure High	915 psi	6.3 MPa
Port/Stbd Drum Pressure Low	850 psi	5.8 MPa
Port/Stbd Safety Valve Setting	1000 psi	7.0 MPa

2.1.1 Superheated Steam System

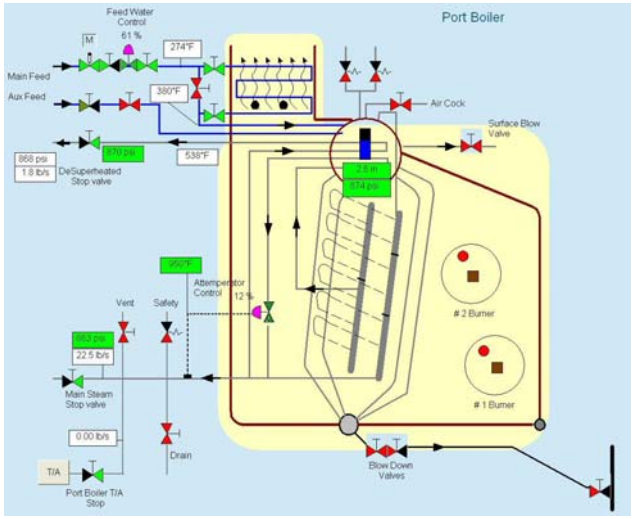
Boiler Details
No. of sets: 2
Model: two drum water tube natural circulation
Maximum evaporation: 65,000kg/h
Normal evaporation: 50,000kg/h
Steam condition: 5.9 MPa superheated steam at 525°C
Safety valve settings: Drum 7.0 MPa
Superheat outlet 6.370Mpa

Description
Two boilers generate all the steam required by the vessel. Each boiler has one steam drum and one water drum, superheaters, economiser, air heater, fuel and gas firing equipment and other necessary accessories. The boilers are also fitted with statutory safety and protection systems including safety valves, pressure gauges, water level gauges, vents, drains and blow down facilities.

In each boiler, steam generated in the steam drum flows through a superheater to produce superheated steam. Part of this flow is directed back to the steam drum through a submerged tube desuperheaters. Here it gives up its superheat to the water and emerges as desuperheated steam at 875 psi (6 MPa) for auxiliary services. Desuperheated steam is supplied in this way to ensure that there is always a flow of steam through the superheater even when the demand for superheated steam is low.
Steam from within the superheater is diverted through an attemporator in the steam drum and mixed with superheated steam to regulate the outlet temperature of steam leaving the boiler. The process is controlled by the Boiler Combustion Control System.

In normal operation, main feed water is passed through an economizer to the water drum but can be supplied directly using a bypass valve. Main Feed water enters the top of the economiser and flows through the elements to the bottom header and from there to the boiler steam drum. This is counter to the gas flow that passes upwards over the elements in order to reduce temperature differences. Auxiliary Feed water is supplied directly to the drum.

Two forced draught fans have adjustable vanes controlled by the Boiler Combustion Control System. The fans are arranged so they can supply either boiler by manually opening a crossover vent.



The boiler is fitted with two fuel oil and two gas burners. The fuel burner is assisted by atomizer steam and has a forced draught air register and fuel oil shut off valve. Fuel is distributed to the burners from separate gas and oil burner manifolds. The operation of increasing or decreasing the number of burners can be manual or automatic.

Steam from the superheater outlet of both boilers is taken to a common main and distributed to the main turbine and turbo alternators.

2.1.2 Desuperheated Steam System

Desuperheated steam at 875 psi (6 MPa) from both boilers is taken to a common main and distributed as follows:

- Via a regulator to the 150 psi (1MPa) main supplying the following services: Gland Steam, Distiller, Hotel Services, LNG and HP (High Pressure Feedwater) heater. The 150 psi (1MP) main is also maintained by the HP Bleed steam when the turbines are operating at full power.
- Via a regulator for boiler atomising steam at 150 psi (1MPa)
- Via regulators to both feed water turbine pumps
- Via a regulator to maintain the 35 psi (290kPa) main supplying the DeAerator Feed Tank (DFT) with a dump to main condenser

2.1.2.1 Procedure for preparing the 875 psi De-Superheated Steam Supply

Steam usage is high initially as the system becomes pressurized. For this reason, when the boilers is up to working pressure and ready to provide de-superheated steam, take care to open the boiler de-superheated Stop valve gradually to about 30% or the transient drop in pressure and water level may trip the boiler. Once the 875 de-superheated line is pressurised the valve may be fully opened.

It may be necessary to add more water to the boiler.

2.1.3 Bleed and Exhaust Steam Systems

High Pressure (HP) Bleed
High pressure (HP) steam is bled from the HP turbine, the bleed off valve opening automatically when sufficient pressure is present. The normal HP bleed steam pressure of around 200 psi (1.4MPa) is reduced by a regulator and joins the 150 psi (1MPa) line. This line is supplied by desuperheated steam when HP bled steam pressure is too low.

The HP bleed can also supply the 35 psi (290kPa) line via a cascade valve and regulator if the IP pressure is too low.

The set point of the HP regulator is set slightly higher than the set point of the 875/150 psi (6/1 MPa) regulator. This introduces a bias in favour of supplying the 150 psi (1 MPa) line from the HP steam rather than the 875 psi (6 MPa) steam

Intermediate Pressure (IP) Bleed System
IP bleed steam is taken from between HP and LP turbines through a valve that opens automatically when normal IP bleed steam pressure of around 42 psi (290 kPa) is present. This feeds the 35 psi (290kPa) line via a regulator

35 psi (240 kPa) System

The IP bleed system and the feed pump turbine exhaust normally supply the 35 psi (240 kPa) System. Excess pressure is dumped to the main condenser. The HP exhaust system provides the steam to the following services:

- Fresh water generator heating steam
- Main turbine and generator turbine gland packing steam
- Deaerator heating steam

2.1.4 Gland Seal System

A gland seal system is provided to reduce the ingress of air into the turbine casings. Steam is supplied from the 150# (1 MPa) line through an isolating valve.

When full away, the system is self-sustaining through the end leakage from the HP cylinder being taken to the LP glands, flow through the regulator ceases and it can be safely shut off. Excess steam is drawn off and taken back to the condenser. The mass flow of air is based on the expected flow in a standard system. The actual mass will vary at differing operating conditions and with differing vacuums.

2.1.5 Steam Dump System

The main boilers burn excess boil-off gas produced from the cargo. If the boil-off gas produced exceeds the requirements the excess steam produced is dumped to the main condenser via the main dump external desuperheaters.

Both turbo alternators also exhaust to the main condenser.

2.1.6 Main Turbines

The turbine plant consists of a High-Pressure (HP) turbine and a Low-Pressure (LP) turbine driving the propeller shaft through a double reduction gear train. Steam from each boiler passes through a master isolating bulkhead valve to supply a common steam line. This main line supplies the HP Ahead and LP Astern throttle valves. These regulate the output power and speed of the turbines ahead or astern. The throttle valves are hydraulically controlled and are fitted with trips for low LO pressure loss of vacuum etc. They can be bypassed using the manual throttle valves.

The astern throttle is protected by a guardian valve to prevent astern steam being applied when steaming Full Ahead.

General Note
When bringing any steam system into service it is important raise the temperature of the pipes, valves and joints slowly because heating mechanical parts of the system too quickly can lead to thermal distortion and damage. The system must be drained of any water during this warming process to prevent steam or water hammer taking place that can cause mechanical damage. For this reason any water should be removed from the system before the pressure and temperature are increased.
Consequently the superheated steam system is designed to allow each section to be warmed though, drained and pressurized at a controlled rate. Similarly when shutting down, all drains along the steam line should be opened in preparation for restart.

2.1.6.1 Procedure to prepare Steam Regulators for normal operation

T/bines and Feed:

1 Ensure IP regulator by-pass is closed
2 Ensure HP regulator by-pass is closed
3 Ensure 875/150 regulator by-pass is closed
4 Ensure Atomizing Steam regulator by-pass is closed
5 Ensure 875/35 regulator by-pass is closed
6 Open IP regulator inlet and outlet valves.
7 Open HP regulator inlet and outlet valves.
8 Open 875/150 regulator inlet and outlet valves.
9 Open Atomising regulator inlet and outlet valves.
10 Open 875/35 regulator inlet and outlet valves.
11 Click the SP button alongside the IP Regulator and check set point is about 36.5 psi (2.52 Bar).
12 Click the SP button alongside the 875/35 Regulator and check set point is about 33.0 psi (225 kPa). Both of these regulators supply steam to the 35 psi line but, because the IP set point is higher, there is a bias in favour of the 875/35 regulator. Consequently if IP steam is available then this is used in preference to the 875/35 steam.
13 The 35 psi (240 kPa) dump regulator is not adjustable. It will dump steam from the 35 psi line at around 40 psi (275 kPa).
14 Click the SP button alongside the HP Regulator and check set point is about 153 psi (1050 kPa)
15 Click the SP button alongside the 875/150 Regulator and check set point is about 145 psi (1000 kPa).
16 Both of these regulators supply steam to the 150 psi line but, because the HP set point is higher, there is a bias in favour of the 875/150 regulator. Consequently if HP steam is available then this is used in preference to the 875/150 steam.

2.1.6.2 Procedure to prepare the Condensate system

Emerg Distrib:

1 Close condensate pump 1 breaker

Main Distrib:

2 Close condensate pump 2 breaker

Condensate:

3 The Condensate pumps will lose suction and may cavitate if the Hotwell level is low. For this reason, check Hotwell water level is at least +1 inch (25mm). If necessary, fill by opening the valve from the DFT to the Hotwell (via the main condenser) until level is satisfactory then close the valve.
4 Open Condensate pump 1 suction vent valve (needed to obtain suction on the pump)
5 Open Condensate pump 1 suction and discharge valves
6 Open Condensate pump 2 suction vent valve (needed to obtain suction on the pump)
7 Open Condensate pump 2 suction and discharge valves
8 Open the condensate recirculation regulator inlet and outlet cutout valves.
9 Close the condensate recirculation regulator bypass valve
10 Start Condensate pump #1 and wait for the Condensate pump pressure low alarm to clear
11 Put Condensate pump 2 into standby

2.1.6.3 Procedure to produce a Vacuum

Main Distrib:

1 Close Main Vac pump #1 breaker
2 Close Main Vac pump #2 breaker

Condensate:

3 Open Main Vac pump #1 suction and discharge valves
4 Open Main Vac pump #2 suction and discharge valves
5 Start Main Vac pump #1

T/Bines and Feed:

6 *Ensure that 150 psi regulated steam is available*
7 Open the Gland Seal feed valve from the 150 psi regulated steam line

Main Condenser:

8 Wait for the Vac alarm to clear

Condensate:

9 Put Main Vac pump #2 into stand-by

Main Condenser:

10 Monitor Vacuum level

2.1.6.4 Procedure to prepare LP Steam Generator

The LP Steam Generator provides a separate (isolated) system for steam heating oil tanks. This isolated steam system is provided to reduce the chance of oil contamination of the steam in the main steam systems.

This procedure assumes 875 psi (6 MPa) De-Superheated steam is available

Main Distrib:

1 Close Contaminated Feed Pump Breaker

Condensate:

2 Open Contaminated Drain Tank (CDT) Tank to CDT pump valve
3 Open CDT pump to LP Steam Gen valve

4 Ensure Contaminated Drain Tank (CDT) is full
5 Start CDT pump

LP Steam Gen:

6 Level in gauge glass rises automatically to a working value
7 Open steam steam generator supply valve
8 Open steam steam generator main feed valve

9 Open steam steam generator regulator supply valve
10 Check the 225 psi (15.5 Bar) regulated pressure rises
11 Check the 120 psi (8.3 Bar) regulated pressure rises. When this settles at the working pressure open the Steam Stem Gen to Bunkers valve
12 Open all the steam heating valves

2.1.6.5 Procedure to run the Main Turbines using the Manual Throttle

In this procedure the hand wheel throttles are used to control turbine speed.

One boiler can run the main turbines and propulsion system but maximum vessel speed is possible only when both boilers are available. This procedure assumes both boilers are producing superheated steam at rated pressure.

Main Condenser:
1 Check the vacuum not in alarm condition

Stbd Boiler:
2 Check drum pressure is not in alarm condition

Port Boiler:
3 Check drum pressure is not in alarm condition

LO + Purifier:
4 Check the gravity tank is sufficiently full

T/Bines and Feed:
5 Close Manual Throttle ahead valve
6 Close Manual Throttle astern valve
7 Open 150 psi feed to the Gland Seal Regulator

Cooling:
8 Open the Main LO cooler inlet and outlet valves

Condensate:
9 Open the LP Bleed valve to the LP Heater

Stbd Boiler:
10 Open Main steam stop valve (Superheated steam)

Port Boiler:
11 Open Main steam stop valve (Superheated steam)

T/Bines and Feed:
12 Check all three Ahead valves to the HP Turbine are shut
13 Check the two Astern valves to the Astern Turbine are shut
14 Put the Astern Guardian valve into Auto. The Guardian valve will open automatically because the turbines are stopped.
15 Open the Warming through valve – a small valve which allows a small steam flow to the turbines to minimize thermal stresses. Allow the turbines to turn on this reduced steam supply until they are warmed through.
16 Close the Warming through valve
17 The turbines can now be run up manually using the Manual Throttle (Ahead) valve. Open this valve a little and (on the *Main Bearings* display) note an increase in turbine pressures and turbine rpm

2.1.6.6 Procedure to run the Main Turbines using the Telegraph/Throttle

In this procedure the Engine Control Room Throttle is used to control turbine speed.
The Throttle is part of the Engine Order Telegraph (EOT) Control Unit and requires hydraulic pressure from the throttle hydraulic pump in order to operate.

Main Condenser:
1 Check the vacuum not in alarm condition

Stbd Boiler:
2 Check drum pressure is not in alarm condition

Port Boiler:
3 Check drum pressure is not in alarm condition

LO + Purifier:
4 Check the gravity tank is sufficiently full

T/Bines and Feed:
5 Close the Manual Throttle (Ahead) valve
6 Close the Manual Throttle (Astern) valve

The hand wheel throttles must be fully closed or the throttle hydraulic pump will trip

Main Distrib:
7 Close Throttle Boost pump circuit breaker

Telegraph Student / Telegraph Instructor:
8 Check Engine Room (control) is illuminated. (If Bridge control is selected then use the Instructor (Bridge) Telegraph together with the student (Engine Room Telegraph) to establish Engine Room Control.
9 Move both control levers to the stop position

Cooling:
10 Open main LO cooler inlet and outlet valves

LO + Purifier:
11 Open LO Throttle hydraulic boost pump inlet and outlet valves
12 Check Throttle Trips (shortcut)
13 All throttle trips should not be illuminated.

14 If a trip light is illuminated e.g. “Boiler Pressure Low” and the Boiler Pressure is in fact normal then a throttle trip reset will be required.
15 Set the ‘Throttle Operating Mode’ to Manoeuvre – this mode automatically opens/closes the cascade valve (HP to IP) and the HP to HP Regulator valve when required and improves overall efficiency of the plant
16 Throttle trips are reset by clicking the Throttle Hydraulic Pump and then clicking “Reset” on the pump control at the bottom of the screen.
17 Start the Throttle hydraulic pump. Note the Throttle hydraulic pump will not start if any trip is illuminated.
18 Note the accumulator fills with oil and the pump pressure rises
19 Hydraulic oil is now available to operate to the main throttle valves (ahead or astern) via the EOT

Note: The throttle pump trip will only reset if the throttle lever is set to the stop position

Stbd Boiler:

20 Open main steam stop valve

Port Boiler:

21 Open main steam stop valve

T/Bines and Feed:

22 Open stbd and port bulkhead valves.

Telegraph (popup)

The left lever is the Telegraph and the right lever the throttle control
23 Drag the right lever up to ‘Dead Slow’. The HP inlet pressure and shaft rpm will increase as a consequence.
24 Gently move throttle to ‘Full’

Main Bearings:

25 Run up to approximately 95 rpm (about 28000 shp)

2.1.6.7 Procedure to Burn Gas

Instructor LNG Tanks:

1 Open all 4 Cargo tank valves to the Vapour Main

LD Compressors:

2 Open the Vapour Main to De-Mister valve
3 Open LD 1 inlet and outlet valves
4 Open LD 2 inlet and outlet valves
5 Open Steam Heating to the gas Heater
6 Start LD compressor 1
Note: The vanes are adjusted by a signal from the Fuel Gas (FG) Control valve which is shut and so the LD compressor does not trip on HP outlet pressure.

Main Distrib:

7 Close the ER Exhaust Fans breaker

Gas Detection:

8 Start up the Vent Duct Fans 1 and 2
9 Start up the Boiler Hood Fans 1 and 2

FG Bnr Mgt:

10 Reset the Master FG Valve – The “FG Extr. Fans” and “ER Extr. Fan Master” FG VV Trip Cause lights extinguish.
11 Fuel Gas (LNG Boil off) can not be used until the gas lines are purged with Nitrogen
12 There are 3 Purge sequences:
a Main Line Purge
b Stbd and Port Header Purge
c Individual Burner Purges

Purge Permissives:

13 Check – It can be seen that all these purge sequences are not available because the Main N2 valves are shut

FG Bnr Mgt:

14 Open the N2 supply valve

Purge Permissives:

15 Check – It can be seen that all purge sequences are now available

FG Bnr Mgt:

16 Main line Purge
17 Click MAIN LINE “N2 Purge” to initiate and run the Main line Purge sequence
18 The Main line Purge sequence is as follows:
19 The Main line header vent valves will open automatically
20 A master gas valve trip due to N2 purge comes up as part of the purging sequence – this is normal.

21 The Main line purge valve will open automatically
22 The Main line darkens to show the expulsion of the gas in the Main line
23 Wait for the purge sequence to complete.
24 The purge is complete when the Main Line N2 Purge light extinguishes
25 Note: The Main Vents are left open at the end of the purge.
26 These will shut automatically when we introduce gas.

HDR/BNR Purge:

27 Click Stbd and Port “HDR/BNR N2 Purge” to initiate and run the HDR/BNR Purge sequence. This runs a purge sequence on the STBD Header (if required) followed by a purge on burners (if required)
28 Watch the purge sequence.
29 The purge is complete when the HDR/BNR N2 Purge light extinguishes (STBD and PORT) Note: The Header Vents are left open at the end of the purge.
30 Close the Stbd Header Vent (Click HDR VENT “CLOSE”)
31 Close the Port Header Vent (Click HDR VENT “CLOSE”)

Stbd/Port Boiler:

32 Click FUEL GAS EMERG SHUT VALVE “Trip/Reset” to clear the HDR VENT V OPEN Trip
33 Click MASTER FUEL GAS VALVE “Trip/Reset” to clear the Trip

BOG Ctrls:

34 Set to Manual and open to say 5% - do not set too high or the Master Gas valve could trip on “BOG TEMP LL”.
35 This can happen if we try to light up all gas burners simultaneously with a high gas flow – the steam heater may not be quick enough to respond
36 Also the LD Compressor vane angle is set by FG valve position and the LD compressor could trip on HP outlet pressure.

FG Bnr Operation:

37 Reset the MASTER FUEL GAS VALVE
38 Open the MASTER FUEL GAS VALVE

LD Compressor:

39 Check for HP OUT trip – reset if necessary

Stbd Light up:

40 Open the STBD FUEL GAS EMERGENCY SHUT valve
41 Light up STBD Burner 1 – the burner light flashes green during the light up sequence
42 Wait for the burner to be lit (steady green)
43 Light up STBD Burner 2 – the burner light flashes green during the light up sequence
44 Wait for the burner to be lit (steady green)

Port Light up:

45 Open the PORT FUEL GAS EMERGENCY SHUT valve
46 Light up PORT Burner 1 – the burner light flashes green during the light up sequence
47 Wait for the burner to be lit (steady green)
48 Light up PORT Burner 2 – the burner light flashes green during the light up sequence
49 Wait for the burner to be lit (steady green)

Note: The FUEL MODE lights now indicate DUAL FUEL

BOG Ctrls:

50 Open up both the controllers to say 30%

Bnr Operation:

51 The FG control valves can be seen to open (to about say 30%) – note that the FO control valves close in reducing FO flow – a natural effect from the cascaded FO PID controllers.
52 This happens because the increased gas burn is tending to raise boiler drum pressures.
53 This results in the Plant Master (FO Controller) reducing it’s output to the Master controllers (which are also FO controllers) and hence reducing the output of the Fuel and Air (FO Controllers)

BOG Ctrls:

54 Set to AUTO and note the set point is now in kg/s (not %). Increase the set-point to say 0.5 kg/s (before the gas manifold pressure has a chance to fall to and we lose the gas burners)
55 Note a manifold gas flow rate of about 0.5 kg/s corresponds to 0.25 kg/s per burner.

Instructor LNG Tanks

56 Observe the gas flow rate is approximately 0.15%/day which is approximately the boil off required for zero pressure rise in the tanks

2.2 COMBUSTION SYSTEMS

Alarms and Trips

Item	Alarm Set Point
Port/Stbd Stack Oxygen Low	1.00%

2.2.1 Combustion Air

Combustion air is supplied for each boiler by Forced Draft (FD) two speed fans that draw air through adjustable dampers and discharge through an air heater to the boiler fronts. Air registers control the airflow along and around the burners into the furnace. In the case of failure of one of the FD fans a cross over damper between the two boiler air passages allows the remaining fan to supply both boilers.

Fans operating at their slower speed setting can only achieve a steam generating rate sufficient enough to maintain around 50 rpm.

2.2.2 Burner Management

Separate Burner Management control panels for Fuel Oil and Gas are provided for each boiler. The panel is divided into four columns of controls and indicators.

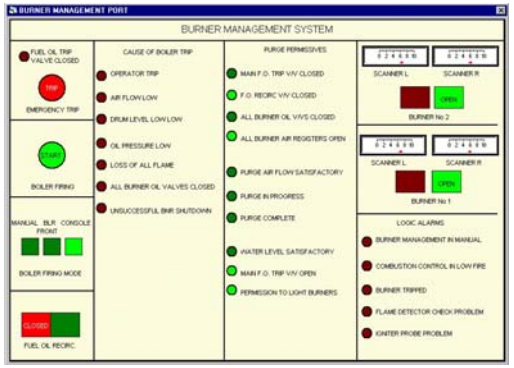
Fuel Oil Burner Management
At the top of the first column is the Emergency Boiler Trip control. This is a red, circular button that will immediately trip the boiler and close the main oil supply valves.

A small indicator above the trip button indicates whether or not the Main Oil Trip Valve (MOTV) is closed. As a safety precaution it is impossible to start the boiler ignition sequence with the MOTV open.

After each boiler trip, a furnace purge must be performed to remove any combustibles from the furnace before fuel is released to the furnace front. Pressing the Start button (located under the Emergency Trip) for 5 seconds initiates a purge and firing sequence for the burners.

Next in the first column are the controls to select Manual, Boiler Front or Console options for the burner management control mode. In Manual mode, each valve must be individually operated. In console (AUTO) mode burner valves are controlled automatically from the Burner Management Panel. The Boiler front option is not available.

The status of the fuel oil re-circulation valve is shown on the bottom left of the panel. It is not possible to sustain adequate pressure for atomization at the burner if this valve is open. Furthermore the fuel oil re-circulation valve must be closed for the purge and ignition procedure to proceed when burner management is in console (AUTO) mode. This valve must also be closed for the purge permissive procedure to progress satisfactorily.



The second column shows the status of possible trip conditions that would either prevent the initial ignition sequence from proceeding or cause a boiler trip. These conditions are:

- Operator Trip
- Air Flow Low
- Drum Level Low-Low
- Oil Pressure Low
- Loss of Flame
- All Burner Oil valves Closed
- Unsuccessful Burner Shutdown

A trip condition is indicated by a red light.

The Third column shows the status of the Purge Permissives. These are conditions that must prevail in order for the purge sequence to proceed satisfactorily. A healthy condition is indicated by a green light. If the condition is not met then the light is not illuminated. Under healthy conditions the indicators illuminate in sequence after the Start button is pressed resulting with permission to light burners. If a light does not illuminate at the appropriate time, the purge sequence will not complete. Purge Permissives are:

- Main FO trip valve closed
- FO recirculation valve closed
- All burner valves closed
- All burner Air registers open
- Purge Air Flow satisfactory
- Purge in progress
- Purge complete
- Water Level Satisfactory
- Main FO trip valve open
- Permission to Light Burners

Once the purge has been completed successfully the trip valve will open together with the appropriate burner valve(s). To ensure that the furnace and the boiler uptake passages have

been adequately purged out with fresh air, time delays are incorporated into the purging sequence.

At the top of the fourth column four analog gauges show the output from the left and right flame sensors on both burners. The scanners sense flame intensity but drop to a zero reading approximately every two minutes during a self-check procedure. During normal operation the scanners should show a slight flickering movement

Manual controls for the Burner Oil Trip Valves (BOTV) located under the flame scanner gauges. Once firing has commenced a second burner can be brought in to operation by pressing the start button for burner No 2.

At the bottom right of the Burner Management Panel are indicators showing the status of logical alarms that may occur while the system is running. These comprise:

- Burner Management in Manual
- Combustion Control in Low Fire
- Burner Tripped
- Flame Detector Check Problem
- Igniter Probe Problem

2.2.2.1 Procedure for lighting a boiler using Diesel Oil

This procedure is applicable to both boilers and assumes the boiler water level is healthy and that there is sufficient Diesel Oil (DO) in the DO Settling Tank and Control Air is available.

Stbd/Port Boiler:

1 Check DO nozzles are fitted (light brown square boxes) in FO Burner. If these are dark brown in colour then use Student Actions (#322, 324, 326 & 328) to change nozzles.

Emerg Distrib:

2 Close the DO Service Pump circuit breaker
3 Close the FD Fan #1 circuit breaker if lighting the Stbd Boiler

Main Distrib:

4 Close the FD Fan #2 circuit breaker if lighting the Port Boiler
5 Close the Burner management circuit breaker for Port/Stbd Boiler

FO Service:

6 Open the DO Settling Tank outlet valve to the DO Service Pump
7 Open the DO Service Pump Suction and Discharge Valves
8 Check the 3-way HO/DO selector valve supplying the boiler to be lit is selected to supply Diesel Oil.
9 Downstream from the HO/DO selector is the Fuel Oil Flow Control valve. This is remotely controlled by the Fuel Oil PID.
10 Next downstream from the FO Flow valve is the Main Oil Trip Valve (MOTV). This is controlled remotely by the Burner Management System
11 Next downstream from the MOTV are two manually operated burner valves – one for each burner. Open both valves.
12 Downstream from the manual burner valves are the two Burner Oil Trip Valves (BOTV). Again, the one BOTV for each burner is controlled remotely by the Burner Management System.
13 Start the DO Service pump.

Comb Air:

14 Start the boiler Forced Draft (FD) fan at the FAST setting.

Comb Ctrlls:

15 Check that the Plant Master controller Set Point (SP) is set to read about 58% on the left side analog gauge. This corresponds to a working steam pressure of 0.58 x 1500 psi = 875 psi (6.9 Mpa).
16 Set all combustion controllers for the boiler's Master, Fuel, and Air controllers to AUTO. Note that the Plant Master only operates in AUTO.
17 Check the boiler's Fuel/Air balance controller is set to approximately 50%.
18 To view the status of each controller, click STATUS on the plant master.

Bnr Mgt Port/Stbd:

19 Select Boiler Firing mode to AUTO. This effectively configures the Burner Management system for Remote Automatic operation.
20 Check that the first three purge permissive lights are illuminated. These are:
    a. Main FO Trip Valve (MOTV) closed
    b. FO Recirculation Valve Closed
    c. All Burner Oil Valves (BOTV) Closed
21 Press the Boiler Firing START button for at least 5 seconds. The ALL BURNER AIR REGISTERS OPEN lamp will illuminate.
22 Once the green PURGE AIRFLOW SATISFACTORY and PURGE IN PROGRESS Lights illuminate, the purge sequence commences. After about thirty seconds of uninterrupted purging, the green PURGE COMPLETE light illuminates.

    During the purge process the Burner Management System overrides the Air Control PID and opens the air damper fully. After the purge is complete, the PURGE control of the air damper is restored to the Air Control PID. The control system checks the drum water level and, if satisfactory, illuminates the WATER LEVEL SATISFACTORY light, opens the Main Oil Trip Valve (MOTV) and gives PERMISSION TO LIGHT BURNERS. An unsatisfactory water level will cause a boiler trip.

23 Burner 1 will light automatically and the Left and Right flame scanners for this burner should show the flickering with an average value of around 5. The flame scanners will periodically read zero for a few seconds during a self-check.
24 Wait until Burner 1 START light is steady – not flashing.
25 Click Burner 2 START button to light the second burner. The Burner Management System will automatically open the BOTV for burner2, insert the igniter, ignite the flame and withdraw the igniter.
26 While Drum Steam Pressure is below 650psi (4,500 kPa) the boiler will operate in Low Fire Mode as indicated by the COMBUSTION CONTROL IN LOW FIRE lamp. During this time the fuel and air controllers are overridden by a low set point signal

in order to produce low flame intensity and limit the rate of thermal expansion. Note the drum level rises slowly due to thermal expansion.

27 Once a positive value of drum steam pressure is established, close the Air Vent. All the air will now be expelled from the drum.

28 Wait for working boiler pressure (about 875psi).

2.2.2.2 Procedure for Setting Boiler Controllers to AUTO

This should be done while boiler(s) come up to pressure:

Boiler Ctrls:

1 Set the Feed Pump Stbd and Port PID controllers to Auto
2 Set the Drum Level Stbd and Port PID controllers to Auto
3 Set the Steam Temp Stbd and Port PID controllers to Auto

2.2.2.3 Procedure to Change Boiler Fuel from Diesel to Heavy Oil

Although the stbd boiler is specified, this procedure applies to either boiler. The procedure assumes the boiler is currently burning Diesel Oil, and a heated HO supply is available.

Bnr Mgt Stbd:

1 Stop Both Oil Burners
2 Click on Student Action icon (Spanner) and enter Action 327 “Stbd Boiler – Change Burner 1 Tip to Heavy Oil Type”
3 Enter Student Action 329 “Stbd Boiler – Change Burner 2 Tip to Heavy Oil Type”

Comb Air:

4 Check that HO Tips are fitted to the Stbd Boiler (Dark Brown)

FO Service:

5 Click on the Stbd Boiler 3 way valve and CLOSE to select HO

Emerg Distrib:

6 Close FO Service pump 1 breaker

Main Distrib:

7 Close FO Service pump 2 breaker

FO Service:

8 Start FO Service pump 1

Bnr Mgt Stbd:

9 Open the Re-circ valve (also opens the MOTV to allow re-circulation of fuel)

FO Service:

10 Open the re-circ valve to the settling tank supplying the HO fuel. HO fuel is now being re-circulated
11 Wait for the Stbd MOTV low outlet temperature alarm to clear (185º F/85º C)
12 The HO Main line fuel pressure should rise towards the desired value of 500 psi (3.4 MPa). Viscosity will fall as the fuel is heated during recirculation.
13 Open both Atomising steam valves

T/bines and Feed:

14 Check Atomising steam pressure is approx 150 psi (1 MPa)
If not then open inlet and outlet cutouts to the atomizing steam regulator and ensure the by pass is shut.

Bnr Mgt Stbd:

15 Close the Re-circ valve (this action automatically closes the MOTV)
16 Check the top 3 green Purge Permissive lights are illuminated.
17 Press the BOILER FIRING START to start the automatic light up sequence of the first burner.
18 Wait for Burner 1 to light up (flashing green burner light stops flashing and illuminates steady green)
19 Press FO Burner 2 START
20 Wait for Burner 2 to light up (flashing green burner light stops flashing and illuminates steady green)

FO Service:

21 If both boilers are running on HO then stop the DO service pump.

2.3 CONDENSATE AND FEED WATER SYSTEMS

Alarms and Trips

Item	Alarm Set Point	Alarm Set Point
Hotwell Level	8.00 in	200 mm
DFT Level High	21 in	525 mm
DFT Level Low	-17.5 in	-445 mm
Distillate Tank Level Low	15 %	15 %
Atmospheric Drain Tank Level High	85 %	85 %
Atmospheric Drain Tank Level Low	17 %	17 %
Feed Header Discharge Pressure Low	925 psi	6.35 MPa
#1 & #2 Feed Pump LO Pressure Low	12 psi	83 kPa
#1 & #2 Feed Pump LO Temperature High	130 °F	55 °C
Main Circ Header Pressure Low	15 psi	102 kPa
Condenser Vacuum Level Low	26 inHg	660 mm Hg

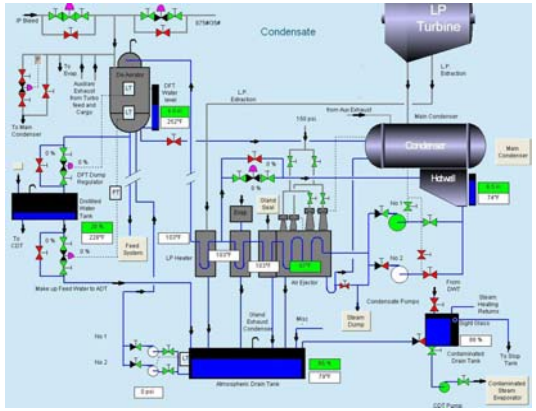
The boiler (or main) feed system circulates water from the De-Aerator via the feed pumps to the boiler steam drum.

2.3.1 Condensate System

Description

The main condensate system is part of a closed feed cycle and circulates feed water from the main condenser to the main feed pumps. Exhaust steam from the main turbines, turbo alternators, dump steam and other auxiliaries is condensed under vacuum in the seawater cooled main condenser. The condensate produced is extracted from the condenser hotwell by one of the two main condensate water pumps and circulated through various heat exchangers, before entering the De-Aerator (DFT) which is located at a high point in the engine room. Water in the De-Aerator provides the main feed pumps with a positive suction head. During the process of circulation from the main condenser to the main feed pump inlet, the condensate temperature is raised from approximately 38°C to 137°C.

One feed pump is used for normal operation with the second in standby. The standby pump will then automatically start and run up should there be a low differential pressure from the duty pump.



A re-circulation valve allows mass flow back to the condenser to maintain a stable level in the De-Aerator and hotwell. The normal operating level in the DFT is 0 inches. In the De-Aerator, condensate is mixed with bled or live steam to raise its temperature further and eliminate the carry over of air into the main feed system.

Level sensors in the De-Aerator (DFT) control the DFT Dump Regulator and Distilled Water Tank (DWT) Make Up Feed to the Atmospheric Drain Tank (ADT) Regulator. High De-Aerator Levels (+5 to +15 inches) cause the DFT dump to progressively open and dump water from the De-Aerator to the DWT.

Low De-Aerator levels (-5 to -15 inches) cause the DWT dump to progressively open and dump water from the DWT to the Atmospheric Drain Tank (ADT).

A level sensor in the ADT controls the ADT pumps which (when in AUTO) start on high ADT level to re-circulate water from the ADT tank to the De-Aerator.

A Contaminated Drain Tank (CDT) collects steam returns from oil tank heaters and which may be contaminated with oil. A sight glass shows the presence of oil. The CDT overflows to a slop tank. The contaminated drain tank (CDT) drains by gravity into the ADT when its outlet valve is closed.

The condensate pumps are fitted with pressure balancing connections back to the condenser. When open, these reduce the onset of cavitation and permit condensate flow into the suction side of the pump.

To facilitate priming of the pumps re-circulation valves are also fitted on the discharge side. The air ejector is of the duplex two-stage type with one pair of ejectors being used at any one time, a “U” tube seal on the drains outlet from these ejectors must be filled before commissioning the condensate system.

2.3.2 Feed Water

Description
The boiler feed is initially supplied by an electric powered pump that is capable of filling the boilers. This pump draws from the De-Aerator and discharges to either or both boilers via their economizers or directly by the auxiliary feed main. The pump is set to provide a maximum of 750 psi.

Two turbo feed pumps are provided; either of these is capable of maintaining adequate feed water flow for full sea speed operations. The speed of the feed pumps is self-regulated by a speed-sensing governor that controls the steam flow to the turbine element of the pumps. The exhaust steam from the pumps is fed into the 35 # main that exhausts to the De-Aerator.

As with the electric pump the turbo feed pumps can also supply the boilers through the auxiliary main, in which case the economizer elements and HP feed heater are by -passed.

2.3.2.1 Procedure for filling Distilled Water Tank from Shore Tank

It is preferable to use the distiller (Fresh Water Generator) to fill the Distilled Water Tank because the water produced has a higher purity than shore water. However, if Distilled water is required before steam is available it may be necessary to use shore water from the shore supply tank.

Distiller:

1 Open the shore tank filling valve.
2 The shore tank slowly fills.
3 Open the shore tank outlet valve to the Distilled Water Tank via the goggle plate.
4 The DWT now fills from the Shore Tank.
5 Close the valves once acceptable levels are achieved (e.g. 50%)

2.3.2.2 Procedure for filling the De-Aerator (DFT)

This procedure assumes there is sufficient water in the Distilled Water Tank (DWT) to fill the De-Aerator (at least 30%). If this is not the case, the DWT must be filled first from the Distiller.

Control air must be available to DFT Dump and Make Up Feed Regulators.

Main Distrib:

1 Close the ADT Pump #1 and ADT Pump #2 circuit breakers

Condensate:

2 Open the ADT Pump #1 Suction and Discharge Valves
3 Open the ADT Pump #2 Suction and Discharge Valves
4 Open the DFT Dump Regulator Inlet and Outlet Valves
5 Open the Make Up Feed Regulator Inlet and Outlet Valves
6 Put ADT Pump #1 into AUTO. If the ADT level exceeds 70% the ADT pump #1 will automatically start and transfer water from the ADT to the DFT.
7 If the DFT water level is below –5 inches (-125mm) then the DWT will dump water into the ADT tank via the make-up feed regulator. If the DFT water level is above +5 inches (125 mm) then the DFT will dump water into the DWT via the DFT dump regulator.
8 Wait for the DFT low water level alarm to clear.

2.3.2.3 Procedure for filling a Boiler with water

This procedure is applicable to both boilers and assumes there is sufficient water in the De-Aerator (DFT). If this is not the case, the DFT must be filled first.

Emerg Distrib:

1 Close the Emergency Feed Pump circuit breaker

T/bines and Feed:

2 Open the Emergency Feed Pump Suction and Discharge Valves

Port/Stbd Boiler:
It is recommended that one boiler is filled first (before the second) so that water level may be monitored.

3 Open Auxiliary Feed Stop Valve.
4 Open Auxiliary Feed Valve about 50%
5 Open Boiler Air Vent Valve

T/bines and Feed:

6 Start the Emergency Feed Pump

Port / Stbd Boiler:

7 Allow the boiler to fill to a level of approximately –4 inches (-100mm) then close a valve on the Auxiliary Feed line.

T/bines and feed:

8 Stop the Emergency Feed Pump

2.3.2.4 Procedure for boiler blow-down

This procedure is applicable if a boiler has been overfilled with water.

Port /Stbd Boiler:

1 Check boiler Auxiliary Feed valves are shut
2 Open the three boiler blow-down valves
3 Allow the boiler to empty to a level of approximately –4 inches (-100mm) for low drum temperature/pressure conditions or 0 inches (0 mm) for temperature/pressure around normal 950°F/875 psi (510°C/6 MPa)
4 Close the three boiler blow-down valves

2.3.2.5 Procedure for maintaining Boiler Drum water Level Control when the Turbo Feed pumps are not available

This procedure applies to both boilers and assumes there is sufficient water in the De-Aerator (DFT).

There are two ways to get water into the boiler when the turbo feed pumps are not available and both methods use the Emergency Feed Pump. The first method employs the Emergency Feed Pump to supply the Auxiliary Feed Line. Because this pump has no pressure or speed controls there is a possibility of over-filling the boiler unless the operation is done carefully.

The second method employs the Emergency Feed Pump to supply the Main Feed Line via a crossover valve. The drum level controller in the main feed line can now be used in AUTO mode to control drum water level.

Method 1 using the Emergency Feed Pump to feed the Aux Feed lines:

T/bines and Feed:

1 Check the emergency feed pump inlet and outlet valves are open
2 Check the emergency feed pump is running

Stbd or Port Boiler:

3 Open the Aux Feed Stop Valve fully
4 Gradually open the Aux Feed valve to about 30% and monitor drum water level. It will be necessary to manually adjust Aux Feed Valve position in order to maintain Boiler Drum water level within acceptable limits.

Method 2 using the emergency Feed Pump to feed the Main Feed lines:

T/bines and Feed:

1 Check the emergency feed pump inlet and outlet valves are open
2 Check the emergency feed pump is running
3 Establish a path for the Auxiliary feedwater to the boilers by opening one of the two crossover valves and either Feed Pump 1 (or 2) to HP Heater Valves as appropriate.

Stbd/Port Boiler:

4 Open Main Feedwater Motorised Stop Valve
5 Open Boiler Feedwater Reg Inlet cutout valve
6 Open Boiler Feedwater Reg Outlet cutout valve
7 Open Boiler Economiser Bypass valve
8 Ensure Drum Level Controller is set to AUTO Ensure there is flow Emerg Feed Pump through HP Heater to Main Feed Line.

T/bines and Feed:

9 Ensure there is flow Emerg Feed Pump through HP Heater to Main Feed Line.

2.3.2.6 Procedure to prepare Drum Level Controller

Stbd/Port Boiler:

1 Open the Feedwater motorized stop valve (located before the Drum Level Controller)
2 Open Drum Level Controller inlet and outlet cutout valves
3 Open Economiser bypass valve

2.3.2.7 Procedure to start a Turbo Feed pump

This procedure assumes that 875psi (6 MPa) De-Superheated steam is available and there is control air supply to the Feed Pump Steam Regulators.

Stbd/Port Boiler:

1 Open Stbd/Port De-superheater Stop Valves

Boiler Ctrlls:

2 Ensure Feed Pump PID Controllers are set to Auto

Cooling:

3 Open the inlet and outlet Feed Pump 1 LO Cooling valves
4 Open the inlet and outlet Feed Pump 2 LO Cooling valves

Emerg Distrib:

5 Close LO Feed Pump # 1 breaker

Main Distrib:

6 Close LO Feed Pump # 2 breaker

T/bines and Feed:

7 Open the Feed Pump discharge to main feed valve
8 Open Feed pump (1 or 2) steam inlet reg cutout valve
9 Open Feed pump (1 or 2) steam outlet reg cutout valve
10 Ensure that the Turbo Feed Pump Regulator by-pass valves are shut
11 Click the Feed Pump to display the Feed Pump Control panel.

Feed Pump Control panel:

12 Open the feed water inlet valve
13 Open the Steam Exhaust outlet valve
14 Put the re-circ valve to AUTO

T/bines and Feed:

15 Click the Feed Pump Aux LO Pump (small LO pump near the Main Feed pump) to display the local Feed Pump Aux LO control panel.
16 Select LOCAL operation and start the Main Feed Aux LO pump.
17 Select REMOTE.
18 The second Turbo Feed pump can be placed into a stand-by position by repeating steps 12 – 14.
19 Put the second Aux LO Pump into Remote and Auto (A).

Feed Pump Control panel:

20 Start the Main Feed Pump

21 The Turbo feed pump regulator will adjust automatically to maintain the main feed main pressure. The main feed pressure must exceed boiler pressure for water to

be able to enter the drum. The set point for the main feed pressure is adjustable and is normally set to about 100 psi (700 kPa) above the highest drum pressure. See *Boiler Ctrls* display.

22 The Turbo feed pumps have Over speed, LO pressure and Instructor activated trips. A red tripped label appearing next to a Feed Pump indicates a trip condition. Click on the label to re-set. In practice a trip are reset by manually operating a lever on the feed pump itself.

23 Once a Main Feed pump is running, stop the Emergency feed pump.

2.3.2.8 Procedure to run the Feed Water Economizers

Stbd or Port Boiler:

1 Open Economizer inlet and outlet valves
2 Close the Economizer bypass valve. (Do not do this in the reverse order or the Main feed flow will temporarily stop)
3 Check the Economizer feed water temperature outlet rises above that of the inlet

2.3.2.9 Procedure to run the Feed Water Economizers

Stbd or Port Boiler:

22 Open Economizer inlet and outlet valves
23 Close the Economizer bypass valve. (Do not do this in the reverse order or the Main feed flow will temporarily stop)
24 Check the Economizer feed water temperature outlet rises above that of the inlet

2.4 SEA WATER SYSTEMS

Equipment
2 off Main Sea Water Circulating Pumps
Scoop Cooling System
2 off Sea Water Service Pumps

Alarms and Trips

Item	Alarm Set Point	Alarm Set Point
Salt\Water Service Pressure Low	50 psi	345 kPa
Distillate Tank level Low	15 %	15 %

Description
There are two separate sea water systems; a circulating system provides cooling water to the main condenser and a service system provides seawater to all other systems such as the auxiliary condenser, distiller and coolers.

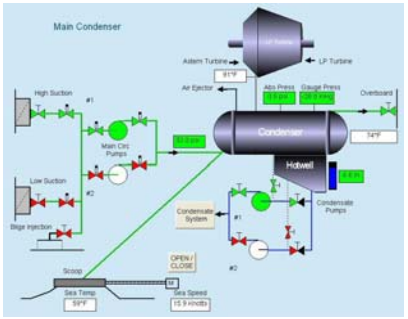
2.4.1 Main Sea Water (SW) Circulating System

This system supplies seawater to the main condenser. The SW circulating pumps take suction from a main that connects to high and a low sea suctions. The pumps deliver seawater through the main condenser to overboard. Normally one circulation pump is operational with the other left in standby.

There is a start interlock prevents the circulating pumps from starting unless the sea inlet and overboard valves are open.

During normal seagoing operations, when the vessel is moving at or above 8 knots, seawater cooling is supplied to the main condenser via the scoop inlet. This system consists of an opening on the flat bottom of the ship's hull directed through the main condenser to an overboard valve.

The difference in water pressure created between the scoop inlet and overboard causes a flow of sea water through the main condenser. The magnitude of this eductive effect increases in proportion to the vessel's speed



Circulation System Control
Because there must be a continuous supply of water to the main condenser when changing between pump and scoop modes there is an overlap on the control so that, as the scoop valve opens to allow water to the condenser, the valve from the main SW circulating pump closes and the circulating pump stops when the pump outlet valve is *10%* open.

2.4.1.1 Procedure to prepare the Sea Water Circulation System (Ship speed < 8 knots)

Main Distrib:
1 Close SW Main Circulation Pump #1 circuit breaker

Main Condenser:
2 Open high (or low) Sea Suction Strainer valve. This is a large valve and slow to operate.
3 Open high (or low) Sea Suction feed valve
4 Open Main Circ Overboard valve
5 Open SW main Circulation Pump #1 suction and delivery valves
6 Start SW Circulation Pump #1

Main Distrib:
7 Close SW Circulation Pump #2 circuit breaker

Cooling:
8 Open SW Circulation Pump #2 suction and delivery valves
9 Put SW Circulation Pump #2 into standby

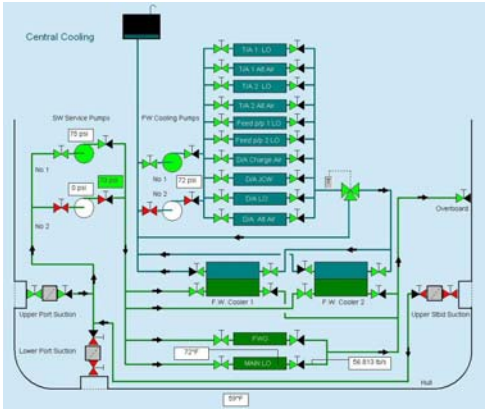
2.4.1.2 Procedure to prepare Main Sea Water Cooling (Ship speed > 8 knots)

Main Condenser:

1 Open the Scoop by clicking on the button
2 Ensure the Main Circ Overboard valve is open.
3 Stop SW Main Circ pump(s)
4 Put a SW Main Circ pump into standby and keep valves open (see previous procedure)

Main Sea Water (SW) Service System

A separate seawater service system supplies seawater to the Fresh Water Generator (FWG) and fresh water coolers (heat exchangers) for the auxiliary systems. Two SW Service pumps take suction from a main that connects to two high and one low sea suctions. The pumps deliver seawater in a parallel piping arrangement through the two Fresh Water (FW) coolers, FWG and main Lube Oil Cooler to overboard. Normally one Seawater service pump is operational with the other left in standby.



2.4.1.3 Procedure for preparing the Sea Water Service System

Emerg Distrib:

1 Close SW Service Pump #1 circuit breaker

Cooling:

2 Open at least one Sea Suction and the overboard valve
3 Open SW Pump #1 suction and delivery valves
4 Open FW Cooler #1 suction and delivery valves on the SW side
5 Open FW Cooler #2 suction and delivery valves on the SW side
6 Open FWG suction and delivery valves on the SW side
7 Open main LO cooler suction and delivery valves on the SW side
8 Start SW Pump #1

2.4.1.4 Procedure for putting the Sea Water Service System in Standby

Main Distrib:

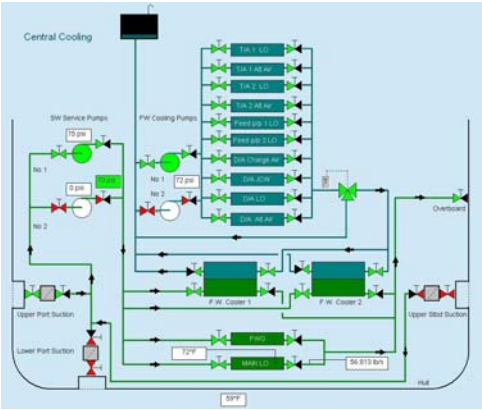
9 Close SW Service Pump #2 circuit breaker
10 Close FW Cooler Pump #2 circuit breaker

Cooling:

11 Open SW Pump #2 suction and delivery valves
12 Select SW Pump #2 control to Standby
13 Select FW Cooler Pump #2 control to Standby

2.5 FRESH WATER SYSTEM

Introduction
The Fresh Water Cooling is a closed system comprising a header tank, two Fresh Water (FW) Pumps, a parallel arrangement of heat exchangers for systems to be cooled by the freshwater, a three-way thermostatically controlled valve and two, seawater cooled heat exchangers.



The following systems are cooled by fresh water:

- Turbo Alternator #1 Lube Oil
- Turbo Alternator #2 Lube Oil
- Turbo Alternator #1 Windings
- Turbo Alternator #2 Windings
- Turbo Feed Pump #1 Lube Oil
- Turbo Feed Pump #2 Lube Oil
- Diesel Alternator Charge Air
- Diesel Alternator Lube Oil
- Diesel Alternator Windings

In normal operation the thermostatically controlled three way valve maintains a constant fresh water temperature by directing a proportion of flow through the seawater cooled heat exchangers and re-circulating the remaining flow without cooling.

2.5.1.1 Procedure for preparing the Fresh Water System

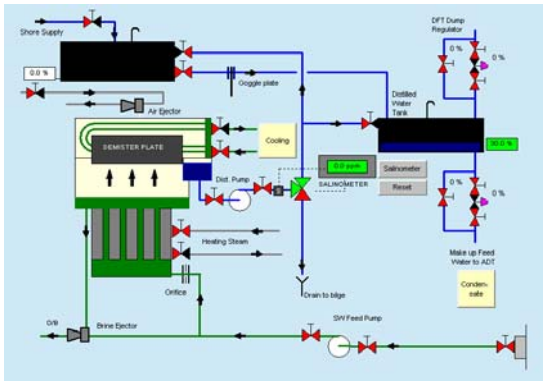
This procedure assumes the Sea Water system is already prepared.

Emerg Distrib:
1 Close FW Cooler Pump #1 circuit breaker

Main Distrib:
2 Close FW Cooler Pump #2 circuit breaker

Cooling:
3 Open FW Cooler Pump #1 suction and discharge valves
4 Open FW Cooler Pump #2 suction and discharge valves
5 Open suction and discharge valves for each system to be cooled
6 Open inlet and outlet valves for each seawater cooler (FW side)
7 Check inlet and outlet valves are open on seawater cooler (SW side) and SW system is operational.
8 Start FW Cooler Pump #1
9 Put FW Cooler Pump #2 into standby.

Distiller
The 875 psi (6 MPa) de-superheated steam is used as a source of heat to evaporate sea water in the distiller. The resulting vapour is condensed in a chamber cooled by sea water and partly under vacuum created by an air ejector supplied by 150 psi (1 MPa) steam.



Fresh water is discharged through a distillate pump and directed by a three 3 way control valve either to storage or, if the salinity is high, to the bilge system. Fresh water is stored in either (or both) the Shore Supply Fresh Water Tank or Distilled Water Tank. Brine ejection is assisted by the flow of seawater generated by the SW Feed Pump.

2.5.1.2 Procedure for preparing the run up the Distiller

This procdure assumes that de-superheated steam is available (875psi or 60.3Bar)

Main Distrib:

1. Close the Evaporator SW Pump breaker
2. Close the Distillate Pump breaker

Distiller:

3. Open the SW suction to SW Feed pump valve
4. Open both inlet and outlet SW Feed Pump valves
5. Start the SW Feed Pump
6. Open the Distiller SW feed inlet and outlet valves
7. Open the Distillate pump inlet and outlet valves
8. Open the Distilled Water Tank feed valve
9. Open the Air Ejector valve
10. Open the De-Superheated Steam inlet and outlet valves
11. Start the Distillate Pump

Distillate flow to the Distilled Water Tank is indicated.

Note:
If the DWT is dumping water to the ADT then the level in the DWT may not be rising.
When the condensate regulators settle and the ADT has >-5 inches of water the DWT dump to the ADT will stop (DWT to ADT regulator valve closes) and the DWT level will rise

2.6 FUEL OIL AND GAS SYSTEMS

Equipment
2 off Fuel Oil Supply Pumps
1 Off Diesel Oil Supply Pump
2 Off HO Settling Tanks
1 Off DO Settling Tank
1 Off Demister
2 off low duty (LD) gas compressors
1 Off Gas Heater

Alarms and Trips

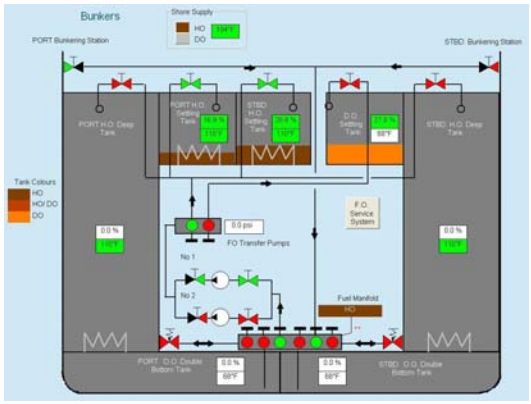
Item	Alarm Set Point	Alarm Set Point
Port/Stbd Deep Tank Temperature High	125 °F	52 °C
Port/Stbd HO Settling Tank Temperature High	150 °F	65 °C
Port/Stbd HO Settling Tank Temperature Low	75 °F	24 °C
Port/Stbd HO Settling Tank Level Low	10 %	10 %
Diesel Service Tank Level High	80%	80%
Diesel Service Tank Level Low	20%	20%
Port/Stbd Fuel Oil Pressure High	440 psi	3000 kPa
Port/Stbd Fuel Oil Pressure Low	80 psi	550 kPa
Port/Stbd Fuel Oil Temperature High	250 °F	120 °C
Port/Stbd Fuel Oil Temperature Low	185 °F	85 °C
Fuel Oil Service Pressure High	525 psi	3.6 MPa
Fuel Oil Service Pressure Low	400 psi	2.75 MPa

Description
The boilers can operate on liquid fuel oil and/or gaseous fuel from cargo tank boil off. The quantity of gaseous fuel used depends upon the cargo tank boil off rate and so HFO must always be available to supplement the gas. Depending upon circumstances it may be necessary to operate with 100% HFO at times. There are two boilers and each is fitted with four burners; two for FO and two for Gas. Each boiler can be treated as a separate item in terms of fuel supply and each burner may also be operated separately. The Fuel and Gas Systems comprise the following subsystems:

- Fuel Oil Storage
- Fuel Oil Transfer
- Gas Supply

Fuel Oil Storage
See *Bunkers* display.

Two wing bunkers and two double bottom tanks are provided for the storage of Heavy Oil (HO) and Diesel Oil (DO) respectively. Both systems can be bunkered from connections on the upper working deck. Pumps are supplied for transferring each fuel to the appropriate settling tanks. A manifold allows the transfer of oil not only between bunkers and settling tanks but also between the bunkers themselves. High level alarms are fitted to all the bunkers and settling tanks.



2.6.1.1 Procedure for bunkering vessel with Diesel Oil

The FO manifold is shown on the *Bunkers* display. Reading from left, valves on manifold are:

a) Port HO Deep Tank
b) Port DO Double bottom tank
c) FO Transfer Pump Suction Valve
d) Stbd DO Double bottom tank
e) Manifold Filling Valve
f) Stbd HO Deep Tank

Bunkers:

1 Select Shore Fuel Supply Type to DO (Diesel Oil)
2 Open the Port DO Double Bottom Tank filling valve on the manifold
3 Open the Stbd DO Double Bottom Tank filling valve on manifold
4 Open manifold Filling Valve
5 Open Port (or Stbd) Bunkering Filling Station valve.
6 Wait until sufficient bunkering has occurred (>50%)
7 Close Port (or Stbd) Bunkering Filling Station valves
8 Wait for manifold contents to drain into DO double-bottomed tanks.
9 Close the Port DO Double Bottom Tank filling valve on the manifold
10 Close all manifold valves

2.6.1.2 Procedure for transfer of DO from bunkers to DO Settling Tank

Emerg Distrib:

1 Close FO Transfer Pump #1 circuit breaker if not already closed

Main Distrib:

2 Close FO Transfer Pump #2 circuit breaker if not already closed

Bunkers:

3 Check all HO valves are closed
4 Check FO Transfer Pumps #1 and #2 are stopped
5 Open the FO Transfer Pump Suction Valve on manifold
6 Open the Port and/or Stbd Double Bottom DO valves on the manifold
7 Open the DO discharge valve on the FO Transfer manifold
8 Open the DO Settling Tank Filling Valve
9 Open the FO Transfer Pump #1 suction and delivery valves
10 Start the FO Transfer Pump #1
11 Open the FO Transfer Pump #2 suction and delivery valves
12 Start the FO Transfer Pump #2
13 Stop the transfer pumps when transfer is complete. (E.g: >50%)
14 Close manifold valves

2.6.1.3 Procedure for bunkering vessel with Heavy Oil

Bunkers:

1 Check all DO valves are closed
2 Select Shore Fuel Supply Type to HO (Heavy Oil)
3 Open the Port HO Deep Tank filling valve on the manifold
4 Open the Stbd HO Deep Tank filling valve on the manifold
5 Open the Port HO Deep Tank filling valve on the tank
6 Open the Stbd HO Deep Tank filling valve on the tank
7 Open manifold Filling Valve
8 Open Port (or Stbd) Bunkering Filling Station valve. Note the tank temperature will rise as the shore supplied fuel is pre-heated.
9 Wait until sufficient bunkering has occurred (>50%)
10 Close Port (or Stbd) Bunkering Filling Station valve
11 Wait for the manifold contents to drain into the HO tanks. Close the Port HO Deep Tank filling valve on the tank.
12 Close the Stbd HO Deep Tank filling valve on the tank
13 Close the Port HO Deep Tank filling valve on the manifold
14 Close the Stbd HO Deep Tank filling valve on the manifold
15 Close manifold Filling Valve

2.6.1.4 Procedure for transfer of HO from bunkers to HO Settling Tank

Emerg Distrib:

1 Close FO Transfer Pump #1 circuit breaker if not already closed

Main Distrib:

2 Close FO Transfer Pump #2 circuit breaker if not already closed

Bunkers:

3 Check all DO valves are closed
4 Check FO Transfer Pumps #1 and #2 are stopped
5 Open the FO Transfer Pump Suction Valve on manifold
6 Open the Port and/or Stbd HO Deep Tank filling valve on the manifold
7 Open the Port and/or Stbd HO Deep Tank filling valve on the tank
8 Open the Port HO Settling Tank filling valve
9 Open the Stbd HO Settling Tank filling valve
10 Open the HO discharge valve on the FO Transfer manifold
11 Open the FO Transfer Pump #1 suction and delivery valves
12 Start the FO Transfer Pump #1
13 Stop FO Transfer Pump when transfer is complete

2.6.1.5 Procedure for flushing contents of manifold and pipe work of HO

The procedure will flush the contents of the manifold and associated pipe work into the HO Settling tank. It should be used before transferring DO in order to ensure that any HO left does not contaminate the DO settling tank.

Emerg Distrib:

1 Close FO Transfer Pump #1 circuit breaker if not already closed

Main Distrib:

2 Close FO Transfer Pump #2 circuit breaker if not already closed

Bunkers:

3 Check FO Transfer Pumps #1 and #2 are stopped
4 Open the FO Transfer Pump #1 suction and delivery valves
5 Check the DO discharge valve on the FO Transfer manifold is closed
6 Open the HO discharge valve on the FO Transfer manifold
7 Open the Port or Stbd HO Settling Tank filling valve
8 Check all HO manifold valves are closed
9 Check all DO manifold valves are closed
10 Open the FO Transfer Pump Suction Valve on the manifold. This will be the only manifold valve open.
11 Start the FO Transfer Pump #1 to empty the pipework and manifold and transfer to the HO settling tank.
12 Monitor the FO Pressure at the FO Transfer manifold. After a short delay, the manifold will be empty causing the pressure to fall due to loss of suction.
13 Stop the Transfer Pump

Fuel Oil Supply
Two HO supply pumps draw from two HO settling tanks or from a Diesel Oil (DO) settling tank. Diesel Oil is normally used only when lighting up from cold ship.

Steam supply to the FO heater is only available after steam has been raised on one or both boilers. Similarly steam heating is required for the HO service tanks and the HO Bunkers. It is essential therefore that adequate steam is raised and the tank thoroughly heated through before any attempt is made to change over to HO firing. If this principle is followed then minimum re-circulation will be required once the heater is brought up to running temperature.

The Heavy Oil (HO) tanks have both high and low suctions. If water is detected in the fuel through the low suction, this outlet should be closed immediately and the high suction opened. Once flame stability has again been established, the low suction can be opened slowly to gradually "burn" off the water. .

HO is pumped through a temperature controlled heater by supply pumps are of the positive displacement type and have their own integral pressure relief system. Oil pressure to the burners is regulated by a spill valve that is controlled by a pressure sensor down stream of the heater**.** Re-circulation valves allow the HO to be heated to around 210^{o}F before burning.

Burner FO pressure of around 500 psi is maintained in the main fuel line by a pressure regulator around the supply pumps. The controller is part of the Boiler Cascade control system.

During initial start-up the boilers are started using Diesel Oil pumped to the burners by the Diesel Oil Service pump. It is necessary to change over to HO Burner tips prior to the use of HO (and Vice Versa) but this can be done on one boiler while the other is steaming on DO.

2.6.1.6 Procedure to Heat HO prior to burning

This procedure assumes steam is available for heating.

FO Service:

1 Open both HO Settling Tank steam heating valves
2 Open the FO Heater steam inlet valve to the FO Heater regulator
3 Open the FO Heater steam outlet valve to the FO Heater regulator
4 Ensure the FO Heater steam Regulator bypass is closed
5 Check the temperature of the HO Fuel in the FO Heater rises
6 Open a high or low HO Settling tank valve (Depending on HO level)
7 Open suction and discharge valves for both FO Supply pump 1 and 2
8 Open FO Pressure Regulator inlet and outlet cutout valves
9 Ensure the FO Pressure Regulator bypass is closed
10 Open the FO Heater FO inlet valve
11 Open the FO Heater FO outlet valve
12 Ensure the FO Heater bypass is closed
13 Open the FO Flow meter inlet valve
14 Open the FO Flow meter outlet valve

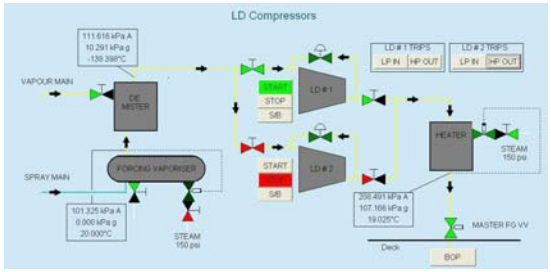
When gas burning commences the burning of fuel oil is reduced and may be shut off completely if sufficient gas is available. In the event of loss of gas during dual firing or 100% gas firing there is automatic changeover to oil firing. For this reason the HFO system must be kept warm at all times.

Gas Supply
The initial volume of LNG in the cargo tanks will be at a preset temperature. The subsequent boil-off rate and pressure will be typical for a generic tank system and will depend on flow. Conditions within the cargo tanks will vary as a consequence of gas usage and environmental conditions, for example; using too much or insufficient gas.

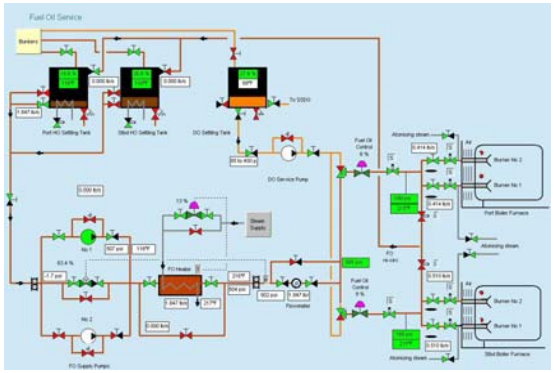
Gas Compression and Heating
Gas from the tanks has to be compressed before being supplied to the boiler burner system - around 1 bar gauge, and two low duty compressors are fitted for this purpose. One gas compressor is sufficient for normal operation; the other is usually isolated or set to Standby mode. Compressor operation is by means of an on/off/standby control. Before burning gas the extraction fan above the boiler hood must be operated.

The LD Compressor display shows system information including temperatures and pressure and the status of the heater isolating valves and the master gas valve.

After the use of gas in the gas burner system the entire pipe work must be purged by blowing nitrogen through the pipes.



A single-pass, shell and U-tube type gas heater is capable of raising LNG temperature from about -105 deg C (min -155) to around ambient (21 deg C) for burning.



The gas heater is itself directly heated by saturated steam and is prepared for operation by opening the steam supply valve and introducing LNG vapour from the compressor. Control is manual or automatic. In manual mode the operator has direct control over the gas inlet & temperature regulating valve. In automatic mode, the operator may set the desired outlet temperature and a control system will regulate steam flow accordingly. The default outlet temperature set point is 25 °C

Flow through the heater is a function of pressure and Gas Control Valve position.

After the heater, gas passes through the Master Gas Valve before entering the Engine Room Space and isolates the Engine Room piping from the LNG cargo area.

2.7 LUBRICATING OIL SYSTEMS

Equipment
2 off LO Pumps
I off LO Cooler
I off LO Purifier
I off Throttle Boost Pump
I off LO Purifier

Alarms and Trips

Item	Alarm Set Point	Alarm Set Point
Gravity Tank Low	60 %	60 %
LO Cooler Outlet Temperature High	120 °F	50 °C
LO Cooler Outlet Temperature Low	80 °F	27 °C
LO Discharge Pressure Low	30 psi	205 kPa
LO Pressure to Bearings Low	10 psi	685 kPa
Main Sump Level Low	20 %	20 %
Main Engine Bearing Temperature High	175 °F	80 °C

Description
The Lubrication Oil (LO) system comprises LO supply system and LO purification and storage systems.

The main turbine is supplied with lubricating oil from the main LO sump tank by one of two LO pumps. One of these pumps will be selected as the duty pump and the other pump as the standby to cut in automatically should the duty pump fail to maintain the lubricating oil supply pressure. An emergency start occurs in the event of blackout, the power being taken from the emergency switchboard.

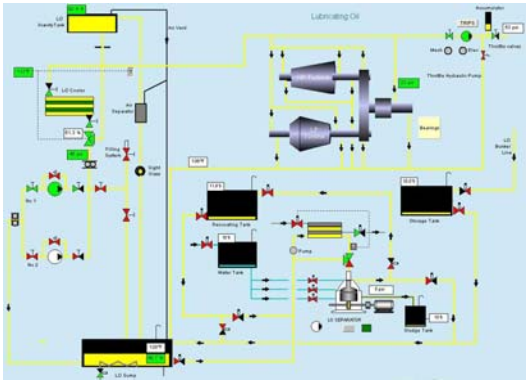
The main LO circulation system supplies LO to the system via the LO coolers, a three-way temperature valve regulating the flow of oil through the LO cooler in order to maintain the desired inlet temperature to the bearings.

A LO gravity tank forms part of the lubricating oil system and this receives a supply of lubricating oil whenever a pump is running. The tank overflows to the main LO sump tank.

The supply to the gravity tank is via a throttling valve to ensure a continuous 'top up' supply to the tank. The emergency outlet is via a larger bore non return valve and orifice to provide an adequate LO supply for a minimum of 8 minutes and allows the gravity tank to provide an emergency lubricating oil supply to the system in the event of complete failure of the pumping system. The emergency supply allows the turbine to be stopped and so prevents damage due to lack of lubricant.

LO supply system

Two Lubrication Oil (LO) pumps draw oil from a sump and deliver oil through filters and a cooler to the bearings and sprayers of the turbine and gearbox. The pumps also maintain a reserve of oil in a gravity tank.



The header system provides a reserve of oil should the main supply from the pumps fail and is sized to provide at least 8 minutes supply of oil to protect the bearings and gearing during coast down time. A sight glass indicates presence of an overflow from the gravity tank back to the LO sump.

The LO cooler has a thermostatically controlled 3-way bypass valve. The LO system is filled via a dedicated filling valve

A throttle boost pump generates a high-pressure hydraulic supply for the main throttling valve. This pump will trip under the following conditions:

a) Turbine Overspeed
b) Vacuum Low
c) Condenser Level High
d) Lube Oil Pressure Low
e) Boiler Pressure Low
f) Valve Over Travel
g) Main Throttle (Hand wheel) Open
h) Boiler Drum Level Low-Low
i) VIAX (Turbine Vibration & Displacement) High High
j) Speed Reduction:
k) Drum Level Low
l) Boiler Pressure

m) VIAX (Turbine Vibration & Displacement) High

Speed reduction can be selected as automatic or off.

Lube Oil Purification
A Lube Oil Purification system is provided comprising purifier, Renovating Tank, water Tank and Storage Tank. Purification can be configured as follows:

a) LO Sump to LO Sump
b) LO Sump to Renovating Tank
c) Renovating Tank to LO Sump

2.7.1.1 Procedure for preparing the Lubrication Oil System

Emerg Distrib:
1 Close the LO Pump #1 circuit breaker

Main Distrib:
2 Close the LO Pump #2 circuit breaker

LO + Purifier:
3 Open the LO Pump #1 Suction and Discharge Valves
4 Open the LO Pump #2 Suction and Discharge Valves
5 Open the LO Cooler Inlet and Outlet Valves
6 Start LO Pump #1
7 When LO pressure reaches its rated operating value, the LO Pressure alarm should clear
8 Put LO Pump #2 into Standby operation
9 The LO Gravity tank fills and will overflow back to the sump at around 90% capacity. The sight-glass will turn yellow indicating a passage of oil in the overflow pipe.

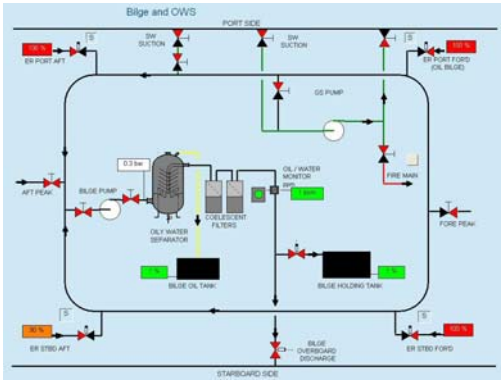
2.8 BILGE & FIRE

Equipment
1 off Bilge Pump
1 off Oily Water Separator

Alarms and Trips

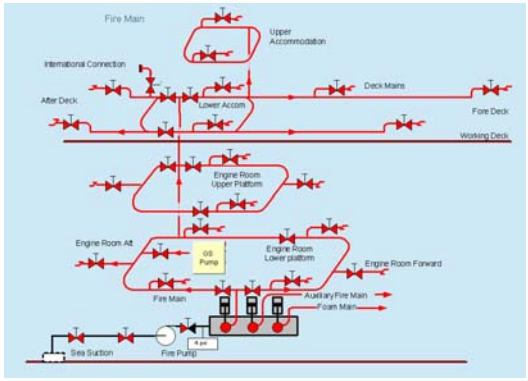
Item	Alarm Set Point
Port/Stbd Aft Engine Room Bilge High	70%
Port/Stbd Aft Engine Room Bilge High High	80%
Port/Stbd For'd Engine Room Bilge High	70%
Port/Stbd For'd Engine Room Bilge High High	80%
Bilge Oil Content High	10 ppm
Bilge Oil Tank Level High	80%
Bilge Holding Tank High	80 %

Bilge Description
The vessel has four bilge suction wells, including one designated as the oily bilge. The bilge pump draws from any well and discharges overboard through an oily water separator capable of reducing the oil contents to below the requisite 15-ppm. When in territorial waters or prohibited zones, the bilges can be discharged into a holding tank.



The bilge pump system can be set to automatic. Cross connections between the general service pumps and the fire pump are also available

Fire System Description
The main fire pump supplies the main fire system with alternative distribution to the Auxiliary Fire main and the foam main. A cross connection from the general service pump is also possible.



The fire main is distributed throughout the height of the engine room as well as through the accommodation and along the working deck. The engine room main can be isolated from the deck main in case there is a fracture in the engine room system.

An international shore connection is also located on the aft working deck to accept or provide water from/to another vessel.

2.8.1.1 Procedure for Preparing Bilge System

Emerg S/B:

1 Close Bilge Pump circuit breaker

Bilge + OWS:

2 Open Bilge Pump inlet and outlet valves
3 Open Bilge Port and Stbd, For'd and Aft Suction Valves
4 Put Bilge Pump into auto

The auto operation of the Bilge controls the Bilge Holding Tank valve and the Bilge Overboard Discharge Valve. If the Oil Water Monitor detects a high oil content the discharge automatically selects the holding tank and automatically closes the Overboard Valve.

2.9 COMPRESSED AIR SYSTEM

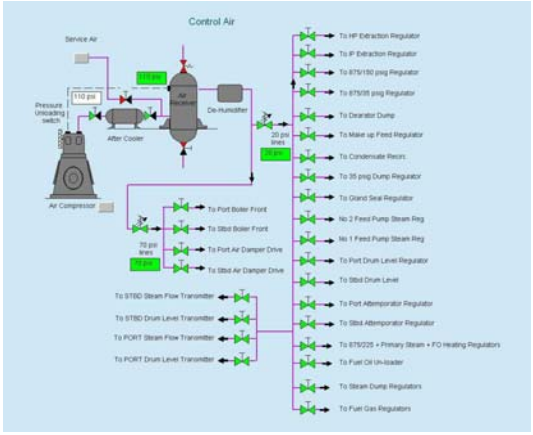
Equipment
1 Control Air Compressor
1 Control Air Dryer

Alarms and Trips

Item	Alarm Set Point	Trip Set Point
Control Air Bottle Pressure Low	75 psi	515 kPa
Control Air Pressure (70psi) Low	55 psi	375 kPa
Control Air Pressure (20psi) Low	15 psi	102 kPa

Introduction
The control air system is supplied from an air receiver that is supplied by a control air compressor. The control air system operates at a pressure of 20 psi (135 kPa) for control valve operation and 70 psi (480 kPa) to actuate the burner igniters on the boiler fronts.

Air at around 110 psi (750 kPa) is processed through a control air dryer (de-humidifier) and associated filter before supplying the control air services via pressure reducing valves. The dryer is of the activated alumina type. The drying process is automatic and the desiccant is regenerated whilst the unit is in operation.



It is essential that the control air is dried before entering the control system as any moisture in the control air can cause problems at actuators or other parts of the control system which could lead to failure. Automatic start and stop is provided for the operating compressor by means of a pressure switch.

Control air must be brought up to pressure before any of the automatic control systems can function Failure of control air pressure will raise an alarm.

2.9.1.1 Procedure for Preparing the Control Air System

Emerg Distrib:

1 Close Control Air Compressor circuit breaker

Control Air:

2 Open valves between the air compressor and cooler and between the cooler and air receiver.
3 Start the Control Air Compressor
4 Wait until pressure in the receiver reaches about 110 psi (750 kPa) and then open valves from the 20 psi (135 kPa) and from 70 psi (480 kPa) main Control Air lines.

2.10 ELECTRICAL SYSTEM

2.10.1 Emergency Diesel Alternator

Equipment
4 stroke, turbocharged diesel engine
Output: 350kW at a 440VAC 3PH

Description
The Emergency Diesel Alternator (EDA) control panel is located on the emergency switchboard. This supports analog instrumentation for EDA voltage, current and power. A Power Available indicator illuminates when the EDA is generating rated voltage and frequency but is not connected to the emergency busbar. The panel also supports START, STOP and AUTO controls for the EDA and controls for the EDA circuit breaker.

The prime mover for the EDA is a turbocharged diesel engine with a self-contained cooling water system. The cooling water is radiator cooled and circulated by an engine driven pump. The engine is lubricated by an engine driven pump drawing oil from an integral sump.

The EDA is started by means of an electric starter motor powered by batteries that are kept constantly charged.

The EDA is connected to the emergency bus by a main breaker that can close only when there is no power on the emergency bus. The EDA can be placed in MAN or AUTO mode. In AUTO the EDA will self start and automatically connect to the emergency switchboard within 45 seconds in the event of loss of main electrical supply. When set to MAN control, the EDA can be started and stopped manually using the START and STOP controls.

The EDA can be used to get the ship under power from dead ship condition and can supply essential services without the need for external services such as starting air, fuel oil supply and cooling water.

2.10.1.1 Procedure for Preparing the EDA for Automatic Start

Emerg S/B:

1 On the Emergency Generator Switchboard set the emergency generator control to AUTO.

The emergency diesel generator is now ready to start automatically and supply power should there be an interruption of power from the main electrical supply.

2.10.1.2 Procedure for Manually Starting the EDA

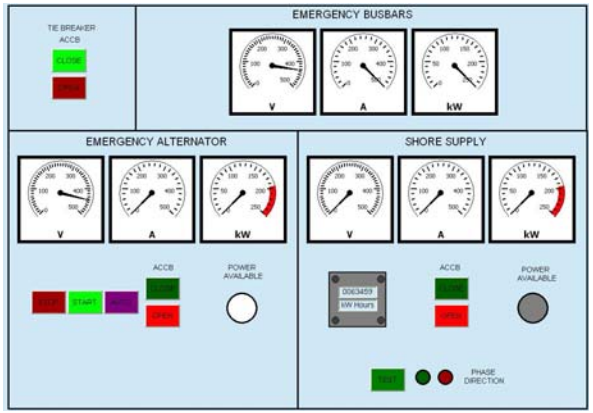
Emerg S/B

1 Set the emergency generator control to MAN by deselecting AUTO.
2 Press START and wait for the generator to run up to speed. The Power available lamp will illuminate when the EDA is ready for connection to the emergency busbar.
3 When the Power Available light is illuminated, press CLOSE to close the EDA circuit breaker and connect to the emergency busbar.

2.10.1.3 Procedure for Manually stopping the EDA after Running on Load

Emerg S/B:

1 Remove any load from the alternator and press OPEN to disconnect the EDA breaker.
2 If the EDA has been supplying a load, allow the engine to idle for 5 minutes before shutting down to allow the cooling water and lubricating oil to carry away heat from the combustion chambers, bearings, shafts etc. Long periods of idling will result in poor combustion and build up of carbon deposits.
3 Press STOP
4 When the engine has stopped, restore the control to AUTO.



The emergency switchboard monitors the emergency busbar conditions and is equipped with meters for Voltage (V), Current (kA) and Real Power (kW). It also supports controls for the tiebreaker ACCB

2.10.2 Shore Supply

Equipment
Shore Supply Rating: 200kW at a 440VAC 3PH

Description
The shore supply control panel is located on the emergency switchboard. This supports analog instrumentation for shore supply voltage, current and power. A Power Available indicator illuminates when the shore supply is at rated voltage and frequency but is not connected to the emergency busbar. An incoming phase direction test button will illuminate a green indicator if phase direction is correct (R-Y-B) or red indicator if incorrect. The panel also supports controls for the Shore Supply circuit breaker.

2.10.2.1 Procedure for Connecting Shore Supply (GROUP MODE)

1 Ask the Instructor for Shore Supply to be made available

Emerg S/B:

2 Power is available when the white Shore Supply light illuminates
3 Check the incoming phase direction is R-Y-B by press the Shore Supply Phase Direction test button. If the green light illuminates proceed to 5).
4 If the red light illuminates, inform the instructor and request that the shore supply phase direction be corrected.
5 Press the Shore Supply CLOSE breaker to connect to the shore supply to the emergency busbar

2.10.2.2 Procedure for Connecting Shore Supply (STAND ALONE MODE)

This is available only when ship is not underway or anchored.

Busbar Display:

1 Select Shore Supply ON.

Emerg S/B:

2 Power is available when the white Shore Supply light illuminates.
3 Check the incoming phase direction is R-Y-B by pressing the Shore Supply Phase Direction test button. If the green light illuminates proceed to 5).
4 If the red light illuminates, inform the instructor and request that the shore supply phase direction be corrected.
5 Press the Shore Supply breaker CLOSE button to connect to the shore supply to the emergency busbar

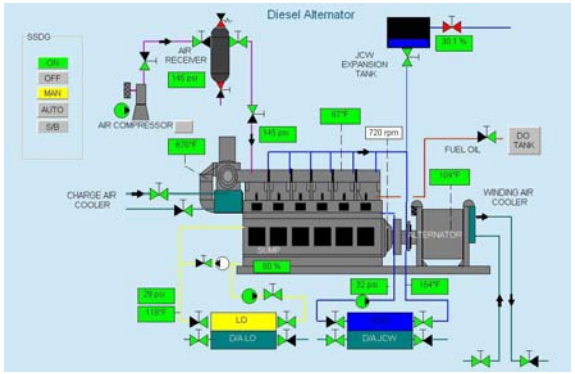
2.10.3 Main Diesel Alternator

Equipment
4 stroke, turbocharged diesel engine
Output: 850kW at a 440VAC 3PH

Alarms and Trips

Item	Alarm Set Point	Alarm Set Point
D/A Air Receiver Pressure Low	100 psi	690 kPa
D/A Average Exhaust Temperature High	930 °F	500 °C
D/A Starting Air Pressure Low	72 psi	500 kPa
D/A Scavenge Air Temperature High	140 °F	60 °C
D/A JCW Header Tank Level Low	20 %	20%
D/A Winding Temperature High	150 °F	65 °C
D/A JCW Outlet Temperature High	165 °F	74 °C
D/A JCW Inlet Pressure Low	10 psi	70 kPa
D/A LO Sump Level Low	30 %	30%
D/A LO Inlet Temperature High	133 °F	56 °C
D/A LO Inlet Pressure Low	20 psi	138 kPa

Description
The Diesel Alternator is a water-cooled, turbo charged, marine diesel engine, driving an AC



generator. The diesel engine is 4-stroke single acting turbo-charged, charge air-cooled trunk piston type engine. It is a self-contained unit with a wet LO sump and following engine mounted auxiliaries:

- Turbo Charger with air filter
- Charge air cooler
- Engine driven LO pump
- Speed governor
- Electrically driven pre-lube pump
- LO and Jacket Water coolers

- Engine driven Jacket water pump and cooler
- Over speed trip

The *Diesel Alt* display shows the fuel, coolant, compressed air and lubrication systems associated with the diesel Alternator with fuel supplied from the diesel service tank.

The diesel alternator is started with compressed air from an alternator air bottle with its own compressor.

A self-driven mechanical pump provides lubrication. The oil is cooled by freshwater and returned to the engine. Gauges and alarms monitor pressure, temperature and tank levels.

The diesel jackets are cooled by fresh water that, in turn, is cooled by the main fresh water circuit. An engine driven pump provides flow. A head of water is maintained on the suction side of the pump by a fresh water expansion/header tank. Pressure and temperature gauges and alarms are provided. The level in the expansion tank is monitored and displayed.

2.10.3.1 Procedure for Preparing the Main Diesel Alternator for Starting

Emerg Distrib:

1 Close SW Service Pump #1circuit breaker
2 Close D/G Pre Lube Pump circuit breaker
3 Close Diesel Gen Winding Heater circuit breaker
4 Close FW Cooler Pump #1 circuit breaker
5 Close Emergency Lighting circuit breaker

Diesel Alt:

6 Open valves from Emergency Air Compressor to Air Receiver
7 Open valves from Air Receiver to Alternator engine
8 Start the Air Compressor
9 Open the JCW Expansion Tank Filling Valve and wait until tank fills to around 50% then close valve.
10 Open Fuel inlet valve to engine

Fuel Oil Service:

11 Open valve from DO Settling Tank to Diesel Alt

Cooling:

12 Open an upper sea suction valve and filter outlet valve
13 Open SW Service Pump #1 suction and delivery valves
14 Open FW Cooler #1 inlet and outlet valves (SW Side)
15 Open Overboard discharge valve
16 Start SW Service Pump #1
17 Open FW Cooler Pump #1 suction and delivery valves (FW Side)
18 Open D/A Charge Air cooler inlet and outlet valves
19 Open D/A JCW Cooling Water cooler inlet and outlet valves
20 Open D/A LO cooler inlet and outlet valves
21 Open D/A Alt Winding cooler inlet and outlet valves
22 Open FW Cooler #1 inlet and outlet valves (FW Side)
23 Start #1 FW Cooling Pump

2.10.4 Diesel Alternator Switchboard

Description
The Diesel Alternator (D/A) control panel is located on the D/A switchboard. This supports analog instrumentation for D/A voltage, current, power, excitation voltage and power factor. . A Power Available indicator illuminates when the D/A is generating rated voltage and frequency but is not connected to the busbar.

Controls are available for the D/A air controlled circuit breaker (ACCB), Excitation control mode (MAN/AUTO), excitation, speed and reverse power trip reset.

2.10.4.1 Procedure for Manually Starting the Main Diesel Alternator

This procedure assumes the alternator is already prepared for starting and is supplied with air, coolant and fuel.

Diesel Alt:

1 Start the D/A Pre Lube Pump
2 Select D/A Control to MAN
3 Start the D/A by pressing START and wait for speed to reach about 700rpm. The speed will depend on the governor position and can be adjusted later.

D/A S/B:

4 Select Incoming Machine to D/A.
5 Monitor D/A Frequency on Synchronizing Section
6 Monitor D/A Voltage on the D/A Switchboard.
7 Select AVR to AUTO
8 Using the Excitation potentiometer, adjust Voltage to approximately 440V
9 Using Raise/Lower control, adjust Frequency to approximately 60Hz
10 Re adjust Voltage and Frequency so supply is 440V 60Hz and the Power Available lamp is illuminated.
11 Check that the Check Synch Switch is off
12 Close the ACCB. Voltage is established on the main busbar, the tie breaker will automatically close, the EDA breaker will open and power available lamp for the D/A will extinguish

Cooling:

13 Start SW Service Pump #1
14 Start FW Service Pump #1

2.10.4.2 Procedure for Preparing the Main Diesel Alternator for Automatic Start

This procedure assumes the alternator is already prepared for starting and is supplied with air, coolant and fuel.

D/A S/B:

1 Put Check Synch to ON

Diesel Alt:

2 Check D/A has air supply with valves open
3 Check D/A has coolant
4 Check D/A has fuel
5 Select D/A Control to AUTO

2.10.5 Turbo Alternators

Equipment

2 off steam driven Turbo Alternators with outputs: 850kW at a 440VAC 3PH

Alarms

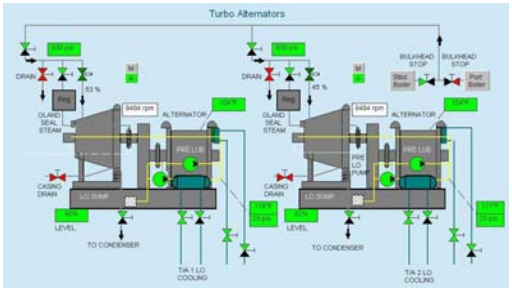
Item	Alarm Set Point	Alarm Set Point
T/A #1 & #2 Steam Pressure Low	750 psi	5.2 MPa
T/A #1 & #2 Winding Temperature High	150 °F	66 °C
T/A #1 & #2 LO Sump Level Low	30 %	30%
T/A #1 & #2 LO Inlet Temperature High	133 °F	56 °C
T/A #1 & #2 LO Inlet Pressure Low	20 psi	138 kPa

Description

Each Turbo Alternator comprises a steam turbine driving an air-cooled alternator through a reduction gearbox. The turbines are fitted with gland sealing systems, casing drains, exhaust to the condenser, over speed trips and tachometers.

Both alternators are cooled by air that passes through a freshwater circulated matrix before passing over the windings. The TAs have a supply of superheated steam from the boilers. A line drain is fitted before the main valve to the turbines.

The reduction gearbox drives a mechanical lubricating oil pump that circulates the oil through a fresh water cooler to the bearings of both the alternator and the turbine.



A pre-lubricating oil pump draws directly from the sump and discharges into the same lubrication manifold. The Pre-lube pump must be started before attempting to start the turbine. However the mechanical pump provides lubrication as the turbine rises to operational speed at which point the pre-lube pump can be shut down.

The *turbo alternators* display shows two the TAs with their steam supply, coolant and lubrication systems.

Separate speed regulating valves control steam supply to each alternator and can be operated in Manual or Auto modes.

2.10.6 Turbo Alternator Switchboard

Description
Control panels for both Turbo Alternators are located on the T/A section of the main switchboard. These support analog instrumentation for T/A voltages, current, power, excitation voltages and power factors. A Power Available indicator illuminates when a T/A is generating rated voltage and frequency but is not connected to the busbar.

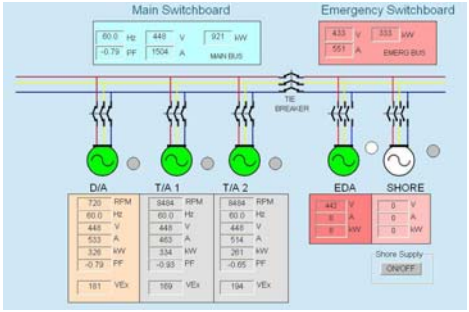
Controls are available for the T/A air controlled circuit breakers (ACCB), Excitation control mode (MAN/AUTO), excitation, speed and reverse power trip reset.

2.10.7 Power Distribution System

Description
The power distribution system consists of a main switchboard and an emergency switchboard that can be linked by a tiebreaker.

The emergency alternator or shore supply can feed the emergency switchboard provided the tiebreaker is open.

One or both of the turbo alternators and/or the diesel generator can feed the main switchboard.



Power from the three main alternators, emergency alternator and shore supply is fed via Air Controlled Circuit Breakers (ACCBs). These have overcurrent, undervoltage and reverse power trip protection.

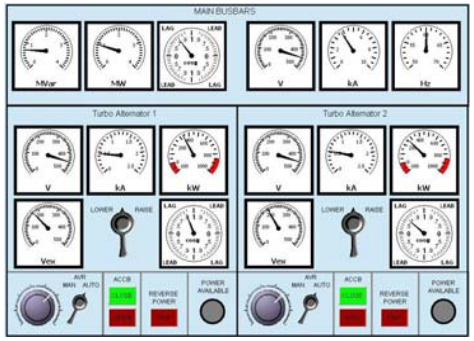
An interlock system will automatically open the emergency generator ACCB if the emergency tiebreaker is closed.

The normal operating condition is for both switchboards to be linked by closing the tiebreaker effectively forming one switchboard.

Power is distributed to the vessel through three panels of load circuit breakers. Two panels are connected to the main switchboard and one by the emergency switchboard. See *Distribution Circuit Breakers* Below.

Main Switchboard

The top panel of the main switchboard monitors the main busbar conditions and is equipped with meters for Reactive Power (MVAr), Real Power (MW), Power Factor (Cos φ), Voltage (V), Current (kA) and Frequency (Hz).



The lower two panels of the main switchboard support controls and instrumentation for the two TAs. Each is equipped with meters for Voltage (V), Current (kA), Real Power (kW), Excitation Voltage (Vex) and Power Factor (Cos φ), a potentiometer to set excitation voltage, and an indicator that illuminates when power is available from the alternator. Controls are available to raise/lower alternator speed, select MAN or AUTO voltage control, and OPEN or CLOSE the ACCB and to reset the ACCB after a reverse power trip.

Emergency Switchboard

The top panel of the emergency switchboard monitors the emergency busbar conditions and is equipped with meters for Voltage (V), Current (kA) and Real Power (kW).

Power Management System

The Power Management System controls turbo alternator frequency and load sharing and the starting, connecting and load sharing of the diesel generator. In the event of a blackout it will automatically start the emergency alternator, connect it to the emergency switchboard and close those circuit breakers feeding critical equipment.

Alternators can be operated in MAN or AUTO modes and power management is only active for an alternator selected to AUTO mode of operation. Some alternators can be in MAN and others in AUTO although the normal mode of operation is for all alternators to be in AUTO.

Each main alternator is equipped with an Automatic Voltage Regulator (AVR) that will attempt to maintain a constant terminal voltage at a value determined by the AVR potentiometer setting. Alternators can be operated in MAN or AUTO AVR modes and voltage regulation is

only active for alternators selected to AUTO mode of operation. In MAN mode, the AVR potentiometer directly controls excitation voltage.

Load Sharing
If an alternator has been manually synchronized then load sharing must be done manually by adjusting the speed and voltage of the relevant alternators.

The Power Management System will control alternators synchronized in AUTO mode so that their Real and Reactive Powers are equally shared.

Real power (kW) is shared between alternators by adjusting alternator speed. Reactive Power (kVAr) is shared between alternators by adjusting excitation voltage or AVR set point voltage.

If an alternator's AVR circuit is selected to MAN control, then the excitation voltage must be adjusted manually.

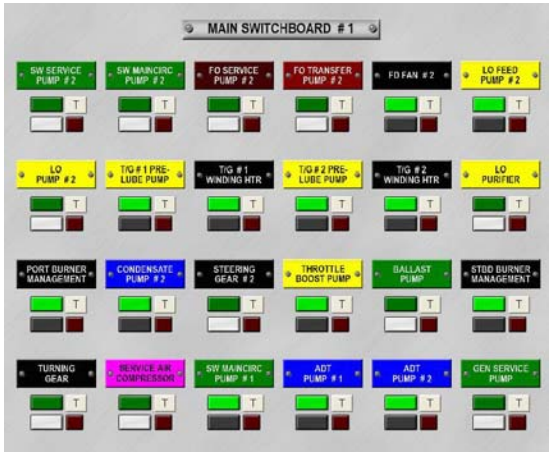
Automatic Startup / Shutdown
This mode is available by placing the Diesel Alternator in Standby. If the main bus bar load increases to over 80% of the maximum available supply capacity and for a pre-determined length of time, then the stand-by diesel engine will be automatically started, synchronized and connected to the bus bar. The load will be equally shared between Alternators.

If the load should decrease below 30% of the maximum available supply capacity (again for a predetermined time) then the standby set will shutdown and be left ready for a re-start if required.

Preferential Tripping and Sequential Restarting
The power management system matches the generator capacity to the power requirements of the vessel. However, non-essential services will be tripped if an overcurrent occurs,
If the current on a running generator exceeds 120% of the rated current for a period of 10 seconds, the PMS will initiate the release of preferential trips, thereby providing protection against the overcurrent which would otherwise trip the ACCB.

When normal conditions resume, the above breakers must be manually reset.

Distribution Circuit Breakers
Electrical power required for running individual pumps, motors and items of machinery is fed from a dedicated load breaker on the main and emergency switchboards. These breakers must be closed to permit operation and each has over-current and under-voltage trip protection. Power is automatically restored to critical plant and machinery once power is available after a blackout.



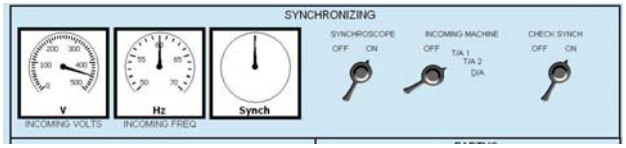
2.10.8 Synchronization

Description
A synchronizing control panel is located on the main switchboard. This supports analog instrumentation for incoming voltage and frequency and a synchroscope. There are controls to switch the synchroscope ON/OFF, another to select the source of the incoming voltage to be any of the three main alternators and a Check Synch switch.

The Check Synch switch has two functions:

a) It prevents the main circuit breaker of an incoming alternator from being closed unless the incoming voltage, frequency and phase are within predetermined acceptable limits for synchronization.

b) It operates as part of the Power Management System (PMS) and enables alternators selected to AUTO to synchronize and connect automatically. A PMS interlock prevents standby alternators being set for AUTO operation unless the Check Synch Switch is ON.



2.10.8.1 Procedure for Manually Synchronizing the Diesel Alternator

This procedure assumes the diesel alternator is already prepared for starting and is supplied with air, coolant and fuel and that at least one T/A is already connected to the Main Switchboard.

Diesel Alt:

1 Start the D/A Pre Lube Pump
2 Select D/A Control to MAN
3 Select D/A AVR control to AUTO.
4 Start the D/A by pressing START and wait for speed to reach about 720rpm. The speed will depend on the governor position and can be adjusted later.

D/A S/B:

5 Select Incoming Machine to D/A.
6 Monitor D/A Frequency on Synchronizing Section
7 Monitor D/A Voltage on the D/A Switchboard.
8 Select AVR to AUTO
9 Using the Excitation potentiometer, adjust Voltage to approximately 440V
10 Using Raise/Lower control, adjust Frequency to approximately 60Hz
11 Switch Synchroscope On and switch the Check Synch On.
12 Re-adjust Frequency until synchroscope rotates slowly in a clockwise direction.
13 Wait until the synchroscope pointer reaches an 11'oclock position or about 15 degrees before top centre and immediately close the D/A circuit breaker (ACCB).
14 Gently increase D/A power by raising the speed a little. If the other synchronized alternator(s) are in MAN control then decrease their speed accordingly so busbar frequency remains at 60 Hz.
15 Repeat the last procedure until the real powers are shared.
16 Gently adjust voltage of the D/A and other synchronized alternator(s) to obtain an acceptable Power Factor.

Diesel Alt:

17 Stop the Pre Lube Pump
18 Stop the D/A Air Compressor
19 Isolate the Air Receiver and close air to engine valve.

2.10.8.2 Procedure to prepare and run up a Turbo Alternator

This procedure supplies the turbo alternator with steam, coolant and lubrication. It assumes sufficient electrical power is available.

It also assumes boiler(s) are running on Heavy Oil (because the DO Service pump cannot deliver sufficient Diesel Oil to the boiler in order to support running a Turbo Alternator).

Main Condenser:

1 Ensure that a vacuum is present in the Main Condenser and not in alarm. Ensure a main circ pump is running to produce SW flow through the condenser.

Main Distrib:

2 Close T/G 1 Pre-Lube pump circuit breaker
3 Close T/G 2 Pre-Lube pump circuit breaker

Stbd Boiler:

4 Open Stbd boiler T/A Stop valve

Port Boiler:

5 Open Port boiler T/A Stop valve

Turbo Alts:

6 Start up the T/A Pre-Lube pump on the T/A you wish to run up by switching to Auto.
7 Note : A T/A cannot be run up without Pre-Lube (unlike the D/A which can)

T/A 1 Preparation:

8 Open T/A 1 LO Cooling inlet and outlet valves (Fresh Water Side)
9 Open T/A 1 Winding cooler inlet and outlet valves (Fresh Water Side)
10 Open Steam to Condenser valve
11 Open Gland Seal Reg valve
12 Select 'M' for Manual operation (of the Steam supply valve)
13 Ensure that the Steam supply valve position is 0%
14 Open both bulkhead stop valves.
15 Open T/A 1 Steam main line supply valve (to the steam control valve which is at 0%)
16 The steam supply pressure just before the steam control valve rises and the low steam pressure alarm is cleared at 750 psi.
17 If the T/A has not been used for some time it is good practice to go through a 'Warming up' procedure.

Warming up:

18 Open the casing drain valve
19 Gently open the steam supply valve to about 5% and run the T/A up to about 1000 rpm to warm through.
20 Close the steam supply and casing drain valve.
21 If the steam supply valve is opened too much the T/A may run up to an overspeed condition and trip (Trip light illuminates red)
22 If this happens then shut the steam supply valve and let the T/A coast down.
23 At low T/A speeds click the reset button and the trip light will extinguish
24 Restart the T/A pre-lube pump.
25 Close the casing drain valve.
26 Click 'A' for Auto and note that the manual control (slider) disappears.
27 The T/A is now under governor control which opens the steam supply valve up to 100%
28 The T/A runs up and the steam supply valve automatically reduces and settles at a running value. The T/A speed adjustment now comes from the raise/lower switches on the T/A S/B

2.10.8.3 Procedure to Parallel a Turbo Alternator

D/A S/B:

1 Check that the alternator on the board is running at 60 Hz 440V – If not then adjust
2 Switch Synchroscope on.

T/A S/B:

3 Select AUTO AVR and adjust the excitation to give 440V terminal voltage (not excitation voltage)
4 The Power Available light illuminates, switch the synchroscope ON
5 Select the Incoming Machine to T/A 1 (or T/A 2 – if paralleling/A 2)

Optional: Switch the Check Synch ON. This device prevents the operator from paralleling out of phase, however a good operator will only attempt to close the Incoming Machine ACCB when the phase difference is small (Synchroscope at approximately 12 o'clock).

5 Adjust the speed of the T/A to just over 60 Hz such that the synchroscope is rotating slowly clockwise.
6 When the synchroscope pointer is close to 12'oclock – (say 5 to 12 – if it were a clock) then close the ACCB

2.10.8.4 Procedure to Load Share between 2 or more Alternators on the Switchboard

1 Select the Alternator S/B which has the highest electrical load e.g. the D/A

D/A S/B:

2 Reduce the speed – thus reducing the electrical load (and overall frequency)

T/A S/B:

3 Increase the speed – thus increasing the electrical load (and overall frequency)

3 FURTHER GAS PROCEDURES & EXERCISES

3.1 STEAM SYSTEMS

USE SNAPSHOT 25 (97 rpm DUAL FUEL 2 Alts High Gas Burn Low HO Burn)

Procedures…
- BO Flow Control Manual and Auto
- Fuel Changeover Manual Burner Operation
- Fuel Changeover Auto Burner Operation

Exercised…
- BOG Heating
- Fuel Gas Recovery
- The need to burn LNG Gas
- Boil off Rate for Zero Pressure Increase

General
The following exercises are suggested for the user to get an idea of the general operation of the simulator. We recommend that the user sets up his own scenarios from his own snapshots.

When running these exercises many things can happen quickly: for this reason we recommend that the simulator "HALT" and "CONTINUE" features are frequently used so that the user can observe what has actually happened after a particular event.

For example if the Master Gas Valve were to trip for some reason the user may want to temporarily HALT the simulator to see what is happening. When satisfied the simulation can be continued by clicking "CONTINUE"

BOG Flow Control Manual and Auto

1. Dual Fuel BOG Flow Control with Manual Burner Operation

1.1 Cold start the simulator then load Snapshot 25 (97 rpm DUAL FUEL 2 Alts High Gas Burn + Low HO Burn)

1.2 Open Burner Operation Panel and BOG Controller Stbd and Port.

1.3 Note the gas consumption is about 0.5 kg/s (per boiler) which equates to about 0.15%/day of cargo usage

1.4 Note that both FO control valves are running at some low level

1.5 Reduce the Auto Set-Point of the Stbd BOG controller to say about 0.1 kg/s

1.6 The FG Control valve closes in on the Stbd side to achieve the required gas flow.

1.7 After a while both FO control valves start opening up (because the FO PIDs are in Auto) – note the more pronounced effect on the Stbd side

1.8 Reduce the Auto Set-Point of the Port BOG controller to say about 0.1 kg/s

1.9 The FG Control valve closes in on the Port side to achieve the required gas flow.

1.10 After a while both FO control valves open up even more

1.11 Reset the BOG set point back to about 0.5 kg/sec to see the converse effect.

1.12 Open the Student EOT and the Main Bearing Screen.

1.13 Reduce the EOT right hand handle setting to the line between the HALF and FULL settings which will reduce the shaft rpm to about 88 rpm

1.14 Note the Fuel Gas consumption remains essentially the same (controlled to about 0.5 kg/s as demanded by the BOG Controller set-point.)

1.15 However the FO control valves close in (to under 5%)

1.16 Wait one minute and note the situation remains much the same (no Auto)

2. Dual Fuel BOG Flow Control with Auto Burner Operation

2.1 Re load Snapshot 25 (97 rpm DUAL FUEL 2 Alts High Gas Burn + Low HO Burn)

2.2 Open Burner Operation Panel and BOG Controller Stbd and Port

Switch boilers to Auto Burner Op Mode.

Repeat operations 1.3 to 1.16 above and note everything is essentially the same

However note the following differences….

In Auto Burner Operation mode if the FO control valve for burner # 2 is less than 5% for one minute then FO burner # 2 shuts down

In Auto Burner Operation mode if the FO control valve for burner # 2 is greater than 95% for one minute then FO burner # 2 lights up. This can be tested by reducing the BOG set-points and increasing steam demand by increasing the EOT right hand handle setting which increases steam demand and hence FO use-age

In Auto Burner Operation mode if the FG control valve for burner # 2 is less than 5% for one minute then FG burner # 2 shuts down

In Auto Burner Operation mode if the FG control valve for burner # 2 is greater than 95% for one minute then FG burner # 2 lights up. This can be tested by increasing the BOG set-points and increasing steam demand by increasing the EOT right hand handle setting which increases steam demand and hence FG use-age

Note: In Auto Burner Operation mode if a gas burner is shut down then an automatic burner purge will follow (if permitted)

FUEL Changeover Manual Burner Operation

3. Dual Fuel to Gas Change-over with Manual Burner Operation

3.1 Re load Snapshot 25 (97 rpm DUAL FUEL 2 Alts High Gas Burn + Low HO Burn)

3.2 Note: Clicking the GAS button does nothing in this mode

3.3 Open Burner Operation Panel and Burner Management Stbd

3.4 Turn off FO burners #1 and #2 using the Burner Management Stbd screen

3.5 Note: The Burner Operation Panel now shows GAS mode on the Stbd side and only Gas burners are running

4. Gas to Dual Fuel Change-over with Manual Burner Operation

4.1 Perform steps 3.1 to 3.5 to get to GAS only mode

4.2 Note: Clicking the DUAL button does nothing in this mode

4.3 Turn on FO burners #1 and #2 using the Burner Management Stbd screen

4.4 Note: The Burner Operation Panel now shows DUAL mode on the Stbd side and both FO and Gas burners are running

5. Dual Fuel to FO Change-over with Manual Burner Operation

5.1 Re load Snapshot 25 (97 rpm DUAL FUEL 2 Alts High Gas Burn + Low HO Burn)

5.2 Open Burner Operation Panel and Burner Management Stbd

5.3 Note: Clicking the FO button does nothing in this mode

5.4 Turn off FG burners #1 and #2 using the Burner Operation Panel screen

5.5 Note: The Burner Operation Panel now shows FO mode on the Stbd side and only FO burners are running

6. FO to Dual Fuel Change-over with Manual Burner Operation

6.1 Perform steps 5.1 to 5.5 to get to FO only mode

6.2 Note: Clicking the DUAL button does nothing in this mode

6.3 Try to light up FG burner #1 or # 2 - nothing happens

6.4 Check the burner start permissives and it can be seen that a burner purge is required

6.5 Check the Purge Permissives and it can be seen that a burner purge **is** permitted but a header purge is **not** because the Emerg shutoff valve is not closed

6.6 However we do not require a header purge and only require a burner purge because the FG Emerg Shut valve was not closed during this procedure.

6.7 Purge the burners by clicking the Stbd HDR/BNR N2 Purge button

Clicking this button would purge the header (if allowed) followed by a burner purge (if allowed). In our case only a burner purge is allowed so we only get a burner purge which is exactly what we want

6.8 Wait for the gas burner purge to complete

6.9 Turn on FG burners #1 and #2 using the Burner Operation Panel

6.10 Note: The Burner Operation Panel now shows DUAL mode on the Stbd side and both FO and Gas burners are running

FUEL Changeover Auto Burner Operation

7. Dual Fuel to Gas Change-over with Auto Burner Operation

7.1 Re load Snapshot 25 (97 rpm DUAL FUEL 2 Alts High Gas Burn + Low HO Burn)

7.2 Open Burner Operation Panel and Burner Management Stbd

Switch boilers to Auto Burner Op Mode.

7.3 Click on the GAS button – both FO burners shut down

8. Gas to Dual Fuel Change-over with Auto Burner Operation

8.1 Perform steps 7.1 to 7.3 to get to GAS only mode

8.2 Click on the DUAL button – both FO burners light up

9. Dual Fuel to FO Change-over with Auto Burner Operation

9.1 Re load Snapshot 24 (95 rpm DUAL FUEL Stable 2 TAs High Gas + Hot FO)

9.2 Open Burner Operation Panel and Burner Management Stbd

Switch boilers to Auto Burner Op Mode.

9.3 Click on the FO button – both Gas burners shut down followed by an automatic gas burner purge cycle.

10. FO to Dual Fuel Change-over with Auto Burner Operation

10.1 Perform steps 9.1 to 9.3 to get to FO only mode

10.2 Click on the DUAL button – both FG burners light up (They are ALREADY purged)

BOG Heating and LD Compressor

11. BOG Heating

The boil off gas from the cargo tanks has to be heated before being sent to the burners. The LD compressor will add heat due to compression to but this is insufficient to raise the gas temperature to the correct value (around ambient). The boil off gas is heated by steam by the de-mister to a controlled value (around -140°C), more heat is added due compression and finally the gas is heated by the BOG heater to a controlled value (around 15°C to 20°C). The job of the LD compressor is to raise the low pressure BOG from the tanks (normally around 5 to 15 kPag) to a more suitable pressure (around 100 kPag) for the gas manifolds. The job of controlling the actual gas flow to the burners is not done by the LD compressor but by the Fuel Gas Control valves (FG CV).

11.1 Cold start the simulator then load Snapshot 25 (97 rpm DUAL FUEL 2 Alts High Gas Burn + Low HO Burn)

11.2 Open Burner Operation Panel and LD Compressors screens.

11.3 Observe a gas de-mister outlet temperature of about -140°C and a BOG heater outlet temperature of about 17°C.

11.5 Turn off the de-mister steam heater by shutting its steam heater supply valve

11.6 Note the de-mister outlet temperature fall and the steam heating control valve open further (indicated by a brightening green on the steam control valve)

11.7 This is not good for the LD compressor as there is danger of liquid droplets forming in the gas vapour

11.8 Open up the de-mister steam heating supply valve to recover (about -140°C)

11.9 Now shut the BOG steam heater by shutting its steam heater supply valve

11.10 Note the BOG heater outlet temperature fall and the steam heating control valve open further (indicated by a brightening green on the steam control valve)

11.11 Very soon the Master Gas Valve trips (BOG Temp LL)

11.12 Note: The gas burners carry on running for a while because there is still gas pressure in the manifolds. However observe that this manifold pressure is falling and we will soon lose the gas burners

11.13 Note the Fuel Gas Control Valves opening up (all the way to 100%) to try to compensate for the falling gas flow. This causes the LD compressor vanes to open further – the end result of which is an LD Compressor trip on High Pressure (HP) outlet pressure

11.14 The LD compressor HP outlet trip can be re-set by clicking the LD # 1 “HP OUT” box

11.15 However all is in vain and soon we lose ALL the gas burners on “FG HDR Pressure LL”

11.16 Note: The Fuel Mode indication has switched from DUAL to FO

Fuel Gas Recovery

12. Fuel Gas Recovery

12.16 Open the BOG Heater steam inlet valve and let the BOG heater temperature rise to about ambient temperature

12.17 Click the Master Fuel Gas Valve “TRIP/RESET” button and note the “BOG TEMP LL” light extinguishes. However we still have “BOTH BOILERS TRIPPED” illuminated

12.18 Click the FUEL GAS EMERG SHUT VALVE “TRIP/RESET” on both boilers to clear the individual boiler “FG HDR PRESS LL” alarms

12.19 Click the Master Fuel Gas Valve “TRIP/RESET” button and note the “BOTH BOILERS TRIPPED” light extinguishes

12.20 Check the Burner Start Permissives and the Burner Purge Permissives and it can be seen that we do not have permission to light any burners (they need to be purged) but we do have permission to purge the Main Line, the Gas Manifolds and the burners

12.21 Purge the main line by clicking Main Line “N2 Purge “

12.22 Wait for the main line to go through the purge sequence

12.23 Purge both Headers by clicking HDR/BNR N2 Purge buttons

12.24 Close both Header Vents

12.25 Reset both Fuel Gas Emerg Shut valves

12.25 Reset the Master Gas Valve

12.26 If not already done (11.14): Reset he LD compressor HP outlet trip can be re-set by clicking the LD # 1 “HP OUT” box

12.27 Open the Master Gas valve

12.28 Open both Fuel Gas Emerg Shut valves

12.29 Start LD Compressor # 1

12.30 Start say Stbd FG burner # 1

12.31 Wait for burner # 1 to light (If all 4 burners are lit too quickly there is a danger of a Master Gas Trip on “BOG TEMP LL” because of the very high gas flow rate in lighting ALL 4 burners simultaneously with the FG CVs at 100%.

12.32 Light up the other 3 FG burners

The Need to Burn LNG Gas

13. The Need to Burn LNG Gas

The following procedure is included to demonstrate why it may be necessary to burn the cargo on an LNG carrier.

It is NOT meant to be a Liquid Cargo Handling Simulator which is specifically intended for the training of cargo handling.

However this simulator is designed to train how to burn the gas produced from cargo boil-off with or without Fuel Oil. Gas production is therefore obviously necessary for this simulation.
An "Instructor" only screen (LNG Tanks) is appropriate to demonstrate why it may be necessary to burn the boil-off gas. The Instructor has the ability to change tank temperatures (hence pressures) and if so desired may show this screen to students to explain why the engine room may be requested to burn gas.

13.1 Cold start the simulator

13.2 Open the Instructor screen "LNG Tanks"

13.3 Note the gas usage is zero (tank valves are shut) and the boiling rate is about 0.000191%/day

13.4 This boiling rate is the result of 129 kJ/s (i.e. 129kW) of heat entering each cargo tank from the outside world. This is the primary cause of boil-off. This heat gain is a function of the thermal conductivity of the insulation around the tanks and also is proportional to the temperature difference between the outside world and the LNG liquid in the tanks. Because this temperature difference of say +20°C (ambient) - - 160.5°C (Tank temp) = about 180°C is approximately constant (as is the thermal conductivity) the figure of 129kW will not vary by very much. This causes a boil-off of about 0.000191%/day.

13.5 Increase the simulation speed of the cargo to x1000

13.6 It can be seen that the gas and liquid temperatures are rising

13.7 Halt the simulator

13.8 Click the Methane SVP box to bring up the Methane Vapour Pressure v Temperature screen. There is a Temperature to SVP and a SVP to Temperature calculator included at the bottom of this screen.

For example if the liquid temperature was -160.387°C then the SVP can be estimated using the SVP calculator to be approx 1.144 539 Bar (114.4539 kPa) or about 114.4539 kPa – 101.325 kPa = approx 13.13 kPag which should agree with the simulated tank SVP.

Note: The actual tank pressure is actually slightly less than the SVP because the liquid is boiling (You may see for example an SVP of 13.131 kPag but a tank pressure of 13.130 kPag)

13.8 Run the simulator again by going to the menu at the top ("Run" "Continue")

13.9 At about 22.90 kPag tank pressure switch to fast time x100

13.10 Note: at 23.00 kPAg tank pressure the high pressure safety valves open and we are illegally venting methane gas to the atmosphere – Hence the need to burn gas

Boil Off Rate for Zero Pressure Increase

14. Boil Off Rate for Zero Pressure Increase

The following procedure is included to demonstrate what gas flow rate is necessary to achieve a zero tank pressure increase rate on an LNG carrier.

It is NOT meant to be a Liquid Cargo Handling Simulator which is specifically intended for the training of cargo handling

14.1 Cold start the simulator then load Snapshot 24 (95 rpm DUAL FUEL Stable 2 TAs High Gas + Hot FO)

14.2 Open the Instructor screen "LNG Tanks"

14.3 Increase the simulation speed of the cargo to x100

14.4 Note that at a BOG rate of about 0.175%/day the tank pressures and temperatures are falling

14.5 This means that the gas use-age is higher than that necessary to keep pressures and temperatures steady (constant). The boiling of the liquid is taking out more latent heat than the incoming 129kW and is refrigerating the cargo

14.6 Open Gas Systems, Controllers, BOG FG Flow Stbd and BOG FG Flow Port screens

14.7 Reduce the Auto Set-points on both controllers to about 0.4 kg/s which will reduce the actual BOG rate to about 0.15%/day

14.8 Note that tank pressures and temperatures are now changing more slowly

14.9 Increase the simulation speed of the cargo to x1000

14.10 Note that by changing the BOG flow rate it is possible for the tank pressures to rise (if the BOG rate is too low <0.15%/day) or to fall (if the BOG rate is too high>0.15%/day)

14.11 A BOG rate of about 0.15%/day is the rate (on this vessel) for Zero Pressure Increase and occurs when the refrigerating effect of the boil off cancels the heating effect of heat entering through the insulation around the tanks

14.12 Compare this rate with the much smaller rate of BOG (0.000191%/day) rate within the tanks (when the tank valves are shut)