UNITEST

MARINE TRAINING SOFTWARE, SIMULATORS AND DIESEL ENGINE TESTERS

MARINE TRAINING SOFTWARE Engineering CBT

Operator's Handbook

Part 4

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Installation instruction

1. Do not insert the Hardlock Key before the software installation!

2. Start the computer and load the Windows 98 / Me / 2000 / XP / 2003 / Vista operating system.

3. Please wait for the CD-ROM auto-start sequence, or:

    a. Insert the CD into the CD-ROM drive.

    b. Click the “Start” menu.

    c. Select “Run…”.

    d. Type “[CD-ROM drive letter]:\setup.exe” (e.g. d:\setup.exe), or click ‘Browse…’ button and locate ‘setup.exe’ file on the CD-ROM.

    e. Click “OK” button.

4. Follow the instructions shown on the screen.

5. After the installation has completed, please insert the Hardlock Key.

6. In order to read the manual pdf files, please install the “Adobe Reader”, which is included on the CD-ROM.

FUEL CONDITIONING MODULE SIMULATOR

Abbreviations

AF	Automatic back flush Filter
CCAI	Calculated Carbon Aromaticity Index
CP	Circulation Pump
CV	Change-over Valve
DO	Marine Diesel Oil
EH	Electric Heater power
EPC	Engineering Process Control
FCM	Fuel Conditioning Module
FT	Flow Transmitter
HFO	Heavy Fuel Oil
LS	Level Switch in mixing tube
MF	Manual by-pass Filter
OP	Operating Panel
PT	Oil Pressure Transmitter
SH	Steam Heater
SP	Supply Pump
SRV	Steam heater Regulating Valve
TH	Thermal oil Heater
TT	Temperature Transmitter
V	Viscosity
VT	Viscosity Transmitter

1. General description

The Alfa Laval's Fuel Conditioning Module (FCM) is an automated two-stage pressurized fuel booster system used for diesel engines in the shipping and power station industries. It supplies clean filtered fuel to the engine at the flow rate, pressure and viscosity specified by the engine manufacturer.

The educational program FUEL CONDITIONING MODULE SIMULATOR is intended for teaching the basic principles of how to operate Alfa Laval's Fuel Conditioning Module.

The simulator introduces 3D model of the Fuel Conditioning Module, based on the real equipment. In order to create the impression of working in the real environment, it provides 3D sound which can be listened on 2, 4 or more speakers.

2. User interface

2.1. Main views

The simulator's 3-dimensional user interface provides possibility to view the Fuel Conditioning Module from 4 different sides. It is possible to change the Main View by selecting one of the radio buttons in bottom-left corner of the screen (fig. 1).

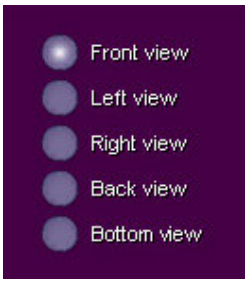


Fig. 1 Main View selection radio buttons

2.2. Zooms

In order to operate on the control panel, switches and valves it is necessary to zoom in the selected part of the Fuel Conditioning Module by clicking the left mouse button on the box surrounding the part. To zoom out and go back to the Main View - click the right mouse button or select one of the Main View radio buttons.

From each view, it is possible to select and zoom in the following parts (in left-to-right order):

1. Front View (fig. 2):
   - Supply Pumps with valves
   - Automatic filter block
   - Manometer before Supply Pumps and 3-way DO/HFO change-over valve
   - Manometer before Pressure Control Valve and thermometer
   - EPC50B process controller and switches
   - Control Cabinet - main switches
   - Circulating Pumps with valves
   - Manometer and thermometer after Circulation Pumps
   - Viscosity Transmitter Block with valves
   - Steam Regulating Valve - SRV - with by-pass
   - Steam Trap with by-pass

2. Back View (fig. 3):
   - Valves - Heat Exchanger oil inlet
   - Valves - Heat Exchanger oil outlet
   - Circulating Pumps with valves

3. Left View (fig. 4):
   - Flow Transmitter with by-pass and valves
   - Manometer before Mixing Tube
   - Automatic and manual deaeration arrangement

4. Right View (fig. 5):
   - Heat Exchanger valves - steam inlet
   - Heat Exchanger valves - steam outlet

The descriptions listed above will be visible only when the question mark button is checked and particular box selected by mouse cursor.

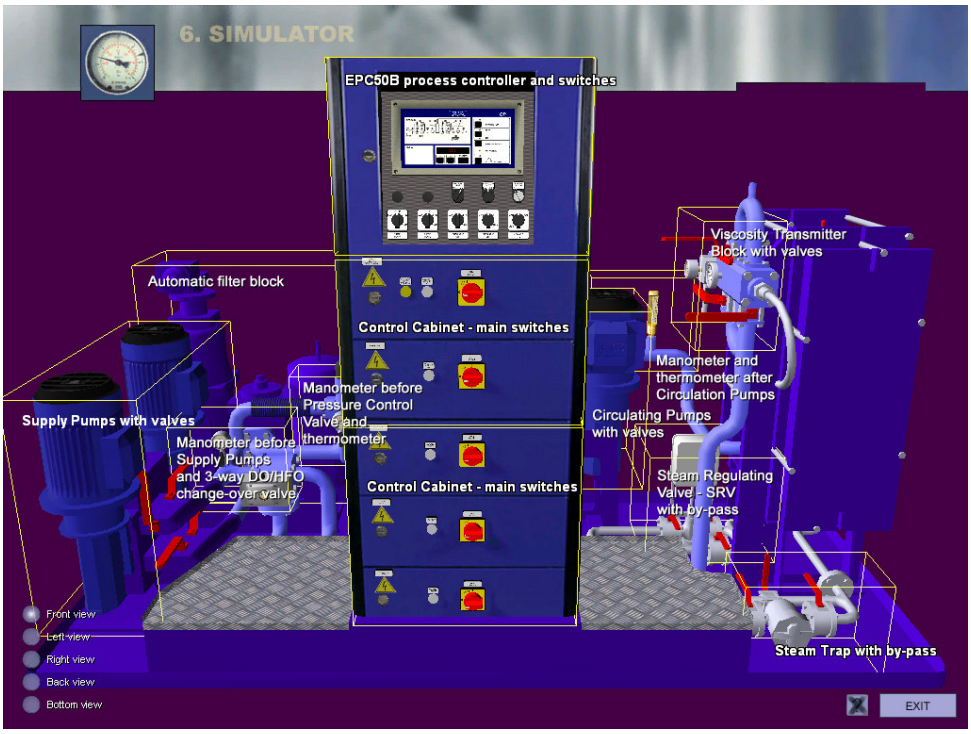


Fig. 2. Zoom options in the front view

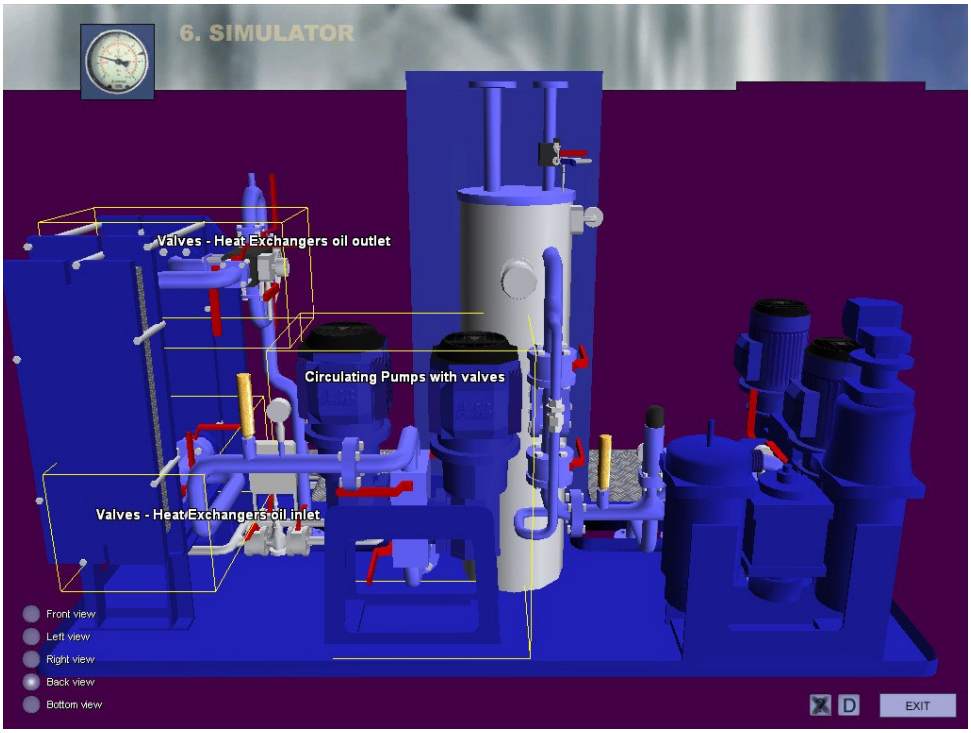


Fig. 3. Zoom options in the back view

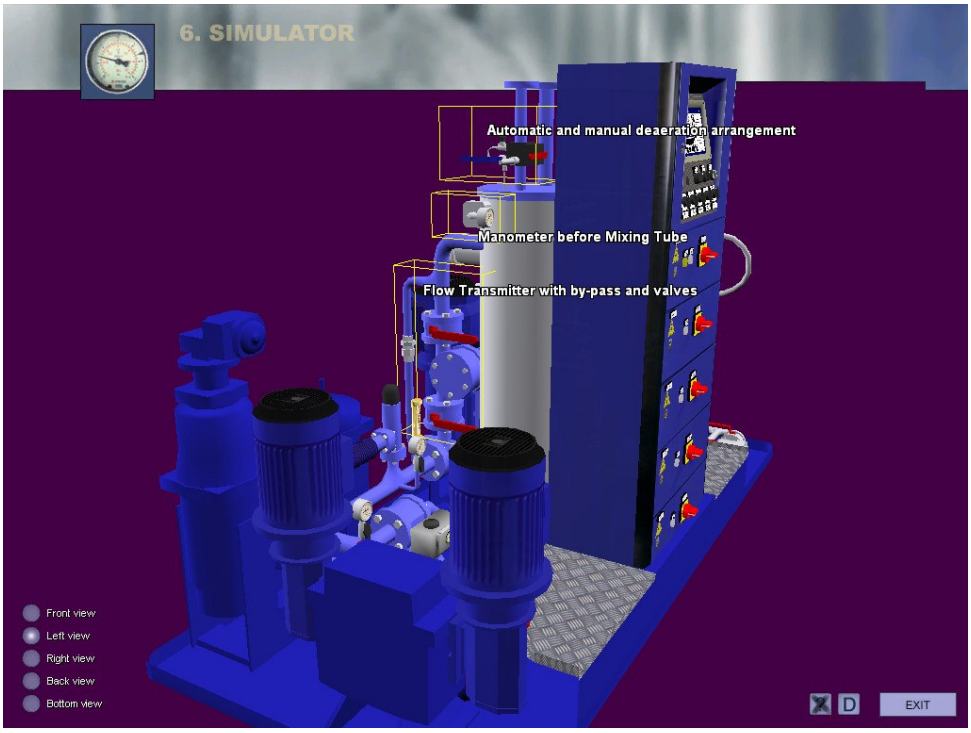


Fig. 4. Zoom options in the left view

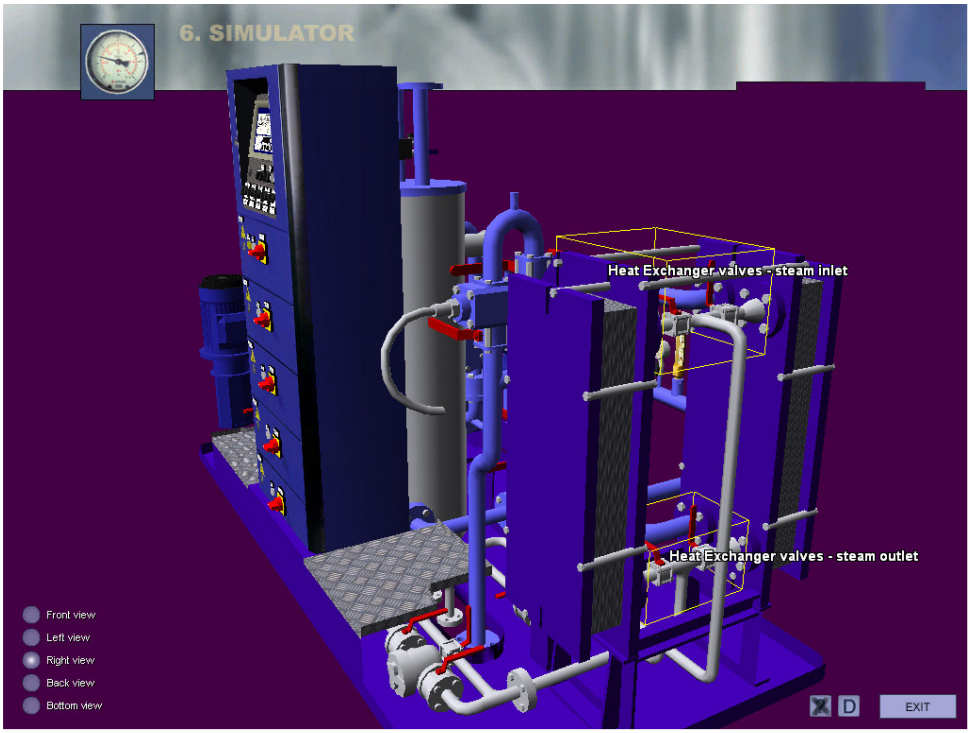


Fig. 5. Zoom options in the right view

2.3. Operating on the valves

When the mouse cursor is over an active valve – the selected valve lights up.

In order to open / close the valve, please click the left mouse button on the valve lever. By selecting question mark button, it is possible to read valve description and to check current state of the valve (open / closed) (fig. 6).

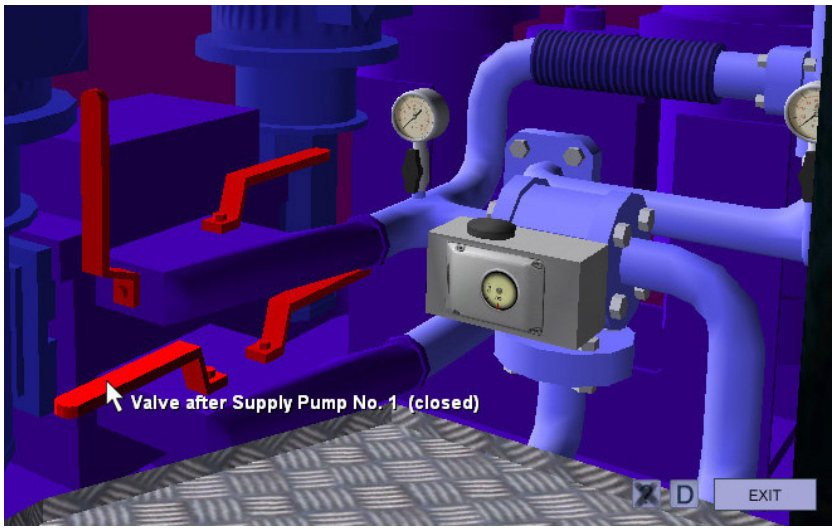


Fig. 6. Valve description and state

2.4. Operating on the switches

When the mouse cursor is over an active region of switch – the selected switch lights up.

In order to change switch position, please click the left mouse button on the position you want to switch to (fig. 7).

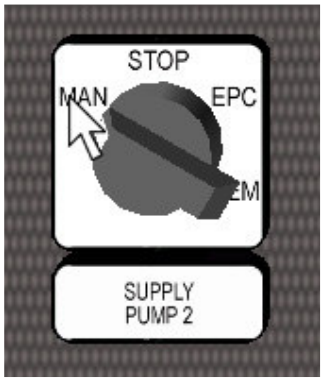


Fig. 7. Operating on the switch

2.5. Diagram

The diagram can be shown by clicking on the 'D' button (fig. 8). In order to hide diagram, it is necessary to click the 'D' button again or press the right mouse button. The diagram shows valves and pumps states and also fuel and steam flows. Additionally you can observe the fuel level in the Mixing Tube. The current view is marked by yellow box. There is also a legend under the diagram which gives a short symbols description.

The diagram provides possibility to zoom in the selected part of the Fuel Conditioning Module by moving mouse cursor above the box surrounding the part (the box will be flashing), and then by clicking the left mouse button. The diagram will be closed and selected part will be shown in the 3D view.

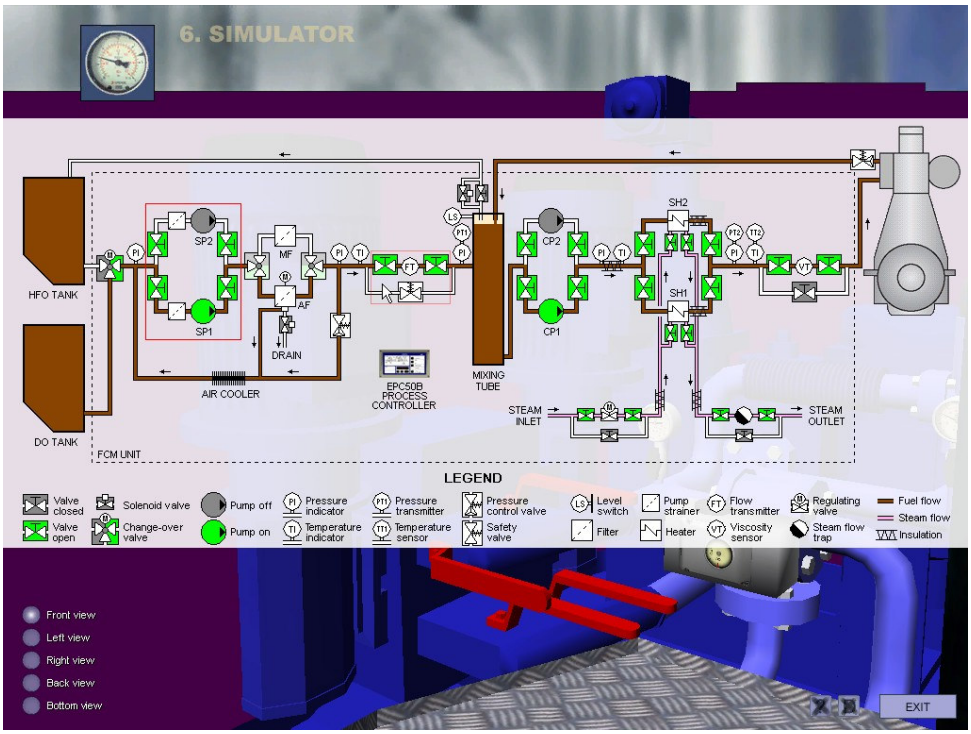


Fig. 8. Diagram

2.6. Parts description

In order to get a short description about each of the FCM part, please check the question mark button and then point the part by the mouse cursor (fig. 9).

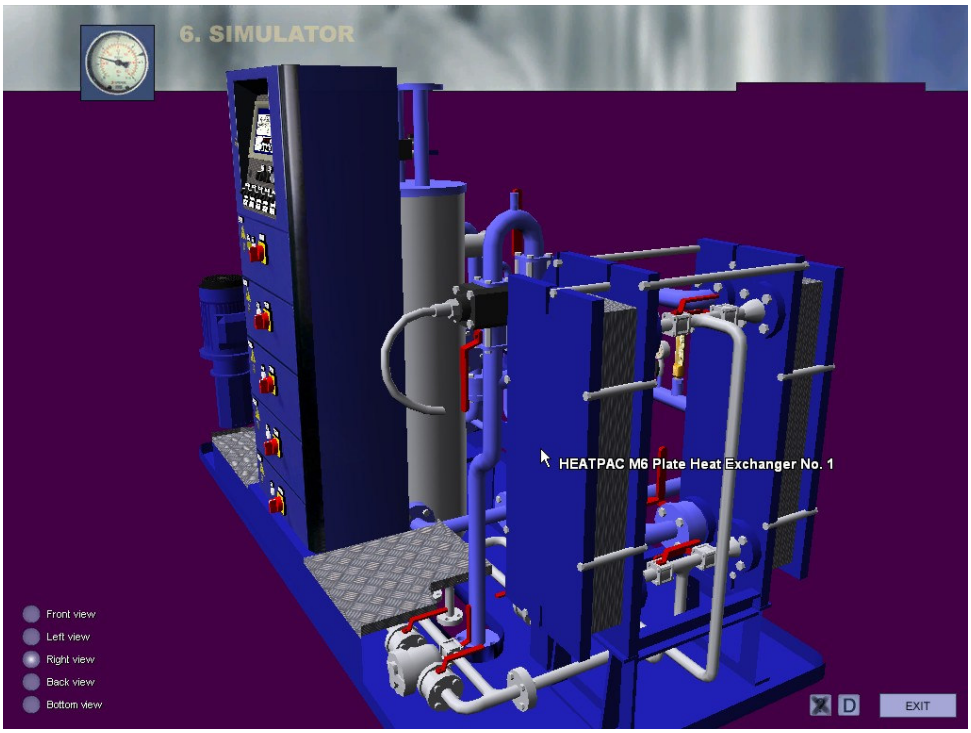


Fig. 9. Part description

3. Operating instructions

3.1. EPC-50B operators panel

The operators panel (local) is positioned on the upper part of the control cabinet (fig. 10).

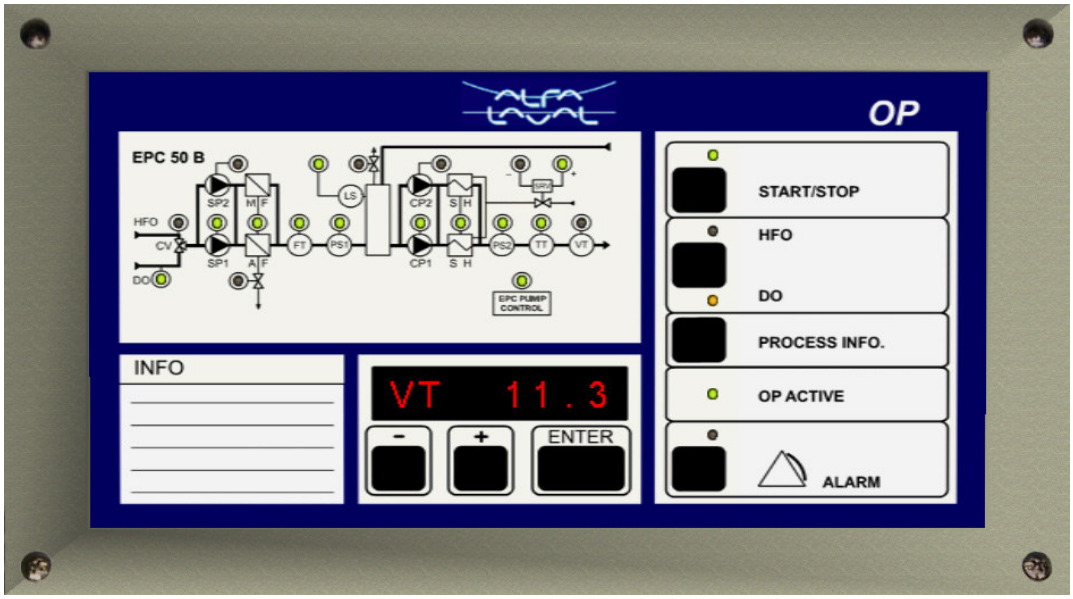


Fig. 10. EPC-50B operators panel

General principle for changing control parameters:
The "Enter" button is used to:

- enter into a parameter list
- enter into a parameter
- accept/store a new parameter value.

The "+" or the "-" buttons are used to change the value flashing in the display window.

Process parameters

Set the process parameters to suit the installation as follows:

1. Push “ENTER” to access the parameter list.
2. Push the “+” button go through the list. The display shows alternately a describing text, and a value.
3. Set the desired parameters.
4. When the parameters have been set, “End” (flashing) shows. Push “+” and “-” simultaneously to return to normal operation.

NOTE:

In the FCM simulator, in order to push “+” and “-” simultaneously, please click left mouse button between “+” and “-” buttons (after moving the mouse cursor between these two buttons, both buttons will be lighted up – fig. 11)

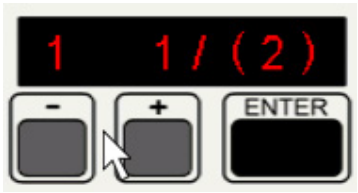


Fig. 11. Pushing simultaneously “+” and “-” buttons

Similarly, to push “+” and “Enter” buttons simultaneously, please click left mouse button between “+” and “Enter”.

For more information on parameter setting and how to change the factory set parameters, see the “Parameter list” chapter in the “Fuel Conditioning Module” application.

NOTE:

Factory and Process parameters can only be changed when the EPC control is started. This is indicated by the green LED next to the start button. Installation parameters cannot be changed.

In the FCM simulator, parameters which can be changed are displayed in red colour (fig.12), and parameters which can not be changed are displayed in dark red colour (fig.13).

Fig. 12. Parameter which can be changed

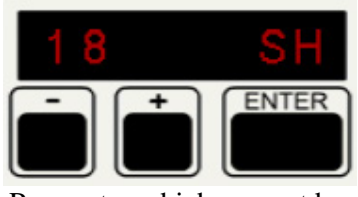


Fig. 13. Parameter which can not be changed

3.1.1. Controller information

Process information is available from the EPC50B controller.
Observe the operators panel information.

LED display information

- Equipment in operation: LED green.
- Activated valve: LED green.
- Ramp activated (temperature or change-over valve) : LED flashing green.
- Heater blocked (by no oil flow or low temperature alarm) : LED flashing green.
- Active alarm: LED flashing red.
- Acknowledged alarm: LED red.

Alpha numeric display

During normal operation the measured temperature, viscosity and fuel consumption scrolls continuously across the display.

NOTE:

All alarms are indicated in the alpha numeric display. For further information see the "Alarms and Fault Finding" chapter in the "Fuel Conditioning Module" application.

3.1.2. Instantaneous value list

More operational information may be read as required, by pressing the "+" button repeatedly.

To return to normal display continue pressing the "+" button, or by pressing "+" and "-" buttons simultaneously.

The following is an example of the information available in the instantaneous value list. The actual values displayed depend on equipment installed, automation level and parameter settings.

Oil temperature outlet

Oil temperature inlet

Oil viscosity 1)

Oil pressure 1, supply pump

Oil pressure 2, circulation pump

Flow transmitter (engine consumption)

Heater regulating valve position

Electric Heater power

Change-over valve. Gradual change-over shown in percent on display (electric change-over valve).

Process information

The information is arranged in 5 lists: Flow, Trip, Run, Viscosity and Timer.

Process information checking procedure:

1. Press the "PROCESS INFO" button on the operator panel.
2. Push "+" to see the different lists. The following lists are available:
    a. Flow list,
    b. Trip list,
    c. Run list,
    d. Viscosity list,
    e. Timer list.
3. Press "ENTER" button to see the information.

    Step through the values with the "+" button.

NOTE:

The information that is specifically available on each installation will depend upon the level of automation that has been purchased.

Flow list:

HFO cons **3256.3 m^3**	The total amount of heavy oil that has passed through the module since it was delivered (If a mass flow meter is installed then display reads in metric tonnes instead of cubic metres).
HFO cons **4543.7 T**	Calculated mass flow, provided temperature sensor is fitted in the oil inlet.
DO cons **856.4 m^3**	The total amount of diesel oil that has passed through the module since it was delivered.

Trip list:

Trip cons **354.3 m^3**	Accumulated consumption. The amount of oil that has passed through the module since last reset to zero. (Parameter Pr7 = 10)
Trip avg **5.06 m^3/ h**	Trip cons divided by Trip time.
24 h cons **121.40 m^3**	Fuel consumption during the last 24 hours.
Trip time **16 : 55**	Time that the module has been in operation since last reset.

Run list:
Run time for the individual components (hours).

SP 1 run **5446 h**	Supply pump 1 run time.
SP 2 run **2067 h**	Supply pump 2 run time.
CP 1 run **5938 h**	Circulation pump 1 run time.
Cp 2 run **2391 h**	Circulation pump 2 run time.
AF run **7513 h**	Automatic filter run time.
SH run / TH run / EH run **8329 h**	Heater run time (total run time for both heaters).
Eh cons **9147 kWh**	Electric heater power consumption (for both heaters).

Viscosity list:

V / 50° C **337 cSt**	The viscosity of the oil in the system at 50° C. The value is obtained by estimating the viscosity according to the viscosity / temperature curve for typical oils (can be changed with parameter Pr35).
V / 100° C **45 cSt**	The viscosity of the oil in the system at 100° C. The value is obtained by estimating the viscosity according to the viscosity / temperature curve for typical oils (can be changed with parameter Pr35).
CCAI **845**	Calculated Carbon Aromaticity Index of the oil in the system. Based on parameter Pr23, if the mass flow meter is not installed, and measured viscosity and temperature.

Timer list:

AF count **546**	Automatic filter total number of automatic draining.
AF to go **3 : 02**	Time to next draining (h and min.).
LS count **5**	Total number of automatic deaeration. Based onsignal from level switch in mixing tank.
LS time **734 : 26**	Time since last deaeration (h and min.).

3.2. Normal operation

3.2.1. Checking valves state

1. Open Supply pumps inlet and outlet valves (fig. 14).

Fig. 14. Front view - Supply pumps with valves

2. Open valves before and after the Flow meter (fig. 15).

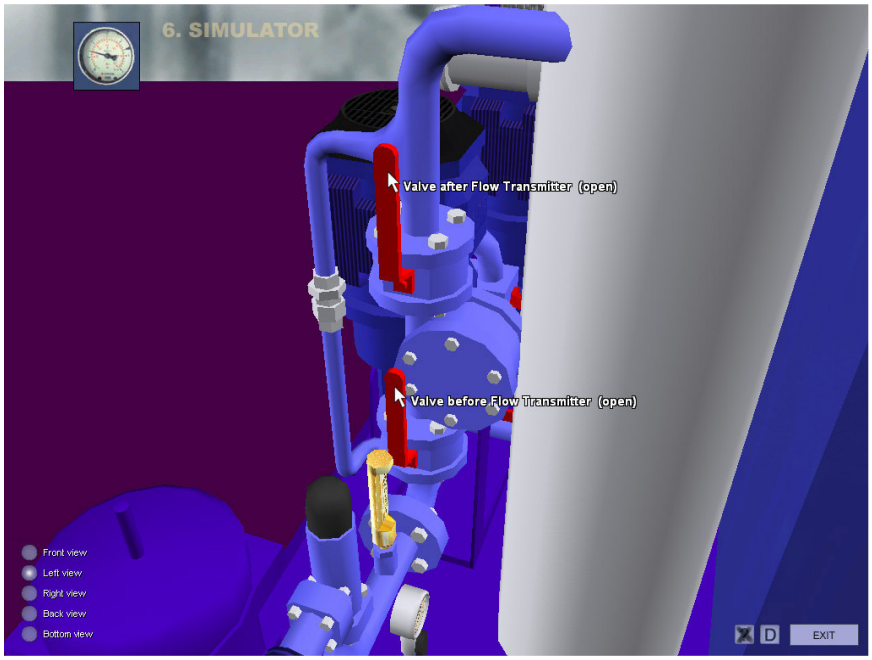


Fig. 15. Left view - Flow transmitter with by-pass and valves

3. Check that the manual deaeration valve on the top of the mixing tube is closed (fig. 16).

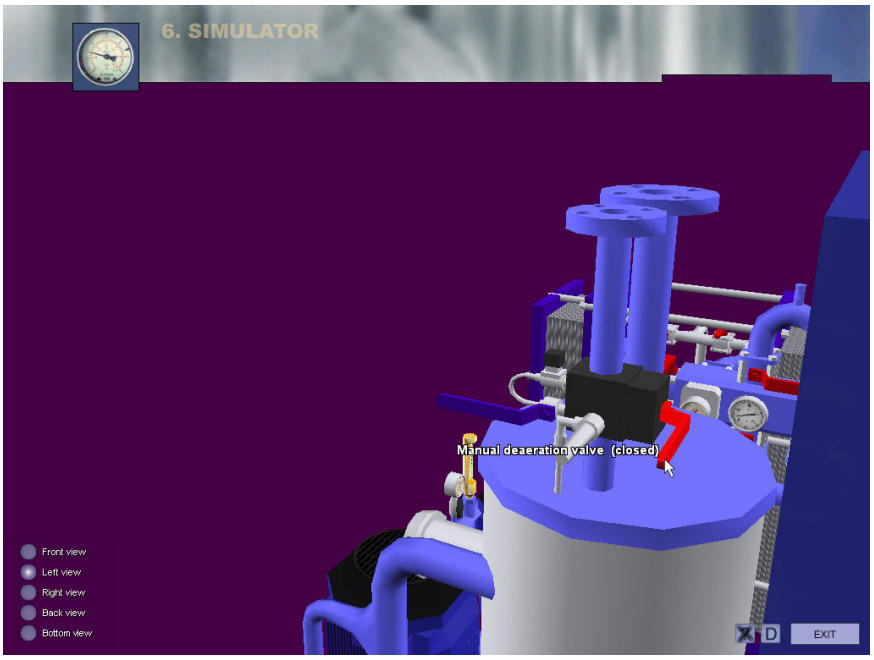


Fig. 16. Left view - Automatic and manual deaeration arrangement

4. Open valves before and after the Circulating pump No. 1 (fig. 17).

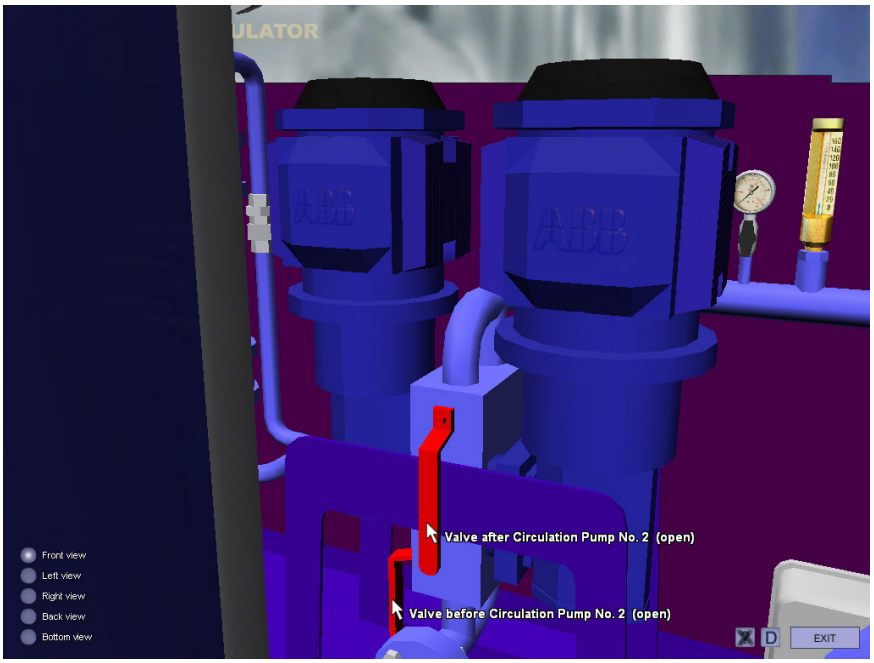


Fig. 17. Front view - Circulating pumps with valves

5. Open valves before and after the Circulating pump No. 2 (fig. 18).

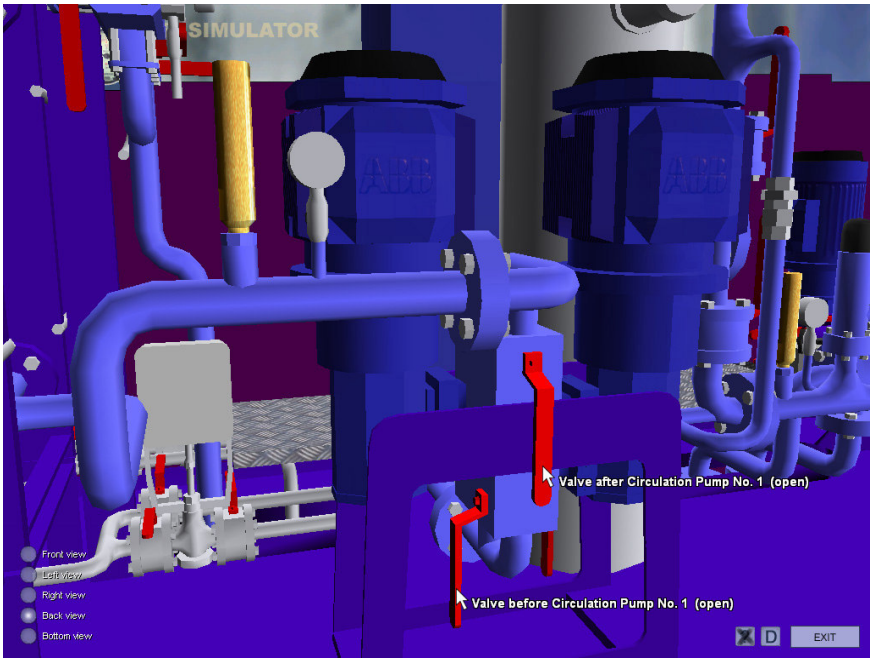


Fig. 18. Back view - Circulating pumps with valves

6. Open valve before one of the Steam heater (e.g. before Steam heater No. 2) (fig. 19).

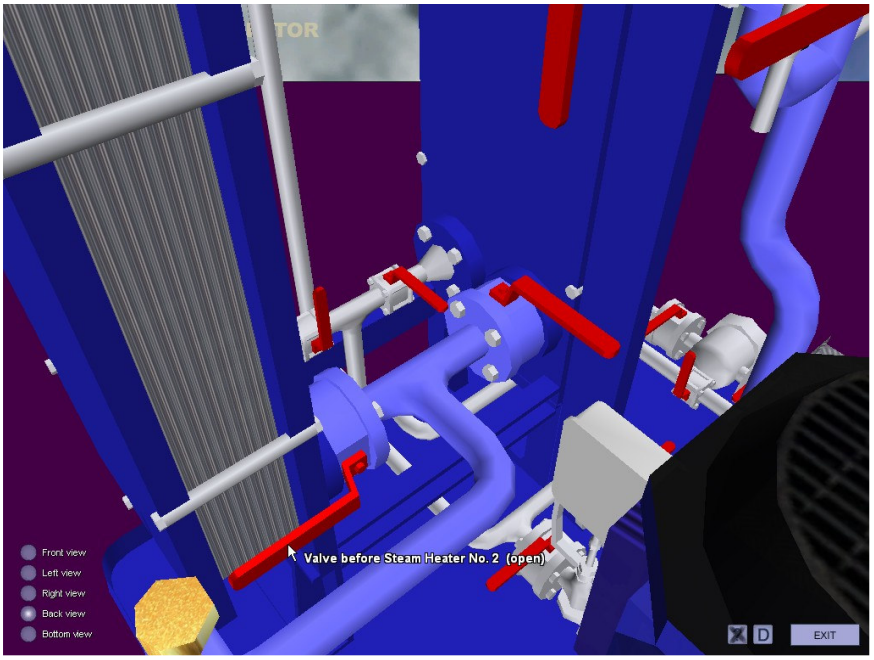


Fig. 19. Back view - Valves - Heat Exchanger oil inlet

7. Open valve after one of the Steam heater (e.g. before Steam heater No. 2) (fig. 20).

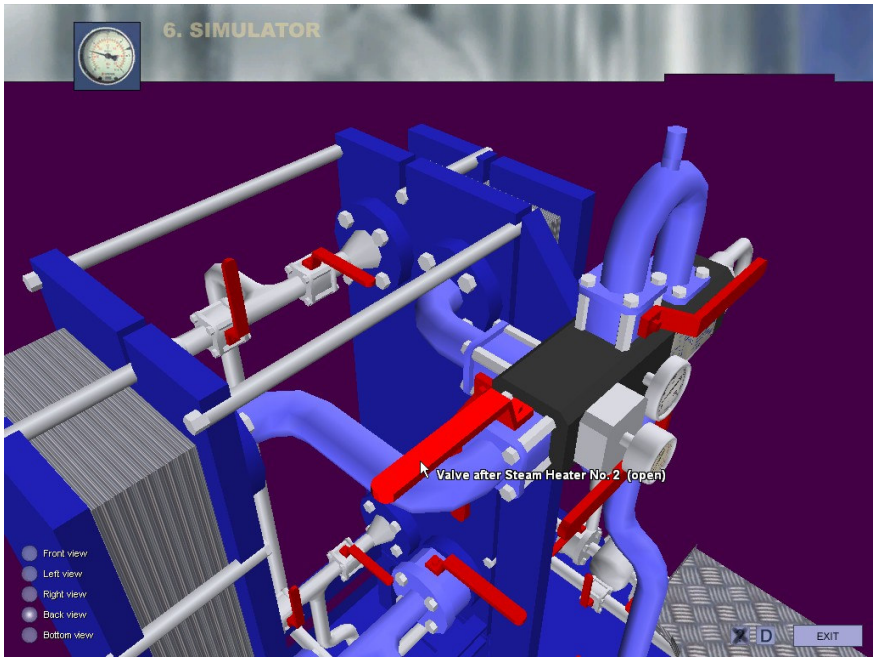


Fig. 20. Back view - Valves - Heat Exchanger oil outlet

8. Open valves before and after the Viscosity sensor, check that the by-pass line is closed (fig. 21).

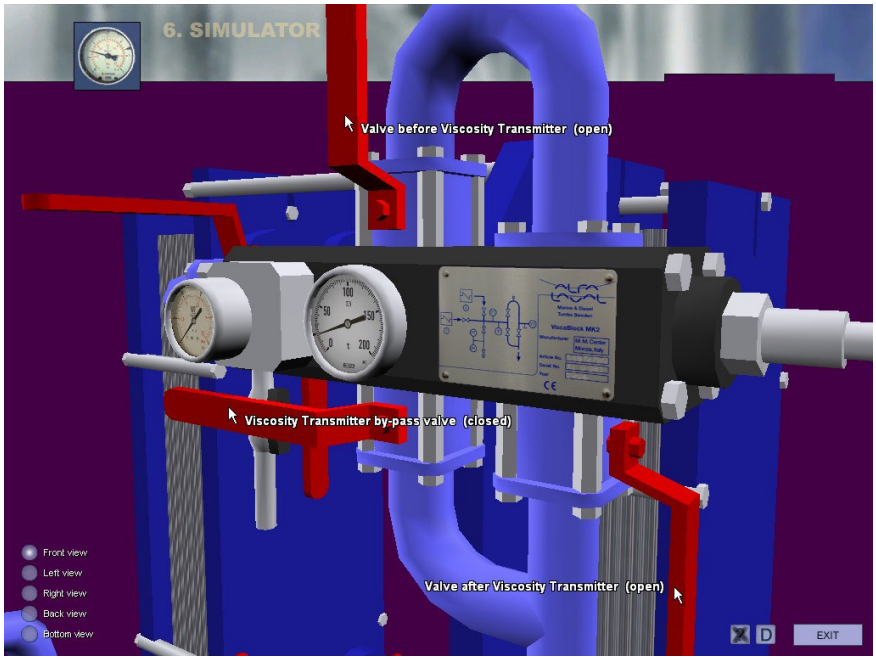


Fig. 21. Front view - Sensors block with valves

9. Open valves before and after the Steam regulating valve, check that the by-pass line is closed (fig. 22).

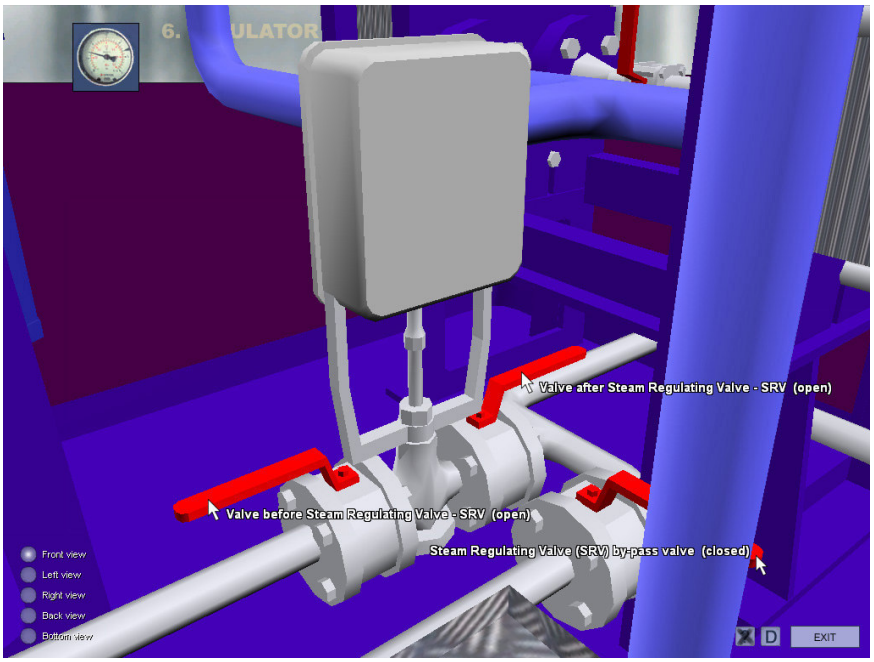


Fig. 22. Front view - Steam regulating valve - SRV - with by-pass

10. Open valves before and after previously selected Steam heater (in this case, before and after Steam heater No. 2) (fig. 23, fig. 24).

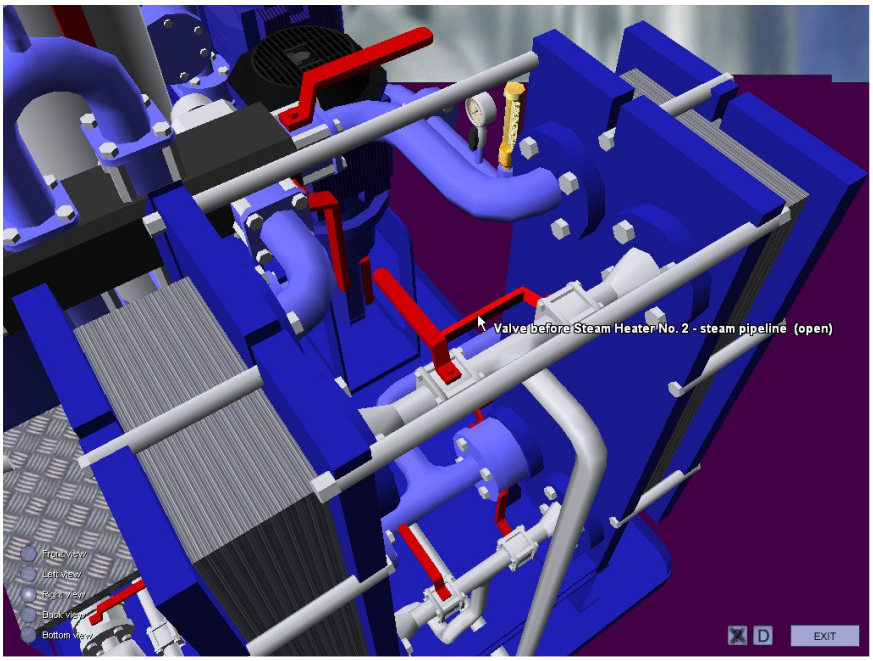


Fig. 23. Right view - Heat exchanger valves - steam inlet

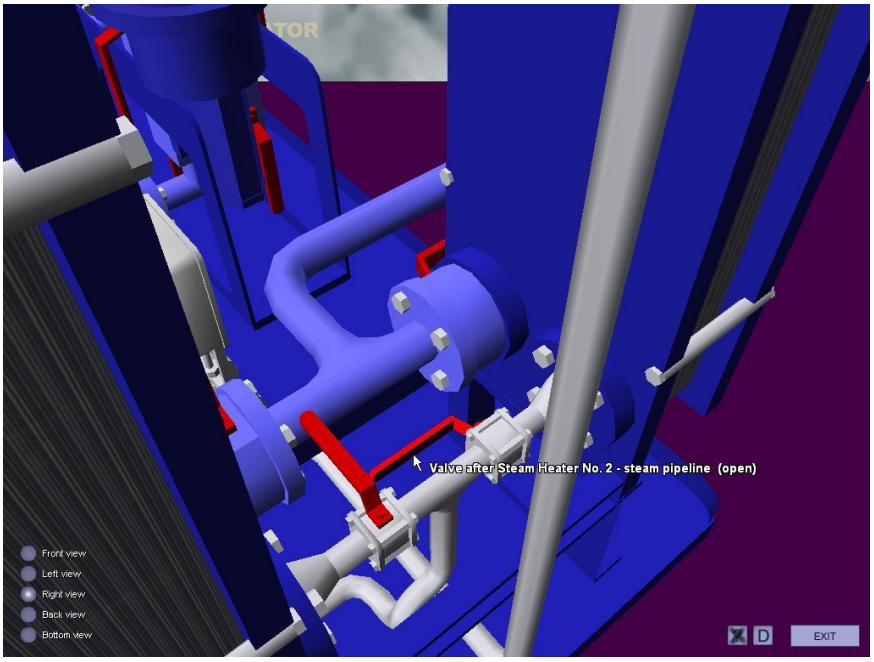


Fig. 24. Right view - Heat Exchanger valves - steam outlet

11. Open valves before and after the Steam trap, check that the by-pass line is closed (fig. 25).

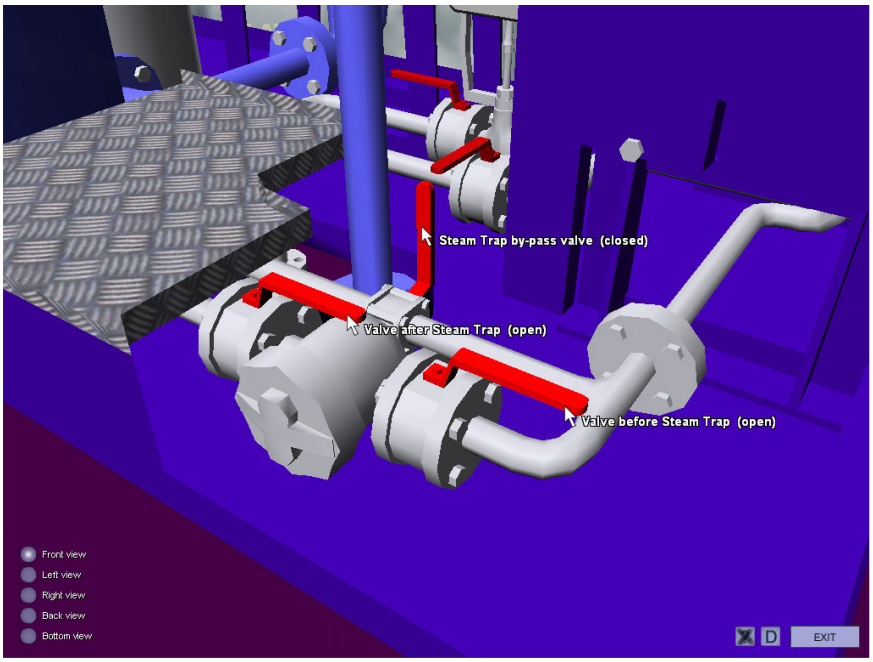


Fig. 25. Front view - Steam Trap with by-pass

3.2.2. Before start

The following procedures are based on the assumption that the commissioning action described in the Installation instruction book of Alfa Laval's Fuel Conditioning Module has been successfully performed.

1. Switch on the EPC with the switch inside the cabinet (fig. 26).

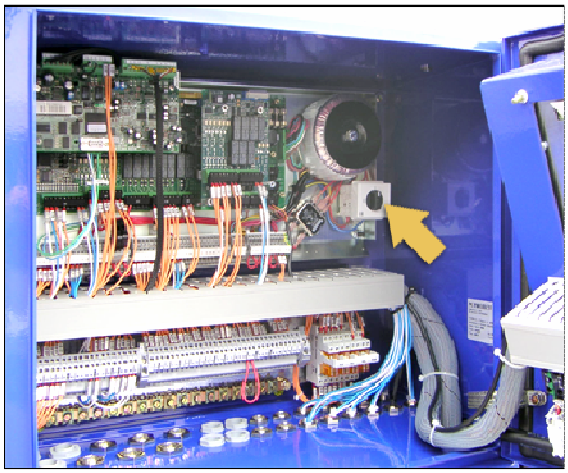


Fig. 26. Switch inside the cabinet

NOTE:
In the simulator it is assumed that the EPC is already switched on.

2. Set automatic filter switch in "auto" position (fig. 27). In this position the filter is hard wired to start when the respective pump is started (supply pump if filter is after the supply pumps, or circulating pump if filter is after the circulating pumps).

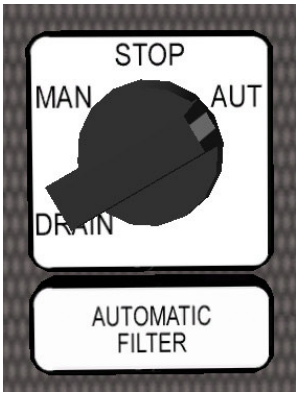


Fig. 27. Automatic Filter switch

3. Set regulating valve switch in “EPC” position (fig. 28).

Fig. 28. Regulating valve switch

4. Switch on the isolators on each starter (fig. 29).

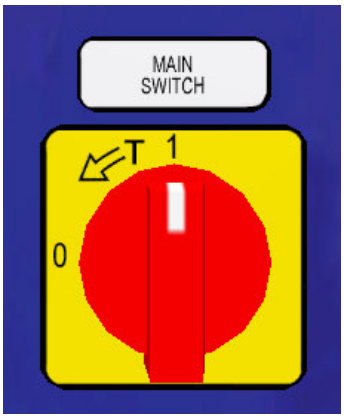


Fig. 29. Main switch

NOTE:

If one pump starter is not available (due to maintenance or other reasons) the unit cannot be started in EPC mode but has to be started manually.

3.2.3. Start – EPC mode

1. Set all four pump switches to the EPC position (fig. 30).

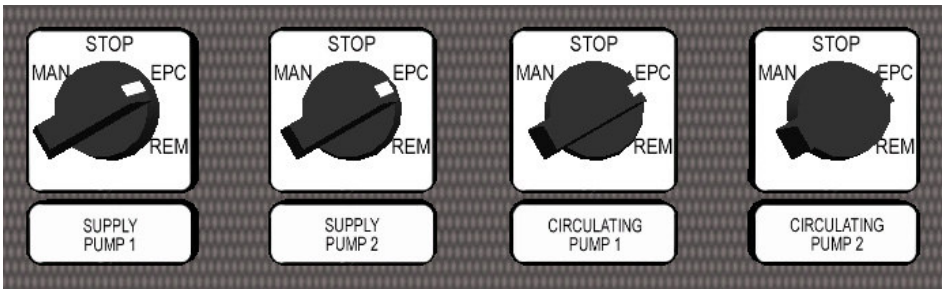


Fig. 30. Supply and circulating pump switches – EPC position

2. Press "Start" on the EPC. A question will appear in the display, "Start?" + = Yes - = No" (fig. 31). Pressing the "+" button will start the system. Pumps and heating will be started according to the module starting sequence.

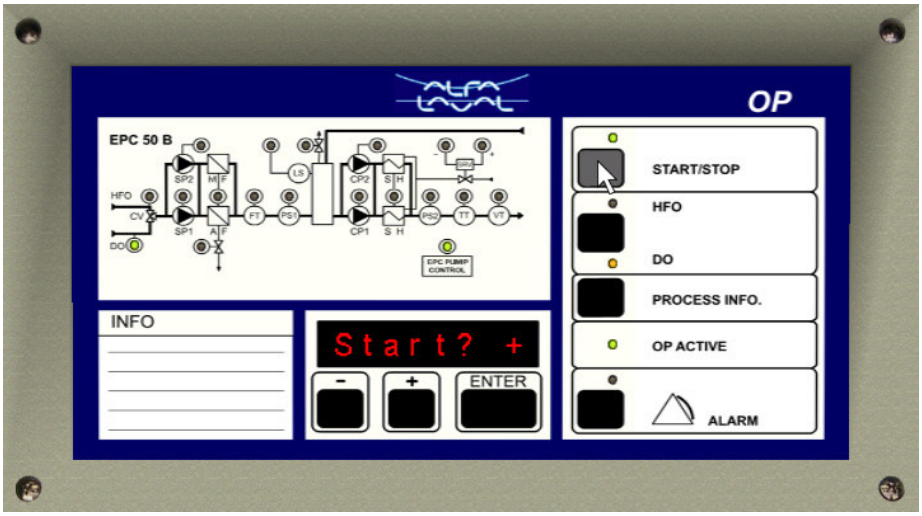


Fig. 31. Starting EPC

Pre-selected supply pump is started. When pressure is above PT1 the alarm low limit - system waits 30 seconds. Then (preselected) circulation pump starts. When pressure is above PT2 the low alarm limit — system waits 30 seconds. Then heating starts.

At start up: low pressure alarms are blocked for 4 minutes, or until the pressure is above the alarm limit. Then the low pressure alarm delay time is as set with parameter Fa9.

NOTE:

If the optional Automatic fuel change over function has been installed, Automatic change over from DO to HFO will be as set with parameters Fa15 and Fa16.

Alternatively

1. Start the supply and the circulation pumps in the manual position (in any order) (fig. 32).

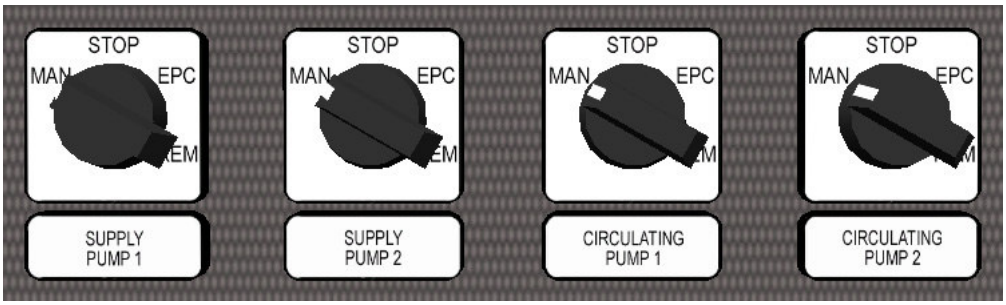


Fig. 32. Supply and circulating pump switches – manual position

2. Start the EPC. (Heating will start if under setpoint.)

3. Set the stand-by pump switches to the EPC position.

4. Change the running pump switches to the EPC position. (The running pumps will stop, and the pumps selected in the EPC will start.)

3.2.4. Stop - complete shut down

By stopping the system as follows, no alarm will be activated.

The system is designed so that the pumps cannot be stopped from the EPC controller even if an error occurs in the controller.

The EPC can only start or switch pumps, but never stop them. For safety reasons, this has to be done manually.

1. Press “stop” on the EPC (fig. 33).

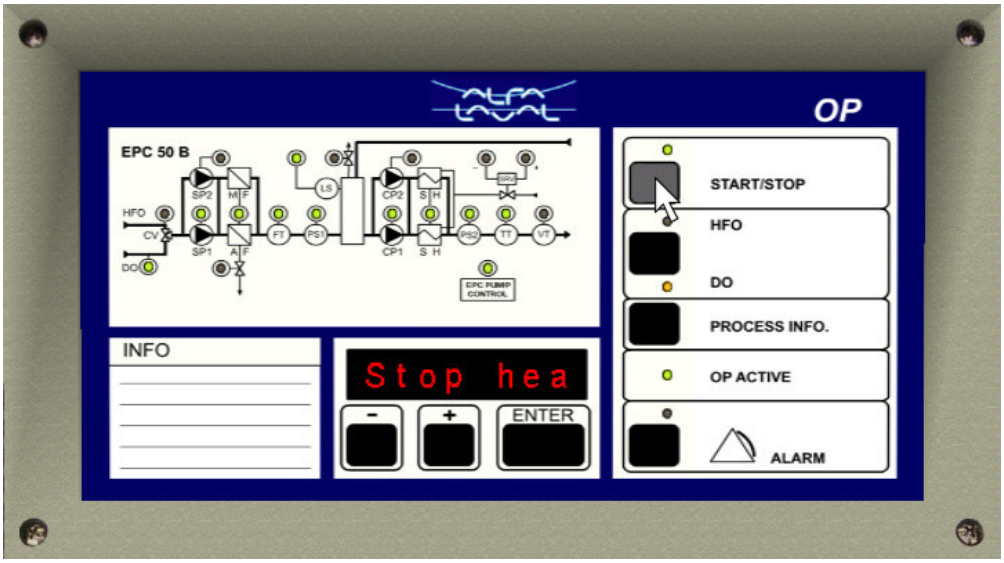


Fig. 33. Stopping the heater

2. A question will appear in the display “Stop heater?”.
3. Heating will be stopped.
4. An instruction will scroll across the display “Stop pumps manually!”.

NOTE:
Wait until the system has cooled before stopping the pumps (if not already on diesel oil).

5. Pumps can now be stopped in any order.

NOTE:
To increase the life-span of the pumps seals, it is recommended to stop (and thus start) the pumps on diesel oil. Cold Heavy Fuel Oil subjects the seals to more wear on start.

3.2.5. Stop – pumps remain on

Each set of pumps (circulating and supply) can be stopped independently of each other. For example, when the engine is not in service, the supply pumps can be stopped, and the circulating pumps (and heating) can remain running.

To stop the supply pumps but leave the circulating pumps on to circulate oil in the engine fuel rail and heater circuit, the EPC should remain on so that the stand-by function is activated.

Stop in the following order to avoid alarm and starting the stand-by pump.

1. Stop the stand-by supply pump (switch from “EPC” to “STOP”).
2. Stop the running supply pump (switch from “EPC” to ”STOP”).

NOTE:
The time allowed to stop the stand-by and running pump in 1 & 2 above is Fa9 seconds (factory default 8 seconds).

If you want the circulation pump to remain on leave switches in “EPC” position.

To restart the pumps, set the switches from “STOP” to “EPC”.

3.2.6. Pump operation

To change over the running pump(s) during normal operation change Pr1 or Pr2 (see "Parameter list" chapter in the FCM application).

NOTE:

To increase the life-span of the pump seals, it is recommended to minimize the number of starts and stops on Heavy Fuel Oil.
Keep the same pump running as long as possible. It is recommended to change pump in connection with the regular service overhaul of the pump.

The control unit can be set to change pumps (running to stand-by, and stand-by to running) at preset intervals during operation.

Alternatively, the control unit can be set to indicate when the time has come to change over pumps.

3.2.7. Pump stand-by function

The pump stand-by function is always active when the four pump switches are in the "EPC" position and the EPC is on (indicated by the green LED next to the START / STOP button).

NOTE:

When a stand-by pump has been started due to a fault and there is a need to change back to the stopped pump or enable the stopped pump as the stand-by, it is necessary to check the setting of parameters Pr1 or Pr2 and change them to suit the required pump selection.

Automatic change over of pumps always changes the selected running (running / stand-by) pump parameter Pr1 or Pr2.

If there is a fault on one pump (e.g. one of the supply pumps) the stand-by function continues to be active on the other pump set (e.g. circulating pumps).

The stand-by function has two different time delays:

- When the running pump contactor opens (perhaps due to over-current protection), there is a 2 second delay before the stand-by pump contactor closes.

- When a low pressure alarm is received the time before the stand-by pump starts is determined by parameter Fa9 (factory default of 8 seconds).

3.3. Oil operating modes

The controller works with two different control modes (set with the control mode button on the EPC): DO control mode, and HFO control mode (fig. 34). The EPC controller has thus two sets of setpoints and alarm limits, one set for each mode. The fuel modes are indicated by respective LED's. Heating control is carried out depending on the selected mode.

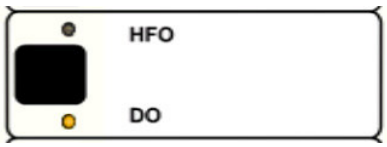


Fig. 34. HFO/DO mode button

In connection with bunkering, it may be necessary to adjust some of the parameter settings. This is certainly the case when changing to an HFO that is of a much different grade. Some of the following parameters may have to be changed:

- Density parameter Pr23. If changing to an oil of a different density, change the density parameter in order to obtain the most accurate viscosity measurement.

- HFO temperature setpoint parameter Pr30. The new oil must be heated to a different temperature (as this temperature set point is used for the end of the temperature start ramp) to obtain the same viscosity setpoint.

- Temperature Pr32

3.3.1. Heating function from OFF to DO

When the control unit is switched ON to DO mode (for temperature control), the fuel oil temperature and viscosity are monitored and displayed.

The heating start sequence is controlled by Fa31, temperature start ramp, which allows the oil to be heated to the set temperature within a set time. (If Fa31 = 0, the ramp function is inhibited, and the control unit regulates directly using normal set points, alarm limits etc.). The TT LED flashes during ramp function.

When the fuel oil temperature is within 3° C of the set temperature, the start ramp is stopped and normal temperature control is initiated. The TT LED changes to steady shine.

- Low viscosity and low temperature alarms are disabled during start ramp.

- At the beginning of the start ramp, a maximum time is set for start ramp duration to ensure that it does not run for too long a time. An alarm is activated if the start ramp exceeds maximum time, See the “Alarms and Fault Finding” chapter in the FCM application.

3.3.2. Heating function from OFF to HFO, or DO to HFO

To change from DO to HFO

1. Press the DO / HFO button (fig. 35).

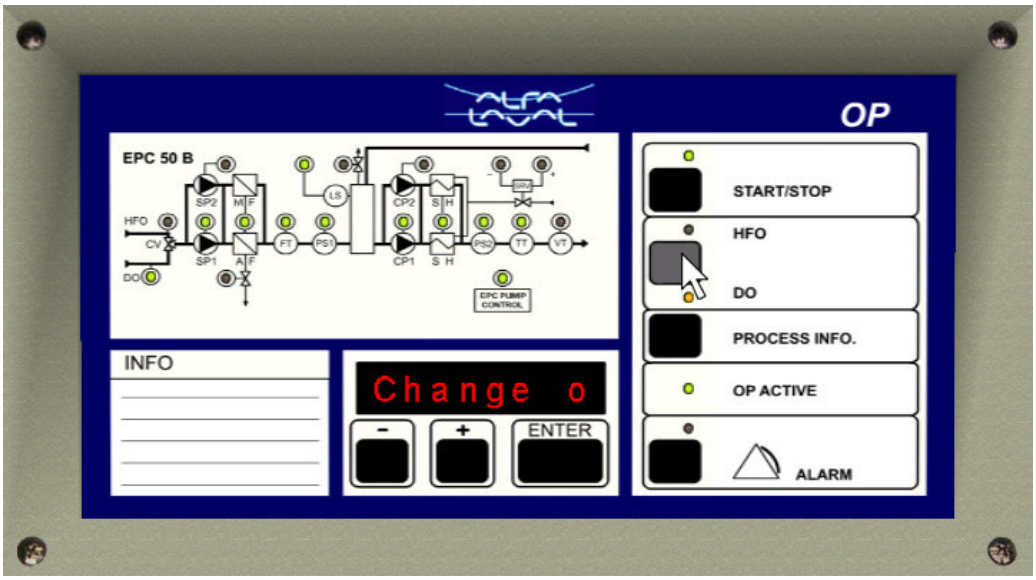


Fig. 35. Changing oil mode

2. A question appears in the display. “Change oil mode? + = yes, - = no”

3. Press “+” to start the charge over.

4. If an electric or pneumatic change over valve is fitted the valve will immediately start changing over to HFO.

NOTE:

If the electric valve with the change over ramp function is installed the change over time can be set with factory parameters Fa12 and Fa13.

When the control unit is switched ON to HFO, or switched from DO to HFO, the fuel oil temperature and viscosity are monitored and displayed. The start sequence is controlled by Fa30, temperature start ramp, which allows the oil to be heated to the set temperature within a set time. The VT LED flashes during ramp function; the TT LED shines steadily if change-over from DO to HFO has been made, but does not shine if change-over from OFF to HFO has been made. (If Fa30 = 0, the ramp function is inhibited, and the control unit regulates directly using normal set points, alarm limits etc.)

On change-over from DO to HFO, heating of the oil begins when the controller detects an increase in viscosity, indicating that Heavy Fuel Oil is entering the system.

Heating is paused if the controller detects a decrease in viscosity during the start ramp.

When the temperature has reached 3° C below the temperature set value of HFO, the control unit automatically switches to viscosity control. When the TT LED switches off and the VT LED shines steadily, the start sequence is complete and viscosity control attained.

- Low viscosity and low temperature alarms are disabled during start ramp.

- At the beginning of the start ramp, a max. time is set for start ramp duration to ensure that it does not run for too long. An alarm is activated if the start ramp runs to max. time.

- When changing over for DO to HFO and vice versa the viscosity at 50° C is displayed in the Instantaneous values list. This makes it possible to see how much DO to HFO is in the system at the usual reference temperature of 50° C.

3.3.3. HFO control heating mode

HFO control type
The HFO control type (temperature or viscosity), is set in parameter Pr19. The selected type is shown by the sensor LED's on the display.

If the viscosity sensor (VT) LED is lit, the unit is in viscosity control.

If the temperature sensor (TT) LED is lit, the unit is in temperature control.

3.3.4. Change-over from HFO to DO

When a change is made from HFO to DO, the control unit continues to control the fuel oil viscosity. The viscosity value is maintained by decreasing the temperature of the HFO-DO blend. The TT LED is flashing and the VT LED shines steadily.
When the temperature reaches the DO set value, the control is automatically switched over to DO mode (temperature control). The TT LED then changes to steady shine, and the VT LED switches off.

3.3.5. Automatic change-over – HFO / DO

Engine conditions
The EPC controller can be configured to change between DO and HFO based on engine conditions. There are two alternatives:

1. Auto change-over – input signal

   The controller receives information from the diesel engine control system on whether or not the conditions are right for HFO operation. If the conditions are right during a two minute period, the controller can be set to either change over automatically, or simply display that the engine conditions are met.

2. Auto change-over — relative engine consumption

   The controller will change to DO when the engine percentage consumption is below a set limit for a two minute period.

During the two minute delay in both cases, the change-over process can be aborted by pressing the DO / HFO button. The function is then cancelled for 20 minutes. If a permanent cancellation of the function is required, the corresponding parameter must be set to zero.

For further information, see the "Parameter List" chapter in the FCM application.

Heater fault
In the event of a heater fault it is possible to arrange for a controlled change over to DO.

The automatic change over valve has to be installed; then by using parameter Fa14 the system can be set to automatically change over to DO in the event of a heater fault.

It is recommended to set Fa14 to a lower value than the low temperature alarm limit. When the set low temperature limit is reached, the change-over countdown timer (2 minutes) starts. The DO LED next to the DO / HFO change-over button starts flashing, and a text appears intermittently showing the time to change-over. The change-over countdown timer can be aborted by pressing the DO / HFO pushbutton.

3.3.6. DO to HFO to DO valve time

When the electric change-over valve is installed the new fuel can be introduced into the system gradually by regulating the time it takes for the change-over valve to change from DO to HFO, or HFO to DO. Although this will be strongly influenced by the level in the respective HFO and DO service tanks.
See parameter Fa12 and Fa13.

3.4. Mixing tube deaeration

If mixing tube needs venting during operation, an alarm will be activated.

If automatic deaeration function is installed, the mixing tube will be automatically deaerated. If the automatic deaeration valve is open for more than 120 seconds, an alarm will be activated.

3.5. Manual operation

These functions are provided in the unlikely event that the EPC50B is not working. They enable components within the system to be operated independently, direct supervision by the operator will be required.

The module is equipped with visual indicators - thermometers, pressure indicators, position indicators - that can be used when the EPC is not working.

3.5.1. Manual operation of parts of the system

Pumps
Pumps can be operated manually by switching the pump switch to the manual position.

NOTE:

> If both pump switches (for one pump set) are set to “manual”, the pump which was switched on first will be the one running. If the contactor of the pump in operation is released, for example, by the motor protection, the other pump will start.

If the EPC is switched off or stops working during operation, the running pumps will continue running (with the selector switches in the EPC position). After the I / O board has been replaced the EPC will take over control when switched on again.

If the pumps have to be run for a longer time without the EPC in control, it is recommended that the pump selectors are switched to manual position.

Heating
Heating can be controlled by the EPC50B (if it is working) even if the pumps are run manually. Pressing the start button on the EPC will start the heating.

The heating media control valve can also be activated directly by first switching the heating media control valve from EPC to manual, then using the switch to activate the valve to open or close as necessary (fig. 36).

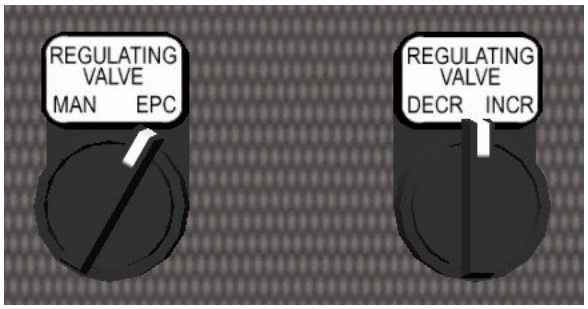


Fig. 36. Heating media control switches

There is also a hand lever under the cover of the valve actuator.

For electric heating the fixed loads within the power unit can be switched on step wise, in up to 5 steps (depends how big the heater is as to the number of elements and the number of steps).

Automatic filter
The Alfa Laval Automatic filter can remain in the "Auto" position, even when the EPC50B is not working, because it is hard wired to start when the pump before the filter is started.

The Alfa Laval Automatic filter can alternatively be switched on in the manual position to start the filter when the pumps are not working.

The automatic drain function is not working if the EPC50B is not working.

The filter then needs to be drained manually at regular intervals (every 8 hours) by putting the filter switch in the DRAIN position (for about 10 seconds). The filter can also be manually drained by using the by-pass valve.

HFO / DO change-over valve
The HFO / DO change-over valve can be maneuvered with the hand lever. (It will be necessary to change Fa12 to disable the change-over valve from the EPC, if the EPC is still ON)

3.6. Automatic start up after power failure

The module can be set to be automatically restarted after a power failure, and if an alarm should be activated or not, with a software parameter; see the parameter list.

When the electric power returns after the power failure, the supply pump, circulating pump and heater are restarted again (after a set delay time) with one second intervals. The same pumps that were running before the power failure will be restarted. If, however, the power to the EPC is not interrupted, the standby pump will be started and alarm activated when power to the pumps returns.

3.7. Regular checks on the system

Regularly check the process values to note any unusual changes. Also, regularly check the automatic filter pressure drop indicator.

If SRV position (or instantaneous electric heater power in the case of electric heater) changes dramatically, this could be an indication of heater clogging, provided other process criteria remain the same.

When the outside ambient temperature is high, regularly check the internal control panel temperature (see parameter list Pr7). This should be max. 70° C.

3.8. Remote control and monitoring

The fuel conditioning module is prepared for 4 levels of remote control.
The levels are:

1. Basic Level 1
2. Extended Level 2
3. Advanced Level 3
4. Fully automated Level 4

It is important that you firstly identify which level of automation is installed.
NOTE:

Every module is prepared for Remote Control, and the pump mode selection switches indicate this with their 4 positions: MANUAL / OFF / EPC / REMOTE. This does not mean there is a remote control location.

Basic Level 1 This control panel is not supplied by Alfa Laval, but will have been produced by a 3rd party.	**Fully Automated Level 4** Fieldbus system integrates with central computerised automation system. (not supplied by Alfa Laval).
Extended Level 2 Control panel supplied by Alfa Laval.	**Advanced Level 3** Features a duplicate Operators panel as on the Fuel conditioning module.

3.8.1. Basic Level 1

Operation is dependent on the functions installed by the automation supplier.
Possible remote features:

- Fuel mode change-over DO / HFO
- Heating start / stop
- Common alarm
- High temperature / low viscosity
- High viscosity / low temperature
- Automatic filter differential pressure high
- Fuel oil pressure low
- Switched to stand-by pump
- 4-20 mA, 2 outputs
- Temperature signal
- Supply pump 1 running
- Supply pump 2 running
- Circulating pump 1 running
- Circulating pump2 running

NOTE:

Alarm accept / reset has to be made at the EPC50B operators panel on the fuel conditioning module.

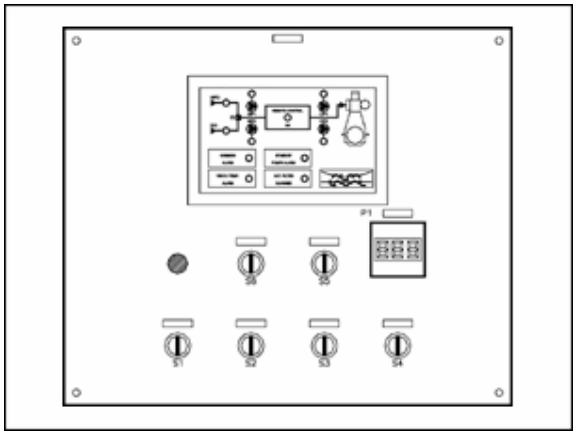
3.8.2. Extended Level 2

Extended Level 2 – features

NOTE:

Alarm accept / reset has to be made at the EPC50B operators panel on the fuel conditioning module.

The local pump selection switches have to be set to “remote”. If you intend to change the running / stand-by pump selection during operation, the switches have to be in “EPC” position (as all pump selection is made from the EPC). First check that the pump mode selection switches on the remote panel are in the “EPC” position.



3.8.3. Advanced Level 3

Advanced Level 3 – features

NOTE:

Alarm accept / reset is possible with the remote operators panel.

The local pump selection switches have to be set to “remote”. If you intend to change the running / stand-by pump selection during operation, the switches have to be in “EPC” position (as all pump selection is made from the EPC). First check that the pump mode selection switches on the remote panel are in the “EPC” position.

3.8.4. Fully automated Level 4

When the remote control is via a fieldbus from the central automation system, operation is as per the automation system makers instructions.

ELECTRIC POWER PLANT SIMULATOR

Abbreviations

ACB	Air Circuit Breaker
BT	Bow Thruster
CM	Control Module
CP	Control Panel
DG	Diesel Generator
DGU	Deif Generator Unit
DO	Marine Diesel Oil
ESB	Emergency Switchboard
FO	Heavy Fuel Oil
FW	Fresh Water
GB	Generator Breaker
HC	Heavy Consumer
MSB	Main Switchboard
NEL	Non Essential Load
PMS	Power Management System
PSM	Power Supply Module
SB	Shore Breaker
SCB	Shore Connector Breaker
SCM	Control and Measuring Module
SW	Sea Water
SWBD	Switchboard
TB	Tie Breaker

1. General description

The educational program ELECTRIC POWER PLANT SIMULATOR is intended for teaching the basic principles of how to operate a typical marine diesel engine generator.
The program is based on the diesel engine type L28/32H produced by MAN B&W and the generator type GDB-1410S/02 produced by Dozamel corporation. The power plant is controlled by Power Management System produced by DEIF corporation.

The program consists of the following parts:

1. Main switchboard
   - Generator 1 control panel
   - Generator 2 control panel
   - Generator 3 control panel
   - Prelubricating pumps control panel
   - Synchronisation panel
2. Power management system
3. Central cooling water system
   - Control panel
   - Diagram
4. Fuel oil system
   - Control panel
   - Diagram
5. Starting air system
   - Control panel
   - Diagram
6. Emergency generator
7. Diesel engine local control panel

Electric power plant
The electric power plant consists of three diesel generators and one emergency diesel generator.
The diesel generators are supplied with heavy fuel and diesel oil by means of booster pumps. The diesel generators are started with compressed air. The automatic voltage regulators are built-in Main Switchboard (MSB).
The main generators are provided for continuous parallel operation.
The emergency diesel generator is started with main electric and emergency hydraulic starting systems.
The generators control system consists of local control panels built-in the diesel generator sets and Power Management System (PMS) installed in MSB. The PMS consists of I/O modules and Local Operating Station.
The automatic control system of the emergency diesel generator is built-in the engine Control Panel. Alarm panel is built-in the Emergency Switchboard.

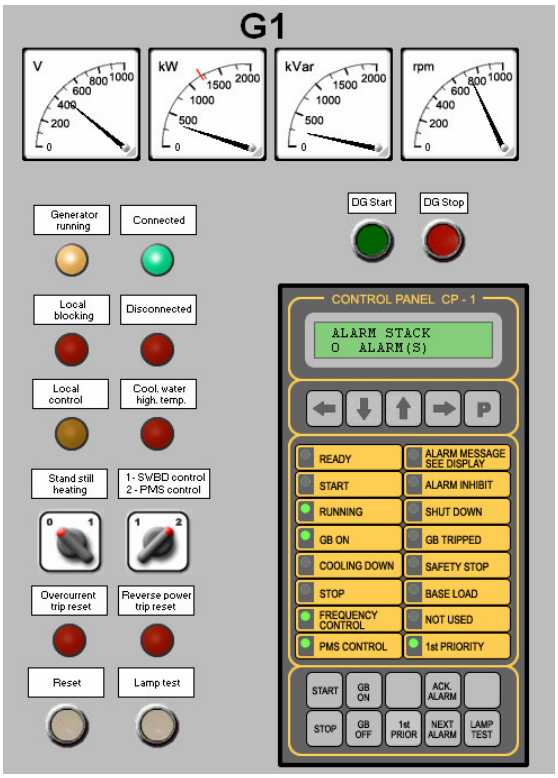


Fig. 1 Generator control panel

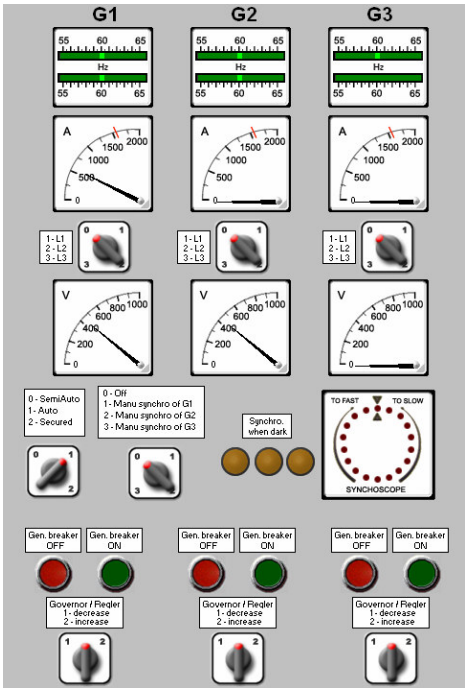


Fig. 2 Synchronisation panel

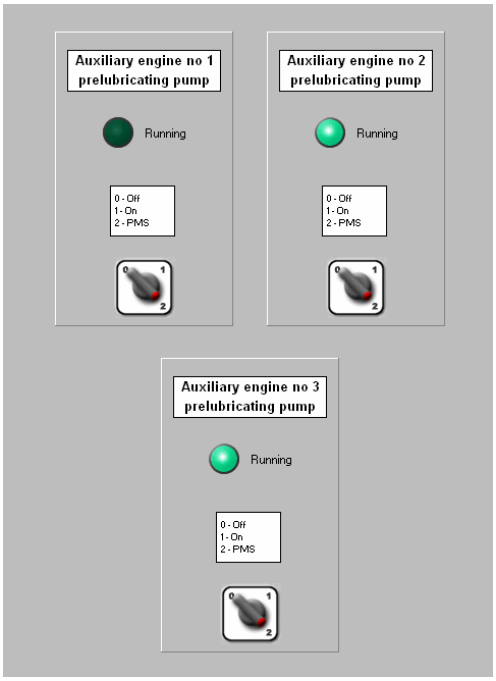


Fig. 3 Prelubricating pumps control panel

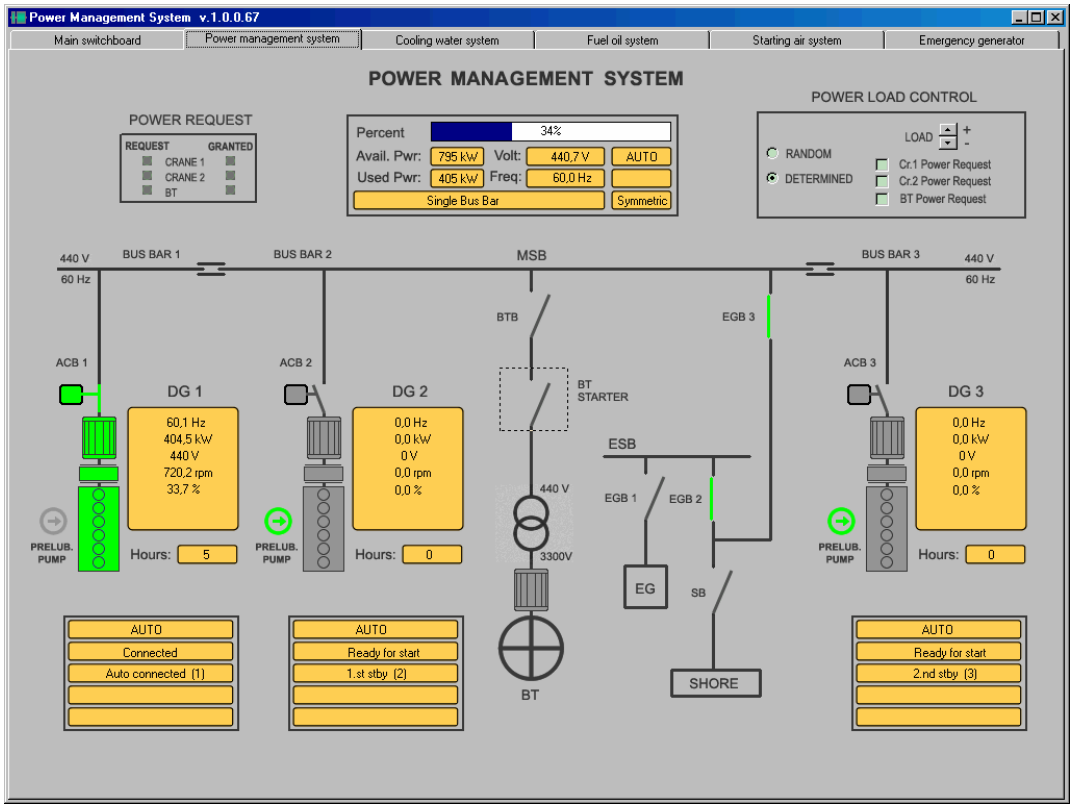


Fig. 4 Power management system

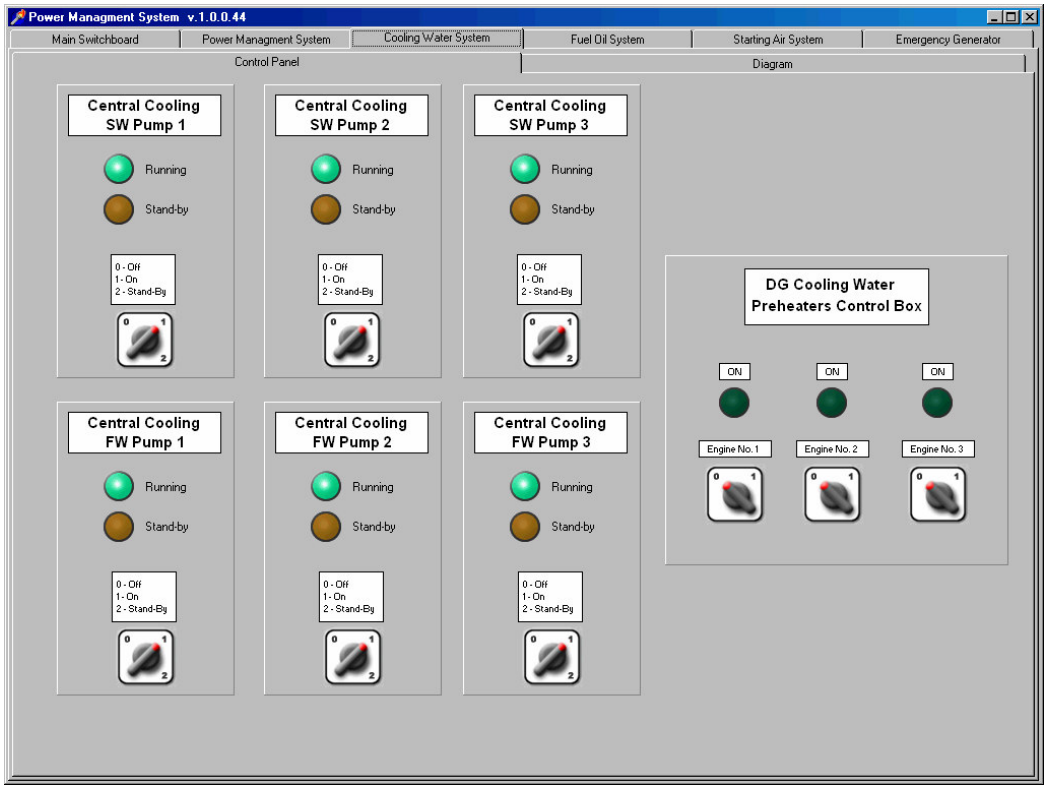


Fig. 5 Central cooling water system – control panel

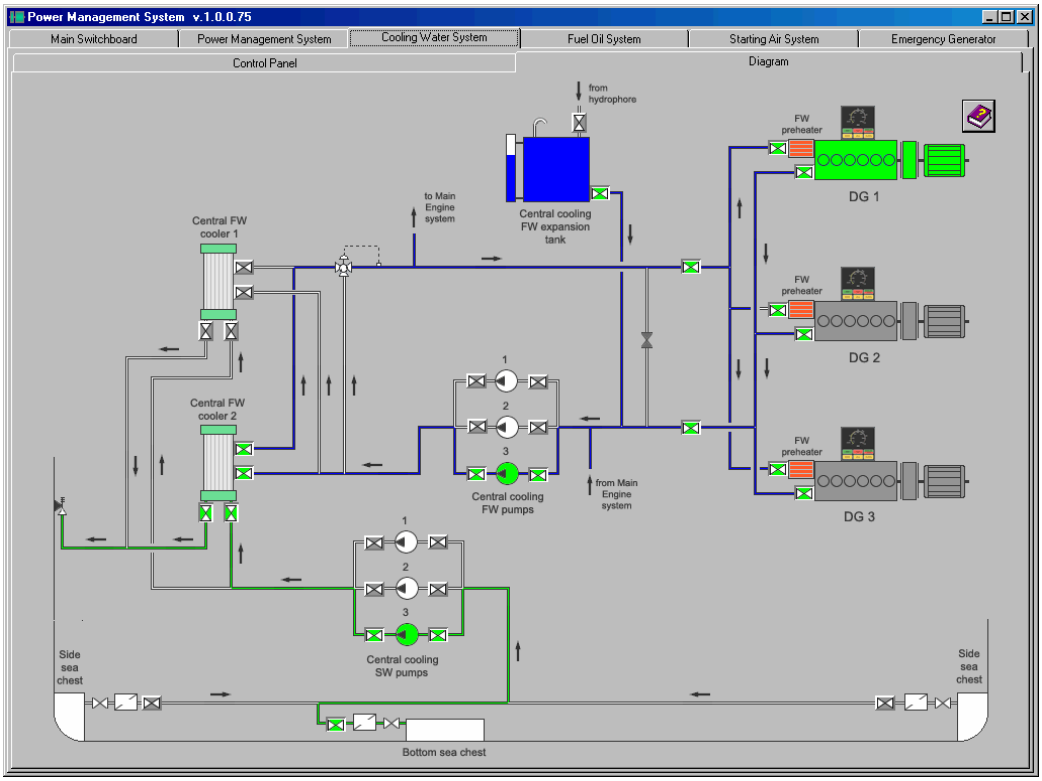


Fig. 6 Central cooling water system - diagram

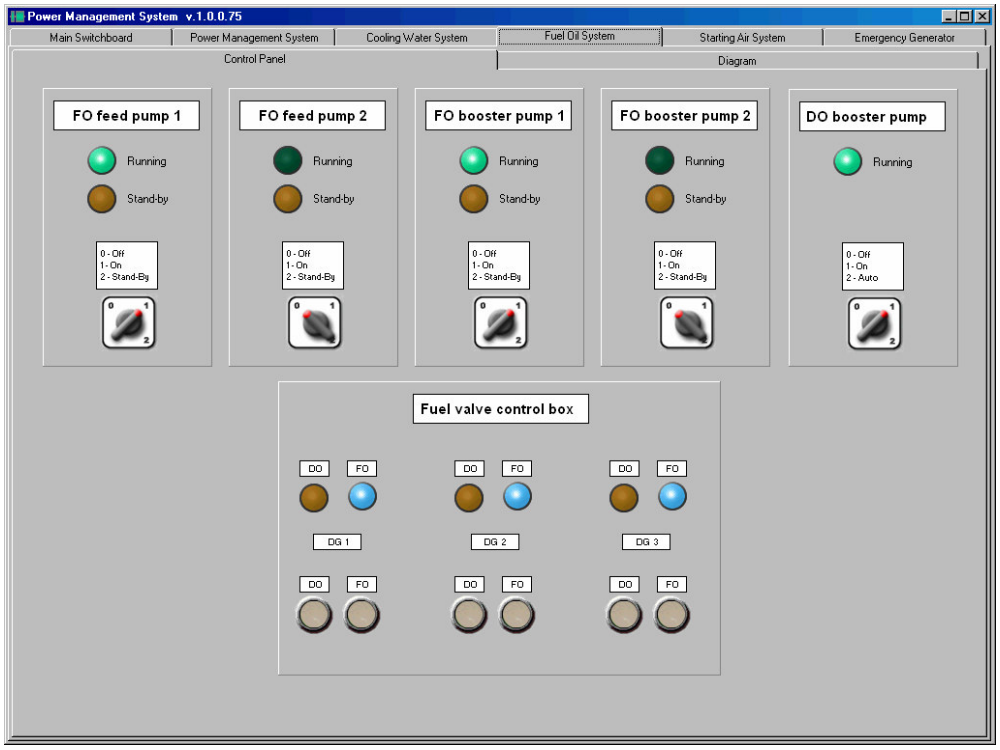


Fig. 7 Fuel oil system – control panel

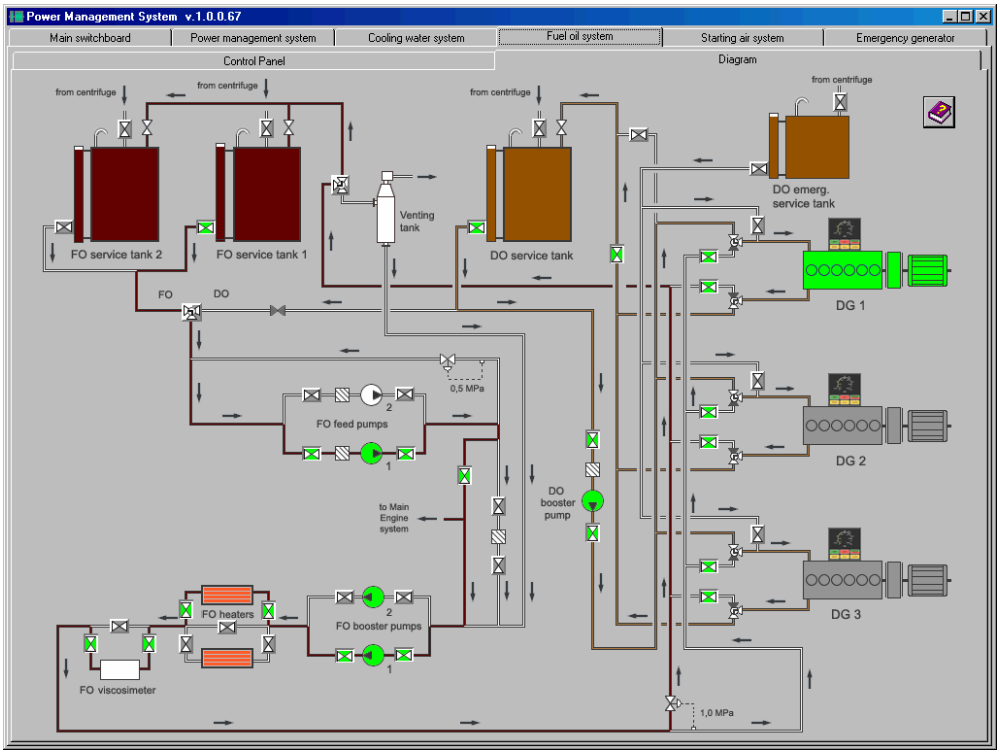


Fig. 8 Fuel oil system – diagram

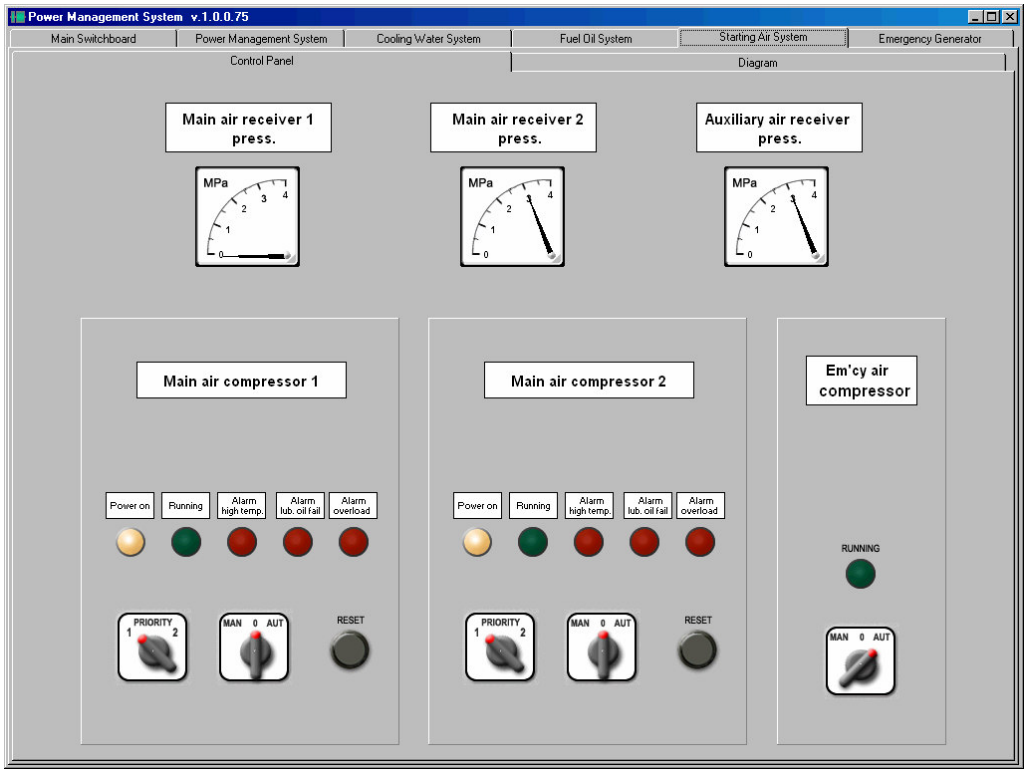


Fig. 9 Starting air system – control panel

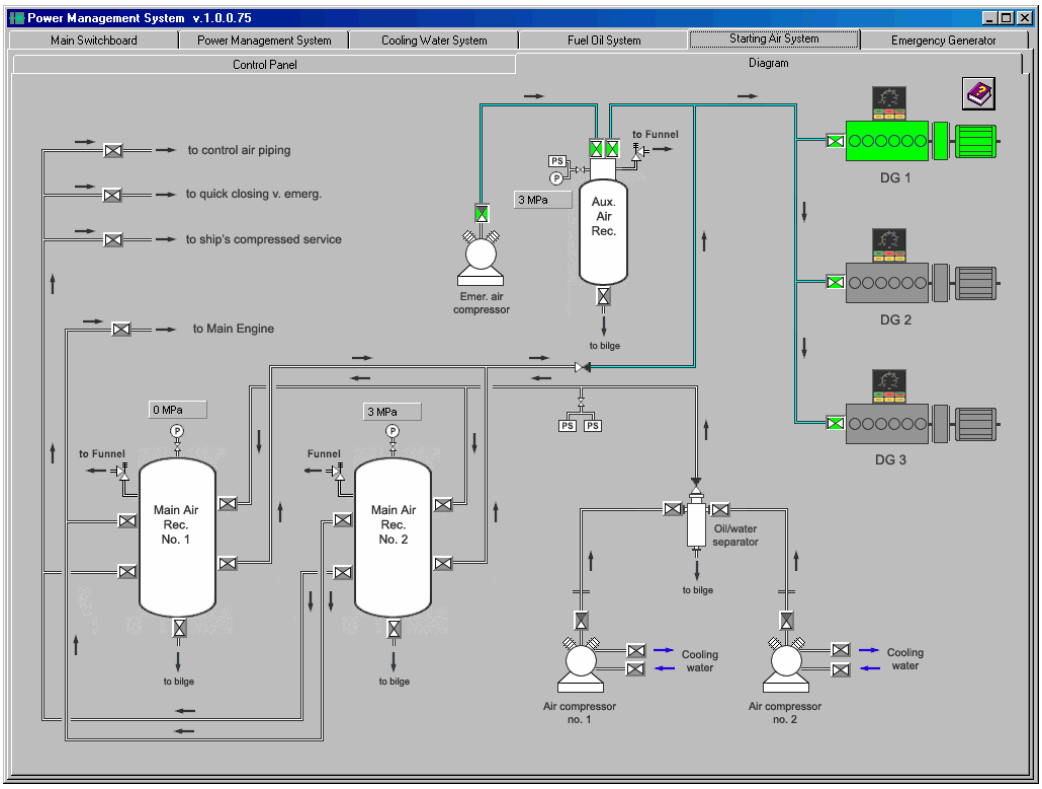


Fig. 10 Starting air system - diagram

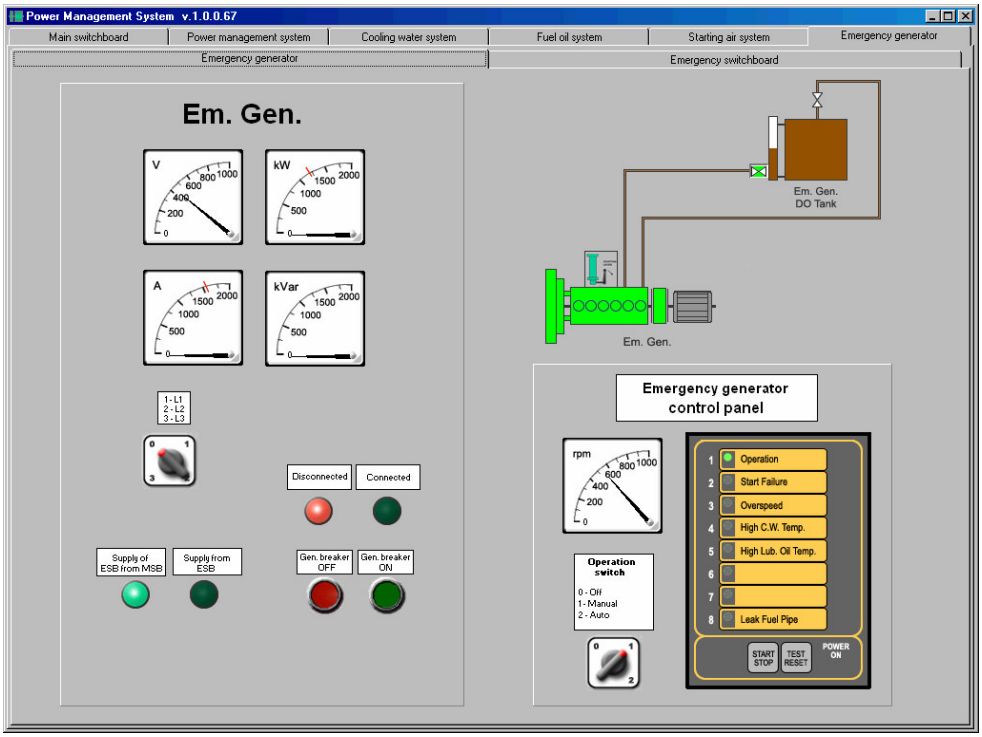


Fig. 11 Emergency generator

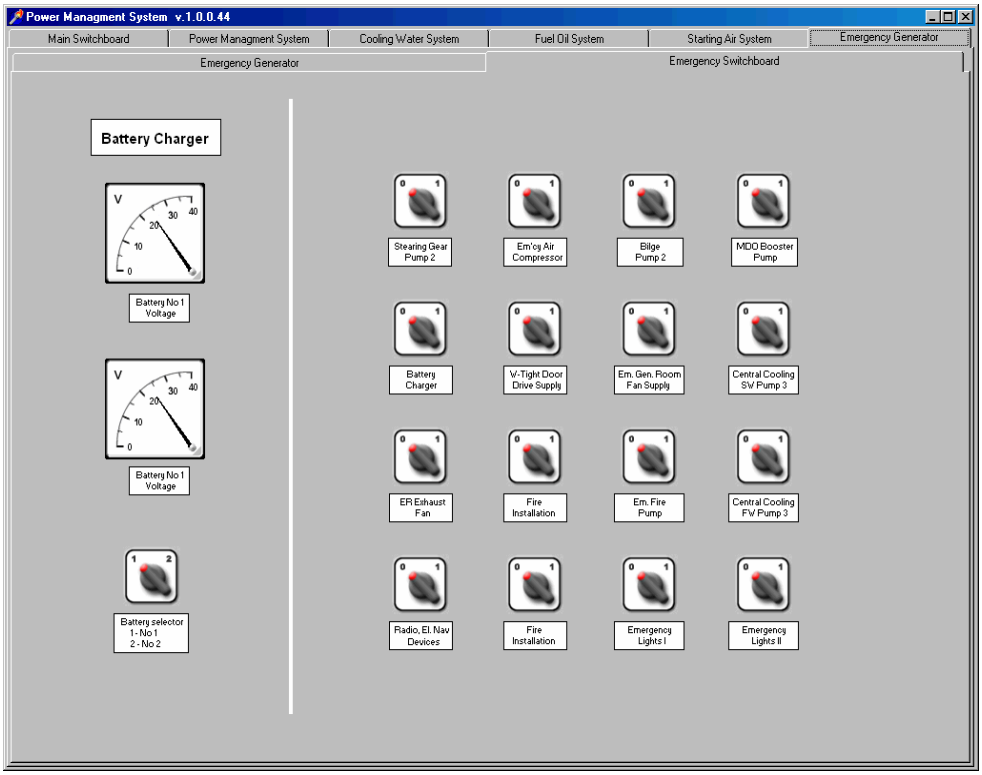


Fig. 12 Emergency switchboard

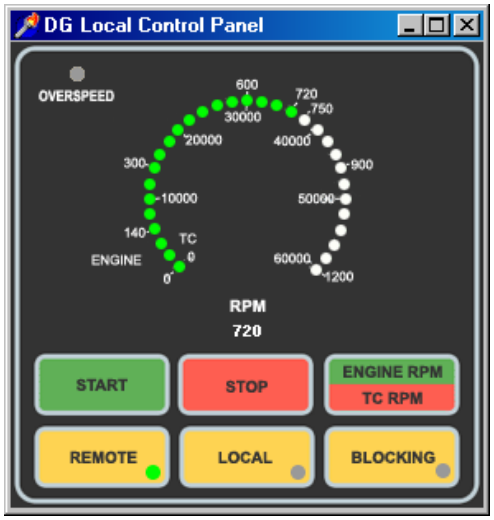


Fig. 13 Diesel engine local control panel

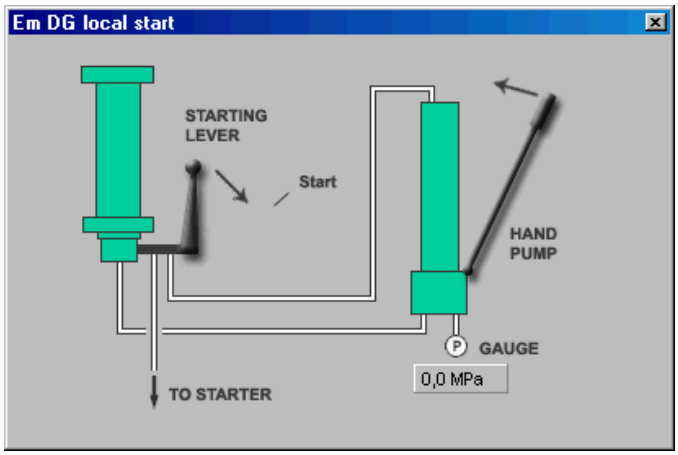


Fig. 14 Emergency generator local control panel

2. Delomatic Power Management System (PMS) - introduction

The DELOMATIC system for control and protection of generator plants is able to combine the following functions into one interactive system:

- Power management system (PMS) functions
- control of generator set(s)
- control of shaft generator
- supervision of tie breaker
- an extensive number of integrated protective functions
- measurement of all relevant AC-values
- system logic
- serial communication interface

The DELOMATIC system is able to carry out control of several generator sets within the interactive system.

The DELOMATIC system consists basically of a Deif Generator Unit (called DGU) and a corresponding Control Panel, (called CP) for each generator set. Each DGU may have as many as 3 corresponding control panels.

The internal communication between the DGU and the corresponding control panel(s) are carried out by an ARC-network (*local area network*). By using a network for communication between the DGUs, very high transmission rates and maximum flexibility regarding placement of the DGUs is achieved.

If more than one DGU are included in the DELOMATIC system the ARC-network is used for exchange information between the DGUs regarding e.g. PMS commands, system status, DGU status as well as communication between the DGU and the corresponding CP(s).

The application software, which consists of two main software units: the generator control software unit and PMS software unit, controls the DELOMATIC system.

DGU no. 1 (Master DGU) contains the Power management system (PMS) software unit. All DGUs (incl. the Master DGU) in the DELOMATIC system contain the generator control software unit and a PMS interface.

The PMS software unit controls and supervises all common PMS functions in the DELOMATIC system according to the functionalism of the selected plant mode, e.g. the SEMI-AUTO or the AUTOMATIC plant modes.

The PMS interface forms a bi-directional communication link between the PMS software unit and the generator set control software units. The PMS software unit transmits e.g. PMS start/stop commands and selected plant mode via the PMS interface. The generator set control software unit(s) transmits signals such as the generator sets operational status (e.g. running or stand-by), relevant measured and calculated values, and the status of the selected control mode (PMS control or SWBD control) for the generator set.

The generator set control software unit controls and supervises all local operations of the generator set. The received PMS commands may initiate e.g. start and stop of the generator set but the generator set control software unit carries out the actual control, protection and supervision of the generator set.

The programmable DELOMATIC set-points and timers
The DELOMATIC system is controlled according to a number of programmable set points and timers (jointly called the system setup).

The operator may program the set points and timers by means of the DELOMATIC menu system which is accessible through the control panels.

The DELOMATIC menu system offers:

- access to set points and timers used for control of the integrated PMS
- access to set points and timers used for local operation of the generator sets
- access to set-points and timers used for the supervision and protective functions
- read-out of measured and calculated values
- system selections
- alarm handling

The Control Panel (CP)
The **CP** is a slave unit, which operates according to received information from its corresponding **DGU**! All information between the DGU and corresponding CP are exchanged through the ARC-network.

All measured values and programmed system setup are stored in the DGU. This (and the separate power supply terminal) enables the DELOMATIC system to continue operation even if a break-down occurs in a CP.

The control panel offers:

- display and control of the DELOMATIC menu structure access to set-points and timers
- access to system selections
- read-out of measured and calculated values
- system status
- operator alarm handling interface
- display of alarm messages
- status by means of LED's

The CP forms the operators interface with the DELOMATIC system by means of:

- 2 lines, each with 16 characters LCD display incl. background light controlled by a dimmer input
- 5 edit and programming push-buttons
- 16 status LEDs (with 3 possible colors)
- 10 control push-buttons

The DEIF GENERATOR UNIT (DGU)
The DGU is configured with a different number of hardware modules, depending of functions in the DELOMATIC system.

The following hardware modules are available:

- Power Supply Module (PSM-1)
- Control Module (CM-2 without external communication)
- Control Module (CM-2 with external communication RS 232/422)
- Input Module (IPM-1)
- Output Module (OPM-1)
- Synchronising, Control and Measuring module (SCM-1)
- Synchronising, Control and Measuring module (SCM-2)
- Current Relay Module (for short circuit protection) (CRM-1)
- Current Relay Module (for differential protection) (CRM-1)
- Analogue Output Module (AOM-1)

2.1. System specifications

The basic values for the electric power plant are stated in the following table:

SYSTEM SPECIFICATIONS				
Value	**DG 1**	**DG2**	**DG3**	**Units**
S_{NOM}	1500	1500	1500	kVA
P_{NOM}	1200	1200	1200	kW
U_{NOM}	3 x 440	3 x 440	3 x 440	V
I_{NOM}	2296	2296	2296	A
f_{NOM}	60	60	60	Hz
PF	0.8	0.8	0.8	

2.2. The PMS functions

The following PMS functions are implemented in the DELOMATIC system (please remember that the PMS functions are the common functions controlled only by the Master DGU):

- Plant modes:
  - SEMI-AUTO
  - AUTOMATIC
  - SECURED

- User-programmable start priority

- Load dependent star/stop function incl.:
    - transmission of PMS star/stop commands
    - safety start of stand-by generator sets due to expected stop of a running generator set
    - transfer of PMS start command in case of failed engagement of the generator set

- Common black-out detection and subsequently black-out start of two generator sets

- Load sharing:
    - symmetrical load sharing
    - asymmetrical load sharing

- Conditional connection of 3 heavy consumers with fixed or variable load

- Supervision of the shore connection position

- Bi-directional serial interface (MODBUS ATU, standard communication protocol) offers remote control or supervision of the DELOMATIC system:

    - access to system control commands
    - access to set-point and timers
    - measured and calculated values
    - system status feedback
    - alarm status feedback

2.3. The generator set functions

The following Generator set functions are implemented in the DELOMATIC system:

- Internal system supervision comprising:
    - I/O error; supervision of hardware configuration
    - breaker position feedback signal
    - supervision of ARC-network communication
    - supervision of the power supply
    - cable supervision

- Selection of local control for each generator set
    - PMS control; the generator set is included in the PMS functions
    - SWBD control, the generator set is excluded from all automatic functions and is controlled manually (protection functions are still active)

- Automatically start sequence
    - programmable start prepare output
    - programmable number of start attempts
    - programmable pause stop during the start sequence
    - programmable priming output

- Automatically stop sequence
    - programmable cooling down time
    - programmable stop time

- GB ON sequence; dynamical synchronisation of the generator set to the busbar
    - programmable dynamical synchronisation parameters (concerning voltage and frequency)
    - supervision of positive sequential order of the phase before synchronisation
    - supervision of generator voltage and frequency before synchronisation
    - programmable closing time of the breaker

- GB OFF sequence:
    - deloading the generator set before opening the generator breaker

- Generator set load control
    - load share supervision

- Generator protection:
    - supervision of generator voltage and frequency
    - overcurrent, I> (two step protection)
    - overload, P> (both protection and supervision)
    - reverse power, -P> (protection)

- Busbar supervision and protection:
    - undervoltage, U_{BB}< (both protection and supervision)
    - overvoltage, U_{BB}> (both protection and supervision)
    - underfrequency, f_{BB}< (both protection and supervision)
    - overfrequency, f_{BB}> (both protection and supervision)

- 5 different alarm sequences
    - DG warning (only information for operator)
    - DG blocked (inhibit of automatic functions of the DG)
    - Safety stop (expected stop when DG has been replaced by another unit)
    - Trip of the generator breaker
    - Shutdown of entire generator set

- Trip of two non-essential loads groups in case of:
    - trip of the generator breaker
    - high load at the generator set
    - low frequency at the busbar

- User setup of all relevant parameters of the DG and the entire plant from the control panel

- Cable supervision for digital and analogue inputs
- Alarm test function of all implemented alarm
- "Test mode" function for indication of any used timer when status "running" is achieved
- Operator programmable binary alarm input function:
    - programmable selection of designated alarm sequence
    - programmable alarm delay
    - programmable status for alarm detection
    - programmable connection to the alarm inhibit function

- Running hour indication on display of the Control Panel
- Indication of rpm at the Control Panel in case of analogue running feedback
- Differential protection of each generator.

2.4. The control panels

Fig. 15 Control panel - front layout

The CP push-buttons

The 5 push-buttons located at the top of the CP are designated for control of the display view and programming of setup values.

PUSH-BUTTON	DESCRIPTION
	*Left arrow push-button:* Moves display view to the left (1) Moves the cursor to the left (2)
	*Down arrow push-button:* Moves display view down (1) Degrades a value or toggle a selection (2)
	*Up arrow push-button:* Moves display view up (1) Upgrades a value or toggle a selection (2)
	*Right arrow push-button:* Moves display view to the right (1) Moves the cursor to the right (2)
	*Programming function control button* Selection of Master CP (3)

1) When the programming function is inactive
2) When the programming function is active
3) Only active when a DGU has more than one corresponding CP

Each Control Panel is provided with 10 push-buttons (S1-S10) located at the bottom of the CP which are designated for alarm handling and control of the DELOMATIC system.

DGU No.	PUSH-BUTTON									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
1	START	GB ON		ACK ALARM		STOP	GB OFF	1 ST PRIOR	NEXT ALARM	LAMP TEST
2	START	GB ON		ACK ALARM		STOP	GB OFF	1 ST PRIOR	NEXT ALARM	LAMP TEST
3	START	GB ON		ACK ALARM		STOP	GB OFF	1 ST PRIOR	NEXT ALARM	LAMP TEST

PUSH-BUTTON	DESCRIPTION
"START"	Initiates the automatic start sequence (only active in semi-auto mode)
"STOP"	Initiates the automatic stop sequence (only active in semi-auto mode)
"GB ON"	Initiates the GB ON sequence (only active in semi-auto mode)
"GB OFF"	Initiates the GB OFF sequence (only active in semi-auto mode)
Not used	
"1st PRIOR"	Moves DG up having first start priority
"ACK ALARM"	Used for acknowledgement of alarms
"NEXT ALARM"	The display view moves to the next un-acknowledged Alarm (1) The display view jumps to the top of the alarm stack (2)
Not used	
"LAMP TEST"	Lamp test of all LEDs

1) When the display view is located in the alarm stack
2) When the display view is located outside the alarm stack

The control panel LEDs
The DELOMATIC control panel has altogether 16 status LEDs (H1-H16).

Left side LEDs
The 8 LEDs (H1-H8) located in the left side are basically used for identification of the operational status of the generator set.

	LED	COLOR	DESCRIPTION
H1	**READY**	*Green*	Indication that the auxiliary engine is ready for start.
H2	**START**	*Green*	Indicates ON status of the "START" output.
		Yellow	Indicates an active "START PREPARE" output previous to the automatic start sequence and the START OFF time during the automatic start sequence.
H3	**RUNNING**	*Green*	Indication of running feedback signal from the auxiliary engine.
		Yellow	Indication of tacho failure.
H4	**GB ON**	*Green*	Indication of a closed generator breaker feedback signal.
		Yellow	The generator set is currently carrying out the GB ON sequence.
		Dark (turned oft)	Indication of an open generator breaker feedback signal.
H5	**COOLING DOWN**	*Green*	Indication that the auxiliary engine is running cooling down.
H6	**STOP**	*Yellow*	Indication of an active "STOP" output during the stop sequence.
H7	**FREQUENCY CONTROL**	*Green*	Indicates that the DGU in question is carrying out frequency control.
H8	**PMS CONTROL**	*Green*	The DGU is selected to be under *PMS control* and the generator set is ready to respond to PMS commands.
		Yellow	Indicates that the DGU is actually selected to be under PMS control but is *forced* into SWBD control.
		Dark (turned oft)	The DGU is selected to be under SWBD control.

Right side LEDs

The 8 LED's (H9-H16) located on the right side of the control panel are, with exception of the "1st START PRIORITY" LED, used by the alarm handing function for identification of alarm status etc.

	LED	COLOR	DESCRIPTION
H9	**ALARM MESSAGE SEE DISPLAY**	*Flashes red* *Red*	Indication of one or more un-acknowledged alarms in the alarm stack. Indication that the alarm stack only contains acknowledged but still active alarm(s).
H10	**ALARM INHIBIT**	*Green*	Indicates that the alarm inhibit function is active.
H11	**SHUTDOWN**	*Red*	Indicates that the shutdown alarm sequence for the corresponding generator set has been activated.
H12	**GB TRIPPED**	*Red*	Indicates that the trip of GB alarm sequence for the corresponding generator set has been activated.
H13	**SAFETY STOP**	*Red*	Indicates that the safety stop alarm sequence has been activated for the generator set in question.
H14	**BASE LOAD**	*Green* *Yellow*	Indicates that asymmetrical load sharing is selected and this DG is running base load. Asymmetrical load sharing is selected but it is automatically canceled due to the load situation at the busbar.
H15 *)	**SCB ON**	*Green* *Dark (turned off)*	Indicates of a closed shore breaker feedback signal. Indicates of an open shore breaker feedback signal.
H16	**1st START PRIORITY**	*Green*	Indicates that the generator set is designated with 1st start priority.

*) Only active on CP 1/DGU 1

2.5. Hardware configuration of DGUs

The hardware configuration of the Master DGU is different from the rest of the DGUs. This is due to the fact that the Master DGU is handling the common functions e.g. such as conditional connection of heavy consumers, and therefore requires additional inputs and/or outputs.

The Master DGU is configured with the following hardware modules:

- 1 Power Supply Module (PSM-1)
- 1 Control Module (CM-2 incl. comm. Port RS 485)
- 2 Input Module (IPM-1)
- 2 Output Module (OPM-1)
- 1 Synchronising, Control and Measuring module (SCM-1)
- 1 Current Relay Module (CRM-1, diff.)

DGU no. 2 are configured with the following hardware modules:

- 1 Power Supply Module (PSM-1)
- 1 Control Module (CM-2)
- 1 Input Module (IPM-1)
- 1 Output Module (OPM-1)
- 1 Synchronising, Control and Measuring module (SCM-1)
- 1 Current Relay Module (CRM-1, diff.)

DGU no. 3 are configured with the following hardware modules:

- 1 Power Supply Module (PSM-1)
- 1 Control Module (CM-2)
- 1 Input Module (IPM-1)
- 1 Output Module (OPM-1)
- 1 Synchronising, Control and Measuring module (SCM-1)
- 1 Current Relay Module (CRM-1, diff.)

3. Alarm system

3.1. Alarm handling

The alarm handler is a software function, which handles all alarms registered by the DELOMATIC system.

The alarm handler may be activated by:

- External alarm signals
- Internal DGU system supervision
- Internal generator set supervision
- Internal PMS supervision

The alarm handler will examine every registered alarm, activate the designated alarm sequence and display the corresponding alarm message.
When a new alarm is registered:

- the LED "**ALARM MESSAGE SEE DISPLAY**" will start flashing red
- the corresponding alarm message will be displayed at the CP
- the corresponding alarm sequence will be carried out

Display of alarms

The alarm messages are displayed at the text line.

"ALARM MESSAGE" No:xxx F:Y U-ACK

All alarm messages concerning a specific generator set (DGU) will be displayed at the corresponding CP.
All alarm messages concerning common PMS functions will only be displayed at the corresponding CP for the Master DGU.

3.2. Alarm types

The alarm handler distinguishes between System alarms and PMS alarms.

System alarms (system supervision)

A system alarm indicates a failure, which may prevent the DGU to operate as expected. A system alarm may be caused by communication error, power supply failure or in/output error and similar.
A registered system alarm will be indicated by:

- an active **SYSTEM ALARM** output

PMS alarms
A PMS alarm may be considered to be caused by a "normal" event meaning that the DELOMATIC system is fully operational and handling the event(s) as expected.

A registered PMS alarm will be indicated by:

- an active **PMS ALARM** output

3.3. Alarm sequences
The alarm sequences are designed to take appropriate action according to the severity of the event which caused the alarm.

The DELOMATIC system is implemented with several different alarm sequences:
- Warning
- DG Block
- Safety stop
- Trip of GB
- Shutdown

Warning
The purpose of the warning sequence is to inform the operator of "nice to know" events. The DELOMATIC system will not take any action but only display an alarm message.

Activation of the **warning sequence** will:
- start flashing the LED "**ALARM MESSAGE SEE DISPLAY**" red
- display the designated alarm message at the CP
- activate the horn output
- set one of the alarm type outputs (SYSTEM or PMS)

The operator is able to reset the horn output by pressing the "**RESET HORN**" push-button. This will not have any influence on the further alarm handling.

DG Block
The DG block alarm sequence is used for blocking any further automatic functions, which will lead to connection of the generator set, if a situation (electrical or mechanical) occurs due to which it is inadmissible to connect the generator set to the busbar.

Activation of the DG block sequence will:
- carry out the warning sequence.
- block all automatic functions which will lead to a connection of the generator set.
- block closing of the generator breaker in question.

(the DG block sequence will not open or trip the generator breaker if it already is closed, when the block alarm becomes active)
- transfer the PMS start command to the next stand-by DGU.

Safety stop
The safety stop sequence is used to carry out a previous intervention and stop a defective engine, instead of waiting until a critical condition becomes fatal for the engine.

Furthermore, the safety stop alarm sequence can prevent a possible black-out situation at the busbar as it replaces the defective generator set before a shutdown occurs on a running generator set.

The safety stop sequence starts and connects the next stand-by generator set to the busbar according to the chosen start priority. When sufficient available power is measured at the busbar the defective generator set is disconnected and stopped (incl. cooling down etc.).

Activation of the safety stop sequence will:

- carry out the warning sequence (alarm message causing the situation)
- transmit a PMS start command to the next stand-by generator set
- connect the next stand-by generator set to the busbar
- display alarm "**Safety Stop**" on the CP for the defective DG
- disconnect and stop the defective generator set (incl. cooling down etc.) block for a new start of the defective DG
- carry out the blocking alarm sequence

An active safety stop alarm sequence is indicated by:

- a red "**SAFETY STOP**" LED at the CP corresponding to the defective DGU

If the defective DGU is not ready for PMS stop the alarm message "Safety Stop" is not displayed and the DG is not stopped either.

Trip of GB
The trip of Generator Breaker sequence is carried out in order to protect the generator set from critical electrical conditions on the busbar, or to protect the busbar from critical electrical conditions in the generator set.

Activation of the trip of GB sequence will:
- immediately open the generator breaker
- disconnect the non essential load groups (NEL)
- carry out the warning sequence
- transmit a PMS start command to the next stand-by generator set
- continue idle run of the defective generator set
- block a re-connection of the defective generator set to the busbar until the alarm is acknowledged

An active trip of generator breaker alarm sequence is indicated by:

- a red "**GB TRIPPED**" LED at the CP corresponding to the defective DGU

Shutdown
The shutdown alarm sequence may be carried out when a fatal condition has occurred in the generator set.

Activation of the **shutdown sequence** will:

- immediately open the generator breaker
- shutdown the engine immediately after disconnecting the breaker from the busbar
- disconnect the non essential load groups (NEL)
- carry out the warning sequence
- transmit a PMS start command to the next stand-by generator set
- block a new start of the detective generator set until the alarm is acknowledged

An active shutdown alarm sequence is indicated by:

- a red "**SHUTDOWN**" LED at the CP corresponding to the detective DGU

SC Block
The SC block alarm sequence is used for blocking of any further automatic functions which will lead connection of the shore connection, if a situation (electrical or mechanical) occurs due to which it is inadmissible to connect it.

Activation of the SC block sequence will:

- carry out the warning sequence.
- block all automatic functions which will lead to a connection (the SC block sequence will not open or trip the breaker if it is already closed, when the block alarm becomes active)

Trip of SC
The trip of Shore Connection sequence is carried out in order to protect the shore connection from critical electrical conditions on the busbar, or to protect the busbar from critical electrical conditions in the shore connection.

Activation of the **trip of SC sequence** will:

immediately open the shore connection breaker
- carry out the warning sequence
- block for a re-connection of the shore connection to the busbar

An active trip of shore connection alarm sequence is indicated by:

- a red "**SCB ON**" LED at the CP corresponding to the Master DGU

TB Block
The TB block alarm sequence is used for blocking of any further automatic functions which will lead to connection of the tie breaker, if a situation (electrical or mechanical) occurs due to which it is inadmissible to close it.

Activation of the TB block sequence will:

- carry out the warning sequence.
- block for all automatic functions which will lead to closing the breaker
- (the TB block sequence will not open or trip the breaker if it is already closed, when the block alarm becomes active)

Trip of TB
The trip of Tie Breaker sequence is carried out in order to protect the tie breaker from critical electrical conditions on the busbar.

Activation of the trip of TB sequence will:

- immediately open the tie breaker
- carry out the warning sequence
- block a re-connection of the tie breaker

An active trip of tie breaker alarm sequence is indicated by:

- a red "**TB ON**" LED at the CP corresponding to the Master DGU

3.4. Alarm registration
All alarm messages are registered and stored in the alarm stack with statement of:
- status as first or not first received alarm
- status as an un-acknowledged or acknowledged alarm

3.4.1. Alarm stack
The alarm handler stores all registered alarm messages in chronological order (as registered by DELOMATIC) in the alarm stack. The received alarms will be stored with the first (oldest) alarm at the top of the stack.
The heading of the alarm stack is indicated by the following text at the CP display:

ALARM STACK XXX ALARM(S)

The total number of un-acknowledged and acknowledged alarms stored in the alarm stack, is displayed at the bottom line of the alarm stack heading.

The operator is able to jump to the top of the alarm stack from any location (outside the alarm stack) in the DELOMATIC sub-menu structure by pressing the "NEXT ALARM" push-button.

The operator is able to browse through the alarm stack by using the "⇑" and "⇓" push-buttons on the CP:

ALARM MESSAGE 1 No:xxx F: U-ACK

Press "⇓"

ALARM MESSAGE 2 No:xxx F: U-ACK

3.4.2. Alarm ID. No

Every alarm in the DELOMATIC multi-function system is identified by an alarm identification number.

LOW SUPPLY VOLT. No: 8 F:Y U-ACK

The alarm identification number is used for a positive identification of alarms, e.g. when corresponding with a DEIF service engineer. In the example shown above, the alarm for low supply voltage is identified by the ID. No. 8.

3.4.3. First alarm

The first alarm status is designated to the first new alarm received by the DELOMATIC.

Some events may cause a chain reaction of further events, each generating an alarm. The first alarm status may indicate which event was the first.

The alarm handler software is sequentially executed, which means that the status of the internal alarm signals is examined once in every program scan. One program scan has an approximate duration of 60 ms. If the DELOMATIC receives several internal alarm signals within one program scan, the alarm signals which were "scanned" first will be designated with the first alarm status.

If the alarm stack contains only acknowledged alarms the next new alarms registered will be designated with the first alarm status. This means several "first alarms" may be registered in the alarm stack simultaneously.

The first alarm is identified by the following code in the status line of the alarm message:

ALARM MESSAGE No:xxx F:Y U-ACK

F:Y (First: Yes)

Any other alarms (registered later than the first alarm) are identified by the following code in the status line of the alarm message:

ALARM MESSAGE No:xxx F:N U-ACK

F:N (First: No)

3.4.4. Acknowledgement of alarms

Any alarm registered by the DELOMATIC system must be acknowledged by the operator, in order to reset the action taken by the alarm sequence.

At the same time the operator becomes aware of any occurring abnormal events, even though the condition which caused the alarm may have disappeared as a result of the action taken by the DELOMATIC alarm sequence.

Each un-acknowledged alarm is identified by:

- a flashing **LED "ALARM MESSAGE SEE DISPLAY"** (red flash)
- the following status line in the display:

ALARM MESSAGE No:xxx F:N **U-ACK**

Un-ACKnowledged

An active alarm is acknowledged by pressing the "**ACK ALARM**" push-button on the CP. Acknowledgement of a still active alarm is confirmed by the following status line in the display:

ALARM MESSAGE No:xxx F:N **--ACK**

--Acknowledged

The operator is able to jump to the next un-acknowledged alarm when viewing the alarm stack by pressing the "NEXT ALARM" push-button.

When only acknowledged alarms are present in the alarm stack then:

- the LED **"ALARM MESSAGE SEE DISPLAY"** will turn to a steady red light

Acknowledgement of active alarms
An active alarm means that the condition(s) which caused the alarm are still present or active.
The acknowledgement results in a change of status for the alarm in question, from un-acknowledged to acknowledged.

When the alarm condition(s) for an alarm with acknowledged status disappears, the alarm message will be removed from the alarm stack and any actions made by the alarm sequence are disabled without further notice.

Acknowledgement of in-active alarms
An in-active alarm means that the condition(s) which caused the alarm disappeared before acknowledgement of the alarm.

An empty alarm stack
When there are no un-acknowledged alarms and no more active alarms:

- the LED "ALARM MESSAGE SEE DISPLAY" will turn off
- the alarm output(s) will be de-activated (PMS or DGU alarm outputs)

When the alarm stack is empty, it will no longer be possible to enter the alarm stack. Furthermore the push-button "NEXT ALARM" becomes inactive.

3.5. Alarm list
The alarm list contains all alarm messages (listed in numerical order) in the DELOMATIC system.

Note! Some of the alarm messages mentioned in this chapter may correspond to functions, which may not be available in your specific DELOMATIC system.

The alarm list constitutes a very helpful and fast approach for the operator, in order to locate a desired piece of information in the DELOMATIC technical documentation based on an actual alarm text.

The alarm list contains the following information:

- the alarm ID no
- the specific alarm text
- a brief description of the event(s) which activated the alarm, and the status after the alarm handling
- which alarm sequence is dedicated to the actual alarm
- the references indicate in which chapter to find detailed information about any set-points, timers and alarm conditions, which have influence on the generation of the alarm message in question

ID no.	ALARM TEXT	DESCRIPTION	ALARM SEQ.	REFERENCES
	Arc Net error no.: 06: Dupl. ID	The control panel has detected another CP with the same LAN ID and the same group number on the ARC-network. The corresponding DGU will, if possible continue operation.	System alarm	18.
	Arc Net error no.: 08: No Token	The control panel has not received the data transmission token on the ARC-network. The corresponding DGU will, if possible continue operation.	System alarm	18.
	Arc Net error no: 12: DGU Missing	The control panel is without communication with the corresponding DGU (with the same ID no.) on the ARC-network. The corresponding DGU will, if possible continue operation.	System alarm	18.
	Arc Net error no: 13: No Activity	The control panel is not able to measure satisfactory activity at the ARC-network. The corresponding DGU will, if possible continue operation.	System alarm	18.
	DELOMATIC-3 CP SW 1.XX	The control panel has not been updated by the corresponding DGU (with the same ID no.) since the last power up. The corresponding DGU will, if possible continue operation.	System alarm	18.
1...3	MEASURE ERROR n	The SCM module with the I/O addr. n (n;0..2) has repeatedly measured an abnormal voltage or frequency. The DGU is *forced* into SWBD control and is as such not included in the automatic PMS control.	System alarm	18.

ID no.	ALARM TEXT	DESCRIPTION	ALARM SEQ.	REFERENCES
4	CB O POS. FAIL.	A conflicting ON and OFF status has been detected on the position feedback signals from the generator breaker controlled by the SCM-1 module in question. The DGU is *forced* into SWBD control and is as such not included in the automatic PMS control.	System alarm	18.
5...6	CB n POS. FAIL	A conflicting ON and OFF status has been detected at the position feedback signals tram circuit breaker no. n; controlled by a SCM-2 module. The DGU is *forced* into SWBD control and is as such not included in the automatic PMS control.	System alarm	18.
7	*I/O* ERROR #-##:#	An I/O hardware configuration error has been detected in the DGU by the system supervision function. *Please refer to the description in the technical documentation for detailed information about the defective module type and location. Notice that only one failed module at the time is shown.* The DGU is *forced into* SWBD control and is as such not included in the automatic PMS control.	System alarm	18.
8	LOW SUPPLY VOLT.	The supply voltage to the DGU has continuously been below 18 VDC (24 VDC - 25%). The DGU is *forced into* SWBD control and is as such not included in the automatic PMS control.	System alarm	18.
9...11	CP n COM. ERROR	A communication error has been detected between control panel n (n;1..3) and corresponding DGU. a) The alarm message is displayed at the detective CP when the communication between CP and DGU *is reestablished.* b) If a DGU have *more than one* corresponding CP the alarm message is displayed at all other operational CPs.	System alarm	18.

ID no.	ALARM TEXT	DESCRIPTION	ALARM SEQ.	REFERENCES
12	COM. ERROR DGU 1	The DGU in question is unable to communicate with the Master DGU (no. 1). The DGU is *forced into* SWBD control and is as such not included in the automatic PMS control.	System alarm	18.
13...19	COM. ERROR DGU n	The Master DGU (no.1) is unable to communicate with DGU no. n (n;2...8). The Master DGU *excludes* DGU no. n from the automatic PMS control.	System alarm	18.
20	CABLE FAIL X:C##	The cable supervision function has detected a cable failure at the IPM-1 Channel no. ##. The detective module is located at I/O address X in the corresponding DGU. *Notice that only one failed channel is shown at the time.*	System alarm	18.
25	f-DG TOO LOW	The *generator frequency* has continuously been below the programmed limit for busbar under frequency during idle run (GB open). The detective generator set will not attempt to synchronise to the busbar. *A PMS start command has been transferred to the next stand-by generator set.*	DG Block	18.
26	f-DG TOO HIGH	The *generator frequency* has continuously exceeded the programmed limit for busbar overfrequency during idle run (GB open). The defective generator set will not attempt to synchronise to the busbar. *A PMS start command has been transferred to the next stand-by generator set.*	DG Block	18.
27	U-DG TOO LOW	The *generator voltage* has continuously been below the *programmed limit for busbar undervoltage* during idle run. The detective generator set will not attempt to synchronise to the busbar. *A PMS start command has been transferred to the next stand-by generator set.*	DG Block	18.
28	U-DG TOO HIGH	The *generator voltage* has continuously exceeded the programmed *limit for busbar overvoltage* during idle run. The detective generator set will not attempt to synchronise to the busbar. *A PMS start command has been transferred to the next stand-by generator set.*	DG Block	18.

ID no.	ALARM TEXT	DESCRIPTION	ALARM SEQ.	REFERENCES
29	START FAILURE	The *auxiliary engine is not running* after execution of the programmed number of start attempts. The detective generator set will not be *"ready for PMS start"* until the alarm has been acknowledged. *The PMS start command has been transferred to the next stand-by generator set.*	DG Block	17.
30	TACHO FAILURE	The running feedback signal is missing. *The generator set will continue normal operation but will not be able to synchronise to the busbar.*	DG Block	18.
31	DGB PHASE SEQ.	A negative sequential order of phases has been detected at the generator with regards to the busbar. The detective generator set will not attempt to synchronise to the busbar. *The PMS start command is transferred to the next stand-by generator set.*	DG Block	17.
32	DG SYNC. FAILURE	The generator set has failed to synchronise to the busbar within the programmable *max. sync. time.* *The PMS start command has been transferred to the next stand-by generator set.* NOTE ! The "DG SYNC. FAILURE" alarm is automatically acknowledged in case of blackout at the busbar.	DG Block	17.
33	DGB ON FAILURE	The DGU has failed to turn the generator breaker into ON position. A command to open the breaker is transmitted. *A PMS start command is transferred to the next stand-by generator set.*	DG Block	17.
34	DGB OFF FAILURE	The DGU has failed to turn the generator breaker into OFF position. The generator set remain connected to the busbar and is included in the load share and load depending start / stop function. *A PMS stop command is transmitted to the next generator set which are to be stopped (according the programmed start/stop priority).*	DG Block	17.
35	DG STOP FAILURE	The DGU has been unable to stop the auxiliary engine. The aux. engine continues idle run *DGU keeps the stop output activated until the auxiliary engine is stopped.*	DG Block	17.

ID no.	ALARM TEXT	DESCRIPTION	ALARM SEQ.	REFERENCES
37	DG SAFETY STOP	The safety stop alarm sequence has been activated on this DG. *The next stand-by generator set is started and connected to the busbar. When sufficient available power is measured at the busbar the defective generator set is disconnected and stopped (incl. cooling down etc.).*	Safety stop	13.
38	U-DIFF. MAX FAIL	The synchronisation of the generator set to the busbar has failed due to a too *high voltage deviation.*	DG Block	17.
39	OVERSPEED	The max. value for overspeed detection regarding to the analogue input function has been achieved meaning that the generator set has been *shutdown* due to aux. engine overspeed. The aux. engine remains blocked for automatic start until the alarm becomes inactive. *A PMS start command has been transmitted to the next stand-by generator set.*	Shutdown	18.
41	DG OVERCURRENT	The generator breaker has been tripped due to the generator current has exceeded the programmed limit for *overcurrent* continuously during the programmed delay. *A PMS start command has been transmitted to the next stand-by generator set.*	Trip of GB	18.
42	DG HIGH LOAD	The load on the generator set has exceeded the programmable limit for *DG high load* continuously during the programmed delay.	Warning	18.
43	DG OVERLOAD	The generator breaker has been tripped due to the real power load on the generator set has exceeded the programmed limit for overload continuously during the programmed delay. *A PMS start command has been transmitted to the next stand-by generator set.*	Trip of GB	18.
44	DG REVERSE POWER	The generator breaker has been tripped due to the reverse power at the generator set continuously has exceeded the programmed limit for reverse power during the programmed delay. *A PMS start command has been transmitted to the next stand-by generator set.*	Trip of GB	18.

D no.	ALARM TEXT	DESCRIPTION	ALARM SEQ.	REFERENCES
45	GB SHORT CIRCUIT	The generator breaker has been *tripped* due to detection of a short circuit above the setpoint (external or internal detection). A *short circuit alarm blocks for black-out Start.*	Trip of GB	18.
47	DG DIFF. CURRENT	The generator breaker has been *tripped* due to detection of a differential current above the setpoint (external or internal detection).	Trip of GB	18.
50	f-BB LOW WARN.	The *frequency at the busbar* has continuously been below the *programmed limit for underfrequency.* *This alarm is also used during supervision of the shore supply when the shore connection breaker is closed.*	Warning	18.
51	f-BB HIGH WARN.	The *frequency at the busbar* has continuously exceeded the programmed *limit for overfrequency.* *This alarm is also used during supervision of the shore supply when the shore connection breaker is closed.*	Warning	18.
52	U-BB LOW WARN.	The *busbar voltage* has been continuously below the programmed *limit for busbar undervoltage.* *This alarm is also used during supervision of the shore supply when the shore connection breaker is closed.*	Warning	18.
53	U-BB HIGH WARN.	The *busbar voltage* has been continuously above the programmed *limit for busbar overvoltage.* *This alarm is also used during supervision of the shore supply when the shore connection breaker is closed.*	Warning	18.
54	f-BB TOO LOW	The generator breaker has been *tripped* due to the frequency at the busbar continuously has been below the programmed *limit for underfrequency.*	Trip of GB	18.
55	f-BB TOO HIGH	The generator breaker has been *tripped* due to the frequency at the busbar has continuously exceeded the programmed *limit for overfrequency.*	Trip of GB	18.
56	U-BB TOO LOW	The generator breaker has been *tripped* due to the voltage at the busbar has been continuously below the programmed *limit for undervoltage.*	Trip of GB	18.

ID no.	ALARM TEXT	DESCRIPTION	ALARM SEQ.	REFERENCES
57	U-BB TOO HIGH	The generator breaker has been *tripped* due to *the voltage at the busbar* has continuously exceeded the programmed *limit for overvoltage.*	Trip of GB	18.
58	P LOADSHARE FAIL	The *power* produced by the generator set has continuously *deviated* more than the max. acceptable limit from the power setpoint.	DG Block	17.
60	DG-I NEL 1 TRIP	Non Essential Load group no. 1 has been tripped due to one of the below mentioned cases: a) The *current* of the generator set has been continuously above the programmed *limit for trip of NEL* 1. b) A shutdown or trip of GB alarm sequence has disconnected the generator set from the busbar.	Warning	18.
61	DG-I NEL 2 TRIP	Non Essential Load group no. 2 has been tripped due to one of the below mentioned cases: a) The *current* of the generator set has been continuously above the programmed *limit for trip of NEL* 2. b) A shutdown or trip of GB alarm sequence has disconnected the generator set from the busbar.	Warning	18.
63	DG-f NEL 1 TRIP	Non Essential Load group no. 1 has been tripped due to the *frequency* at the busbar has been continuously below the programmed *limit for trip of NEL* 1.	Warning	18.
64	DG-f NEL 2 TRIP	Non Essential Load group no. 2 has been tripped due to the *frequency at* the busbar has been continuously below the programmed *limit for trip of NEL* 2.	Warning	18.
66	DG DELOAD FAIL	The DGU has been unable to deload the generator set below the programmed power limit for opening of the GB. The generator set remains connected to the busbar and is included in the load share and load dependent start / stop calculation. *A PMS stop command is transmitted to the next generator set which are to be stopped (according the programmed start/stop priority).*	DG Block	17.

ID no.	ALARM TEXT	DESCRIPTION	ALARM SEQ.	REFERENCES
70	DG SHORT CIRCUIT ALARM	The *custom binary alarm input channe/1..6* has detected the programmed alarm status. The designated/selected alarm sequence is carried out *). The entered alarm text is displayed at the corresponding CP. *Please notice custom alarm inputs can have* a *customized alarm text.*	*) Selected alarm sequence	18.
71	DG ALARM 1			
72	L.O.P. LOW ALARM			
73	H.T. WATER OUTLET TEMP. ALARM			
74	MICRO SWITCH TURN GEAR ALARM			
75	GEN. WIND/BEARING ALARM			
76	GS OVERSPEED ALARM	By detection of over speed the requested alarm sequence will be executed.	Shutdown	19
91	ASYM.LD.SH.CANC.	The asymmetrical load share function is automatically cancelled due to the load situation. The connected DGU's *forced back to* symmetrical load share.	Warning	16.
92	TB POS. OFF	By detection of TB position = OFF the system will be forced into SWBD mode.	Warning	
93	SCB POS. ON !	The shore connection breaker is closed and at the same time one or more generator breakers are closed, meaning the DG is running in parallel with the mains. *No DG is running frequency control.*	Warning	20.

4. Menu system

The DELOMATIC menu systems, which are operated via the control panel(s), provide access to all programmable set-points/timers, system selections and read-out of selected measured values.

4.1. The menu structure

The DELOMATIC menu structure is based on 4 main sections. Each main section contains a number of sub-menus.

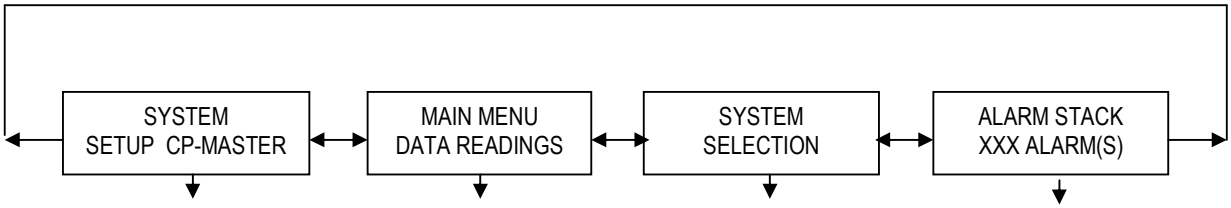


Fig. 16 The main sections of the DELOMATIC menu system

- The system setup section contains e.g. sub-menus for programming of set-points and delays used for control of the DELOMATIC system.
- The data readings section contains read-out sub-menus for display of actual measured values.
- In the system selections section, a number of system selections are available (only visible on the CP for the Master DGU).
- The alarm stack contains the alarm messages for all alarms.

The operator is able to browse through the DELOMATIC menu system via the CP push buttons:

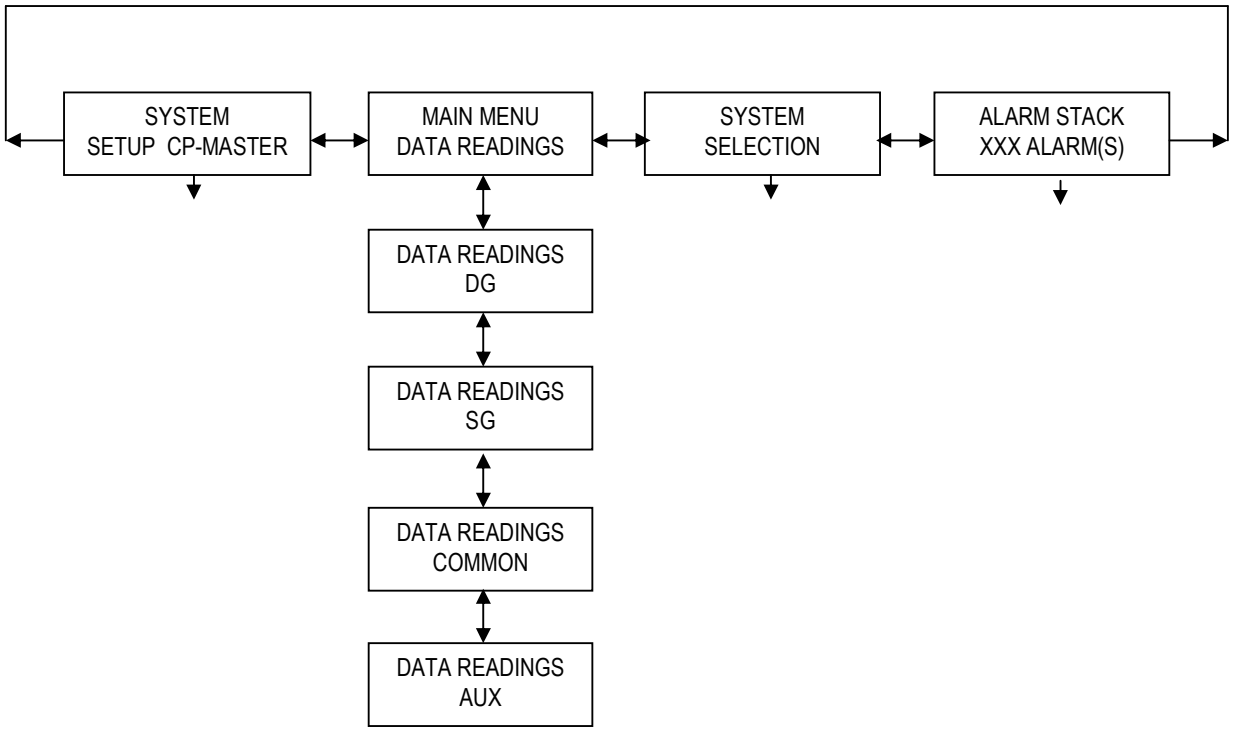
	Moves the focus to the left in the menu structure
	Moves the focus down in the menu structure
	Moves the focus up in the menu structure
	Moves the focus to the right in the menu structure

The programming function

The programming function (P-function) must be active whenever the operator wishes to change set points and timer values through the DELOMATIC menu system.

4.2. Data readings

The data readings section is divided into 3 or more subsections:



The data readings DG section contains measured values such as:

- generator phase-phase voltage
- generator phase currents
- generator frequency
- generator active and re-active power

The data readings SG section contains measured values such as:

- generator phase-phase voltage
- generator phase currents
- generator frequency
- generator active and re-active power

The common data readings section contains measured values such as:

- busbar voltages
- busbar frequency
- available power at the busbar
- consumed power at the busbar

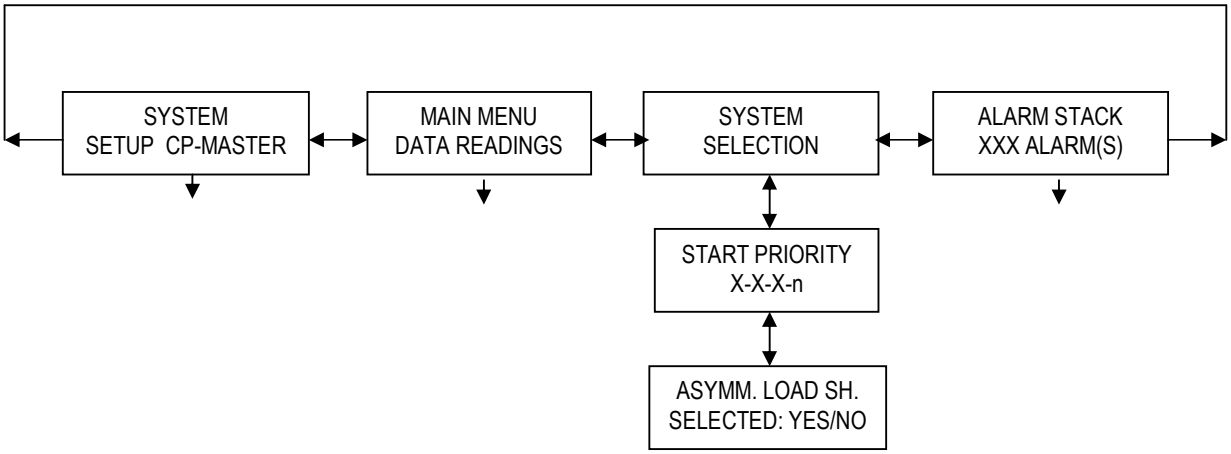
The aux. data readings section contains a number of miscellaneous measured values such as:

- the measured supply voltage at the supply terminals (PSM-1)
- the total running hours of the generator set
- the number of running hours since last reset of the trip counter
- value present at the analogue alarm input channels
- actual rpm at the engine
- the power consumed by any HC with analogue power feedback signal
- the software ID number

4.3. System selections

Through the system selection sections, the operator is able to program and activate common system function such as:

- selection of start priority (the DELOMATIC system may handle several generator sets)
- selection of asymmetrical load share (only possible if the asymmetrical load share function is available in the DELOMATIC system)



NOTE !
The system selection menus are only visible on CP(s) corresponding to the Master DGU.

4.4. Alarm stack

In the alarm stack, all registered and active alarm messages are available for read-out. If there are no active or un-acknowledged alarms registered in the DELOMATIC system, the alarm stack is empty.

5. Power management system

The Power management system (PMS) unit is the backbone of the DELOMATIC system. The PMS unit controls all functions regarding superior or common control of the entire power plant by means of PMS commands.

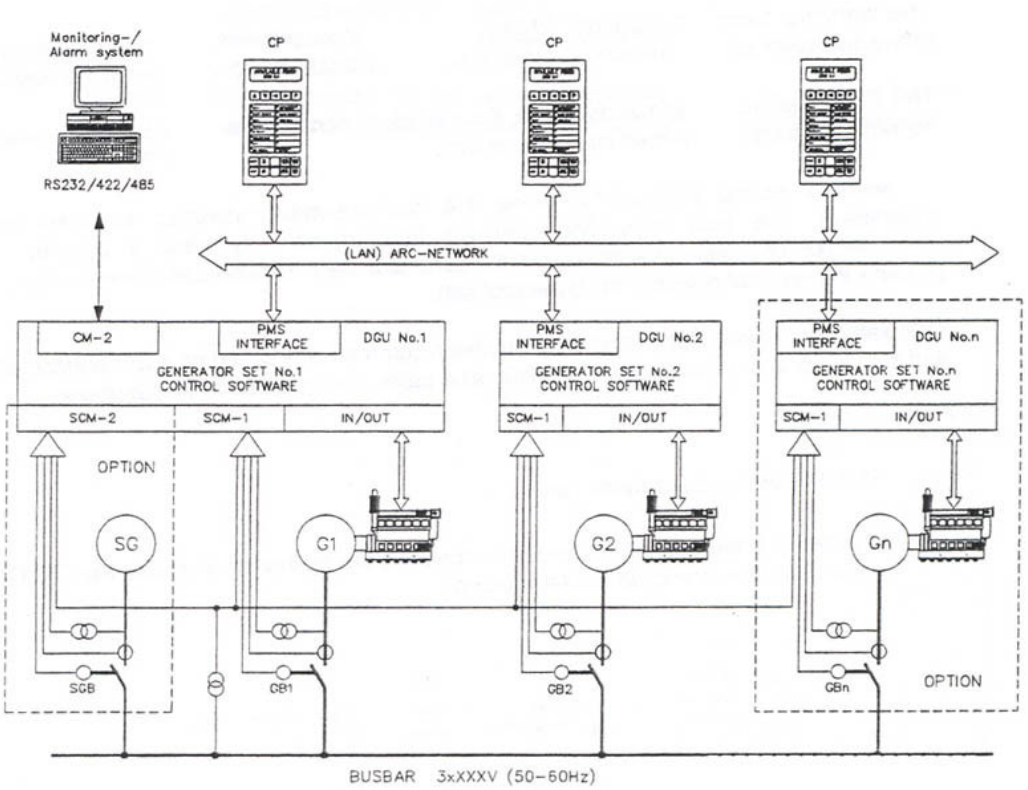


Fig. 17 Operating principle of the integrated PMS system

The PMS in the DELOMATIC system operates as an integrated unit in the Master DGU.

The PMS interface in each DGU carries out distributed control of the generator sets according to the received PMS commands and PMS status feedback signals.

Only generator sets (DGUs) selected to be under PMS control are included in the automatic PMS functions.

5.1. Plant modes

The DELOMATIC system operates according to the functionalism of the selected plant mode.

The plant modes combine the automatic functions in the DELOMATIC system according to the desired functionalism of each plant mode. This means some of the automatic functions may not be used in all plant modes.

The system is able to handle the following plant modes:

- **SEMI-AUTO MODE**
- **AUTOMATIC MODE**
- **SECURED MODE**

The plant modes are only accepted by DGUs which are selected to be under PMS control.

Selection of the plant mode for the entire power plant is done by a set of push-button inputs located on Master DGU.

x = active - = inactive (1) = Push-button activated	**SWBD CONTROL**	**PMS CONTROL**		
		PLANT MODES		
AUTOMATIC PMS FUNCTIONS		**SEMI-AUTO MODE**	**AUTOMATIC MODE**	**SECURED MODE**
1. Load depending start/stop	-	-	x	x
2. Selection of start/stop priority	-	-	x	x
3. Frequency control	-	x	x	x
4. Symmetrical load share	-	x	x	x
5. Asymmetrical load share	-	-	x	-
6. Black-out start	-	x	x	x
7. Shore connection supervision	x	x	x	x
8. Conditional connection of heavy consumers	-	x	x	x
9.				
10.				
GENERATOR SET FUNCTIONS				
11. Automatic start sequence	-	(1)	x	x
12. GB ON sequence	-	(1)	x	x
13. Frequency/load control	-	x	x	x
14. Manual control of freq./load	x	-	-	-
15. GB OFF sequence	-	(1)	x	x
16. Automatic stop sequence	-	(1)	x	x
GENERATOR SET PROTECTION				
17. Internal system supervision	x	x	x	x
18. Engine supervision	x	x	x	x
19. Busbar supervision	x	x	x	x
20. Generator protection	x	x	x	x
21. Short circuit protection	x	x	x	x
22. Trip of non essential load groups	x	x	x	x
23. Binary alarm inputs	x	x	x	x
24. Analogue alarm inputs	x	x	x	x

5.2. SEMI-AUTO plant mode

The SEMI-AUTO plant mode is an operator dependent AUTO mode.

In this mode the automatic sequences are carried out only on request of the operator, via the push-buttons at the CP-Master for the DGU; the automatic start sequence, the GB ON sequence incl. dynamical synchronisation, the GB OFF sequence and the automatic stop sequence.

Selection of SEMI-AUTO plant mode will have no effect on running generator sets.

Following push buttons at the CP-Master's are only active when SEMI-AUTO mode is selected.

PUSH-BUTTON	DESCRIPTION
"START"	Start of engine; the programmed automatic start sequence is carried out.
"STOP"	Stop of engine; the programmed automatic stop sequence is carried out.
"GB ON"	Closing of GB; the programmed automatic GB ON sequence is carried out.
"GB OFF"	Opening of engine; the programmed automatic GB OFF sequence is carried out. [1)]

1) The DELOMATIC will only open the GB if the generator set is expendable at the busbar.

NOTE ! Any auxiliary engines, which carry out idle run when SEMI-AUTO mode is cancelled, are automatically stopped by the function for stop of non connected DGs.

5.3. AUTO plant mode

During this full-automatic mode, called AUTO mode, the automatic control is carried out by all generator sets, which are selected to be under PMS control.

The DELOMATIC system carries out automatic frequency and load control during the AUTOMATIC plant mode.

The busbar load is shared between the running generator sets either as:

- symmetrical load share

or

- asymmetrical load share

Load depending start and stop of the generator is are carried out according to the actual power demand at the busbar with respect to: the programmed start/stop priority and the programmed limits for start and stop.

If the DELOMATIC system detects a blackout situation at the busbar, a conditional blackout start of two generator sets is carried out.

5.4. SECURED plant mode

The SECURED plant mode is almost the same as the AUTO mode. But the load depending start/stop set-points are increased with the nominal power of the largest connected generator set.

This means the nominal load of the largest connected generator set is available at the busbar at any time during SECURED mode.

The SECURED plant mode ensures that in this way, any of the running generator set may suddenly be cut-out from the busbar (e.g. by a shutdown or trip of GB alarm sequence) at any time without causing an imminent black-out situation.

5.5. Load dependent start/stop function

The load dependent start/stop function is active when the AUTO or SECURED plant mode is selected and shore connection is not closed.

The start/stop functions transmits PMS start and stop commands, which are based on a calculation of how many generator sets are needed in order to satisfy the actual power demand at the busbar.

The PMS start/stop commands cause the individual generator sets to carry out respectively start and stop according to the programmed start/stop priority.

Furthermore, during SEMI-AUTO mode, the load depending start/stop functions operate as hidden load supervision. The load depending start/stop function will only allow a push-button initiated semi-auto disconnection of a generator breaker, if the generator set is expendable at the busbar (the predicted available power > the nominal power of the generator set).

Calculation of the load depending PMS start/stop commands is based on a comparison of the programmed start and stop limits and a special DELOMATIC value called the predicted available power.

5.6. Selection of Start/Stop priority

Depending on the programmed priority sequence and the operational status of the generator sets, the start/stop priority function continuously designates each generator set with respectively a PMS start priority and a PMS stop priority.

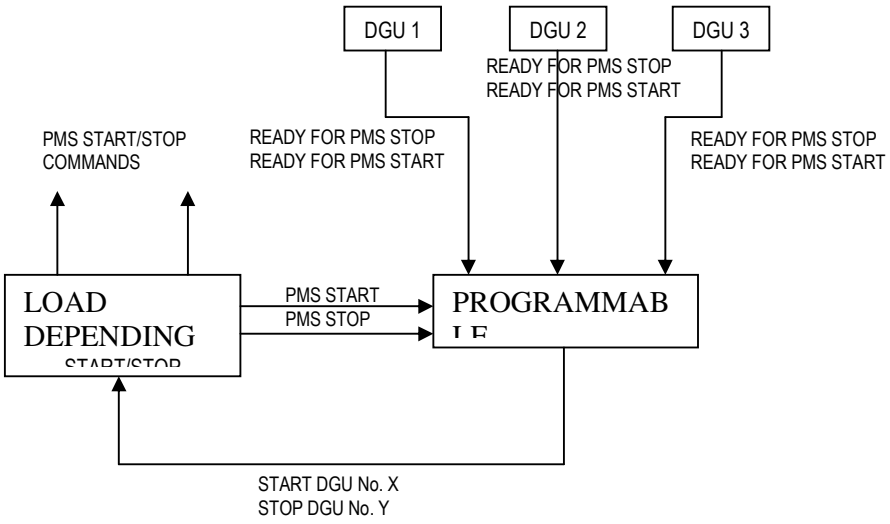


Fig. 18 Operating principle for determination of the start/stop priority.

The load depending start/stop function uses this information when the PMS start/stop commands are to be transmitted.

NOTE: The start/stop priority function keeps account with which DGUs are "ready for PMS start", and which DGUs are "ready for PMS stop". Any running DGU, which during operation, becomes not "ready for PMS stop" are not accepted as the next generator to be stopped.

5.6.1. Programming of the start/stop sequence

Programming and read-out of the start/stop priority sequence are carried out for all generator sets through the CP corresponding to the Master DGU.

The DELOMATIC multi-function will not accept the start/stop priority sequence if:

- two or more generator sets are programmed to the same start/stop priority number
- a generator set is programmed to have several start/stop priority numbers

The example below shows a start/stop priority sequence for a 4 generator set power plant, programmed to start priority 2-3-1-4.

	START PRIORITY
DGU no.	2 - 3 - 1 - 4
START PRIORITY	1st 2nd 3rd 4th

NOTE!
The DELOMATIC system is able to control the start/stop priority for as many as 6 generator sets.

When the operator changes the priority sequence, the generator sets automatically re-arrange according to the new start/stop priority, any stand-by generator sets which have been designated with a higher start priority than any running generator sets, will automatically substitute these.

5.6.2 Determination of the start priority

The Master DGU continuously designates each generator set with a PMS start priority number according to the programmed priority sequence.

The priority sequence 2 - 3 - 1 - 4 in the display designates:

- DGU no. 2 with start priority no. 1 (to be started first) .
- DGU no. 3 with start priority no. 2
- DGU no. 1 with start priority no. 3
- DGU no. 4 with start priority no. 4 (to be started last)

The DGU designated with start priority no. 1 is indicated by:

- a green "**1ST START PRIORITY**" LED

5.6.3 Determination of the stop priority

The Master DGU continuously designates each generator set with a PMS stop priority number according to the programmed priority sequence.

A priority sequence 2 - 3 - 1 - 4 in the display designates:

- DGU no. 4 with stop priority no. 1 (to be stopped first)
- DGU no. 1 with stop priority no. 2
- DGU no. 3 with stop priority no. 3
- DGU no. 2 with stop priority no. 4

5.6.4 "1st PRIOR" push-button

The operator is able to designate the highest start priority to any generator set via the corresponding CP by pressing the:

- "**1st PRIOR**" push-button

The example below shows how the start priority changes if the operator presses the "**1st PRIOR**" push-button at the CP corresponding to DGU no. 4:

The start priority sequence before as read-out on the CP:

2-3-1-4 meaning:

- DGU no. 2 is designated with start priority no. 1 (to be started first)
- DGU no. 3 is designated with start priority no. 2
- DGU no. 1 is designated with start priority no. 3
- DGU no. 4 is designated with start priority no. 4 (to be started last)

Then the push-button "1st PRIOR" on the CP corresponding to DGU no. 4 is pressed!

The start priority sequence after as read-out on the CP:

4-2-3-1 meaning:

- DGU no. 4 is designated with start priority no. 1 (to be started first)
- DGU no. 2 is designated with start priority no. 2
- DGU no. 3 is designated with start priority no. 3
- DGU no. 1 is designated with start priority no. 4 (to be started last)

The load depending start/stop function will subsequently re-arrange the running generator sets according to the new start priority.

5.6.5 Automatic designation of 1st start priority

This function ensures the operating hours (running hours) are equally distributed at all generator sets in the power plant.

The total accumulated running hours for each generator set is counted and stored by the corresponding DGU in a register "TOTAL RUN HOURS".

The example below shows the operating principles of the automatic designation of 1st priority.

The start priority before the automatic designation function is carried out (2 - 3 - 1 - 4):

- DGU no. 2 is designated with start priority no. 1; "TOTAL RUN HOURS" = 12550
- DGU no. 3 is designated with start priority no. 2; "TOTAL RUN HOURS" = 12520
- DGU no. 1 is designated with start priority no. 3; "TO TAL RUN HOURS" = 12500
- DGU no. 4 is designated with start priority no. 4; "TOTAL RUN HOURS" = 12560

The start priority sequence after the automatic designation function is carried out (1 - 2 - 3 - 4):

- DGU no. 1 is designated with start priority 00. 1; "TOTALRUN HOURS" = 12500 *)
- DGU no. 2 is designated with start priority no. 2; "TOTAL RUN HOURS" = 12550
- DGU no. 3 is designated with start priority no. 3; "TOTAL RUN HOURS" = 12520
- DGU no. 4 is designated with start priority no. 4; "TOTAL RUN HOURS" = 12560

*) DGU no. 1 have the smallest number of accumulated running hours.

5.7. Black-out function

The blackout function is active whenever one of the following plant modes are selected:

- SEMI-AUTO mode
- AUTO mode
- SECURED mode

The blackout function consists of two separate functions:

- a common detection of "dead busbar" status
- the black-out start sequence

An individual detection of "dead busbar" status is made by all DGUs in the system.

The blackout start sequence is initiated once the Master DGU receives the internal "dead busbar" status from all DGUs in the DELOMATIC system.

5.7.1. Dead busbar detection

The individual "dead busbar" internal signal is transmitted when the following conditions have been continuously registered by a DGU during the programmable delay.

- the largest measured busbar phase-phase voltage (U_{L-L}) is below 20 % of nominal value
- the corresponding generator breaker is in OFF position
- no short circuit alarm is active in the DGU *)

*) A short circuit alarm at any of the DGUs will block the entire blackout start sequence. ***The operator must in such cases acknowledge the short circuit alarm(s) in order to enable the blackout start sequence.***

If one or several of the above mentioned initiating conditions disappear, the "dead busbar" detection is immediately disabled.

A synchronisation-alarm is automatically acknowledged (reset) in case of an active "dead busbar" status in the DGU. This allows the generator set in question to attempt to connect to the busbar.

5.7.2. The blackout start sequence

If the Master DGU is unable to communicate with a DGU (indicated by a communication alarm message) the signal from the defective DGU is not required in order to initiate the blackout start sequence.

NOTE! Activation of the blackout start sequence is only possible, if at least one of the DGUs selected to be in PMS control and "ready for PMS start".

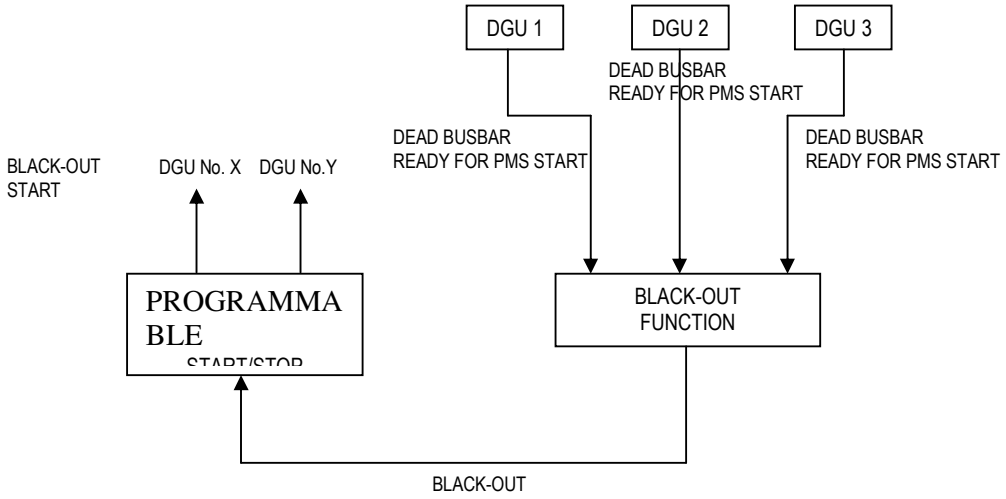


Fig. 19 Operating principle of the black-out function

The blackout start sequence carries out the following step-by-step sequence:

a) A PMS start command (activates the automatic start sequence in the DGUs) is transmitted to the DGUs with the highest and second highest start priority, which at the same time are "ready for PMS start".
b) The DGU which first obtains normal running feedback and normal generator voltage/ frequency will close the breaker immediately (after receiving an acknowledge-signal from the Master DGU).

   If this does not result in the closing of the generator breaker, the other black-out started generator set will (after approx. 2 sec. delay) be requested to close this breaker without synchronisation.

c) The second black-out started DGU initiates synchronisation of the generator breaker, approx. 2 s, after satisfactory voltage and frequency have been detected at the busbar.
d) If any of the two chosen generator sets fails during the start sequence, the PMS start command is transferred to the next stand-by generator set as long as the blackout situation is present.
e) When one generator set is successfully connected to the busbar, the black-out function is considered to be completed. The DELOMATIC system switch back to "normal" operation again.

5.8. Conditional connection of heavy consumers

The conditional connection of Heavy Consumers function is able to handle 3 heavy consumers (HCs).

When requested by a heavy consumer, the function for conditional connection of heavy consumers reserves the programmed max. power at the busbar and blocks engagement of the heavy consumer until sufficient predicted available power is present at the busbar.
After achieving sufficient predicted available power, the heavy consumer is subsequently blocked until the programmed delay runs out.

The heavy consumers (HC) are connected according to their priority.

This means, if two or more heavy consumers request for start acknowledgement at the same time, the HC with the highest priority is handled first, subsequently HCs with lower priority etc.

HC 1 is designated the highest priority e.g.; HC 1 is handled before HC 3, if they request for start at the same time. If there are any preferential HCs, these must be connected to the hardware interface for HC 1 in order to ensure 1st priority handling.

The DELOMATIC system carries out the following step-by-step sequence, in case of a HC request for start acknowledgement:

a) The programmed "HC n MAX POWER" value is reserved at the busbar.
b) A PMS start command is transmitted to the next stand-by generator set if the predicted available power is below the programmed "LOAD START LIMIT",

If the predicted available power at the busbar is below O kW, the timer "DELAY ACK. HC n" is blocked until the stand-by generator set is connected and sufficient predicted available power is present at the busbar.

The timer "DELAY ACK. HC n" starts running at this point if the predicted available power at the busbar is above O kW.

c) When sufficient predicted available power is present at the busbar, the timer "DELAY ACK. HC n" starts running.
d) The start acknowledge signal is transmitted to the HC in question, when the timer "DELAY ACK. HC n" runs out and sufficient available power still is measured at the busbar.

6. Generator set control

Generator set control is handled by the DGUs according to a number of automatic sequences.

The automatic sequences form jointly a complete cycle of operation for a generator set.

The Master DGU is able to initiate a complete cycle of operation for a generator set by means of the PMS start command and the PMS stop command.

A DGU “ready for PMS start" will respond to the PMS start command by carrying out:

- the automatic start sequence
- the automatic GB ON sequence.

All generator sets in operation which are "ready for PMS stop" respond to the PMS stop command by carrying out:

- the automatic GB OFF sequence
- the automatic stop sequence.

During an active SEMI-AUTO plant mode, the initiation of the automatic sequences is carried out step-by-step (sequence by sequence) according to the operator commands via the push-buttons at the CP(s).

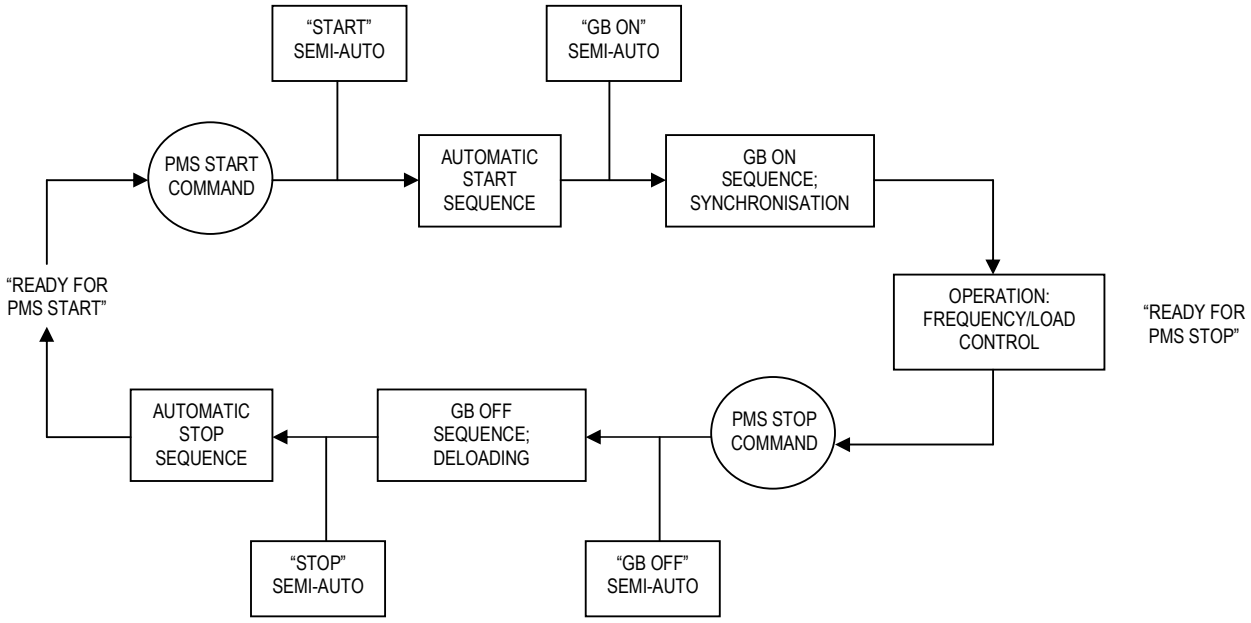


Fig. 20 The automatic sequences contained in the cycle of operation for a generator set

All the above mentioned automatic sequences are controlled according to a number of programmable set-points and timers - this enables the operator to adjust the automatic operation of the generator set.

6.1. DGU operational modes for the generator set

Each generator set is controlled according to the selected DGU operational mode for the controlling DGU.

Each generator set may be selected to be under either:

- Switchboard (SWBD) control

or

- Power management system (PMS) control

Switchboard control (DGU operational mode)

Generator sets under switchboard control (SWBD control) are only to be operated manually. A generator set under SWBD control is excluded from all automatic PMS functions.

SWBD control is strictly local; all other generator sets operating under selected PMS control will not be affected.

The synchronising unit in the SCM-1 module turns into SWBD control, when SWBD control is selected on the DGU.

SWBD control enables manual control of the speed governor via the synchronising unit in the SCM-1 module. The speed governor may be manually decreased and increased by means of two binary inputs.

All supervision and protective functions regarding the generator set are still active for generator set(s) under SWBD control e.g.:

- generator protection
- busbar supervision

PMS control (DGU operational mode)

Generator sets under PMS control are automatically controlled by the DELOMATIC system according to the selected plant mode.

6.1.1. Automatic start sequence

The automatic start sequence starts the corresponding auxiliary engine and detects if the start is completed successfully. A successfully completed start sequence initiates the GB ON sequence.

The automatic start sequence is carried out when a DGU receives a PMS start command. The PMS start command may e.g. be generated by the load depending on start/stop or by the blackout function.
An operator dependent initiation (push-button) of the automatic start sequence may take place in SEMI-AUTO mode (this will not initiate the GB ON sequence).

The start sequence is initiated when the DGU receives a PMS start command.

Each DGU in the DELOMATIC system is able to carry out the automatic start sequence, which includes:

- continuous supervision of "ready for PMS start" status
- programmable time for the "START PREPARE" output
- programmable ON time for the “START” output
- programmable OFF time for the “START” output
- programmable activation of the stop output during OFF time
- programmable number of start attempts
- detection of start failure
- supervision of generator voltage and frequency during idle run
- transfer of the PMS start command to the next stand-by generator set in case of:
  - start failure
  - generator voltage or frequency failure

6.1.2. Automatic GB ON sequence

The GB ON sequence is automatically initiated (except during SEMI-AUTO mode) when the automatic start sequence has been successfully completed.

The automatic GB ON sequence includes:

- detection of "ready for PMS synchronisation" status for the generator set
- programmable dynamical synchronisation
- generator breaker ON control
- transfer of the PMS start command to the next stand-by generator set in case of:
  - a failed synchronisation
  - a generator breaker ON failure

When the GB ON sequence is initiated it is indicated at the CP corresponding the DGU by:

- a yellow "GB ON" LED

6.1.3. Automatic GB OFF sequence

The GB OFF sequence is initiated when the DGU receives a PMS stop command from the Master DGU (or a SEMI-AUTO initiated GB OFF) and the PMS stop command is only accepted by the DGU if the generator set is "ready for PMS stop".

The GB OFF sequence deloads the generator set and will finally open the generator breaker.

6.1.4. Automatic stop sequence

The automatic stop sequence is carried out when the DGU has successfully completed the GB OFF sequence.
The stop sequence is automatically initiated when the GB OFF sequence has been completed.

The DGU in the DELOMATIG system is able to carry out the automatic stop sequence, which includes:

- Automatic stop sequence incl.:
  - programmable cooling down time
  - "STOP" output with programmable extended ON time
- Semi-auto stop of engine incl.:
  - programmable cooling down time
  - "STOP" output with programmable extended ON time

7. Generator set supervision and protection

The DGU in the DELOMATIC system is able to handle local supervision and protection of the corresponding generator set. Each DGU is implemented with the protective and supervision functions.

NOTE! All local supervision and protective functions are also active during SWBD control.

7.1. Internal system supervision

The DGUs in the DELOMATIC system are implemented with an extensive number of internal system supervision functions for supervision of their ability to carry out safe and correct operation.

Each DGU continuously carries out the following system supervision functions:

- CP-1 supervision of the ARC-network
- CM-2 supervision of ARC-network and internal communication
- supervision of the generator breaker position feedback signals
- supervision of I/0 configuration (hardware)
- power supply supervision
- supervision of the multi-transducer unit in SCM modules
- cable supervision

7.2. Engine supervision

Engine supervision is handled by the DELOMATIC system according to the status on a number of alarm inputs.

Each DGU in the DELOMATIC system is able to carry out the following engine supervision functions:

- tacho feedback
- 6 user programmable alarms

The engine supervision functions are disabled when the engine is not running (stand-by). Disabling of the engine supervision means that no alarms are generated by the supervision functions.

The engine supervision functions are furthermore disabled during the automatic start sequence until the auxiliary engine has obtained running status.

Each DGU is implemented with the following hardware interface, which is used in coherence with the engine supervision functions.

7.3. Busbar supervision and protection

The DELOMATIC busbar supervision and protective functions are activated whenever a generator set is connected to the busbar.

Busbar supervision is also activated at the Master DGU when a shore connection is supplying the busbar (only if shore connection is present).

Each DGU carries out busbar supervision and protection according to individual programmable set points and delays.

This means the DGUs may be programmed differently, but it is highly recommended to program the busbar supervision functions with set points and delays common for the entire DELOMATIC system.

Each DGU implements the following busbar supervision (warning) and protective (trip of GB) functions:

- 2 level undervoltage, $U_{BB}<$
- 2 level overvoltage, $U_{BB}>$
- 2 level underfrequency, $f_{BB}<$
- 2 level overfrequency, $f_{BB}>$

7.4. Generator protection

The DELOMATIC generator set protection is separated into two parts:

- supervision of the generator during an idle run (the breaker is open)
- a set of protective functions which are active when the breaker is closed

The following generator supervision and protective functions are implemented in each DGU in the DELOMATIC system:

- supervision of generator voltage and frequency during idle run
- protection against overcurrent; I > (2 steps; slow and fast)
- protection against reverse power; -P>
- protection against overload; P > (2 steps; high load and overload)

Each DGU carries out the generator protection according to individual programmable set points and delays.

This means that the protective functions in the DGUs may be programmed differently according to different characteristic values.

7.5. Trip of non essential load groups

The trip of **N**on **E**ssential **L**oad (NEL) groups is carried out in order to protect the busbar against an imminent black-out situation due to either a high load on a generator set or a low busbar frequency.

The trip of NEL groups function is implemented in each DGU. This means each DGU executes the trip of NEL groups according to individual settings. But it is highly recommended to program all DGUs with identical settings in order to obtain a uniform operation.

Each DGU is able to trip two NEL groups due to:

- the measured load of the generator set
- the measured frequency at the busbar

The load groups are tripped as two individually load groups. Thus, the trip of load group no. 1 has no direct influence on the trip of load group no. 2. Only the measurement of either the busbar frequency or the load on the generator set is able to trip the load groups.

Trip of NEL groups due to high load
Trip of the NEL groups due to the load of a running generator set will reduce the load on the busbar and thus reduce the load percentage on the running generator set. This may prevent a possible black-out at the busbar caused by an overload on the running generator sets.

NOTE ! Furthermore, both steps of NEL groups are tripped at the same time by the DGU if the corresponding generator breaker is tripped.

8. Operating procedures

8.1. Starting the first generator from dead engine room condition

Local start of the emergency generator

1. Open valve from Em. Gen. DO tank
2. Set emergency generator operation switch to position MANU
3. Click on emergency generator local control panel
4. Set engine to maximum fuel before operating starter
5. Ensure the pressure is 30 MPa, if not operate hand pump to charge the system
6. Do not snatch starting lever
7. Move starting lever gently until resistance is felt, overcome resistance and without pause complete full lever travel in one movement
8. When engine fires release starting lever

Starting the emergency generator automatically

1. Open valve from Em. Gen. DO tank
2. Set emergency generator operation switch to position AUTO

Starting the emergency generator manually

1. Open valve from Em. Gen. DO tank
2. Set emergency generator operation switch to position MANU
3. Press the **STOP/START** button
4. Switch on the generator on the bars by pressing the **Gen. breaker ON** push-button in the emergency generator's field

Preparing starting air system

1. Open valves from emergency air compressor to auxiliary air receiver
2. Drain auxiliary air receiver
3. Open valves to diesel engines
4. Set emergency air compressor "MAN - AUTO" switch to position "AUTO"

Preparing fuel oil system

1. Open valves from DO service tank via DO booster pump to diesel engines
2. Set DO booster pump switch to position AUTO

Preparing cooling water system

1. Open valves from sea chest via main cooling SW pumps, central fresh water coolers to overboard valve
2. Open valves from diesel engine via central cooling FW pumps, central FW coolers to diesel engine
3. Set central cooling SW pump 3 switch to position On
4. Set central cooling FW pump 3 switch to position On

Starting the engine from local control panel

1. Click on DG local control panel
2. Press the **LOCAL** button on DG local control panel.
3. Press the **START** button on DG local control panel.

Starting the first generator /or after BLACK OUT/

1. Switch on the generator on the bars by pressing the **Gen. breaker ON** push-button in the generator's field.

Attention:
The switching of the generator on the bars is confirmed by green control lights in the generator field and the synchronisation block. In the synchronisation block, the frequency indicator should indicate 60 Hz.

8.2. Preparing the diesel engine and auxiliary systems

Preparing starting air system

1. Open valves from fresh water cooling system to air compressors nr 1 and nr 2
2. Open valves from compressors to main and auxiliary air receivers
3. Drain all air receivers
4. Set main air compressor no. 1 "PRIORITY" switch to position "1"
5. Set main air compressor no. 2 "PRIORITY" switch to position "2"
6. Set main air compressor no. 1 "MAN - AUTO" switch to position "AUTO"
7. Set main air compressor no. 2 "MAN - AUTO" switch to position "AUTO"
8. Open valves to main engine, auxiliary engines (DG) and other receivers

Preparing fuel oil system

1. Open valves from FO service tanks via FO feed pump, FO booster pumps, FO heaters and FO viscosimeter to diesel engines
2. Set one of FO feed pump switch to position On and other to position Stand-by
3. Set one of FO booster pump switch to position On and other to position Stand-by

Preparing cooling water system

1. Open valves from sea chest via main cooling SW pumps, central fresh water coolers to overboard valve
2. Open valves from diesel engine via central cooling FW pumps, central FW coolers to diesel engine
3. Set central cooling SW pump 1 switch to position On
4. Set central cooling SW pump 3 switch to position Stand-By
5. Set central cooling FW pump 2 switch to position On
6. Set central cooling FW pump 3 switch to position Stand-By

Preparing diesel engine for start

1. Set auxiliary engine prelubricating pump to position PMS

The engine shall be prelubricated at least 2 minutes prior to start

2. Set auxiliary engine cooling water preheater to position On

Note: To avoid shock effects owing to large temperature fluctuations just after the start, it is recommended:

a) to preheat the engine, cooling water of at least 60^{o} C should be circulated through the frame and cylinder head for at least 2 hours before start.

- either by means of cooling water from engines which are running or by means of a built-in preheater (if installed).

or

b) when starting without preheated cooling water, the engine must only be started on DO (Diesel Oil).

The engine should not be run up to more than 50% load to begin with, and the increase to 100 % should take place gradually over 5 to 10 minutes.

3. Set auxiliary engine fuel valve control switch FO (only when started on FO), circulate preheated oil through the nozzles for at least 15 minutes

Starting on FO: circulate preheated fuel through the pumps until correct working temperature has been obtained. This takes normally 30-60 minutes.

8.3. Manual operation

Starting the engine from SWBD

1. Start for a few minutes the prelubricating pump /switch the PRELUBRICATING PUMP MODE on the ON position and then on the OFF position/.
2. Press the **REMOTE** button on DG local control panel.
3. Set DG mode switch to position SWBD control.
4. Press the **Reset** button in the generator's field on SWBD.
5. Press the **DG Start** button in the generator's field on SWBD.

Starting the first generator /or after BLACK OUT/

1. Before starting the generator the switch **Stand still heating** should be ON, while after starting the generator on the bar it should be OFF /heating off /. After starting the engine the voltage indicator in the generator field will display 440 V.
2. Switch on the generator on the bars by pressing the **Gen. breaker ON** push-button in the generator's field.

Attention:
The switching of the generator on the bars is confirmed by green control lights in the generator field and the synchronisation block. In the synchronisation block, the frequency indicator should indicate 60 Hz.

The generator's synchronisation procedure

1. Check whether the engine of the generator for synchronisation has been started /the voltage indicator in the generator's field should display around 440 V/
2. Switch the generator control mode switch to **SWBD control**.
3. Select the generator for manual synchronisation by using control switch:
   - **Manu Synchro of G1 –** synchronisation of generator 1
   - **Manu Synchro of G2 –** synchronisation of generator 2
   - **Manu Synchro of G3 –** synchronisation of generator 3

Attention:
After selecting the manual method, the lamps **SYNCHRO WHEN DARK** will switch on and off with a frequency depending on the difference between the frequencies of the generator on the bars and the generator synchronised. Also the SYNCHROSCOPE will indicate by the rotating LED the differences in their frequencies. If the LED rotates on the right, the frequency is too fast / TOO FAST /, on the left - too slow / TOO SLOW /. The adjustment of the appropriate frequency of the synchronised generator is realized by Governor/Regler switch.

4. A synchronised generator can be switched on the bars with **Gen. breaker ON** push-button, in their generator's field, in the case the synchronisation lamps "dark" are completely extinguished and the LED in the synchroscope is switched on in the position marked with an arrow.
5. After synchronisation, take over power load by using Governor/Regler switch.

Attention:
After an unsuccessful attempt of manual synchronisation both the generators will turn off of the bars / BLACK - OUT / and the whole procedure of turning on and synchronisation will have to be repeated from the beginning /i.e. from the moment the first generator was started/.

The unloading and switching off the generator procedure

1. Slowly unload generator by using Governor/Regler switch (decrease).
2. Press the **Gen. breaker OFF** button in the generator's field.

Stopping the engine from local control panel

1. Press the **LOCAL** button on Engine Local Control Panel.
2. Press the **STOP** button on Engine Local Control Panel.
3. Start for a few minutes the pre-lubricating pump /switch the PRELUBRICATING PUMP MODE on the ON position and then on the OFF position/.

Stopping the engine from SWBD

1. Press the **REMOTE** button on Engine Local Control Panel.
2. Press the **DG Stop** button in the generator's field on SWBD.
3. Start for a few minutes the prelubricating pump /switch the PRELUBRICATING PUMP MODE on the ON position and then on the OFF position/.

8.4. Automatic operation

SEMI-AUTO MODE

Starting the engine

1. Press the **REMOTE** button on DG local control panel.
2. Set PMS mode switch to position **SemiAuto**.
3. Set prelubricating pump mode switch to position PMS /the pumps will start and stop automatically according to the state of the engine/.
4. Press the **START** button on generator Control Panel CP-n /engine will start automatically/

The generator's synchronisation procedure

1. Press the **GB ON** button on generator Control Panel CP-n /generator will synchronise automatically/.

The unloading and switching off the generator procedure

1. Press the **GB OFF** button on generator Control Panel CP-n /generator will unload and switch off automatically/.

Stopping the engine

1. Press the **STOP** button on generator Control Panel CP-n /generator will unload and switch off automatically/.

AUTOMATIC and SECURED MODE

1. Set PMS mode switch to position **Auto** or **Secured**.

During those full-automatic modes, the automatic control is carried out by all generator sets, which are selected to be under PMS control.

The DELOMATIC system carries out automatic frequency and load control during the AUTOMATIC plant mode.

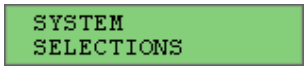
Load depending start and stop of the generator set is carried out according to the actual power demand at the busbar with respect to the programmed start/stop priority and the programmed limits for start and stop.

If the DELOMATIC system detects a blackout situation at the busbar, a conditional blackout start of two generator sets is carried out.

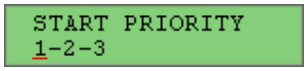
8.5. Programming of the start priority

The example below shows how to change start/stop priority sequence from 1-2-3 to start priority 2-3-1.

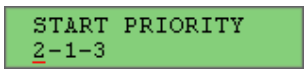
1. Go to the SYSTEM SELECTION menu by means "⇐", "⇑" , "⇒", "⇓" "push-button".



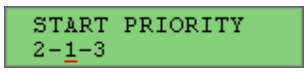
2. Press "⇓" "push-button" to enter START PRIORITY sub-menu



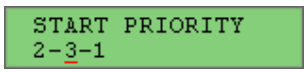
3. Press "⇑" "push-button" 1 time to set first priority generator



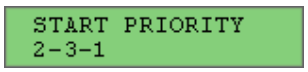
4. Press "⇒" "push-button" 1 time



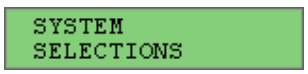
Press "⇑" "push-button" 3 times to set second priority generator



Press "⇒" "push-button" 1 time



Press "⇑" "push-button" 1 time to exit from START PRIORITY sub-menu



Note ! The programming start priority function is only available in the Master DGU (DGU number 1).

COMPRESSED AIR SYSTEM SIMULATOR

1. Introduction

The educational program COMPRESSED AIR SYSTEM SIMULATOR is intended for teaching the basic principles of how to operate a typical compressed air system.
The program is based on the compressor type HV2/200 (main air system), LL2/105 (control air system), HL2/77 (emergency air system) produced by Sperre Industri A/S.

The program consists of the following parts:

- Control Panel
- Main Air System
- Control Air System

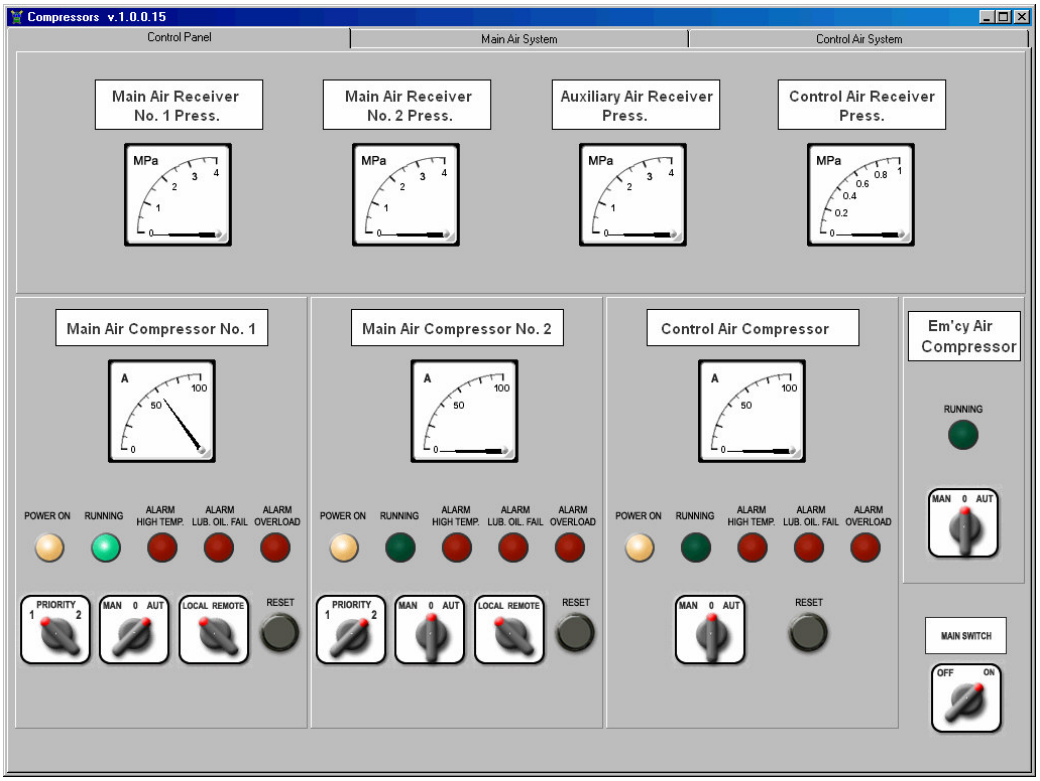


Fig. 1 Control Panel

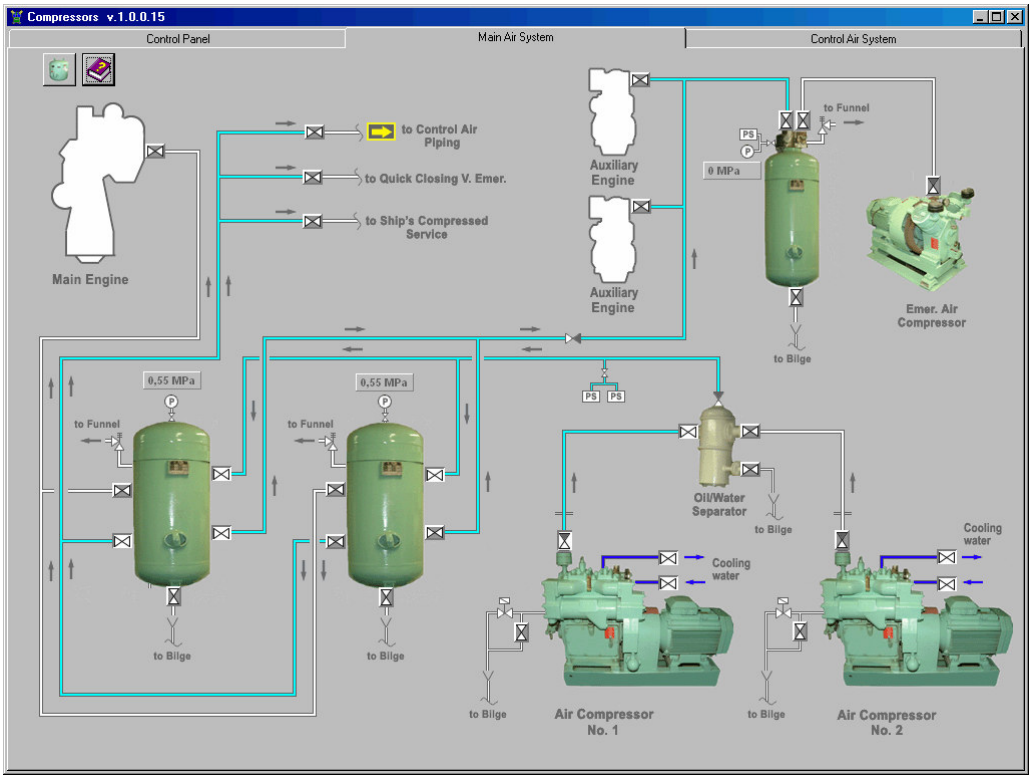


Fig. 2 Main Air System

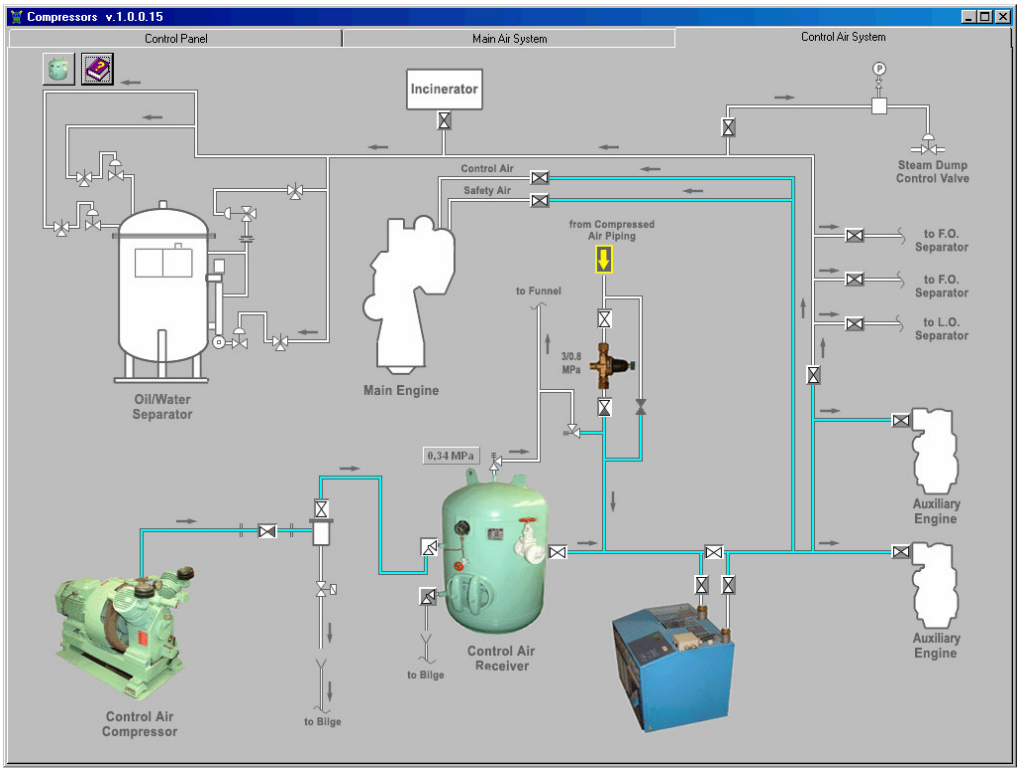


Fig. 3 Control Air System

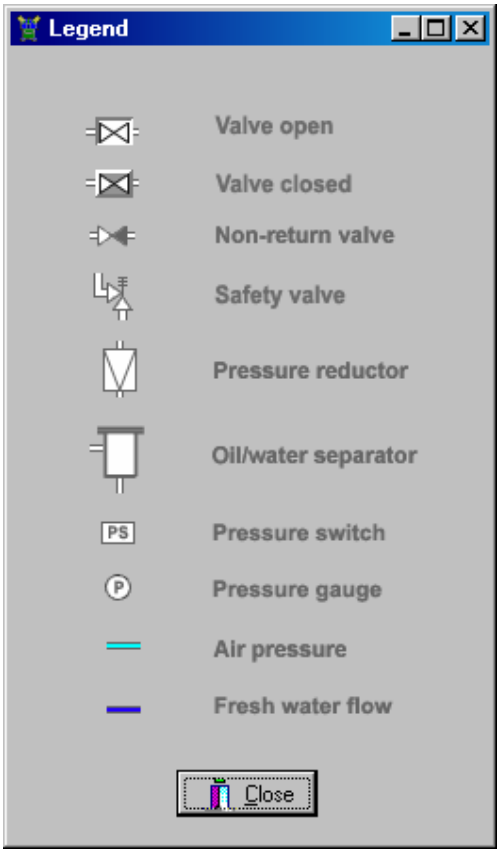


Fig. 4 Legend

2. Operating procedures

The compressors may be operated manually (**"MAN - AUTO"** switch in position **"MAN" –** manual operation) or automatically (**"MAN - AUTO"** switch in position **"AUTO" –** automatic operation).
In manual operation compressor is controlled by the operator. Start and stop function depends on "**MAN - AUTO**" switch position : 0 – stop, MAN – running.
In automatic operation compressor is controlled by the pressure switch:

a) first priority – start 2.5 MPa , stop 3 MPa
b) second priority – start 2.3 MPA, stop 3 MPa

Usually compressors may be controlled locally from local control panel or remotely, from the control room. Remote control of compressors is not implemented in the simulator.

2.1. Preparing Main Air System

1. Open valves from fresh water cooling system to air compressors nr 1 and nr 2.
2. Open valves from compressors to main and auxiliary air receivers.
3. Switch on "**Main switch**".
4. Set main air compressor no. 1 **"PRIORITY"** switch to position **"1"**.

5. Set main air compressor no. 2 **"PRIORITY"** switch to position **"2"**.
6. Set main air compressor no. 1 **"LOCAL - REMOTE"** switch to position **"LOCAL"**.
7. Set main air compressor no. 2 **"LOCAL - REMOTE"** switch to position **"LOCAL"**.
8. Set main air compressor no. 1 **"MAN - AUTO"** switch to position **"AUTO"**.
9. Set main air compressor no. 2 **"MAN - AUTO"** switch to position **"AUTO"**.
10. Drain all air receivers.
11. Open valves to Main Engine, Auxiliary Engines and other receivers.

2.2. Preparing Control Air System

1. Open valves from control air compressor to control air receiver.
2. Set on "**Main switch**".
3. Set control air compressor **"MAN - AUTO"** switch to position **"AUTO"**.
4. Drain control air receiver.
5. Open valves to Main Engine, Auxiliary Engines and other receivers through air dryer.

2.3. Emergency operation

In emergency operation (no electric power and empty air receivers) it is possible to use emergency compressor which is powered by emergency generator to fill auxiliary air receiver.

1. Open valves from emergency air compressor to auxiliary air receiver.
2. Switch on "**Main switch**".
3. Set emergency air compressor **"MAN - AUTO"** switch to position **"AUTO"** .
4. Drain auxiliary air receiver.
5. Open valves to Auxiliary Engines.