Kongsberg K-Chief 700 Integrated Control System

Product Description

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Note

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KONGSBERG

Table of contents

Glossary

Abbreviations

.io	File extension for input/output configuration files
.ps	File extension for process station configuration files
AI	Analog Input
AIM	Advanced Integrated Multifunction
AO	Analog Output
AOM	Analog Output Module
ASCII	American Standard Code for Information Interchange
BOP	Burner Operation Panel
BOG	Boil-off Gas
CAN	Controller Area Network
CCR	Cargo Control Room
CCTV	Closed Circuit Television
CPM	Central Processor Module
CPU	Central Processor Unit
CSBD	Cargo Switch Board
CTS	Custody Transfer System
DCS	Distributed Control System
DDE	Dynamic Data Exchange
DDG	Diesel Driven Generator
DI	Digital Input
DNV	Det Norske Veritas
DP	Dynamic Positioning
DO	Digital Output
ECR	Engine Control Room
ESD	Emergency Shutdown
F&G	Fire & Gas
FDP	Fire Detection and Protection
FDS	Functional Design Specification
FO	Fuel Oil
FOST	Final Output Stage Test
FPSO	Floating Production, Storage and Offloading
FS	Field Station
GMS	Gas Management System

GPS	Global Positioning System
GTDG	Gas Turbine Driven Generator
GUI	Graphical User Interface
HD	High Duty
HMI	Human-Machine Interface
HTML	Hyper Text Markup Language
HS	History Station
HVAC	Heating, Venting and Air Condition
HW	Hardware
IEC	International Electrotechnical Commission
IGV	Inlet Guide Vane
IMS	Information Management System
IO (I/O)	Input/Output
K-Bridge	Kongsberg Maritime integrated navigation system
K-Chief	Kongsberg Maritime integrated vessel control system
K-Gauge	Kongsberg Maritime tank gauging system
K-Pos	Kongsberg Maritime Dynamic Positioning
K-Pro	Kongsberg Maritime distributed monitoring and control system
K-Safe	Kongsberg Maritime safety system
K-Thrust	Kongsberg Maritime Thruster Control
LAN	Local Area Network
LCD	Liquid Crystal Display
LD	Low Duty
LED	Light Emitting Diode
LNG	Liquefied Natural Gas
MLP	Manual Loader Panel
MPC	Modular Panel Controller
MS	Microsoft ™
NDU	Network Distribution Unit
NMEA	National Marine Electronics Association
ODBC	Open Database Connectivity
OFAS	Operator Fitness Alarm System
OLE	Object Linking and Embedding
OPC	OLE for Process Control
OS	Operator Station
OSHS	Operator Station and History Station
OSK	Operator Station Kernel

OSV	Offshore Support Vessel
PC	Personal Computer
PCS	Process Control System
PID	Proportional Integral Derivative
PMS	Power Management System
PSD	Process Shutdown
PU	Process Unit
RBUS	Remote I/O Bus
RCA	Redundancy and Criticality Assessment
RCU	Remote Controller Unit
RIO	Remote Input Output
SG	Shaft Generator
SPM	Kongsberg Maritime Position Mooring
SQL	Structured Query Language
STP	Shielded Twisted Pair
SW	Software
TB	Termination Board
TCP/IP	Transmission Control Protocol/Internet Protocol
UMS	Unmanned Machinery Space
UPS	Uninterruptible Power Supply
URL	Uniform Resource Locator
WBU	Watch Bridge Unit
WCP	Watch Call Panel
WCU	Watch Cabin Unit
WD	Watch Dog

1 SYSTEM OVERVIEW

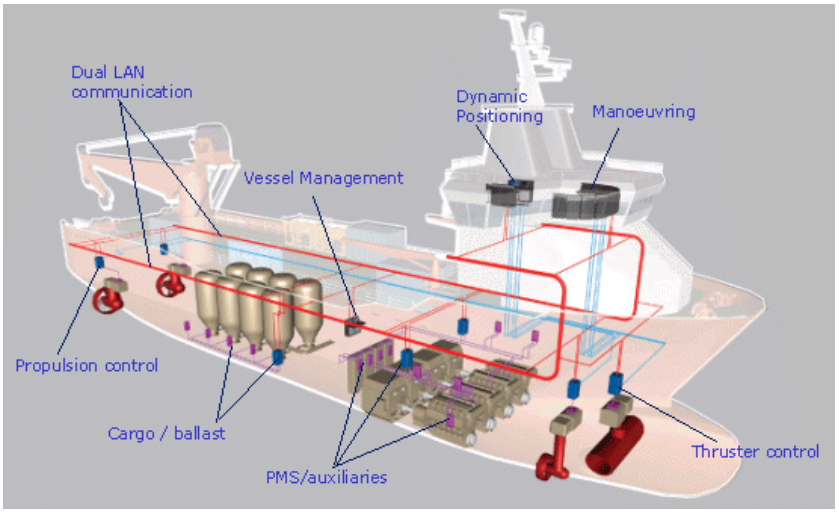
1.1 Introduction

The Kongsberg Maritime K-Chief 700 is a an integrated control system (ICS) used for distributed monitoring and control in marine applications. Its flexible, unique architecture allows it to be used for a wide range of tasks in the offshore industry, chemical industry, safety systems, and vessel control systems.

The K-Chief 700 does the following important functions on board a vessel:

- General purpose alarm and monitoring
- Power management
- Auxiliary machinery control
- Ballast/bunker monitoring and control
- Cargo monitoring and control
- Fully automated climate control
- Watch call system
- Operator fitness alarm system.

The K-Chief 700 system is built with modular hardware components, and modular application software. Any number of these modules can be combined to provide an optimal solution for a vessel's requirements and specification. The modular architecture also makes the K-Chief 700 suitable for small vessels.



1.1.1 Distributed processing

The K-Chief 700 is an automation system based on the concept of distributed processing, in which the various processes are controlled by input/output (I/O) modules located close to the processing units.

The remote I/O modules that use the Kongsberg RIO-420 technology, may also be installed in cabinets supplied by other manufacturers, such as switchboards or valve control cabinets. This allows precomissioning before installation on the vessel. The K-Chief 700 remote I/O range includes modules for installations in hazardous areas.

1.1.2 Integrated vessel control

The K-Chief 700 automation system can be seamlessly integrated with the other Kongsberg K-range systems, such as:

- K-Pos
- K-Thrust
- K-Bridge
- K-Gauge
- K-Safe
- K-Pro.

The advantages of integrated solutions over stand alone systems are given below:

- Proven solutions that focus on the operation of the entire vessel
- Operational consistency
- Free flow of information throughout the entire system
- Common technology in all the systems.

Integrating all the functions for monitoring and control of a vessel provides both technical and economical benefits. Functions can be integrated in order to reduce the overall need for hardware and software functions, and to reduce interface requirements. The benefits of system integration are maximised when the hardware and software components are based on the same technology.

1.1.3 Modular technology

Using similar technology for all products in the Kongsberg portfolio has allowed us to develop modular products. The benefits of modular design are:

- The same range of hardware modules can be used in the K-Pos (dynamic positioning) and K-Chief systems
- An identical basic software platform can be used in the K-Thrust (thruster control), K-Pos and K-Chief systems

- Free flow of information between the K-Thrust, K-Pos and K-Chief systems
- Consistent operation
- Reduced spare part inventories
- Reduced training requirements.

1.1.4 Safety and reliability

The K-Chief 700 is designed to satisfy the most stringent safety and reliability requirements. It supports redundancy at all levels including communication, process controllers, remote I/O modules and power supplies.

The built-in self-diagnostic facilities monitor the entire control system, extensively monitor the field circuits, and do earth-fault detection. A Fail-to-safe mode philosophy is implemented in the entire system, to ensure that components always fail in a way that does not cause dangerous faults in the rest of the system.

Both the hardware and the software have been type-approved by major classification societies.

1.1.5 Cost optimisation

The K-Chief 700 offers significant time and cost reductions for installation, when compared with traditional solutions. These savings result from:

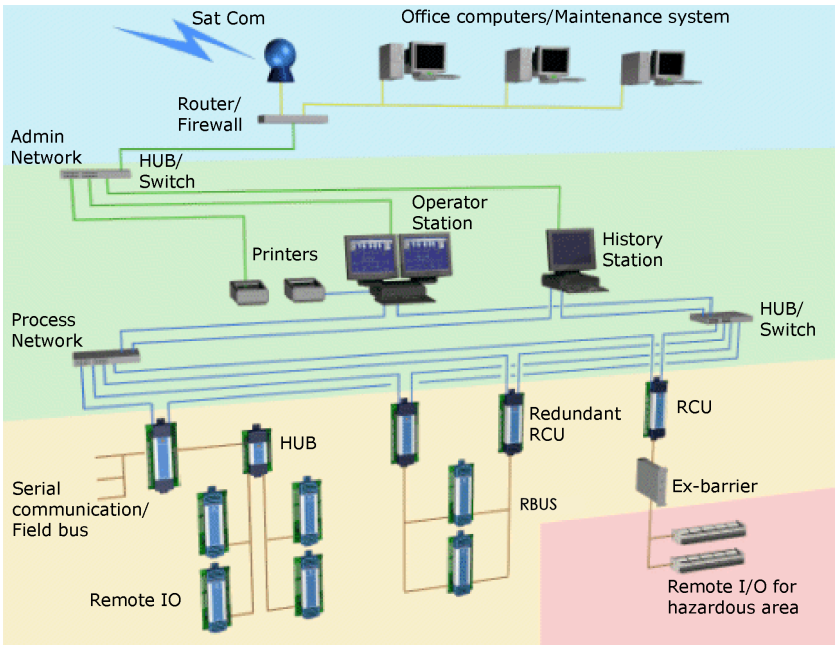
- Extensive reduction in the amount of cabling required
- Less man-hours required for engineering, installation, commissioning and documentation
- Reduced vessel building time
- Quality improvement in control system testing.

2 SYSTEM DESIGN

2.1 K-Chief 700 concept

The K-Chief 700 uses the AIM-2000 Distributed Control System (DCS) software. The system architecture interconnects Operator Stations and Field Stations through a dual redundant data network. Refer to the sections *Operator stations* on page 14 and *Field stations* on page 15 for more information on Operator and Field Stations.

The K-Chief 700 system is highly scalable due to its modular design and flexible architecture. New Process Stations (PS) can be connected to the network to control additional process areas, or to extend the functionality of the system. A process station consists of an RCU module, and the loaded software and configuration.



2.1.1 Operator stations

The Operator Stations are the main interface between the operator and the processes that the operator controls. More than one OS is normally installed in an automation system. Operator Stations may be connected to an administrative data network in addition to the process network. This provides an interface for other systems and devices.

2.1.2 Field stations

The field station (FS) controls and monitors processes in Kongsberg automation systems. Field Stations may contain single, or redundant RCUs, and/or remote I/O (RIO) modules. The configuration varies according to the needs of the application.

The Kongsberg RIO system consists of a single or dual (redundant) Remote Bus (RBUS) link network, with RIO modules connected. The dual RBUS configuration provides redundancy. The RBUS link is based on multidrop RS485 serial lines, and is controlled by an RCU controller computer in the process network.

The RIO system provides a cost-effective solution for connecting I/O to a Kongsberg automation system.

2.1.3 History stations

A history station is a computer connected to the network. It contains the operator station software. It also contains the database that stores samples of process variable measurements. History Stations can be connected to an administrative data network in addition to the process network. This provides a connection interface for other systems and devices.

2.1.4 Network

The network is dual redundant, since it is critical for all communication between the stations. All communication between the operator and the equipment being controlled, takes place over this network.

2.1.5 Information management system

The information management system enables exchange of information between onboard and onshore data systems using industry-standard interfaces. You can access real-time data on the administrative network. Reports generated in the automation system can be mailed to the onboard office network, and via the ship's mail system, to shore.

2.1.6 Printers

Some Operator Stations are directly connected to a dedicated printer for printing out events and alarms. The OS can also be connected to one or more network printers for event and report printing. Network colour printers provide high quality colour printouts of the current monitor image on an operator station.

2.1.7 Open solutions

Modern standards for communication allow data to be exchanged between computer systems from different suppliers, without the need for tailor made software.

2.1.7.1 Intersystem communication

K-Chief 700 uses several industry standard interfaces for the export and import of data. They are:

- ODBC
- TCP/IP
- Dynamic Data Exchange (DDE)
- OPC Data Access (OPC-DA)
- OPC Alarms and Events (OPC-A&E)
- OPC Historical Data Access (OPC-HDA)
- File Transfer Protocol (FTP)

2.1.7.2 Generic field interface protocols

K-Chief 700 uses the following generic field interface protocols:

- Profibus DP
- DeviceNet
- Modbus/Modbus TCP/IP
- NMEA 0183
- Foundation Fieldbus.

2.1.7.3 Proprietary interface protocols

K-Chief 700 uses proprietary interface protocols for the following:

- Fire centrals
- Level gauging systems.

I/O drivers for proprietary protocols are easily implemented in the K-Chief 700 system. The control applications are the same regardless of the type of I/O driver installed.

2.1.8 Third party applications/software

Standalone applications (e.g. load calculator, ship performance system or other standard third party applications) may be installed on the operator station. The communication between the K-Chief 700 process control and third party applications is usually done by the OPC.

3 OPERATOR STATION

3.1 Operator station

The operator stations (OS) are process independent and are connected to the communication networks, the process network, and the administrative network. They collect and display data from the individual process stations. An operator station acts as a backup for the other operator stations, and each process area can be controlled and monitored from any operator station. For operational reasons, the access levels to the process area can be limited by various means. These methods include the use of key switches, and/or passwords, or restrictions programmed into the system access software. The graphic display is provided by an industrial graphic controller which runs on Microsoft® Windows technology.

The OS is based on a PC that satisfies the requirements for marine use. These requirements are set out by the classification societies such as the American Bureau of Shipping, Lloyds Register, Det Norske Veritas, etc. The OS has the following features:

- Microsoft® Windows XP™ 32-bit operating system
- Kongsberg Maritime operator consoles with single or multiple screens, controlled from one operator panel and keyboard
- Big screen or projector
- Low amount of operator training is required
- One operator station is an autonomous, self contained unit
- Two or more operator stations can be provided, for redundancy.

The Windows-based display interface provides a high level of flexibility in the presentation of information. Familiar Windows features such as the menu bar and dialogue boxes are used. Functions that do not have dedicated panel buttons are controlled from the menu bar.

Operator stations can be fitted in a number of different ways, for example in a standard Kongsberg Maritime console or as separate units for desktop operation. More than one operator station is normally installed as part of a K-Chief 700 system. You will find them on the bridge, in cargo control rooms and engine control rooms.

The OS has a hard disc containing the software files for the plant/vessel installation. Process variables and parameter values to be displayed by the operator stations are generated in the field stations and transferred to the operator stations upon request. The information displayed on an operator station screen is gathered directly from all the field stations.

The K-Chief 700 system has capabilities for alarm handling, event handling, time-series, trends, reports, decorations, and interactive dialogue with dynamic elements.

The OS can be located away from the process areas which they monitor and control, anywhere on the plant or vessel.

3.1.1 Human-machine interface

The operator station is the main interface between the operator and the processes that the operator controls.

The human-machine interface (HMI) is an important feature which enables efficient and safe operation of the system, by helping the operator to make optimum operational decisions. This reduces the risk of human error during normal operation. Logical operation, effective presentation of relevant information and user-friendliness are the important design considerations.

The K-Chief 700 HMI is based on Microsoft® Windows technology.

The HMI of the operator station has three main parts:

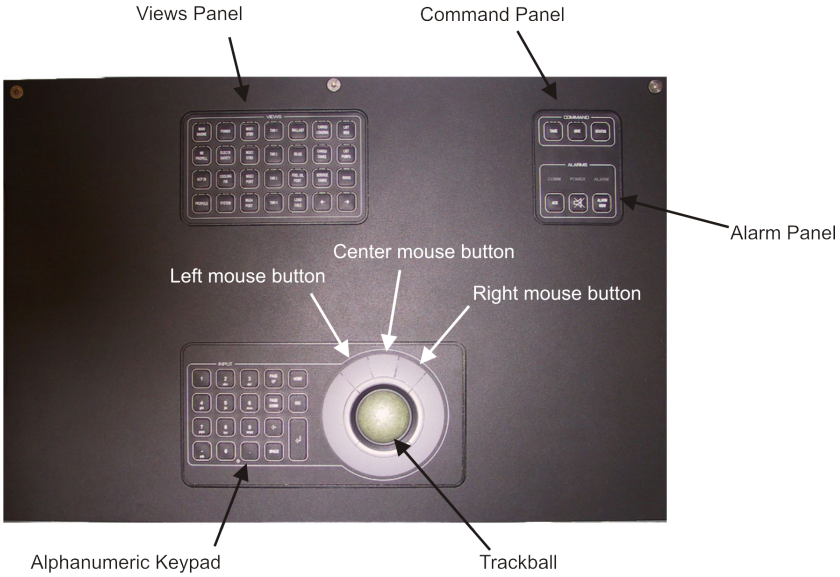
- An operator panel with buttons and trackball.
- An alphanumeric keyboard for operator input.
- Colour monitor(s) for the presenting information.

3.1.2 Operator panel

The operator panel (OP) is used to interact with the images on the colour monitor and to control the various processes. For example, you can use the operator panel to view the image navigator and choose a new image, or to interact with an image. You can use

the trackball and the three mouse buttons above it, to point and click on symbols and menus. The USB operator panel is designed to replace older operator panels with a single common operator system. The USB operator panel is easy to install and connect. The USB OP consists of several sub panels, and these can be mounted in various configurations to suit user requirements.

The layout of the push buttons, lamps and controls in the USB operator panel are shown in the figures that follow.

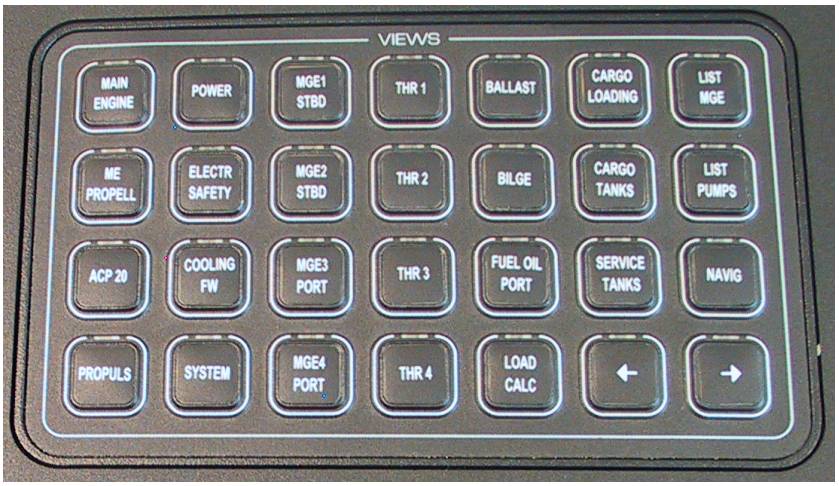


3.1.2.1 Views panel

The buttons of the Views panel are used to select and display images, representing the various process areas defined during the system configuration. The most important and commonly used images are assigned to these buttons, so that they are instantly accessible from the operator panel.

Each button has an image assigned to it, and is labelled with the name of the image.

The navigator panel features three view selection buttons, the next image, the previous image and the image navigator.



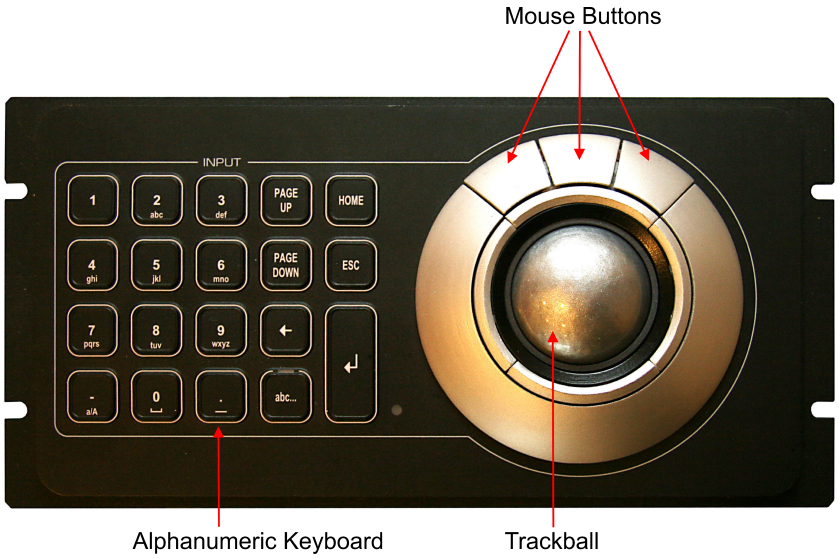
3.1.2.2 Input panel

3.1.2.2.1 Keypad group

The keypad group contains function, numeric, alphanumeric and cursor control buttons.

3.1.2.2.2 Trackball group

The trackball group has three mouse buttons and a trackball. The trackball is used to position the cursor on the colour monitor screen. The mouse buttons are used to select symbols, open and operate menus, and click buttons in the views and dialogue boxes, that are displayed on the screen. You can also click the buttons to popup shortcut menus. The button functions are identical to those of a three button mouse.



3.1.2.3 Alarm & command panel

3.1.2.3.1 Panel group

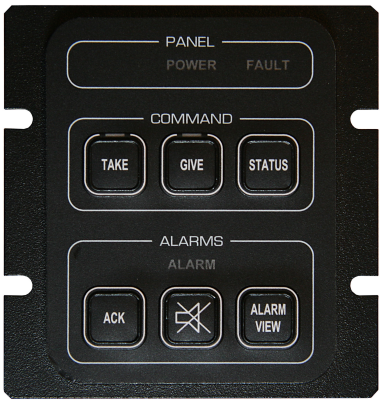
This group has power and fault status lamps are provided. The power lamp is lit green when power is ON. The fault lamp is lit red when a panel has lost communication with the host computer.

3.1.2.3.2 Command group

The command group has three buttons that you can use to transfer control of the process from one operator station to another. You can also view the command status.

3.1.2.3.3 Alarms group

The Alarms group has lamps and buttons that are used to indicate, acknowledge and handle alarms and events.



3.1.3 Alphanumeric keyboard

A standard alphanumeric keyboard is located in a compartment below the Operator Panel. You can press the F1 key on the keyboard to view context-sensitive help.

3.1.4 Images

A K-Chief 700 installation has various types of images which have different functionality, according to their function. An image contains menu, tool, and status bars.

A K-Chief 700 system has the following types of images:

- Process image
- List image
- Trend image
- Event list image
- System status image
- I/O system image
- PDF image

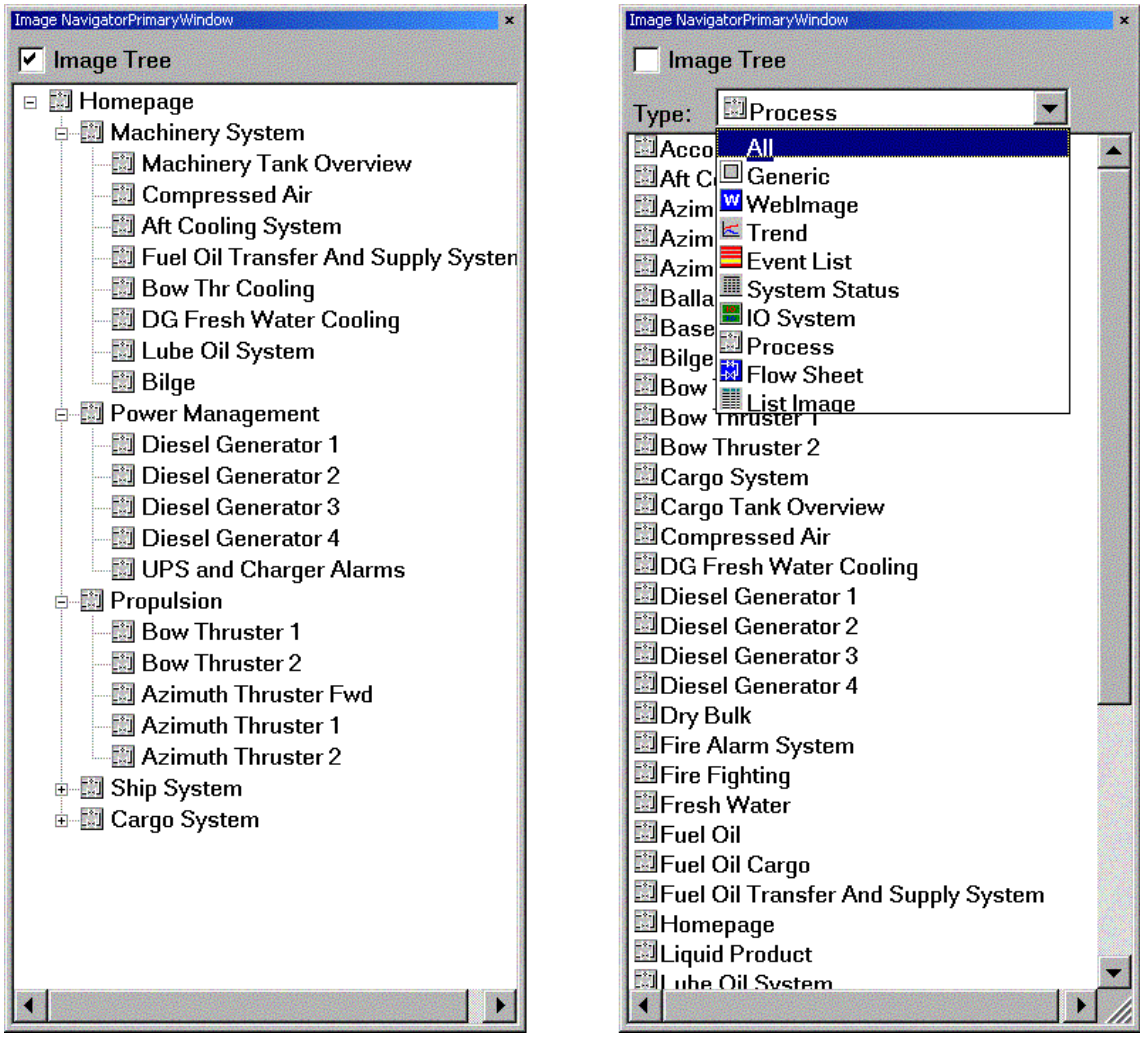
- Flow sheet image
- Multiple images.

These images are described in the sections that follow.

3.1.4.1 Image navigation

Image navigation is primarily done using the image navigator, which shows a list of the images. This list can also be viewed as a tree. You can configure the image navigator, and set up groups of any of the image types supported by the automation system. You can dock the image navigator to the side of the workspace screen. The image navigator is then available at all times, and does not hide any of the views.

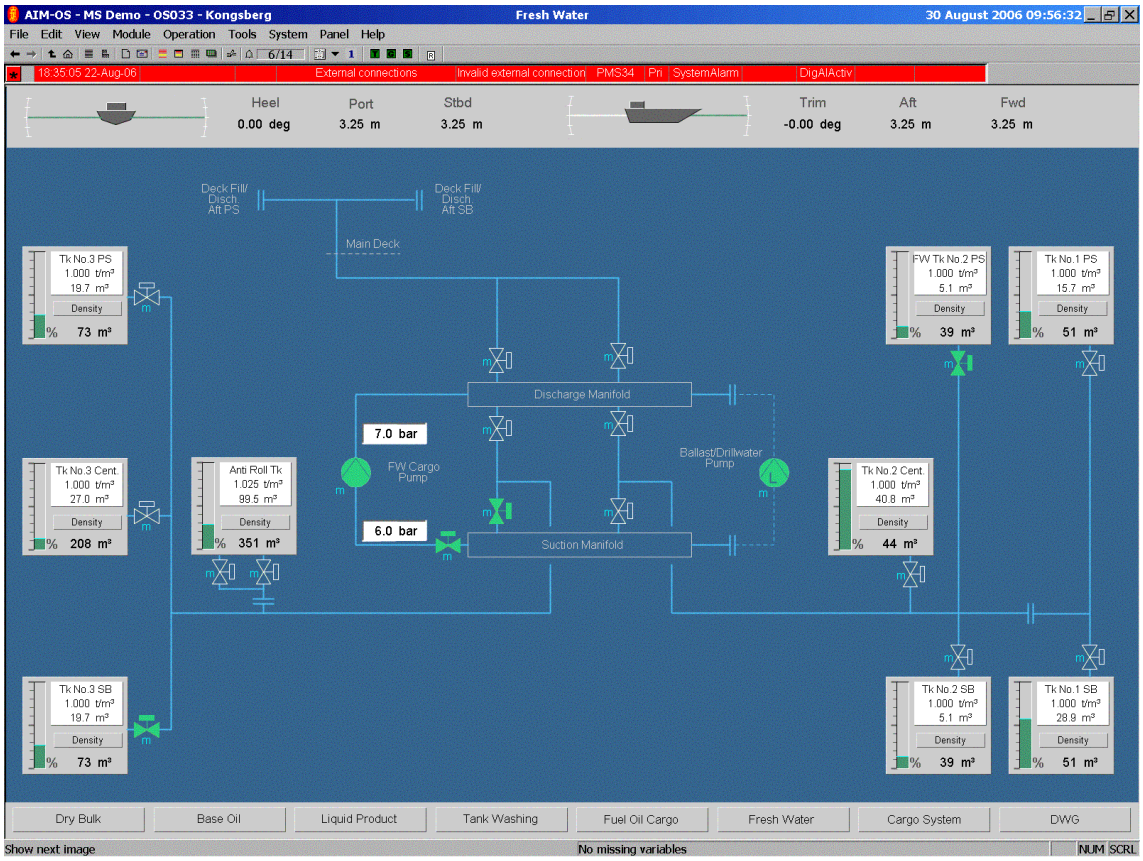
An example of the image navigator window is given in the figure that follows.



3.1.4.2 Process image

The process image gives enhanced graphical presentation of some part of a process. The parts of these images can be linked to one or several function modules.

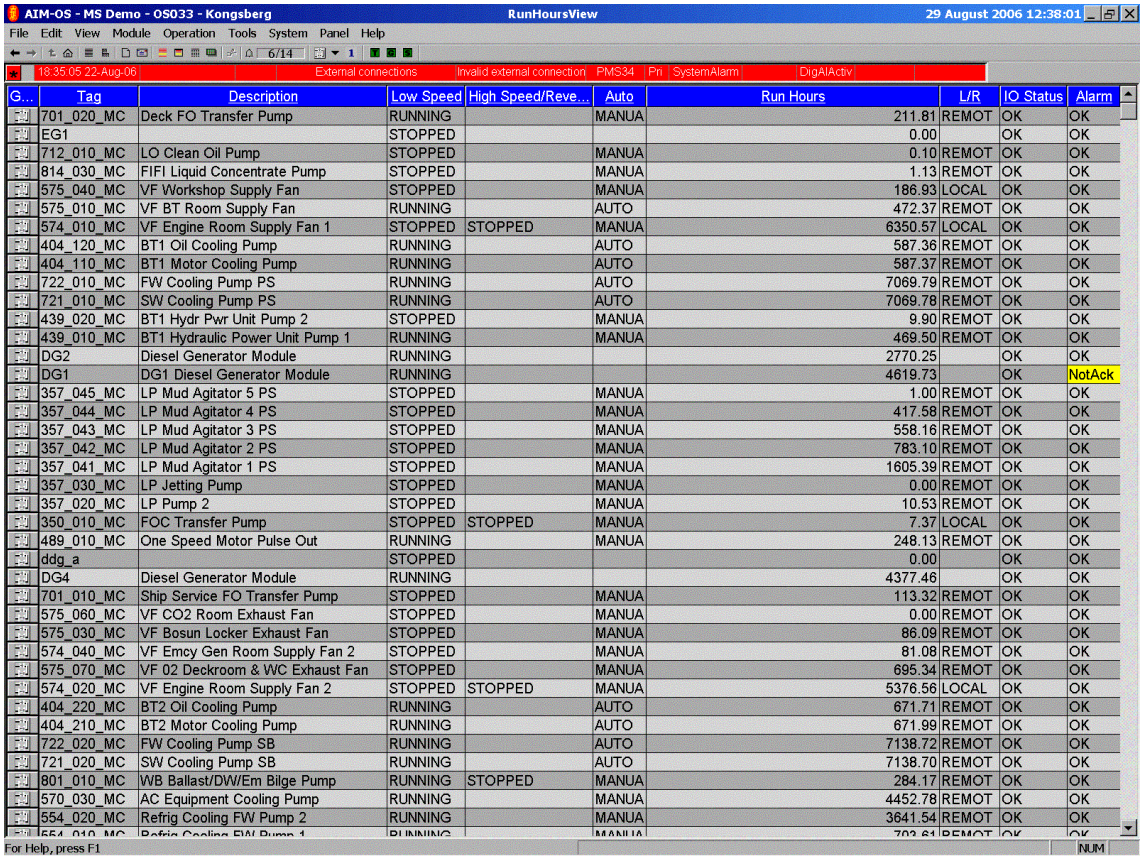
An example of a process image is shown in the following figure.



3.1.4.3 List image

The list image allows you to easily set up tabular views, that contain selected information from the function modules (tags) in the system.

The following figure shows an example of motor status and running hours.



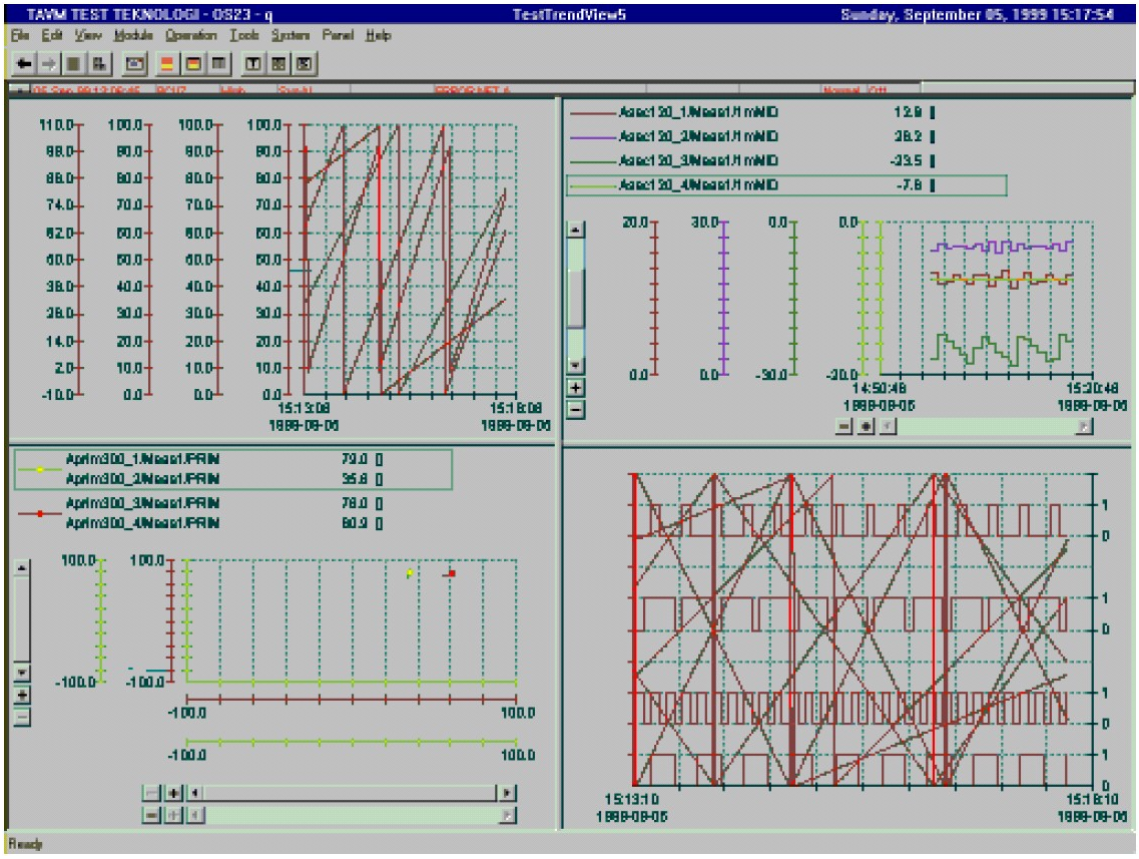
G...	Tag	Description	Low Speed	High Speed/Reve...	Auto	Run Hours	L/R	IO Status	Alarm
	701_020_MC	Deck FO Transfer Pump	RUNNING		MANUA	211.81	REMOT	OK	OK
	EG1		STOPPED			0.00		OK	OK
	712_010_MC	LO Clean Oil Pump	STOPPED		MANUA	0.10	REMOT	OK	OK
	814_030_MC	FIFI Liquid Concentrate Pump	STOPPED		MANUA	1.13	REMOT	OK	OK
	575_040_MC	VF Workshop Supply Fan	STOPPED		MANUA	186.93	LOCAL	OK	OK
	575_010_MC	VF BT Room Supply Fan	RUNNING		AUTO	472.37	REMOT	OK	OK
	574_010_MC	VF Engine Room Supply Fan 1	STOPPED	STOPPED	MANUA	6350.57	LOCAL	OK	OK
	404_120_MC	BT1 Oil Cooling Pump	RUNNING		AUTO	587.36	REMOT	OK	OK
	404_110_MC	BT1 Motor Cooling Pump	RUNNING		AUTO	587.37	REMOT	OK	OK
	722_010_MC	FW Cooling Pump PS	RUNNING		AUTO	7069.79	REMOT	OK	OK
	721_010_MC	SW Cooling Pump PS	RUNNING		AUTO	7069.78	REMOT	OK	OK
	439_020_MC	BT1 Hydr Pwr Unit Pump 2	STOPPED		MANUA	9.90	REMOT	OK	OK
	439_010_MC	BT1 Hydraulic Power Unit Pump 1	RUNNING		MANUA	469.50	REMOT	OK	OK
	DG2	Diesel Generator Module	RUNNING			2770.25		OK	OK
	DG1	DG1 Diesel Generator Module	RUNNING			4619.73		OK	NotAck
	357_045_MC	LP Mud Agitator 5 PS	STOPPED		MANUA	1.00	REMOT	OK	OK
	357_044_MC	LP Mud Agitator 4 PS	STOPPED		MANUA	417.58	REMOT	OK	OK
	357_043_MC	LP Mud Agitator 3 PS	STOPPED		MANUA	558.16	REMOT	OK	OK
	357_042_MC	LP Mud Agitator 2 PS	STOPPED		MANUA	783.10	REMOT	OK	OK
	357_041_MC	LP Mud Agitator 1 PS	STOPPED		MANUA	1605.39	REMOT	OK	OK
	357_030_MC	LP Jetting Pump	STOPPED		MANUA	0.00	REMOT	OK	OK
	357_020_MC	LP Pump 2	STOPPED		MANUA	10.53	REMOT	OK	OK
	350_010_MC	FOC Transfer Pump	STOPPED	STOPPED	MANUA	7.37	LOCAL	OK	OK
	489_010_MC	One Speed Motor Pulse Out	RUNNING		MANUA	248.13	REMOT	OK	OK
	ddg_a		STOPPED			0.00		OK	OK
	DG4	Diesel Generator Module	RUNNING			4377.46		OK	OK
	701_010_MC	Ship Service FO Transfer Pump	STOPPED		MANUA	113.32	REMOT	OK	OK
	575_060_MC	VF CO2 Room Exhaust Fan	STOPPED		MANUA	0.00	REMOT	OK	OK
	575_030_MC	VF Bosun Locker Exhaust Fan	STOPPED		MANUA	86.09	REMOT	OK	OK
	574_040_MC	VF Emcy Gen Room Supply Fan 2	STOPPED		MANUA	81.08	REMOT	OK	OK
	575_070_MC	VF 02 Deckroom & WC Exhaust Fan	STOPPED		MANUA	695.34	REMOT	OK	OK
	574_020_MC	VF Engine Room Supply Fan 2	STOPPED	STOPPED	MANUA	5376.56	LOCAL	OK	OK
	404_220_MC	BT2 Oil Cooling Pump	RUNNING		AUTO	671.71	REMOT	OK	OK
	404_210_MC	BT2 Motor Cooling Pump	RUNNING		AUTO	671.99	REMOT	OK	OK
	722_020_MC	FW Cooling Pump SB	RUNNING		AUTO	7138.72	REMOT	OK	OK
	721_020_MC	SW Cooling Pump SB	RUNNING		AUTO	7138.70	REMOT	OK	OK
	801_010_MC	WB Ballast/DW/Em Bilge Pump	RUNNING	STOPPED	MANUA	284.17	REMOT	OK	OK
	570_030_MC	AC Equipment Cooling Pump	RUNNING		MANUA	4452.78	REMOT	OK	OK
	554_020_MC	Refrig Cooling FW Pump 2	RUNNING		MANUA	3641.54	REMOT	OK	OK

The values can also be displayed as a bar graph.

3.1.4.4 Trend image

The trend image fills the main view area. It may contain several trends, which may be a mixture of X-Y trends and time trends. Each trend may in turn contain several trend plots, or curves.

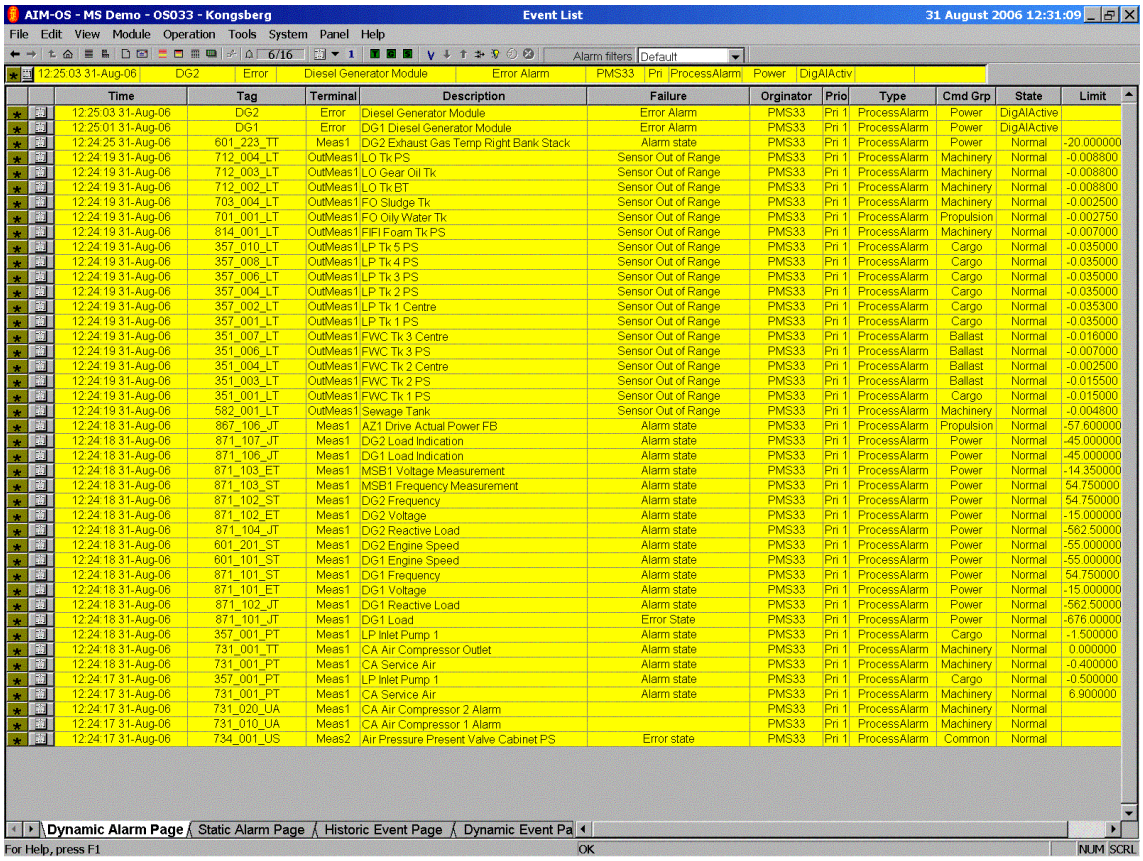
An example of a trend image containing four trends is shown in the following figure.



3.1.4.5 Event list image

An event notifies you of a condition in the system or the process, that needs your attention. The event that is notified, depends on the list that is displayed, and the filter that is applied.

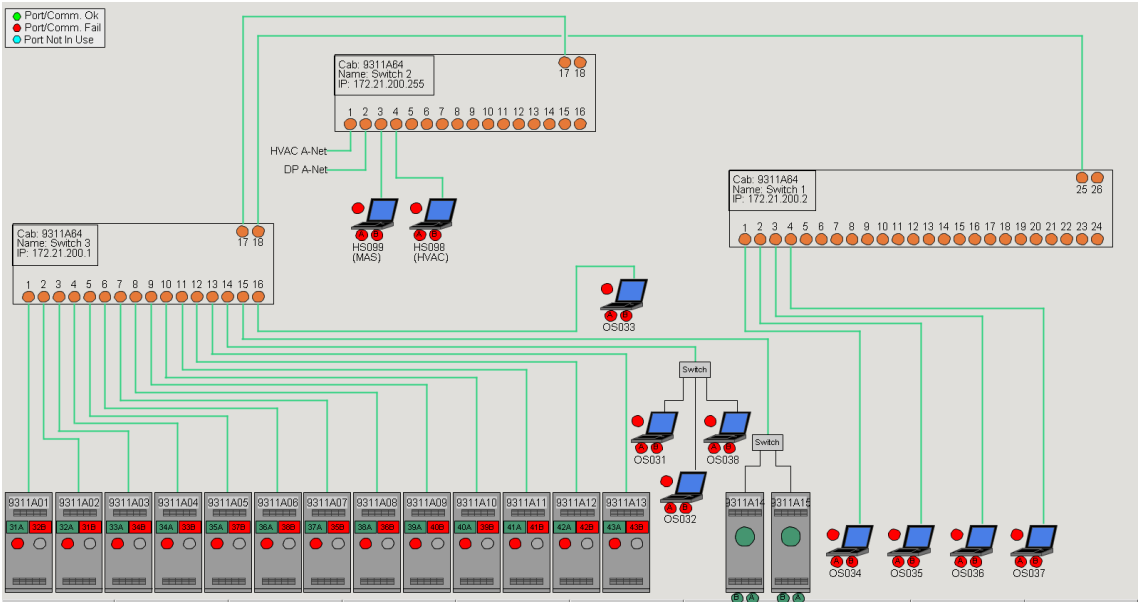
An example of an event image is shown in the following figure.



3.1.4.6 System status image

The system status images show operational status information about the field stations, the history stations and the operator stations. They also show information about communication with other equipment connected to the communication network, and equipment that is connected through serial lines.

An example of a system status image is shown in the following figure.

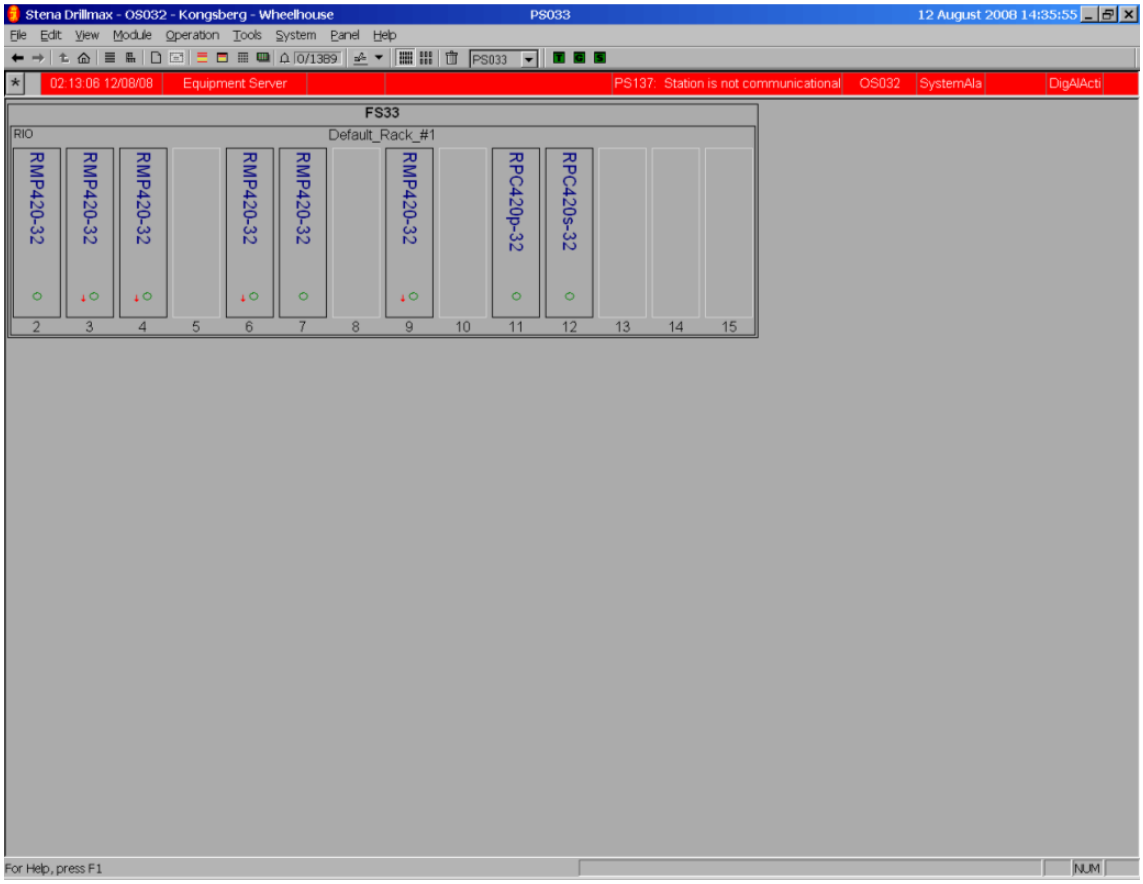


3.1.4.7 I/O system image

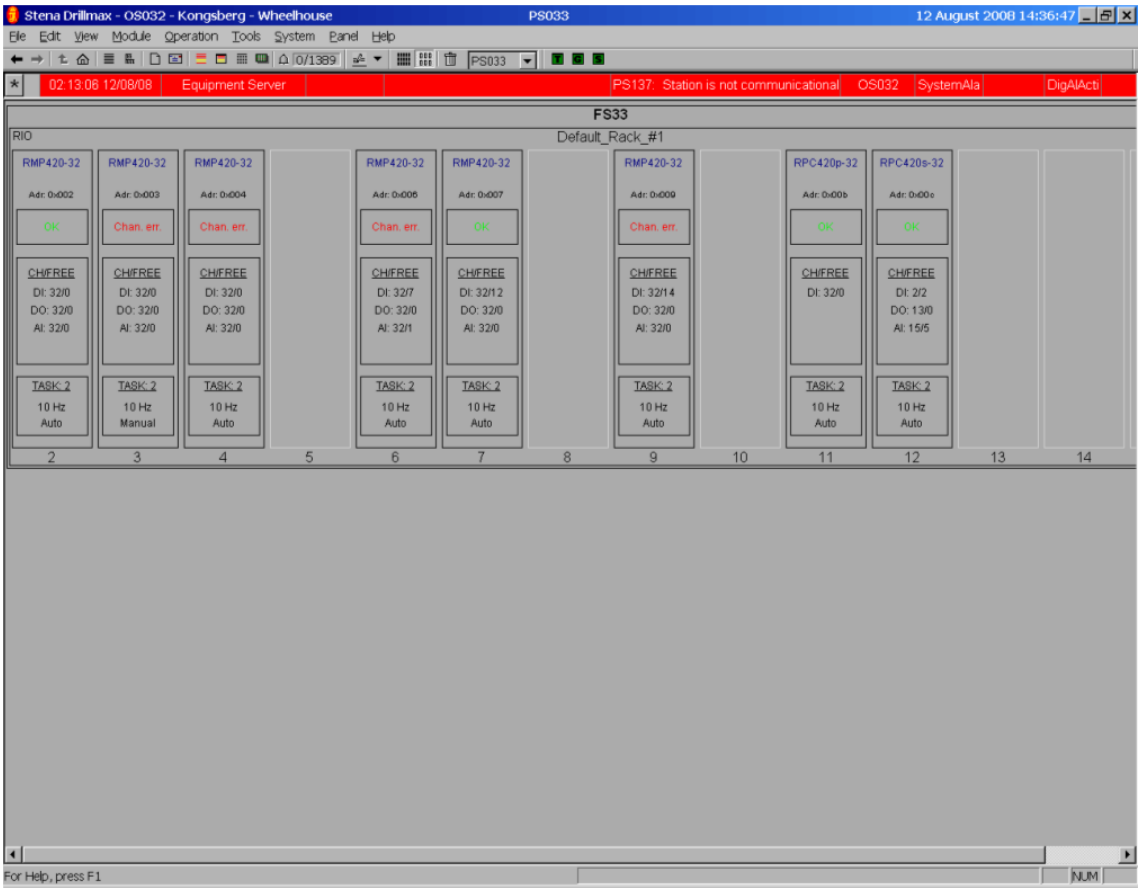
During normal operation, two different levels of information, the overview and the detailed levels, are given in the PBUS I/O image.

To show the RIO modules with different levels of information, you can toggle between the overview and the detailed views. When the overview level is selected, the RIO modules are shown.

An example of the overview level image is shown in the following figure.

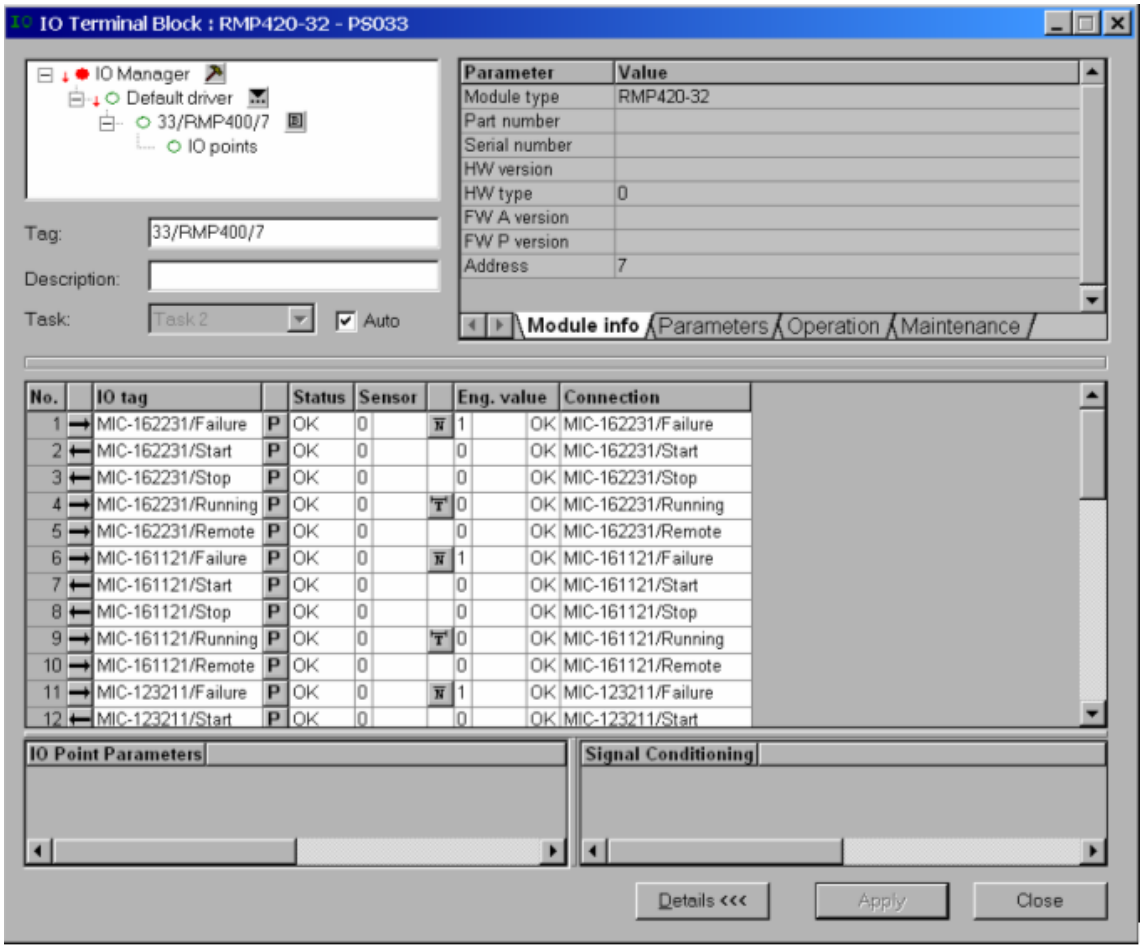


When the detailed level is selected, the status for all RIO modules is shown. An example of the detailed level is shown in the following figure.



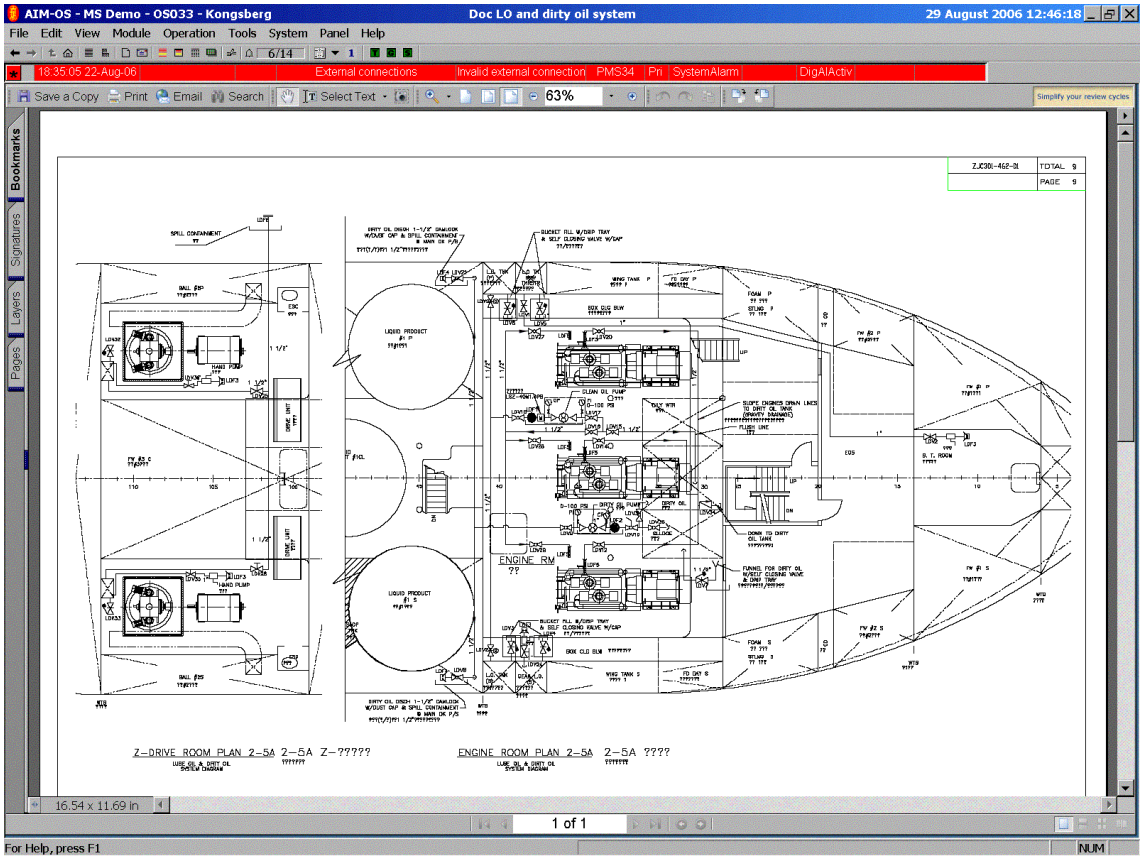
When you select the I/O terminal block view, the status for all I/O channels is shown.

An example of the I/O terminal block view is shown in the following figure.



3.1.4.8 PDF image

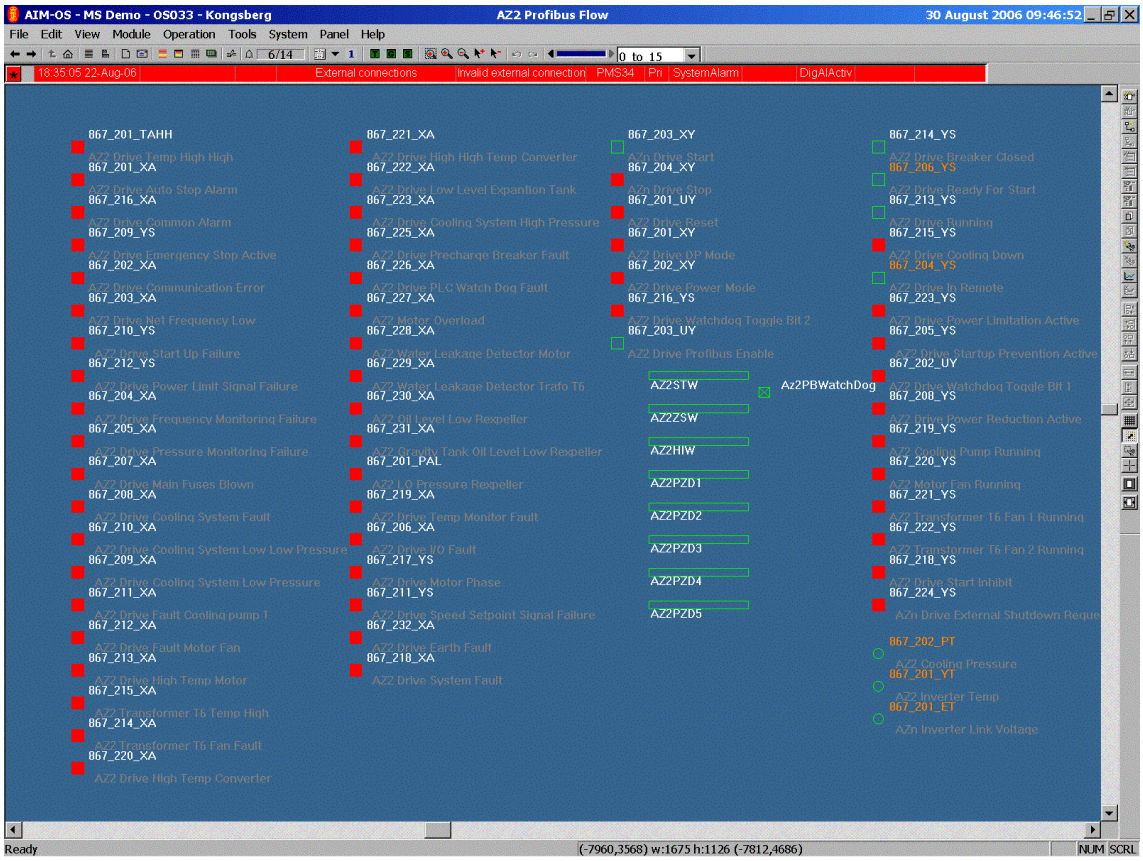
An example of a PDF image shown in the AIM workspace is shown in the following figure. The Portable Distilled Format (PDF) is a proprietary Adobe file format that enables cross-platform display of documents. In AIM, the Adobe viewer is integrated with the PDF image application.



3.1.4.9 Flow sheet image

A flow sheet image is used for advanced technical maintenance and online system configuration.

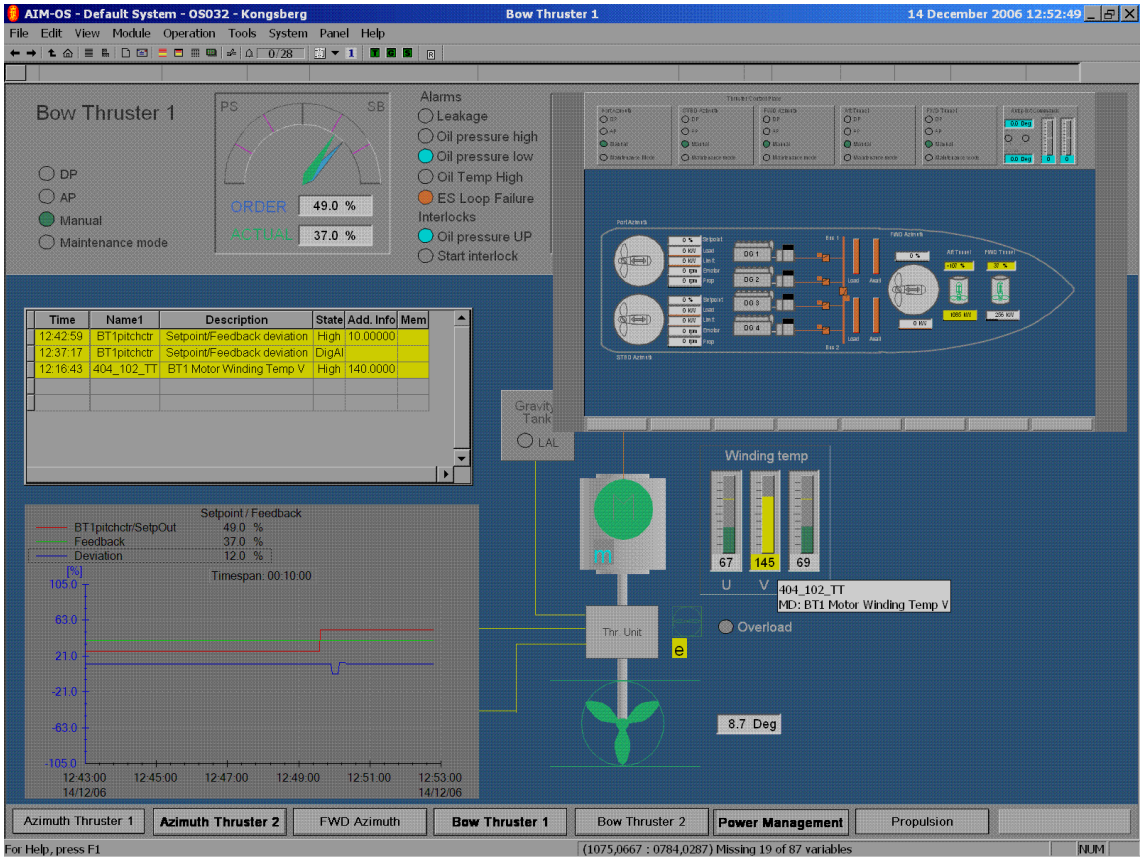
An example of a flow sheet image is shown in the following figure.



3.1.4.10 Multiple images

Multiple images are useful to keep many image views open within the same window. For example, you can view all the propulsion units for the vessel in one window, and have a detailed image for the bow thruster in another. You can also view a third image, such as the events image for the bow thruster. This can give you a complete view of the overall state of the propulsion units, and detailed information for those parts of the propulsion system you require. All these images are displayed in the same window, so you do not have to open other windows or tab between images.

An example of multiple images is shown in the following figure.

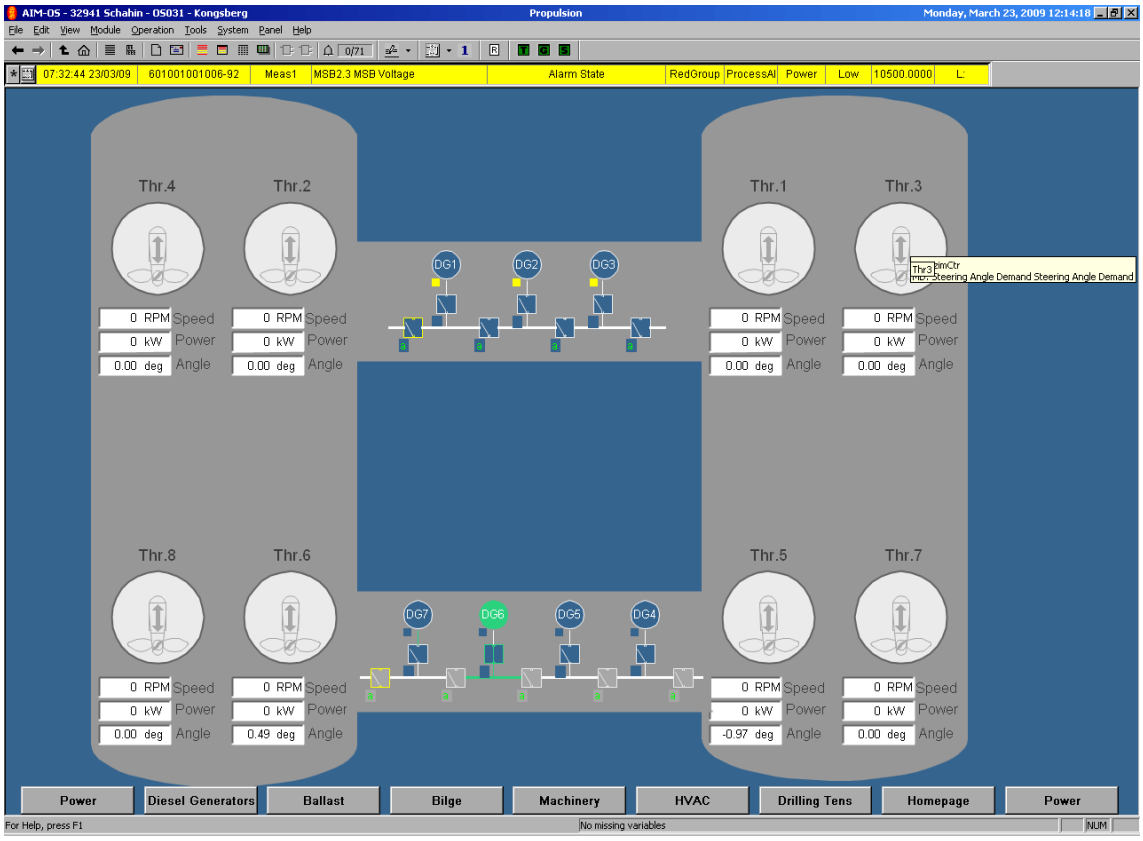


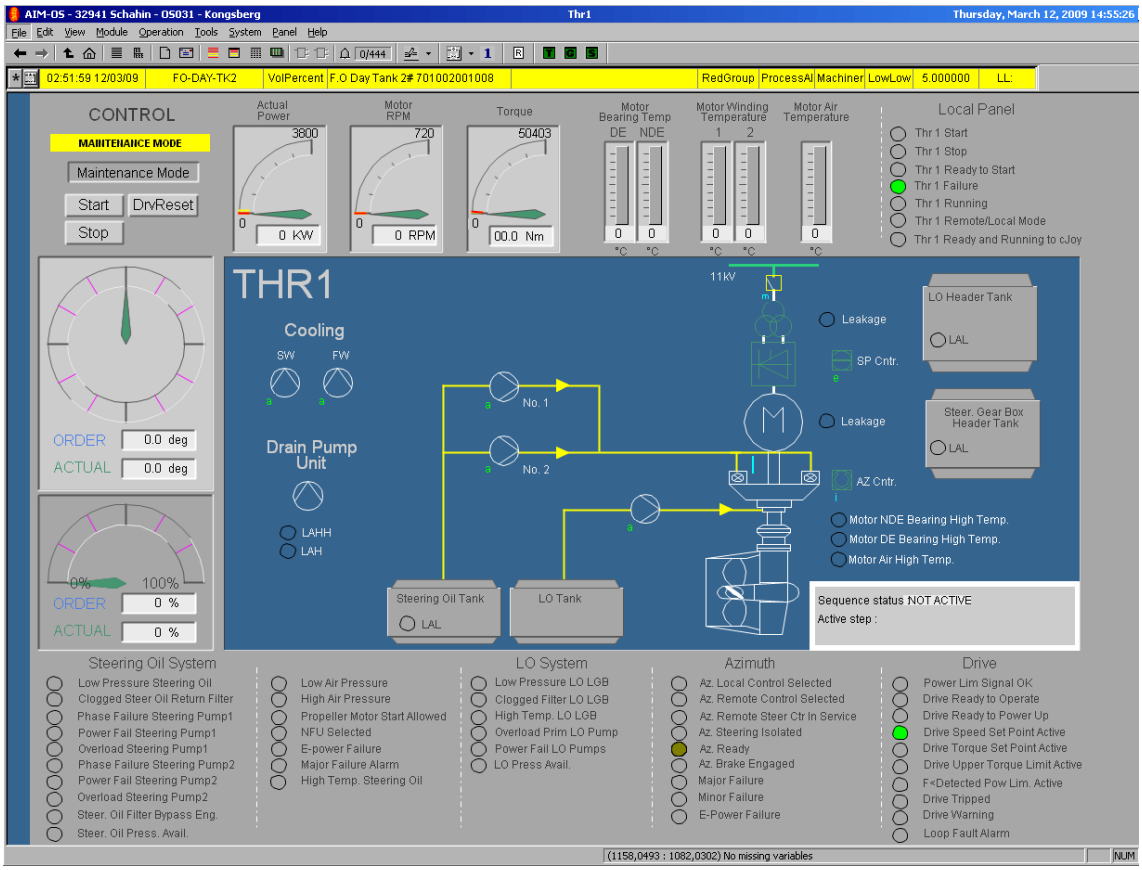
3.1.5 Process display and control

The number of images depends on the amount of equipment that K-Chief 700 controls. The various images are designed to give different levels of detail about a process.

When an image showing an overall process is selected, such as the power management image, there may not be enough space to display all the detail on a single screen. The K-Chief 700 system has a number of images linked to the main image, to show detailed information.

The following images show a screen example of a vessel's propulsion system, and a screen showing details of one thruster.





Two levels of images are normally used, more can be added if required.

3.2 Events

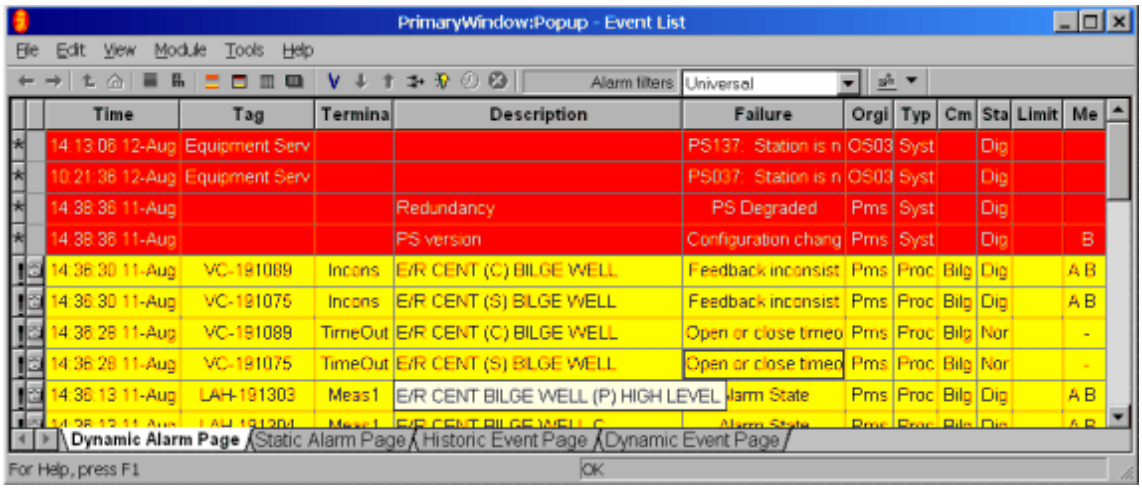
The event utility handles reporting, presentation and storage of events in the automation system.

The event utility provides the following:

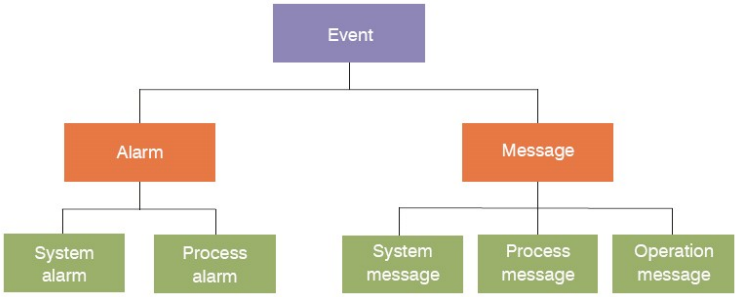
- Presentation of events
- Event list views
- Last alarm line
- Alarm indications in process views
- Alarm and message printing
- Audible alarm
- Alarm acknowledgement
- Alarm suppression
- Event filtering.

An event shows a change in the way a part of the process, or the system, functions. Events can also provide information on the history of events over a specified period of time, for example, during a shift.

All events are time stamped and logged as they occur.



Events are divided into two categories, shown in the figure that follows.



An alarm is generated when a change of state occurs in the process, that is outside the predefined limits.

A message is generated when a change of state occurs in the process, that is within the predefined limits.

Alarms are of the following types:

- Process alarms that indicate undesirable (illegal) process conditions.
- System alarms that indicate system failure conditions.

Messages are of the following types:

- Process messages that indicate the occurrence of process changes that are subject to logging.
- Operator messages that indicate user actions.
- System messages that:
  - Give additional information about system alarms.
  - Indicate a state change, as a result of user actions.
  - Indicate other events that are logged, but are not related to the process, or user actions.

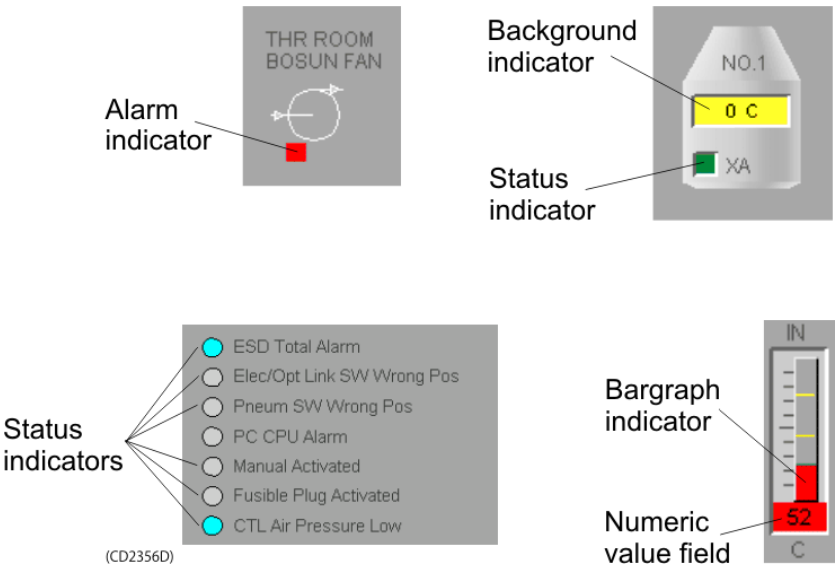
You can use the buttons to view an event list as a popup. This allows you to open a new child view without closing the parent view.

All alarms can be made audible, and the alarms/events are printed using dedicated printers. If the system has a network printer, all event views can be printed out on the network printer. All alarms and events are recorded and stored. The event system handles the notification of system and process alarms, and messages.

Various filters are also available. Different attributes can be applied to a filter in order to view alarms/events based on conditions that you choose.

The last alarm line is continuously updated to display the event record for the most recent, unacknowledged, alarm. It displays the same record cells as shown by the event list view and event list popup.

Alarms can be displayed in a view in various ways, as shown in the following figure.



3.3 Trend views

Trend views are used for displaying trends to the operator. Split windows are used to create and present one or many trends, as separate panes in a trend image. A trend may contain one or many trend curves.

The AIM trend views have functions for controlling how trends are created and displayed.

A trend is a display of one or more trend curves in scaled axes, such as X and Y. You can configure the display of the trend and its contents, and operate on the displayed trend by using the trend context menu. The trend context menu applies to the trend from which it was invoked. This is significant when two or more trends are displayed simultaneously.

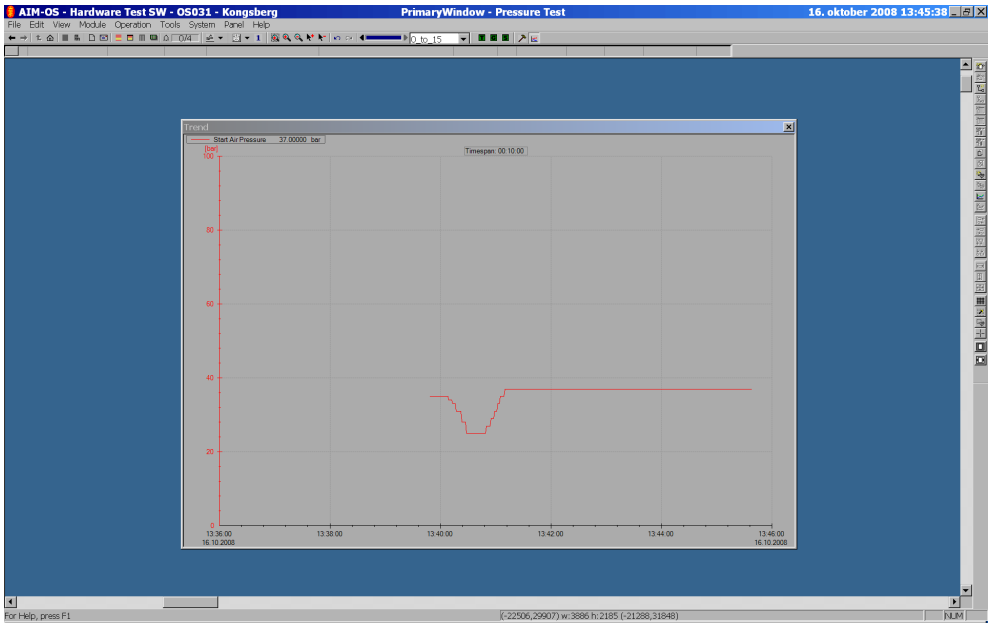
For an example of a trend image window, see *Trend image* on page 25.

3.3.1 Trend presentations

There are two types of trend presentations:

- The trend image, which is displayed in the main view area, and may contain several trends in separate panes. See *Trend image* on page 25. You can add, split, or merge trend panes.

- The trend popup, which contains a single trend in a resizeable popup window. The popup is displayed irrespective of the view selected, and can be positioned anywhere within the main view area. See the following figure.

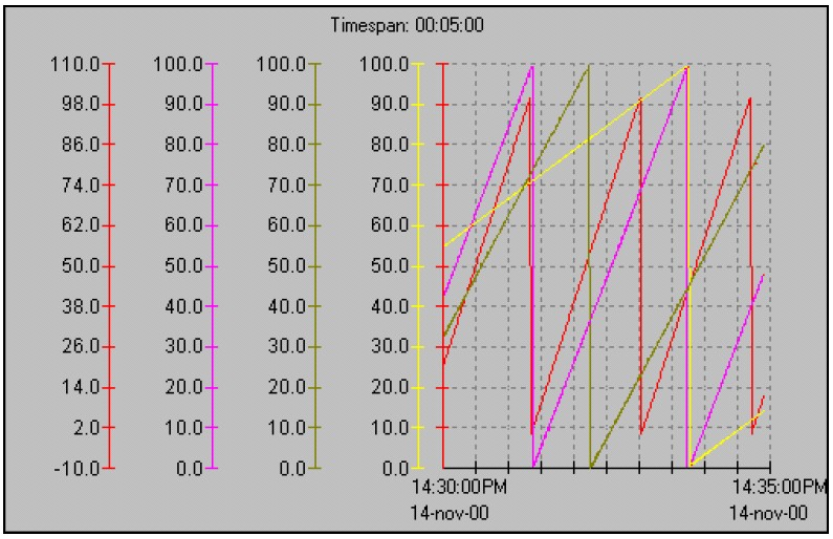


Both trend presentations have a context menu, that you can use to control their appearance.

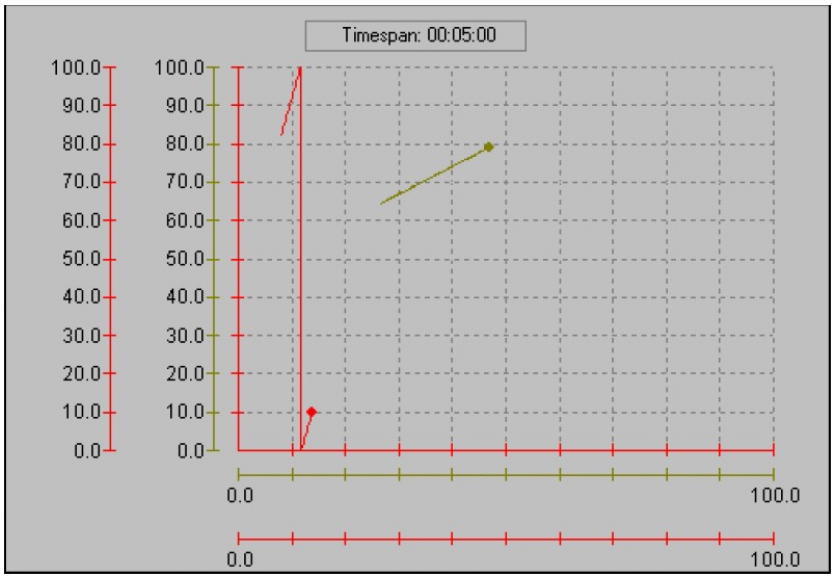
3.3.2 Trend types

There are two types of trends:

- The time trend, which shows the development of single process values over a given time period.

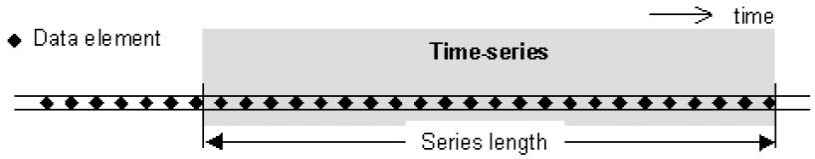


- The X-Y trend, which shows the correlation between two process values in a time trend.



3.4 Time series

A time-series is a log of time-stamped values. It extracts data from a single variable as the input, performs a mathematical transformation, and stores the resulting values, according to the selected time-series attributes.



Data stored in time-series is used as input for trends and reports.

3.5 Reports

The report system is used to design and generate reports. It provides report management, including report scheduling, storage, printing, and email.

Information from any ODBC compatible data source can be presented in the AIM reports

The main purpose of the report system is to generate reports. The data is:

- Fetched from the control system through ODBC
- Presented in a suitable layout.

The report system displays process variable values from a PS, historical time-series data from a history station (HS), and data from the historical event database.

The report formats define the layout of the report; the data that is to be presented in the report and the time span for time-series data.

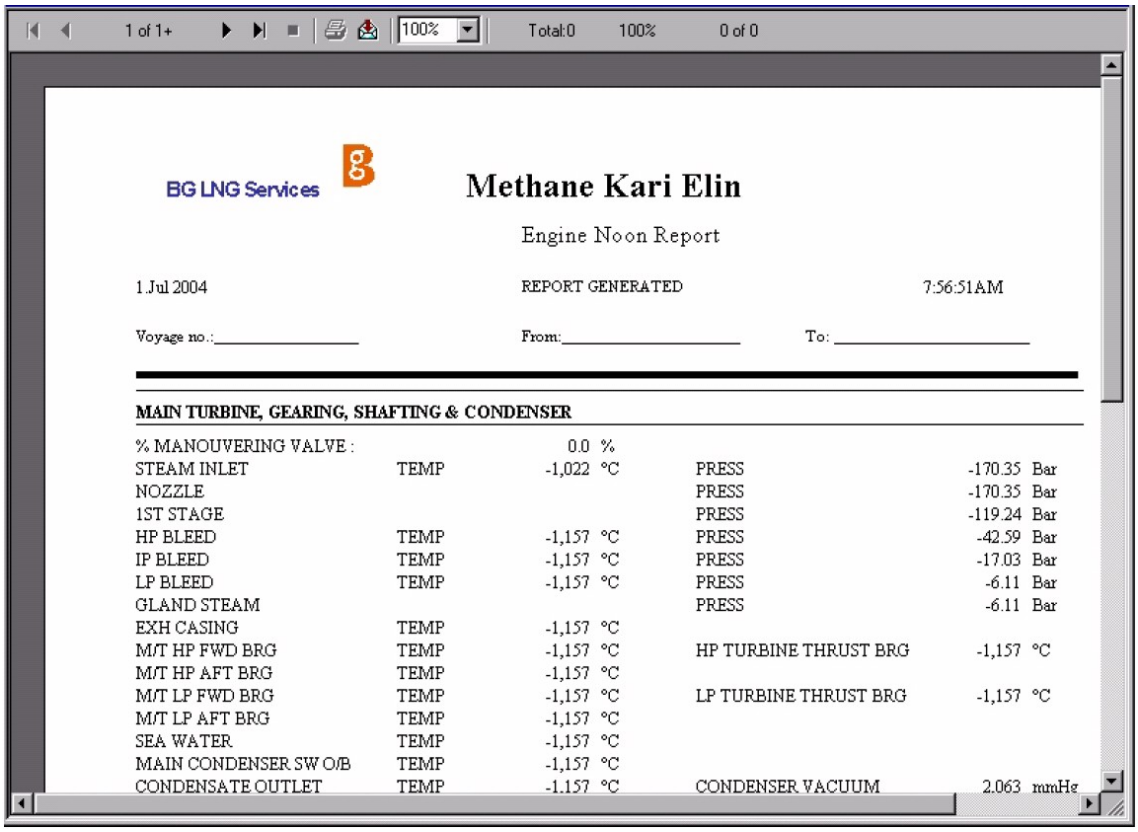
You can use the report manger to generate, schedule, and view reports in predefined formats.

3.5.1 Reports

The Report system is not bundled with the Integrated Control System, but the operator station includes the necessary run time files to produce the reports.

The Report system has the following features:

- It generates dynamic and historical reports.
- The reports can be viewed, printed, or stored as a file such as an Excel spreadsheet.
- The reports can be generated periodically (watch report, day report etc.), or on user request.
- The reports may be transferred or emailed to other computer systems.
- It includes a set of predefined reports (report templates).
- AIM has built-in reports that list modules with abnormal conditions, e.g. alarm suppression, inhibit, or override.



BG LNG Services

Methane Kari Elin

Engine Noon Report

1 Jul 2004 REPORT GENERATED 7:56:51AM

Voyage no.:_____ From:_____ To: _____

MAIN TURBINE, GEARING, SHAFTING & CONDENSER

% MANOUVERING VALVE :		0.0	%			
STEAM INLET	TEMP	-1,022	°C	PRESS	-170.35	Bar
NOZZLE				PRESS	-170.35	Bar
1ST STAGE				PRESS	-119.24	Bar
HP BLEED	TEMP	-1,157	°C	PRESS	-42.59	Bar
IP BLEED	TEMP	-1,157	°C	PRESS	-17.03	Bar
LP BLEED	TEMP	-1,157	°C	PRESS	-6.11	Bar
GLAND STEAM				PRESS	-6.11	Bar
EXH CASING	TEMP	-1,157	°C			
M/T HP FWD BRG	TEMP	-1,157	°C	HP TURBINE THRUST BRG	-1,157	°C
M/T HP AFT BRG	TEMP	-1,157	°C			
M/T LP FWD BRG	TEMP	-1,157	°C	LP TURBINE THRUST BRG	-1,157	°C
M/T LP AFT BRG	TEMP	-1,157	°C			
SEA WATER	TEMP	-1,157	°C			
MAIN CONDENSER SW O/B	TEMP	-1,157	°C			
CONDENSATE OUTLET	TEMP	-1,157	°C	CONDENSER VACUUM	2.063	mmHg

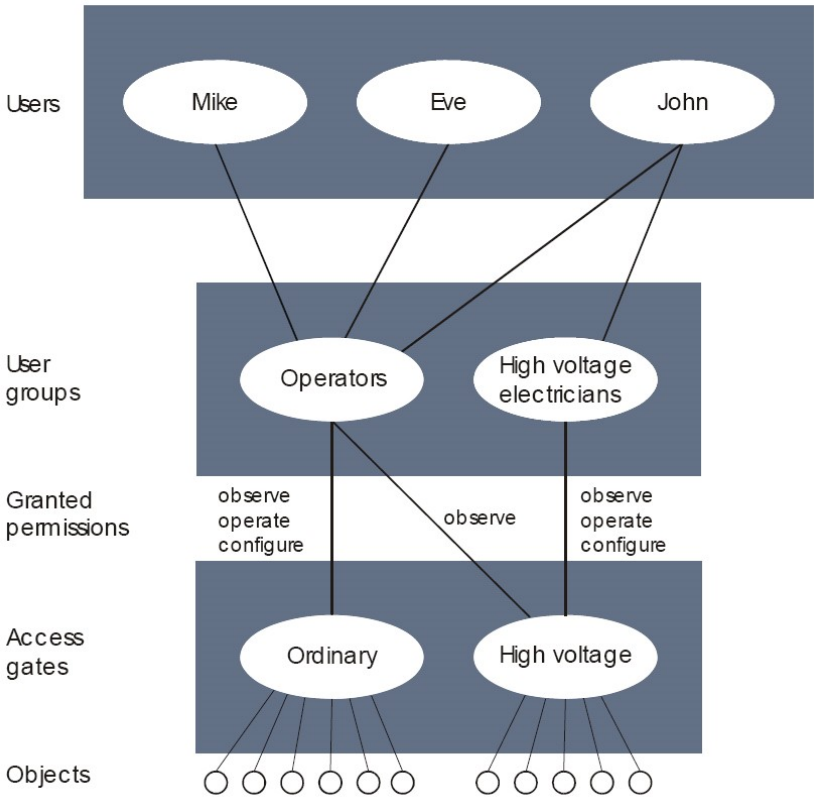
3.6 System control functions

3.6.1 Access control

You use the access control to restrict access to the system. The access control consists of a list of users with unique passwords. These users are associated with various user groups. Each user group has specific access rights, and they can be associated with access gates, which can control access to specified areas. The access control system limits the number of functions that are available to the user from the OS.

Restrictions on the modules that can be operated are handled by the command control system.

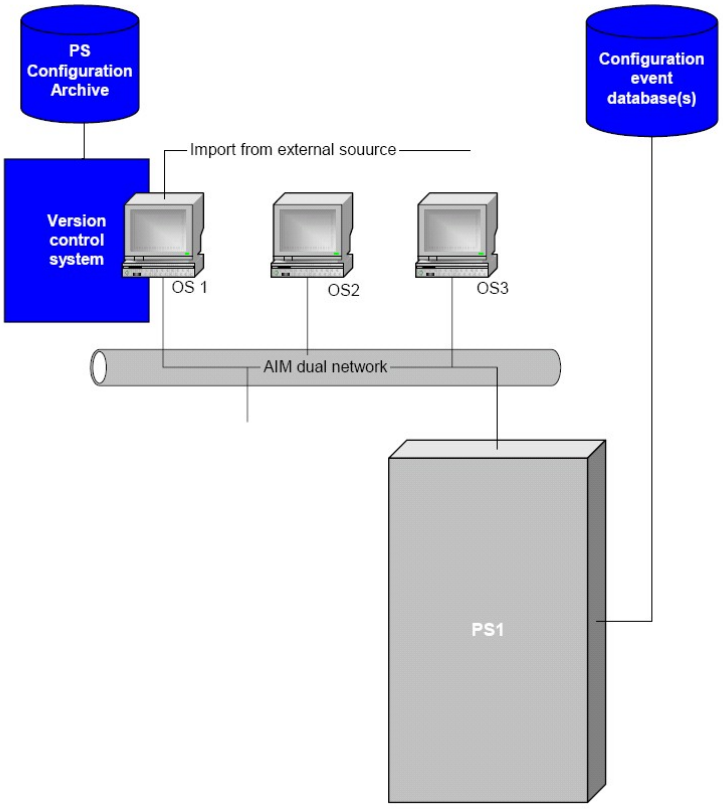
All operators use the access system as they log on and off the Integrated Control System system. All configuration tasks, such as adding, editing or deleting user accounts and user groups are the responsibility of the system administrator.



3.6.2 Version control

The Version control system logs all changes made to all the modules/tags of the process station configuration. All backups of the PS configuration changes are stored in an archive, allowing you to restore files from any of the backups.

The following figure shows the version control system and its environment.



The PS configuration archive contains all previous backups of the PS configuration files. The PS servers, which are housed in the OS, contain only the most recent backup of the PS configuration files.

The PS contains information on the configuration changes. These events are also copied to the configuration event database as they occur, and they can be viewed by the user.

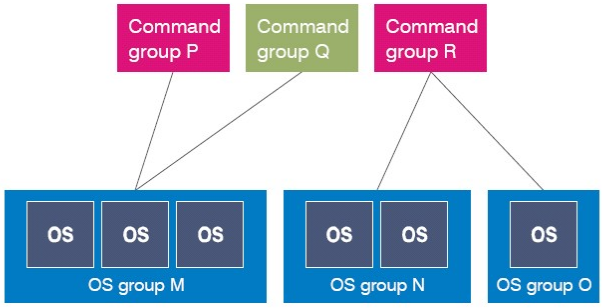
The import function lets you import PS configuration files from external sources.

3.6.3 Command control

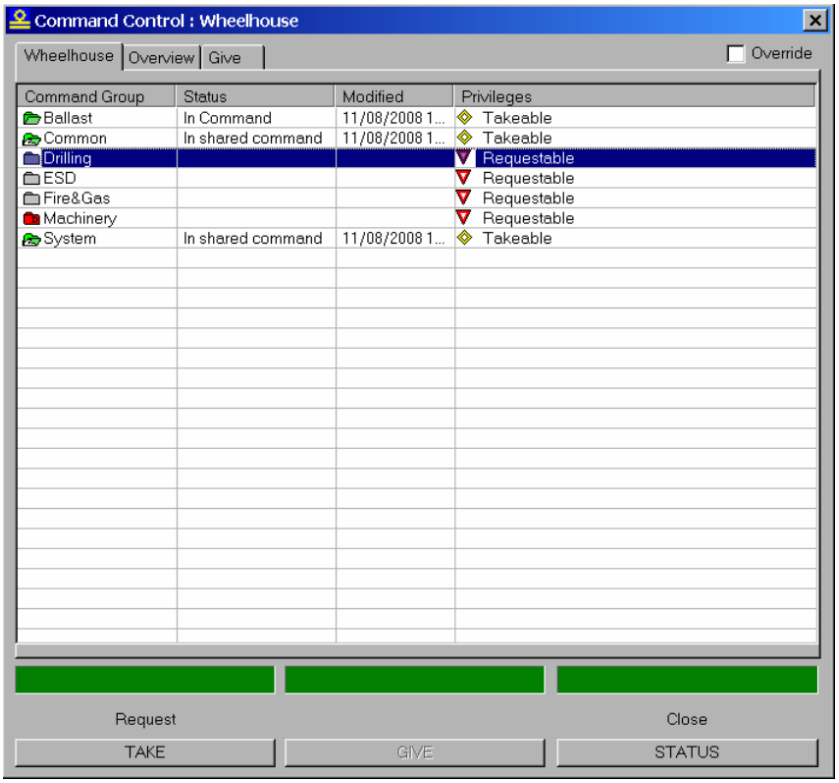
The process sectioning and transfer of control functions is done by the command control system. A software module, representing an instrument, equipment, logic etc., is assigned to a command control group representing the process section. The command control group is given a descriptive name identifying the process section. The command control system provides mechanisms to manage and distribute responsibility between operator stations on a plant.

If concurrent operations are not allowed, the command control ensures that concurrent operations are not carried out. Using command control assumes that the following are defined clearly:

- The fields of responsibility (the command groups)
- The actors (OS groups) that can claim, or be given the responsibility over the command groups.



Every OS is assigned to an OS group. Every OS group is assigned privileges regarding the different command control groups. These privileges control the right of each OS group to take and maintain control of the different command control groups. Operator Stations belonging to two different OS groups cannot hold the same command control group, unless this group is defined as shared.



Transfer of control functions is by means of give and take functions incorporated in the OS. The right to take control can be limited to certain OS groups. Groups that are not permitted to take control, can own the right to request control.

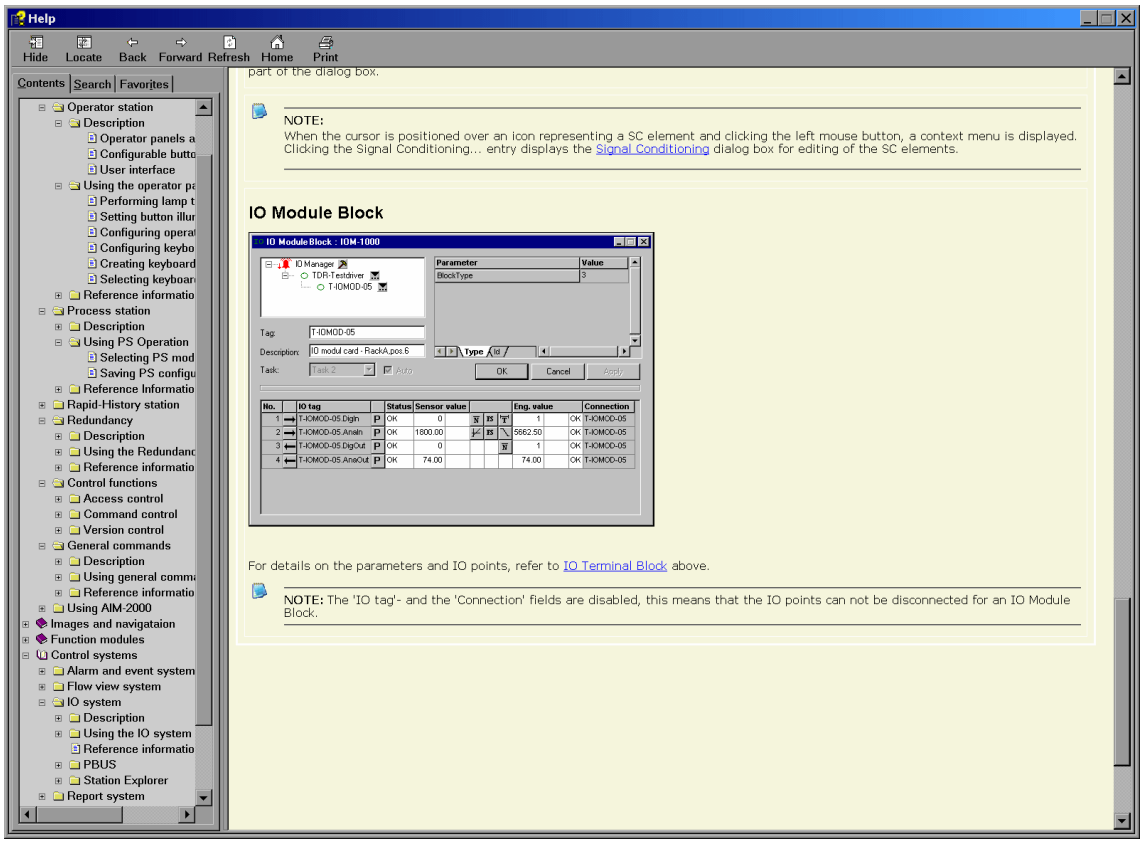
3.7 Online user guide

The online user guide is a complete reference for personnel involved in the operation and configuration of the AIM system. The online user guide provides several ways to locate the information you are looking for, such as a table of contents, text search with advanced features, and favourites.

The online user guide has the following advantages:

- Quick access. The online user guide is always available when the control system is in operation
- Search capabilities. You can directly search for a particular piece of information
- Quick cross references, such as references to related topics, for example
- Easy to use, with a familiar user interface.

The following view is an example from the online user guide showing the help function for an I/O module block.



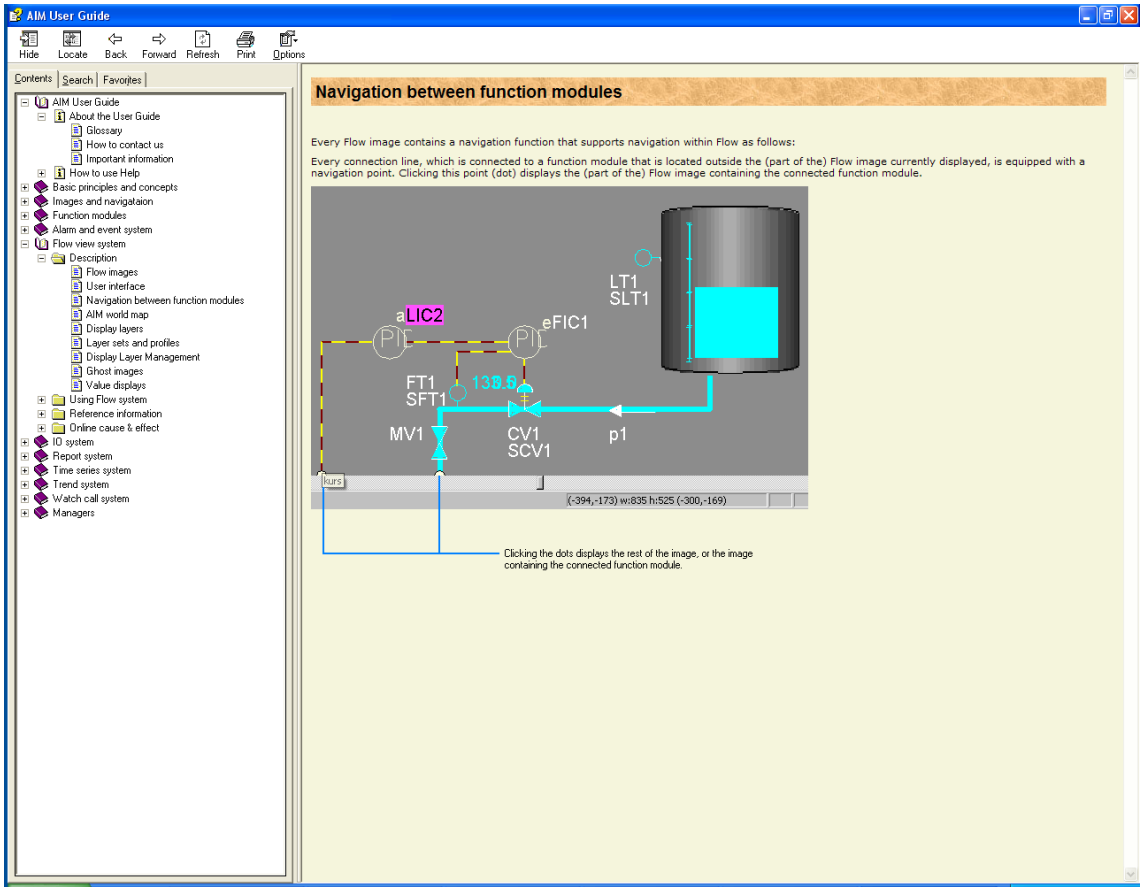
3.8 Context-sensitive help

You can use the context-sensitive help to view the help pages for any control within the AIM user interface. Click the control you require help on, and press the F1 button to open the help file for that control.

The Context-Sensitve help has the following advantages:

- Quick access. You can find the exact information you require.
- User friendly interface. The help system uses the familiar windows help interface.

The following image is an example from the Context-Sensitve help, which displays help on navigation between function modules.

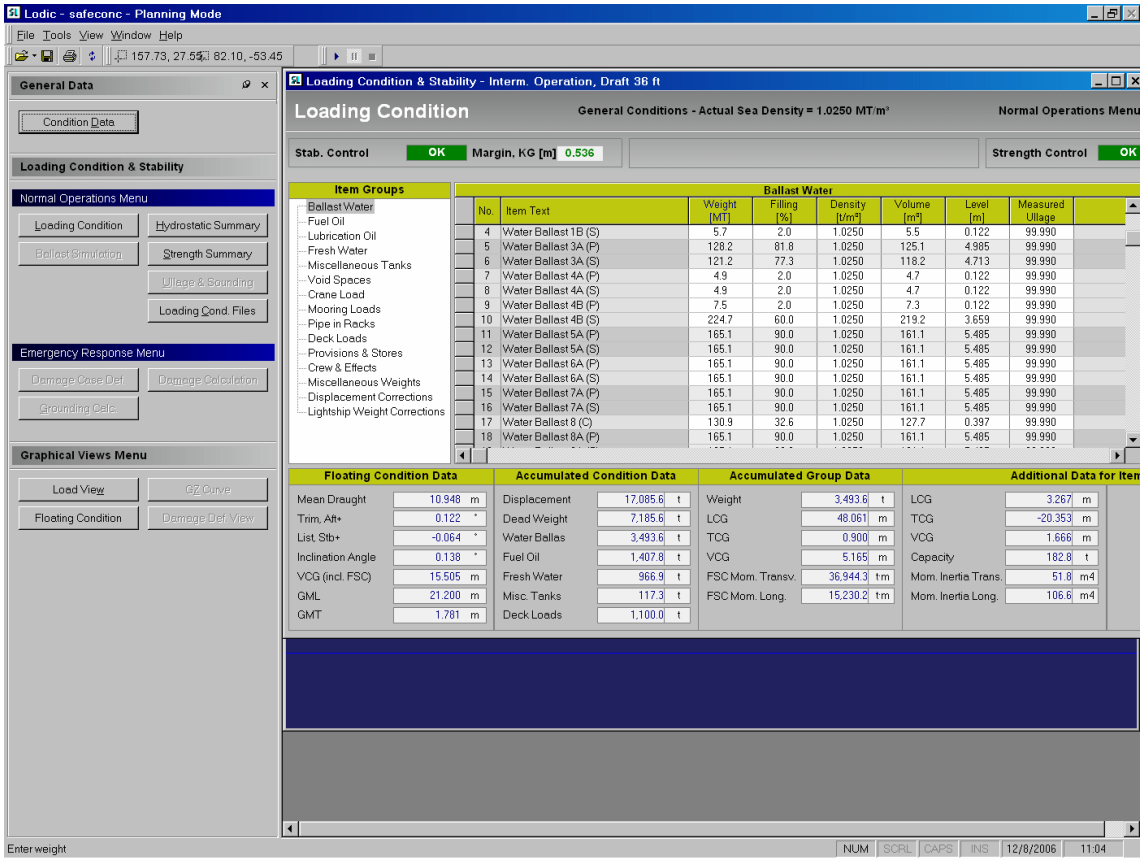


3.9 Integration of 3rd party applications

A standalone application that runs on a PC, can usually run within the K-Chief 700 environment, and the user interface can be displayed on the operator stations. For example, a load & stability program can either be run locally on an operator station and be displayed by K-Chief 700, or run on an external computer, and communicate with the automation system through the administrative network, or over serial lines. However,

there are exceptions, as some applications cannot be run from within K-Chief 700. In this case, the application can be run as a standalone application in the Microsoft Windows™ Operating System.

An example of a load and stability calculator view is shown in the figure that follows.



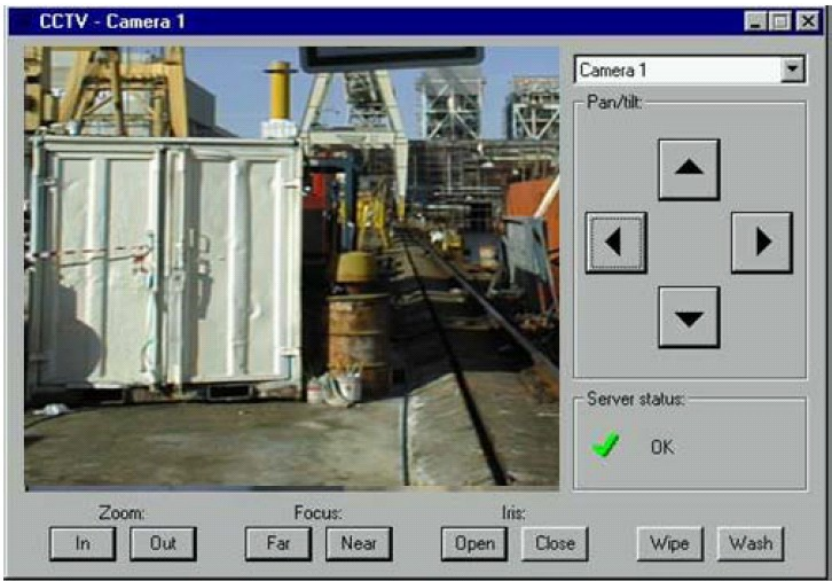
3.9.1 Integrated CCTV

Any Closed Circuit Television (CCTV) solution that provides its own Windows application, ActiveX control components, or any external video sources using a free-floating window, can be integrated in the system. The view can show live video, which can be displayed:

- On command from the operator
- On demand from a procedure
- When an alarm occurs in the area where the camera is located.

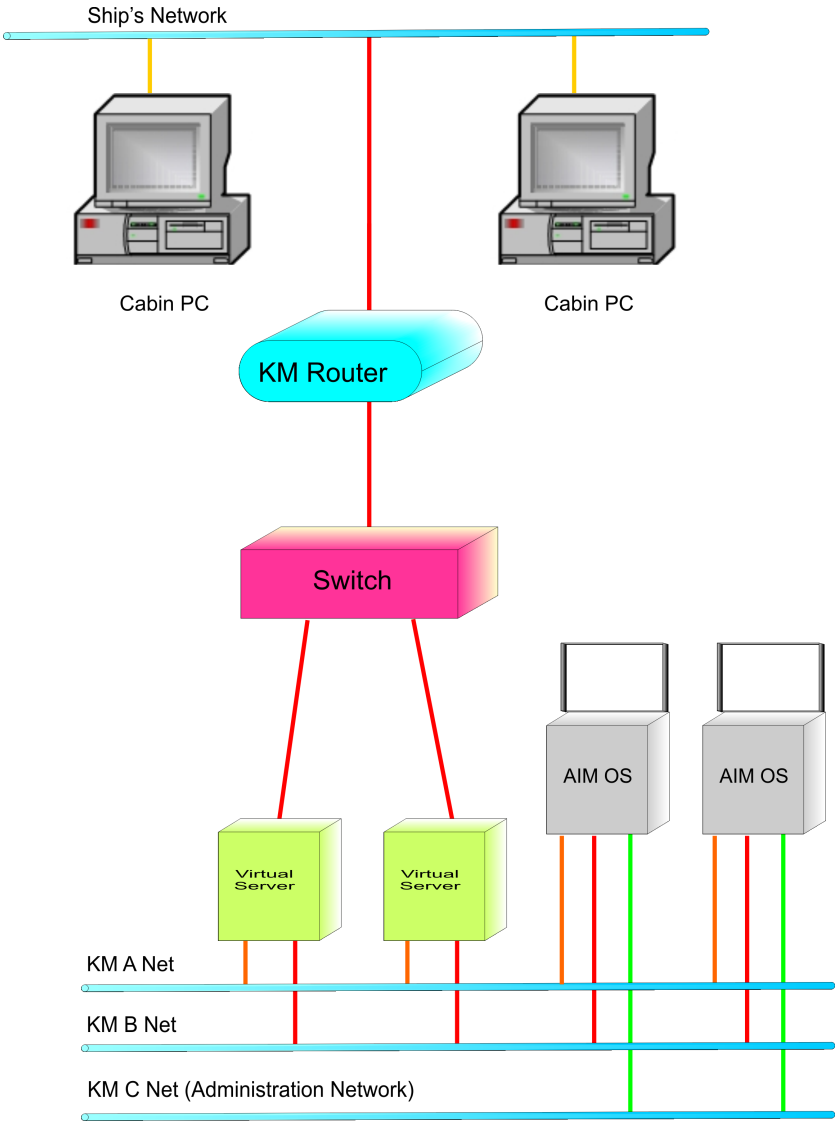
The operator can choose the camera to display on the OS, or a defined view/camera is displayed for a specific situation.

Advanced solutions exist for connecting a larger number of cameras, such as the interface to Scan CCTV systems. Functionality such as pan, tilt, zoom and camera select are then available.



3.10 Operator stations in cabin computers

The user interface for the operator station can be shown on PCs in accommodation spaces, such as cabins. The cabin computers are connected to the KM networks through virtual servers, which are hosted on workstations running Microsoft Windows XP. You can launch a virtual machine from the cabin PC by clicking a desktop icon. The operators of cabin operator stations are given guest access only. The following figure shows a block diagram of the AIM OS on cabin computers.



4 HISTORY STATION

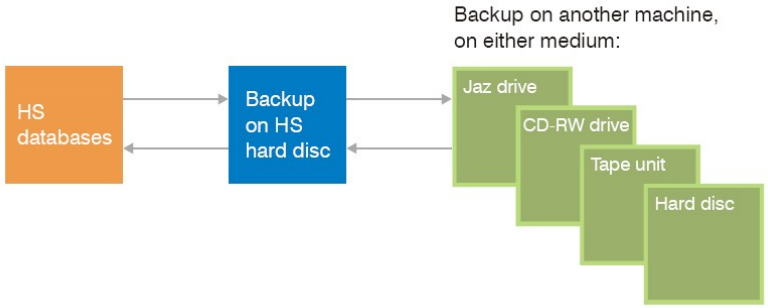
4.1 History station

The history station (HS) provides long-term storage of alarms, events and time-series. Depending on the amount of data to be stored, the HS can be installed on a standalone PC, or integrated with an operator station. The integrated unit is called the OSHS. Various models of HS are available, suitable for varying amounts of I/O, such as the:

- HS 500
- HS 3000
- HS 5000.

Up to 32,000 time series are supported by some models of the HS.

The storage media for history databases can be Jaz, Tape, CD-RW, or optical media. The storage systems are used for backup and retrieval of the databases. This is illustrated in the following figure:



The HS incorporates a database, which is divided into two different parts, the time series and the event databases.

If the historical data is critical, you can set up several HS servers in a split configuration.

4.1.1 Time series database

This database receives time-series data from the function modules that are configured on the PS. The time-series data that comes from the PS can be either a primary or a secondary time-series.

These stored time-series are utilised by other AIM applications like Trend images and Reports. The time-series database has an Open Database Connectivity (ODBC) interface. A separate export function is also incorporated in the HS.

There are two types of time-series databases:

- Primary time-series, which are process values logged by the PS
- Secondary time-series, which are processed primary series, for example mean values for a process value, for a given period.

The databases contain data reduction (mean, max, min, hysteresis), and data accumulation (hour counters, consumption, etc.).

4.1.2 Event database

The event database stores alarms and messages. These are stored by setting up an operator station or a history station as an event server. This allows you to view the event history, and apply filtering to search results.

The event database receives event data from the event server. Events are generated by the function modules running on the PS, or by the rest of the system. These events are used by Event images, where they are displayed as alarms and messages. The event database also has an SQL interface.

The database allows export to the following:

- The maintenance system
- The alarm management database
- The history station
- The information management system.

4.1.3 Configuration event database

The configuration event database stores changes made to the K-Chief 700 system configuration, by all users. You can setup the configuration filter to view configuration events, based on your specifications.

5 FIELD STATION

5.1 Field station overview

The field station is used to control and monitor individual processes in Kongsberg Maritime automation systems. Field Stations may be located centrally, or distributed to save on cabling costs.

A field station is modular, and this makes the system flexible, and highly scalable. A field station cabinet contains the following modules:

- Controller (RCU) modules
- Remote I/O modules
- Net connection sockets
- Power supplies
- Circuit breakers
- Cable trays
- Field cable entry
- Protective earth (PE) bar for cable shield termination
- Instrument earth (IE) bar
- Earth bolt.

Field stations are available in various sizes:

FS-60	2 modules, typically 60 I/O (wall mount)
FS-120	4 modules, typically 120 I/O (wall mount)
FS-240	8 modules, typically 240 I/O (floor mount)
FS-400	16 modules, typically 400 I/O (floor mount)

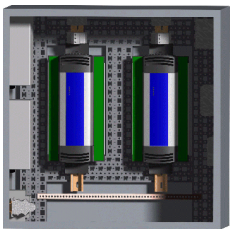
Field stations can contain none, one, or many RCU controller computers in a single or redundant configuration, and/or, one or many RIO modules. These quantities vary according to the application requirements. Field stations require 24 VDC or 115/230 VAC power supply, and redundant power supplies can be fitted. Field stations conform to the enclosure protection standard IP 44.

5.1.1 Field station layout

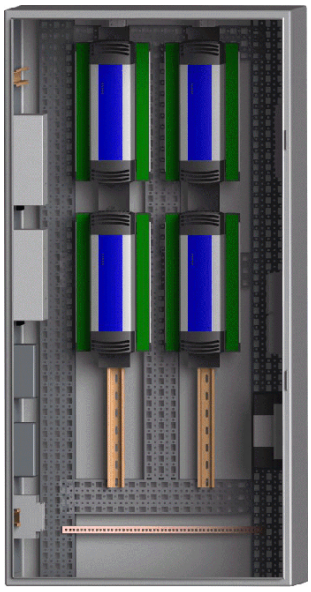
The illustration below shows the cabinet layout of the FS-60, FS-120, FS-240, and FS-400 Field Stations.

The FS-400 has a deeper cabinet than the FS-240. This allows RIO modules to be mounted on the side walls.

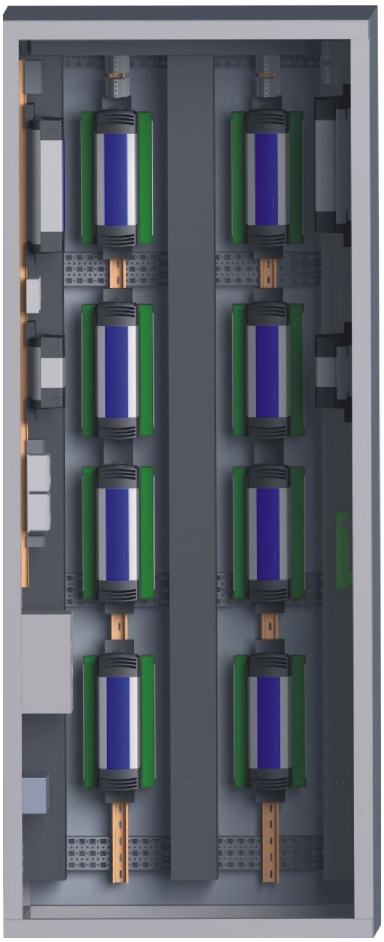
FS-60



FS-120

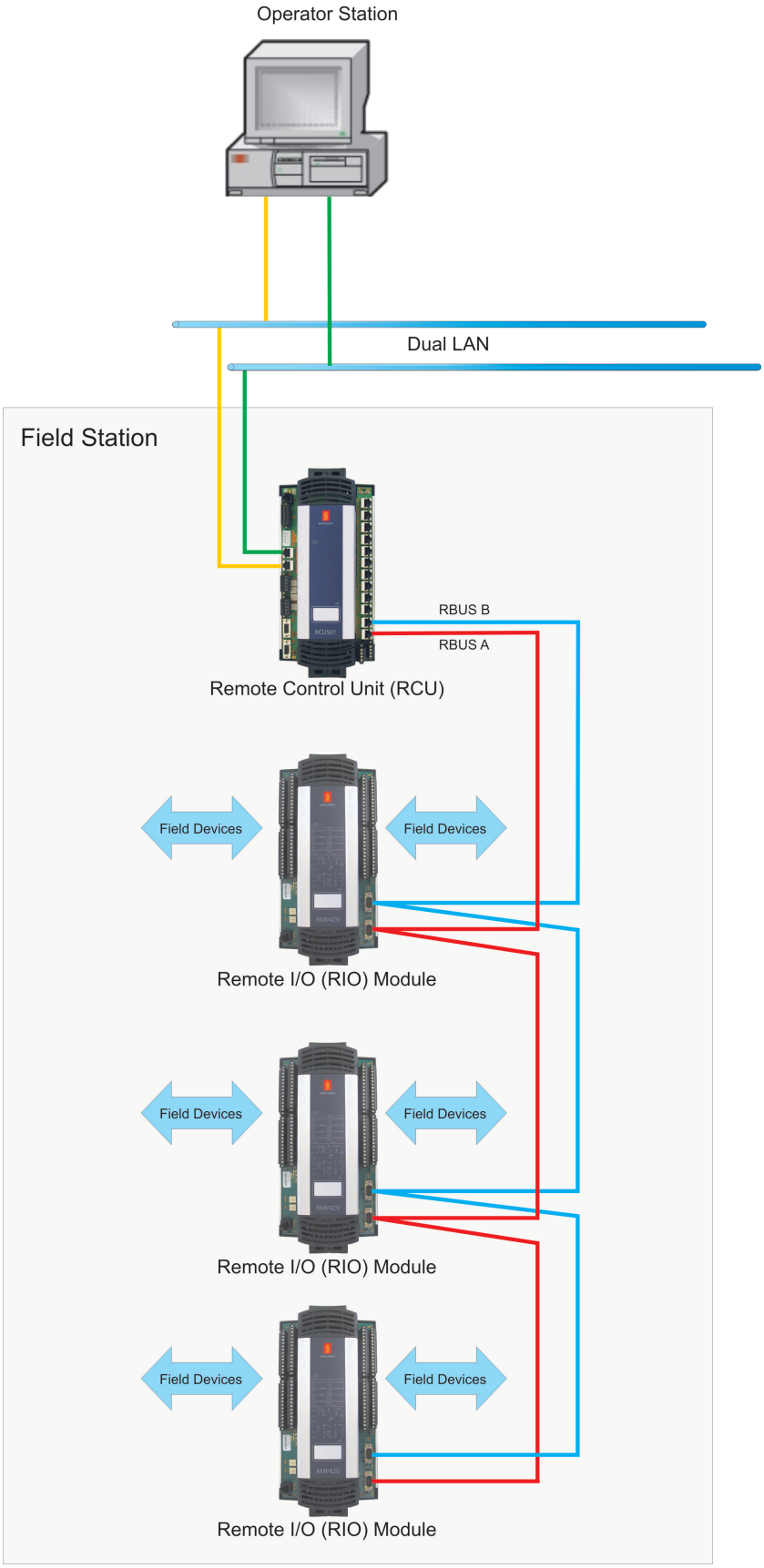


FS–240/FS-400



5.2 RIO devices

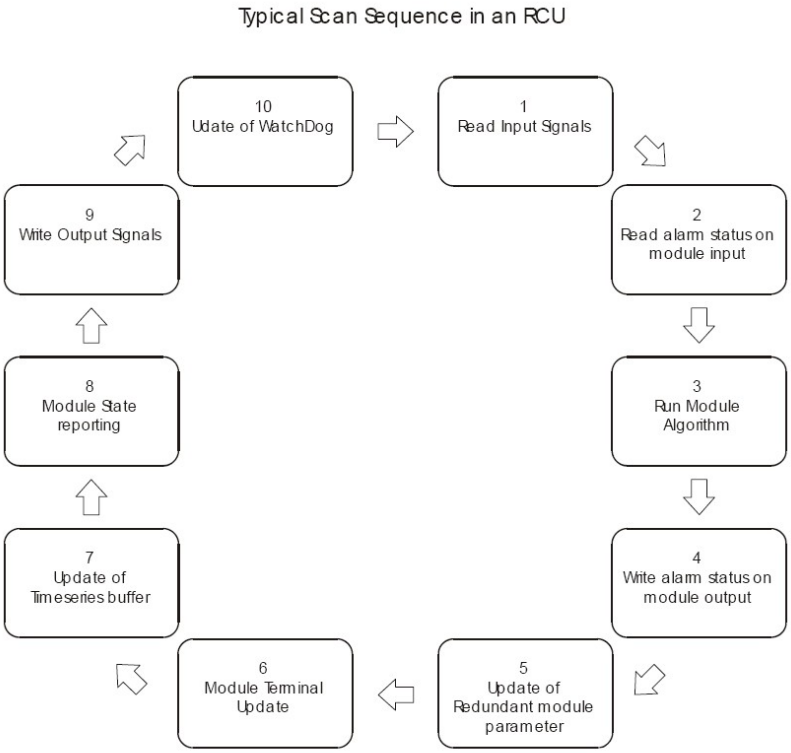
The RIO devices use the remote controller unit (RCU) as the host for the bus interface (RBUS). The serial I/O signals flow between the field equipment, the RIO devices and the RIO modules. The RIO modules act as termination boards and signal converters for the I/O signals from the field. Kongsberg Maritime provides several models of the RIO for different types of I/O and applications.


Operator Station
Dual LAN
Field Station
RBUS B
RBUS A
Remote Control Unit (RCU)
Field Devices
Field Devices
Remote I/O (RIO) Module
Field Devices
Field Devices
Remote I/O (RIO) Module
Field Devices
Field Devices
Remote I/O (RIO) Module

5.3 RCU modules

The RCU is the real time controller computer in the RIO concept. The RCU interfaces between the field equipment (RIO), and the operator station. The RCU modules have interfaces to the dual Ethernet, multiple serial line Profibus, and the I/O bus (RBus). A version of the RCU is available with 32 I/O channels, in addition to the RBus, serial-lines and Ethernet interfaces.

The process station (PS) is a logical name for processing and I/O modules inside a field station (FS). A PS can consist of one or more RCUs, the associated software and configuration, and the RIO modules.



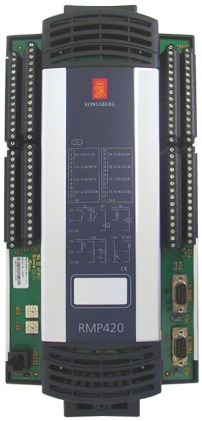
The RCU performs high-throughput data processing for the applications, while simultaneously performing general monitoring tasks. It provides the logic for specific process areas, while the RIO modules provide signal connection between the field devices and the ICS. The RCU communicates through discrete I/O signals and serial lines with the field devices it controls.

The ICS has a distributed database, and the PS provides the software platform for the program, configuration, and data associated with the process area. Both the program and the configuration, that run on a PS can be regularly backed up to an

OS or HS, for long term storage. This is achieved by setting one or more Operator Stations up as boot servers for one or more Process Stations. A download dialogue is available, to download a configuration to any PS in the network. A switch is available on the RCU501, to set the PS to boot from its own flash memory. The embedded software in the RCU501 can also be run from flash memory.

5.4 RIO modules

RIO modules interface between the field devices and the RCU.



RIO modules are available with digital input and output interfaces, with analogue input and output interfaces, and with a combination of these. All RIO modules feature up to 32 channels. They all contain advanced firmware that can be upgraded at any time during the project lifecycle or delivery timeframe. All RIO420 modules have the same RBUS interface, with a 9-pin D-Sub connector. Field device connections and power connections are also the same throughout the RIO family. Various signal interface, and self-diagnostic options are available.

The primary requirement of a fault-tolerant system is the successful detection the faults that occur within itself. Extensive self-diagnostics are therefore, built into the RIO modules.

All RIO modules have a unique identification code (ID-code). This ID-code identifies the type of RIO module installed. The system uses the ID-code to detect if the correct module is installed at the correct address.

Various types of RIO modules are available. The most commonly used modules are:

- **RMP420**

  The Remote I/O multipurpose module RMP420 is an advanced interface module placed between 32 combined digital/analog inputs/outputs on the field side, and a controller computer on the other side.

  32 multipurpose I/O channels, these can be any combination of :

  – Analogue inputs (0-20 mA/0-10 V)
  – Analogue outputs (0-20 mA/0-10 V)
  – Analogue inputs (Pt100, 2- or 3-wire)
  – Analogue inputs (potentiometer, 2 or 3-wire)
  – Digital inputs (pot. free)
  – Digital inputs (PNP/NPN, Namur)

  - Digital outputs (24 VDC/max 1 A)
  - Pulse/frequency input (max 10 kHz) (ch. 31/32 only).
- **RMP200–8**
  - Six multipurpose channels (DI/DO/AI/AO/Pot)
  - Two isolated channels (AI/AO/DI)
  - Run/error LED on front showing module status
  - Isolated redundant communication bus (RBUS Link) interfaces
  - Isolated redundant power connections (RBUS Power)
  - 99 RMP200-8 modules can be attached to one RBUS
  - Configurable fail-safe functionality
  - All internal voltages are monitored
  - Built-in test Equipment (BITE) active while running
  - Complies with standards IEC 60945 and IACS E10.
- **RDIO-420 S**

  Up to 32 digital input or 32 digital output signals, configured in four DI or DO groups of eight channels each

  Identical input and output channels from two different modules can be connected in parallel (redundant operation)

  Two serial process bus interfaces (RBUS A and RBUS B) for redundant communication to the redundant controllers

  Each serial process bus interface is galvanically isolated from other circuitry

  Easy installation and replacement:
  - DIN-rail mounting
  - Plug in connections
  - Two digit address switch

  Status LED on the front shows running or error status

  Loop monitoring of digital input and output signals

  Short-circuit proof I/O loops

  Module temperature and voltage monitored and alarmed if outside limits

  Fail-safe activation of outputs upon loss of communication

  Built-in tests for self-diagnostics and fault identification while running

  Suitable for use in SIL applications:
  - SIL 2 as single module configuration
  - SIL 3 as single module configuration

  Built in FOST (Final Output Stage Test).

- **RDIOR-420**

  16 solid-state digital inputs or 16 solid-state digital outputs, individually configured

  16 digital relay outputs

  Two remote I/O bus interfaces (RBUS A and RBUS B) for redundant communication to the controller computer(s)

  Each remote I/O bus interface is galvanically isolated from other circuitry

  Easy installation and replacement:

  – DIN-rail mounting
  – Plug in connections
  – Two digit address switch

  Status LED on the front shows running or error status

  Loop monitoring of solid-state digital inputs and outputs

  Relay coil monitoring for relay outputs

  Short-circuit proof I/O loop current drivers

  Fail-safe activation of outputs upon loss of communication

  Built-in tests for self-diagnostics and fault identification while running.

- **RSER-200–4**
  – Isolated serial line field channels
  – Run/error LED on the front panel shows module status
  – Blinking LEDs on front showing transmit and receive data activity for each channel
  – All internal voltages are monitored
  – Allows hot module replacement
  – Complies with standards IEC 60945 and IACS E10.

- **RHUB-200–5**
  – Five RBUS Downstream Link interfaces
  – Isolated RBUS interface for each RBUS Downstream Link
  – Run/error LED on front showing module status
  – Blinking LEDs on front showing receive data activity for each Link
  – Link connection LED for each RBUS Downstream Link
  – Complies with standards IEC 60945 and IACS E10.

- **RBUS-Term**

  RBUS-Term is a termination board for the Kongsberg RBUS (remote I/O bus), which is a serial communication bus between the RCU (remote controller module) and related RIO (remote I/O) modules (e.g. RMP420, RDIOR420).

- **RMC-ST**

  The RMC-ST is a media converter that can convert serial signals to light signals for transmission over fibre optic cable. It extends and galvanically isolates the Kongsberg RBUS or SPBUS (remote I/O buses) using optical fibre. A range of up to a kilometre can be obtained without any degradation of signal quality, even when several pairs of media converters are connected to the RBUS.

  – Fibre link length up to 1 km

  – Up to five fibre links can be inserted in series in one RBUS or SPBUS

  – Easy snap-on mounting to DIN rail.

- **Earth Fault Indicator**

  The Earth Fault Indicator (EFI) is a leakage-current sensor module. It monitors the difference in power supply current to and from a single RIO, or other similar module. The monitoring system can detect the RIO module where an earth fault has been introduced to an I/O signal. The sensor module is available in a high current 16 A, and a low current 6 A version.

  – Both analog-voltage outputs and relay outputs are available

  – The EFI analogue output voltage provided with a high-accuracy difference-current sensor for accurate detection

  – The EFI digital output provided with 10 selectable trigger levels

  – Separate RESET switch for releasing output relay

  – Separate TEST button for internal test function

  – Snaps on to the DIN rail mounting of the module

  – Complies with standards IEC 60945 and IACS E10.

5.5 RBUS

The RBUS is a serial communication bus based on the RS-485 standard. The bus has a fixed communication speed of approximately 6 Mbit/s. Repeaters (RHUB) must be fitted for distances greater than 300 meters, or when segregation between the RIO modules is required.

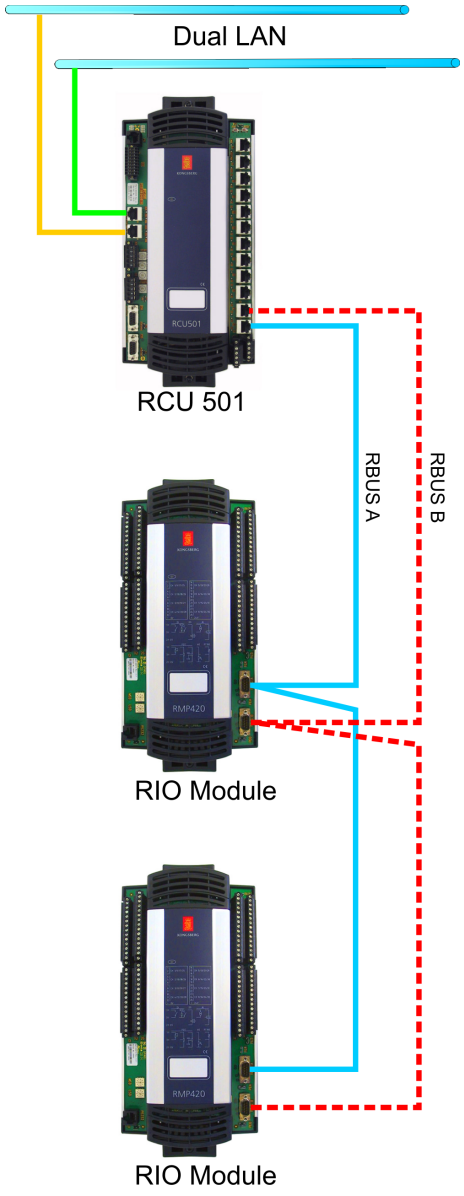
For longer cable runs, or for cabling through EX zones, fibre optic cables can be used. The RBUS media converter module (RMC-ST) is used to convert the electrical signals to fiber optic signals, and vice versa.

The RBUS cable contains both signal and power wires for the isolated bus interfaces on the RIO modules. Up to 99 RIO modules can be connected to one RBUS.

5.6 Examples of RIO topology

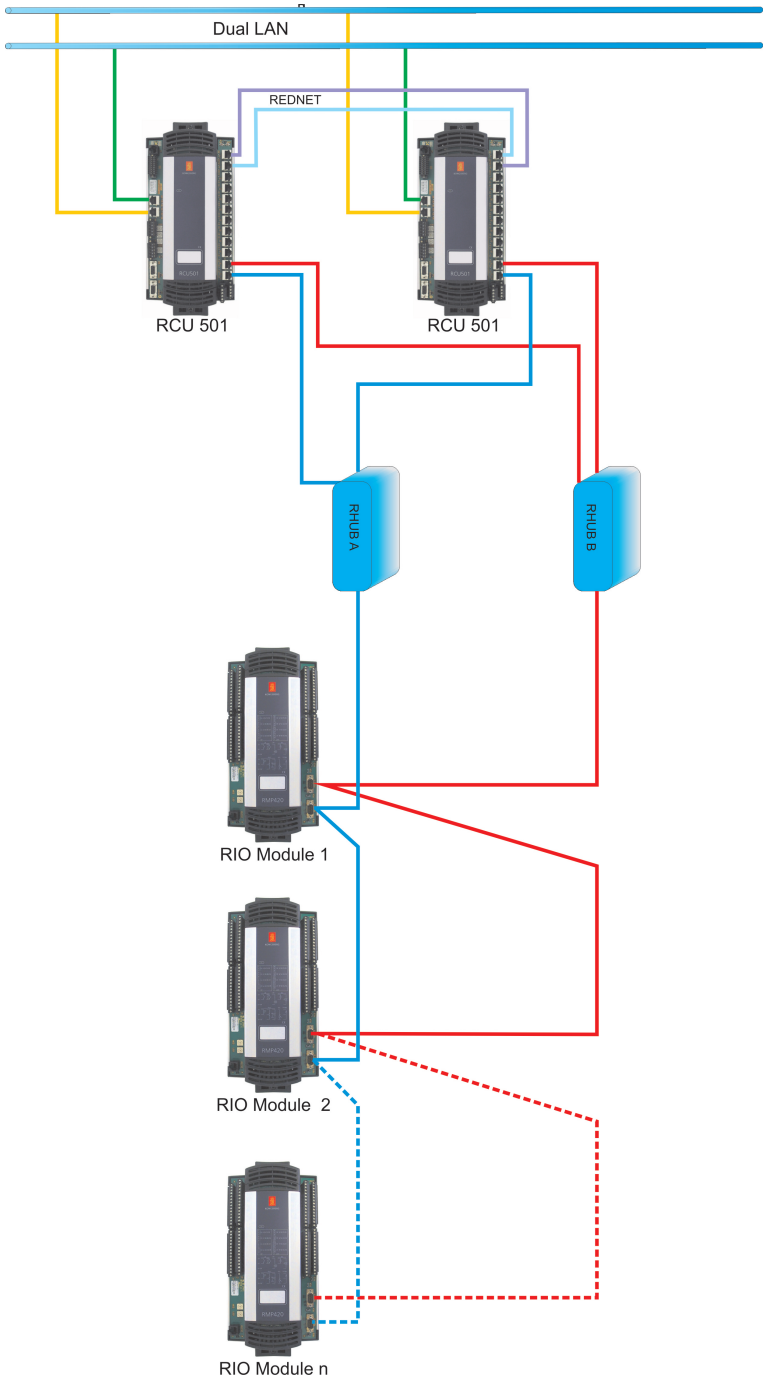
5.6.1 Single system

The basic topology for the RIO concept is a single-system configuration with a single RCU, RBUS and a RIO. Power redundancy can be provided for the cabinet.


Dual LAN
RCU 501
RBUS A
RBUS B
RIO Module
RIO Module

5.6.2 Hot standby

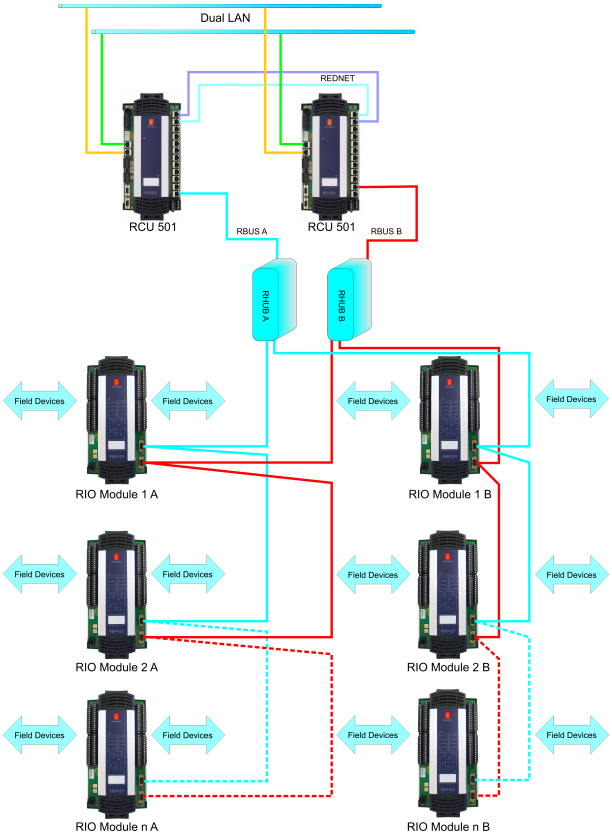
This topology is called hot standby as one RCU controls the RIO modules. If a preset switch criteria is met, control is automatically switched to the other RCU in mid operation, without any loss of process control. This solution can handle both analog and digital output signals. A mixture of input and output signals can be handled on a single RIO pair.



5.6.3 One out of two

In the one out of two (1oo2) topology, the RBUS provides independent communication paths for a two-channel architecture. This is a requirement for safety systems. Both RCUs read and evaluate the input independently.

This solution can handle both analog and digital output signals, and a mixture of both input and output signals can be handled by the RIO modules.



5.7 Hardware modules for hazardous areas

The remote I/O modules for hazardous areas use the Profibus to interface between the remote controller computer (RCU), and a central processor module (CPM). The CPM contains a power module that supplies power to remote control devices such as valves, relays, and other field equipment. Some modules can provide analogue/digital input or output.

The modules are certified for installation in zone 1 or zone 2/Division 2 areas, or safe areas.

The typical application is as a single system with a single controller.

Redundant solutions are also available if required.

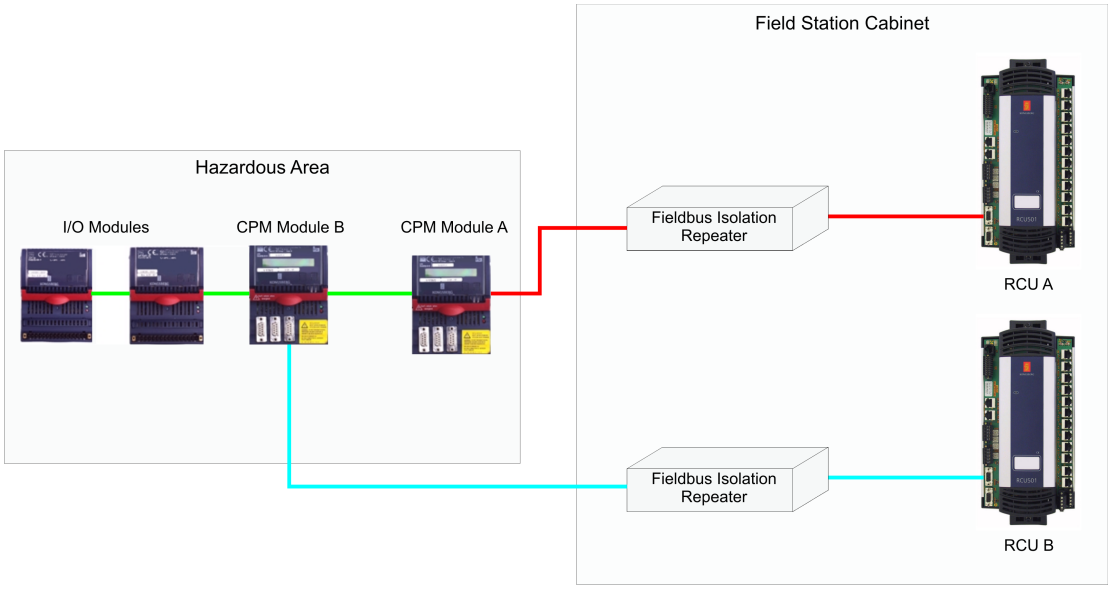
Standard features for these modules are:

- Cenelec, FM, TÜF and DNV approved
- Standards: IEC 61131-2, 60945, IACS E10
- Galvanically isolated inputs and outputs
- Hart communication
- The module can be hot swapped with power on, in a hazardous area
- Open and short circuit monitoring of field signals
- Self test facility
- Profibus DP interface between the process computer (RCU), and the central processor and power module (CPM).

The modules are:

- CPM Zone 1 or 2 (central processor and power module)
- AOM 08 (eight intrinsically safe [IS] analogue output channels)
- AIM Hart 08 (eight IS analogue input channels)
- DOM 08 (eight IS digital output channels)
- DIM 16 (sixteen IS digital input channels)
- TIMR 6480 (eight channel PT100/resistor input for 2, 3 and 4 wire)
- Field bus isolating repeater (IS RS 422/, RS485 fieldbus EEx ib IIC).

A typical topology for an application in a hazardous area is shown in the figure below.



5.8 I/O system overview

The main features of the I/O system are as follows:

- During normal operation, the I/O system provides you with necessary information and status indications for every configured RIO module, and the status of the I/O channels.
- The PS configuration mode is available to users with appropriate access rights. In this mode, you can configure the cabinets with RIO slots, including the connections between the function module tags/terminals and the I/O channels, in addition to performing other normal operation functions.
- All I/O that is connected to the same RBUS (from one RCU) are displayed on the same main I/O image. You can select the detail image for the RIO modules from this main image.

The I/O system provides interfaces with the processes. It is used to configure and control the input and output devices in the field.

The I/O system supports several I/O solutions, for example:

- Serial process bus (RBUS) with Kongsberg proprietary communication protocol
- Profibus DP standard
- Serial line protocols (e.g. RSxxx, Modbus, NMEA)
- Device Net.

5.8.1 Serial process bus (RBUS)

RIO modules are connected to the RCU through the high speed serial process bus (RBUS). The distributed RIO modules communicate over the RBUS to the corresponding RCU using the RBUS communication protocol.

See the section *RBUS* on page 61.

5.8.2 Profibus DP standard

Profibus DP is a widely accepted international networking standard for automation, in manufacturing and process control. It can handle large amounts of data at high speed, and serve the needs of large installations.

The high speed, long range, and good data handling capabilities of Profibus DP makes it ideal for many process control and data intensive applications. Profibus DP is a polling network, the master device periodically requests the status of each node. This ensures that all the status of all devices on the network are constantly updated, and therefore reliable.

5.8.3 Serial line protocol

The K-Chief 700 uses the RS232, RS422 and RS485 serial communication interfaces for multipoint communications over a single line.

The MODBUS standard is an application-layer messaging protocol sited at level 7 of the OSI model. The protocol provides client/server communications between devices connected on different types of buses or networks. It also standardizes a specific protocol on serial lines, to communicate MODBUS requests between a master device, and one or many slave devices, up to a maximum of 247.

NMEA 0183, or NMEA, is a combined electrical and data specification for communication between marine electronic devices and many other types of instruments. It is defined and controlled by the US National Marine Electronics Association.

5.8.4 Devicenet protocol

DeviceNet™ is a low-level industrial application layer protocol for industrial automation applications. DeviceNet connects simple industrial devices (sensors and actuators) with higher-level devices such as Programmable Controllers. Built on the standard CAN (Controller Area Network) physical communications standard DeviceNet uses CAN hardware to define an application layer protocol that structures the task of configuring, accessing and controlling industrial automation devices.

5.8.5 Field ethernet protocol

Modbus TCP is also supported. Other field ethernet protocols can be provided on request.

6 NETWORK

6.1 Network overview

Kongsberg Maritime delivers a complete Local Area Network (LAN) for the K-Chief 700. This includes network topology design, specification of cables, delivery of network control units, and final testing.

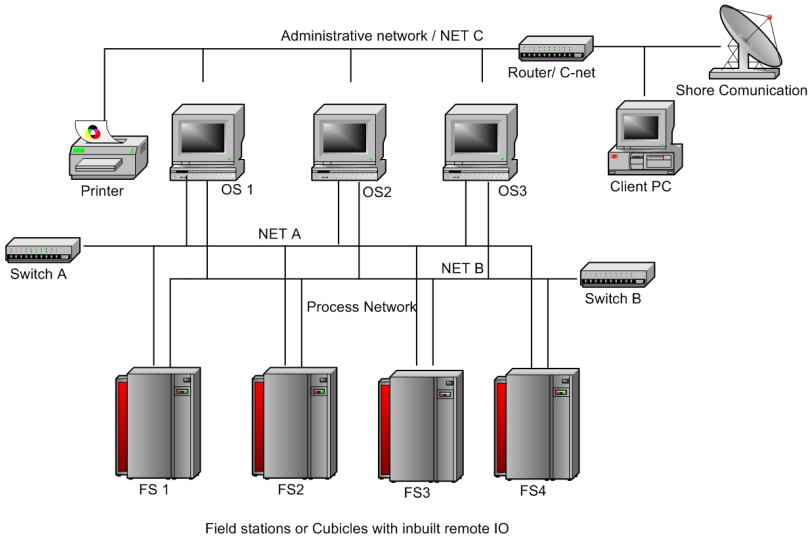
Process Network

The dual redundant process network connects all the field stations and operator stations. Equipment located in one area of the vessel is normally connected to a network distribution unit (NDU), which acts as a star coupler. NDUs are typically connected with fibre cables. Shielded twisted pair (STP) cable is used where feasible. The two process networks with connected NDUs are located in physically separate areas on the vessel, to ensure redundancy.

Administrative network

A third network, the administrative network, is used for separate communication between operator stations, and for external communication through firewalls.

A typical network is shown in the following figure.



6.1.1 Network standards

The following network standards and protocols are used in the Kongsberg Maritime LAN.

- The LAN is IEEE 802.3 compliant, and uses the TCP/IP protocol

- Switch management is based on SNMP and Telnet/Web communication
- 10/100 Mbit/s connections are used.

6.1.2 Network performance

The network configuration has the following features:

- Star topology isolates errors within the star cluster
- Network switches optimize internal traffic in each segment
- Fast Ethernet (100 Mbit/s) can be seamlessly used with 10 Mbit/s connections
- Packet collisions are avoided by use of full duplex communication.

Network performance is evaluated throughout the engineering and FAT process, and during the commissioning tests. A separate network test procedure for the delivery is also prepared.

6.1.3 Network distribution unit

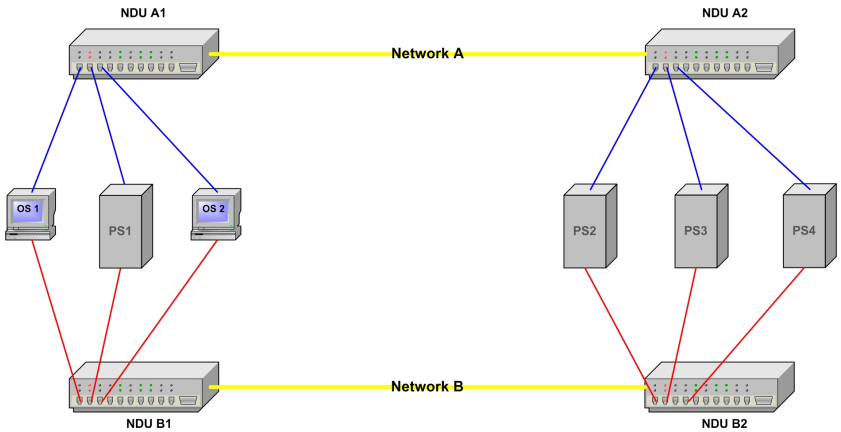
The network distribution units (NDUs) are wall-mounted cabinets containing converters, network switches and patch panels. This allows simple and cost effective connection of both fibre optic and STP network cables.

6.1.4 Cable and connector standards

Recommended specifications are available for shielded twisted pair (STP), fibre optic cables, and connecting terminals.

6.1.5 Network redundancy

Authority requirements for essential functions, such as propulsion control, generator and machinery control etc., are provided by the dual network installation. Dual process networks are standard in all Kongsberg Maritime systems.



Some important aspects of the dual process network are:

- Identical information is sent on both networks
- The failure of one network due to cabling, network switch or network interface failure, does not compromise the operation of the rest of the network
- No latency in data transmission when one network fails
- Administrative data communication, such as print files from the Operator Stations uses a third network, separate from the dual process network
- The networks can be routed through different fire zones.

6.1.6 Network monitoring

The main features of the network monitoring service are given below.

- The network traffic is monitored from all the operator stations.
- If a network interfaces fails, statistics are displayed, and alarms are generated.

6.1.7 Network security

Antivirus protection

Anti virus software can optionally be integrated into the network nodes, this is done in consultation with the customer.

Network protection

Network storm is a network protection strategy, that protects the nodes in the LAN from spurious traffic generated by faulty devices within the network. Any LAN interface that generates an exceptionally large traffic volume is monitored to ensure that the signals are not spurious. The interface can be shut down by network storm if necessary. Normal traffic is then carried over the other functioning network.

7 ELECTRICAL POWER

7.1 Electrical power

The system normally requires a 110/220 VAC supply for its field stations, operator stations and network components. Field stations may also be delivered with direct 24V DC input.

7.1.1 Uninterruptible power supply

An uninterruptible power supply (UPS) protects different types of sensitive electrical equipment such as computers, work stations, critical instrumentation, process control systems, etc. Sensitive electrical equipment must also be protected from electrical interference. Interference from inside and outside the facility can create problems in the AC power. The UPS protects electrical equipment from problems associated with utility power, poor quality, or a complete loss of power.

The UPS cleans the utility AC power and maintains a constant voltage, and if necessary, isolates the output to the critical load. This helps to keep power line problems from reaching the critical systems, where they can damage hardware, and cause the equipment to operate erratically.

A UPS with a 30 minute supply capacity is normally sufficient to keep the system operational until power is restored. In integrated systems when DP is included in the delivery, a 30 minute UPS is normally a requirement from the classification society.

The most commonly used UPS is the 2-3 kVA unit. UPS units up to 60 kVA are available.

7.1.2 Earth fault detection

All centralized 110/220 VAC or 24 VDC UPS units can detect earth faults. Any detected earth fault is given as a common alarm to the operator. The earth fault indication (EFI) modules in the field stations can also monitor earth faults. The earth fault can be viewed as a trend image, to see changes in current leakage over time. When using a centralized 24 VDC UPS, the earth fault monitoring will only be carried out from the UPS.

7.1.3 Power distribution

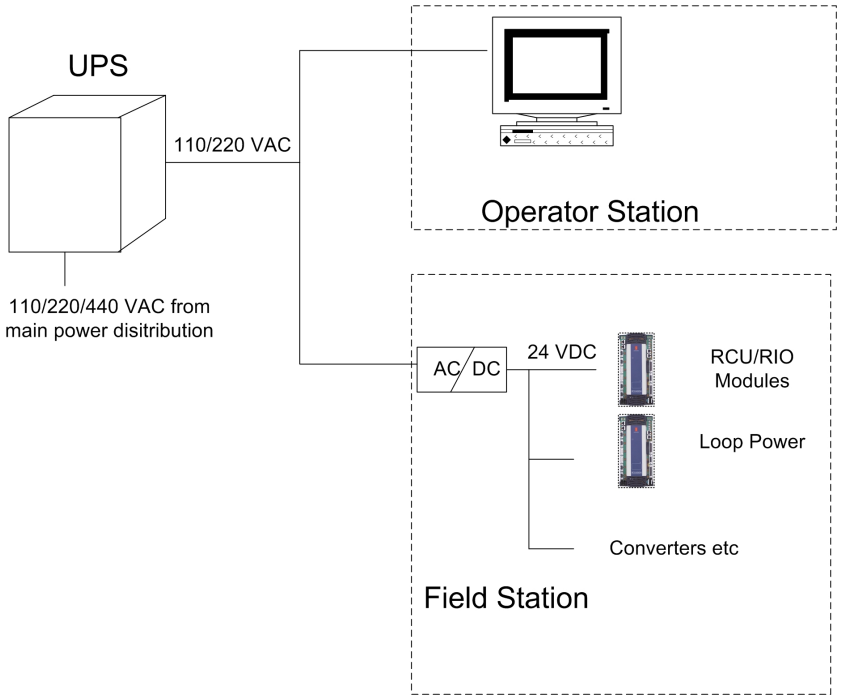
Power distribution can be arranged in three basic configurations:

- Centralised 110/220 VAC UPS
- Centralised 24V DC UPS
- Decentralised 24 VDC UPS (battery bank).

7.1.3.1 Centralised 110/220 VAC UPS

This is a self contained and free standing UPS cabinet that provides the operator stations, field stations, and other equipment with 110/220 VAC power. In this configuration, AC/DC converters are required in every operator station and field station, to generate 24 VDC, and other required voltages.

The following figure shows a centralised 220 VAC (110 VAC) UPS.

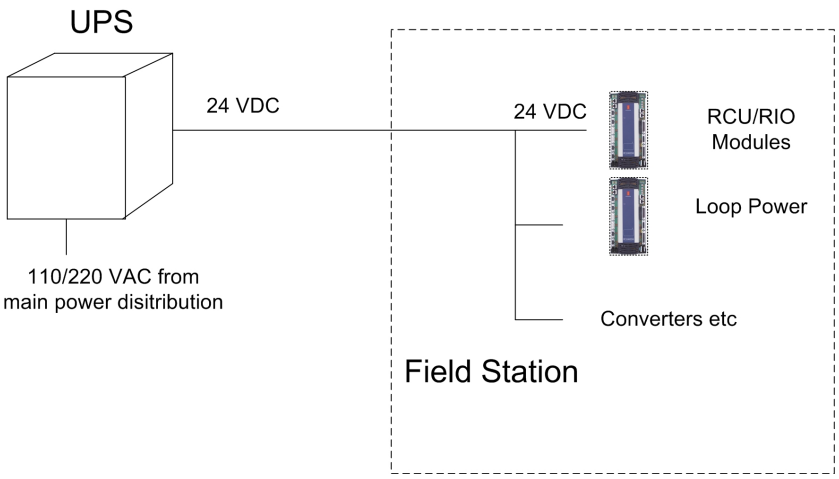


Field stations can also have redundant power inputs, and internal redundant power supplies. Typically, this configuration is used in critical applications such as power management and ballast control.

7.1.3.2 Centralised 24 VDC UPS

This is a self-contained, free standing UPS cabinet that provides the field stations and other equipment with 24 VDC. In this configuration, AC/DC converters are not required in the field stations, because all the internal equipment uses 24 VDC power.

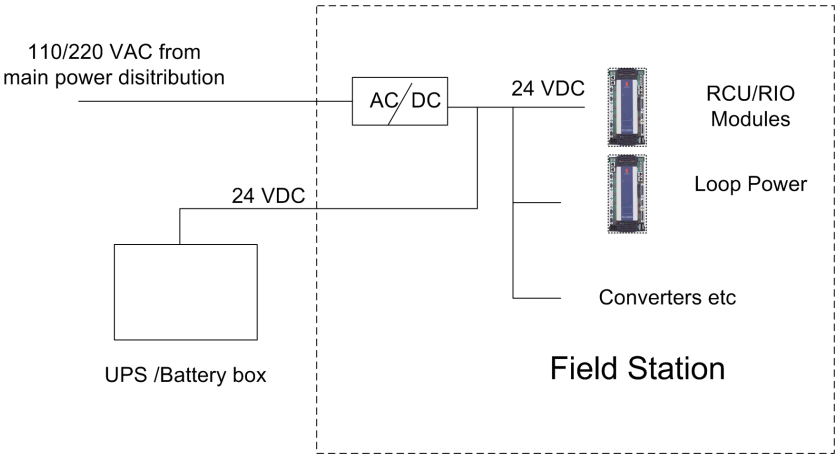
The following figure shows centralised 24 VDC UPS.



7.1.3.3 Decentralised 24 VDC UPS

This is a self-contained, free standing UPS battery cabinet/box that provides the field station with 24 VDC. The batteries are charged from the internal power supply in the FS. This charger's input is 110/220 VAC ship supply.

The following figure shows decentralised 24 VDC UPS.



8 CONFIGURATION AND MAINTENANCE TOOLS

8.1 Configuration and maintenance tools

The K-Chief 700 system is designed for online configuration and hot repair.

Online configuration allows you to change the configuration in a PS while it is in operation. You do not have to restart the system when the configuration is changed.

Online configuration also lets you add new I/O signals to existing RIO modules, and add new RIO modules in FS cabinets that have spare RIO slots.

The K-Chief 700 system design allows Hot Repair, which enables you to replace existing HW system modules such as RIO modules and RCU, while the FS is powered up, and in normal operation.

8.1.1 Function module architecture

Function modules are the main software-based building blocks in the K-Chief 700 system. The modules are self contained automation objects that represent field devices, process functions or system-specific functions. A module library with dedicated modules for various purposes and project specific modules, if required, is available for online configuration.

8.1.2 Function module parameters

Function module parameters are a set of variables used to define the characteristics and behaviour of the module.

The functional capabilities of a module are defined in the module's algorithm.

In addition to the algorithm, the module has parameters for measurement, states, setpoints and configuration.

The flexi module is a type of function module that is similar to other modules, with the exception that the algorithm is configured by combining logic and arithmetic elements, using a dedicated graphic editor.

The operator interacts with the module parameters through the operator menu and the parameter view. All the parameters can be changed using online configuration.

8.1.3 Function module terminals

Function module terminals are communication channels to other modules and I/O channels. Terminals are used to transfer operational values between modules, and between the module and the K-Chief 700 environment.

The terminals interact with measurement and control signals. Input terminals provide input values to the algorithm while output terminals provide values as a result of algorithm execution. Terminals are classified as analog or digital terminals, according to the type of value they carry. On analog terminals, you can specify an operational range with alarm limits. On digital terminals, you can assign an alarm value. When the value exceeds the preset limit, the corresponding alarm is triggered.

8.1.4 Operator menu

The function module operator menus allow you to:

- Set the parameter values
- Interconnect function modules
- Set the mode
- Initiate control commands
- Acknowledge alarms.

Three types of operator command buttons are provided:

- Commands that set a digital value, independent of the current value
- Commands that set an analog value. These commands invoke a dialog
- Toggle buttons such as start/stop, on/off.

8.1.5 Configuration tools

Various configuration tools are available in the K-Chief 700 system, such as the PS configuration tools, operator station configuration tools, etc.

The configuration tools are available on any operator station in the Integrated Control System system.

Access to the configuration tool is password protected. The operator station logon level sets the allowed configuration level.

PS configuration tools provides online configuration facilities that lets you:

- Add new Function Modules
- Add new I/O signals to existing RIO units
- Make/change connections between various modules
- Configure Alarms and Alarm levels

- Maintain and configure existing Function Modules
- Maintain and configure existing I/O signals
- Add new RIO units.

Configuration-help tools include functions for:

- Trending directly from any I/O signal in I/O images
- Searching for tag names (find tag search mechanism)
- Showing function module connections
- Showing connections between clusters of function modules (schematics)
- Editing various properties on Function Modules (clusters) (e.g. changing command group, tag name etc.).

All changes to the system when new software function modules are added, new I/O points connected, or the configuration for existing function modules is changed, is done online. This is done from the system. However, additional lists for I/O configuration, value settings etc., based on the configured system, can be prepared by offline tools. The system configuration can be backed up in one or more operator stations.

Operator station configuration tools have the following functions:

- Configuring interactive reports made from predefined templates
- Configuring trends from any function module tag in the system
- Configuring process images using a licensed editor
- Configuring list images.

8.1.6 Offline configuration tool

The offline configuration tool (OCT) allows the offline configuration software modules in K-Chief 700. The OCT has functions for import and export of Excel spreadsheets to build the I/O list. It also reports changes to the I/O made by Kongsberg Maritime, and the shipbuilder. The subsystems are configured using modules from a library.

9 APPLICATIONS

9.1 Introduction

The K-Chief 700 provides the following main applications:

- Alarm monitoring
- Watch call System
- Operator fitness alarm system (OFAS)
- Power management
- Auxiliary machinery control
- Cargo control
- Ballast control
- Process control system.

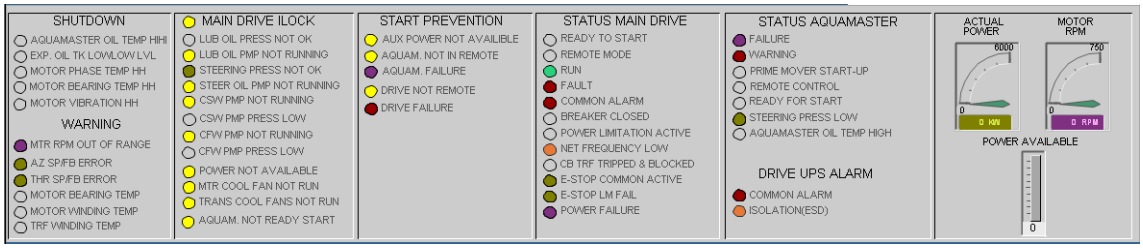
Standard control functions are used within several of the main management functions to provide standardised operator interaction.

In addition to the main management applications, a Vessel Performance Monitoring system can be integrated into the K-Chief 700. The system is dependent on vessel type and use.

For operator training, a system with simulation of process events and dynamics is available.

9.2 Alarm monitoring

Some of the system images are provided with alarm indicators, you can use these to monitor for alarm conditions and events. The following figure shows the alarm indication panel for a detailed thruster image.



9.3 Watch call system

The watch call system is an extended alarm system for vessels. The system monitors the cargo, engine machinery and navigation alarms. You can use this system to leave the engine control room unmanned during normal operation. Dedicated alarm panels, which may be located in various places throughout the vessel,

display the alarms and information about the alarm conditions. The system is an extension of the event system, combined with an officer call facility.

The watch call system is made up of a number of self-contained, wall-mounted watch call panels. These are installed at specific locations on the vessel. These panels give an alarm to the watch responsible, and the on-duty personnel.

The watch call system is in accordance with classification societies' requirement for unmanned engine room operation. It features:

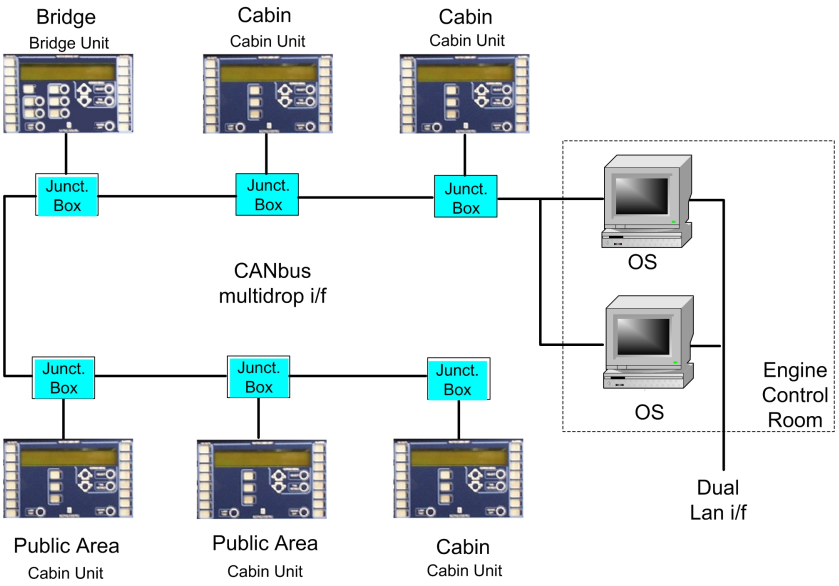
- Selection and indication of duty engineer
- Group alarm indication
- LCD display for detailed alarm information
- Repeat alarm
- Built-in engineer call function
- Operator fitness alarm system.

The system monitors the following primary functional areas:

- Cargo
- Engines
- Navigation.

The duty roster is assigned through the operator stations.

See the following figure for an illustration of the watch call user interface.



The system can contain up to 30 watch call panels. This includes cabin panels, public panels and the bridge panel.

The watch call panels are connected together by the controller area network (CAN) bus. The panels are usually controlled by the two engine control room operator stations, for redundancy.

9.3.1 Watch call panels

All panels are available in flush mounting and wall mounting. All panels have duty indicators in a column to the left with alarm indicators to the right. The bottom most alarm indicator serves as a system fault indicator to indicate faulty communication.

9.3.1.1 Watch bridge unit

The watch bridge unit (WBU) panel features buttons and indicators for engine and cargo duty call functionality, and watch responsibility transfers for transition to unmanned machinery space (UMS). The WBU also shows the status of the OFAS, and a repeat alarm indicator.

9.3.1.2 Watch cabin unit

The watch cabin unit (WCU) is used in officer cabins and public areas. The panels feature three indicators to show where a call is coming from (Bridge, ECR or cargo control room).

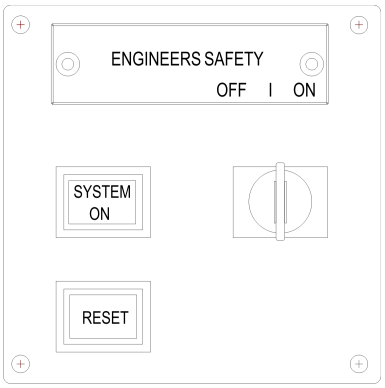
9.4 Operator fitness alarm system

The OFAS is used to provide an alarm if operator fitness significantly degrades during a watch cycle. The OFAS panels are fitted at the entrance to, and inside the engine control room (ECR), and in other locations in the engine room (ER). The operator presses the On button on the panel to start the alarm

countdown, while entering the engine room. If the operator does not press the Reset or Stop buttons on one of the Safety On/Off boxes, or the Safety/Reset Calling box within a predetermined time interval, a warning is given. If the operator still does not reset the alarm within a predetermined time limit, an operator fitness/dead man alarm is given.

9.4.1 Engineers safety panel

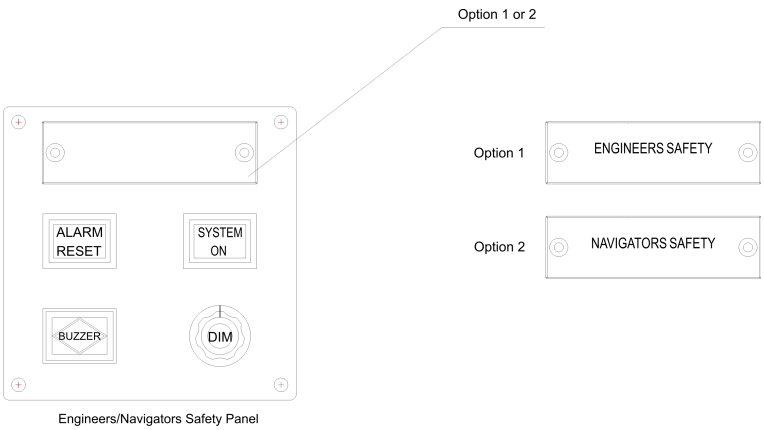
The Engineers safety panel has a key to switch the system on or off. A lamp is lit when the system is switched on. The Reset button is used to reset the alarm system. This panel is generally located near the entrance to the engine room.



Engineers Safety Panel

9.4.2 Engineers/Navigators safety panel

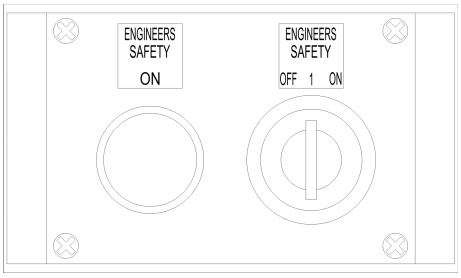
The Engineers safety panel has a key to switch the system on or off. This panel is generally located near the entrance to the engine room, or the bridge.



Engineers/Navigators Safety Panel

9.4.3 Engineers safety on/off box with key

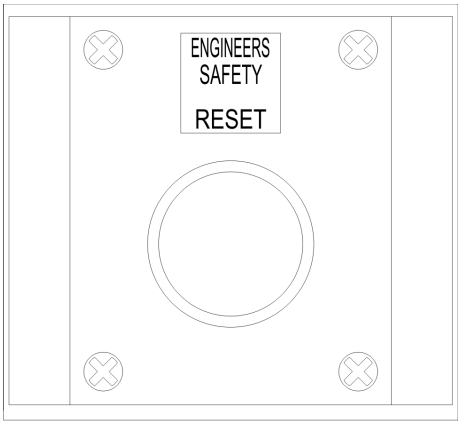
The Engineers safety on/off box with key has a Reset button. The operator should press this button before a preset interval to reset the alarm. This box has a key provided, to switch the OFAS on or off. The box is placed in strategic locations in machinery spaces, and other locations.



Engineers Safety On/Off Box with Key

9.4.4 Engineers safety reset/calling Box

A separate panel with a reset button is provided in strategic locations in machinery spaces, and other locations. The operator presses this button at preset intervals to reset the alarm.



Engineers Safety Reset/Calling Box

9.5 Power management system

The power management system (PMS) is an intelligent system that can manage both conventional marine power plants for merchant vessels, and complex power generation systems for offshore vessels.

It has the following main features.

- The PMS can manage multiple-segment power plants and ring bus systems, up to a maximum of sixteen switchboards and up to four generators per switchboard.
- Purpose built equipment for engine control and safety, and for generator control and protection are available

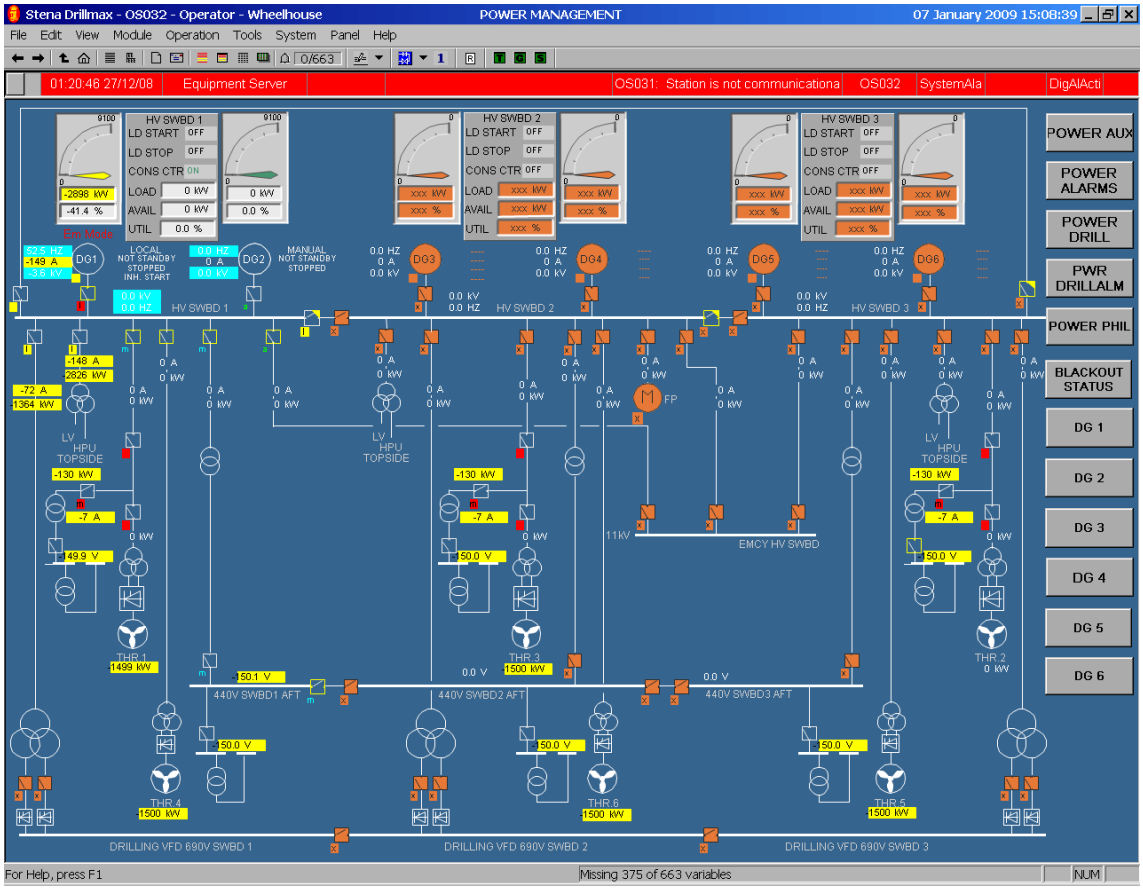
- Intelligent load control with ramp function
- Engine governor/automatic voltage regulator (AVR) failure detection with quick load reduction and trip. This is an optional feature
- Engine/Bus-tie trip detect with quick load reduction
- Bus-tie current compensating functions and advanced integration with the K-Pos, for optimal control of the electric propulsion plants.

9.5.1 The user interface

You can use the PMS process images to monitor and control the power generation system. The process image shows the whole power scheme, including the generators and the consumers. From this image you can monitor the power network; and operate the generators, switchboards and circuit breakers. Major power consumers are also shown.

Additional images showing the generator set and low voltage distribution can be viewed using the image navigator, or by clicking on hotspots in the process image.

A typical PMS process image is shown in the following figure.



The PMS application does the following high level functions:

- Diesel generator control
- Turbine driven generator control
- Shaft generator control
- Bus-tie breaker control
- Symmetric and asymmetric load sharing
- Consumer load control and limitation
- Integration with the K-Pos.

All power management monitoring and control functions are available to the operator at all K-Chief 700 operator stations.

The main input signals to the power management system are monitored for error conditions.

9.5.1.1 Diesel engine control

The diesel engine control application features the following functions:

- Remote start and stop
- Running hours computation
- Standby/priority selection
- Load-dependent start and stop based on kW and/or current
- Blackout start
- Standby start if an alarm occurs on the running generator
- Diesel auxiliary control
- Alarm suppression
- Exhaust gas deviation
- Optional engine safety protection
- Optional engine dynamic ramp control.

9.5.2 Power management philosophy

A dependable power source is essential during critical vessel operations such as dynamic positioning. The main function of the PMS is to safely, reliably, and economically manage the power generation systems on various types of vessels. It does so by using failure-proof power management strategies that provide high availability of power, under all working conditions.

PMS does the following:

1 Monitors the condition of every diesel engine/generator set, and starts up or shuts down specific generator sets, in response to alarm conditions.

2 Controls the load sharing of the generator sets.

3 Monitors the load on the grid and starts or stops engines and generator sets as required, to maintain sufficient power to the electrical equipment. This is done simultaneously with preventing unnecessarily high amounts of power from being connected to the grid.

4 Maintains sufficient power at all times for the operation of the thrusters to maintain position.

5 Does fast reduction of thruster speed and other loads if the generators are overloaded.

6 Does Ramp Control of heavy consumers, either by sensing bus frequency, or dynamic kW/sec, according to the number of generators online.

One of the core capabilities of the power management system is the ability to prevent power outages by preventing electrical power overload scenarios. It also has the capability to quickly cope with sudden overload situations due to unexpected loss or shutdown of the generators.

9.5.3 Control modes

The PMS enables remote control of the diesel generators, local control is done by the manufacturers of the diesel generator.

9.5.3.1 Remote control

The control mode provisions are given below.

- Remote control, automatic mode
  - Diesel generator control in standby
  - Heavy consumer control on
  - Load dependent start on/off
  - Load dependent stop on/off
  - Advice mode off
- Remote control, manually initiated
- The **Remote control, automatic mode** is the normal operation mode. All the equipment necessary to connect and disconnect a diesel generator to and from the main switchboard, is set for remote control.

9.5.3.2 Local control

For details regarding local control of the diesel generators or the main switchboard, refer to the documentation supplied by the generator set and main switchboard suppliers.

9.5.4 Modes of operation

Some examples of operational modes that are supported by the PMS are given in this section. It can also manage generators in operational modes other than that shown here. Transfer from one mode to another is done by remotely operating the breakers from PMS.

The following modes of operation are supported:

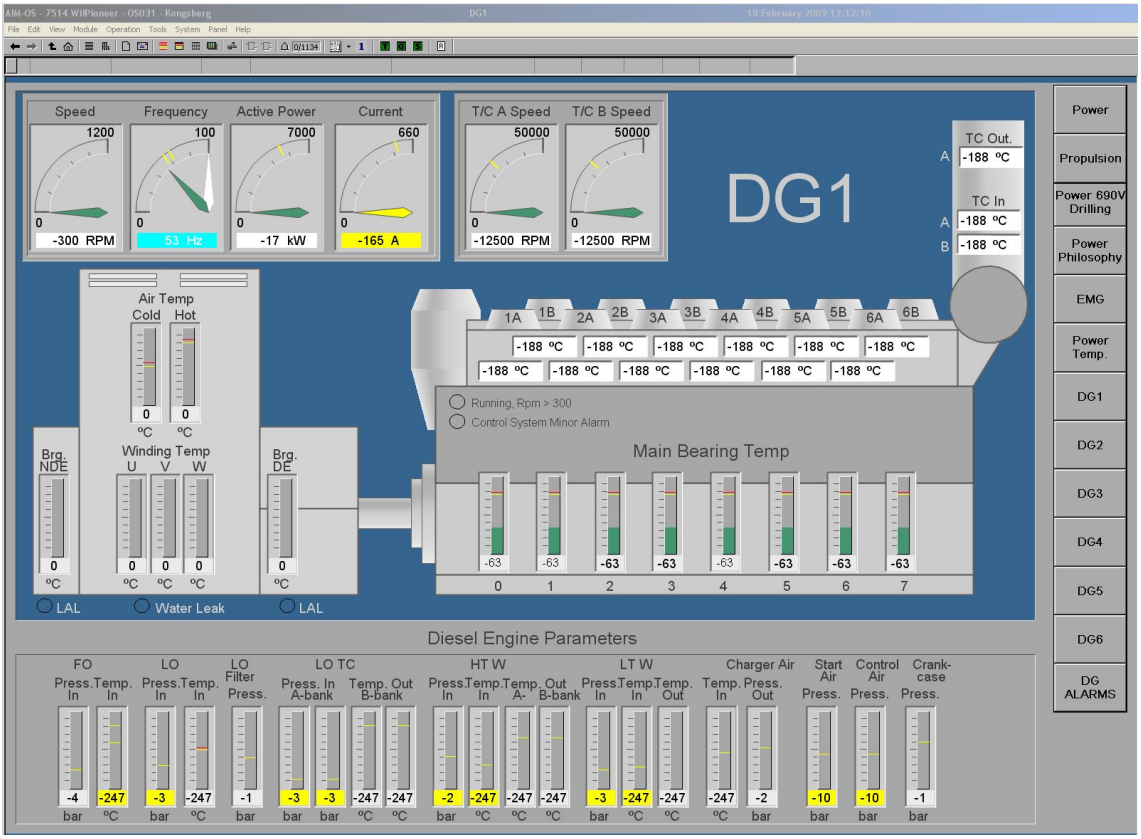
- Closed ring
- Open ring
- Two split.

9.5.5 Diesel generator control

The diesel generator control features the following functions:

- Monitors electrical parameters of the generators and buses
- Activates an external synchronisation unit
- Generator load sharing (balanced, unbalanced, fixed load, manual)
- Net frequency control
- Energy counter (MWh)
- Integration with the dynamic positioning system
- Isochronous/Droop mode selection (if applicable)
- Optional isochronous with MW/base load control
- Optional advanced generator failure management. This can detect and trip a faulty engine, with load reduction before tripping
- Fuelling management for dual/triple fuel applications.

A typical diesel generator control image is shown in the following figure:



9.5.5.1 Diesel generator start/stop

9.5.5.1.1 Diesel generator normal start

The diesel generator can be started by the following means:

- Manually initiated start
- Standby start initiated by the switchboard control system, on the following events:
  - Load dependant start
  - Heavy consumer start
  - Power outage in the main switchboard
  - Alarm start of standby generator due to the failure of a running generator.

Various stop and start modes are featured, such as:

- Alarm start
- Blackout Start
- Normal stop
- Safety stop.

9.5.5.2 Diesel generator start/stop inhibited

PMS can prevent diesel generators from starting or stopping under certain conditions.

9.5.5.3 Diesel generator connect/disconnect inhibited

9.5.5.3.1 Diesel generator connect inhibited

PMS can prevent diesel generators from connecting to or disconnecting from the bus under certain conditions.

9.5.6 Diesel generator alarm and monitoring

Alarms are shown in the diesel generator process images and in the power management process image.

9.5.6.1 Diesel generator exhaust gas deviation

The exhaust gas temperatures are monitored by PMS. Alarms are given in the exhaust gas temperatures exceed the set thresholds. If the deviation exceeds the alarm limit, the diesel generator with the next standby priority is alarm started.

9.5.6.2 Diesel generator alarm suppression

The alarms are inhibited when the diesel generator is disconnected, stopping or stopped.

9.5.7 Consumer load control

The consumer load control monitors the consumer loads and the available power.

The consumer load control provides the following functions:

- Blackout prevention
- Blackout recovery
- Blackout restart of auxiliaries
- Heavy consumer control
- Load shedding (preference tripping)
- Circuit breakers, and bus-tie breaker control
- Load transfer for bus-tie breaker disconnection
- Main switchboard alarm and monitoring.

9.5.7.1 Blackout prevention

Blackout prevention is a strategy used by the PMS to prevent blackouts due to spikes in heavy consumer loads, that overload and trip the running generators. This strategy regulates the

consumption to prevent the generators from being overloaded. The sections below give more information on the blackout prevention strategy.

9.5.7.1.1 Power reduction by the K-Pos system

The K-Pos system limits the thruster RPM if the load on the corresponding bus section exceeds a preset limit. This function is available in both the dynamic position mode as well as the manual thruster control or joystick control mode.

9.5.7.1.2 Integration with the K-Pos

The K-Pos system and the PMS communicate over the dual network. The PMS takes the reserved load on the generators into consideration when sending the maximum load available for each generator to K-Pos. For example if a generator is in manual mode, then the instantaneous load on the generator is considered to be the maximum load for that generator. K-Pos calculates and uses the correct amount of power in different power availability scenarios. When one or more thrusters are set to manual lever control, the blackout prevention system is not in operation for these thrusters. The function is disabled, for quicker response to commands given by the manual lever control. The PMS blackout prevention can operate in the manual mode.

9.5.7.1.3 Dynamic thruster bias

Sea conditions such as large swells can cause heaving. This causes large fluctuations in the thruster load as the thrusters engage cyclically to hold the vessel in position. To flatten the fluctuation, a bias value is added to the thruster load demand. The bias is dynamically calculated, with input from the total electrical loads on the power generation equipment, and from environmental conditions. This type of load control is also called the constant power mode.

9.5.7.1.4 Power limitation/load reduction

The power limitation/load reduction function prevents generators from tripping because of overload. The system calculates the maximum allowed load for the different consumers. The following functions are included:

- Limitation of consumers load increase based on available bus capacity
- Load reduction based on average bus load
- Load reduction based on individual generator load
- Load reduction based on individual generator current
- Load reduction based on bus frequency

- Load reduction based on generator/bus-tie breaker/interconnection breaker trip.

To prevent overload and blackouts when the load increases quickly, the load reduction function must respond instantly. The function modules of the power limitation/load reduction system are executed at 10Hz and the necessary I/O signals are monitored at the same scan rate.

9.5.7.1.5 Standby start

The Diesel generator standby start is described in the section *Load dependent start and stop* on page 93.

9.5.7.1.6 Load shedding (preference tripping)

This feature is normally not required, due to the rapid load reduction function for heavy consumers. Load shedding can be implemented if necessary.

Load shedding can be done when the following conditions occur:

- Low frequency readings in the main switchboards
- High current in the main switchboards
- Lack of, or very low, spare capacity on the main bus.

9.5.7.1.7 Splitting the main switchboards

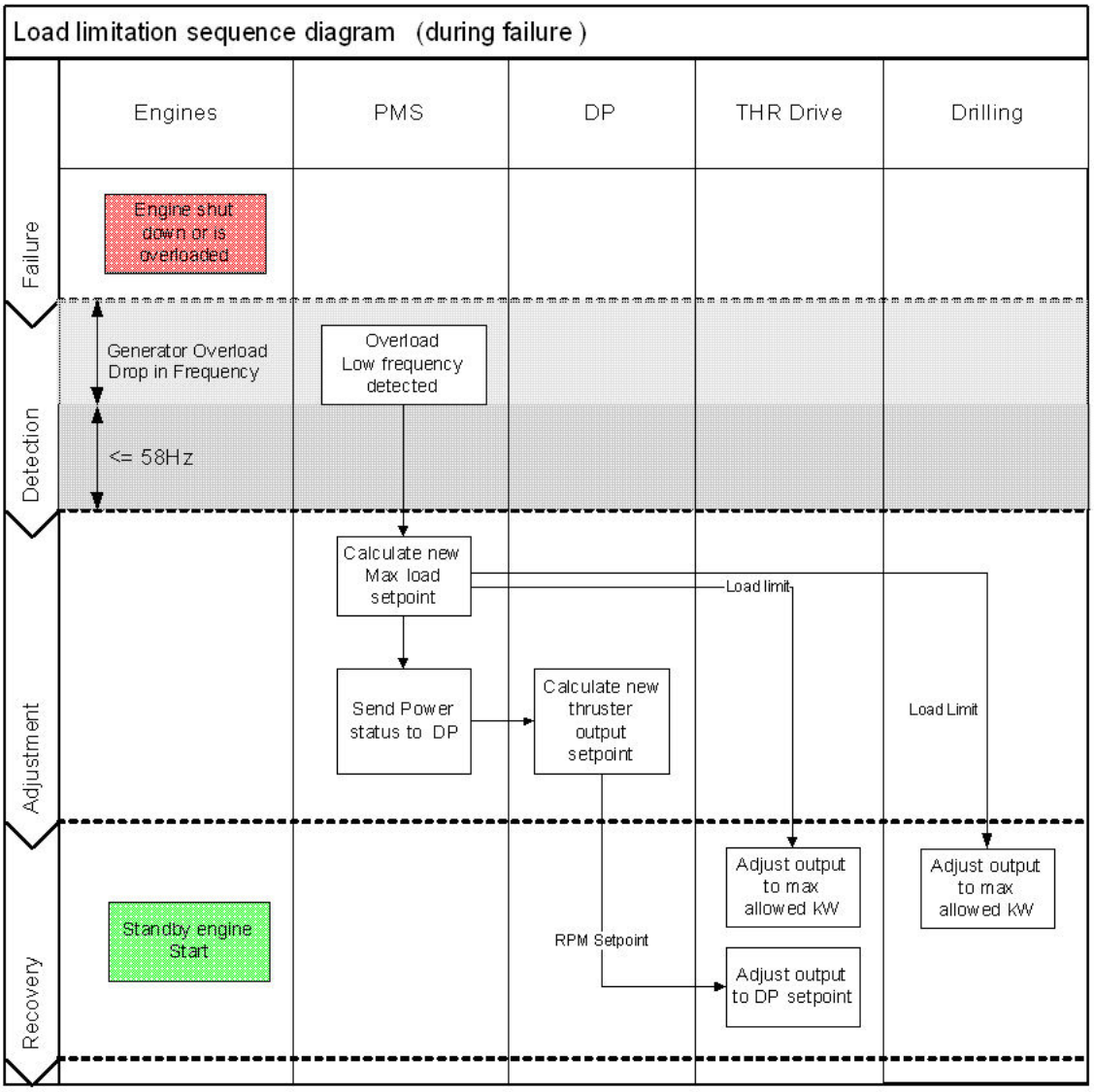
Splitting the main switchboards is applicable only when the port and starboard switchboards are connected together. The interconnection breakers are opened to make the split. If low frequency is read on the main switchboards, the port and starboard side are separated, and act as two independent switchboards. This is to prevent loss of all the generators, and limit the extent of the blackout.

9.5.7.2 Blackout prevention summary

Large consumers with variable loads require control of the rate of load increase, and load limitation. This is to prevent generator overload when the loads increase. These consumer loads must be reduced when loads from other consumers increase, or if a generator goes offline.

9.5.7.2.1 Load limitation sequence

The load limitation sequences are triggered by various events, such as a drop in the generator frequency, or a very large increase in consumer load. The following figure shows the sequence of events in the power limiting system; from when a failure is sensed, to the recovery from the failure.



9.5.7.2.2 Consumer load increase rate control

The PMS can control the rate of increase of the consumer load. This rate, or ramp, is automatically adjusted by sensing the frequency of the bus. The rate of change ramp can be applied to various heavy consumers. A fixed kW/Sec limit can also be applied. This allows heavy consumers to make faster demands on the power grid when there is spare power capacity available.

9.5.7.2.3 Dynamic kW/Sec

The power available limit signal can be ramped up, based on the load up parameters for the engines, and the number of generators online.

9.5.8 Blackout recovery

9.5.8.1 Blackout recovery of the main switchboards

The available standby diesel generators are started when a blackout is sensed. The diesel generator designated the **First to start** is started up, synchronized, and connected to the main switchboard. The diesel generators that are next in line automatically synchronize, according to a sequence list. If a failure occurs, the next diesel generator is started and synchronized automatically. If another blackout in the main switchboard is sensed within a preset time after the first blackout, the recovery sequence is abandoned.

9.5.9 Load sharing

PMS supports the following load sharing methods:

- Isochronous load sharing
  - Base load functions
- Compensated droop load sharing
- Symmetric load sharing
- Asymmetric load sharing
- Fixed load sharing
- Manual load sharing.

9.5.10 Advanced generator failure handling

The AGFH utility continuously compares measured values with expected values derived from an internal model. AGFH actively manages generators that deviate from the internal model. AGFH can handle failures in generators in compensated droop, fixed droop and isochronous modes. Generators in the different asymmetric load sharing modes are also handled. This includes asymmetric loading (base load/MW control), when the load sharing is controlled by an external system in fixed droop or isochronous mode.

AFGH has two main functions:

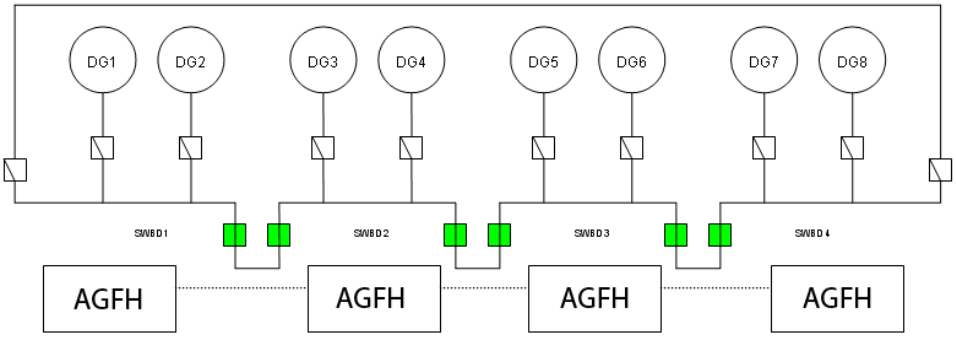
- Monitoring the speed control system, called active load sharing
- Monitoring the voltage control system, called reactive load sharing.

The two functions are combined and compared to an internal model, to sense the engine with the fault condition. AFGH gives an alarm if a faulty generator set is sensed. Every switchboard segment is equipped with its own AFGH, which can work in either droop or isochronous mode. If the difference between the

internal model and the response is larger than the deviation limit, AFGH trips the faulty generator. Some error conditions can also trip the tie breaker.

The following errors in speed control system are sensed:

- Generator is not generating the necessary power, this can be caused by governor failure or a clogged fuel filter.
- Generator is generating too much power, this can be caused by governor feedback failure.
- Generator power does not vary proportionally with the fuel rack position.



9.5.10.1 Monitoring the speed control system

AFGH does failure analysis on the power and frequency, caused by faults in the speed regulator/governor. It continuously compares the internal load sharing set points and estimated values from the internal model with actual measurements from the generators and switchboards. The bus-tie breakers are not tripped to detect the faulty generator set. The PMS does a load reduction on the heavy consumers if necessary, before tripping the generator breaker for the faulty engine. There is no transient overload placed on the other generators when the generator breaker is tripped. This reduces the unnecessary tripping of generators and power blackouts.

9.5.10.2 Monitoring the voltage control system

AFGH does failure analysis of the automatic voltage regulator (AVR). It checks for voltage transients, and continuously compares the relationship between kW and the KVAr readings against the internal voltage droop curve. The droop curve compensates for different power factors. PMS trips the generator if it does not correspond with the internal model.

The following errors in the AVR are sensed:

- Over-excitation
- Under-excitation
- Loss of excitation.

The advantage of AFGH is that the unnecessary tripping of generators and power blackouts are greatly reduced.

9.5.10.2.1 Software structure

The software has a separate module for each switchboard segment. These modules share information so that all the modules are updated with the condition of the power plant and the tiebreakers.

9.5.10.2.2 Hardware structure

The AFGH can be integrated in the power management controllers or be implemented in a redundant controller.

9.5.10.3 Bus-tie trip function

If the frequency on the switchboard continues to drop after the faulty generator is tripped, PMS splits the switchboards when the low-frequency setpoint is reached.

9.5.11 Heavy consumer start control

The heavy consumer control function monitors the bus and generator status. The start up restrictions are based on the spare capacity of the bus and/or the number of generators connected to the bus. The heavy consumer control function monitors for startup restrictions of each heavy consumer, requesting standby generators if necessary.

9.5.12 Load dependent start and stop

The PMS controls the number of diesel generators connected to the main switchboard. This makes sure that the load is supplied by an optimal number of diesel generators. This is done to achieve a safe limit of available power output in case of a fast load increase if one of the generators are tripped. This also improves energy efficiency and fuel economy. The load dependent start/stop function is normally based on the percentage load of the generators online. A load dependent stop is done if necessary. If the power plant is running in a split busbar configuration, the load dependent start/stop function independently controls the number of diesel generators on each side.

9.5.13 Shaft generator control

The PMS can manage shaft generators (SG), which can be used in parallel with normal diesel/turbine driven generators or as standalone units.

Shaft generator control can be implemented from the PMS, with or without main engine speed control. However, for both alternatives, the main engine must be set to fixed speed, not combinatory, before the SG can be connected to the bus.

The following shaft generator control description is based on a SG with main engine speed control implemented.

9.5.13.1 Manual control functions

The control functions available at the operator stations, when the shaft generator control function is in the manual mode, are as follows.

- Generator connect/disconnect
- Manual load sharing.

9.5.13.2 Automatic control functions

The control functions available at the at the operator stations, when the shaft generator control function is in the automatic mode, are as follows:

- Automatic frequency control
- Fixed load
- Symmetric load sharing
- Maximum shaft generator load.

9.5.14 Turbine driven generator control

Gas turbine driven generators (GTDG) can be managed by the PMS. The functions that are available for a GTDG are as follows:

- Manual control functions
  - Generator connect/disconnect
  - Frequency/load sharing
- Automatic control functions
  - Speed/Net frequency adjustment
  - Fixed load
  - Symmetric load sharing
  - Asymmetric load sharing
  - Load control
- Safety functions
  - Shut down.

Optionally, generator control, including start and stop sequences, can be included in the PMS. This is an application that is dependent on the installation, and can be customized.

9.6 Machinery control

The machinery control application enables control and monitoring of pumps, compressors, valves, reservoirs and tanks that make up the various auxiliary subsystems onboard a vessel. Because these subsystems vary in different vessels, the machinery control application is divided into functional areas which can be configured to suit most vessel requirements.

The machinery control application provides the following:

- Fuel oil control
- Lubrication oil control
- Cooling water control
- Potable and fresh water control
- Compressed air control
- Bilge control
- Boiler control/monitoring.

These applications are usually operated at one of the operator stations in the ECR. Operation may be performed from one of the other OSs, provided it has control over the proper command groups.

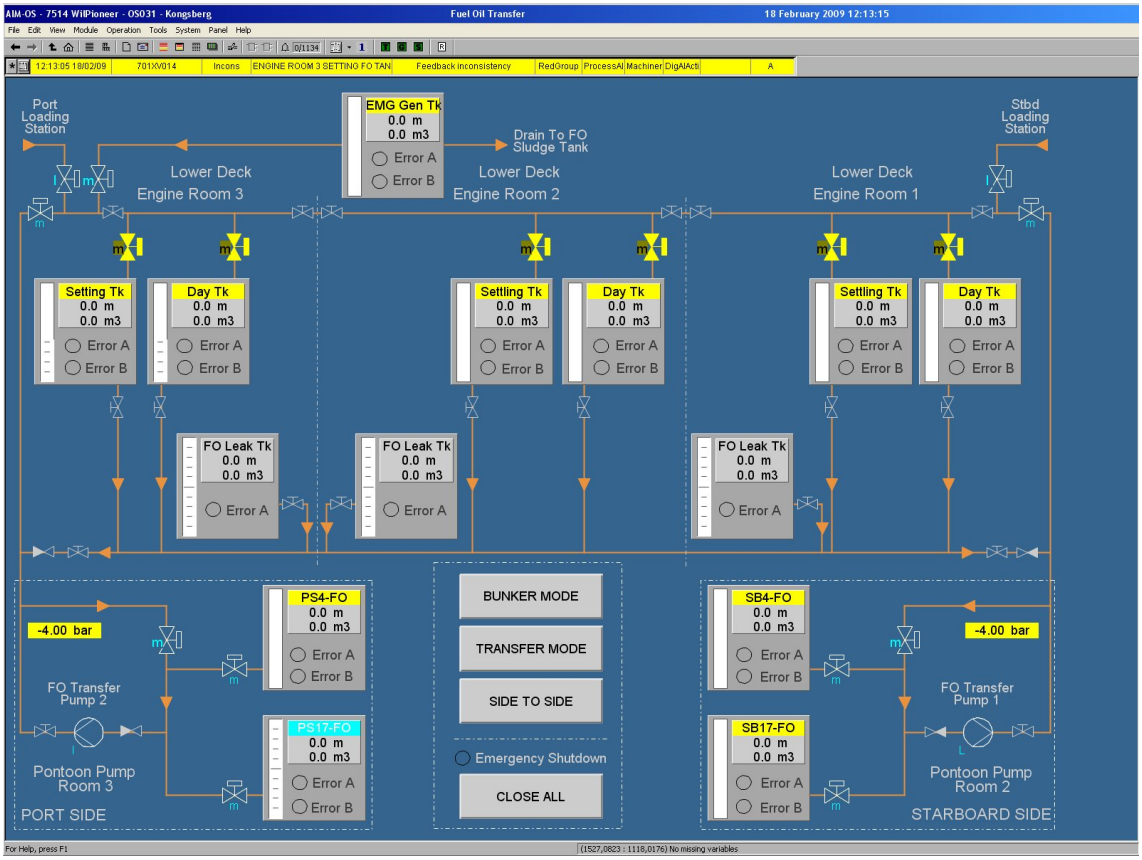
Depending on the configuration, one or more process images may be configured and viewed, and accessed by means of navigation or hot spots, one for each process image of the system.

9.6.1 Fuel oil control

The fuel oil control application is a monitoring and control facility that monitors and controls the:

- Fuel oil supply system
- Fuel oil transfer system
- Fuel oil purification system.

The process image shows the fuel oil system, as shown in the figure that follows.



9.6.1.1 Fuel oil supply

The fuel oil supply system is normally represented by one or more process images, that include all the generators and main engines. The images include the processes for the supply and distribution of heavy and light fuel oil from day and service tanks, to the auxiliary and main engines.

The fuel oil supply system usually provides functions for:

- Supply and circulation pump control
- Isolation and direction selection valve control
- Viscosity and temperature control
- Tank level and content monitoring
- Fuel oil pressure and temperature monitoring.

9.6.1.2 Fuel oil transfer

The fuel oil transfer system is normally represented by a single process image that represents the entire vessel. The image includes the processes for the transfer distribution of heavy and light fuel oil from storage tanks to day and service tanks.

The fuel oil transfer system usually provides functions for:

- Transfer pump control

- Isolation valve control
- Tank level and status monitoring
- Fuel oil temperature monitoring.

9.6.1.3 Fuel oil purification

The fuel oil purification system is normally represented by a single process image that displays the circulation of heavy and light fuel oil from the day, and service tanks, through the purifiers.

The fuel oil purification system usually provides functions for:

- Circulation pump control
- Isolation and direction selection valve control
- Purifier and purifier sludge tank status monitoring
- Fuel oil temperature monitoring.

The image displays measurement, tank valve and pump modules, together with various static symbols that are interconnected by means of piping.

9.6.2 Lubrication oil control

The lubrication oil control application is a monitoring and control facility, controlled by the Integrated Control System. It monitors and manages the:

- Lubrication oil circulation system
- Lubrication oil purification system.

9.6.2.1 Lubrication oil circulation

The lubrication oil circulation system is normally represented by a process image that represents the circulation of lubrication oil from sumps and gravity or seal tanks to generators, thrusters and main engines. The lubrication oil circulation system usually provides functions for:

- Prelubrication pump control
- Isolation valve control
- Lubrication oil temperature control
- Sump/tank level and status monitoring
- Lubrication oil pressure and temperature monitoring.

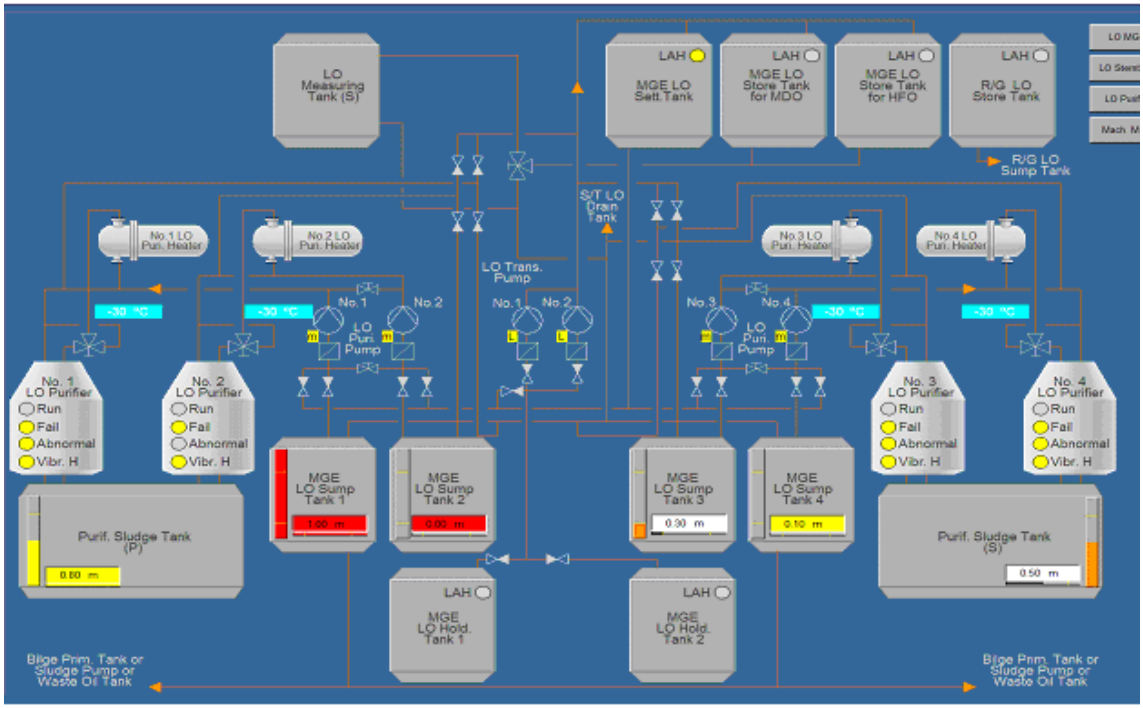
9.6.2.2 Lubrication oil purification

The lubrication oil purification system is normally represented by a process image displaying the circulation of lubrication oil from the drain tanks and sumps, through the purifiers and back to the main storage tanks. The lubrication oil purification system usually provides functions for:

- Circulation pump control

- Isolation and direction-selection valve control
- Purifier status monitoring
- Lubrication oil temperature monitoring
- Tank level and status monitoring.

A typical lubrication oil process image is shown in the following figure:



The image displays measurement, tank, valves and pump modules, together with various static symbols that are interconnected by means of piping.

9.6.3 Cooling water control

The typical systems monitored and controlled by the cooling water control application are the:

- Sea water cooling system
- Fresh water cooling system.

Normally, these two systems are represented separately, by single process images that display the entire vessel. However, for complex installations, they may be displayed in several images, e.g. one for the fore and one for the aft of the vessel. The process image shows the relevant water cooling system, you can open this image from the cooling water process image.

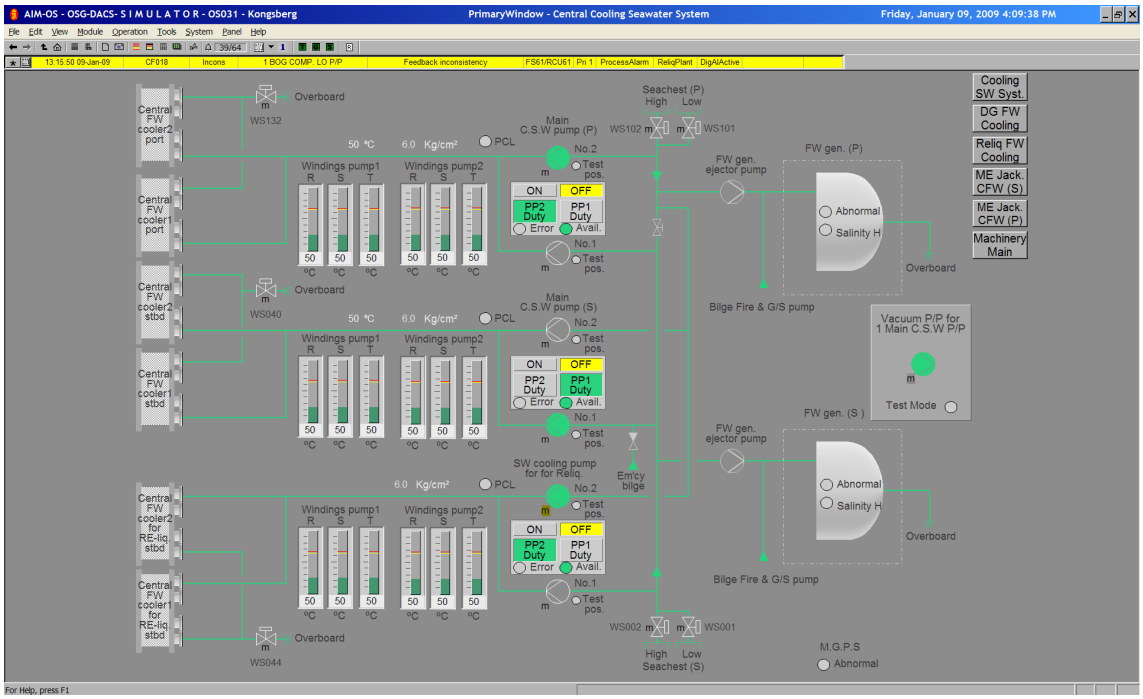
9.6.3.1 Sea water cooling system

The sea water cooling application is a monitoring and control facility that shows the onboard sea water system. The application normally shows the supply and distribution of sea water from the sea chests to the coolers of the vessel machinery such as generators, thrusters, main engine, scrubbers, steam condensers, deck services etc.

The sea water cooling application usually provides functions for the following processes:

- Sea chest selection and temperature control
- Sea water temperature control
- Supply and auxiliary pump control
- Isolation and direction selection valve control
- Sea chest and supply tank level monitoring
- Sea water pressure and temperature monitoring.

A typical sea water cooling process image is shown in the following figure:



The image displays measurements, coolers, valves and pump modules, together with various other static symbols.

9.6.3.2 Fresh water cooling system

The fresh water cooling application is a monitoring and control facility that displays the onboard fresh water cooling system. It normally shows the supply and distribution of freshwater from supply tanks to the coolers of the vessel machinery such as generators, thrusters, main engines, auxiliary systems etc.

The Fresh Water Cooling control usually provides functions for the following processes:

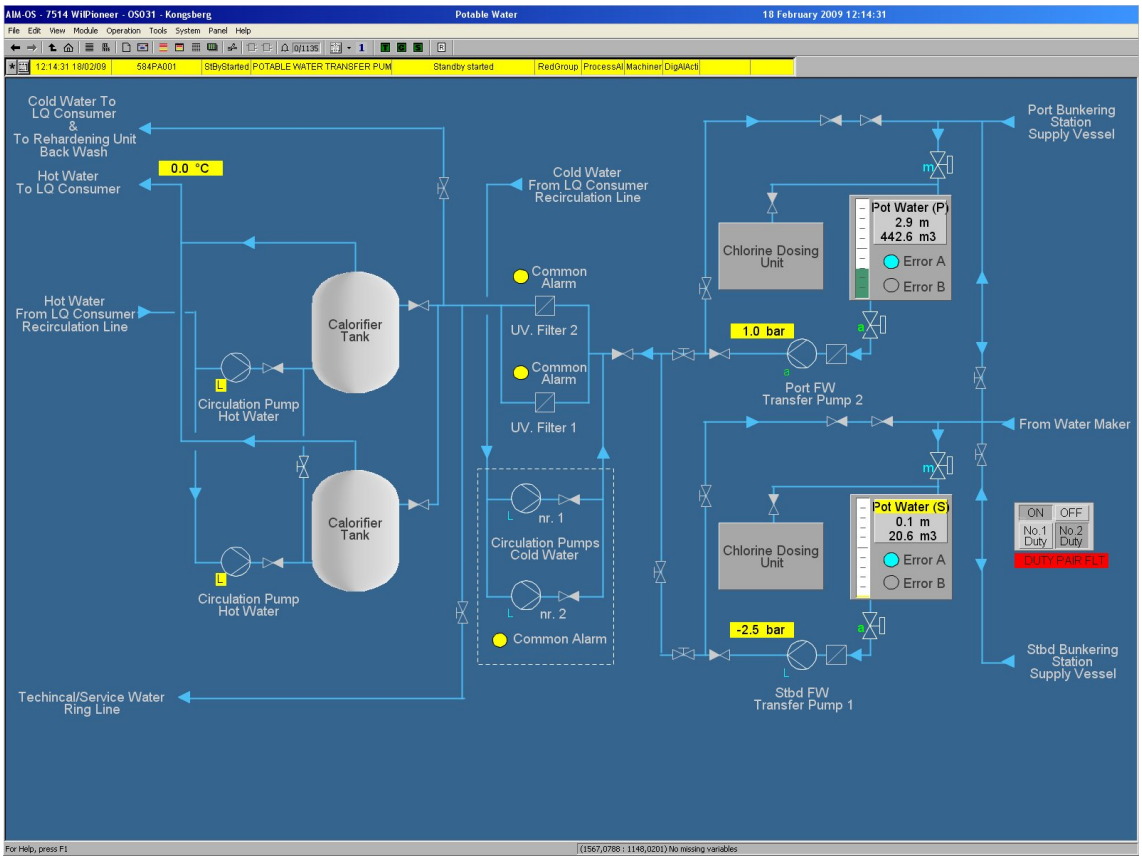
- Supply tank level monitoring
- Supply and auxiliary pump control
- Isolation and direction selection valve control
- Freshwater temperature control
- Freshwater pressure and temperature monitoring.

The image shows measurement, tank, valves, motors and pump modules, together various static symbols that are interconnected by means of piping.

9.6.4 Potable and fresh water control

The potable and fresh water control application is a monitoring and control facility for the onboard potable water system. The application normally monitors and controls the supply and distribution of potable and fresh water from supply tanks to the hydrophore tanks for ship services such as the gallery, toilets, showers, and washing facilities. The process image will also normally cover the supply, distribution and circulation of warm water.

The process image given below shows the potable and fresh water system.



The potable and fresh water control system usually provides the functions for:

- Supply tank level monitoring
- Potable and fresh water hydrophore and hot water circulation pump control
- Isolation and direction selection valve control
- Hydrophore water pressure monitoring
- Warm water temperature monitoring.

The image displays measurements, tank and pump modules, action buttons, and various static symbols interconnected by piping.

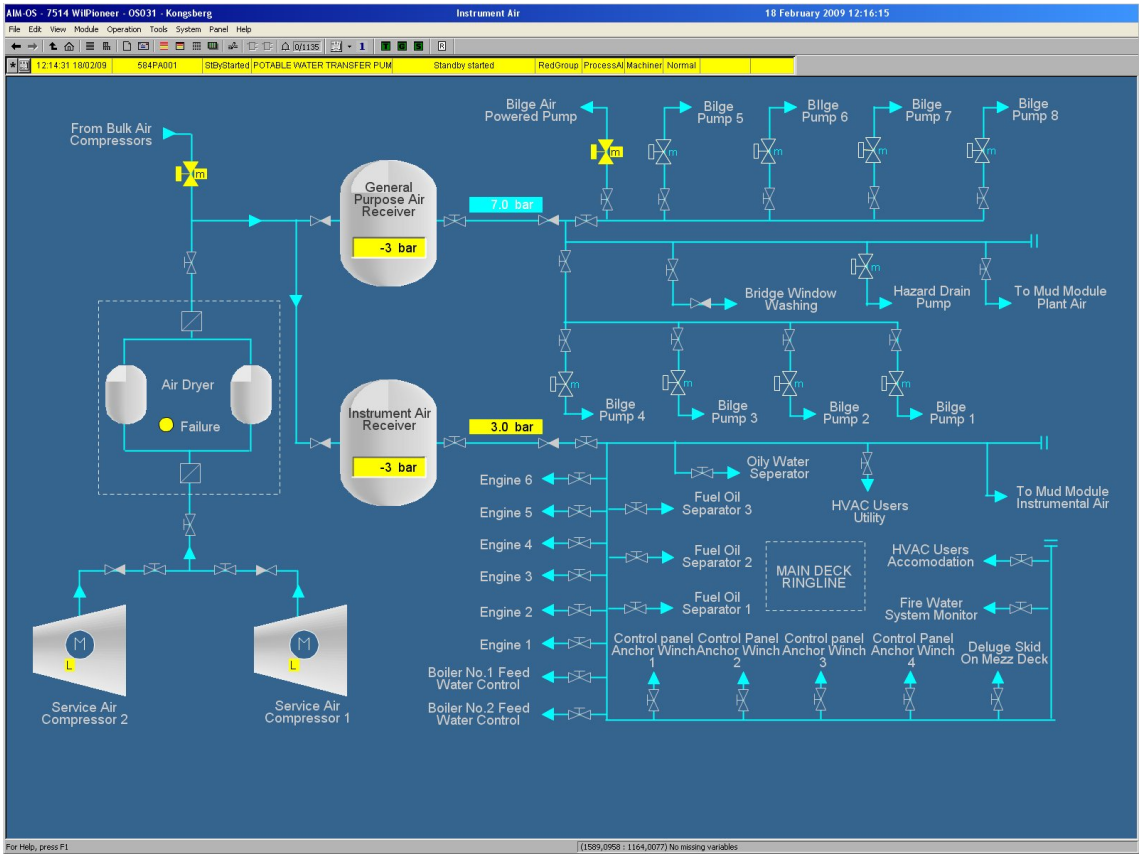
9.6.5 Compressed air control

The compressed air control application is a monitoring and control facility that monitors and manages the:

- Starting air system
- Control air system
- Working air system.

These systems may be represented separately, by single process images that cover the complete vessel. However, for relatively simple installations, all three systems can be represented by a single, common process image.

The process image shows the compressed air control system, you can access this image from the compressed air control process image.



The starting air system is normally represented by a process image that shows the production, storage and distribution of starting air for the main and emergency generators.

The starting air system usually provides functions for:

- Compressor control and status monitoring
- Pressure and reservoir status monitoring
- Isolation valve control.

The control air system is normally represented by a process image that shows the production, drying, storage and distribution of control air for the vessel.

The control air system usually provides functions for:

- Compressor control and status monitoring
- Air dryer status monitoring

- Pressure and reservoir status monitoring
- Isolation valve control.

The working air system is normally represented by a process image that shows the production, drying, storage, and distribution of compressed air for the vessel's store room, workshops, deck services etc.

The working air system usually provides functions for:

- Compressor control and status monitoring
- Pressure and reservoir status monitoring
- Isolation valve control.

The image displays measurement and compressor modules, valves and pump modules, and various static symbols interconnected by piping.

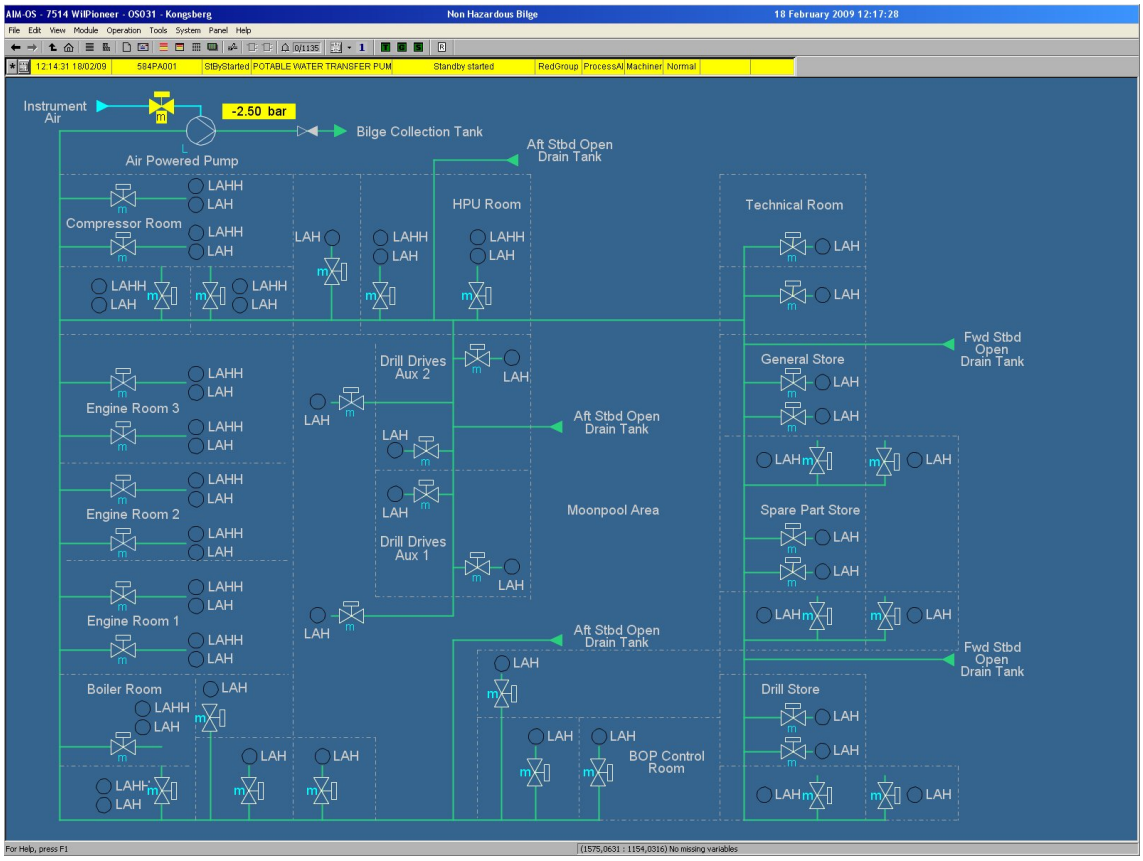
9.6.6 Bilge control

The bilge control application monitors and controls the bilge system. The controls may be located in the engine control room, pump room or in other places onboard the vessel. The configuration and functions of the bilge control depends on the vessel build, and the design and specification of the bilge system.

The bilge system can be controlled in either manual or automatic mode, both of which can be selected from the bilge process image.

- In manual mode, you can use the bilge process image to easily locate the bilge well in the alarm state. You can then take action to empty the bilge well, such as manually opening the appropriate bilge valve and starting the bilge pump.
- In automatic mode, the bilge control function automatically empties the bilge wells.

The following figure below shows a typical bilge process image.

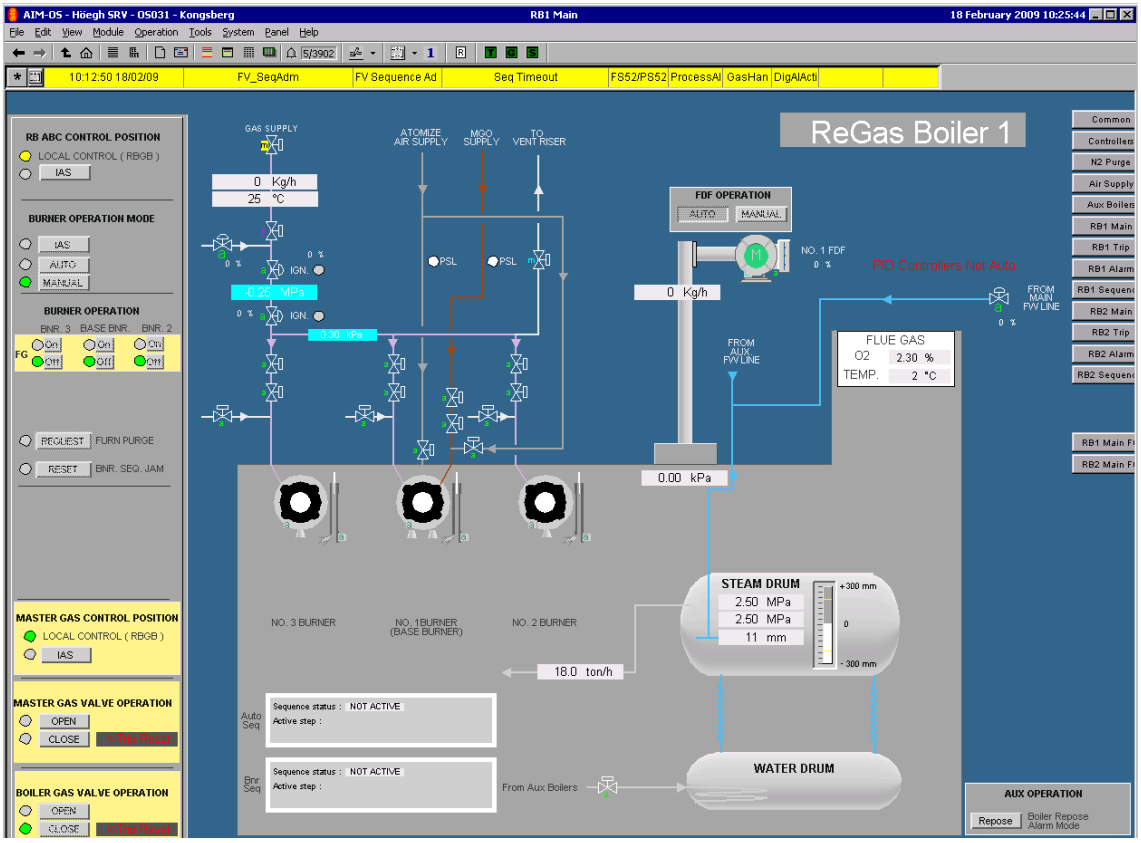


The image displays measurements, tank, valve, and pump modules, and various static symbols interconnected by piping.

9.6.7 Boiler control/monitoring

The K-Chief 700 system controls the boiler from the operator station in the ECR. However, monitoring is available from all the K-Chief 700 operator stations.

The process image shows the subsystem of the boiler control. You can view the image from the boiler control process image.



9.6.7.1 Control

The burner operation panel contains buttons to control sequences and indicator lights for feedback. The manual loader panel (MLP) manually controls the control valves.

The process image is divided into several areas, which display the various subsystems of the boiler control. The content of the process image depends on the type of boiler control.

The boiler control consists of a number of process stations/cabinets, normally one station/cabinet for boiler no. 1, one station/cabinet for boiler no. 2 and one common station/cabinet for both boilers. These communicate over the dual network to make a complete boiler management system. For safety, both boilers normally have a separate shutdown cabinet.

Some of the alarms and controls from the boiler auxiliary systems are connected to other process stations.

The main functions of the boiler control application are:

- Start/stop the burners
- Purge the gas lines with Nitrogen
- Fuel mode changeover
- Automatic burner control according to boiler load

- Automatic fuel oil (FO) boost-up in case of gas supply failure
- Drum water level control
- Steam temperature control
- Atomising steam pressure control
- FO pressure control
- Steam pressure control (including ratio control and combustion controls)
- Steam dump control
- Local panels with operation.

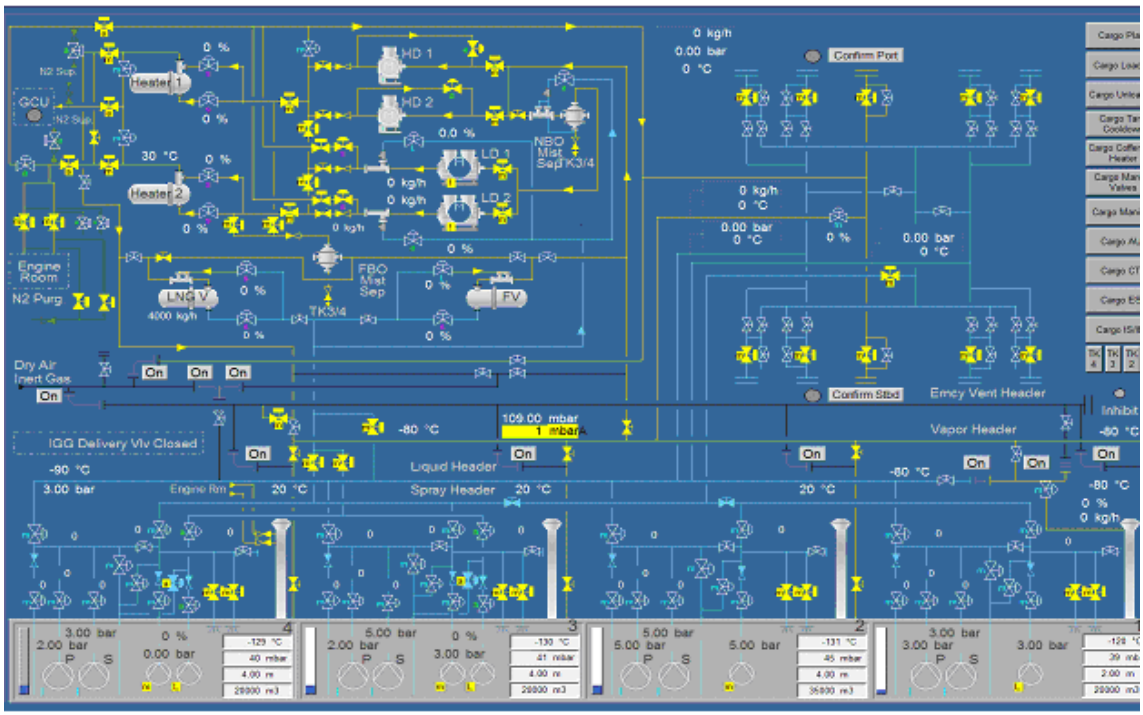
9.6.7.2 Monitoring

Boiler control is sometimes performed by the boiler manufacturer's control system. In these cases, the K-Chief 700 is interfaced to the boiler control, and performs monitoring and alarm annunciation.

9.7 Applications for LNG

K-Chief 700 features applications for controlling and monitoring liquefied natural gas (LNG) tankers. It also has specialised LNG applications such as process control for LNG reliquefaction, regas, and dual fuel systems.

The cargo control application provides control and monitoring for pumps, valves, compressors, heaters, vaporizers, and tank levels.



The K-Chief 700 cargo control application provides the following basic functions:

- Cargo pump load control
  - Loading sequence
  - Unloading sequence
  - Tank cooldown sequence
  - Cargo pump load control
  - Stripping/Spray pump load and pressure control
  - Emergency cargo pump control
  - Vaporiser control
- Gas Management, steam propulsion
- Anti-surge control
- Vaporising LNG
- Heater control system
- Gas management dual fuel (diesel electric propulsion)
- Gas management reliquefaction (diesel propulsion, low speed engine)
- Gas management reliquefaction/dual fuel
- Regasification.

9.7.1 Cargo handling

9.7.1.1 Loading sequence

The loading sequence does all the operations for loading the cargo tanks from the shore terminal, and returning the vapour back to shore terminal. All the pumps, valves, compressors and heaters are controlled by the sequence.

9.7.1.2 Unloading sequence

The unloading sequence is split into several sequences for each cargo pump. A sequence starts and stops other equipment like the HD compressors, heaters etc. The operator starts the pump, and the pump stops when the stop setpoint is reached.

9.7.1.3 Tank cooldown sequence

The tank cooldown sequence is used for cooling down the cargo tanks before loading. The spray pump in the tank with remaining LNG is used, and the cargo tanks are cooled down to the set temperature.

9.7.1.4 Cargo pump load control

The cargo pumps are controlled, to avoid over and under current due to different loading conditions.

9.7.1.5 Stripping/Spray pump load and pressure control

The stripping/spray pump load is controlled to avoid over and under current. The pressure on the stripping/spray header is also controlled.

9.7.1.6 Emergency cargo pump control

The emergency cargo pump load is controlled to avoid over and under current.

9.7.1.6.1 LD/HD compressor control

?.1 HD compressor

The HD compressors are of the fixed speed type, and the flow through the compressor is regulated by varying the position of the inlet guide vane (IGV). In remote mode, you can select the control input for the IGV. This can be either the flow controller, or the pressure controller.

Surge protection is done by the anti-surge controller. The anti-surge controller protects the compressor in both local and remote mode. The compressor can be operated in local or remote mode by the local/remote switch on the local control panel at the compressor skid.

?.2 Local mode

In local mode, you can use the controls in the local control panel to start and stop the compressor.

?.3 Remote mode

In Remote mode, you can use the controls in the cargo control application.

9.7.1.7 Vaporiser control

The LNG vaporiser is used for the following operations:

- Pressurizing the cargo tank
- Gassing up, after injecting inert gas to create an inert atmosphere
- Vaporising LNG for use in the boiler.

9.7.1.7.1 Cargo tank pressurizing

When the cargo is discharged to shore, and the terminal is unable to supply sufficient vapour to replace the volume of discharged cargo, the LNG vaporiser produces vapour to maintain stable pressure in the tank and vapour header.

9.7.1.7.2 Gassing up

Before cooling down cargo tanks prior to loading LNG, the inert gas should be replaced by natural gas vapour.

LNG is supplied from the shore to the vaporiser through the strip/spray line.

9.7.2 Gas Management, steam propulsion

The tank pressure is controlled by the LD compressor sending the Boil Off Gas (BOG) to the steam boilers. Depending on operational mode the LD compressor will follow the boiler demand (limited by high / low tank pressure) or by the tank pressure (excess gas mode). In addition to the BOG extra gas can be fed to the steam boiler by vaporizing LNG.

9.7.2.1 LD compressor

The LD compressors are either of the fixed speed, or the variable speed type. If they are of fixed speed type, the flow through the compressor is regulated by varying the position of the IGV. If they are of the variable speed type, the flow is regulated using a combination of IGV and speed control. The speed is increased when the IGV reaches a specific position.

The compressor capacity can be controlled by boiler demand, vapour header pressure (including high and low tank pressure protection), or constant flow.

Surge protection is done by the anti-surge controller. The anti-surge controller protects the compressor, in both local and remote mode.

The compressor can be operated in either local or remote mode, using the local/remote switch on the local control panel, near the compressor skid.

- Local mode

  In local mode, you use the push buttons in the local control panel to start and stop the compressor.
- Remote mode

  In remote mode, you use the start and stop buttons in the cargo control application.

9.7.3 Anti-surge control

The anti-surge control application is bundled with the hardware that controls the compressors, heaters and vaporisers.

The anti-surge control requires three measurements:

- Flow, represented as a differential pressure measured across an orifice flow element
- Compressor inlet pressure

- Compressor outlet pressure.

9.7.4 Vaporising LNG

When boilers are running in the gas-only mode, the LNG vaporiser controls the production of gas. Any available boil-off gas from the cargo tanks is also used by the boiler.

9.7.5 Heater control system

The LD/HD heater outlet temperature is controlled by a split range control by using the bypass valve and inlet valve.

9.7.6 Gas management dual fuel (diesel electric propulsion)

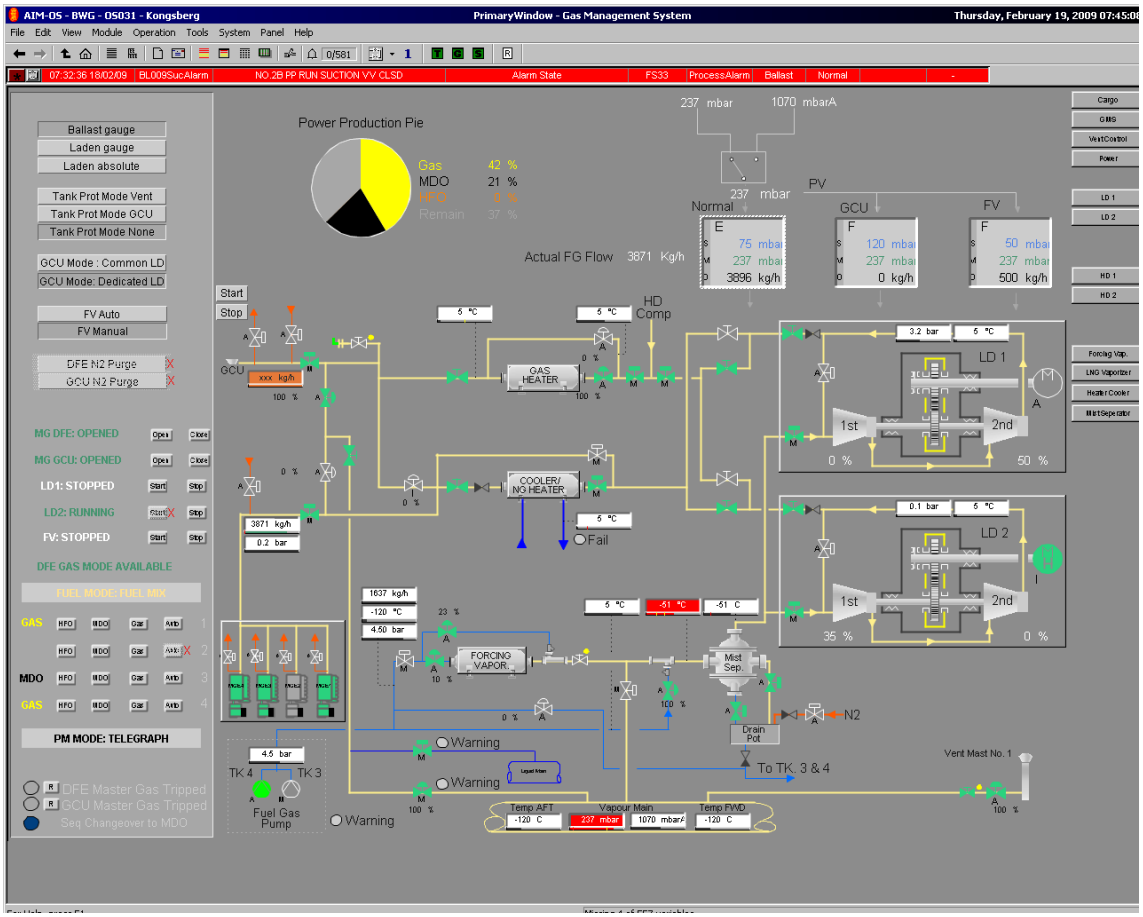
The K-Chief 700 gas management system (GMS) maintains the cargo tank pressure within normal operating limits. If the tank pressure exceeds the normal operating limits, a safety function reduces the pressure. An optimal operation function keeps the system operating in optimal conditions. The cargo tank pressure is controlled by the tank pressure controller, which calculates the normal boil off (NBO). The NBO values are used to calculate the gas loading for the dual fuel engines (DFE). In program mode, the electric propulsion load is calculated according to the tank pressure. The LD compressors supply gas vapour at a constant pressure to the DFE.

The GMS has a pressure relief valve which returns liquified boil off gas (LBOG) to the cargo tank. This valve opens to prevent the fuel supply equipment from high pressures that occur during large load reductions and anti-surge control operations. The forcing vaporiser (FV) is used to convert LNG to vapour, which is called the forced boil off (FBO). The FV can be used if gas-only fuelling, or if an increased gas loading is required. The gas combustion unit (GCU) controls the tank pressure by burning off gas if the tank pressure is above normal. An additional pressure control mechanism opens the vent valve to the mast to vent gas, reducing the tank pressure.

The main functions of the gas management system are:

- Tank pressure control
- Overall fuel mode controls
- Fuel supply control to the DF
- Gas supply control to the GCU
- Vent control
- Forcing vaporiser control.

The mimic in the following figure shows an example of the dual fuel gas management system.



9.7.7 Gas management reliquefaction (diesel propulsion, low speed engine)

The K-Chief 700 reliquifaction application does the process control for the reliquefaction plant. The Moss RS LNG reliquefaction system, for example, controls tank pressure by liquefying all the boil-off vapour from the cargo tanks during normal ship operations, protecting the cargo tanks from overpressure. The vapour pressure is normally maintained at between 3 to 12 kPag. The boil off gas (BOG) from the cargo tanks is collected in a header. The BOG is compressed in a three-stage centrifugal compressor, cooled and condensed in a large multi-stream heat exchanger, called a cold box. LNG and any non-condensable gases are separated in the separator. The reliquified LNG, called liquified boil off gas (LBOG) is returned to the cargo tanks by the differential pressure between the separator and cargo tank, the gas phase is vented, or routed to the GCU for burning. The reliquefaction system provides sufficient cooling capacity to absorb the heat ingress to the cargo tanks, the vapour header and LBOG piping, in addition to the heat introduced by the BOG compressor during normal operation.

The reliquefaction plant has the following equipment:

- Two BOG compressors, one duty and one standby
- Two N2 compressors, one duty and one standby
- One plate-fin heat exchanger
- One LBOG phase separator
- One LBOG forced return pump
- One nitrogen reservoir
- Two N2 booster compressors, one duty and one standby
- Auxiliary systems.

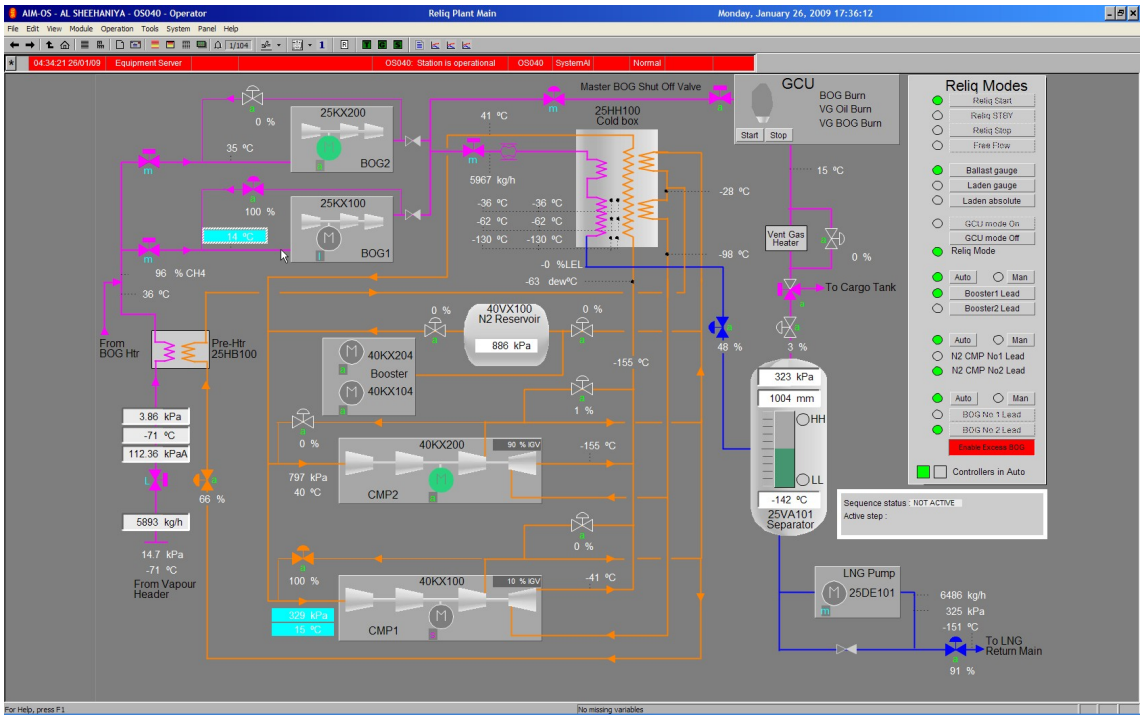
The main control functions for the BOG loop are:

- Tank pressure control
- Control of BOG compressor inlet temperature
- Control of the LNG level in the separator
- Control of the LNG pump discharge pressure
- Control of pressure in the separator
- Control of vent gas burning in the GCU
- Control of the cold box outlet temperature
- Control of the vent gas heater
- Control of the BOG compressor.

The main control functions for N2 loop are:

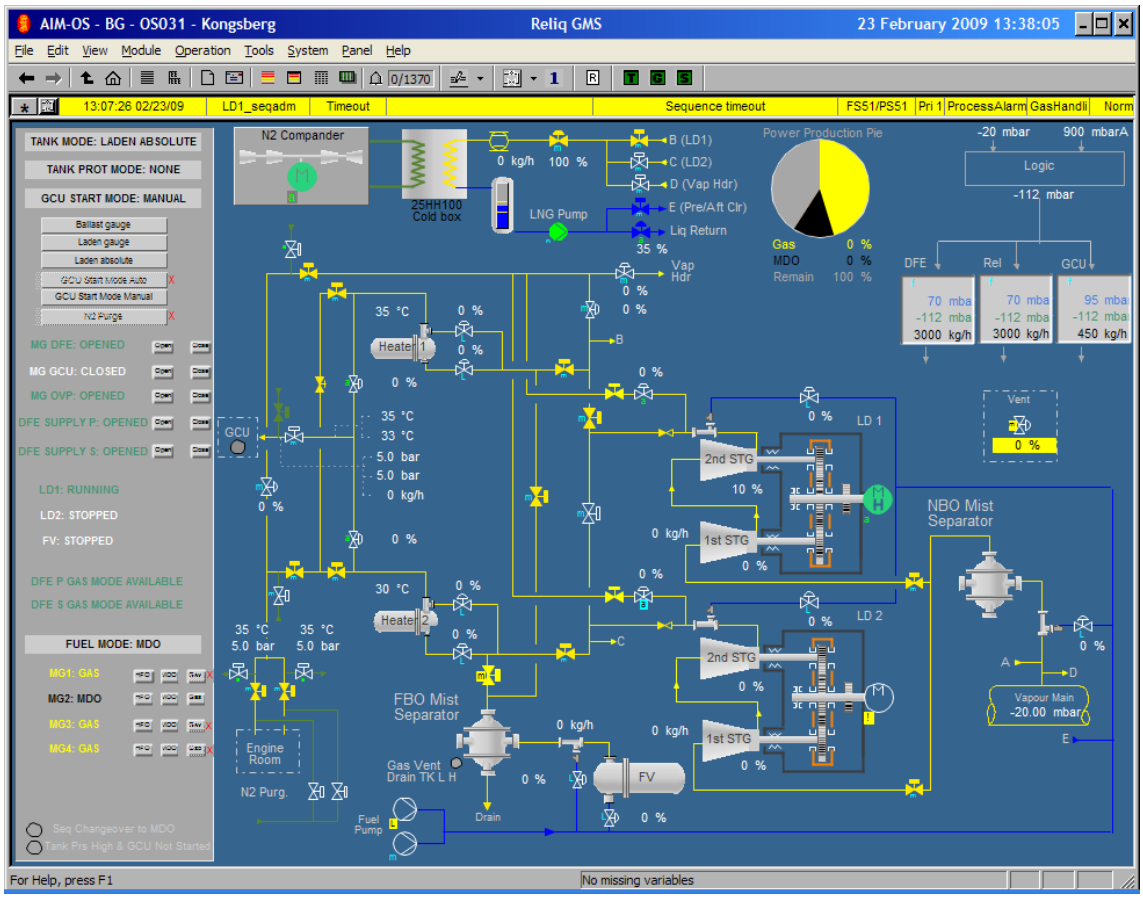
- N2 inventory control
- Coldbox inlet temperature control
- Control of the N2 compander
- N2 Booster control.

The mimic given in the following figure shown an example of a reliquefaction process image.



9.7.8 Gas management reliquefaction/dual fuel

In the reliquefaction/dual fuel application, the LBOG from the reliquefaction plant is used for cooling the gas vapour in the pre- and post-compressor stages. This application has all the benefits of both dual fuel and reliquefaction. Additionally, residual gas left in the tanks after offloading can be liquified, enabling the LD compressors to be started. The main engines can run on the residual gas, which is otherwise wasted by venting or burning in the GCU. In laden voyages, you can either reliquify the BOG, or use it as fuel for the main engines. In ballast voyages, the residual vapour in the tank can be liquified to obtain LBOG, which can be used as coolant for the LD compressor, enabling it to be started. Some of the residual vapour can be compressed to use as fuel. The mimic in the following figure shows a reliquefaction/dual fuel application.



9.7.9 Regasification

The K-Chief 700 regasification application does the process control for the regasification system. The main purpose of the regasification system is to produce gas from LNG stored in the cargo tanks. The regasification system can generate gas through a maximum of three skid-mounted units running simultaneously. However, any one these units can function on its own. A suction drum supplies subcooled LNG to the 3 units. LNG is pumped from the storage tanks (ST) to the suction drum (SD) by several LNG production pumps (PP), resulting in an SD operating pressure dependant on the pump output.

The low pressure LNG is pressurized by the booster pumps (BP) and vaporized in closed loop vaporizers heated by propane. The propane loop is heated by seawater.

The regasification system consists of the following equipment:

1 Suction drum

2 Pump/vaporizer skids, each skid contains:

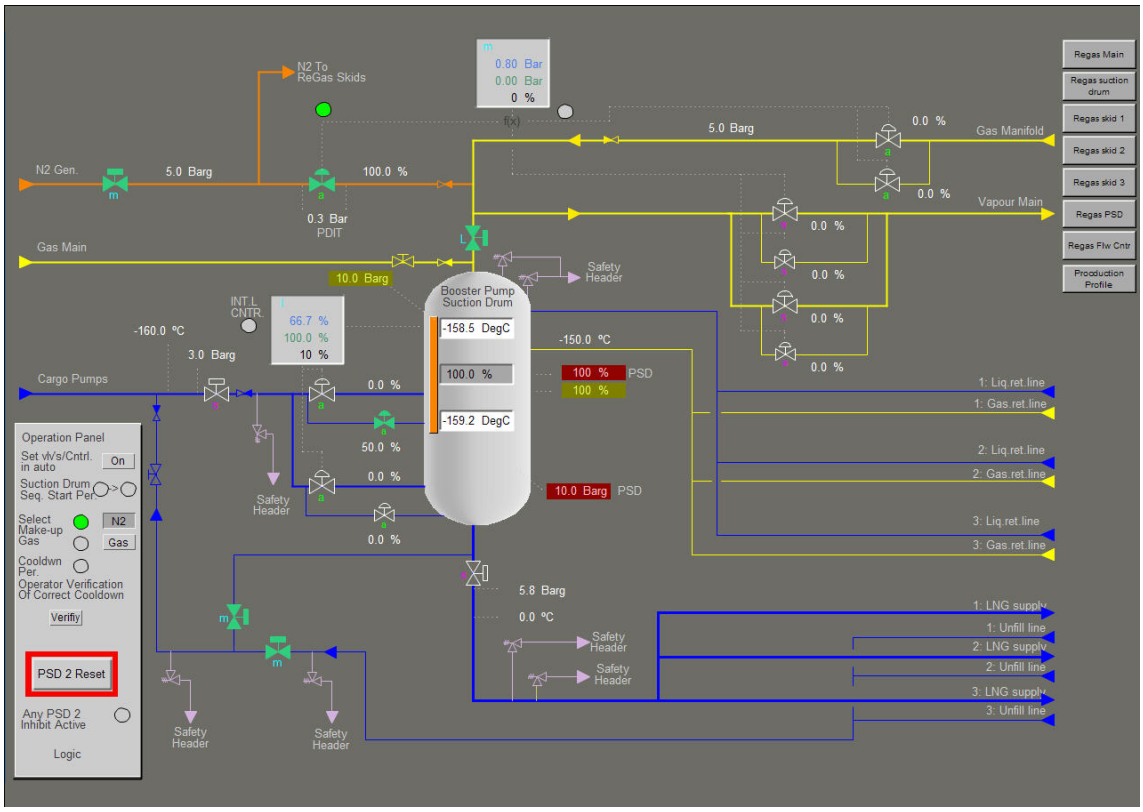
- High pressure booster pumps
- Heat exchanger

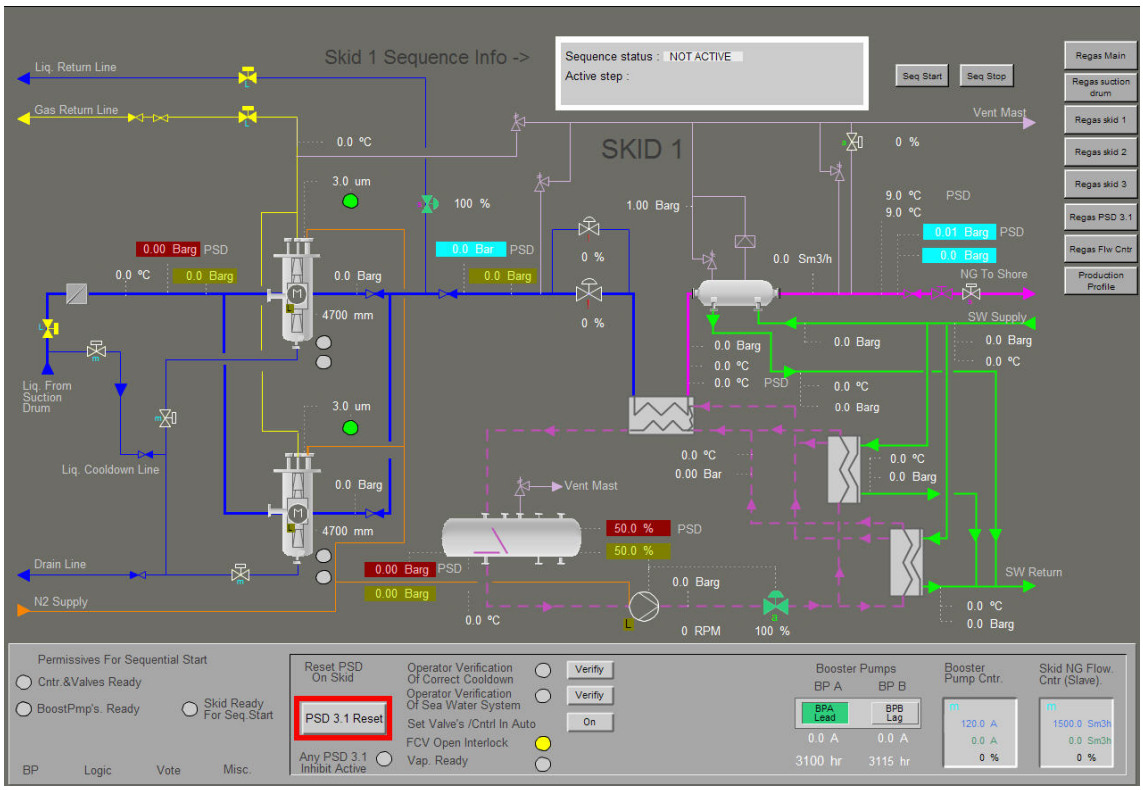
- Trim heater

The main control functions of the K-Chief 700 regasification application typically are:

- Voting of safety and control transmitters
- Pressure control of the suction drum
- High/Low protection level controller
- Recycle valve control
- Starting interlock for the booster pump
- Control of the second lead/lag booster pump
- Booster pump protection and shutdown
- Propane tank level control
- Propane pump throttle valve control
- Startup interlock for the vaporiser
- Vaporiser gas outlet low temperature protection
- Trim heater gas outlet low temperature protection
- Seawater return low temperature protection
- Skid flow (slave) control
- Regasification flow (master) control
- Sequential regasification startup sequence
- Sequential regasification stop-up sequence
- Process shutdown functions based on a visual cause and effect matrix.

The mimics given in the following figures show the top level process images for the regasification suction drum, and a regasification unit.


N2 To ReGas Skids
0.80 Bar
0.00 Bar
0 %
N2 Gen.
5.0 Barg
100.0 %
0.3 Bar
PDIT
5.0 Barg
0.0 %
Gas Manifold
Vapour Main
Gas Main
10.0 Barg
Safety Header
Booster Pump Suction Drum
INT.L CNTR.
66.7 %
100.0 %
10 %
-160.0 °C
3.0 Barg
-158.5 DegC
100.0 %
-159.2 DegC
-150.0 °C
100 %
PSD
100 %
10.0 Barg
PSD
Cargo Pumps
0.0 %
50.0 %
Operation Panel
Set vlv's/Cntrl. in auto
On
Suction Drum Seq. Start Per.
Select Make-up Gas
N2
Gas
Cooldwn Per.
Operator Verification Of Correct Cooldown
Verify
PSD 2 Reset
Any PSD 2 Inhibit Active
Logic
5.8 Barg
0.0 °C
1: Liq.ret.line
1: Gas.ret.line
2: Liq.ret.line
2: Gas.ret.line
3: Liq.ret.line
3: Gas.ret.line
1: LNG supply
1: Unfill line
2: LNG supply
2: Unfill line
3: LNG supply
3: Unfill line
Regas Main
Regas suction drum
Regas skid 1
Regas skid 2
Regas skid 3
Regas PSD
Regas Flw Cntr
Production Profile


Skid 1 Sequence Info ->
Sequence status : NOT ACTIVE
Active step :
Seq Start
Seq Stop
SKID 1
Liq. Return Line
Gas Return Line
Vent Mast
0.0 °C
3.0 um
100 %
1.00 Barg
0 %
9.0 °C
9.0 °C
PSD
0.01 Barg
PSD
0.0 Barg
0.00 Barg
PSD
0.0 °C
0.0 Barg
0.0 Barg
0.0 Bar
PSD
0.0 Barg
0.0 Sm3/h
NG To Shore
4700 mm
SW Supply
0.0 Barg
0.0 °C
0.0 °C
PSD
Liq. From Suction Drum
Liq. Cooldown Line
0.0 °C
0.00 Bar
Vent Mast
50.0 %
PSD
50.0 %
Drain Line
0.00 Barg
PSD
0.00 Barg
N2 Supply
0.0 °C
0.0 Barg
SW Return
0 RPM
100 %
Permissives For Sequential Start
Cntr.&Valves Ready
BoostPmp's. Ready
Skid Ready For Seq.Start
BP
Logic
Vote
Misc.
Reset PSD On Skid
PSD 3.1 Reset
Any PSD 3.1 Inhibit Active
Operator Verification Of Correct Cooldown
Operator Verification Of Sea Water System
Set Valve's /Cntrl In Auto
FCV Open Interlock
Vap. Ready
Verify
Verify
On
Booster Pumps
BP A
BP B
BPA Lead
BPB Lag
0.0 A
0.0 A
3100 hr
3115 hr
Booster Pump Cntr.
120.0 A
0.0 A
0 %
Skid NG Flow. Cntr (Slave).
1500.0 Sm3h
0.0 Sm3h
0 %
Regas Main
Regas suction drum
Regas skid 1
Regas skid 2
Regas skid 3
Regas PSD 3.1
Regas Flw Cntr
Production Profile

9.7.10 Loading sequence

The loading sequence is a complete sequence for loading the cargo tanks from the shore terminal or (loading), and returning the vapour back to shore terminal (offloading).

All the pumps, valves, compressors and heaters are controlled by the sequence.

9.7.11 Unloading sequence

The unloading sequence is split into several sequences for each cargo pump. A sequence starts and stops other equipment like the HD compressors, heaters etc. The operator starts the pump, and the pump stops when the stop setpoint is reached.

9.7.12 Tank cooldown sequence

The tank cooldown sequence is a complete sequence for cooling down the cargo tanks before loading. The spray pump in the tank with remaining LNG is used, and the cargo tanks are cooled down to the set temperature.

9.8 Cargo control - OSV

K-Chief 700 features standard applications for controlling and monitoring offshore support vessels (OSV). The level of automation may vary from basic semi-automated operation, to fully automated systems.

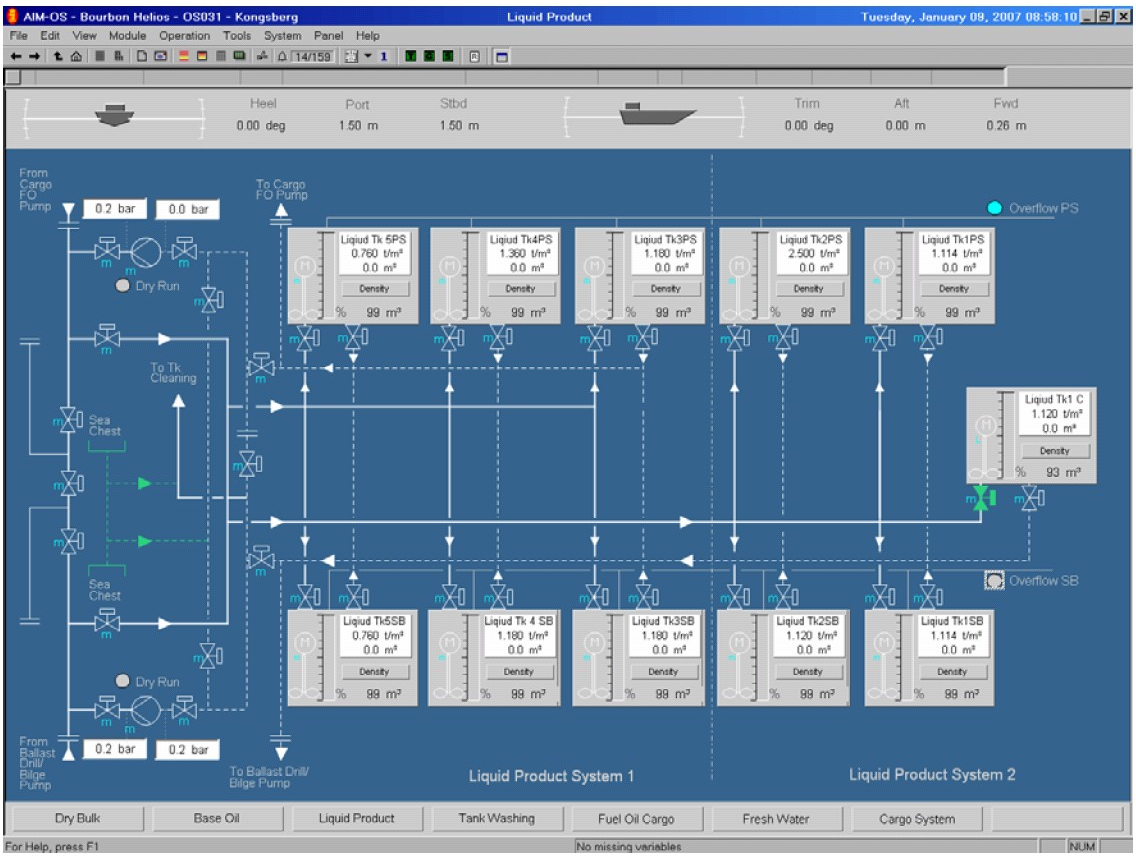
The KM cargo control application is made for controlling and monitoring various cargo systems such as:

- Liquid products (e.g. brine, mud, etc.)
- Dry bulk products (e.g. cement, etc.)
- Water products (e.g. fresh water, drill water, potable water, etc.)
- Oil products (e.g. fuel oil, base oil, lubrication oil, etc.).

9.8.1 Liquid products

A typical control and monitoring system for liquid products provides functions for monitoring tank levels, pump pressure and load, product flow, and control of remote operation of valves, pumps and agitators. The application would vary between vessels, and is shown here as an example only.

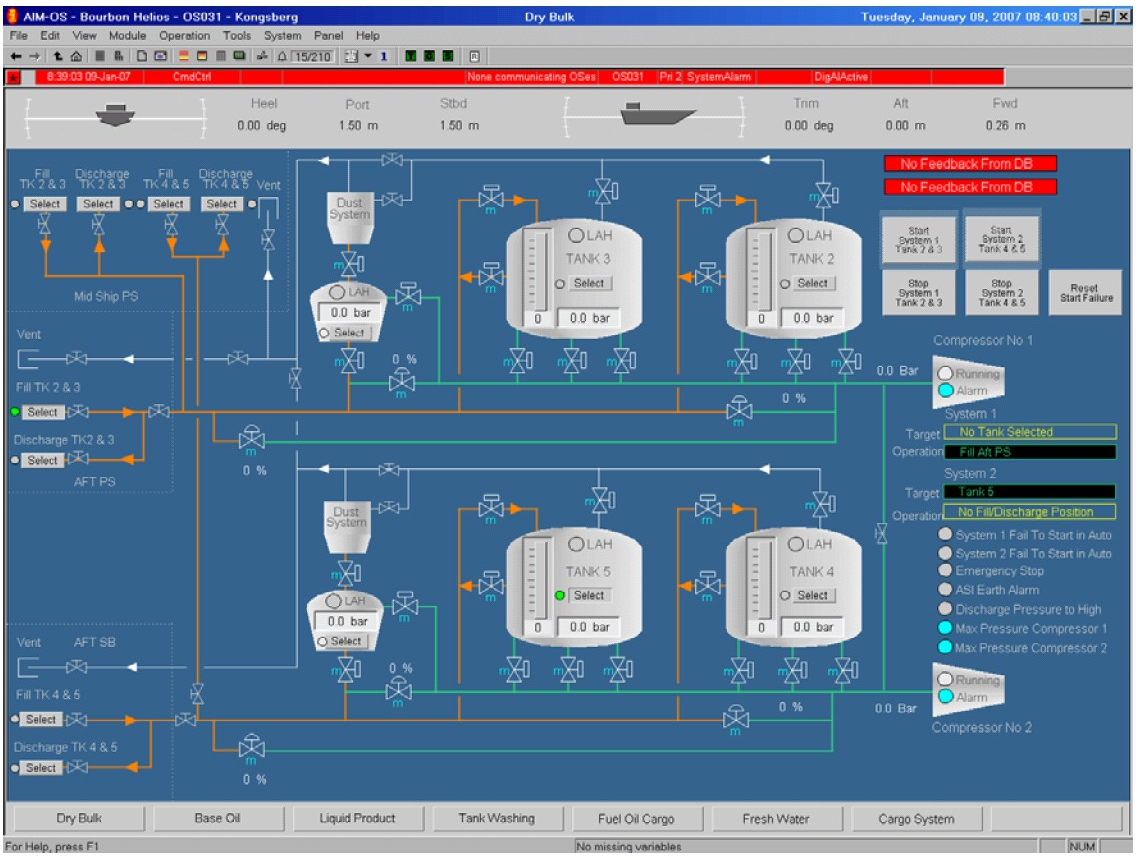
The following mimic shows the main mimic for a mud cargo system.



9.8.2 Dry bulk products

A typical control and monitoring system for dry bulk products provides functions for monitoring tank levels and weight, pump pressure and load, product flow, and control of remote operation of valves and compressors. The application would vary between vessels, and is shown here as an example only.

The following mimic shows the main mimic for a dry bulk cargo system.



9.8.3 Typical monitoring and control functions

Typical cargo control and monitoring functions are:

- Remote control of cargo pumps
  - Remote control of electric or hydraulic driven cargo pumps
  - Running hour counters
  - Speed/capacity control of cargo pumps
  - Safety protection of cargo pumps, tanks and pipes
  - Remote control of cargo stripping pumps or vacuum stripping system (crude oil/shuttle tanker).
- Remote control of valves
  - Remotely open/shut the on/off valves
  - Remote control of the positioning valves/throttle valves
  - Remote start and stop of the hydraulic power pack for valve control
  - Tank washing pump/valve control
  - Cargo heating control.

- Cargo tank level gauging
  - Tank level monitoring — from the tank radar gauge system, direct from the pressure sensor in the tank, or through the air purge system.
  - Tank levels are low-pass filtered at sea (no filtering in harbour)
  - Full integration with the K-Gauge tank gauging system
  - Tank volume and/or weight calculation (density input from the keyboard)
  - Tank temperature and inert gas pressure monitoring (if applicable)
  - High/HighHigh level alarms for alarm and stopping loading
  - Calculation of total cargo content (in m^3) (of different types of cargo, if applicable)
  - Trim/list correction of tank level/volume (trigonometric calculation)
  - Display of corrected data (level volume) from the load computer.

9.9 Cargo control - floating production, storage and offloading (FPSO) and shuttle tankers

K-Chief 700 features applications for controlling and monitoring FPSO and shuttle tankers.

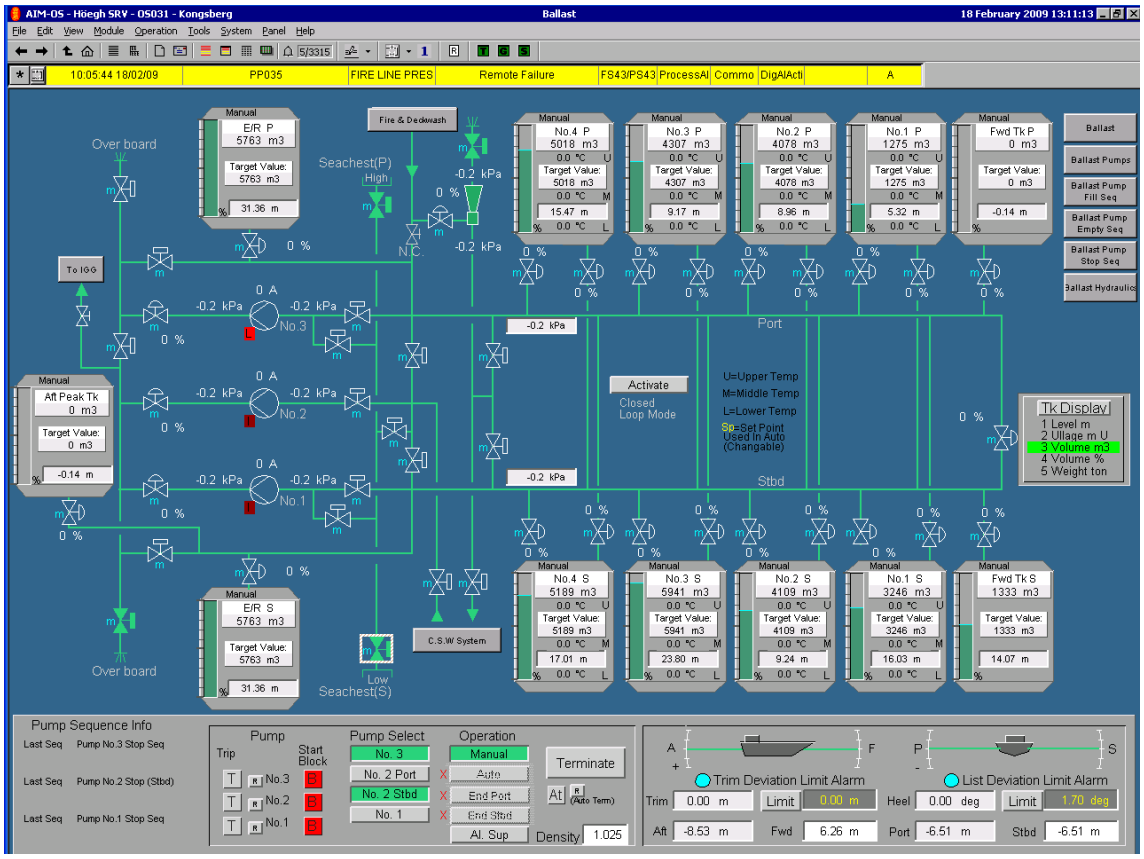
Typical cargo control and monitoring functions are:

- Remote control of cargo pumps
  - Remote control of electric- or hydraulic-driven cargo pumps
  - Running hour counters
  - Speed/capacity control of cargo pumps
  - Safety protection of cargo pumps, tanks and pipes
  - Remote control of cargo stripping pumps or vacuum stripping system (crude oil/shuttle tanker).
- Remote control of valves
  - Remotely open/shut the on/off valves
  - Remote control of positioning valves/throttle valves
  - Remote start and stop the hydraulic power pack for valve control
  - Tank washing pump/valve control
  - Cargo heating control.

- Cargo tank level gauging
  - Tank level monitoring from tank radar gauge system, direct from pressure sensor in tank, or via air purge system.
  - Tank levels are low pass filtered at sea (no filtering in harbour)
  - Full integration with the Kongsberg K-Gauge tank gauging system
  - Tank volume and/or weight calculation (density input from keyboard)
  - Tank temperature and inert gas pressure monitoring (if applicable)
  - High/HighHigh level alarms for alarm annunciation and stopping loading
  - Calculation of total cargo content (in m^3) (of different types of cargo, if applicable)
  - Trim/list correction of tank level/volume (using trigonometric calculations)
  - Display of corrected data (level/volume) from the load computer.

9.10 Ballast control

The Ballast control application controls and monitors the pumps, valves and tank levels.



The K-Chief 700 ballast control provides the following basic functions:

- Ballast control modes
- Ballast/Deballast control
- Ballast exchange.

9.10.1 Ballast control modes

You can select the ballast control mode from the ballast or ballast exchange mimic. Two modes of operation are available:

- Manual ballast control
- Automatic ballast control.

9.10.1.1 Manual ballast control

In manual mode, you can start or stop the pumps and open or close the valves from the operator station.

The ballast pump safety system and start interlock also work in manual mode.

9.10.1.2 Automatic ballast control

In automatic mode, all valves and pumps are set to automatic control. The valves and pumps are then controlled by sequential logic.

9.10.2 Ballast/Deballast control

The automatic ballast/deballast sequence can be started by:

- Selecting a tank to be ballasted or deballasted, and pressing the ballast or deballast button from the tank module menu.
- The automatic ballast tank exchange sequence.

The corresponding line valves are automatically set to the required position, and the pumps are started. This operation is controlled by the respective ballast or deballast start sequence. The operator can then set the desired water level (in metres), volume (in cubic metres), volume percent (percentage filling) or weight if the tank is not to be completely filled or emptied. When the desired tank content is reached, the pump stop sequence is started closing the valves and stopping the pump automatically.

9.10.3 Ballast exchange

The ballast water management avoids the introduction of undesirable organisms from the discharge of ballast water into waterways and harbours. Ballast water exchange replaces coastal water with open-ocean water during a voyage. This reduces the density of coastal organisms in ballast tanks, replacing them with oceanic organisms that have a lower probability of survival in coastal waters. Ballast water exchange is recommended as a voluntary measure by the International Maritime Organization (IMO).

Ballast water exchange can be done using the sequential empty-refill method. This method is effective in preventing the offloading of undesirable aquatic organisms in ports and near-shore waterways.

The K-Chief 700 Ballast Exchange application offers an automated or semi-automated ballast water exchange process.

9.10.3.1 Automatic ballast exchange

You can start a ballast exchange operation when the system is in Automatic mode, and the ship’s ballast condition is in a predefined initial start condition.

If a fault such as a pump failure is detected when the ballast exchange continues, the operation is set to the hold mode, and a stop sequence is executed for the duty pump, so that both pumps

are stopped, and all valves are closed. Once the fault is cleared, you can command the operation to automatically continue the from the paused step in the sequence.

Any ballast pump can be used for the ballast exchange mode.

9.10.3.2 Semi automatic ballast exchange

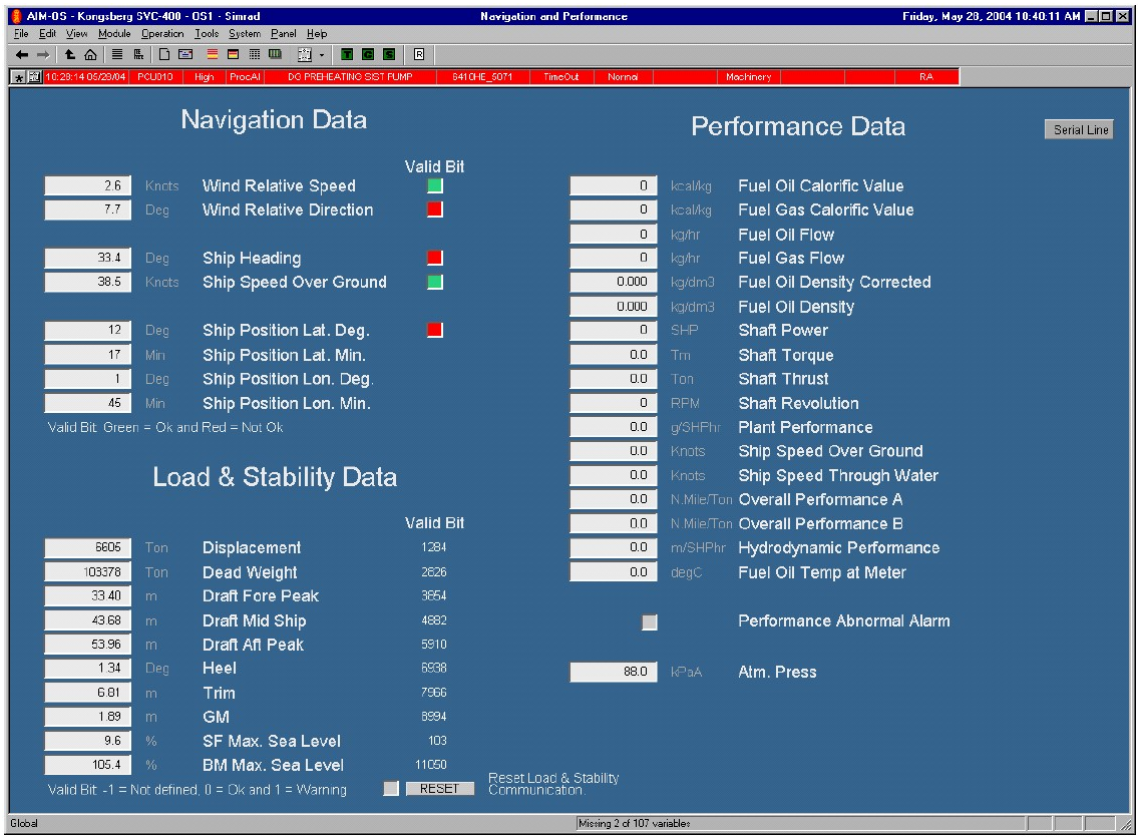
The semi automatic ballast exchange operates in a similar manner to that of the automatic ballast exchange. The main difference is that during the exchange sequence, the operator gives a continue command after every empty or fill operation. The system circulates water while waiting for the continue or stop command.

9.11 Vessel performance monitoring

The vessel performance monitoring system is an application group in K-Chief 700. It does not require any extra hardware, other than the online sensors. The online sensors are normally supplied with K-Chief 700. A sensor is interfaced at only one point, and the measurement data is available to other users through the communication network.

The vessel performance monitoring system, which is available at all operator stations aboard the vessel, can be re-configured online to include other parameters from the K-Chief 700 system, in addition to the minimum requirements.

A typical vessel performance monitoring image is shown in the following figure:



9.11.1 Online sensor inputs

The following sensors are either interfaced directly to the K-Chief 700 system, or through the K-Pos or K-Thrust system.

- Vessel speed (from a doppler log)
- Vessel speed and position (from the GPS)
- Wind speed and direction
- Diesel engine fuel oil consumption
- Fuel oil temperature (sensed near the consumption flow meters)
- Generated electrical power (for each diesel driven generator)
- Propulsion motor power
- Shaft torque (of the thruster and propulsion propeller)
- Shaft speed (RPM)
- Vessel trim and draught.

9.11.2 Manual input

The following data is normally entered manually through the K-Chief 700 OS:

- Fuel oil density at 15 °C
- Fuel oil water content
- Fuel oil sulphur content.

The fuel oil density is a calculated value, that is based on the measured fuel oil temperature. A separate fuel oil temperature sensor may be needed.

Fuel oil density, water content, and sulphur content are used to calculate the calorific value of the fuel oil. The actual fuel oil consumption is corrected to the corresponding consumption of a standard fuel oil, in order to provide a meaningful comparison.

9.11.3 Vessel performance calculations

The following vessel performance data is calculated and shown:

- Total fuel oil consumption (in litres/hour and kilograms/hour)
- Propulsion motor fuel oil consumption (in tonnes/Nm)
- Propulsion motor fuel oil consumption in comparison with standard fuel oil (in tonnes/Nm).

Calculations of the fuel oil consumption of the propulsion motor are based on the total fuel oil consumption, and the electrical power consumed by the propulsion motors when using diesel/electric propulsion.

9.11.4 Engine performance calculations

For diesel generators, the following parameters are calculated:

- Fuel oil consumption per engine or engine pair in l/h and kg/h.
- Corrected fuel oil consumption per engine or engine pair, in comparison with a standard fuel oil in Kilograms/kWh.

The consumption is shown in a performance monitoring image, as shown in the following figure.

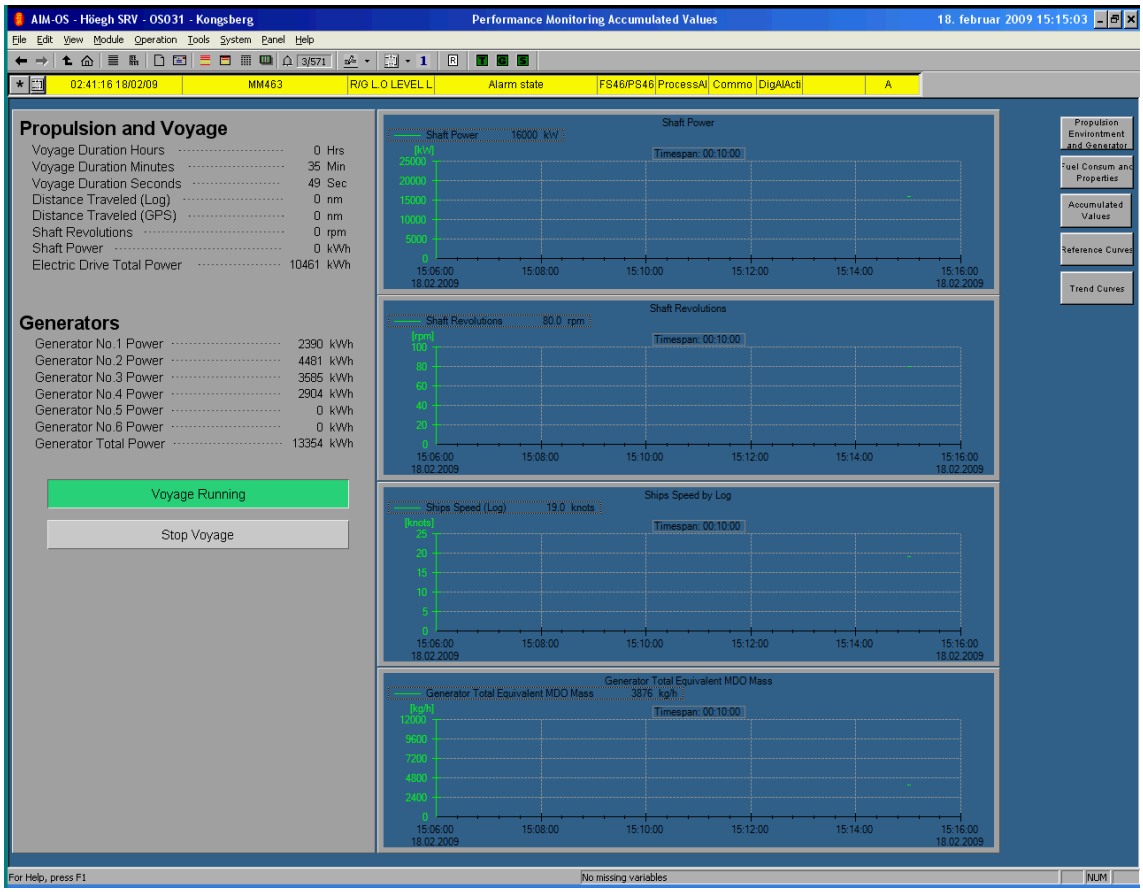
9.11.5 Accumulated data

The input signals and calculated values are accumulated.

From this accumulated data, the following totalled data is available:

- Total fuel oil consumption of the diesel engines (in tonnes)
- Total corrected fuel oil consumption of the diesel engines in comparison with standard fuel oil (in tonnes)
- Total fuel oil consumption of the propulsion motor (in tonnes)
- Total corrected propulsion motor consumption of fuel oil in comparison with standard fuel oil (in tonnes)
- Total distance sailed
- Total generator power
- Total propulsion motor power
- Total shaft revolutions.

The accumulated values are shown in a performance monitoring accumulated values image, as shown in the following figure. The voyage reports give detailed information on the voyage.

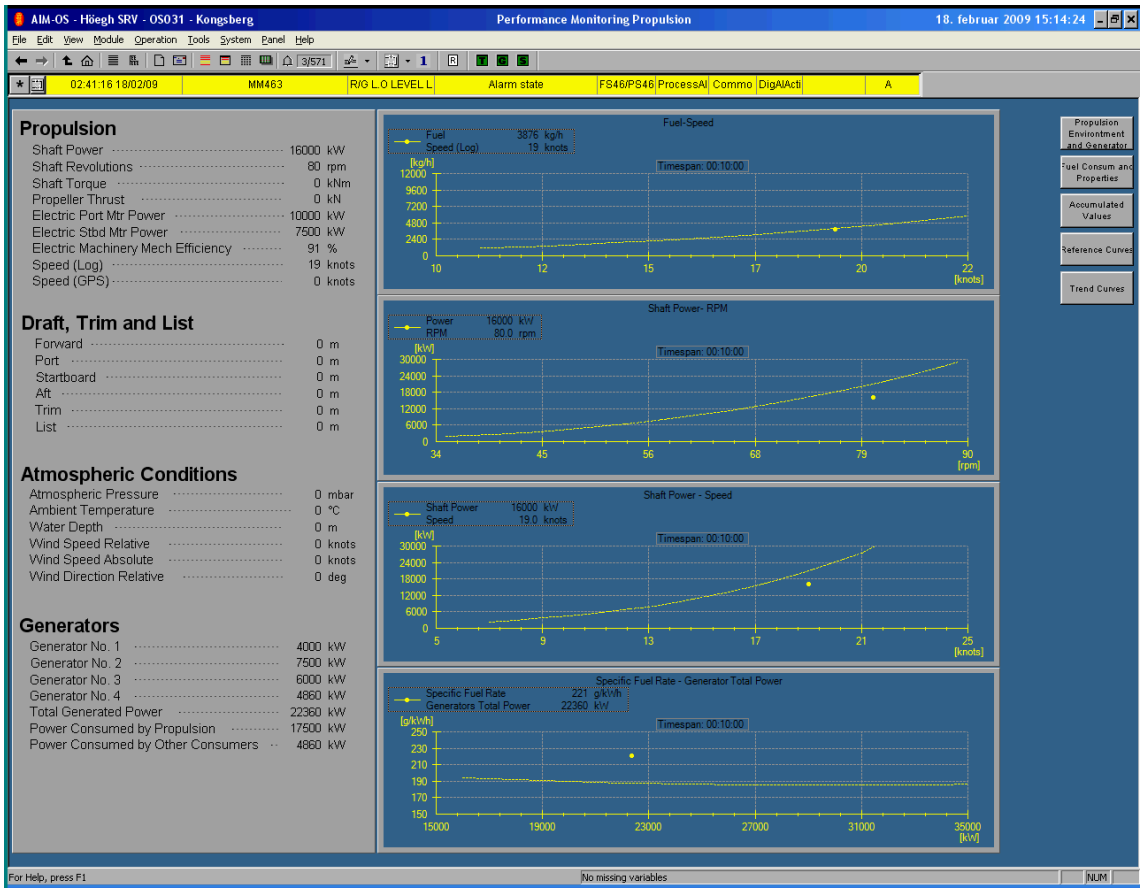


9.11.6 Performance monitoring - propulsion

Standard performance displays are shown as two-axis graphs such as:

- Generator power over generator fuel oil consumption
- Vessel speed over corrected propulsion motor fuel oil consumption
- Vessel speed over total propulsion motor power
- Vessel speed over propulsion propeller RPM.

The performance display is shown in a performance monitoring image, as shown in the following figure.

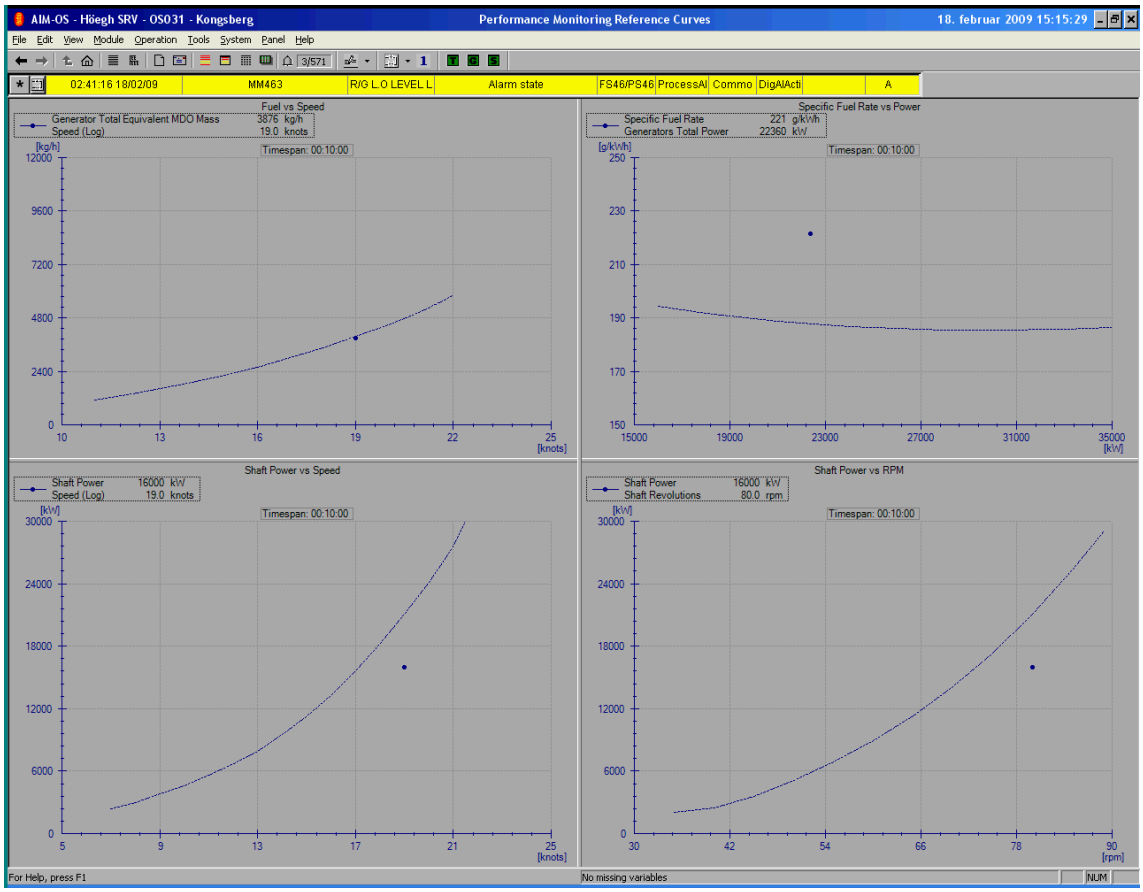


9.11.7 Performance monitoring - reference curves

You can view reference curves such as:

- Generator total equivalent MDO mass over speed
- Specific fuel rate over the total power of the generator
- Shaft power over speed
- Shaft power over shaft revolutions.

The following figure shows a mimic with reference curves.

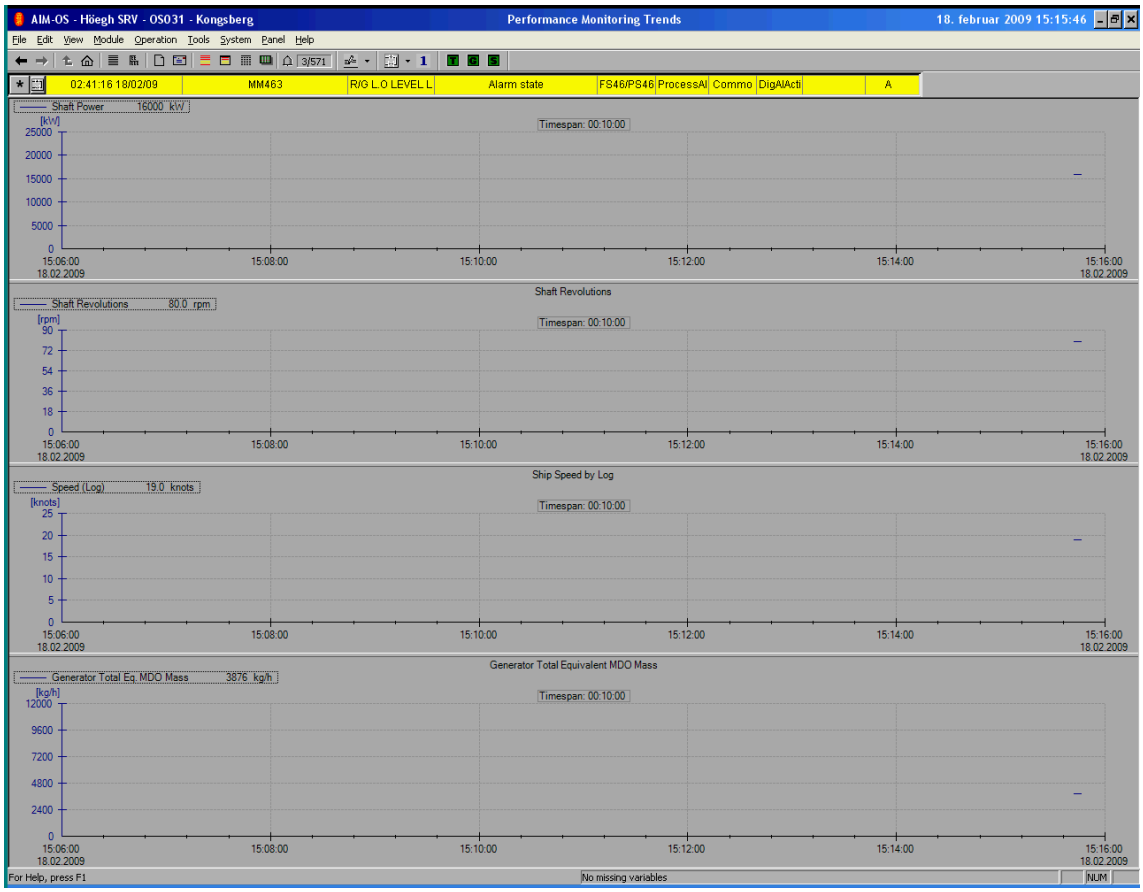


9.11.8 Performance monitoring - trends

You can view trends such as:

- Shaft power over time
- Shaft revolutions over time
- Ship speed by log over time
- Generator total MDO mass over time.

The following figure shows a performance monitoring trends mimic.



9.12 Vessel mode control

Before and during a dynamic positioning (DP) operation, you must make sure that the vessel machinery is configured in accordance with the required DP class.

The redundancy and criticality assessment (RCA) system is an online system which monitors the vessel's station-keeping equipment. This includes the propulsion/thruster units, electric power generation system, auxiliary machinery systems, and machinery control system. The RCA system informs you when the required mode of DP operation is, or can be, obtained.

The RCA system can be combined with a mode control system for optimum performance, enabling automatic configuration of different DP modes by controlling thrusters, electric generators, switchboard configuration, etc.

9.12.1 Mode selection and verification

You can select the desired mode of operation from a dedicated display. If the automatic Mode Control system is included, the Machinery Control System (MCS) automatically establishes the

selected mode according to a predefined sequence. If not, you should configure the machinery as required, before selecting the new mode.

To use the mode control sequences, the related systems and subsystems should be in remote operation, and no critical failures present.

From a mode control page several modes can be selected (when generators and thrusters etc., are combined in different ways, you get different modes).

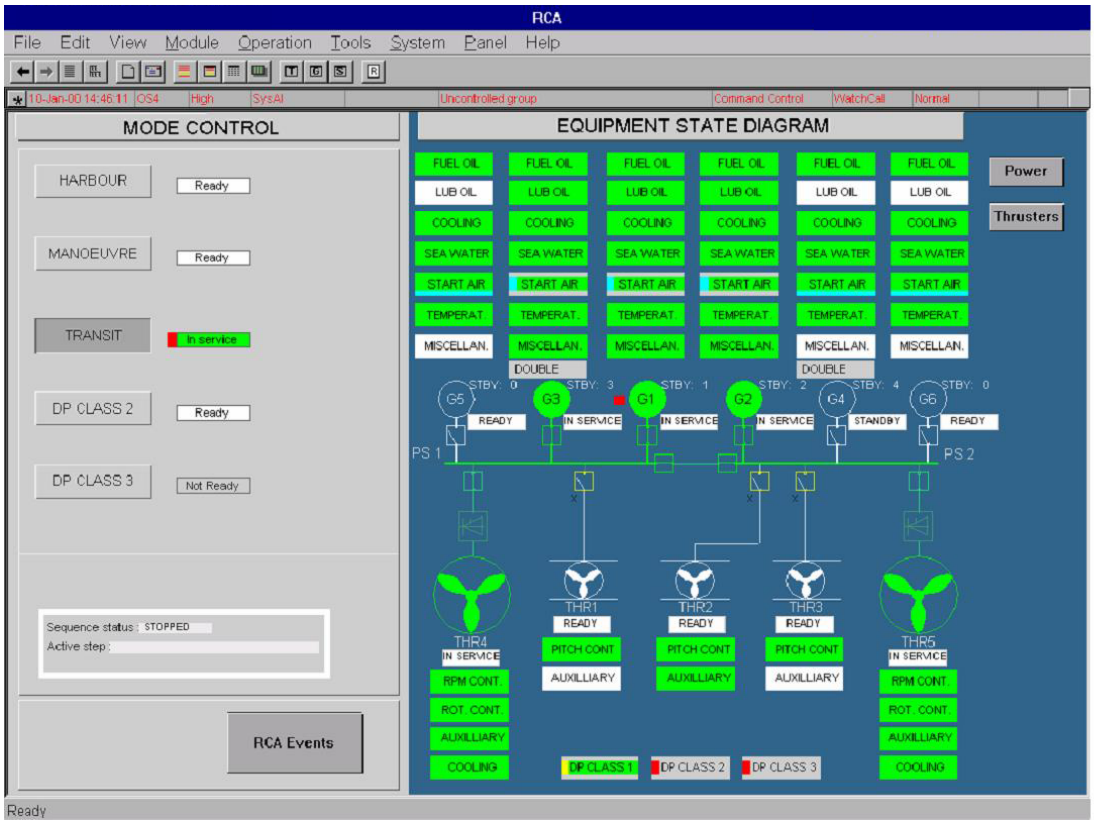
You can select the operation modes from the Mode Control image. This image given below shows:

- The current operation mode
- The selected mode, (if a new mode has been selected)
- The status for all defined modes.

9.12.2 Redundancy and criticality assessment

The redundancy and criticality assessment (RCA) system is an online fault monitoring and assessment tool. It monitors the resources, and confirms that the resources required for a specific operational control mode are available.

The RCA application first verifies that the required equipment is configured correctly for the intended vessel control mode. When the mode is in operation, the application continuously checks that the mode is healthy, and functions correctly. The software also monitors and reports the status of all standby equipment, to provide an overall redundancy status. If a malfunction is sensed, the application reports the situation according to the criticality of the event.



The RCA system process image provides functions for operational mode control, and displays the status of the equipment. This image contains symbols that represent machinery (such as thrusters, generators with power buses, and main engines) and subsystem symbols that represent the various auxiliary systems associated with each propulsion unit. From this image, you can select vessel control modes and monitor the status of the equipment.

9.13 Heating, venting and air condition controls

The K-Chief 700 system provides heating, venting and air condition (HVAC) control and monitoring. It also includes the following functions:

- Supply and exhaust fan control
- Ventilation damper control
- Temperature control of hot and cold ducts
- Humidity control
- Monitoring chilled water compressors.

Emergency shutdown of the ventilation fans, and closing fire dampers, are some of the typical functions of the K-Chief 700 ESD/fire & gas system.

The HVAC system is normally shown by process views that display the supply and distribution of warm and cold air to the working and living accommodation areas of the vessel.

9.14 Operator trainer

The K-Chief 700 operator trainer (OT) is used to train the operators of the K-Chief 700 ICS.

The OT is a stand alone station, that is not connected to the K-Chief 700 ICS.

Operators that are not familiar with the K-Chief 700 ICS can gain hands-on experience by performing standard operations, and experiencing system responses. This is done without interfering with the vessel control functions.

The operator trainer can be run from any location such as classrooms, ship owner offices, etc.

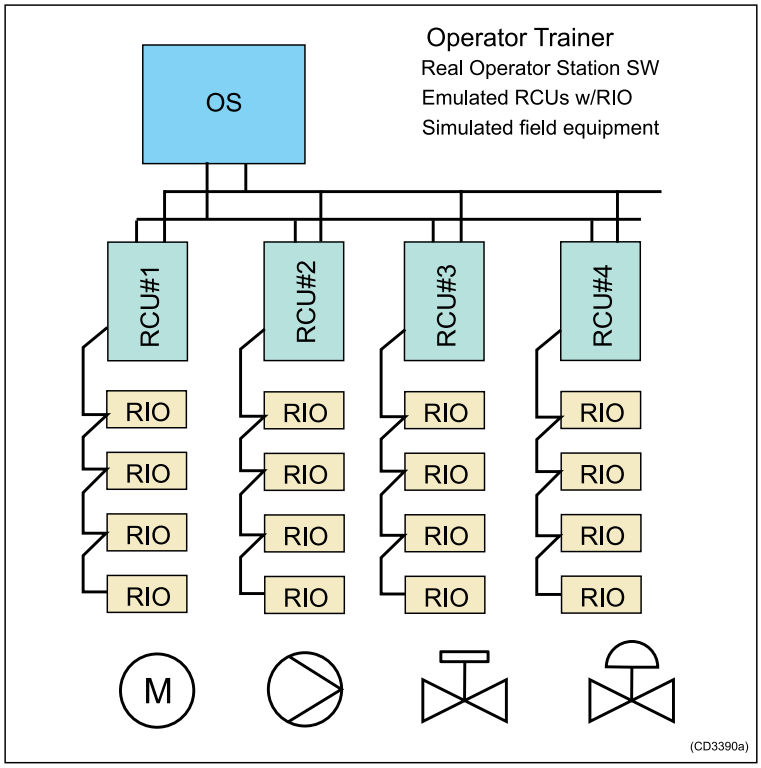
The OT contains operator station software like that installed in the K-Chief 700 ICS in the vessel. All elements of the OT user interface such as mimics and images, and software functions such as navigation, operation, dialogues etc., are identical to the K-Chief 700 ICS system. This improves operator recognition, and ensures seamless operator migration to the K-Chief 700 ICS when the training is complete.

The main features of the operator trainer are:

- Configuration files of the real-life system are used unchanged
- No field wires needed for I/O
- Fast response time (real time)
- K-Chief 700 operator trainer can be run on a PC
- Operator trainer has the look and feel of a real-life K-Chief 700 ICS
- Available number of simulated I/O ranges from 0 to 10,000 signals
- Operators can be fully trained onshore
- Vessel system is not affected by the operator trainer.

9.14.1 Operator trainer platform

The process software runs on the OT as real-time emulated remote controller units (RCUs), with simulated feedback from field equipment models. The OT can be run on a PC with a keyboard, mouse and one or more monitors. The layout of the operator station panel can be simulated in the OT, which can optionally be supplied with a standard OS panel.

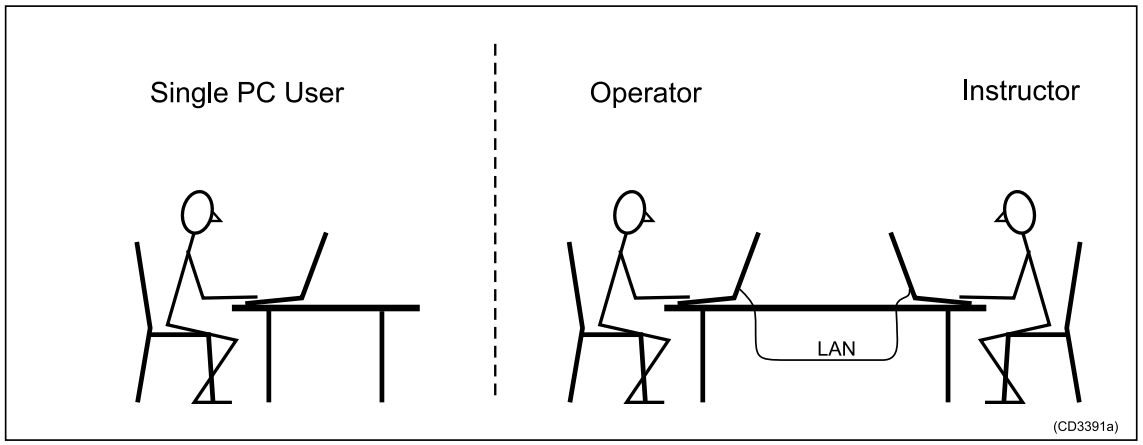


9.14.2 Instructor - led training

The operator can also be trained by an instructor, who controls the emulated system parameters and operating modes from another PC workstation.

The OT workstation runs the OS software only, and all the system mimics are available to the operator.

The operator can train in the use of all the system functions in various simulated scenarios. This provides a very high level of operator qualification when migrating to the real-life onboard control system.

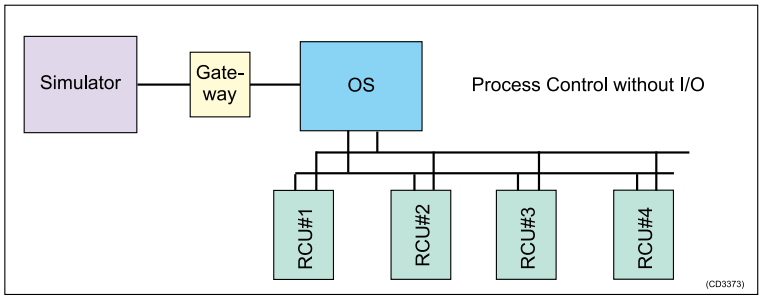


9.15 External simulator interface

The K-Chief 700 external simulator interface is a generic interface, that is compatible with serial line and networking protocols that are commonly used for linking a dynamic/process simulator.

The interface lets you connect the K-Chief 700 control system to a simulator, instead of the field I/O and real processes.

The control system can be run without a lot of hardware and I/O wiring. The simulator interface is very fast and allows real time simulation for advanced and complex control systems such as the power management system.



9.15.1 Software architecture

The external simulator interface allows parts of the system to be interfaced to the field, and other parts to the simulator. Change over between field and simulator can be done online, from the OS. Parts of the system that should not be simulated are not influenced by the simulator. The simulator interface can be used in the following scenarios:

- Process control with emulated controllers
- Process control with simulated I/O
- Process control with complete hardware, selectable simulated and field I/O.

The main features of the external simulator interface are:

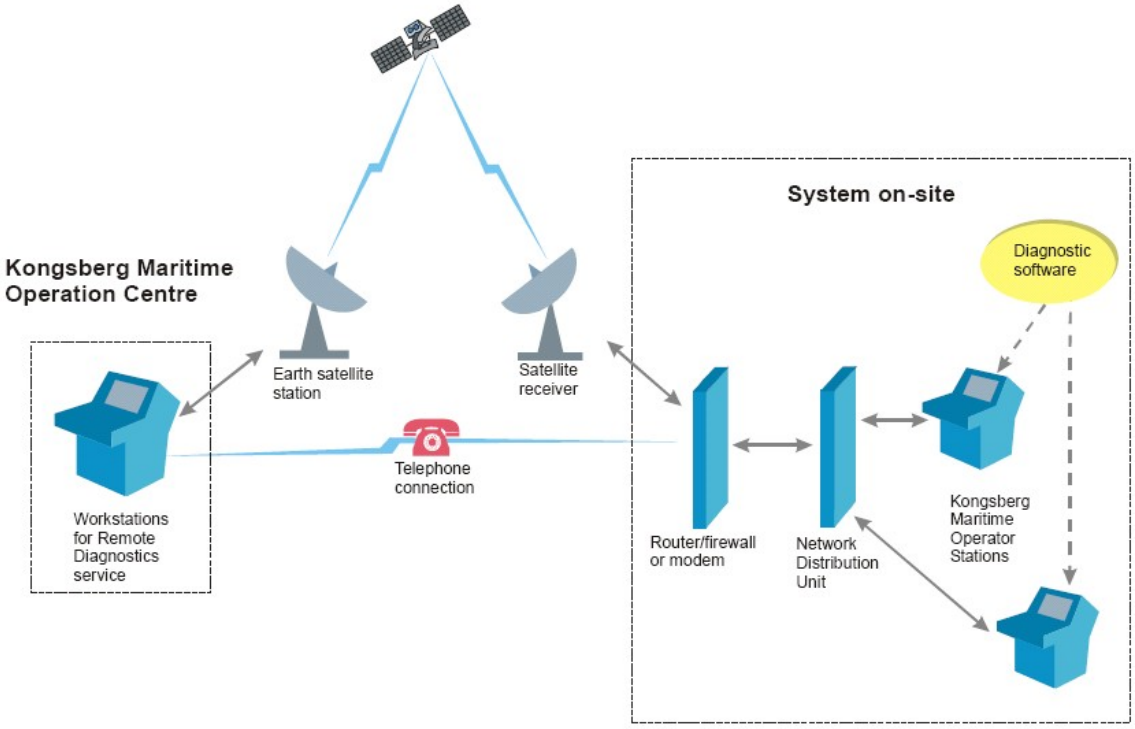
- Configuration files/data are kept unchanged
- No additional field wires needed for I/O
- Only serial/network connection needed
- Fast response time (real time)
- K-Chief 700 emulator can be run on a PC
- Simulator has the look and feel of the real system
- Number of simulated I/O ranges from 0 to 3000.

Supported standard interfaces:

- Modbus TCP (LAN)
- Modbus serial line

- OPC-DA (LAN)
- NMEA (LAN or serial)
- Profibus DP (master).

10 REMOTE DIAGNOSTICS



Online support from Kongsberg Maritime is available through the remote diagnostics service.

The user can get direct support for operational problems, and other assistance, for the Kongsberg Maritime K-Pos and K-Chief 700 systems.

The service is for offshore systems, and is based on telecommunication through the vessel's satellite communication system.

At the Kongsberg Maritime office, an operation centre is equipped with computers and communication utilities for the remote diagnostics service.

Using the remote diagnostics service, the system engineer at the operation centre can see the same information on the operator stations as the operator on the vessel. Log files and databases can be transferred to the operation centre for further analysis, and updates can be uploaded to the K-Chief 700 ICS on the vessel.

The remote diagnostics service is an add on to the 24 hour on-call service, and separate service contracts are required for this service extension. The response time from request to connection online is typically 2 to 4 hours.

11 ENVIRONMENTAL SPECIFICATIONS

11.1 General

A summary of compliance with environmental requirements is given below.

For further details, refer to the Kongsberg Maritime company handbook/environmental specification (spec-001_v2).

11.1.1 Requirements

Kongsberg Maritime products satisfy the Kongsberg Maritime company handbook/environmental specification requirements, which are based on classifications established by national and international authorities, and classification societies.

11.1.2 References

Kongsberg Maritime meets or surpasses the test requirements given in the following table.

Test	Reference	Comments
Vibration and shock	IEC 60945/E10/IEC 61131-2	
Temperature	IEC 60945/E10/IEC 61131-2	In locations 1, 2, 3, 5 and*, see *Locations* on page 140
Humidity	IEC 60945/E10/IEC 61131-2	
High Voltage	IACS E10	
Insulation resistance	IACS E10	
Power supply variation	IACS E10	
Power supply failure	IEC 60945/ IACS E10	
Power supply harmonic distortion	IEC 60092-101	
Salt mist	IEC 60945/ IACS E10	
Enclosure	IEC 60945 (and class societies)	

Inclination	IACS E10	
Acoustic noise	IEC 60945	
EMC	IEC 60945	
Compass Safe Distance	IEC 60945	

11.1.2.1 Locations

1 Inside cubicles and desks

2 Machinery spaces, control rooms, accommodation, bridge and similar industrial environments

3 Open deck, mast and similar environments

4 Submerged

5 On machinery such as internal combustion engines, compressors and pumps, including piping on such machinery

* The temperature requirements may be altered due to other class society requirements (i.e. DNV open deck is +70°C, IEC 60945 and E10 says +55°C)

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