Alphatronic 2000 PCS

Propulsion Control System

Engineering the Future – since 1758.

MAN Diesel & Turbo

Contents

MAN Diesel & Turbo, Frederikshavn, Denmark

Alphatronic 2000 PCS Propulsion Control System

Introduction

The purpose of this Product Information brochure is to act as a guideline during project planning and lay out of the Alphatronic Propulsion Control Systems. The brochure gives a description of the system in general, standard control elements and options available for tailoring a remote control system for the individual vessel and its propulsion system configuration, operating modes and manoeuvre stations.

Our product range is constantly under review, being developed and improved according to present and future requirements and conditions. We therefore reserve the right to make changes to the technical specifications and data without prior notice.

Alphatronic Propulsion Control Systems are usually specified together with MAN Diesel & Turbo's Alpha Controllable Pitch Propellers.
The propeller programme may be studied in separate literature.

Ship's Propulsion Power – controlled by Alphatronic

MAN Diesel & Turbo, launched the first CP propeller as part of a propulsion system in 1902. A complete package including engine, clutch, shafting and propeller. A package where all control and manoeuvre actions were carried out, in accordance with the standards of that time, locally by hands–on.

Evolution of control

In view of the following years of development, not only in the physical dimensions of the ships, but also in the propulsion equipment itself, – the control and manoeuvre actions shifted from local to remote by means of different intermediates. These intermediates developed from mechanical push/pull rod systems, flexible cable systems, pneumatic systems up till today's electronic systems. Year by year, both the operator and the equipment itself required more and more sophisticated control systems for economical cruising at various operating modes, engine load sharing, redundant propulsion using PTI/PTH etc.

The latest version of the Alphatronic system described in this material is type Alphatronic 2000 PCS. PCS is an abbreviation of Propulsion Control System.

Accumulated expertise

Since 1902, more than 7.000 propellers and propulsion packages have gone into service – operated by various types of MAN Diesel & Turbo control systems. Today's standard for MAN Diesel & Turbo's Alpha CP propellers and propulsion packages is the well–proven electronic remote control system, Alphatronic.

Since its introduction in 1982, more than 1400 systems have been delivered for a wide range of propulsion plant combinations with two-stroke engines and propellers, four-stroke engines, reduction gearboxes and propellers for the output range up to 30,000 kW per propeller.

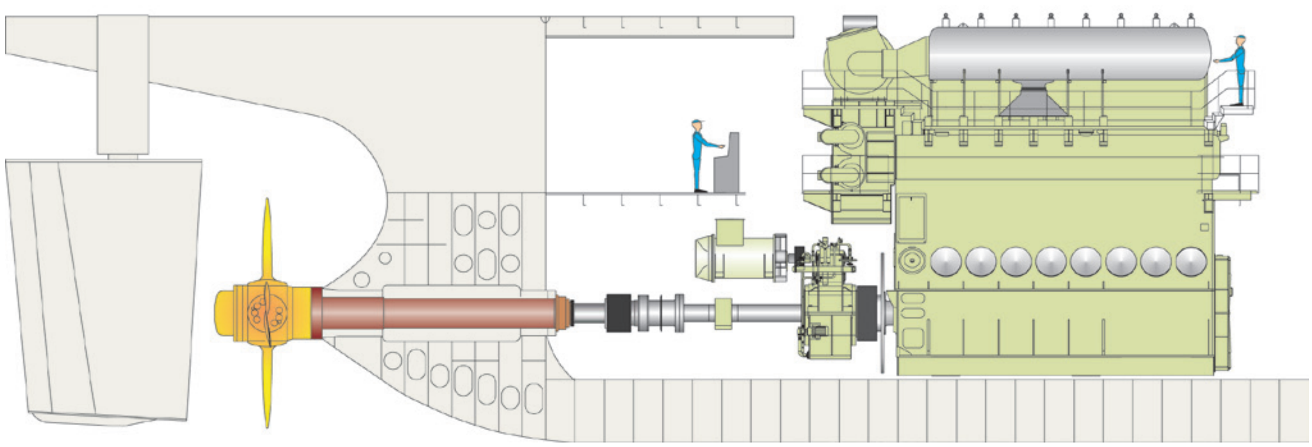

Fig. 1: Two–stoke propulsion package (8S50MC-C engine, tunnel gear, VBS1680 propeller)

Control is crucial

In the process of projecting and estimating propulsion systems, the associated control system is a ‘soft’ item frequently handled with less attention. The propulsion control system is often regarded as a necessary auxiliary element that just follows the primary propulsion elements. Fuel consumption, emision levels and propulsion efficiency of the ‘hard’ engine and propeller elements are, however, undermined – without the correct matching and performing control system!

Inherent advantages

A tailored Alphatronic control system ensures:

- Safe control of the propulsion plant and reliable manoeuvring of the ship
- Economic operation due to optimised engine/propeller load control
- Quick system response and efficient CP propeller manoeuvrability
- Load changes controlled in such a way that the governor always keeps the engine speed within the range required, and thus prevents black-out during shaft alternator operation
- Good long term engine performance due to overload protection
- Thermal protection of the engine via controlled running–up programmes
- Environmental friendliness due to balanced manoeuvring dynamics during acceleration with minimal smoke emission
- Flexibility and individual customization due to modular system principles
- Project support, simple installation procedures and safe commissioning
- Minimal service and maintenance requirements
- User–friendly operator functions due to logic and ergonomic design of control panels
- Overall system reliability and durability
- Type approval by all major Classification Societies

The engine and propeller manufacturer’s advantage

In general, the control system acts as the central propulsion package element, being in charge of the remaining propulsion package elements, their coherence and their interaction with one another.

The experience inherent in the Alphatronic systems, accumulated during 25 years of service – is full knowledge of:

- All propulsion package elements
- Two-stroke and four-stroke engine designs
- CP propeller designs
- Overall operating economy, long term performance, load characteristics and system dynamics

– and that makes all the difference.

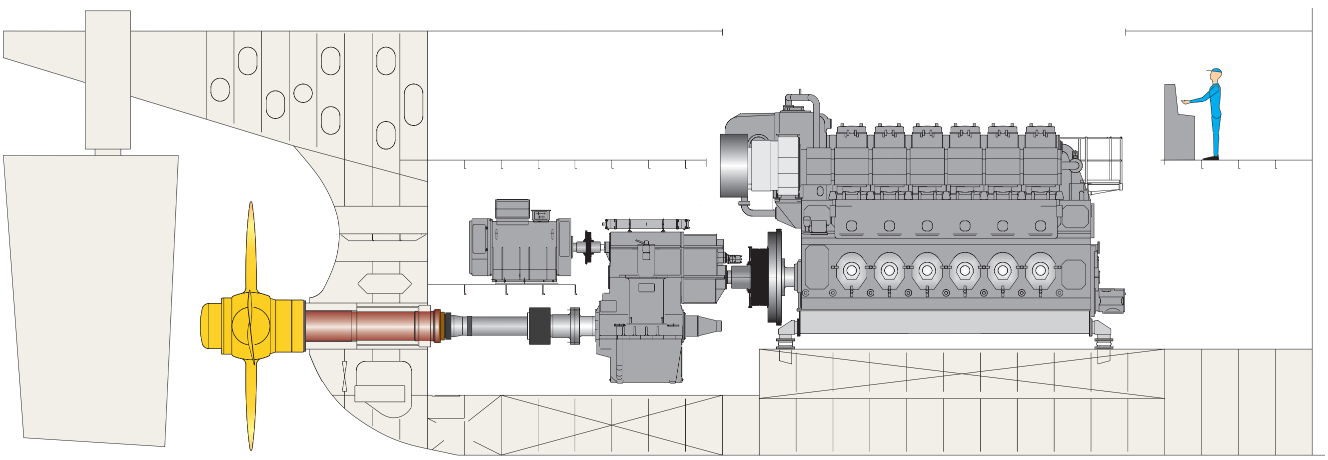

Fig. 2: Four–stroke propulsion package (6L48/60B engine, reduction gear, VBS1460 propeller)

Alphatronic Propulsion Control System – General

With this electronic propulsion control system it is possible for the navigator to manoeuvre the ship from the bridge.

The navigator may operate the control system without consideration for the engine load condition, since the system ensures automatic engine overload protection.

When desired, the manoeuvre responsibility may be transferred from the main bridge panel to the bridge wing panels or to the control room panel.

Plant configurations

The Alphatronic propulsion control system is designed for propulsion plants consisting of a CP propeller and a two–stoke or a four–stroke engine in several plant configurations. From the relatively simple plants shown in fig.1 and fig. 2 to many different and more complex configurations, e.g.:

- Multiple engines on one gearbox
- Multiple propeller plants
- Redundant propulsion solutions with Power Take-Home (PTH) using a combined shaft generator / shaft motor
- Interface to dynamic positioning (DP) and joystick system.

Included in the system

A typical system consists of the following main components shown in the principle diagram fig. 3:

1 Manoeuvre panels for main bridge (centre and wings)
2 Manoeuvre panel for engine control room
3 Main cabinet including the process computer
4 Propeller servo electronics (closed loop amplifier and propeller indication electronics)

Engine equipment

The governor and the safety system are considered part of the engine and therefore not a part of the propulsion control system. Nevertheless, there is a close connection between these. For details of interfacing engine, governor and safety system, please refer to the interface descriptions on page 13.

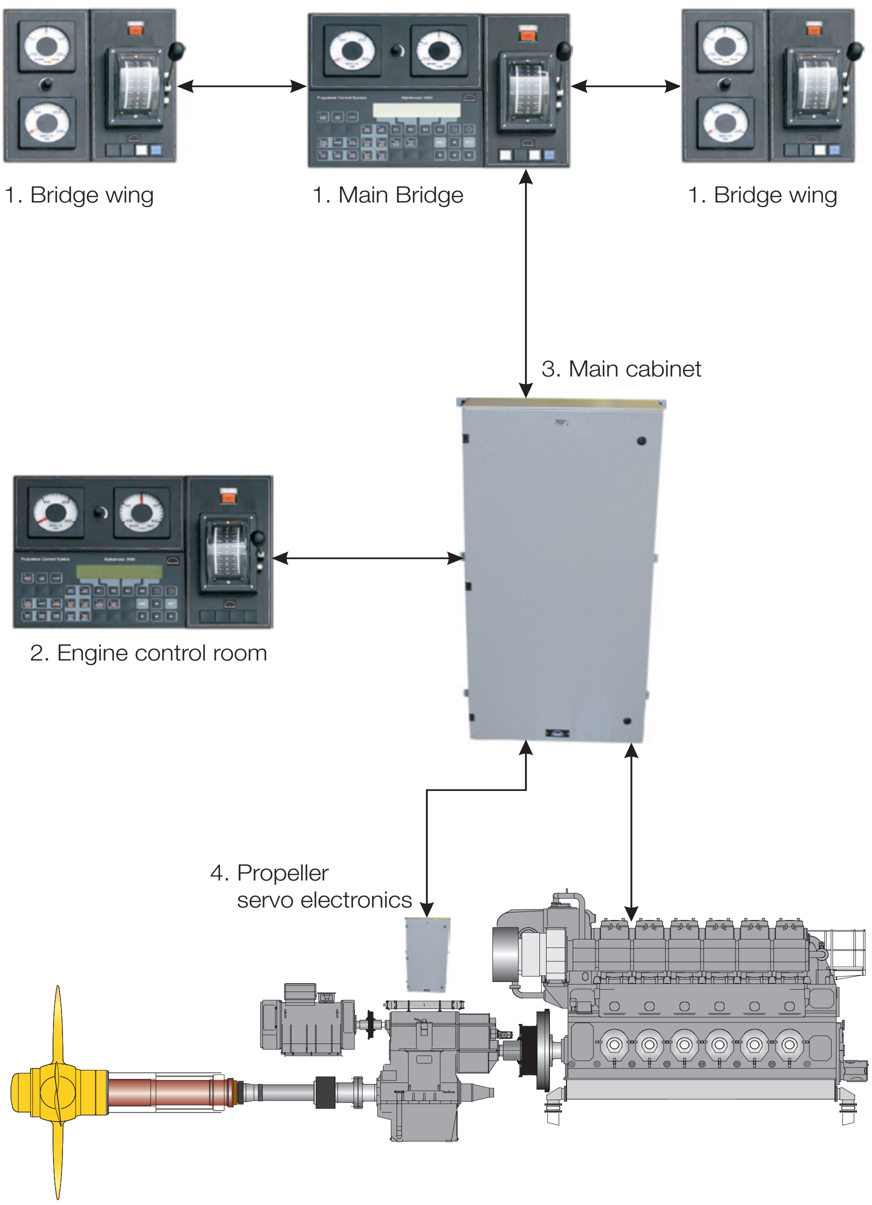

Fig. 3: Control system structure

Primary control function

The manoeuvre panels are fitted with manoeuvre levers for controlling the propeller speed and pitch. The lever on the bridge centre panel and the lever on the ECR panel have individual potentiometers connected to the main cabinet. Depending on the chosen mode of operation, these lever signals will be used for setting the engine speed and the propeller pitch accordingly.

An electric speed setting signal is transmitted from the PCS main cabinet to the engine governor. If the engine has a governor with pneumatic speed setting, the electric speed order is converted into a pressure using an E/P–converter.

The propeller pitch is controlled by two solenoid valves in the hydraulic system. The electronic servo unit controls the solenoid valves for 'ahead' and 'astern' pitch changes by comparing actual pitch and set point. Actual propeller pitch is measured by two transmitters. One transmitter is used for indication of the actual position of the propeller. The other transmitter gives the feedback signal to the electronic servo unit.

In case of emergency

If the propulsion control system is out of service, the propulsion plant may still be operated from the bridge using the back-up system. The back-up system is independent of the main control system, although it is operated from the same lever on the bridge.

Selection of back-up will set the governor to a fixed speed (normally corresponding to the nominal shaft generator speed) and set the propeller pitch corresponding to the present thrust. Change between normal control and back-up control will thus not change the actual propeller thrust.

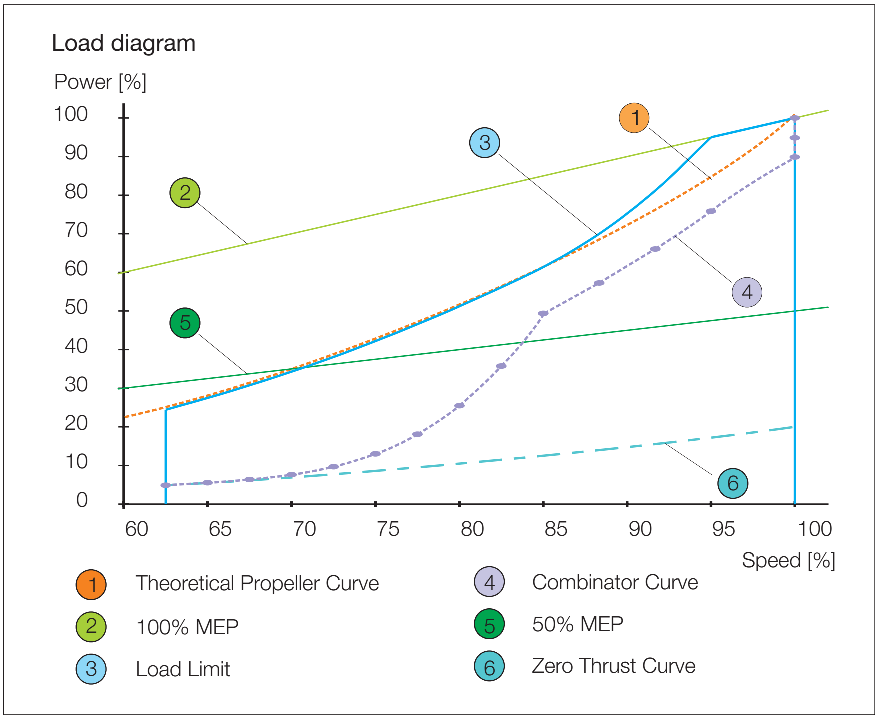

Fig. 4: General load diagram

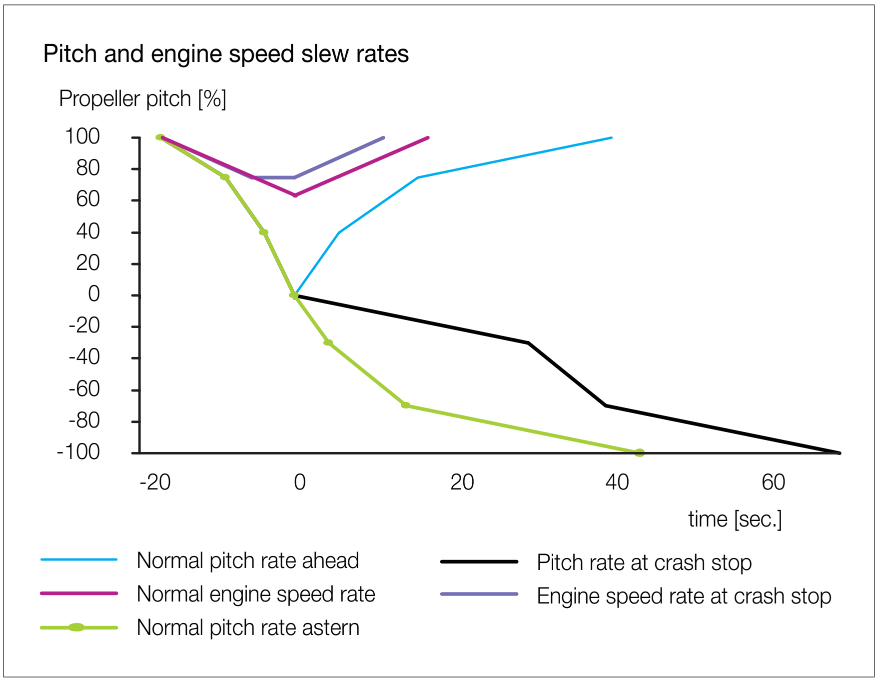

Fig. 5: Control lever slew rate for propeller pitch command

Load control

The control system uses the propeller pitch and engine speed as controlling parameters. Fuel pump index, engine speed and charge air pressure are used as feedback. The engine load is kept within the limits as specified by the load limit curve of the engine. The load curve for combined mode is adjusted according to the specific engine and propulsion equipment – taking fuel oil consumption, propeller efficiency and manoeuvrability into consideration in order to obtain optimum overall propulsion efficiency.

Control lever orders and commands

In order to allow the engine and the vessel to respond, the system is able to control the rate at which the engine speed and the propeller pitch is changed. The control lever orders are translated into engine speed and propeller pitch commands as shown in fig 5. The slew rates will vary with the plant configurations.

In addition to these slew rates, pitch will be dynamically limited by the load program and the actual charge air pressure.

Load program

A running-up load program is included for the engine as illustrated in the example in fig 6. In the figure, both the normal load-up of the engine as well as the load-up during cancelled load restrictions are illustrated.

Charge air limit curves

In order to allow the engine to take up load as fast as possible without generating smoke, the control system uses a measurement of the actual charge air pressure to limit the engine fuel index (by not increasing the pitch before sufficient charge air is available). See change air limit curves in fig. 7.

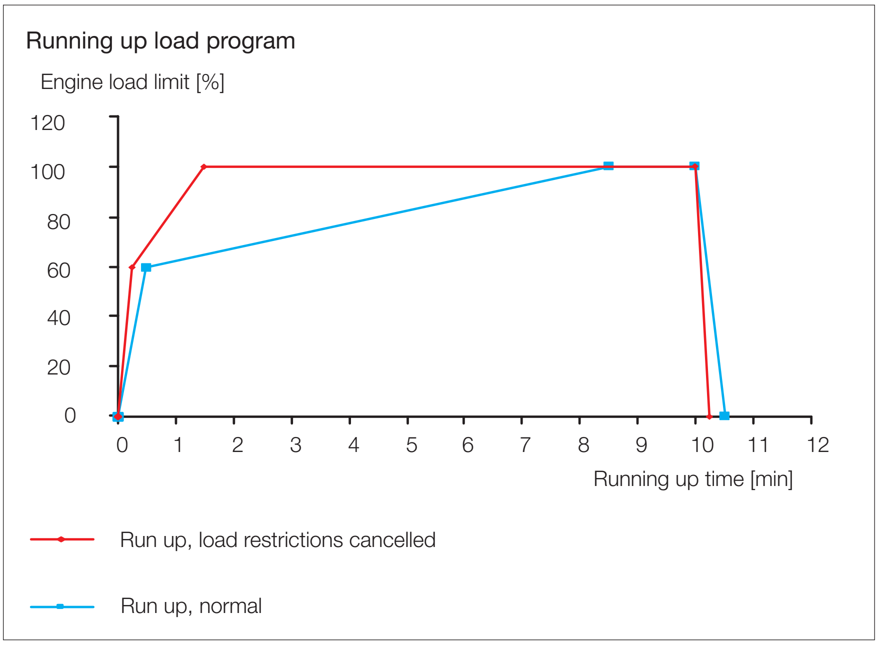

Fig. 6: Running up load program

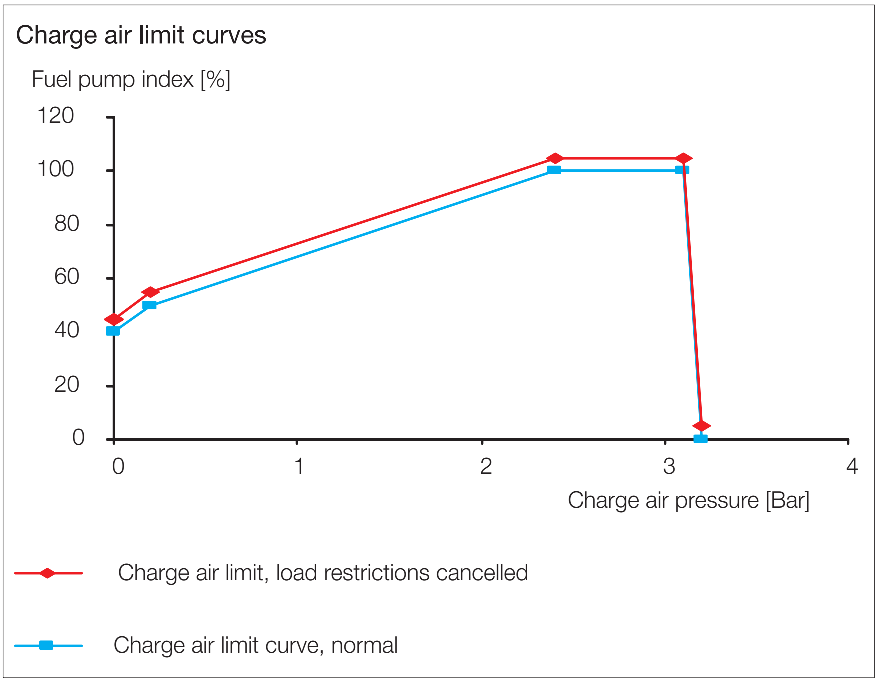

Fig. 7: Charge air limit curves

Modes of Operation

The propulsion plant can be operated in three different modes.

Combined mode

In combined mode, both pitch and speed are controlled by using the lever. This is done according to the combinator curve as shown in fig 8, ensuring optimum operation and propulsion economy – considering propeller efficiency, manoeuvrability and minimized fuel consumption

Constant speed mode

When constant speed mode is selected, the levers in the manoeuvre panels will only control the propeller pitch. The speed is set to a fixed value corresponding to the nominal speed of the shaft alternator – if any.

The automatic load control is, however, still active for engine overload protection. With the shaft alternator in service, the load control system can handle a crash stop order, without any risk of a black-out.

Separate mode

Separate mode specifies the condition where pitch and speed can be controlled individually. The pitch is adjusted using the lever and the engine speed is adjusted using the Propulsion Control Panel.

Bridge Main Manoeuvre Panels

As a minimum the propulsion control system will always include a main bridge panel per engine/propeller, please refer to fig. 9.

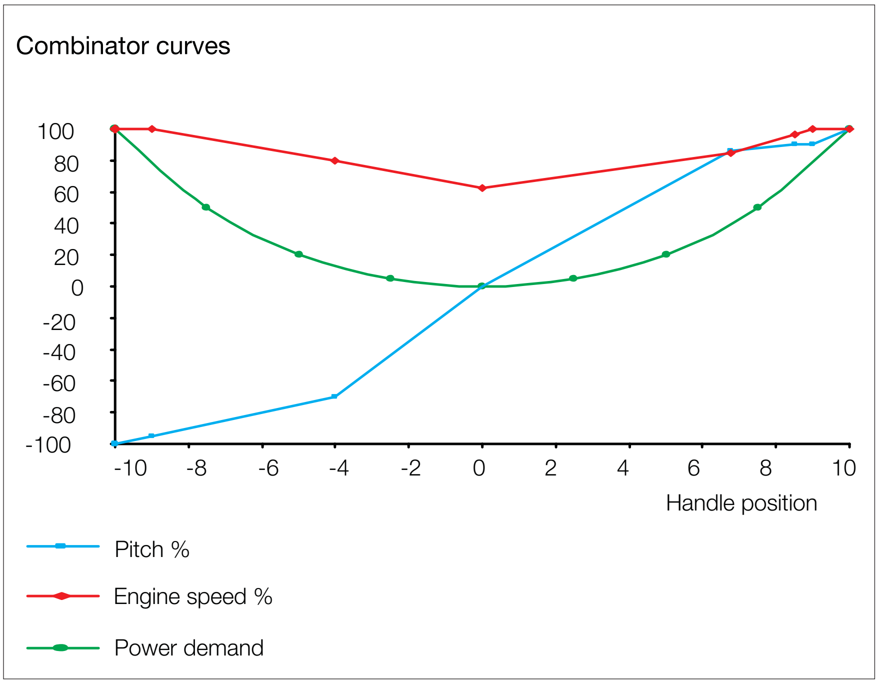

Fig. 8: Combined mode – combined pitch/speed order and engine load curve for a two-stroke propulsion package

The main manoeuvre panel consists of three individual panels:

- Propeller Instrument Panel, PIP Indicating propeller speed and propeller pitch. These two instruments are working independently of the remote control system. The light dimmer is operating on both PIP and MHP.

- Manoeuvring Handle Panel, MHP Incorporates the control lever and normally also an emergency stop push-button, a push-button for selection of back-up control and push-button /indicator for selection of control position.

- Propulsion Control Panel, PCP The primary functions of the panel are selection of control position and operating mode. In addition, certain safety functions and special machinery operation, including alarm lists, are available.

All three panels have the standard instrument sizes 144 mm x 288 mm for convenient installation together with other standard instruments in the bridge and ECR consoles.

Bridge wing manoeuvre panels

Typically, two bridge wing panels are supplied. Wing panels are available in indoor and outdoor versions. Indoor wing panels may optionally be equipped with a Propulsion Control Panel if desired. Please refer to figures 10 and 11.

Control levers in the manoeuvring handle panels

Fig. 12 shows a typical control lever configuration. The control lever in the bridge main manoeuvre panel is connected to the main cabinet of the remote control system.

As standard the engine control room (ECR) is equipped with a similar control lever. Optionally the system can be delivered without equipment in the engine control room.

The control lever in the bridge main manoeuvre panel and the control lever in the ECR are independent of each other.

Electrical shaft system

Ships with bridge wing control are equipped with an electrical shaft system interconnecting the bridge main and bridge wing control levers.

The electric shaft system is a so-called synchronizing system, in which the non-active control levers are following the active control lever. I.e. when the bridge main manoeuvre panel is selected as “IN CONTROL”, the two bridge wing levers will automatically follow the bridge main control lever.

This system design secures that the handle chosen to be “IN CONTROL” will act as a master and the other handles on the bridge will follow its posi-

Fig. 9: Bridge manoeuvre panel – main bridge

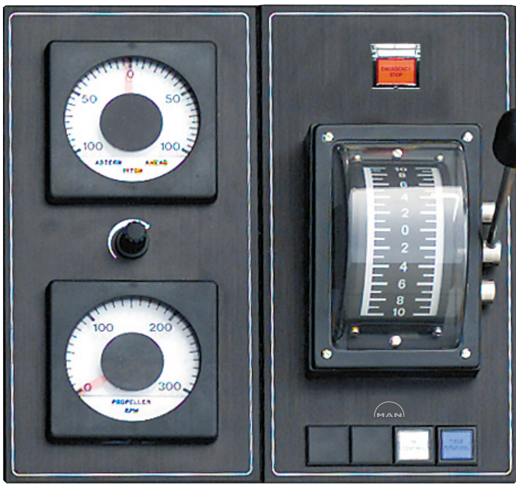
Fig. 10: Bridge manoeuvre panel – bridge wing indoor

Fig. 11: Bridge manoeuvre panel – bridge wing outdoor

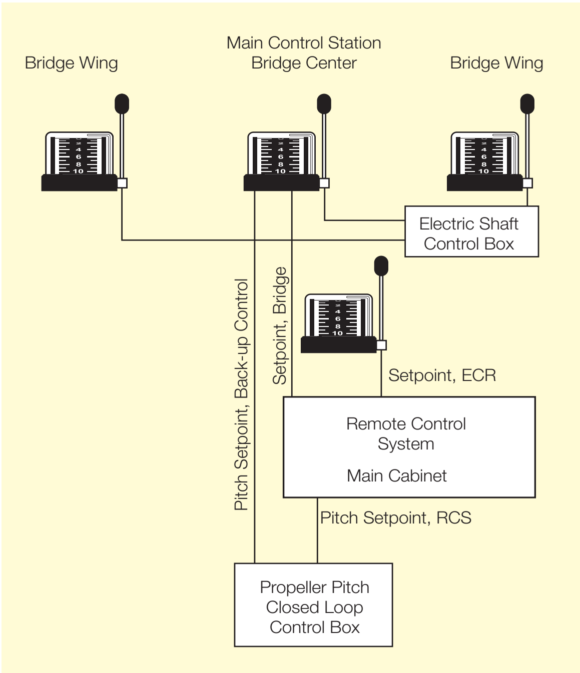

Fig. 12: A configuration of manoeuvre handles

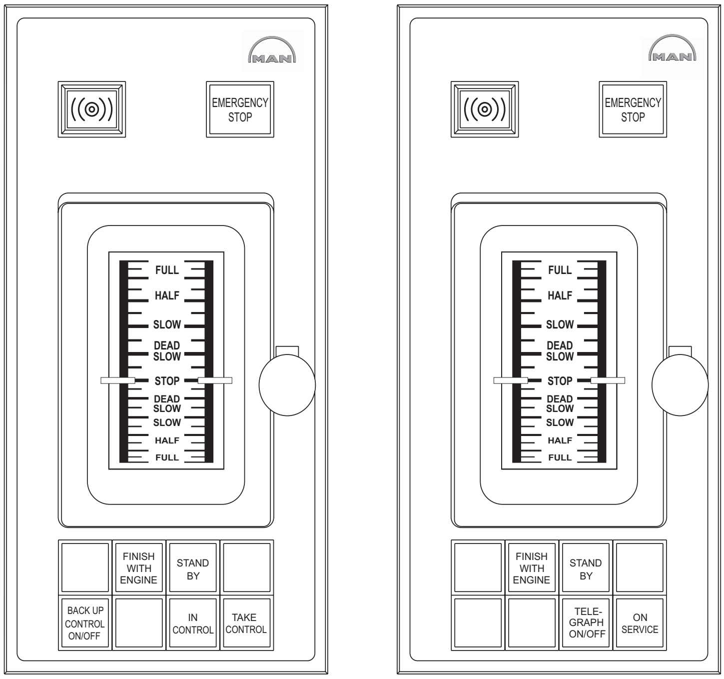

Fig. 13: Main bridge and ECR manoeuvring panels with integrated telegraph function

tion. This will avoid any synchronizing of handles at the time of changing control position on the bridge.

The electrical shaft standard solution can handle three panels on the bridge. However additional manoeuvring panels may be added, providing for typically also an aft bridge. A maximum of 16 panels can be controlled in one electrical shaft system.

Telegraph system integrated in manoeuvre panels

Optionally, the levers at the main bridge and in the ECR may be equipped with a telegraph dial and one additional pointer. The additional pointer on the bridge always shows the position of the corresponding telegraph lever, being either the lever in the ECR or in the engine room depending on the actual control position. When an active lever is moved, normally the bridge lever, the telegraph bells will sound until the reply pointer has the same position as acknowledgement by the machinery crew that the requested order has been understood. Please refer to fig. 13 showing the main bridge and ECR manoeuvring panels with integrated telegraph function.

The telegraph function is a means of communication between the bridge and the engine area. It is normally only used in case of problems with the remote control system, and thus it is electrically independent of the remote control system.

In addition to the function of communicating manoeuvring orders between bridge and engine area, the telegraph system will normally also have the two additional communication functions for Finished With Engine (FWE) and Stand By included. Activating the push button FWE on the bridge will start the telegraph bells until the corresponding push button is acknowledged in the machinery area. The same principle applies for the Stand By function.

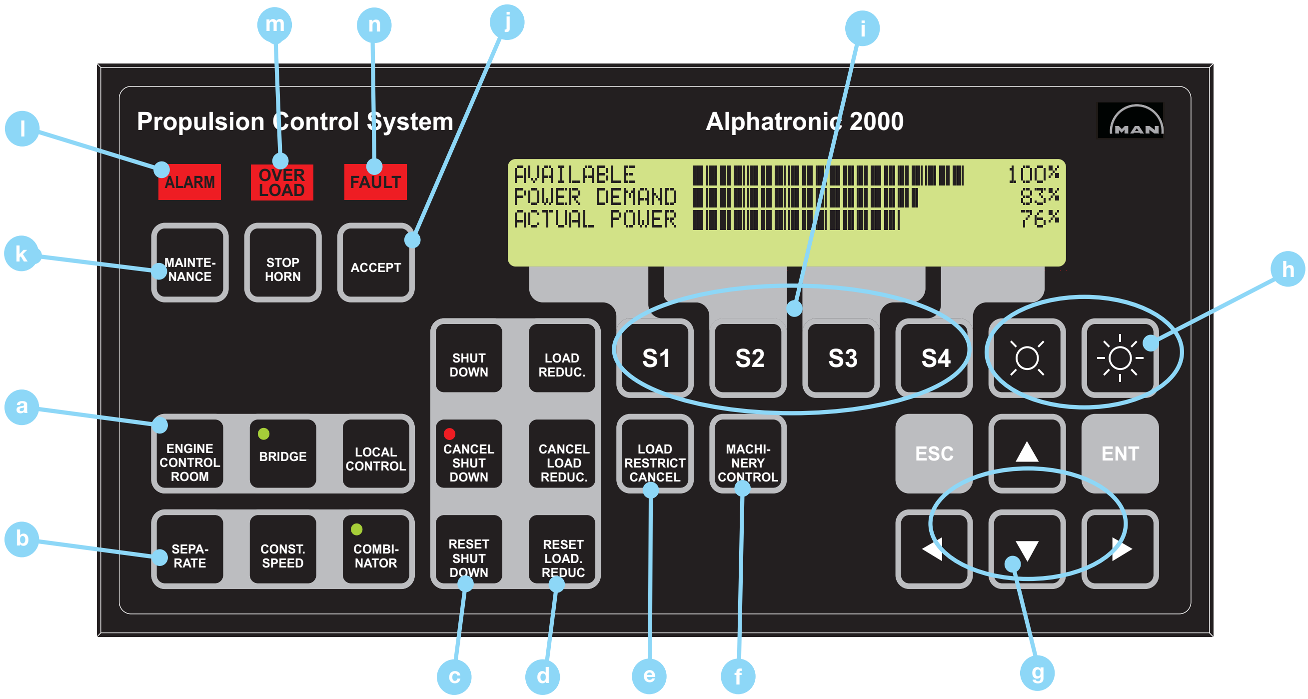

Fig. 14: Propulsion Control Panel

Propulsion Control Panel

Fig. 14 shows the Propulsion Control Panel. The contents of the display will vary during operation. In basic mode, the display will indicate the available power, the power demand from the active control position and the actual power delivered by the engine. The last line will show the oldest unacknowledged alarm, if any.

The keys and indicators of the panel have the following functions:

a. Control position selection and indication

b. Operating mode selection and indication

c. Shut down indication and operation (cancel and reset)

d. Load reduction indication and operation (cancel and reset)

e. Indication of active load restrictions. May be cancelled by pushing key

f. Machinery control. E.g. start and stop of engine, clutching in and out. Operation via softkeys S1 through S4

g. Navigation keys for moving around in lists and changing parameters

h. Collective dimming of keys, indicators and display in panel

i. Softkeys for operation. Actual function will be explained in the display above the key

j. Keys for stopping the horn and acknowledge of alarms

k. Maintenance key Gives access to alarm lists and advanced features and adjustments

l. Alarm lamp. Flashing when new alarms arrive

m. Lamp for indication of engine overload. Used during back-up control where no load control is in function

n. Lamp for indication of internal faults in the propulsion control panel itself

Generally, operation of the plant will only be possible from the active control location, i.e. bridge or engine control room. However, display facilities are always open at all panels.

Interfaces to External Systems

The Alphatronic remote control system can be interfaced with a variety of external systems. Included in this document, there is a description of a number of often used interfaces that have proven to work. For each of the below described interfaces, there is a more comprehensive description available.

Voyage Data Recorder

The Alphatronic propulsion control system is equipped with a standard interface for a voyage data recorder (VDR) following the standard IEC 61996 as required by the IMO. The electrical interface is done according to IEC 61162-1
.

Power Take Home (PTH)

For a number of vessels, e.g. chemical tankers, it is desired to have a possibility of alternative propulsion power if the main engine is not available. Such alternative propulsion can be established by using the shaft alternator as a shaft motor. A number of prerequisites must be considered. It must be possible to disengage the main engine before the shaft motor can be engaged, and there must be a way of bringing the shaft motor from stand still to nominal speed.

As a rule of thumb, there must be electrical power available corresponding to at least 25 - 30 % of the main engine power. Preferably, the combined PTO/ PTI could be connected via a two speed gear. This will reduce the size of the required PTI and the associated equipment for starting the PTI from stand still. Fig. 15 shows the interface for a PTH solution.

Power Boost

This feature may be relevant for short term boosting of the propulsion power. It is necessary that the gear and the propeller are designed for the total power of diesel engine and shaft motor. It is necessary that the amount of power supplied by the shaft motor is controlled by the ships power management system. No electrical interface is thus necessary to the remote control system.

Power Take Off

The most common type of power take off (PTO) is a shaft generator running at a fixed frequency. However other types of shaft generators exist, which are able to work at variable engine speed.

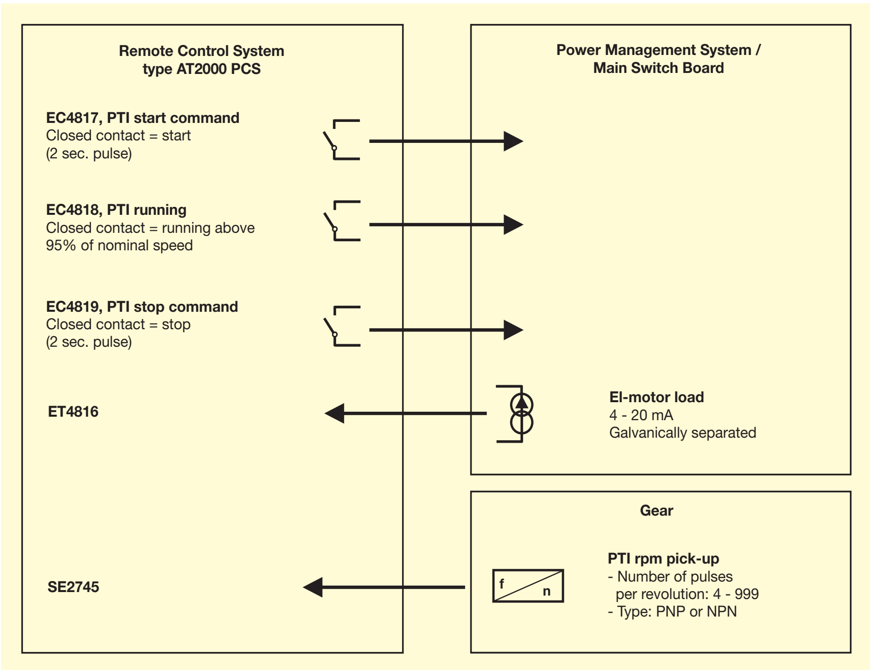

Fig. 15: Interface for a PTH solution

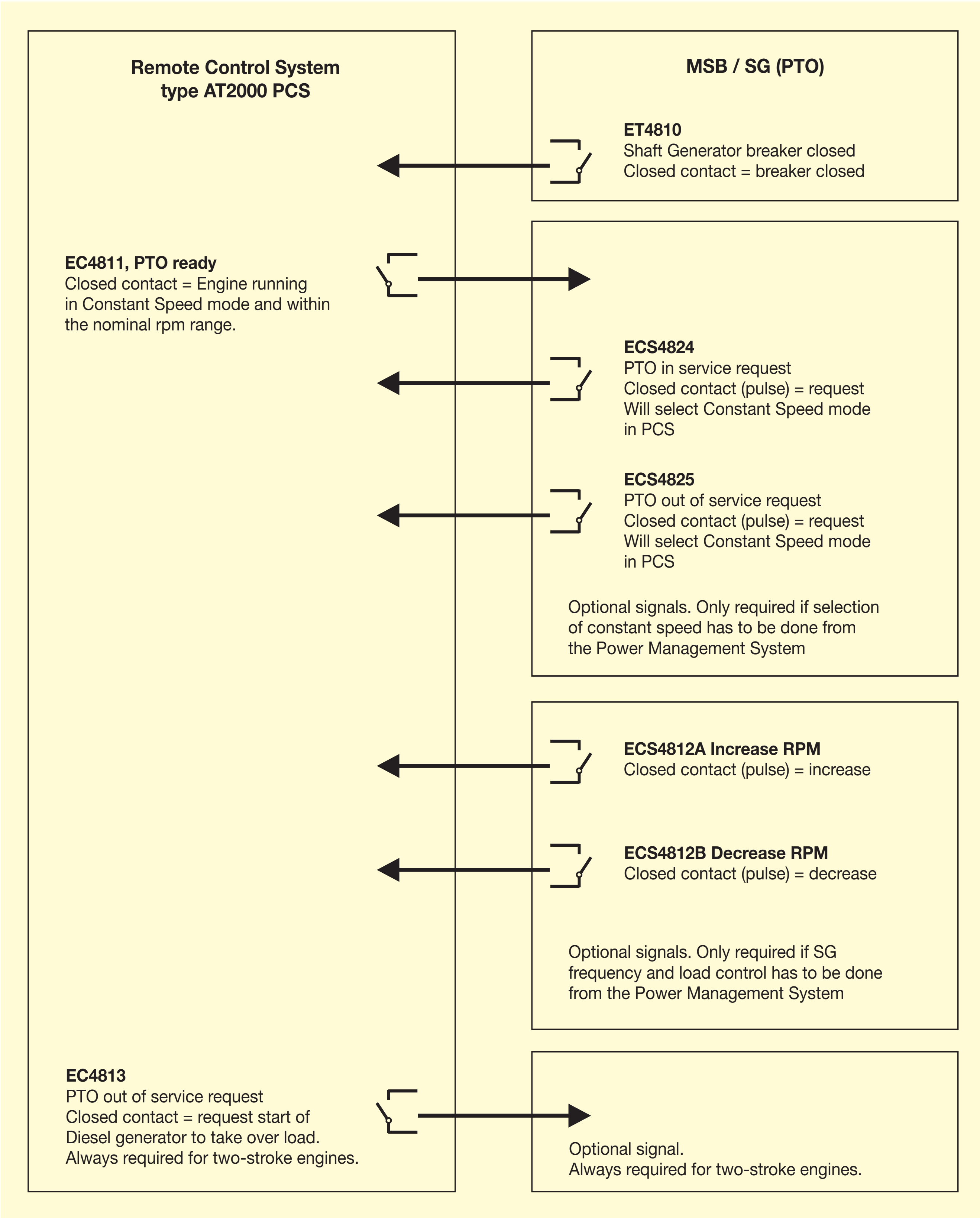

Fig 16: Interface for a PTO solution

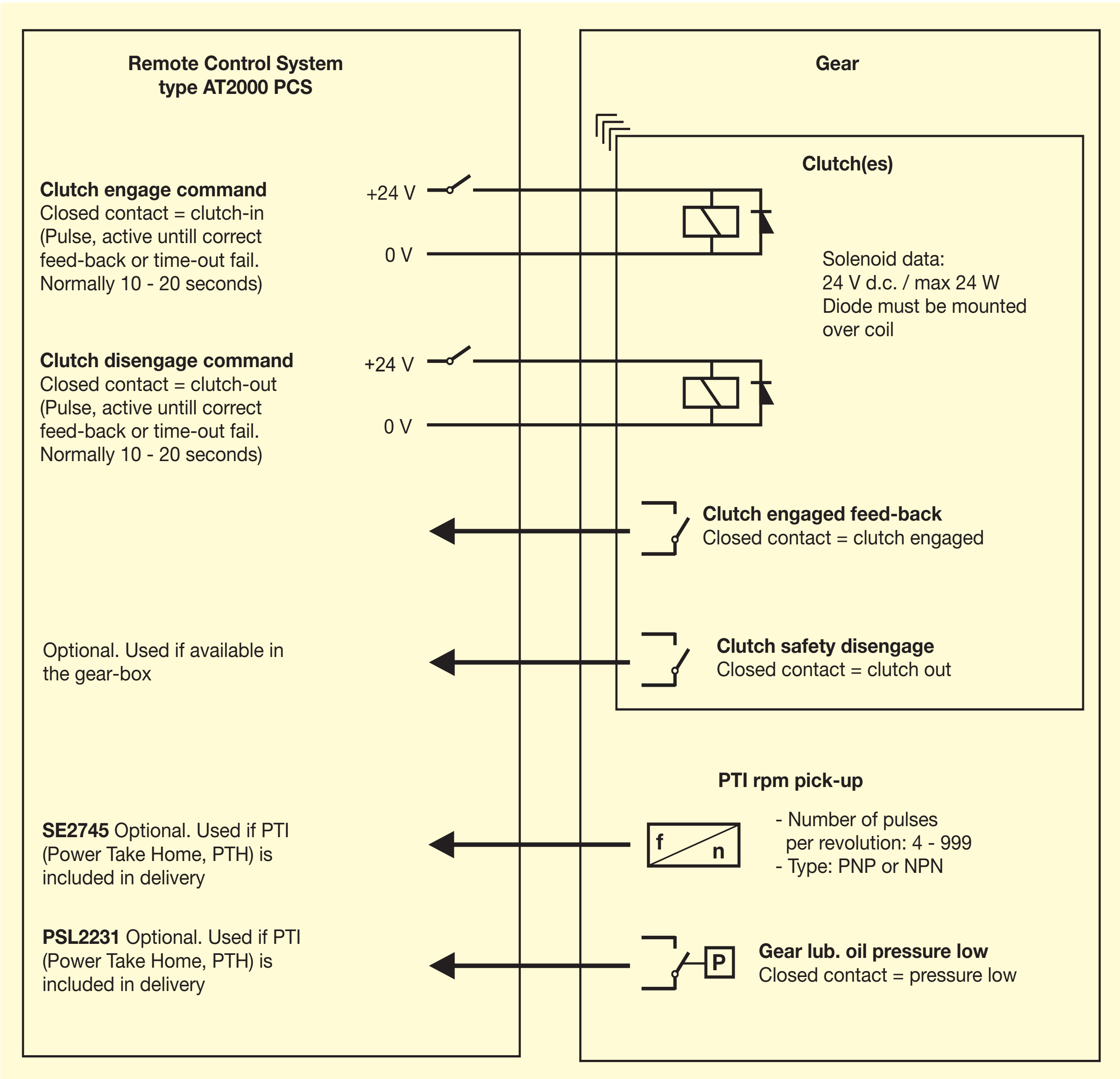

Fig. 17: Interface for a reduction gear/clutch solution

Gear and clutches

When connecting a gear that is not of MAN Diesel & Turbo make, the interface shown on fig.17 applies.

Safety system

When the engine is not of MAN or MAN B&W make, neither is the safety system. Fig. 18 shows the details of the necessary interface between the engine safety system and the Alphatronic propulsion control system.

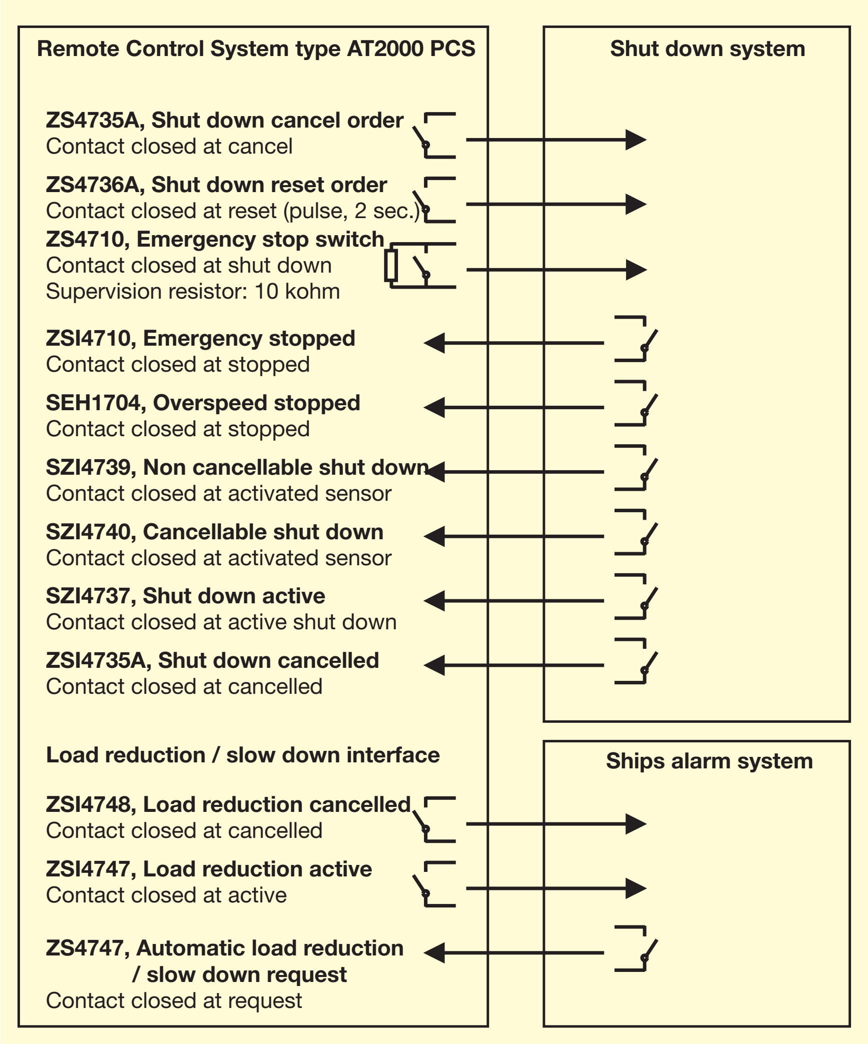

Fig. 18: Interface for safety system with an engine not of MAN or MAN B&W make

Engine

When the engine is not of MAN or MAN B&W make, the interface shown on fig. 19a and 19b applies for a two-stroke engine. Fig. 20 applies for a four-stroke engine.

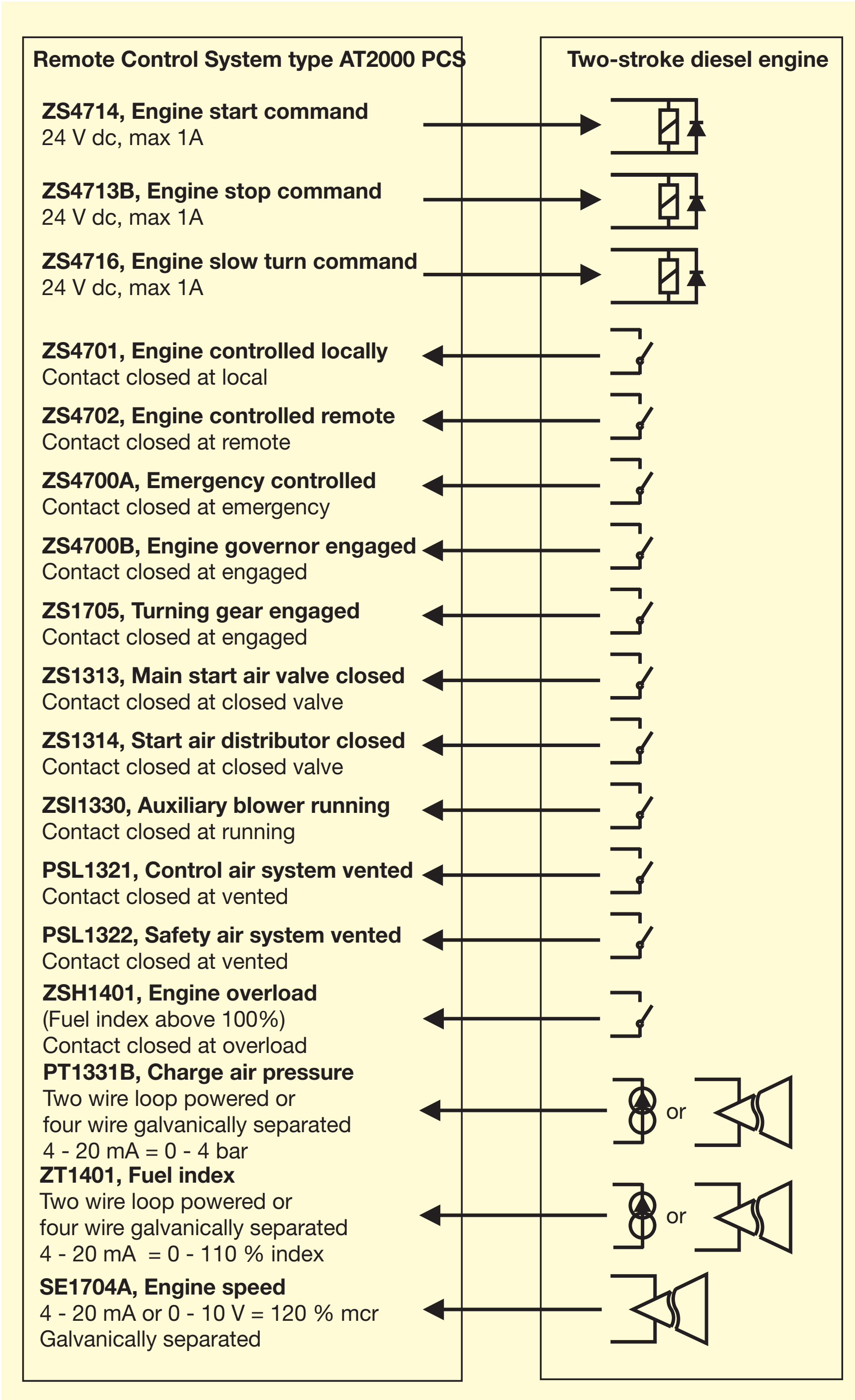

Fig. 19a: Interface for a two-stroke diesel engine not of MAN B&W make

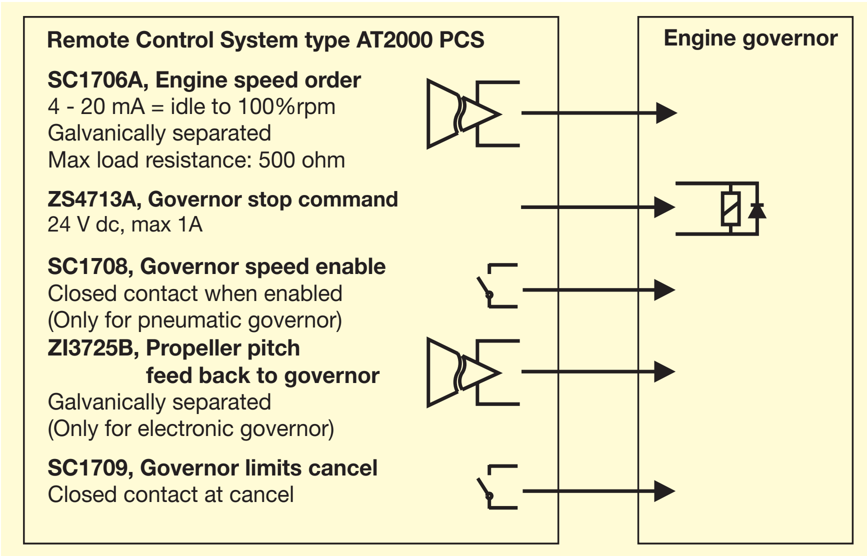

Fig. 19b: Interface for a two-stroke diesel engine not of MAN B&W make

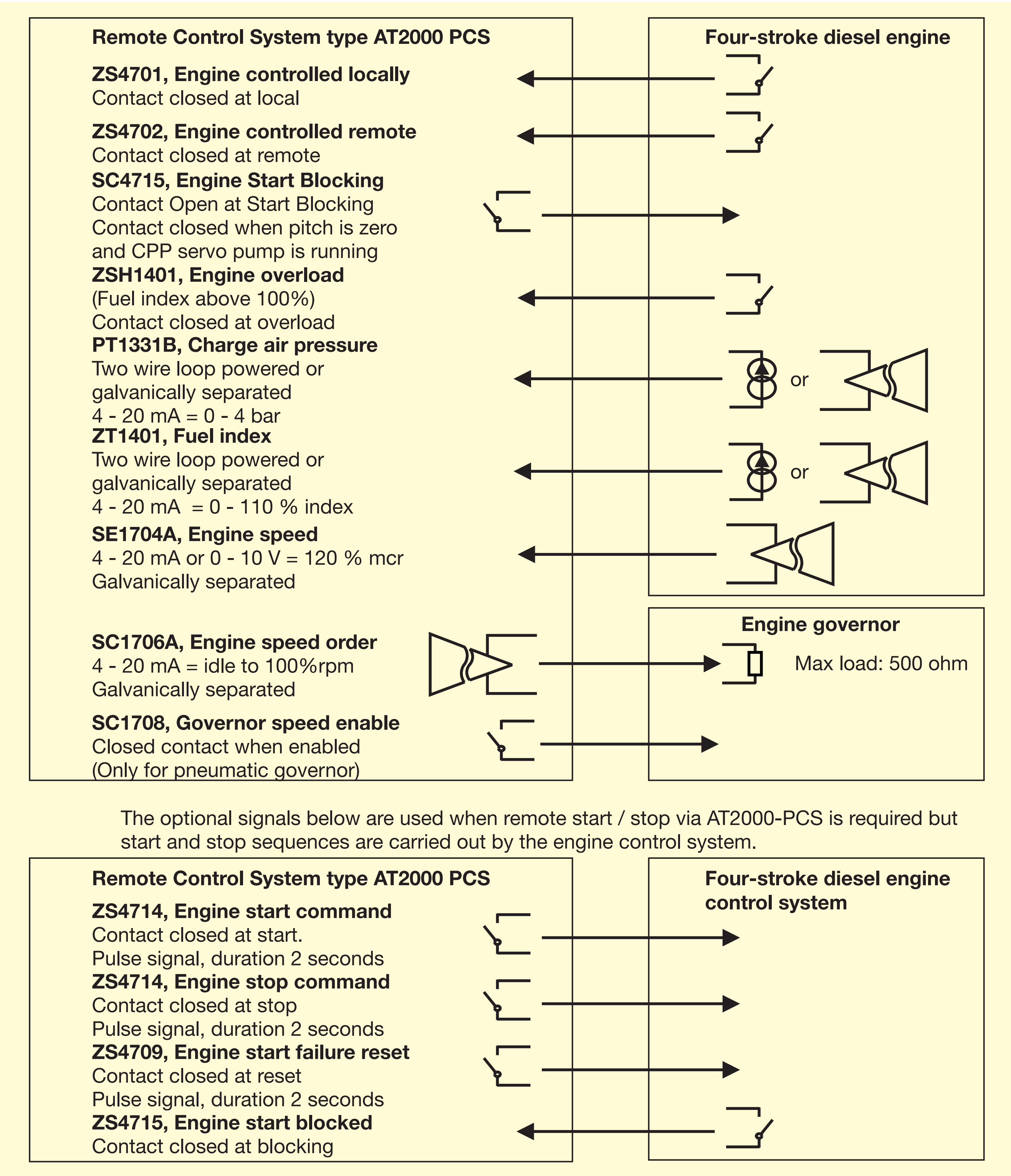

Fig 20: Interface for a four-stroke diesel engine not of MAN make

Joystick / coordinated control system

It is possible to transfer the control of the main propeller pitch to an external control system such as a joystick control system. Control can be transferred when the manoeuvring responsibility is on the bridge, the engine is running and the propeller is engaged.

During joystick control, the engine is still fully protected against overload.
Fig. 21 is showing the interface between an external control system and the propulsion control system.

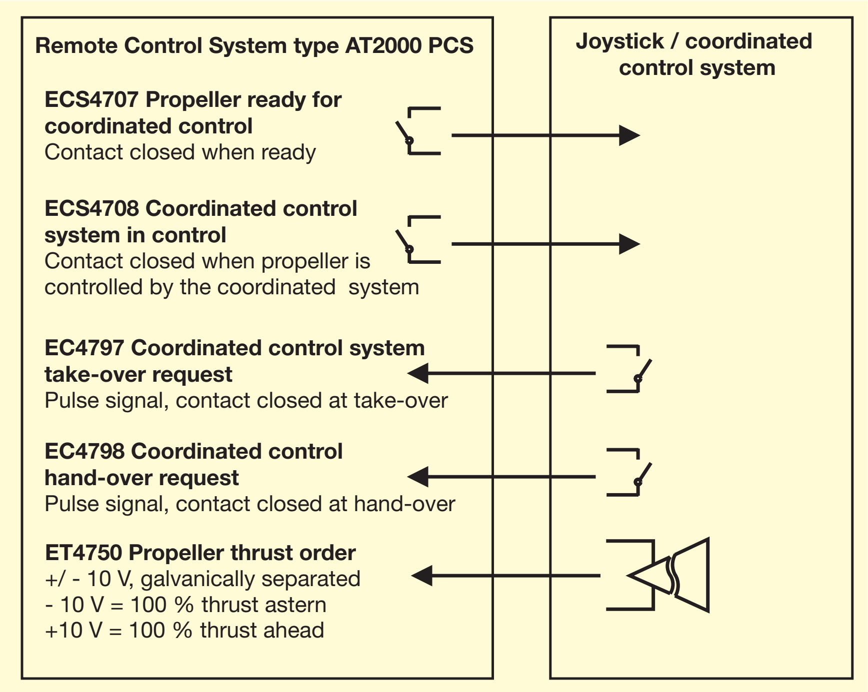

Fig 21: Interface for external control system

Main Cabinet

The heart of the remote control system consists of a main cabinet shown in fig. 22. Inside the cabinet, a process computer and a number of input/output units are located.

Installation

Layout examples. To illustrate the bridge and control room layout for different Alphatronic control system applications examples are given in fig. 23 to fig. 31.

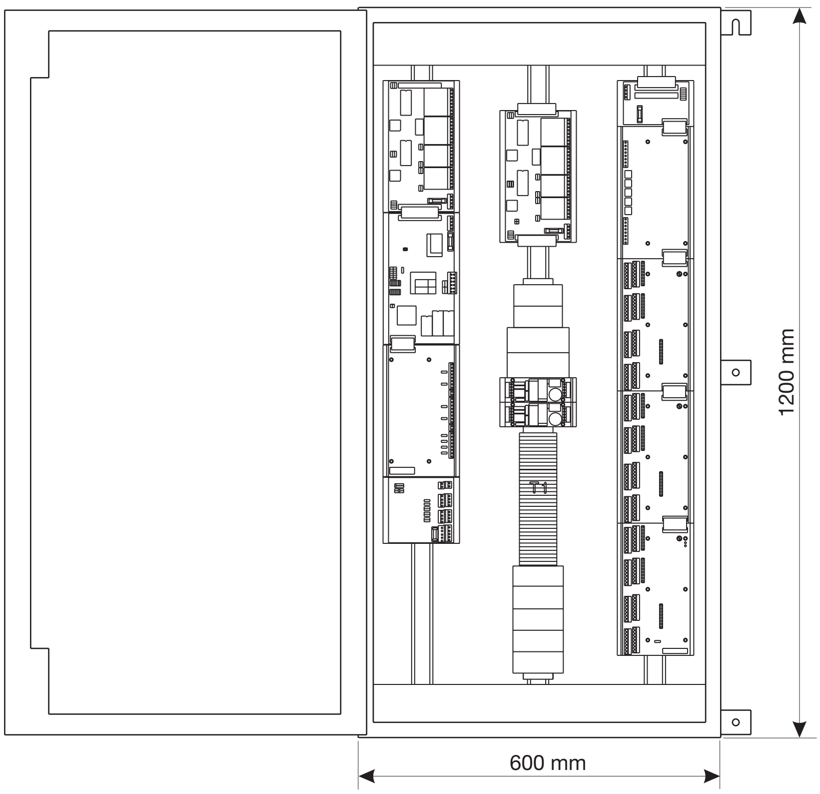

Fig. 22: Control system main cabinet

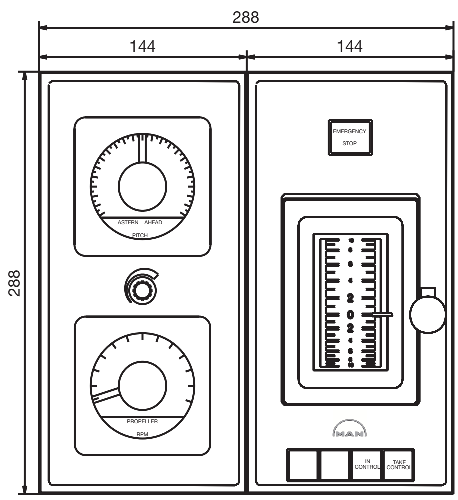

Fig. 23: Bridge wing layout (indoor) for single propeller plant

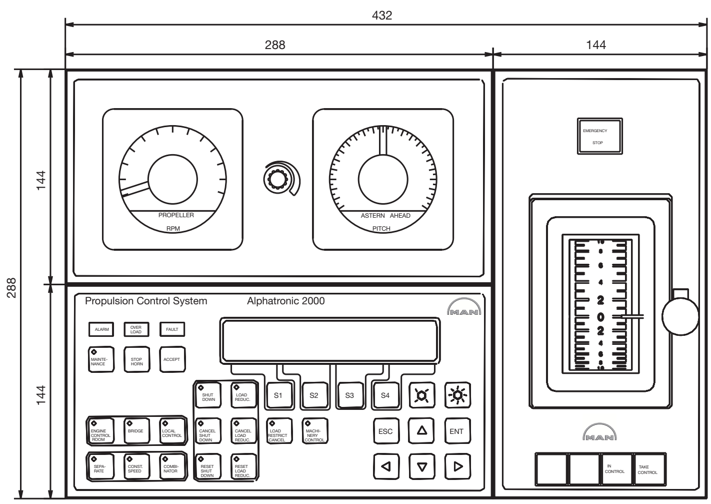

Fig. 24: Main bridge layout for single propeller plant

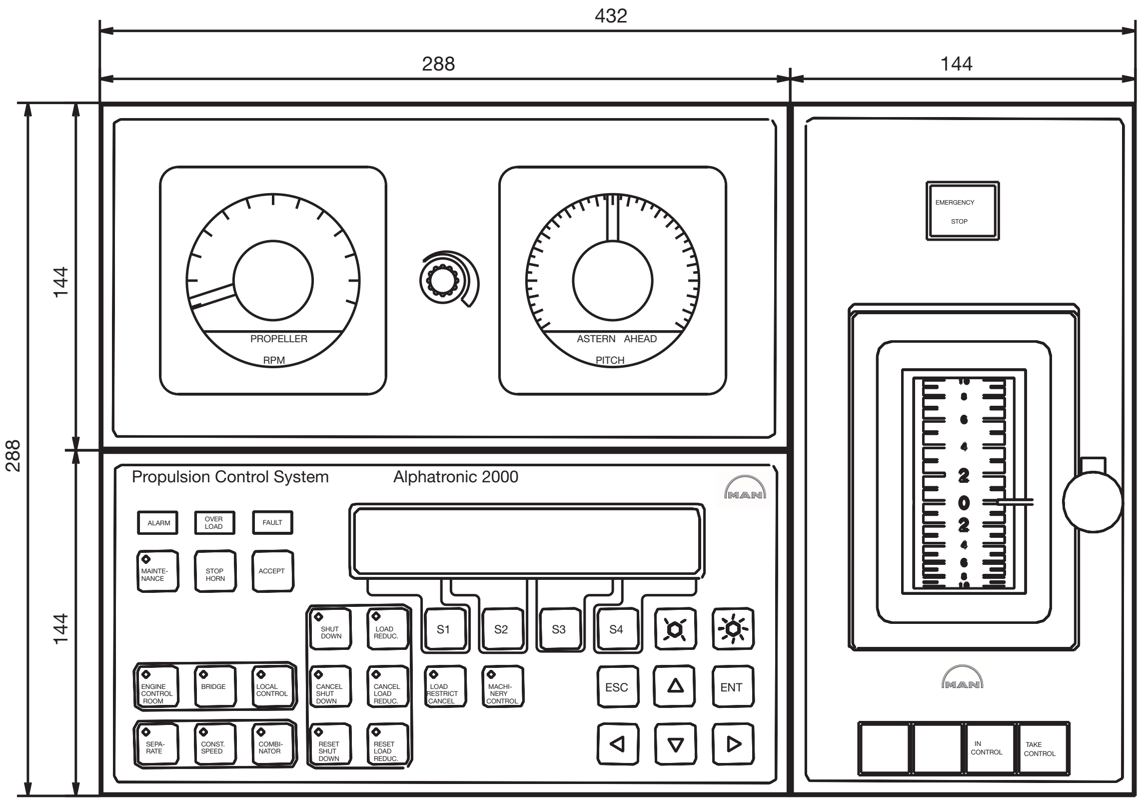

Fig. 25: Bridge wing layout including propulsion control panel

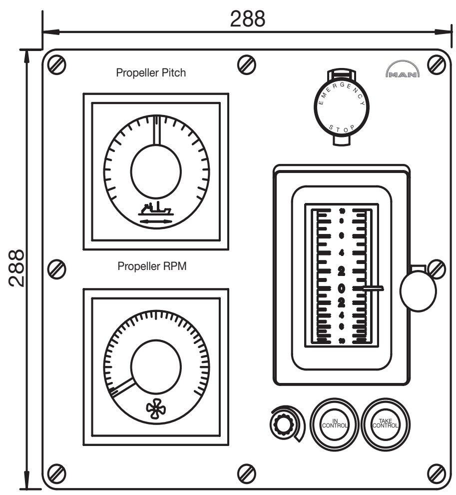

Fig. 26: Bridge wing layout (outdoor) for single propeller plant

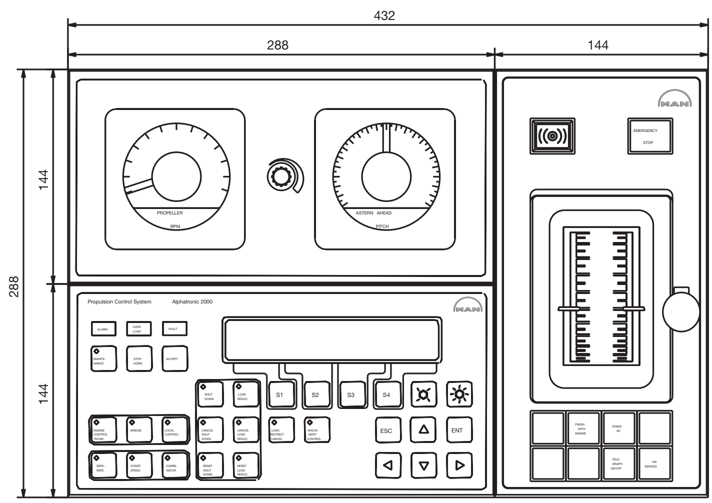

Fig. 27: Main bridge layout including telegraph for single propeller plant

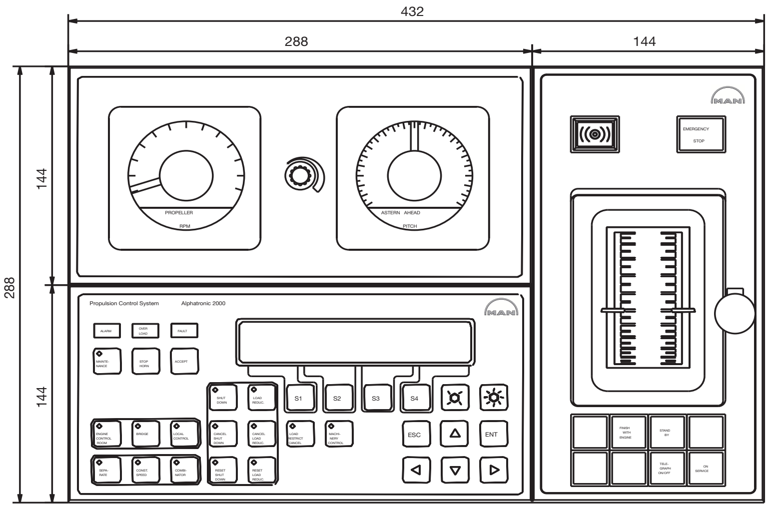

Fig. 28: Engine control room layout including telegraph for single propeller plant

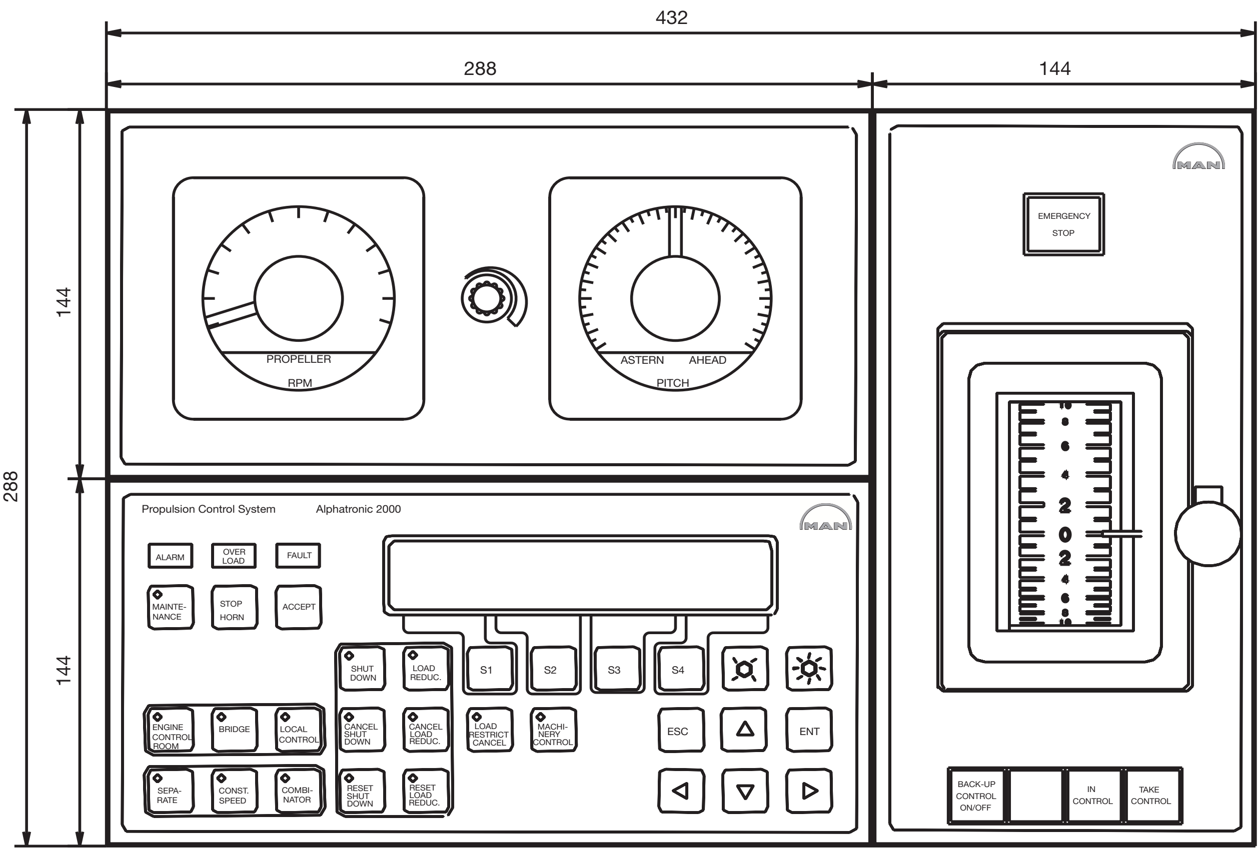

Fig. 29: Main bridge layout for single propeller plant

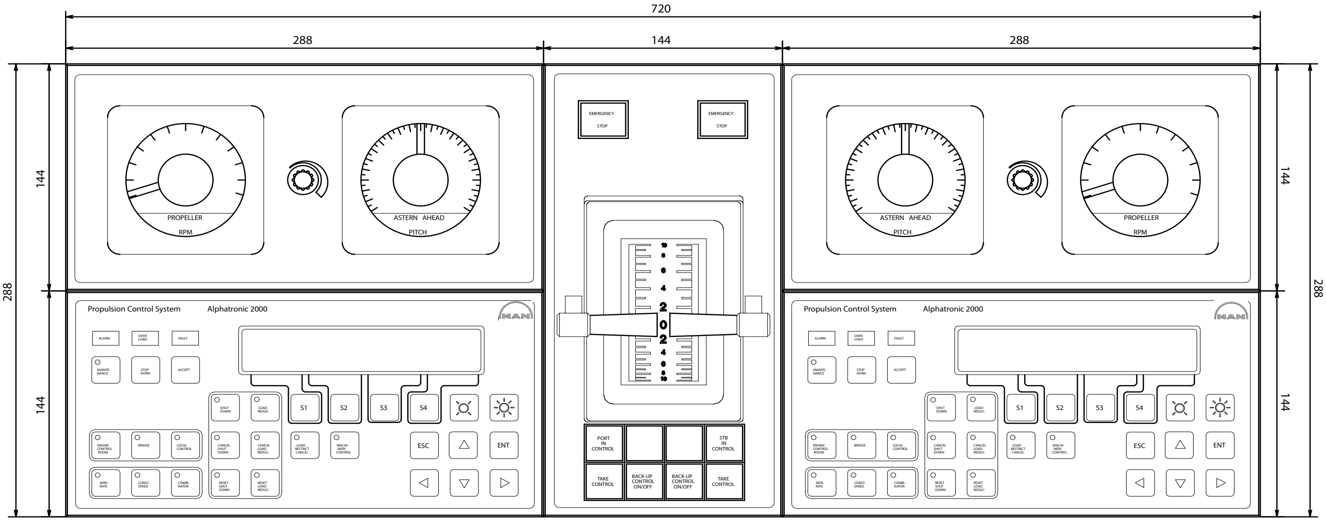

Fig. 30: Main bridge layout for double propeller plant

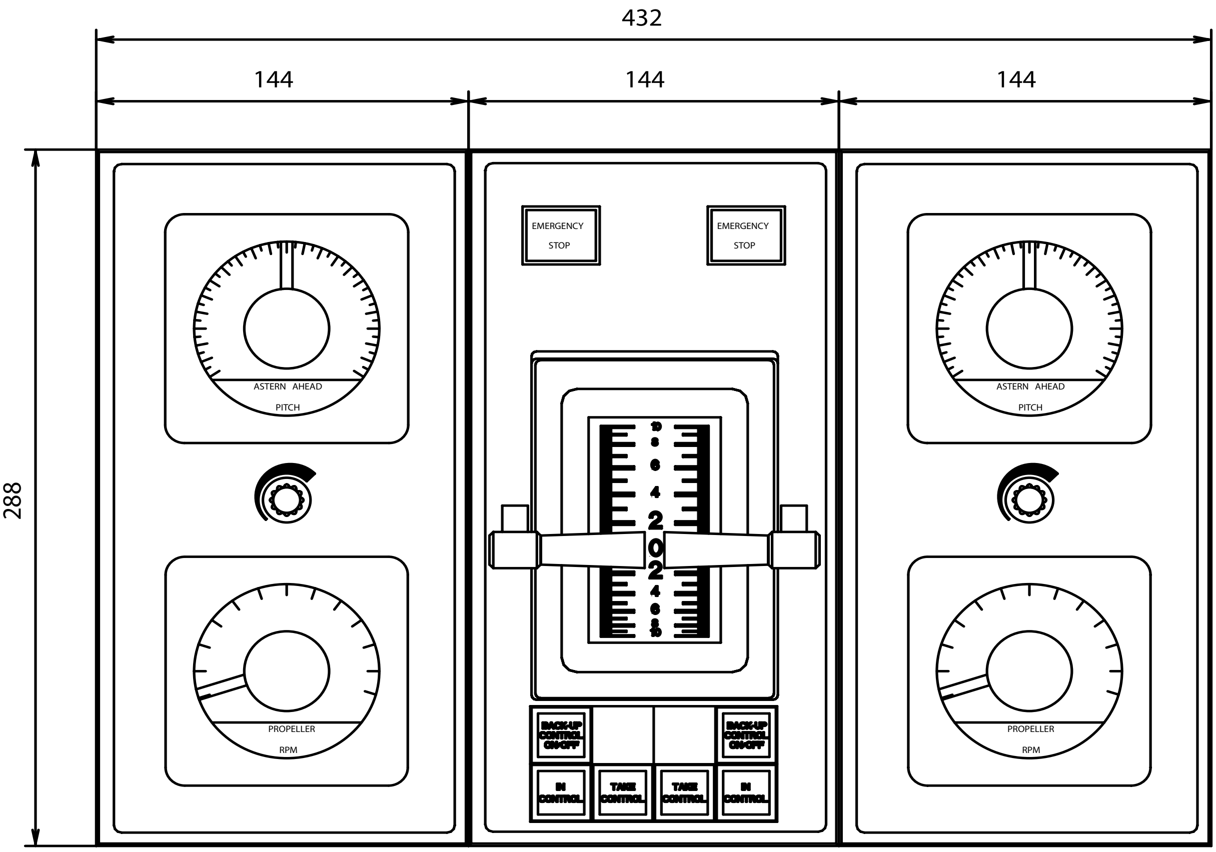

Fig. 31: Bridge wing layout for double propeller plant

Cable Plans

Cable plan and connection lists showing each cable connection to control system terminals are supplied by MAN Diesel & Turbo – after the Purchase Contract has been signed and upon receipt of all necessary shipyard information.

In order to ensure the optimum function, reliability and safety of the control system, without compromise – the following installation requirements must be taken into consideration:

- Power supply cables must be at least of size 2.5 mm^2
- If the supply cable length between the bridge and the engine room is in excess of 60 metres, the voltage drop should be considered
- The signal cables should have wires with cross sectional area of min 0.75 and max 1.5 mm^2
- All cables should be shielded and the screen must be connected to earth (terminal boxes) at both ends
- Signal cables are not to be located alongside any other power cables conducting high voltage (ie large motors etc) or radio communication cables. The remote control signals can be disturbed by current induced into the cables from their immediate environment. Induced current may disturb or even damage the electronic control system if the cables are not installed according to our Installation Guidance.

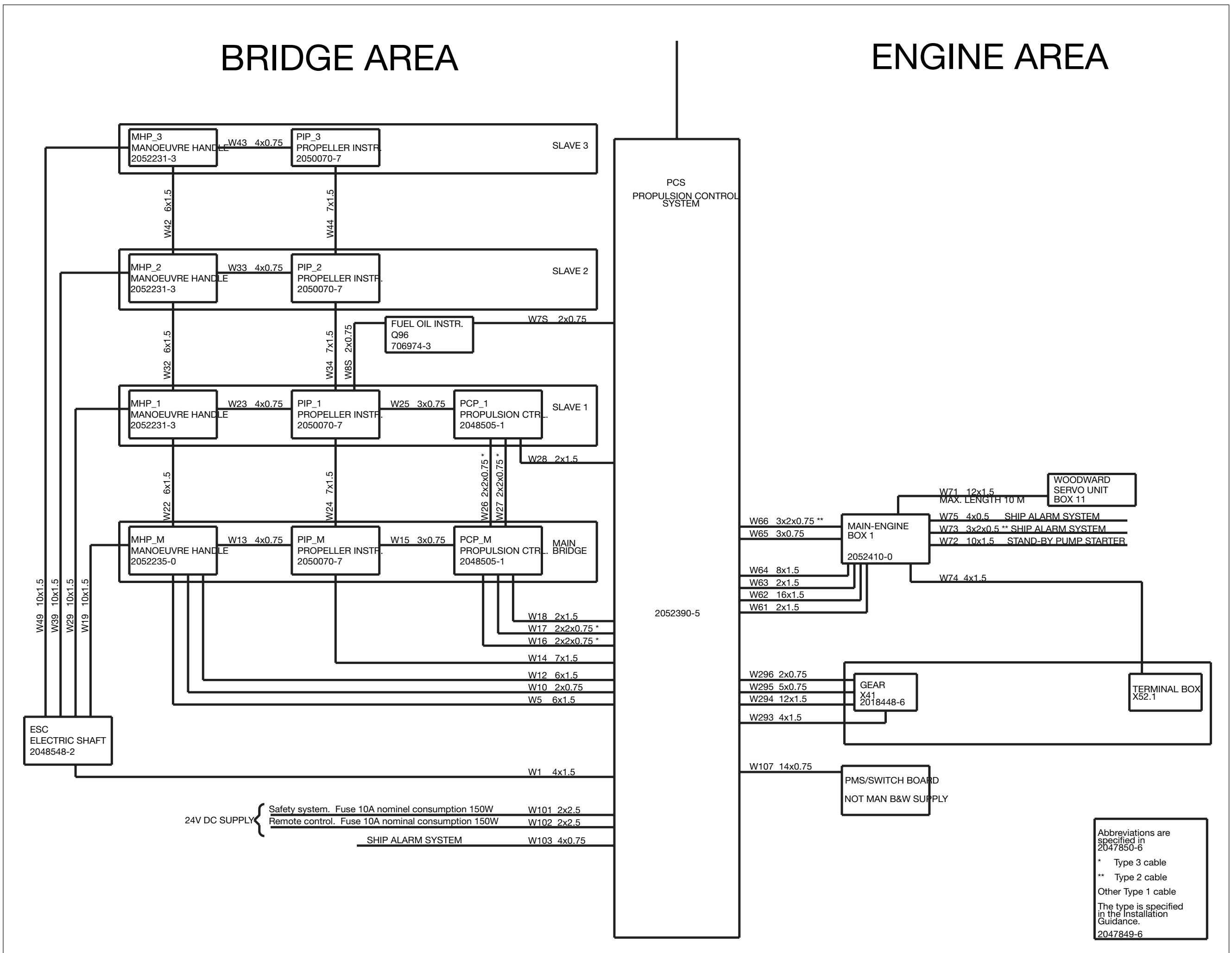

Fig. 32: Example of cable plan

Commissioning

As part of the on–board acceptance procedures, a final system test of the remote control system is carried out by MAN Diesel & Turbo commissioning engineers.

A number of Classification Societies usually require the on–board test to be performed in the presence of a surveyor before the official sea trial. Prior to the functional test, and even before the power supply voltage is switched on – the cable plan and connection lists are cross–checked with all wiring and connections made by the shipyard.

The MAN Diesel & Turbo procedure for Alphatronic Remote Control System Test is carried out in accordance with an exhaustive check list covering a number of tasks within the following categories:

- Power up and control room responsibility
- Control panel operations and indications
- Manoeuvre responsibility and transfer
- Failure and alarm simulation
- Propeller pitch back–up control
- Shaft alternator control

The commissioning engineers will adjust all lever positions and order signals as preparation for the fine tuning of settings for propeller pitch, fuel index etc performed during the sea trials.

Instruction Manual

As part of our technical documentation, an instruction manual will be forwarded. The instruction manual is tailor–made for each individual control system and includes:

- Descriptions and technical data
- Operation and maintenance guide lines
- Spare parts plates

The standard manual is supplied in a printed version – and can as an option be forwarded in electronic file formats.

Core no:	Core colour:	Conn. in: PCS / Term. no:	Signal carried		Conn. in: Box1 Engine / Term. no:
		SIM 1			ACS
		J4:1	MODBUS Transmitet data+	pair 1	J06:5
		J4:2	MODBUS Transmitet data -	pair 1	J06:1
		J4:3	MODBUS Received data +	pair 3	J06:4
		J4:4	MODBUS Received data -	pair 3	J06:2
		J4:5	MODBUS Ground	both wires in pair 2	J06:3
		Box	Screen		Box

Number of cores: 3x2 | Core size: 0,75 mm² | Not connected terminal: ===

Basic Standards (MBD SB) & Suppl. Drawing No.: | EN21C Surf. roughness | EN21F-m Tolerances | Projection: | Mass (kg): | Material / Blank: | Final User Material:

Date	Des.	Chk.	Appd.	A.C.	Change / Replacement		C.No
					Replaced by Ident. No.:		5
							4
							3
20001005	AAS	SNB		X3	Received data and ground twisted	/2-A791	2
20000329	AAS	HHJ	SNB	X3	Additional text added	/2-A461	1
19991130	AAS	HHJ	SNB			/2-A144	0

Similar Drawing No.: | Replacement for Ident. No.:

Scale:	Size:	Type:	Page No.:	
:	A4	AT2000	01(01)	MAN B&W Diesel A/S
Info. No.:		Description: W066 - Connection List		Ident. No.: 2 04 78 30-3
Final User Info. No.:		Final User Description:		Final User Ident. No.:

Fig. 33: Example of connection list

MAN Diesel & Turbo
Niels Juels Vej 15
9900 Frederikshavn, Denmark
Phone +45 96 20 41 00
Fax +44 96 20 40 30
info-frh@mandieselturbo.com
www.mandieselturbo.com