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RULES

FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

PART XV

AUTOMATION

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RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

Rules for the Classification and Construction of Sea-Going Ships of Russian Maritime Register of Shipping (RS, the Register) have been approved in accordance with the established approval procedure and come into force on 1 January 2023.

The present edition of the Rules is based on the 2022 edition taking into account the amendments and additions developed immediately before publication.

The procedural requirements, unified requirements, unified interpretations and recommendations of the International Association of Classification Societies (IACS) and the relevant resolutions of the International Maritime Organization (IMO) have been taken into consideration.

The Rules are published in the following parts:

Part I "Classification";

Part II "Hull";

Part III "Equipment, Arrangements and Outfit";

Part IV "Stability";

Part V "Subdivision";

Part VI "Fire Protection";

Part VII "Machinery Installations";

Part VIII "Systems and Piping";

Part IX "Machinery";

Part X "Boilers, Heat Exchangers and Pressure Vessels";

Part XI "Electrical Equipment";

Part XII "Refrigerating Plants";

Part XIII "Materials";

Part XIV "Welding";

Part XV "Automation";

Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships";

Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships";

Part XVIII "Additional Requirements for Structures of Container Ships and Ships, Dedicated Primarily to Carry their Load in Containers". The text of the Part is identical to IACS UR S11A "Longitudinal Strength Standard for Container Ships" (June 2015) and S34 "Functional Requirements on Load Cases for Strength Assessment of Container Ships by Finite Element Analysis" (May 2015);

Part XIX "Additional Requirements for Cargo Ships of Less Than 500 Gross Tonnage";

Part XX "Additional Requirements for Yachts";

Supplement to Rules and Guidelines of Russian Maritime Register of Shipping "IACS Procedural Requirements, Unified Requirements, Unified Interpretations and Recommendations".

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REVISION HISTORY[1]
(purely editorial amendments are not included in the Revision History)

Amended paras/chapters/sections	Information on amendments	Number and date of the Circular Letter	Entry-into-force date
Table 4.2.10-4	Monitored parameters and types of automatic protection for main gas turbines have been specified considering provisions of IACS UR M60 (Rev.1 Nov 2021)	315-24-1782c of 03.06.2022	01.01.2023
Para 8.2.1	Definitions "Common element", "Cross connection" and "Technical system configuration (TSC)" have been introduced for DP systems	315-24-1919c of 06.04.2023	01.05.2023
Para 8.10.4	Requirements for Class 1 DP systems have been specified	315-24-1919c of 06.04.2023	01.05.2023
Chapter 8.15	New Chapter has been introduced containing requirements for development of FMEA for DP vessels	315-24-1919c of 06.04.2023	01.05.2023

[1] Amendments and additions introduced at re-publication or by new versions based on circular letters or editorial amendments.

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of Sections 1, 2, 3, 7 apply to automation equipment subject to survey irrespective of whether the ship has an automation mark in the class notation or not.

The requirements of Sections 4, 5, 6 also apply to ships, which have one of the automation marks added to the character of classification in conformity with 2.2.6, Part I "Classification".

1.1.2 The present Part contains technical requirements for the automation equipment and ships, in which it is installed and defines the extent of remote automated control, protection, alarming and indication.

1.1.3 Ships with electric propulsion plants and ships with nuclear propulsion plants shall additionally comply with the requirements of Chapter 17.14, Part XI "Electrical Equipment" of these Rules or Part XI "Automation" of the Rules for the Classification and Construction of Nuclear-Powered Vessels and Floating Facilities" accordingly, together with the requirements of this Part.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations relating to the general terminology of the Rules are given in Part I "Classification".

For the purpose of the present Part the following definitions have been adopted.

Automated machinery plant is a complex of machinery and equipment fitted up with an automation system.

Uninterruptible power supply is a device supplying output power in some limited time period after loss of main and/or emergency input power with no interruption of the output power.

Acknowledgement is a confirmation of receipt of an alarm or call.

Group alarm subsystem is the structural part of the centralized alarm and monitoring system comprising individual additional blocks (panels) wherein some alarms derived from the combining (grouping) of alarms relating to individual machinery and arrangements into one common alarm are concentrated.

The group alarm shall be named after the item to be monitored, e.g. "main engine", "electric power plant", etc.

The group alarm blocks are arranged in accommodation, service and other spaces where the responsible personnel (chief engineer, watch engineers, electrician engineer, etc.) may be present.

Standby power source is a source of electric power independent of the ship main and emergency power sources.

Alarm and monitoring system is equipment for signalling whenever the controlled parameters reach the preset limit values or deviations of machinery and associated systems from normal working ranges occur. Individual alarms may be grouped in common alarms.

Automation system is equipment intended for an automatic and/or automated control, regulation, monitoring, signalling and protection of machinery or systems.

Remote automated control system is equipment intended for control of machinery from a remote control station enabling an automatic execution of intermediate operations for collection and processing of information on the object and making commands to the executive devices realizing the mode of the machinery functioning set up by the operator.

Safety system is equipment to automatically influence, in a specific way, the operation of machinery under control in order to prevent an emergency or limit its consequences.

Indication system is equipment providing information on the values of certain physical parameters and certain conditions in machinery.

Automation device is a part of automation system comprising components, which form a structural and functional unity.

Automation component is a structurally independent item (e.g. sensor, relay, logic element) forming part of automation devices and systems.

1.3 SCOPE OF SURVEYS

1.3.1 General provisions concerning classification procedure, survey of ships being designed or constructed, manufacture of equipment and items shall be found in Part I "Classification" and General Regulations for the Classification and Other Activity.

1.3.2 Subject to survey during manufacture are automation components, apparatus and control devices of the following:

.1 main machinery and propellers;
.2 electric power plants;
.3 auxiliary machinery;
.4 main and auxiliary boilers;
.5 refrigerating plants;
.6 alarm and monitoring systems;
.7 safety devices;
.8 other systems as required by the Register.

1.4 TECHNICAL DOCUMENTATION

1.4.1 For the automation equipment listed under 1.3.2, the technical documentation to be submitted to the Register depending on the object of survey, is as follows:

.1 functional description including technical parameters and operating conditions;

.2 block diagram of control system;

.3 functional process diagram with indication of all instruments and control devices;

.4 general arrangement and layout;

.5 user interface description showing the physical layout, a list of all alarms, functions allocated to each keyboard/screen;

.6 power supply arrangement and connection diagram;

.7 cable routing layout diagram;

.8 instrument and equipment list with indication of performance specifications;

.9 description of functions covered by software and test program for application software at manufacturer's;

.10 schematic diagrams of input and output circuits;

.11 failure mode description;

.12 test program;

.13 operation manual;

.14 installation and maintenance manual;

.15 structural and mounting drawings of consoles and control and monitoring switchboards as well as mounting drawings of elements of automation systems and devices, sensors, signalling and instruments.

2 DESIGN OF AUTOMATION SYSTEMS, AUTOMATION COMPONENTS AND CONTROL DEVICES

2.1 GENERAL

2.1.1 Reliable operation of automation systems, automation components and control devices shall be ensured under the following ambient temperature conditions:

+5 °C to +45 °C in enclosed spaces;

–25 °C to +45 °C on open deck.

Electronic components and devices of automation systems shall reliably operate at ambient temperatures up to +55 °C.

No damage to automation components and control devices intended for installation in switchboards, control panels or enclosures together with other heat-generating equipment shall be caused by temperatures up to +70 °C.

Categories of equipment according to heat stability depending on operating conditions are given in Table 2.1.1-1.

Table 2.1.1-1

Category of equipment	Temperature	Description
TH1	up to +55 °C	Equipment not related to categories TH2 and TH3.
TH2	up to +70 °C	Components and devices intended for installation in switchboards, control panels or enclosures together with other heat-generating equipment.
TH3	above +70 °C	The equipment for which higher operating temperatures are possible, for example, directly fitted to internal combustion engines, boilers, etc.
N o t e . Equipment falling into a higher category meets the requirements for all lower categories of equipment.		

Categories of equipment according to cold endurance depending on the operating conditions are given in Table 2.1.1-2.

Table 2.1.1-2

Category of equipment	Temperature	Description
TL1	not below +5 °C	The equipment intended for installation in heated spaces.
TL2	not below -25 °C	The equipment installed on the open deck or in unheated spaces.
TL3(**DAT**)[1]	design ambient temperature (**DAT**)	The equipment installed on the open deck or in unheated open spaces of ships with the distinguishing mark **WINTERIZATION(DAT)** in the class notation.
[1]Instead of **DAT**, the value of design ambient temperature shall be indicated in brackets. N o t e . Equipment falling into a higher category meets the requirements for all lower categories of equipment.		

2.1.2 Reliable operation of automation systems shall be ensured at relative air humidity of (75±3°) % and temperature of (45±2) °C or at relative air humidity of (80±3) % and temperature of (40±2) °C, as well as at relative air humidity of (95±3) % and temperature of (25±2) °C.

2.1.3 Depending on the category of equipment, reliable operation of automation systems shall be ensured at vibrations conditions specified in Table 2.1.3-1.

Table 2.1.3-1

Category of equipment	Vibration conditions	Description
V1	Within the frequency range of 2^{+3}_{-0} Hz – 13,2 Hz with shift amplitude of ±1 mm; within the frequency range of 13,2 Hz – 100 Hz with an acceleration of ± 0,7*g*	Equipment not related to categories V2 and V3.

Category of equipment	Vibration conditions	Description
V2	Within the frequency range of 2^{+3}_{-0} Hz – 25 Hz with shift amplitude of ±1,6 mm; within the frequency range of 25 Hz – 100 Hz with an acceleration of ± 4,0*g*	The equipment operating under the conditions of increased vibration (e.g. the equipment to be installed directly on the internal combustion engines, air compressors, etc.).
V3	Within the frequency range of 40 Hz – 2000 Hz with an acceleration of ±10,0*g* at the temperature of 600 °C, duration 90 min	The equipment intended for operation under the conditions of increased vibration, e.g. in exhaust-gas receivers or diesel engine injection systems, etc.
N o t e . The equipment of category V2 meets the requirements for the equipment of category V1.		

Depending on the category, automatic equipment shall also operate reliably at shocks with the parameters specified in Table 2.1.3-2.

Table 2.1.3-2

Category of equipment	Shock parameters	Description
G0	Not rated	The equipment intended for installation on berth-connected ships and fixed offshore platforms.
G3	With an acceleration of 3,0*g*, duration of 6 or 30 ms, number of shocks of 100 ±5 in each position	The equipment not related to the category G0 intended for installation on floating offshore oil-and-gas production units, ships of no ice class or ships of **Ice1**, **Ice2**, **Ice3** ice classes.
G5	With an acceleration of 5,0*g*, duration of 6 or 30 ms, number of shocks of 100 ±5 in each position	The equipment intended for installation on ships of ice classes **Arc4 – Arc9**, **Icebreaker6 – Icebreaker9**.
N o t e . Equipment falling into a higher category meets the requirements for all lower categories of equipment.		

2.1.4 Reliable operation of automation systems shall be ensured at long-term heel up to 22,5° and at motions of 22,5° with a period of (8±1) s.

2.1.5 The protection of automation systems, automation components and control devices shall be chosen in accordance with 2.4, Part XI "Electrical Equipment" proceeding from their location.

2.1.6 Electrical and electronic components and devices shall operate reliably in case of deviation of the power parameters listed in Table 2.1.6-1 from nominal values.

Table 2.1.6-1

Power parameter	Deviation from nominal value		
	Long-term, %	Short-term	
		%	Time, s
Voltage (a. c.)	+6... 7 10	+ 20	1,5
Frequency	+ 5	+ 10	5
Voltage (d. c.)	+ 10	5	Cyclic deviation
		10	Ripple

Automatic equipment supplied from accumulator batteries shall operate reliably with the following voltage variations from the nominal value:

from +30 to –25 % for the equipment, which is not disconnected from the battery during battery charging;

from +20 to –25 % for the equipment, which is disconnected from the battery during battery charging.

Categories of the equipment depending on type of power supply are given in Table 2.1.6-2.

Table 2.1.6-2

Category of equipment	Description
P1	The equipment supplied from the battery connected to a charging battery.
P2	The equipment not connected to the battery during charging.

The operability of automation systems shall not be affected by three successive power supply interruptions during 5 min with switching-off time of 30 s in each case.

2.1.7 Pneumatic and hydraulic components and devices shall be operable under variations of the working medium pressure within ±20 % of the nominal value.

2.1.8 Provision shall be made to ensure the electromagnetic compatibility of automation equipment and to keep the radio interference from it to a permissible level.

Categories of equipment according to electromagnetic compatibility depending on the operating conditions are given in Table 2.1.8.

Table 2.1.8

Category of equipment	Description
E1	Equipment installed on the open deck and navigation bridge.
E2	Equipment installed in enclosed machinery and other enclosed spaces of the ship.

2.1.8.1 For the equipment of category E1, the levels of radiated electromagnetic emission at a distance of 3 m shall not exceed the following values within the frequency ranges stated below:

0,15 — 0,3 MHz – 80 — 52 dBμV/m;

0,3 — 30 MHz – 52 — 34 dBμV/m;

30 — 1000 MHz – 54 dBμV/m;

1000 — 6000 MHz – 54 dBμV/m;

except for the range 156 — 165 MHz where 24 dBμV/m shall be established.

For the equipment of category E2, the levels of radiated electromagnetic emission at a distance of 3 m shall not exceed the following values within the frequency ranges stated below:

0,15 — 30 MHz – 80 — 50 dBμV/m;

30 — 100 MHz – 60 — 54 dBμV/m;

100 — 1000 MHz – 54 dBμV/m;

1000 — 6000 MHz – 54 dBμV/m.

Artificial mains network and quasi-peak measuring receiver shall be used to measure the intensity level of electromagnetic emission. The transmission bandwidth of the receiver for the frequency range 0,15 to 30 MHz and from 156 to 165 MHz shall be 9 kHz, and in the frequency range from 30 to 156 MHz and from 165 MHz to 1 GHz — 120 kHz.

2.1.8.2 For the equipment of category E1, the levels of caused interference in the supply and input-output circuits shall not exceed the following values within the frequency ranges stated below:

10 — 150 kHz – 96 — 50 dBμV;

150 — 350 kHz – 60 — 50 dBμV;

350 kHz — 30 MHz – 50 dBμV.

For the equipment of category E2, the levels of caused interference in the supply and input-output circuits shall not exceed the following values within the frequency ranges stated below:

10 — 150 kHz – 120 — 69 dBμV;

150 — 500 kHz – 79 dBμV;

500 kHz — 30 MHz – 73 dBμV.

The transmission bandwidth of the receiver when measurements are made in the frequency range from 10 kHz to 150 kHz shall be 200 Hz and in frequency range from 150 kHz to 30 MHz — 9 kHz.

2.1.8.3 Automation equipment shall be capable of reliable performance when exposed to the following external electromagnetic interference:

.1 conductive low frequency interference with the parameters as below:

for the equipment supplied by direct current:

frequency range: 50 Hz to 10 kHz;

test voltage (effective value): 10 % of the nominal supply voltage;

test signal maximum power — 2 W;

for the equipment supplied by alternating current:

frequency range: from rated frequency to 200-th harmonic;

test voltage (effective value): 10 % of the rated supply voltage to the 15-th harmonic, reducing from 10 % to 1 % in the range from 15-th to 100-th harmonic; 1 % in the range from 100-th harmonic to 200-th harmonic;

test signal maximum power — 2 W, minimum value of test voltage effective value — 3 V. The specified value of test voltage may be reduced in case the maximum power exceeds;

.2 conducted radio frequency interference:

for the equipment of E2 category, the effective voltage value: 3 V at the frequency varying in the range from 150 kHz to 80 MHz.

for the equipment of E1 category, the effective voltage value shall be increased up to 10 V at points with frequencies: 2 MHz, 3 MHz, 4 MHz, 6,2 MHz, 8,2 MHz, 12,6 MHz, 16,5 MHz, 18,8 MHz, 22 MHz and 25 MHz;

frequency variation rate: ≤1,5 x 10^{-3} decade/s (or 1 % / 3 s);

modulation depth: 80 %;

modulation frequency 1000 Hz;

.3 nanosecond pulse interference in the AC supply lines, signal, data and control circuits with the parameters as below:

pulse rise time: 5 ns (between 10 % and 90 % amplitude level);

duration of unit pulse: 50 ns (at 50 % value);

amplitude: 2 kV when applied to the supply circuits relative to the casing;

amplitude: 1 kV when applied to the signal, control and communication supply circuits;

unit pulse recurrence frequency: 5 kHz or 100 kHz;

pulse burst duration: 15 ms;

burst recurrence period: 300 ms;

duration: 5 min for each positive and negative pulse polarity;

.4 microsecond pulse interference with the parameters as below:

pulse rise time: 1,2 μs (front time);

pulse duration: 50 μs (time to half value);

amplitude: 1 kV line/earth;

amplitude: 0,5 kV line/line;

recurrence frequency: ≥ 1 pulse/min;

pulse number: 5 pulses for each positive and negative pulse polarity.

Short circuit current:

pulse rise time: 8 μs (front time);

pulse width: 20 μs (time to half value);

repetition rate: ≥ 1 pulse/min;

number of pulses: 5 per polarity;

.5 electrostatic discharge with the parameters as below:

amplitude: 6 kV for contact discharge;

amplitude: 2 kV, 4 kV and 8 kV for air discharge;

number of pulses: 10 per polarity.

2.1.8.4 The automation equipment shall be immune to electromagnetic field with the parameters as below:

frequency range: 80 MHz — 6 GHz;

frequency sweep rate: ≤1,5 x 10^{-3} decade/s (or 1 % / 3 s);

field strength: 10 V/m;

modulation depth: 80 %;

modulation frequency: 1000 Hz.

If an equipment is intended to receive radio signals for the purpose of radio communication (e.g. wi-fi router, etc.), then the immunity limits at its communication frequency do not apply.

2.1.9 Automation equipment shall operate reliably in case of harmonic distortions of the supply voltage curve as specified under 2.2.1.3, Part XI "Electrical Equipment".

2.1.10 Components and devices to be installed in locations with specific operating conditions (high or low temperature, excessive mechanical loads, etc) shall be designed and tested with regard to the conditions.

2.1.11 Automation equipment shall be made of materials resistant to marine environment or shall be reliably protected from its harmful effect.

Categories of equipment according to corrosion resistance depending on the operating conditions are given in Table 2.1.11.

Table 2.1.11

Category of equipment	Description
C0	The equipment intended for installation indoors.
C1	The equipment intended for installation on the open deck or in open spaces.
N o t e . Equipment falling into a higher category meets the requirements for all lower categories of equipment.	

2.1.12 Automation systems shall comprise arrangements to preclude false alarms from momentary changes of parameters due to roll of the ship, machinery switch-on and switch-off, etc.

2.1.13 Automation systems shall be based on the "fail-to-safe" principle.

2.1.14 The list of spare parts for automation equipment and systems is made up by the manufacturer.

For a particular ship, the total number of spare parts is determined on the basis of agreement between the shipbuilder and equipment manufacturer on one part and the shipowner on the other with due regard to the equipment reliability.

2.2 REQUIREMENTS FOR COMPONENTS AND DEVICES

2.2.1 The components and devices of automation systems shall additionally comply with the applicable parts of the Rules.

2.2.2 Replaceable components, which require adjustment, as well as check-up points (terminals, monitoring jacks) shall be so arranged that easy access is possible at any time.

2.2.3 The devices shall be capable of being tested during normal operation.

2.2.4 Equipment shall preferably function without forced cooling. Where such cooling is indispensable, precautions shall be taken to prevent the equipment from being damaged in the event of failure of the cooling unit.

2.2.5 Setting components shall be protected against spontaneous change of setting. Such protection shall not preclude the possibility of adjustment.

2.2.6 Actuators shall be so constructed that no spontaneous change of their setting is possible.

2.2.7 Sensors used for measuring temperature of fire-hazardous, toxic liquids, vapours and gases, liquids, vapours and gases under pressure shall be isolated from the medium tested.

2.2.8 Provision shall be made for checking and calibrating of the pressure transducers at their connections to the test points, without dismantling.

2.2.9 All units, devices and test points shall be clearly and permanently marked. The marking shall be preferably placed adjacent to them.

2.2.10 Electrical and electronic equipment.

2.2.10.1 The contacting connections shall be so designed as to prevent the increase of contact resistance restricting the equipment performance.

2.2.10.2 At cable and wire inlets, especially in way of connections to movable elements and devices, provision shall be made to avoid tension effects.

2.2.10.3 Printed circuit boards shall be coated with insulating varnish.

2.2.10.4 Provision shall be made to prevent incorrect mounting of removable items (modules) having plug-and-socket connections and to ensure their efficient fixing in the working position. Where necessitated by the operating or structural features of components or devices, their position assuring proper mounting shall be clearly marked or, alternatively, they shall be so constructed that the possibility of being mounted in a wrong position is excluded.

2.2.11 Hydraulic and pneumatic equipment.

2.2.11.1 Hydraulic and pneumatic components and devices shall not be damaged by overloads due to a working medium pressure rise equal to 1,5 times the working pressure.

2.2.11.2 The fluids of hydraulic systems shall retain their physical properties under all possible operating conditions, to possess good lubricating properties and a vapour flash point not less than 60 °C, not to cause the damage to components and piping and not to be toxic.

2.2.11.3 Hydraulic automation equipment shall not be connected with other systems and shall be supplied from separate tanks. The use of fluid from other systems may be permitted for actuating systems subject to provision of the relevant filtering arrangements.

2.2.11.4 Connections of the outlet pipes shall be located below the working fluid level in the tanks under any operating conditions of the ship.

2.2.11.5 Pneumatic automation systems shall have arrangements to ensure the required degree of cleanliness and dryness of the air.

2.2.11.6 Pneumatic automation systems of the main propulsion plants and electrical power plants shall generally have two devices for cleaning and drying the air interconnected in such a way that one of them remains operative while the other is cut off.

A single air cleaning and drying device may be permitted where automatic cleaning is provided or its design is such that a rapid replacement of filtering elements is possible without interruption of the air supply.

2.2.11.7 The feeding pipes of pneumatic automation systems shall be fitted up with safety valves set to operate when the nominal working pressure is exceeded by more than 10 %. Reducing valves, if any, shall be duplicated.

2.2.11.8 Where hydraulic, pneumatic and electronic or electric elements and devices are combined in desks, cabinets or cubicles, they shall be effectively separated so that eventual leaks from pipes and hoses and from their connections would not damage such elements and devices.

Desks, cabinets and cubicles accommodating equipment, which contains working fluid, shall be fitted up with appliances for collection and retrieval of the leaks.

2.3 AUTOMATED CONTROL SYSTEMS

2.3.1 Machinery and plants shall be constructed in conformity with the applicable requirements of the relevant parts of the Rules, and equipped with local control stations.

2.3.2 Automated control shall keep all controlled parameters within the limits specified by the normal operating conditions of the machinery and plants under control.

2.3.3 The automated control shall be stable over the entire control range. The margin of stability shall be sufficient to ensure that variations in the controlled parameters that may be expected under normal conditions will not cause instability.

2.3.4 Machinery and plants, which can be started automatically or remotely, shall be fitted up with devices at local control stations to switch off the automatic or remote control, respectively.

In case of automatic or remote control failure, local control is still to be possible.

2.3.5 Changeover from local control mode to automatic or remote control mode shall be possible from local control stations only. Changeover from remote to automatic control mode may be effected from remote control stations.

2.3.6 If the preset sequence of operations is disturbed, the automated control system shall stop performing the program and shall bring the machinery to a safe condition with an alarm given at all cases at the permanently attended control station.

2.3.7 The starting system of powerful consumers of electrical power, the switching on of which may result in the inadmissible loss of voltage or the main switchboard busbars failure, shall provide for the following:

preliminary automatic start of the standby generator, synchronization, load acceptance and distribution; or

interlocking device preventing the switching on of such consumers prior the standby generator switching to the main switchboard busbars, and the appropriate indication.

2.4 ALARM AND MONITORING, SAFETY, INDICATION AND LOGGING SYSTEMS

2.4.1 Alarm and monitoring system.

2.4.1.1 The alarm and monitoring system shall be independent of control and safety systems, i.e. it shall not be affected by malfunction or failure of such systems.

Partial integration of the alarm and monitoring system with control systems may be allowed for integrated systems provided that the applicable requirements of 7.6.5 including appropriate redundancy.

2.4.1.2 Provision shall be made for the self-monitoring of the alarm and monitoring system; the alarm signal shall be applied in the case of at least such typical faults as short-circuits, line wire break and earth fault, and the failure of the power supply.

If discrete signals are utilised in alarm and monitoring systems, normally closed loops shall be used.

2.4.1.3 The alarm and monitoring system shall give visual and audible signals simultaneously. In this case the possibility of simultaneous indication of more than one fault shall be provided. The acknowledgement of one signal shall not prevent the entry of another. The failure of one component (device) of the system shall not cause failure of the alarm and monitoring system in general. When common monitors are applied instead of individual light signalling devices, at least two such monitors shall be provided.

2.4.1.4 The alarm and monitoring system with its central information panels usually arranged in the main machinery control room shall structurally include the group alarm subsystem, which blocks shall be located:

in spaces between the watertight boundaries, containing main and auxiliary machinery, including boilers, generators and electric propulsion motors (light columns);

on the navigation bridge (in the wheelhouse);

in service and public spaces of a ship;

in accommodation spaces of the responsible personnel.

The switching-off of an audible alarm signal on the group alarm blocks (e.g. on the navigation bridge or in accommodation spaces) shall not cause its switching-off in the main machinery control room.

2.4.1.5 In machinery spaces, along with the audible signal devices of the alarm and monitoring system provision shall be made for visual devices (light columns) for the signal identification, for which colours and symbols shown in Table 2.4.1.5 shall be used.

Table 2.4.1.5

Signal	Colour	Symbol
Fire detection and fire alarm in spaces other than machinery spaces	Red	
Machinery spaces fire detection and fire alarm	Red	
Release indication of fire smothering system	Red	$CO_2^{1,2}$
Alarm	Yellow	
Steering gear alarm	Yellow	
Bilge alarm	Yellow	
Engineers' alarm	Yellow	
Telephone	White	

Signal	Colour	Symbol
Engine-room telegraph. Command transmission	White	
Release indication of fixed local application fire extinguishing system	Red	
[1]Extinguishing media other than CO_2 shall be specified. [2]For water mist fire-extinguishing systems in machinery spaces of category A and cargo pump-rooms specified in 3.4.1 of Part VI "Fire Protection", instead of signal warning of putting the fire-extinguishing system into action the alarm on activation of valves on the distribution pipes (red colour, symbol "W" or "WATER MIST") shall be provided.		

Visual indicators shall be clearly visible and distinguishable either directly or by reflection in all parts of the spaces in which light columns are required, flash in accordance with 2.4.1.7, be of high luminous intensity. When visibility and distinctiveness in the space cannot be provided by one light column, several columns shall be installed. Instead of individual flashing lights a single flash or rotating white light in addition to a permanent individual indication may be used for light columns.

2.4.1.6 In spaces with high ambient noise levels, additional audible and visual (flashing or rotating light) signal devices shall be installed.

2.4.1.7 The visual signals shall indicate the fault condition resulted in alarm operation and are generally to flash. The flashing alarm shall be illuminated for at least 50 % of the cycle and have a pulse frequency in the range of 0,5 and 1,5 Hz.

2.4.1.8 Alarms at workstations shall normally be acknowledged in two steps:

switch-off audible signal and additional visual signal (e.g. rotating light signals, etc) leaving the visual signal on the workstation unchanged;

acknowledgment of the visual alarm on the workstation. After being accepted, the flashing light shall change to steady condition.

Cancelling of a visual signal shall only be possible after the abnormal condition has been corrected.

2.4.1.9 Self-eliminating faults shall be indicated by the alarm and monitoring system in such a way that the signal remains applied until it is accepted.

2.4.1.10 Checking of the alarm and monitoring system shall be possible while machinery in operation.

2.4.1.11 Irrespective of the extent of automation and the monitoring order used for the machinery, the alarm and monitoring system shall give warning signals at:

.1 parameters reaching predetermined limit values;

.2 operation of safety devices;

.3 power failure in the circuits of particular automation systems or start of emergency power sources;

.4 deviation from predetermined values of other parameters or operating conditions as regulated by this Part.

2.4.1.12 The alarm and monitoring system shall be so arranged that signals not pertinent to navigation and navigational situation are in the first place relayed to the panels in machinery spaces and main machinery control room, as well as to group alarm device in the accommodation, service and public spaces, in which the members of machinery crew might be staying. Then, if the signals are not acknowledged within a specified period of time (e.g. 2 min), they shall be directed to the navigation bridge.

2.4.1.13 The engineers' alarm referred to in 7.8.1, Part XI "Electrical Equipment" shall be additionally activated automatically where an alarm for machinery plant is not acknowledged at the place of its destination within a specified period of time to be determined by the ship's size but not exceeding 5 min.

2.4.1.14 The personnel alarm referred to in 7.9.1, Part XI "Electrical Equipment" shall be additionally activated automatically when the engineer on duty has to attend machinery space

in case of a machinery alarm. Acknowledgement of the personnel alarm shall not be possible before the engineer has acknowledged the alarm in the machinery space.

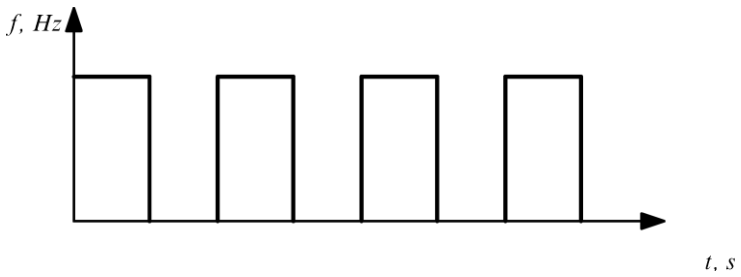
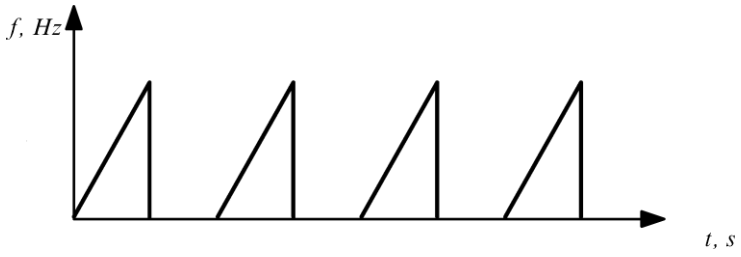
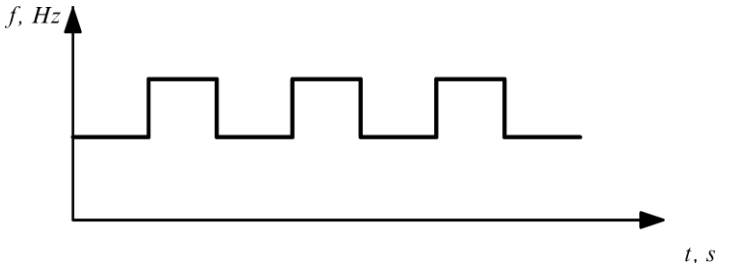
2.4.1.15 Manual blocking of separate alarms shall be clearly indicated at the workstation.

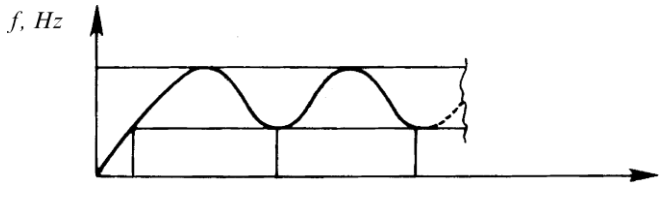
2.4.1.16 Blocking of alarm and safety functions in certain operating modes of machinery (e.g. during start-up) shall be automatically disabled in other modes.

2.4.1.17 The audible signals of the alarm and monitoring system shall be readily distinguishable from audible signals of other systems. The audible signals shall have a frequency from 200 up to 2500 Hz. Provision may be made for means to adjust the frequency of audible signals within the range specified above. The waveform of audible signal released by alarm and monitoring system shall correspond to one of the waveforms shown in Table 2.4.1.17. The sound pressure level at a distance of 1 m from the sound source shall be not lower than 75 dB and more than by 10 dB higher than the ambient noise existing during the normal functioning of the equipment with the ship underway under moderate weather conditions. The sound pressure level in a space shall not exceed 120 dB. The sound pressure level shall be measured within the frequency band of 1/3 octave with respect to the frequency of the first harmonic of the signal. To ensure that the signal can be properly heard in large spaces and in spaces with high level of ambient noise, several audible signal units shall be installed. The audible signal of the alarm and monitoring system shall be clearly heard even though one of the signal display units fails.

Table 2.4.1.17

Waveforms of audible signals of the alarm and monitoring system

Nos.	Waveform
1	
2	
3	

Nos.	Waveform
4	

2.4.1.18 In addition to the monitored parameters listed in Sections 4 — 6, visual and audible alarm shall be provided for the following equipment:

.1 steering gear in accordance with 5.5.11 and 5.5.13, Part XI "Electrical Equipment";

.2 emergency diesel-generators in accordance with 9.6, Part XI "Electrical Equipment";

.3 uninterruptible power systems (UPS) in accordance with 9.7, Part XI "Electrical Equipment";

.4 electric propulsion motors in accordance with 17.12, Part XI "Electrical Equipment";

.5 podded azimuth thruster drives and steerable propeller drives in accordance with 17.13, Part XI "Electrical Equipment";

.6 electric propulsion plants control systems in accordance with 17.14, Part XI "Electrical Equipment";

.7 control systems for gas internal combustion engines in accordance with 9.9 and 9.12, Part IX "Machinery";

.8 active means of the ship's steering in accordance with 7.3, Part VII "Machinery Installations".

2.4.2 Safety systems.

2.4.2.1 The safety system shall be activated automatically at faults that could involve an emergency condition of machinery or equipment in order to:

.1 restore normal operating conditions (by starting standby units);

.2 temporarily adjust the operation of machinery to the prevailing conditions (e.g. by reducing the load upon the machinery);

.3 protect machinery from emergency condition by stopping the machinery.

Automatic stopping of main machinery shall be executed only in cases of deviation of those parameters, which could lead to serious damage, complete breakdown or explosion.

A safety system shall include an indicator to show the parameter, for which the system was put into operation.

2.4.2.2 The safety systems arranged to shut down the machinery shall be independent of control and alarm systems including sensors so that the faults and failures of those systems including their supply systems would not influence the safety systems.

Where arrangements for overriding the shutdown of machinery are fitted, these shall be such as to preclude inadvertent operation. Light signal shall be provided on the machinery control panel to indicate when the override has been activated.

2.4.2.3 Provision shall be made for the self-monitoring of the safety systems: at least at such faults as short-circuit, line wire break and earth fault an alarm signal shall be activated.

If discrete signals are utilised in safety systems of essential equipment and machinery, normally open circuits with loop monitoring shall be used.

2.4.2.4 The safety systems of particular machinery and plants shall be independent of each other so that a failure in the safety system of certain machinery or plant would not affect the operability of the safety systems of the rest of the machinery and plants.

2.4.2.5 When the safety system stops the machinery, the machinery shall not start again automatically while the emergency condition is corrected.

2.4.2.6 Provision protection be made within the automatic safety system of the main machinery (propulsion plant) for the alarm to warn of the forthcoming inevitable activation

of the safety system for slowdown or shutdown propulsion so that the watch officer has an opportunity and sufficient time to assess navigational situation and in an emergency, if necessary, to counteract the activation of the safety system except for those cases when manual intervention will result in total failure of the main machinery within a short time, for example in the case of overspeed.

2.4.3 Indication and logging systems.

2.4.3.1 Indications sufficient to allow safe operation of essential and important functions shall be installed at all control locations from where the function shall be accomplished. Alarms shall not be considered as substitutes for indications for this purpose.

2.4.3.2 Indication and logging systems shall be independent of any other systems so that their failure would not affect such other systems.

2.4.3.3 When logging systems fail, the alarm signal shall be activated.

2.4.3.4 Provision shall be made for easy reading of indicated data with regard to the illumination at the locations of indicators.

2.4.3.5 Provision shall be made for displaying the readings of indication systems in units normally used for the parameters, i.e. without recalculation.

3 POWER SUPPLY OF AUTOMATION SYSTEMS

3.1 GENERAL

3.1.1 Where automated units shall be supplied from both the main and emergency power sources, the automation systems shall also be supplied from these two power sources independent of each other.

3.1.2 The control systems of main machinery shall be supplied by two separate feeders from separate sections of the main switchboard or from switchboards intended for the power supply of essential services and connected to the separate section of the main switchboard. If main switchboard busbars are not divided into sections, one of the feeders may be connected to the main switchboard and the other may be connected to the supply switchboard of essential services or to the nearest distribution board. The changeover from one feeder to another shall be effected automatically with appropriate signal activated at the control station.

3.1.3 Provision shall be made in the power supply for safety arrangements to allow selective disconnection of failed components.

3.1.4 Where the automation systems of particular auxiliary machinery are supplied by the same feeders as the corresponding electric drives, provision shall be made for a start of standby unit and for connection of the automation system to its feeder in case of a loss of power at the running unit.

3.1.5 Hydraulic and pneumatic automation systems shall be supplied from two sources. The second source shall be connected automatically upon pressure loss with application of an alarm signal.

The use of starting air for automation systems is permitted, provided the air receivers are filled automatically and the requirements of 2.2.11.5 and 2.2.11.6 are complied with.

3.1.6 Alarm and safety systems shall be supplied from an uninterruptible power source, with an alarm being activated upon loss of its input voltage.

The capacity of the accumulator battery of the said power source shall be sufficient for servicing the alarm and safety systems during at least 30 min.

3.1.7 The controls of generator drives shall be supplied independently of the main switchboard busbars.

4 SHIPS WITH AUT1 IN CLASS NOTATION

4.1 GENERAL

4.1.1 Self-propelled ships and floating facilities with the automation mark **AUT1** in class notation shall be equipped with machinery plant automation systems in compliance with the requirements of the Section and to the extent sufficient to ensure their manoeuvrability and safety under all operating conditions without permanent attendance of personnel in machinery spaces and engine control room.

4.1.2 Provision shall be made for an integrated alarm system to cover all the parameters and working conditions under control as mentioned in this Section.

4.1.3 Provisions concerning fire protection shall be found in 4.2.3, Part VI "Fire Protection".

4.1.4 All equipment installed in machinery spaces shall be capable of operating in an unattended machinery space and main machinery control room. Some operations (replenishment of tanks, cleaning of filters, etc.) may be performed manually, if carried out at certain intervals (not more than once every 24 h).

4.2 AUTOMATED MAIN MACHINERY AND PROPELLERS

4.2.1 Provision shall be made for remote automated control system of starting and stopping, as well as of rotational frequency of the main machinery, propeller thrust value and direction within the whole permissible operating range of the propulsion system from the navigation bridge.

4.2.2 Remote automated control system shall meet the following requirements:

.1 automatic attempts, which fail to produce a start, shall be limited so that after the last ineffective attempt the starting air quantity or accumulator battery capacity is sufficient to provide manually a half number of starting attempts as required in 16.1, Part VIII "Systems and Piping" or 13.7.2, Part XI "Electrical Equipment";

.2 the last command given shall be executed regardless of the order sequence and quickness;

.3 setting of the thrust value and direction may be effected by means of a single control unit;

.4 an automatic passing of the critical rotational frequency ranges irrespective of the set-operating mode;

.5 overload of the main machinery in the normal operating modes shall be prevented;

.6 remote automated control systems and engine telegraph systems shall be independent of each other (common control lever may be used);

.7 provision shall be made for signalling to indicate power loss and malfunction of the remote automated control system;

.8 impermissible operating modes of the main machinery and propellers (spontaneous increase of rotational frequency, start and reverse) in the event of failure of the remote automated control system shall be precluded;

.9 emergency manoeuvring shall be ensured within the shortest time possible, and along with that, relevant limitations and protections may be removed.

4.2.3 Where there are several control locations, the one in the main machinery control room shall be predominant over the one on the navigation bridge. The same is true in respect of the local control station of the main machinery as compared to the main machinery control room.

4.2.4 The transfer of control from one control location to another shall be possible from a predominant location only, irrespective whether the controls at the locations are matched or not.

The transfer of control shall be accompanied with audible and visual signals at all the control locations. At the locations, provision shall be made for visual indicators showing from which location control is performed.

4.2.5 The possibility of simultaneous control from different locations shall be eliminated. Use of interconnected controls at one location (e.g. at bridge wings and spaces) may be permissible.

4.2.6 At all the control locations including disconnected ones, provision shall be made for permanent indication of commands transmitted by engine telegraph.

4.2.7 The main engine emergency stop device required by 3.2.1.6, Part VII "Machinery Installations", if electrically operated, shall be independent of the remote automated control system, alarm and monitoring system and of the ship mains.

4.2.8 In case of main internal combustion engine as a propulsion plants, the temperature of the working media listed below shall be automatically adjust within the prescribed limits:

cylinder coolant;

piston coolant;

nozzle coolant;

lubricating oil;

fuel oil (if heavy oil is used and viscosity regulation is not available).

As far as main machinery of other types is concerned, the automatic regulation of working medium temperature shall be provided to the extent sufficient to ensure safety operation without permanent attendance of personnel in machinery spaces and engine control room.

4.2.9 With regard to geared diesel plants (two diesels and more), provision shall be made that, with one engine shut down, the others go on running without being overloaded.

4.2.10 Monitored parameters of automated main machinery and propellers, measuring points, limiting values of parameters and types of automatic protection and indication shall be found in Tables 4.2.10-1 — 4.2.10-5.

Table 4.2.10-1

Main internal combustion crosshead engines

Nos.	Monitored parameter	Group 1: remote indication, alarm, automatic slowdown with alarm	Group 2: automatic start of stand-by pumps with alarm	Group 3: automatic shutdown of engine with alarm
1	**Fuel oil system**			
1.1	Fuel oil pressure after filter (engine inlet)	●↓	■	–
1.2	Fuel oil viscosity (temperature) before injection pumps	↑(↓)	–	–
1.3	Fuel oil leakage from high-pressure pipes	○	–	–
1.4	Fuel oil level in daily service tank[1]	↓	–	–
1.5	Common rail fuel oil pressure	Min		
2	**Lubricating oil system**			
2.1	Lubricating oil to main bearing and thrust bearing pressure	●↓▼	■	×
2.2	Lubricating oil to crosshead bearing pressure[2]	●↓▼	■	×
2.3	Lubricating oil to camshaft pressure[2]	↓	■	×
2.4	Lubricating oil to camshaft temperature[2]	↑	–	–
2.5	Lubricating oil inlet temperature	↑	–	–
2.6	Thrust bearing pads temperature or bearing outlet lubricating oil temperature	↑▼	–	×
2.7	Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: — the engine main, crank and crosshead bearing oil outlet; or — the engine main, crank and crosshead bearing)[3]	○▼	–	–
2.8	Flow rate cylinder lubricator. Each apparatus	↓▼	–	–
2.9	Level in lubricating oil tank[4]	↓	–	–
2.10	Common rail servo oil pressure	Min		
3	**Turbocharger**			
3.1	Turbocharger lubricating oil inlet pressure[5]	↓	–	–
3.2	Turbocharger lubricating oil outlet temperature of each bearing[6]	↑	–	–
3.3	Rated speed of turbocharger[12]	●↑	–	–
4	**Piston cooling system**			
4.1	Piston coolant inlet pressure[7]	↓▼	■	–
4.2	Piston coolant outlet temperature of each piston	↑▼	–	–
4.3	Piston coolant outlet flow of each piston[8]	↓▼	–	–
4.4	Piston coolant level in expansion tank	↓	–	–
5	**Sea water cooling system**			
5.1	Sea water pressure	↓	■	–
6	**Cylinder fresh cooling water system**			
6.1	Cylinder water inlet pressure	↓▼	■	–
6.2	Cylinder water outlet temperature (from each cylinder) or cylinder water outlet temperature (general)[9]	↑▼	–	–
6.3	Oily contamination of engine cooling water system[10]	○	–	–
6.4	Level of cylinder cooling water in expansion tank	↓	–	–
7	**Starting and control air systems**			
7.1	Starting air pressure before main shut-off valve	●↓	–	–
7.2	Control air pressure	↓	–	–
7.3	Safety air pressure	↓	–	–
8	**Scavenge air system**			
8.1	Scavenge air receiver pressure	●	–	–
8.2	Scavenge air box temperature (fire)	↑▼	–	–
8.3	Scavenge air receiver water level	↑	–	–
9	**Exhaust gas system**			
9.1	Exhaust gas temperature after each cylinder	●↑▼	–	–
9.2	Exhaust gas temperature after each cylinder, deviation from average	↑	–	–
9.3	Exhaust gas temperature before each turbocharger	●↑	–	–
9.4	Exhaust gas temperature after each turbocharger	●↑	–	–

Nos.	Monitored parameter	Group 1: remote indication, alarm, automatic slowdown with alarm	Group 2: automatic start of stand-by pumps with alarm	Group 3: automatic shutdown of engine with alarm
10	**Fuel valve coolant**			
10.1	Fuel valve coolant pressure	↓	■	–
10.2	Fuel valve coolant temperature	↑	–	–
10.3	Fuel valve coolant level in expansion tank	↓	–	–
11	**Engine speed/direction of rotation**	●	–	–
12	**Wrong way**	○	–	–
13	**Engine overspeed**	–	–	×
14	**Control, safety and alarm systems power supply failure**	○	–	–
15	**Gas concentration in machinery spaces[11]**	↑	–	–

S y m b o l s :
● — remote indication;
↑ — alarm for high value;
↓ — alarm for low value;
○ — alarm signal;
■ — automatic start of stand-by pumps;
▼ — slowdown;
× — engine shutdown.

[1]High level alarm is also required if not suitable overflow arrangement is provided.
[2]If separate lubricating oil systems are installed.
[3]For engines having power more than 2250 kW or a cylinder bore more than 300 mm and dual-fuel engines in accordance with the requirements of 9.5.3, Part IX "Machinery".
[4]Where separate lubricating oil systems (for camshaft, rocker arms, etc.) are installed, individual level alarms shall be provided for each system.
[5]Unless provided with a self-contained lubricating oil system integrated with the turbocharger.
[6]Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
[7]Slowdown is not required if the coolant is oil taken from the main cooling system of the engine.
[8]Where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted.
[9]Where one common cooling space without individual stop valves is employed for all cylinder jackets.
[10]Where main engine cooling water is used in fuel and lubricating oil heat exchangers.
[11]Required where installations with dual-fuel (gas – liquid fuel) engines are used.
[12]Only for turbochargers of Categories B and C (refer to 2.5.7.5, Part IX "Machinery").

N o t e . For Group 1 parameters a common sensor is provided for indication, alarm and safety systems (for slowdown);
for Group 2 parameters — a sensor for automatic start of stand-by pumps;
for Group 3 parameters — a sensor of safety system (engine shutdown).

T a b l e 4.2.10-2

Main internal combustion trunk piston engines

Nos.	Monitored parameter	Group 1: remote indication, alarm, automatic slowdown with alarm	Group 2: automatic start of stand-by pumps with alarm	Group 3: automatic shutdown of engine with alarm
1	**Fuel oil system**			
1.1	Fuel oil pressure after filter (engine inlet)	●↓	■	–
1.2	Fuel oil viscosity (temperature) before injection pumps[1]	↑(↓)	–	–
1.3	Fuel oil leakage from high-pressure pipes	○	–	–
1.4	Fuel oil level in daily service tank[2]	↓	–	–
1.5	Common rail fuel oil pressure	Min		
2	**Lubricating oil system**			
2.1	Lubricating oil to main bearing and thrust bearing pressure	●↓	■	×
2.2	Lubricating oil filter differential pressure	●↑	–	–
2.3	Lubricating oil inlet temperature	●↑	–	–
2.4	Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: — the engine main and crank bearing oil outlet; or — the engine main and crank bearing)[3]	○	–	×
2.5	Flow rate cylinder lubricator. Each apparatus	↑▼	–	–
2.6	Common rail servo oil pressure	Min		

Nos.	Monitored parameter	Group 1: remote indication, alarm, automatic slowdown with alarm	Group 2: automatic start of stand-by pumps with alarm	Group 3: automatic shutdown of engine with alarm
3	**Turbocharger**			
3.1	Turbocharger lubricating oil inlet pressure[4]	●↓	–	–
3.2	Turbocharger lubricating oil outlet temperature, each bearing[5]	↑	–	–
3.3	Rated speed of turbocharger[9]	●↑	–	–
4	**Sea water cooling system**			
4.1	Sea water pressure	●↓	■	–
5	**Cylinder fresh cooling water system**			
5.1	Cylinder water inlet pressure or flow	●↓▼	■	–
5.2	Cylinder water outlet temperature[6]	●↑▼	–	–
5.3	Level of cylinder cooling water in expansion tank	↓	–	–
6	**Starting air and control air systems**			
6.1	Starting air pressure before main shut-off valve	●↓	–	–
6.2	Control air pressure	●↓	–	–
7	**Scavenge air system**			
7.1	Scavenge air receiver temperature	↑	–	–
8	**Exhaust gas system**			
8.1	Exhaust gas temperature after each cylinder[7]	●↑▼	–	–
8.2	Exhaust gas temperature after each cylinder, deviation from average[7]	↑	–	–
9	**Engine speed**	●	–	–
10	**Engine overspeed**	–	–	×
11	**Control, safety and alarm systems power supply failure**	○	–	–
12	**Gas concentration in machinery spaces**[8]	↑	–	–

S y m b o l s :
● — remote indication;
↑ — alarm for high value;
↓ — alarm for low value;
○ — alarm signal;
■ — automatic start of stand-by pumps;
▼ — slowdown;
× — engine shutdown.

[1]For heavy fuel oil burning engines only.
[2]High level alarm is also required if no suitable overflow arrangement is provided.
[3]For engines having power more than 2250 kW or a cylinder bore more than 300 mm and dual-fuel engines in accordance with the requirements of 9.5.2.3, Part IX "Machinery". One oil mist detection arrangement (or engine bearing temperature monitoring system or equivalent device) is required for each engine having two independent outputs (for initiating the alarm and shutdown) satisfy the requirements for independence between the alarm and shutdown systems.
[4]Unless provided with a self-contained lubricating oil system integrated with the turbocharger.
[5]Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
[6]Two separate sensors are required for the alarm and slowdown.
[7]For engines with cylinder output of more than 500 kW.
[8]Required where installations with dual-fuel (gas – liquid fuel) engines are used.
[9]Only for turbochargers of Categories B and C (refer to 2.5.7.5, Part IX "Machinery").

N o t e . For Group 1 parameters a common sensor is provided for indication, alarm and safety systems (for slowdown);
for Group 2 parameters – a sensor for automatic start of stand-by pumps;
for Group 3 parameters – a sensor of safety system (engine shutdown).

T a b l e 4.2.10-3

Main steam turbines

Nos.	Monitored parameter	Group 1: indication, alarm	Group 2: automatic start of stand-by pumps with alarm	Group 3: automatic shutdown of turbine
1	Lubricating oil pressure after oil cooler	●↓	■	×
2	Lubricating oil differential pressure across filter	◗↑	–	–
3	Lubricating oil temperature at each bearing outlet	●↑	–	–
4	Lubricating oil level in gravity tank	◗↓	–	×
5	Steam temperature before manoeuvring valves[1]	◗↑↓	–	–
6	Steam pressure before manoeuvring valves	●↑	–	–
7	Steam pressure in condenser	●↑	–	×
8	Pressure in deaerator	◗↑↓	–	–

Nos.	Monitored parameter	Group 1: indication, alarm	Group 2: automatic start of stand-by pumps with alarm	Group 3: automatic shutdown of turbine
9	Water level in deaerator	◗↑↓	–	–
10	Water level in condenser	◗↑↓	–	×
11	Water pressure after condensate pump	◗↓	■	–
12	Condensate salinity	↑	–	–
13	Turbine vibration	↑	–	×
14	Axial displacement of rotor	↑	–	×
15	Steam pressure in end glands	●↑	–	–
16	Sea water pressure at circulating pump outlet	●↓	■	–

S y m b o l s :
● — remote indication (continuous);
◗ — remote indication (on call);
↑ — alarm for high value;
↓ — alarm for low value;
■ — automatic start of stand-by pumps;
× — turbine shutdown.

[1]When re-heating is used, an additional alarm is required at turbine inlet.

N o t e . For Group 1 parameters a common sensor is provided for indication, alarm and safety systems (for slowdown);
for Group 2 parameters — a sensor for automatic start of stand-by pumps;
for Group 3 parameters — a sensor of safety system (turbine shutdown).

T a b l e 4.2.10-4

Main gas turbines

Nos.	Monitored parameter	Group 1: indication, alarm	Group 2: automatic start of stand-by pumps with alarm	Group 3: automatic shutdown of gas turbine
1	Lubricating oil pressure at inlet	●↓[4]	■	×
2	Lubricating oil temperature at inlet	◗↑	–	–
3	Bearing temperature	◗↑	–	–
4	Gas temperature at gas turbine outlet	●↑	–	×
5	Flame failure or ignition system failure or stratification of temperatures over flame tubes	◗↑	–	×
6	Automatic start system failure	○	–	–
7	Fuel oil pressure at gas turbine inlet	●↓	–	×[1]
8	Fuel oil pressure before burners	●↓	–	×[1]
9	Fuel oil temperature before burners[2]	◗↑↓	–	–
10	Pressure differential across air cleaner	◗↑	–	–
11	Gas turbine vibration at each support	◗↑[4]	–	×
12	Axial displacement of rotor	↑	–	×
13	Gas turbine speed (at each rotor)	●↑	–	×[3]
14	Oil level in lubricating oil tank	◗↓	–	–
15	Automatic gas turbine shutdown	○	–	–
16	Gas pollution of machinery room	●↑	–	×[1]
17	Temperature under sheath	●↑	–	–
18	Gas temperature after gas turbine	◗↑[4]	–	×
19	Failure of power supply to control, alarm and safety systems	○	–	–
20	Coolant temperature	●↑	–	–
21	Pressure differential across lubricating oil filter	↑	–	–
22	Vacuum pressure at the compressor inlet	↑[4]	–	×

S y m b o l s :
● — remote indication (continuous);
◗ — remote indication (on call);
↑ — alarm for high value;
↓ — alarm for low value;
■ — automatic start of stand-by pumps;
× — turbine shutdown;
○ — alarm signal.

[1]When gas is used.
[2]When high-viscosity fuels are used.
[3]Shutdown resulted from power turbine speed.
[4]Alarm at the measuring point shall be activated prior to arriving the critical condition for the activation of safety devices.

N o t e s : 1. For Group 1 parameters a common sensor is provided for indication and alarm systems;
for Group 2 parameters — a sensor for automatic start of stand-by pumps;
for Group 3 parameters — a sensor of safety system (turbine shutdown).
2. The list of monitored parameters and types of automatic protection and indication specified in the table may be amended by the manufacturer based on the results of the relevant failure mode and effect analysis (FMEA), which shall be submitted to the RS for agreement.

T a b l e 4.2.10-5

Shafting, CPP, reduction gear and couplings

Nos.	Monitored parameter	Group 1: indication, automatic slowdown	Group 3: automatic shutdown of engine (turbine)
1	**Shafting**		
1.1	Temperature of thrust bearing (or lubricating oil), including those built in engine and reduction gear	↑▼	×
1.2	Temperature of shaft bearings (or lubricating oil)	↑	–
1.3	Temperature of sterntube bearing (or lubricating oil)[1]	↑	–
1.4	Lubricating oil level in sterntube lubricating tank[2]	↓	–
1.5	Water flow at sterntube inlet[3]	↓	–
2	**CPP**		
2.1	Hydraulic oil pressure at outlet of filter	↓	–
2.2	Hydraulic oil level in sterntube oil lubricating tank	↓	–
2.3	Loss of auxiliary power (power supply to controls)[4]	○	–
3	**Reduction gears and couplings**		
3.1	Lubricating oil pressure at reduction gear inlet[5]	●↓	×
3.2	Lubricating oil temperature in reduction gear	◗↑▼	–
3.3	Temperature of each sliding bearing[6]	↑	–
3.4	Hydraulic oil pressure at coupling inlet	●↓	–

S y m b o l s :
● — remote indication (continuous);
◗ — remote indication (on call);
↑ — alarm for high value;
↓ — alarm for low value;
▼ — slowdown;
○ — alarm signal;
× — turbine shutdown.

[1]Refer to 5.6.3, Part VII "Machinery Installations".
[2]With closed sterntube.
[3]When water lubrication is used.
[4]Indication at navigation bridge.
[5]Where a coupling is fitted, disengagement of coupling may be effected instead of engine shutdown.
[6]For engines having power of more than 2250 kW.

N o t e . For Group 1 parameters a common sensor is provided for indication, alarm and safety systems (for slowdown); for Group 3 parameters — a sensor of safety system (engine (turbine) shutdown).

4.3 AUTOMATED BOILER PLANTS

4.3.1 The requirements of this Chapter cover boiler plants with oil-burning installations, waste-heat boilers and composite boilers, as well as combinations of such boilers forming part of the ship's machinery plants.

4.3.2 When two or more boilers fitted on board feed a common steam main, provision shall be made for automatic control of each boiler singly operating under load, where such operation is provided by the design, keeping the standby boilers in readiness and putting the boilers under load, parallel operation of boilers and securing all steam.

Automatic transfer from one operating mode to another shall not initiate operation of the safety valves, alarms to indicate steam pressure and water level in boilers and in hot well (deaerator) of steam boiler plants, and in case of thermal fluid boilers, alarm to indicate the fluid temperature after the boilers and before the consumers, as well as the alarm to indicate the level in the expansion tank.

4.3.3 In waste-heat boilers the transfer of the evaporative mode to the water-heating mode and vice-versa shall not initiate operation of the safety valves, alarms to indicate steam pressure and water level in boilers and in hot well, as well as the necessity of the additional feed water.

4.3.4 Steam pressure and thermal fluid temperature shall be regulated automatically. Besides, the steam boilers shall be provided with automatic feed water regulators.

The waste-heat boilers may have no automatic steam pressure and thermal fluid temperature regulation, if alternative arrangements are provided to stabilize the said parameters.

4.3.5 Steam boilers shall have at least two low water level detectors independent of each other and connected to different output devices. The lower one shall be used solely for no-water protection.

The second detector may also be used for shutdown in case of low water levels, or for alarm and feed water regulating systems.

The above requirement does not apply to forced-circulation boilers, waste-heat boilers, the design of which allows operation without water, and to the secondary system headers of double-pressure boilers.

4.3.6 Provision shall be made for a remote shutdown of the burning boilers and closing of dampers in waste-heat boilers allowing no "dry" operation, from the control station where continuous watch is kept.

4.3.7 Automated oil-burning boilers shall be fitted up with interlocking devices to permit fuel oil being fed into the boiler furnace during firing-up, when the requirements listed below are complied with in addition to those of 5.3.2, Part X "Boilers, Heat Exchangers and Pressure Vessels":

.1 fuel temperature (viscosity) is such that adequate atomisation is assured;

.2 pressure of steam or air for atomisation is within the normal range.

4.3.8 Automated oil-burning boilers shall be equipped with protective devices in accordance with the requirements of 5.3.3, Part X "Boilers, Heat Exchangers and Pressure Vessels".

4.3.9 Starting of boiler plants from cold condition and after being shut down by the protection system and if the ignition of oil fuel fails shall be possible from the local control station only.

4.3.10 Boilers with inherent in air supply casing and supply ducts and in flue gas uptake and ducts shall be provided with alarms to indicate fire outbreak in accordance with the requirements of 4.4.5, Part X "Boilers, Heat Exchangers and Pressure Vessels". Position of detectors shall be selected depending on the design features of boilers.

4.3.11 Monitored parameters of automated boiler plants, measuring points, limited parameter values and types of automatic protection and indication shall be found in Table 4.3.11.

Table 4.3.11

Automated boiler plants

Nos.	Monitored parameter	Indication, alarm	Automatic protection
1	**Main steam boilers and essential auxiliary steam boilers, waste-heat boilers and alternately fired boilers**		
1.1	Steam pressure in boiler drum (at super-heater outlet)[1]	●↑↓	–
1.2	Steam temperature at super-heater outlet	●↑	–
1.3	Steam temperature at steam cooler outlet	●↑	–
1.4	Water level in boiler drum	↑[2]↓	×[3]
1.5	Feed water pressure or pressure differential[4]	●↓	–
1.6	Stoppage of circulation in forced-circulation boilers	○	×
1.7	Water level in steam separator	↓	–
1.8	Water level in hot well	↓	–
2	**Automatic oil-burning installations**		
2.1	Fuel oil pressure at burner inlet[4]	↓	–
2.2	Atomization air or steam pressure	↓	–
2.3	Fuel oil temperature at burner inlet[5]	●↓	–
2.4	Air pressure before oil-burning installation[6]	↓	×
2.5	Flame failure	○	×
3	**Thermal liquid boilers and boiler plants**		
3.1	Thermal liquid temperature at boiler outlet	↑	×
3.2	Thermal liquid flow at boiler outlet	↓	×
3.3	Thermal liquid level in expansion tank	↑↓	×[3]■[3]
3.4	Thermal liquid leakage in the furnace of the auxiliary boiler	○	×■
3.5	Thermal liquid leakage in the drain chamber of the waste-heat boiler	○	×■
3.6	Increase of gas temperature in the flue duct of the auxiliary boiler	○	×■
3.7	Increase of gas temperature in the flue duct of the waste-heat boiler	○	×■

Symbols:
● — remote indication (continuous);
↑ — alarm for high value;
↓ — alarm for low value;
○ — alarm signal;
■ — circulating pump shutdown;
× — shutdown (stoppage of heat application).

[1]For auxiliary boilers, alarm may be provided in the main steam line only.
[2]Only for boilers to power machinery.
[3]Only after parameter reaches low value.
[4]For main boilers only.
[5]For heavy oil burning installations.
[6]May be dispensed with, where the forced-draft fan and fuel oil pump are directly driven by a single prime mover.

4.4 AUTOMATED ELECTRIC POWER PLANTS

4.4.1 Automated electric power plants shall ensure remote starting of generator sets with automatic synchronization, taking over and load sharing.

4.4.2 Besides compliance with the requirements of 3.1.3, Part XI "Electrical Equipment", in order to ensure continuous power supply on board ships where electrical power is normally supplied from one generator, control devices shall be provided to ensure automatic starting of standby generator, automatic synchronization, taking over and distribution of load in cases where:

maximum permissible load is reached by the generator during operation;

there is malfunction of the operating unit, which enables an automatic synchronization of generators to be carried out.

4.4.3 Indicators shall be provided at relevant control stations to warn that the generator sets are ready to start immediately (automatically).

4.4.4 Provision shall be made for preliminary determination of sequence, in which the generators shall be started automatically and connected to the busbars of the main switchboard.

4.4.5 If the shaft-generator rotational speed or inlet steam pressure of exhaust gas steam turbine-generator is lowered so that the working parameters as stated under 2.11.3, Part IX "Machinery", as well as 10.6.2 and 10.7.2, Part XI "Electrical Equipment" cannot be achieved, at least one independently driven generator shall be automatically started to ensure compliance with provision of 4.4.2.

4.4.6 Monitored parameters of automatic electric power plants (except emergency), measuring points, limiting values of parameters and types of automatic protection and parameter indication shall be found in Tables 4.4.6-1 — 4.4.6-3.

Table 4.4.6-1

Automated ship electric power plants

Nos.	Monitored parameter	Indication, alarm	Automatic protection
1	**Ship mains**		
1.1	Voltage	●↓	×
1.2	Current frequency	●↓	–
1.3	Insulation resistance	↓	–
2	**Generators**		
2.1	Load (current)	●↑	▼×
2.2	Reverse power (current)	↑	×
2.3	Winding temperature[1]	↑	–

Symbols:
● — remote indication;
↑ — alarm for high value;
↓ — alarm for low value;
▼ — disconnection of non-essential consumers;
× — disconnection of generator. Effected by the protection system of the generators (refer to 8.2, Part XI "Electrical Equipment").

[1]Required only for a.c. generators having output of more than 5000 kW or axial length of active steel more than 1000 mm.

Table 4.4.6-2

Internal combustion trunk piston engines for driving generators

Nos.	Monitored parameter	Alarm	Automatic shutdown of engine with alarm
1	Fuel oil leakage from high-pressure piping	○	–
2	Lubricating oil temperature	↑	–
3	Lubricating oil pressure	↓	×
4	Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: — the engine main and crank bearing oil outlet; or — the engine main and crank bearing)[1]	○	×
5	Cooling water pressure or flow	↓	–
6	Cooling water or air temperature	↑	–
7	Cooling water level in expansion tank[2]	↓	–
8	Fuel oil level in daily tank	↓	–
9	Starting air pressure	↓	–
10	Overspeed	–	×
11	Fuel oil viscosity (temperature) at inlet of high-pressure pumps[3]	↑(↓)	–
12	Exhaust gas temperature at each cylinder outlet[4]	↑	–
13	Gas concentration in machinery spaces[5]	↑	–
14	Common rail fuel oil pressure	Min	–
15	Common rail servo oil pressure	Min	–
16	Rated speed of turbocharger[6]	↑	–

Symbols:
↑ — alarm for high value;
↓ — alarm for low value;
○ — alarm signal;
× — engine shutdown.

[1]For engines having power more than 2250 kW or a cylinder bore more than 300 mm and dual-fuel engines in accordance with the requirements of 9.5.2.3, Part IX "Machinery". One oil mist detection arrangement (or engine bearing temperature monitoring system or equivalent device) is required for each engine having two independent outputs (for initiating the alarm and shutdown) satisfy the requirements for independence between the alarm and shutdown systems.

[2]If separate cooling system provided.

[3]When working on heavy fuel.

[4]For engines with cylinder output more than 500 kW.

[5]Required where installations with dual-fuel (gas – liquid fuel) engines are used.

[6]Only for turbochargers of Categories B and C (refer to 2.5.7.5, Part IX "Machinery").

Table 4.4.6-3

Steam turbines driving generators

Nos.	Monitored parameter	Indication, alarm	Automatic shutdown of turbine
1	Lubricating oil pressure at oil cooler outlet	◗↓	×
2	Lubricating oil temperature at bearing outlets	◗↑	–
3	Steam pressure in condenser	◗↑	×
4	Steam pressure before turbine	◗↓	–
5	Water level in condenser	↑	–

Symbols:
◗ — remote indication (on call);
↑ — alarm for high value;
↓ — alarm for low value;
× — turbine shutdown.

4.5 AUTOMATED COMPRESSOR PLANTS

4.5.1 Compressed air systems shall be fitted up with arrangements for automatic removal (blow out) of water and oil.

4.5.2 The automated compressor plants shall be capable of operating manually from the local and remote control stations and automatically.

In automatic mode of operation, the compressors shall keep up nominal pressure of compressed air in the air receivers so that:

.1 when the air pressure drops to the preset value, for example, to 90 %, the preselected compressor shall be automatically started and automatically shut down once the air pressure have reached a value equal to the nominal one;

.2 in case of an intensive air consumption and further drop of air pressure, for example, to 80 %, a second compressor turned on automatic mode shall be automatically started, and both compressors shall keep operating until the nominal pressure is attained.

4.5.3 Monitored parameters of automated compressor plants, measuring points, limiting values of parameters and types of automatic protection and indication shall be found in Table 4.5.3.

Table 4.5.3

Automated compressor plants

Nos.	Monitored parameter	Indication, alarm	Automatic protection
1	Lubricating oil pressure at compressor inlet	↓	×
2	Coolant flow at compressor outlet[1]	↓	×
3	Air temperature at cooler outlet	↑	–
4	Starting air pressure at air receiver outlet	●↓	–
5	Control air pressure	↓	–

Symbols:
● — remote indication;
↑ — alarm for high value;
↓ — alarm for low value;
× — compressor shutdown.

[1]Instead of flow, maximum coolant temperature may be monitored.

4.6 AUTOMATED PUMPING UNITS

4.6.1 Automated pump control system shall ensure automatic starting of standby pumps and changeover as necessary in plants in case of pump failure or upon reaching the highest permissible deviations of parameters in essential plants. The faulty pump shall be stopped and an alarm given only after the standby pump has been started.

4.6.2 The electric circuit of pumps having equal output shall make it possible to use each of them as the main pump.

This requirement does not apply to attached pumps.

4.7 AUTOMATED BILGE PUMPING OF MACHINERY SPACES

4.7.1 Depending on the water level in the bilge wells, the bilge wells in machinery spaces shall be drained either automatically or remotely. Indication for pump operation shall be provided.

4.7.2 If, after the bilge pumps have been started, they do not come to stop within a specified period of time, that is, the water in the bilge wells does not fall, an alarm shall be given.

4.7.3 A separate sensor shall be provided to signal the highest permissible level, which would be independent of the sensors fitted to control the bilge pumps.

4.7.4 Monitored parameters of automated bilge plants, measuring points and limiting values of parameters shall be found in Table 4.7.4.

Table 4.7.4

Automated bilge plants of machinery spaces

Nos.	Monitored parameter	Alarm
1	Water level in bilge wells	↑[1] ↓[1]
2	Emergency water level in bilge wells and shaft passages[2]	↑

Symbols:
↑ — alarm for high value;
↓ — alarm for low value.

[1]When remotely controlled.
[2]Alarm signal is brought out to the wheelhouse.

4.8 AUTOMATED REFRIGERATING PLANTS

4.8.1 In accordance with 1.1, Part XII "Refrigerating Plants", automated refrigerating plants shall comply with the requirements of 7.2 of the same Part, as well as to provide automatic maintenance of temperature in the refrigerated spaces.

4.8.2 Provision shall be made for indication of the automated refrigerating plant operation and for alarm of its malfunction.

4.8.3 Monitored parameters of automated refrigerating plants, measuring points, limiting values of parameters and types of protection shall be found in Table 4.8.3.

Table 4.8.3

Automated refrigerating plants

Nos.	Monitored parameter	Alarm	Automatic protection
1	**Driving motors**		
1.1	Motor load (current)	↑	▼
2	Compressors		
2.1	Suction pressure	↓	×
2.2	Discharge pressure[1]	↑	×
2.3	Discharge temperature	↑	×
2.4	Lubricating oil pressure or flow	↓	×
2.5	Lubricating oil temperature	↑	×
2.6	Rotor displacement[2]	↑	×
2.7	Bearing temperature[2]	↑	×
3	**Pressure vessels, heat exchangers, refrigerant, secondary refrigerant, cooling water pumps**		
3.1	Refrigerant flow in pump	↓	□
3.2	Secondary refrigerant flow in evaporator	↓	×[3]
3.3	Cooling water discharge pressure or flow in discharge pipeline	↓	×
3.4	Refrigerant level in circulation receivers, liquid separators, intermediate vessels, level type evaporators[4]	↑	×
3.5	Secondary refrigerant temperature at evaporator outlet	↓	×[3]
3.6	Secondary refrigerant level in expansion tank	↑↓	–
4	**Spaces with controlled atmosphere, atmosphere control arrangements**		
4.1	Air temperature in refrigerated cargo spaces	↑↓	–
4.2	Stopping of air cooler ventilator for refrigerated cargo space[5]	○	–
4.3	Refrigerant concentration in air of spaces with equipment under refrigerant pressure[6]	↑	■
4.4	CO_2, O_2, N_2 concentration in refrigerated cargo spaces[7]	↑↓	–
4.5	Relative air humidity in refrigerated cargo spaces[7]	↑↓	–

S y m b o l s :

● — remote indication;
↑ — alarm for high value;
↓ — alarm for low value;
○ — alarm signal;
▼ — engine shutdown;
□ — pump stop;
■ — switching-on of emergency ventilation, except emergency ventilation of refrigerated cargo spaces, for switching-on of which it is necessary previously to render the air duct shut-off devices operative;
× — compressor shutdown.

[1]In case of piston two-stage compressors, for each stage.
[2]For centrifugal compressors.
[3]Or stopping the delivery of refrigerant into evaporator.
[4]Compressor shutdown when the level is maximum. In case of liquid separators performing only protective functions, the refrigerant level indication may be dispensed with.
[5]For each ventilator.
[6]Separate alarm on the navigation bridge.
[7]Where applicable: for systems with atmosphere control, for carriage of fruits and vegetables.

4.9 EQUIPMENT ARRANGEMENT ON THE BRIDGE

4.9.1 Provision shall be made for a control station to effect-automated remote control of main machinery and/or propellers in conformity with 3.2, Part VII "Machinery Installations".

4.9.2 An alarm device shall be fitted to give group or individual signals of malfunctions of machinery installation, including those that require immediate shutdown of the main machinery and those that require reduction of the main machinery power. In this case a system of alarms included in common alarm shall be provided separately at main control stations or, alternatively, at local control stations.

In the latter case, a master alarm display shall be provided at the main control station showing which of the local control stations is indicating a fault condition.

4.9.3 On the bridge, provision shall be made for the following separate alarms:

"water in machinery space";

"fire in machinery space";

"alarm system failure";

as well as separate alarm "high gas concentration in machinery space", if the ship is provided with main and/or auxiliary dual-fuel (gas – liquid fuel) engines.

4.9.4 Provision shall be made for visual signalling (indication) in case of signals required by 4.9.2 and 4.9.3 being acknowledged in the machinery space.

4.9.5 Provision shall be made for remote control bilge system wells of machinery spaces, where no provision is made for an automated bilge system in compliance with 4.7.1.

4.10 EQUIPMENT ARRANGEMENT IN MACHINERY SPACES

4.10.1 Provision shall be made in the vicinity of the local control station of the main machinery for alarms and indicators of parameters as required by 4.2.

4.10.2 The controls of auxiliaries (pumps, separators, boiler plants, generator prime movers) and alarms and indicators of parameters as required by 4.3 — 4.8 are recommended to be installed in close proximity to the local control station of the main machinery.

4.10.3 Main machinery control room, if provided, shall be fitted up with the following:

.1 devices required by 3.2, Part VII "Machinery Installations";

.2 alarm panel;

.3 devices to indicate the operating modes of machinery and plants;

.4 disconnecting devices of the oil-burning installations of boilers, incinerators, ventilators of machinery spaces, separators fuel oil and lubricating oil pumps.

.5 remote controls of bilge wells for drainage in machinery spaces, where no provision is made for an automated bilge system in compliance with 4.7.1.

4.10.4 Where there is an enclosed main machinery control room, a device shall be fitted therein to call personnel from the machinery spaces.

4.10.5 At the main machinery control room, the following separate signals shall be provided:

"water in machinery space";

"fire in machinery space";

as well as separate alarm "limiting gas concentration level in machinery space", if the ship is provided with main and/or auxiliary dual-fuel (gas – liquid fuel) engines.

4.11 DEVICES IN ENGINEERS' ACCOMMODATION

4.11.1 In engineers' cabins, public spaces, as well as in spaces where watch is kept while in port, group alarm devices shall be fitted to warn of the malfunctions of machinery and plants, as well as signal devices in accordance with 4.9.3 of this Section and 3.8.3.8, Part VI "Fire Protection".

The acknowledgement of each signal from these devices shall cancel the audible signal only.

4.11.2 Where there are several cabins a switch for the devices mentioned in 4.11.1 may be provided to select the responsibility (watch keeper). The remaining cabin devices are disconnected in this case.

5 SHIPS WITH AUT2 IN CLASS NOTATION

5.1 GENERAL

5.1.1 Ships and floating facilities with the automation mark **AUT2** in class notation shall be equipped with machinery plant automation systems to the extent sufficient to ensure the manoeuvrability and safety of self-propelled ships or the safety of non-self-propelled ships under all operating conditions without permanent attendance of personnel in machinery spaces, but if watch is kept at the main machinery control room.

5.1.2 Unless otherwise provided hereafter, the requirements of Section 4, except for 4.11, shall be complied with.

5.1.3 Provision shall be made for automation of main machinery and propellers in accordance with the applicable requirements of 4.2.

5.1.4 An alarm system shall be provided for all applicable parameters and working conditions mentioned in Section 4.

5.1.5 All equipment installed in machinery spaces shall be capable of operating in an unattended machinery space. Some operations (replenishment of tanks, cleaning of filters, etc.) may be performed manually, if carried out at certain intervals (not more than once every 12 h).

5.2 EQUIPMENT ARRANGEMENT ON THE BRIDGE

5.2.1 Provision shall be made for remote automated control of the main machinery and/or propellers from the navigation bridge, in which case:

.1 equipment as required by 3.2, Part VII "Machinery Installations" shall be fitted;

.2 provision shall be made for alarm, which would enable to identify the reason of failure that requires slowdown and/or shutdown of the main machinery.

5.3 EQUIPMENT ARRANGEMENT IN MACHINERY SPACES

5.3.1 Provision shall be made for an enclosed main machinery control room fitted out in conformity with 4.10.3 and, additionally, with remote controls of essential auxiliaries if the latter are not automated.

5.3.2 Provision shall be made for the call and signal devices as stipulated by 4.10.4 and 4.10.5.

5.4 ELECTRIC POWER PLANTS

5.4.1 Besides compliance with the requirements of 3.1.3, Part XI "Electrical Equipment", where no provision is made for an automated electric power plant in conformity with 4.4, the following shall be available:

remote start and shutdown of generator prime movers from the main machinery control room;

remote synchronizing, switching on and load sharing from the main machinery control room. These operations may be effected from the main switchboard if installed at the main machinery control room.

5.5 BILGE SYSTEMS OF MACHINERY SPACES

5.5.1 Where no provision is made for an automated bilge system in conformity with 4.7, bilge wells in machinery spaces shall be remotely drained from the main machinery control room.

5.5.2 Alarm shall be provided in conformity with 4.7.4.

6 SHIPS WITH AUT3 IN CLASS NOTATION

6.1 GENERAL

6.1.1 Ships and floating structures with the automation mark **AUT3** in class notation, the main machinery of which have the power up to 2250 kW, shall be fitted with machinery installation automation systems to the extent, by which their manoeuvrability and safety would be ensured without permanent attendance of personnel in machinery spaces and main machinery control room (as far as non-self-propelled ships are concerned, the above power is the power of the prime movers of generators, which ensure that the main purpose of the ship is fulfilled).

6.1.2 Unless otherwise provided hereafter, the requirements of Section 4 shall be complied with.

6.1.3 Monitored parameters of machinery and plants, measuring points, limiting values of parameters and types of automatic protection and parameter indication shall be found in Table 6.1.3.

Table 6.1.3

Nos.	Monitored parameter	Group 1: indication, alarm, automatic slowdown	Group 2: automatic start of stand-by pumps with alarm[1]	Group 3: automatic shutdown of engine
1	**Main internal combustion engines**			
1.1	Lubricating oil pressure at engine inlet	●↓	■	×
1.2	Lubricating oil temperature at engine inlet	●↑	–	–
1.3	Lubricating oil flow at lubricator outlet	↓▼[2]	–	–
1.4	Lubricating oil pressure differential across filter	◗↑	–	–
1.5	Turbocharger lubricating oil pressure at bearing inlet[3]	↓	–	–
1.6	Oil mist concentration or bearing temperature at each crank or bearing	↑▼[2, 4]	–	×[5]
1.7	Coolant pressure or flow at engine inlet	●↓▼[2]	■	–
1.8	Coolant temperature at engine outlet	◗↑▼[2]	–	–
1.9	Cooling sea water pressure or flow	●↓	■	–
1.10	Exhaust gas temperature in main line	↑	–	–
1.11	Exhaust gas temperature at each cylinder outlet[6]	◗↑▼[2]	–	–
1.12	Exhaust gas temperature. Deviation from mean value by cylinders[6]	↑	–	–
1.13	Starting air pressure before starting valve	●↓	–	–
1.14	Air pressure in engine control system	↓	–	–
1.15	Scavenging air temperature at scavenging air cooler outlet	↑	–	–
1.16	Fuel oil pressure at high-pressure pump inlets	◗↓	■	–
1.17	Fuel oil viscosity (temperature) at engine inlet[7]	↑(↓)	–	–
1.18	Fuel oil level in daily service tank	↓	–	–
1.19	Fuel oil leakage from high-pressure piping	○	–	–
1.20	Engine speed	●↑	–	×
1.21	Power supply for control, alarm and protection system	○	–	–
1.22	Gas concentration in machinery spaces[8]	↑	–	–
1.23	Rated speed of turbocharger[10]	●↑	–	–
2	**Boilers of machinery installation[9]**			
3	**Internal combustion engines used as generator drives**			
3.1	Lubricating oil pressure at engine inlet	↓	–	×
3.2	Coolant pressure or flow at engine inlet	↓	–	–
3.3	Coolant temperature at engine outlet	↑	–	–
3.4	Fuel oil leakage from high-pressure piping	○	–	–
3.5	Engine speed	●↑	–	×
3.6	Starting air pressure (before starting valve)	↓	–	–
4	**Reduction gear**			
4.1	Lubricating oil pressure at reduction gear inlet	↓	–	×
4.2	Lubricating oil temperature in reduction gear	↑	–	–
5	**Starting air compressors**			
5.1	Lubricating oil pressure at compressor inlet	↓□	–	–
5.2	Air temperature at compressor outlet	↑	–	–

Nos.	Monitored parameter	Group 1: indication, alarm, automatic slowdown	Group 2: automatic start of stand-by pumps with alarm[1]	Group 3: automatic shutdown of engine
6	**Tanks**			
6.1	Lubricating oil level in daily service tanks	↓	–	–
6.2	Oil leakage level in oil leakage tank	↑	–	–
6.3	Fuel oil level in daily service tank	↓	–	–
6.4	Fuel oil level in overflow tank	↑	–	–
6.5	Coolant level in expansion tank	↓	–	–
7	**Ship mains**			
7.1	Voltage	●↑↓	–	–
7.2	Load (current)	●↑	–	–
7.3	Current frequency	●↓	–	–
7.4	Insulation resistance	↓	–	–

S y m b o l s :

● — remote indication (continuous);
◗ — remote indication (on call);
↑ — alarm for high value;
↓ — alarm for low value;
○ — alarm signal;
■ — automatic start of stand-by pumps;
□ — compressor shutdown;
▼ — slowdown;
× — engine shutdown.

[1]When independent stand-by pumps are available.
[2]Special visual and audible alarm may be provided instead of slowdown.
[3]When an independent lubrication pump is available.
[4]For low-speed engines with cylinder bore over 300 mm and dual-fuel low-speed engines in accordance with the requirements of 9.3.2.3, Part IX "Machinery".
[5]For medium- and high-speed engines with cylinder bore over 300 mm and dual-fuel medium- and high-speed engines in accordance with the requirements of 9.3.2.3, Part IX "Machinery".
[6]For engines with cylinder output above 500 kW.
[7]When working on heavy fuel.
[8]Required, where installations with dual-fuel (gas – liquid fuel) engines are used.
[9]Refer to Table 4.3.11.
[10]Only for turbochargers of Categories B and C (refer to 2.5.7.5, Part IX "Machinery").

N o t e . For Group 1 parameters a common sensor is provided for indication, alarm and safety systems (for slowdown);
for Group 2 parameters — a sensor for automatic start of stand-by pumps;
for Group 3 parameters — a sensor of safety system (engine shutdown).

6.2 EQUIPMENT ARRANGEMENT ON THE BRIDGE

6.2.1 Provision shall be made for a remote control station for main machinery and/or propellers in conformity with 3.2, Part VII "Machinery Installations".

6.2.2 As far as applicable, provision shall be made for remote control of essential auxiliaries.

6.2.3 Provision shall be made for shutting down the oil burning installations of automated boiler plants, incinerators, machinery space fans, fuel oil pumps, if any.

6.2.4 An alarm device shall be fitted to indicate malfunction of the machinery installation in accordance with 4.9.2.

6.2.5 On the bridge, provision shall be made for the following separate alarms:

"water in machinery space";

"fire in machinery space";

"alarm system failure";

as well as separate alarm "high gas concentration in machinery space", if the ship is provided with main and/or auxiliary dual-fuel (gas – liquid fuel) engines.

6.2.6 Visual alarm shall be provided to indicate acknowledgement of alarms in machinery space as required in 6.2.4 and 6.2.5.

6.2.7 Provision shall be made for remote drainage of bilge wells in machinery spaces. The requirements of 4.7.2 – 4.7.4 shall be complied with.

6.3 EQUIPMENT ARRANGEMENT IN MACHINERY SPACES

6.3.1 In the vicinity of the main machinery local control station alarms and indicators of parameters, as stipulated by Table 6.1.3, shall be provided.

6.3.2 As far as applicable, the controls of auxiliaries shall be located in conformity with 4.10.2.

6.3.3 Where provision is made for an enclosed main machinery control room, the applicable requirements of 4.10.3 — 4.10.6 shall be complied with.

6.4 DEVICES IN ENGINEERS' ACCOMMODATION

6.4.1 As far as applicable, the requirements of 4.11 shall be complied with.

7 COMPUTERS AND COMPUTER-BASED SYSTEMS

7.1 APPLICATION

7.1.1 The requirements of this Section apply to computers and computer-based systems used for monitoring and control of essential machinery and arrangements, which ensure in combination with other automation systems (requirements thereto are set forth in Sections 2 to 6) the operation of the machinery installation with unattended machinery spaces.

Ships fitted with such automation systems may be assigned, in accordance with 2.2.6, Part I "Classification", one of the following distinguishing automation marks in the class notation:

.1 **AUT1-C**, **AUT2-C** or **AUT3-C** — where automation of the machinery installation is based on computers or programmable logic controllers;

.2 **AUT1-ICS**, **AUT2-ICS** or **AUT3-ICS** — where computer-based systems are combined into a network forming a common integrated system.

7.1.2 The requirements of this Section apply also to computers and computer-based systems used for control of non-essential machinery and devices where loss of control results in serious damage to the ship or its machinery, e.g. explosion of domestic water boilers.

7.2 DEFINITIONS AND EXPLANATIONS

7.2.1 Owner is a Party developing a relevant specification and responsible for contracting for supply of computer-based system, sub-systems and software with the system integrator and (or) suppliers providing these products in accordance with the specification. The owner is usually the builder or shipyard during construction. After ship delivery, the owner may delegate some responsibilities to the shipowner or operator.

Simulation tests are computer-based system testing where the object under control as well as data communication links are partly or fully replaced with simulation tools, or where parts of the communication network and lines are replaced with simulation tools.

Integrated system is a combination of computer-based systems, which are interconnected, in order to allow centralized access to sensors information and/or command/control.

Interface is a transfer point, at which information is exchanged. Examples of interface include: input/output interface used for interconnection with sensors and actuators; man-machine interface, e.g. monitors, keyboards, tracker-balls, etc. used for communication between the operator and the computer; communications interface used to enable serial communications/networking with other computers or peripherals.

Computer is a programmable electronic device for storing and processing data in the digital form, making calculations or performing control. A computer may be monoblock or may consist of several interconnected units.

Computer-based system is a system of one or more computers, associated software, peripherals and interfaces.

Monitor is an electronic device for representing data.

Peripheral is a device performing an auxiliary action in the system, e.g. printer, data storage device, etc.

Quality Plan is a document containing information on the requirements prescribed by the quality management system to be applied for the specific computer-based system and/or software, the minimum scope of which is specified in 7.5.2.2.

Supplier is a contracted or subcontracted provider (party) of computer-based system, sub-systems and/or software to the system integrator and/or owner, under the coordination of the system integrator or shipyard. The supplier also provides a description of the software functionality that meets the owner's specification, applicable international and national standards, and the requirements specified in the RS rules.

Software is programs, data and documentation associated with the operation of a computer-based system.

Programmable logic controller (PLC) is a computer device designed as a stand-alone functional unit and intended to perform functions relevant to control and monitoring of ship's machinery and processes.

System Integrator is a party integrating computer systems, sub-systems and software provided by suppliers into the system, into the system invoked by the requirements specified herein, as well as creating an integrated system. The system integrator may also be responsible for installation and integration of systems in the ship.

The role of system integrator are taken by the builder/shipyard. An alternative organization may specifically contracted/assigned the system integrator's responsibilities, provided the corresponding contract is available.

If there are multiple parties performing system integration at any one time a single party may be a system integrator to coordinate the integration activities. If there are multiple stages of integration different System Integrators may be responsible for specific stages of integration but a single party shall be responsible for defining and coordinating all of the stages of integration.

Node is a point of interconnection to a data communication link.

7.3 GENERAL REQUIREMENTS FOR THE DESIGN OF COMPUTER SYSTEMS USED FOR CONTROL AND MONITORING

7.3.1 Computer-based systems shall fulfil the functional requirements of the system under control for all operating conditions including emergency conditions, taking into account:

danger to persons;

environmental impact;

damage to equipment;

usability;

operability of non-computer devices and systems.

7.3.2 If process times for functions of the system are shorter than the reaction times of the operator and therefore damage cannot be prevented by manual intervention, means of automatic intervention shall be provided.

7.3.3 A computer-based system shall have sufficient capability to:

perform necessary autonomous operations;

accept operator (user) commands;

inform the operator (user) correctly under all operating conditions including emergency.

7.3.4 System capability shall provide adequate response times for all functions, taking into consideration the maximum load and maximum number of simultaneous tasks, including network communication speed, under normal and abnormal process conditions.

7.3.5 Computer-based systems shall be designed in such a way that they can be used without special previous knowledge, otherwise appropriate assistance shall be provided for the user.

7.3.6 Computer-based systems shall be protected against unintentional or unauthorized modification of programs and data.

7.3.7 Engineering solutions shall be provided on users' access control to computer system resources (programs, processes, etc.). These measures shall ensure specification of the users' list authorized to get access to computer system resources, and assign relevant functions (account administration, monitoring, modifications, etc.) available to a specific user.

7.4 HARDWARE REQUIREMENTS

7.4.1 Hardware shall function reliably in conditions normally encountered in ships as specified in 2.1.

7.4.2 The design of the hardware shall ensure easy access to interchangeable parts for repairs and maintenance.

7.4.3 Each replaceable part shall be simple to replace and shall be constructed for easy and safe handling. All replaceable parts shall be arranged in such a way that it is not possible to connect them incorrectly or to use incorrect replacements. Where this is not practicable, the replaceable parts shall be clearly marked.

7.5 SOFTWARE REQUIREMENTS

7.5.1 General.

7.5.1.1 The software development procedure shall comply with the applicable international or national standards spanning the software lifecycle and integration of the latter into an appropriate computer-based system.

7.5.2 Quality Management Systems Requirements.

7.5.2.1 System integrators and suppliers shall operate a quality system regarding software development and testing and associated hardware such as ISO 9001 taking into account ISO 90003, GOST R ISO/IEC 90003-2014, etc.

7.5.2.2 The quality management system specified in 7.5.2.1 shall include the following:

.1 relevant procedures regarding responsibilities, system documentation, software configuration management and competent staff;

.2 procedures regarding organization set in place for acquisition of related software and hardware from suppliers;

.3 procedures regarding organization set in place for software code writing and verification. Having a specific procedure for programmable electronic systems verification of Category II and III (refer to 7.10.3) at the level of systems, sub-systems and programmable devices and modules. Having check points for Category II and III systems and providing possible verification by the Register, i.e. submitting technical documentation to RS for review, performing the relevant tests, submitting the peer review results to RS and audits of the firm's technical control, etc., in compliance with 7.10.8;

.4 having a specific procedure for software installation and amendments thereto on board the ship including interactions with owners.

7.5.3 Software lifecycle.

7.5.3.1 Design.

.1 risk assessment of system.

This step shall be undertaken to determine the risk to the system throughout the lifecycle by identifying and evaluating the hazards associated with each function of the system.

A risk assessment report shall be submitted to the Register upon request. This document shall normally be submitted by the system integrator or the supplier, including data received from other suppliers.

IEC/ISO 31010 "Risk management – Risk assessment techniques" may be applied to determine a method of risk assessment. The method of risk assessment shall be defined in the report submitted to the Register.

If based on the risk assessment, system category is changed; such changes shall be submitted to the Register for review.

Where the risks associated with a computer-based system are well understood, the risk assessment may be omitted upon submission of the relevant justification by the supplier or system integrator. Such justification shall include the following:

risk identification technique;

equivalence of the context of use of the current computer-based system and the computer-based system initially used to determine the risks;

adequacy of existing control measures in the system intended use under consideration.

.2 code production and testing.

The following documentation shall be provided to the Register for Category II and III systems (refer to 7.10.3) by the supplier and system integrator:

software modules functional description and associated hardware description for programmable devices;

evidence of verification (detection and correction of software errors) for software modules, in accordance with the selected software development standard. Evidence requirements of the selected software standard may differ depending on how critical the correct operation

of the software is to the function it performs (for example, IEC 61508 and GOST R 61508 have different requirements depending on Safety Integrity Levels (SILs), similar approaches are taken by other recognized standards).

In addition, for Category II and III systems evidence of functional tests for programmable devices at the software module, subsystem, and system level shall be supplied by the supplier via the system integrator. The functional testing shall be designed to test provided by the operating system, function libraries, software shell, etc. and used by the inspected software.

7.5.3.2 Integration testing before installation on board.

Intra-system integration testing shall be carried out between system and sub-system software modules before being integrated on board. The objective is to check that software functions are properly executed, that the software and hardware it controls interact and function properly together and that software systems react properly in case of failures. Faults shall be simulated as realistically as possible to demonstrate appropriate system fault detection and system response. The results of integration testing shall also confirm findings of the appropriate failure mode and effects analysis (FMEA), if the latter shall be submitted according to the requirements of the Rules. Functional and failure testing can be demonstrated by simulation tests.

7.5.3.3 Approval of programmable devices.

Programmable devices integrated inside a computer-based system shall be delivered with the RS documents listed in the Nomenclature of items of the RS technical supervision (refer to Appendix 1, Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships).

List of technical documentation submitted to the Register in addition to the documentation specified in 1.4.1, as well as the list of relevant tests and checks is specified in 7.10.8. Technical documentation shall address the compatibility of the programmable device with the relevant computer-based systems in the ship's application, list of necessary tests to be carried out on the ship during integration into the ship computer-based systems and it shall identify the programmable device scope of application as well as the ship computer-based system components using, if possible, such a device.

7.5.3.4 Final integration and on board testing.

.1 prior to final integration the simulation tests of a computer-based system shall be undertaken to check safe interaction of the latter with other computerized systems and functions that could not be tested previously;

.2 after final integration of the computer-based system the relevant tests shall be carried out on board to check the computer-based system in actual operating conditions and integrated with all other systems in interaction:

performing functions it was designed for;

reacting safely in case of failures originated internally or by devices external to the system;

interacting safely with other systems implemented on board a ship.

The list of relevant tests and checks is given in 7.10.8.

7.5.3.5 Software modifications during operation.

7.5.3.5.1 Responsibilities.

.1 organizations in charge of software modifications during operation shall be clearly declared by owner to the Classification Society. A system integrator shall be designated by the owner and shall fulfil the requirements specified in 7.5.1, 7.5.2, 7.5.3.1 to 7.5.3.4;

.2 during the ship operation, it is the responsibility of the owner to manage traceability of these modifications. The system integrator shall support traceability of these modifications by updating the software registry. This software registry shall contain the following:

list and versions of the software installed in Category II and III systems;

date and results of the software security scans carried out in accordance with 7.5.3.6.

7.5.3.5.2 Change management.

The owner shall ensure that necessary procedures for software and hardware change management exist on board, and that any software modification and (or) upgrade are

performed in strict compliance with the procedures. All changes to computer-based systems in the operational phase shall be recorded in accordance with 7.5.3.5.1.2.

7.5.3.6 Software security.

Owner, system integrator and suppliers shall adopt security policy and include it in their quality management systems.

For Category I, II, and III systems, physical and logical security measures shall be in place to prevent unauthorized or unintentional modification of control software or limiting values of controlled parameters within the computer-based systems, the appropriate structural means and organizational measures shall be provided. The above means and measures shall provide protection whether undertaken directly at the physical system or remotely.

Prior to software installation on board, the software code, executables and physical medium used for installation on the ship shall be scanned for viruses and malicious software. Results of the scan shall be documented and kept with the software registry.

7.6 SYSTEM CONFIGURATION REQUIREMENTS

7.6.1 General.

7.6.1.1 The hardware and software shall be of modular, hierarchical design in order to maximize the fault tolerance of the system.

7.6.1.2 The selection of the computer equipment shall be consistent with safe operation of the system under control.

7.6.2 Self-test.

Computer-based systems shall have self-test capability to monitor for correct operation and alarm shall be given for an abnormal condition.

7.6.3 Power supply.

7.6.3.1 The sources of power supply shall be monitored for failure and shall give an alarm in the event of abnormal condition.

7.6.3.2 Program and data held in the system shall be protected from corruption by loss of power.

7.6.3.3 Redundant systems shall be selectively fed and separately protected against short circuits and overloads.

7.6.4 Installation.

7.6.4.1 Equipment and its associated cabling shall be installed in such a way as to minimize electromagnetic interference between the equipment concerned and other equipment on board.

7.6.4.2 Cables used for data communication shall be of adequate mechanical strength, suitably supported and also protected from mechanical damage.

7.6.5 Data communication links.

7.6.5.1 The data communication link shall be continuously self-checking, for detecting failures on the link itself and data communication failure on nodes and shall give an alarm in the event of abnormal condition.

7.6.5.2 When the same data communication link is used for two or more essential functions, this link shall be redundant. Redundant data communication links shall be routed with as much separation as practical.

7.6.5.3 Switching between redundant links shall not disturb data communication or continuous operation of functions. An automatic switching alarm signal shall be transmitted.

7.6.5.4 To ensure that data can be exchanged between various systems, standardized interfaces shall be used.

7.6.6 Fail-to-safe principle.

7.6.6.1 In the event of a failure of a computer-based system, systems under control shall automatically revert to the least hazardous condition.

7.6.6.2 The failure and restarting of computer-based systems shall not cause processes to enter undefined or critical states.

7.6.6.3 Control, alarm and safety functions shall be arranged such that a single failure will not affect more than one of these functions.

7.6.7 Integration of systems.

7.6.7.1 Operation with an integrated system shall be at least as effective as it would be with individual, stand-alone equipment. Where multifunction displays and controls are used they shall be duplicated and interchangeable.

7.6.7.2 Failure of one part (individual module, equipment or subsystem) of the integrated system shall not affect the functionality of other parts, except for those functions directly dependent upon information from the defective part.

7.6.7.3 A complete failure in connectivity between parts shall not affect their independent functionality.

7.6.7.4 An alternative means of operation, independent of the integration, shall be available for all essential functions.

7.6.7.5 When systems under control are required to be duplicated and in separate compartments this shall be also applied to computer-based systems used for control and monitoring.

7.7 USER INTERFACE

7.7.1 General.

7.7.1.1 Computer-based systems shall be designed for ease of handling and user-friendliness and shall follow ergonomic principles.

7.7.1.2 The operational status of a computer-based system (on, off, non-failed, failed, etc.) shall be easily recognizable.

7.7.1.3 A user manual shall be provided. The user guide shall describe for example:

function keys;

menu displays;

computer-guided dialogue steps, etc.

7.7.1.4 An alarm shall be displayed at relevant operator stations for failure or shutdown of a subsystem.

7.7.2 Input devices.

7.7.2.1 Input devices shall have clearly definable functions, be reliable in use and operate safely under all conditions. The acknowledgement of the instruction given shall be recognizable.

7.7.2.2 Dedicated function keys shall be provided for frequently recurring commands and for commands, which shall be available for rapid execution. If multiple functions are assigned to keys, it shall be possible to recognize, which of the assigned functions is active.

7.7.2.3 Control panels on the bridge shall be provided with separate lighting. The level of lighting and the brightness of visual display units shall be controllable.

7.7.2.4 Where equipment operations or functions may be changed via keyboards access to such operations shall be provided for authorized personnel only.

7.7.2.5 If operation of a key is able to cause dangerous operating conditions, measures shall be taken to prevent the instruction in question from being executed by a single action such as:

use of a special key lock;

use of two or more keys.

7.7.2.6 Conflicting control interventions shall be prevented by means of interlocks or warnings. The active control status shall be recognizable.

7.7.2.7 The operation of input devices shall be logical and correspond to the direction of action of the controlled equipment.

7.7.3 Output devices.

7.7.3.1 The size, colour and density of text and graphic information displayed on a visual display unit shall be such that it may be easily read from the normal operator position under all operational lighting conditions. The brightness and contrast shall be capable of being adjusted to the prevailing ambient conditions in order to enable the information to be normally recognized.

7.7.3.2 Information shall be displayed in a logical priority.

7.7.3.3 If alarm messages are displayed on colour monitors, the distinctions in the alarm status shall be ensured even in the event of failure of a primary colour.

7.7.4 Graphical user interface.

7.7.4.1 Information shall be presented clearly and intelligibly according to its functional significance and association. Screen contents shall be logically structured and their representation shall be restricted to the data, which is directly relevant for the operator.

7.7.4.2 When using general purpose graphical user interfaces, only the functions necessary for the respective process shall be available.

7.7.4.3 Alarms shall be visually and audibly presented with priority over other information in every operating mode of the system; they shall be clearly distinguishable from other information.

7.7.4.4 All display and control functions in control stations operated by the same operators shall adopt a consistent user interface. Particular attention shall be paid to symbols, colours, controls, information priorities and layout.

7.8 TRAINING

7.8.1 Training shall be provided at a level required to effectively operate and maintain the system and shall cover normal, abnormal and emergency conditions. The user interface for training shall correspond with the real system.

7.8.2 Documentation shall be provided to support the training and shall be available for repeated use on board during maintenance of the computer systems.

7.8.3 Where a training mode is incorporated in a computer-based system it shall be clearly indicated when the training mode is active.

7.8.4 Whilst in the training mode the operation of the system shall not be impaired, and neither are any system alarms or indications to be inhibited.

7.9 TESTS AND CHECKS

7.9.1 The computer-based systems shall be designed, manufactured and tested in accordance with the requirements of this Section and other requirements of the Rules. In the case of any integrated systems, evidence shall be furnished by a party responsible for the integration that the requirements applied to the integration of the subsystems have been fully satisfied.

7.9.2 In addition to the requirements of the Section, manufacturers shall ensure by means of quality control system that their products meet with their specifications.

7.9.3 Tests and checks of a computer-based system shall be carried out with the aim of establishing the correct operation and the quality of a product.

7.9.4 Modifications of program contents and data, as well as change of version, shall be checked and tested.

7.10 PROGRAMMABLE ELECTRONIC SYSTEMS

7.10.1 Scope.

These requirements apply to the use of programmable electronic systems which provide control, alarm, monitoring or safety functions in addition to the requirements set forth in this Section.

Navigational equipment and ship loading instruments are excluded.

7.10.2 General.

7.10.2.1 Programmable electronic systems are to fulfill the requirements of the system under control for all operating conditions, taking into account danger to persons, environmental impact, damage to ship as well as equipment, usability of programmable electronic systems and operability of non computer devices and systems, etc.

7.10.2.2 When systems or their devices and components other than provided by these Rules are applied, an engineering analysis carried out in accordance with a relevant international or national standard and proving the equivalent effectiveness of the specified systems, devices and components with regard to those determined in these Rules in accordance with 1.3.4 of General Regulations for the Classification and Other Activity, shall be obligatory submitted to the Register.

7.10.2.3 The use of unconventional technology for category III systems shall not be permitted.

7.10.3 System categories.

7.10.3.1 Programmable electronic systems shall be assigned into three system categories as shown in Table 7.10.3.1 according to the potential (possible) extent of the damage caused by a single failure within the programmable control and monitoring electronic systems.

Table 7.10.3.1

System categories

Category	Effects	System functionality
I	Those systems, failure of which will not lead to dangerous situations for human safety, safety of the ship and/or threat to the environment	Monitoring function for informational/administrative tasks
II	Those systems, failure of which could eventually lead to dangerous situations for human safety, safety of the ship and/or threat to the environment	Alarm and monitoring functions; control functions which are necessary to maintain the ship in its normal operational and habitable conditions
III	Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of the ship and/or threat to the environment	Control functions for maintaining the ship's propulsion and steering; safety functions

Notes: 1. Consideration shall be given to the extent of the damage directly caused by a failure, but not to any consequential damage.

2. Identical redundancy will not be taken into account for the assignment of a system category.

7.10.3.2 Assignment of a programmable electronic system to the appropriate category shall be carried out depending on the greatest likely extent of direct damage to machinery and equipment, based on risk assessment for all operating conditions of the ship specified in 3.1.5 of Part XI "Electrical Equipment".

The relevant examples of the assignment of a programmable electronic system to the appropriate categories are given in Table 7.10.3.2. The list of the examples given is not exhaustive.

7.10.4 Data communication links.

7.10.4.1 These requirements apply to system categories II and III using shared data communication links (local network) to transfer data between programmable electronic systems and equipment.

7.10.4.2 Loss of a data communication link shall be specifically addressed in risk assessment analysis.

If a single failure in any component of the data communication link hardware or software causes loss of data communication link, they shall be automatically treated in order to restore proper working of the data communication means shall be provided to automatically restore data communication.

Table 7.10.3.2

Examples of assignment to system categories

System category	Examples
I	Maintenance support system Information system Diagnostic system Ballast water management system
II	Liquid cargo transfer control system Automation system for bilge pumping system of machinery spaces Fuel oil treatment automation system Ballast remote automatic control system Stabilization and ride control systems Alarm and monitoring systems for propulsion systems
III	Control system of propulsion system of a ship, meaning the means to generate and control mechanical thrust in order to move the ship. Control system of devices used only during manoeuvring (e.g. bow tunnel thrusters) are not in the scope of this requirement Steering system control system Electric power system (including power management system) Fire detection system Fire-fighting system Flooding detection and fighting system Control bilge system Internal communication systems involved in evacuation phases Ship systems involved in operation of life saving appliances equipment Control system of dynamic positioning system of equipment classes 2 and 3 Towing winch emergency release system (refer to 6.6.3.2.8, Part IX "Machinery")

For category III systems a single failure in data communication link hardware shall not influence the proper working of the system in general.

7.10.4.3 Loss of a data communication link shall not affect the ability to operate essential services by alternative means.

7.10.4.4 Means shall be provided to ensure the integrity of data and provide timely recovery of corrupted or invalid data.

7.10.4.5 The data communication link shall be self-checking, detecting failures on the link itself and data communication failures on nodes connected to the link. Detected failures shall initiate an alarm.

7.10.4.6 System self-checking capabilities shall be arranged to initiate transition to the least hazardous state for the complete installation in the event of data communication failure.

7.10.4.7 The characteristics of the data communication link shall be such as to transmit all necessary information in adequate time and to prevent overloading.

7.10.4.8 At least the following local network hardware statuses shall be monitored:

link up of each port on the network device/network topology change;

link down of each port on the network device;

power on or network hardware reset;

temperature increase of network devices in case this parameter is critical for operation, and the manufacturer has provided its necessary monitoring.

7.10.5 Additional requirements for wireless data communication links.

7.10.5.1 For system category III, the use of wireless data communication links is not allowed.

7.10.5.2 Functions that are required to operate continuously to provide essential services dependant on wireless data communication links shall have an alternative means of control that can be brought in action within an acceptable period of time.

7.10.5.3 Wireless data communication shall employ recognized international wireless communication system protocols that incorporate the following:

.1 message integrity. Fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message;

.2 configuration and device authentication. Shall only permit connection of devices that are included in the system design;

.3 message encryption. Protection of the confidentiality and or criticality the data content;

.4 security management. Protection of network assets, prevention of unauthorised access to network assets.

7.10.5.4 The wireless system shall comply with the radio frequency and power level requirements of International Telecommunications Union and flag state requirements.

Consideration shall be given to system operation in the event of port state and local regulations that pertain to the use of radio-frequency transmission prohibiting the operation of a wireless data communication link due to frequency and power level restrictions.

7.10.5.5 During mooring and sea trials for wireless data communication equipment, tests shall be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not its self-fail as a result of electromagnetic interference via wireless data communication links during expected operating conditions.

7.10.6 Protection against modifications.

7.10.6.1 Programmable electronic systems of category I and II shall be protected against program modification by the unauthorized personnel (user).

7.10.6.2 For systems of category III modifications of parameters by the manufacturer shall be approved by the Register.

7.10.6.3 Any modifications in software or hardware made after performance of the tests witnessed by the Register as per item 6 of Table 7.10.8 shall be documented and submitted to the Register for approval.

7.10.7 Technical documentation.

7.10.7.1 For approval of programmable electronic systems of category II and III documentation in compliance with 1.4 shall be submitted.

When alternative design or arrangement is intended to be used, an engineering analysis carried out in accordance with a relevant international or national standard shall be submitted in addition (refer to 7.10.2.2).

For ships with the distinguishing marks **AUT1-ICS**, **AUT2-ICS**, **AUT3-ICS** in the class notation where computer-based systems are combined into a network forming a common integrated system, the designer shall submit a vision document of a system architecture specifying where computer-based systems and network hardware are installed, brief description of the systems interaction and, if provided, with outside ship systems and devices, as well as protection principles against malicious information attacks of an integrated system, its division plan, if necessary, into subsystems, or other actions aimed at preventing cyber threats or failure consequences caused by such attacks. The vision document shall be supplemented with an initial review of probable vulnerabilities, as well as the failure mode and effect analysis of the integrated system with shipboard computer-based systems used for control and monitoring combined into a network. The analysis to be submitted shall include, as a minimum, the

programmable electronic systems of categories II and III, as well as network hardware. A single failure concept shall be applied during the analysis, and failure spread probabilities through a network combining integrated computer-based systems shall be taken into account. Upon the integrated system analysis completion, it is necessary to draw conclusions and provide recommendations to reduce risks of failures caused by cyber threats that may lead to dangerous situations for human safety, ship safety and/or threat to the environment. The vision document and analysis shall be used and specified by the system integrator of ship computer-based systems, and the recommendations on the performed analysis shall be used by the shipowner.

7.10.7.2 For all tests required in accordance with the system category a test program shall be submitted and the test results shall be documented (by reports).

7.10.7.3 Additional documentation may be required for systems of category III. The documentation shall include a description of testing methods and required test results.

7.10.7.4 For wireless data communication equipment, the following additional technical documentation shall be submitted:

.1 details of manufacturer's recommended installation and maintenance practices;

.2 network plan with arrangement and type of antennas and identification of location;

.3 specification of wireless communication system protocols and management functions (refer to 7.10.5.3);

.4 details of radio frequency and power levels;

.5 evidence of type testing in accordance with shipboard conditions;

.6 on-board test program (mooring and sea trials).

7.10.7.5 Necessary documents for approval of programmable electronic systems of category I shall be submitted if requested.

7.10.7.6 All changes or modifications shall be documented by the manufacturer and submitted to the Register for review and approval. Subsequent significant modifications to the software and hardware for system categories II and III shall be submitted anew for review and approval.

N o t e . A significant modification is a modification which influences the functionality and/or safety of the system.

7.10.8 Tests and evidence.

Tests and appropriate documents (reports, certificates) shall be issued in accordance with Table 7.10.8.

T a b l e 7.10.8

Tests and evidence according to system category

Requirement	Signal	Colour				
	Supplier involved	System integrator involved	Owner involved	Category I[1]	Category II	Category III
Quality Plan	×	×		Ⓐ[2]	Ⓐ	Ⓐ
Risk assessment report		×		Ⓘ[2]	Ⓘ[2]	Ⓘ[2]
Software modules functional description and associated hardware description	× (if necessary)	×			Ⓘ	Ⓘ
Evidence of verification of software code	× (if necessary)	×			Ⓘ	Ⓘ
Evidence of functional tests for elements included in systems of Category II and III at the level of software module, sub-system and system	×	×			Ⓘ	Ⓘ
Test programs and procedures for functional tests and failure tests including a supporting FMEA or equivalent, at the RS request, depending on available relevant requirements in the RS rules		×			Ⓐ	Ⓐ

Requirement	Signal	Colour				
	Supplier involved	System integrator involved	Owner involved	Category I[1]	Category II	Category III
Factory acceptance test including functional and failure tests	×	×			Ⓦ	Ⓦ
Test program for simulation tests for final integration of the system		×			Ⓐ	Ⓐ
Simulation tests for final integration of the system		×			Ⓦ	Ⓦ
Test program for on-board tests – mooring and sea (includes wireless data communication testing)		×			Ⓐ	Ⓐ
On-board mooring and sea tests (includes wireless data communication testing)		×			Ⓦ	Ⓦ
– List and versions of software installed in system – Functional description of software – User manual including instructions during software maintenance – List of interfaces between system and other ship systems – List of standards for data communication links – Additional documentation, at the RS request, if relevant requirements are available in the RS rules including "Failure modes and effects analysis" (FMEA) or an equivalent document		×			Ⓘ	Ⓘ
Updated software registry		×	×		Ⓘ	Ⓘ
Procedures and documentation related to security policy		×	×		Ⓘ	Ⓘ
Test program for compliance with the shipboard service conditions	×	×		Ⓐ[3]	Ⓐ	Ⓐ
Tests for compliance with the shipboard service conditions	×	×			Ⓦ	Ⓦ
Test reports according to the shipboard service conditions	×	×		Ⓐ[3]	Ⓐ	Ⓐ

S y m b o l s :

× — the Party shall design and submit the relevant technical documentation to the Register for review and/or carry out the relevant tests and submit the item of technical supervision to the Register;

Ⓐ — technical documentation shall be submitted for approval;

Ⓘ — technical documentation shall be submitted for reference (for information purposes);

Ⓦ — the RS representative shall take part in the tests.

[1]RS may request additional technical documentation if relevant requirements are available in the RS Rules.

[2]Risk assessment is permissible to be omitted considering the requirements of 7.5.3.1.1.

[3]If relevant requirements are available in the RS rules.

8 DYNAMIC POSITIONING SYSTEMS

8.1 APPLICATION AND MARKS IN CLASS NOTATION

8.1.1 The requirements of this Section apply to the following:
electric and electronic equipment of the dynamic positioning systems;
automated control systems for thruster units;
ship systems affecting dynamic positioning system operation as specified in 8.14.1.

8.1.2 Observance of the requirements of this Section and applicable requirements of other sections of this Part is mandatory for ships, which are assigned in compliance with 2.2.9, Part I "Classification", one of the following marks: **DYNPOS-1**, **DYNPOS-2** or **DYNPOS-3**, added to the class notation.

8.2 DEFINITIONS AND EXPLANATIONS

8.2.1 Common element means an element of a DP system with a function which depends upon or supports more than one redundant groups, excluding direct interfaces.

Cross connection means an interface between redundant groups.

Dynamic positioning control system (DP control system) means a computer-based programmable system intended for automatic and remote automated control of the auxiliary thrusters, propulsion plants, steering gear, if part of the dynamic positioning system, in order to dynamically keep position and/or heading of the ship with prescribed accuracy under the action of disturbing environmental forces, and consisting of the following:

computer-based system with associated software and interfaces for generation of control signals in automatic mode or with the use of a single control device (joystick);

operator panel system with controls and data displays;

position reference systems;

external force sensors;

power cabling;

information and control cabling.

Dynamic positioning operation (DP operation) means using the dynamic positioning system to control at least two degrees of freedom in the horizontal plane automatically.

Dynamic positioning system (DP system) means the complete installation intended for control of power supply system of the ship, auxiliary thrusters, propulsion plants, steering gear, if part of the dynamic positioning system, in order to dynamically keep position and/or heading of the ship with prescribed accuracy under the action of disturbing environmental forces.

The dynamic positioning system shall comprise, but not be limited to, the following main systems:

power supply system;

thruster system;

dynamic positioning control system.

Failure modes and effects analysis (FMEA) of dynamic positioning system of ships with distinguishing marks **DYNPOS-2** or **DYNPOS-3** in the class notation means a systematic analysis of all potential failures and effects with respect to ship systems and sub-systems, individual machinery items and devices involved in ship dynamic positioning operations carried out to a level of detail that is required to demonstrate that no single failure will cause a loss of position and/or heading as per the worst-case failure design intent.

Hidden failure means a failure that is not immediately evident to dynamic positioning system operator or maintenance personnel and has the potential for failure of equipment to perform a dynamic positioning control system on-demand function (back-up devices, systems and sub-systems of the dynamic positioning system, protective devices for diesel-generator plants, protective devices in main switchboard and switchboards, back-up power supplies, other equipment of the dynamic positioning system).

Independent joystick system means a system for automated control of thruster system using one control providing remote automated positioning control and automatic heading control. The system shall be independent of the main or back-up dynamic positioning control system and shall have its own UPS.

Joystick system means a system for remote automated control of thruster system using one control and providing remote automated positioning and remote automated or automatic heading control.

Loss of position and/or heading of the ship means that the ship's position and/or heading is outside the limits set for carrying out the dynamic positioning activity in progress.

Main dynamic positioning control station (main DP control station) means an operator workstation designated for dynamic positioning operations, which is equipped with control panels, ensures a good view of the ship's exterior limits, and where dynamic positioning control system panels and displays are installed, as well as relevant devices for automatic and joint automated control and devices for separate remote control of thrusters, propulsion plants, steering gear, if part of the dynamic positioning system, emergency stop devices for propulsion plant and thrusters, independent joystick system, devices for switching between control systems, necessary information sources, such as indicators and displays, position reference systems, alarm panels, communication systems.

Power supply system means the system necessary to supply the dynamic positioning system with power under all operating conditions including emergency ones and comprising:

prime movers of generators with necessary piping and auxiliary systems including fuel, cooling, lubrication oil, hydraulic, pneumatic and pre-heating systems;

generators;

switchboards;

cabling;

independent power supplies, including uninterruptible power supplies;

power management systems.

Redundancy of dynamic positioning system means duplication or multiple redundancy of its components, at which an installation consisting of an power supply system and thruster units with their individual control systems is functioning under control of a computer-based system in such a way that failure of particular control systems, particular thruster units or components of the power supply system does not affect the performance of the task to ensure the ship position keeping and/or heading holding.

Ship dynamic position and/or heading keeping means maintaining a desired position and/or heading within the required accuracy and under specified environmental conditions.

Single failure in dynamic positioning system means a failure in active components and/or passive elements of a dynamic positioning system, as defined in 8.5.5 and 8.5.6.

Technical System Configuration (TSC) means a setup of ship's systems for dynamic positioning, including all elements with an impact on the redundant separation, performance, protection and detection. The setup can be provided in a tabulated format at system and sub-system levels with a specific operating mode and status identified.

Thruster system means the system intended for providing adequate thrust in longitudinal and lateral directions at each instant of time as well as yawing moment which can compensate for the environmental factors affecting the ship.

The system shall comprise the following items:

thrusters with drives and auxiliary equipment including hydraulic piping and tanks (if any);

main propulsion plant of the ship with supporting systems and steering gear if under the dynamic positioning system control;

means for individual manual control of each propulsion unit, steering gear and thruster; and

associated cabling connecting all system's machinery and systems to the dynamic positioning control system.

Worst-case failure (WCF) means the identified single fault in the dynamic positioning system resulting in maximum detrimental effect on the dynamic positioning system capability to maintain a desired position and/or heading of ship as determined through the FMEA.

Worst-case failure design intent (WCFDI) means the specified minimum dynamic positioning system capabilities to be maintained following the worst-case failure. The

worst-case failure design intent is used as the basis of the design. This usually relates to the number of thrusters and generators that can simultaneously fail.

8.3 SCOPE OF SURVEYS

8.3.1 The following equipment of the DP system is subject to survey during manufacture and on board:

electric machines and electric machine converters of ship’s power supply system;
electric drives of propulsion units, steering gear and thrusters;
power static semi-conductor converters and transformers;
switchboards;
switchgear and control gear and protective devices;
uninterruptable power supply arrangements;
power and control, including information, cabling;
control and monitoring consoles of dynamic positioning control system;
computers and computer-based systems with software;
ship's position reference systems;
external force sensors.

8.4 TECHNICAL DOCUMENTATION REVIEW

8.4.1 Prior to commencement of survey of DP system equipment and in addition to the information specified in 1.4 hereof, the following documentation shall be submitted to the Register for review:

Table 8.4.1

List of documentation for products

Equipment/system	Name of documentation	Description	Distinguishing mark in class notation
Dynamic positioning control system	Technical description**	Technical description shall contain information as follows: description of the DP control system operating modes; description of interaction with ship systems including control system for ship's power supply system (response times, positioning accuracy, operating conditions, etc.); list of redundant equipment in compliance with the requirements covered by class notation; functional diagram of the system; list of system components (control stations, position reference systems, etc.); description of self-check system and alarm and monitoring system within dynamic positioning control system, list of the alarm and monitoring system signals; user interface description;	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
		description of software solutions responsible for function of continuous analysis which provides verification that the ship will remain in position and/ or heading will be maintained if the worst-case failure occurs under current environmental conditions as well as simulation of the DP system behaviour following the worst-case failure based on the manual input of environmental condition data; DP capability plots demonstrating position keeping capacity at least for fully effective DP system and following a single worst-case failure in DP system, as determined through the FMEA	**DYNPOS-2** **DYNPOS-3**
	Software description**	This document shall contain as follows: list of software modules specifying their purposes; protection measures against unauthorized modification of software; protection measures against modifications of settings; record keeping and procedure of software updating; methods and programme for software testing	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Schematic and functional diagrams*	DP control system diagrams with indication of inputs and outputs, feedbacks and power supplies	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Failure modes and effects analysis (FMEA)**	The document shall specify analysis of possible failures and their effects to confirm compliance with the requirements in the ship class notation	**DYNPOS-2** **DYNPOS-3**
	Procedure for DP system recovery**	Blackout recovery procedure for dynamic positioning system	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Factory testing programme*		**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Programme of mooring and sea trials*	The document shall include testing procedures to verify the system functioning in all operating conditions as well as to check all FMEA provisions (for systems **DYNPOS-2**, **DYNPOS-3**)	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Operation manual**	Operation manual, equipment installation instruction and maintenance instruction may be combined to form one document	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Equipment installation instruction**		**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Equipment maintenance instruction**		**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**

Equipment/system	Name of documentation	Description	Distinguishing mark in class notation
Independent joystick system	Technical description**	Technical description shall contain information as follows: description of the system operating modes; system performance (reaction times, positioning accuracy, operating conditions, etc.); functional diagram of the system*; list of the system components; user interface description	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Software description**	This document shall contain as follows: list of software modules specifying their purposes; protection measures against unauthorized modification of software; protection measures against modification of settings; record keeping and procedure of software updating; methods and programme for software testing	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Schematic diagrams*		**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Factory testing programme*		**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Programme of mooring and sea trials*	The document shall include testing programme to verify the system functioning in all operating modes as well as to check FMEA findings (for systems **DYNPOS-2**, **DYNPOS-3**)	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Operation manual**	Operation manual, equipment installation instruction and maintenance instruction may be combined to form one document	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Equipment installation instruction**		**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Equipment maintenance instruction**		**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
Position reference systems	Programme of mooring and sea trials*	The document shall include testing programme to verify the system functioning in all operating modes	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Operation manual**	User interface description; description of the system operating modes	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Technical description**	Technical description shall contain information as follows: list of equipment; equipment characteristics; operating conditions; connection diagrams*	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
External force sensors (heading, motions, wind speed, wind direction)	Technical description**	Technical description shall contain information as follows: list of equipment; equipment characteristics; operating conditions; connection diagrams*; user interface description	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
	Sea and mooring trials programme*	The document shall include testing programme to verify the system functioning in all operating modes	**DYNPOS-1** **DYNPOS-2** **DYNPOS-3**
Power management system	Failure modes and effects analysis (FMEA)**	The documents shall specify analysis of possible failures and their effects to confirm compliance with the requirements in the ship class notation	**DYNPOS-2** **DYNPOS-3**
	Blackout recovery procedure for ship's power supply system**	Procedure shall describe recovery process for ship's power supply system in relation to the mode of ship dynamic position and/or heading keeping	

* The document shall be approved.
** The document shall be agreed.

8.4.2 When the DP system components are manufactured by various manufacturers, each of them shall submit a set of technical documentation for the manufactured equipment compliant to the applicable requirements of 1.4 and 8.4.1.

8.5 DESIGN OF THE DP SYSTEM, CLASSES

8.5.1 The design of the dynamic positioning control systems shall conform to the general requirements set forth in Section 2.

8.5.2 Where the propulsion plant and rudder system of a self-propelled ship form part of the DP system, the requirements of this Chapter shall be fully applied thereto, in addition to the requirements placed upon the propulsion machinery and rudder system.

8.5.3 The DP systems shall be subdivided into classes based on their design capability to maintain position and/or heading of the ship if the worst-case failure occurs, as specified below.

8.5.4 Class 1 DP system, which corresponds by its characteristics to mark **DYNPOS-1** in the class notation, is a system with minimum redundancy as indicated in 8.5.8. In this case, the loss of position and/ or heading of the ship may occur in the event of a single failure.

8.5.5 Class 2 DP system, which corresponds by its characteristics to mark **DYNPOS-2** in the class notation, shall have such redundancy that a loss of position and/or heading shall not occur in the event of a single failure under specified/considered environmental conditions according to the design in any active component or system (generator, thruster, propulsion unit and steering gear, if part of the DP system, main switchboard section or switchboard, control cabling, remotely controlled valve, etc.) or one passive component of the system (cable, piping, heat exchanger, manually controlled valve, etc.), failure of which may immediately cause deterioration of the DP system capability to maintain ship's position and/or heading.

Common passive components may be used in the systems, which will not immediately affect heading or position keeping capabilities upon failure (e.g. components in ventilation and seawater systems not directly cooling DP system running machinery). Common passive components of the system shall not be usually considered to fail owing to adequate protection from mechanical damage and component properties confirmed by results of technical supervision of the Register.

8.5.6 Class 3 DP system, which corresponds by its characteristics to mark **DYNPOS-3** in the class notation, shall have such redundancy that a loss of position and/or heading shall not occur in the event of a single failure or an accident under specified/considered environmental conditions according to the design in the system components in the following cases:

failure in any component, as indicated in 8.5.5, as well as any passive component in the DP system;

failure in all active and passive components located in any one watertight compartment, from flooding or fire;

failure in all active and passive components located in any one fire subdivision, from fire or flooding.

8.5.7 For Class 2 and 3 DP systems, the controls of operator panels of the dynamic positioning control system shall be designed so that no single inadvertent act of the operator of the dynamic positioning control system can lead to a loss of position and/or change in heading.

8.5.8 Class 1 DP system shall be designed with redundancy of the position reference system.

Duplication of computer-based DP control system is not mandatory; however, it is necessary to provide independent joystick system with automatic ship heading keeping function as specified in 8.9.4.

8.5.9 Class 2 DP system shall be designed with redundancy of the following components:

power supply system;

thrusters with their local control systems;

computer-based systems with the operator panels and controls of DP control system;

position reference systems and external force sensors.

8.5.10 Class 3 DP system shall be designed with redundancy of components as provided for Class 2, but in addition, all the redundant components shall be separated by "A-60" class fire-resisting bulkheads and in case of equipment below the main bulkhead deck they shall be also separated by watertight bulkheads.

8.5.11 The redundant components ensuring single failure tolerance shall function continuously or be switched on automatically. In this case, the redundant equipment performance shall be sufficient for carrying out the DP activity in progress with account of the ship purpose and required accuracy until such activity can be safely completed.

For Class 2 and 3 DP systems, the provision shall be made regarding possible tracking of hidden failures that, as determined through the FMEA, can lead to loss of duplication of equipment or systems included in DP system operation upon request of the control system algorithm. In this case, various software and hardware may be used (tracking continuity of data communication links, tracking of equipment "status", available unacknowledged failure signals, etc.). To achieve the purposes above, start of the periodical equipment testing programmes is allowed as well as monitoring of certain systems.

8.6 POWER SUPPLY SYSTEM

8.6.1 The power system necessary to supply the thruster system shall have a sufficient capacity and shall respond in time to power demand changes caused by operating modes needed at the moment.

Sudden load changes in ship's power supply system resulting from any single failures in DP system shall not cause loss of ship's electric power.

8.6.2 For Class 1 DP systems, the power system need not be redundant.

8.6.3 For Class 2 DP systems, the power system shall be divisible into two or more independent systems, so that after failure of one of them the remaining power supply systems can supply power to the connected thruster units with supporting systems to ensure maintaining of position and/or heading of the ship. While in use, the power system may be run as a common electric power supply system.

8.6.4 For Class 3 DP systems, the power system shall have characteristics mentioned in 8.6.3, but in addition, it shall be physically divided by "A-60" class division (bulkhead) into two or more independent systems. Where the power supply systems are located onboard below the operational waterline, they shall be also divided by watertight bulkheads. During operation, such systems shall function separately.

8.6.5 For Class 2 and 3 DP systems at least one power management system shall be provided. Such system shall have structure ensuring performance in case of any single failure, as indicated in 8.5.5 and 8.5.6.

8.6.6 The programmable electronic systems (computer-based or microprocessor (PLC) systems) shall be supplied in such a way as to minimize voltage bumps, harmonic interference and to provide protection against erroneous connection (connection with a wrong polarity).

8.7 THRUSTER SYSTEM

8.7.1 Each electric drive of the thrusters shall be power supplied by a separate supply circuit without the use of common feeders or common protective devices.

8.7.2 Each electric drive of thrusters shall be provided with its own control system supplied by a separate circuit without the use of common feeders or common protective devices. Such control system shall provide, if necessary, remote automated control of the respective thruster, which shall be independent of the dynamic positioning control system.

8.7.3 Failures in the thruster system, including failed control commands for propeller pitch, azimuth and/or propeller speed, shall not cause change in heading or increase in thrust magnitude.

8.7.4 To eliminate electromagnetic interaction between command signals, feedback signals of the local control systems of thruster units and electronic (computer-based) dynamic positioning control system, the mentioned control systems shall meet the requirements set forth in 2.2, Part XI "Electrical Equipment".

8.7.5 The thruster system with thrusters control systems and support auxiliary arrangements and equipment of Class 2 and 3 DP systems shall be supplied with power in compliance with 8.6.3 and 8.6.4. If a failure of one of the power supply systems with thruster units connected to it occurs, the thruster units remaining in operation shall provide sufficient resultant thrust in the longitudinal and lateral directions as well as yawing moment for maintaining position and/or heading of the ship under the environmental forces action stipulated in the design.

8.7.6 Each thruster unit shall have an emergency stop system accessible for actuation both from the thruster unit local control station and the DP control station. Emergency stop systems of thruster units used in Class 2 and 3 DP systems shall have control loop monitoring. In Class 3 DP systems the engineering solutions shall be provided for such monitoring in the event of failure or accident according to 8.5.6.

8.8 CONTROL STATIONS

8.8.1 The main dynamic positioning control station shall be generally located on the navigation bridge where the operator has a good view of the ship's exterior limits. DP system operator's workstation shall be equipped with the panels of the dynamic positioning control system with relevant devices for automatic and automated control, including devices for remote automated control system for thrusters, propulsion plants and rudders, if part of the DP system, emergency stops for propulsion plants and thrusters, independent joystick system, devices for switching between control systems, necessary information sources, such as indicators, controls for position reference systems, alarm panels, communication systems.

8.8.2 The display switching system and controls shall be designed with due regard to the national ergonomic standards. The thruster and propulsion unit control mode shall be selectable by simple actions of the operator and the mode selected shall be clearly distinguishable among the following control modes provided:

automatic control of thruster system;

remote automated control of all units within thruster system with the use of a single control device;

remote automated control of each unit being part of the thruster system;

manual control of ship's propulsion plant, thrusters and rudders from the local control stations.

8.8.3 The alarm and monitoring system of the DP system shall meet the general requirements set forth in 2.4.

8.8.4 The alarm and monitoring system of the DP system, in addition to audible and visual signals relating to the DP system machinery and devices, shall contain textual and graphic information on failures.

8.8.5 The control system shall provide for quick transfer from the automatic to remote automated control of the thrusters, propulsion plants and rudders, if involved in DP system operations, using both individual controls (according to the number of thruster units) and a single common joystick. Transfer from the remote automated to automatic control shall be effected with similar quickness.

8.9 COMPUTER-BASED DYNAMIC POSITIONING CONTROL SYSTEMS

8.9.1 The redundancy requirements shall not be applicable to computer-based systems in Class 1 dynamic positioning control systems.

8.9.2 Computer-based systems in Class 2 dynamic positioning control systems shall be duplicated and independent of one another.

The dynamic positioning control systems shall be designed with a logic that would render fault development and transfer from one system to another impossible. The redundant system components shall interact in such a manner that if one of these components fails, it is isolated (disconnected) while the other component is activated. The control station shall represent sufficient visual and audible information on transfer to the back-up system or component. Malfunctions of common facilities, such as plant interfaces, arrangements for switching between systems, data transfer, data buses and software, including self-checking routines shall not be capable of causing the failure of both systems.

8.9.3 Computer-based systems in Class 3 dynamic positioning control systems shall be duplicated as indicated in 8.9.2, and furthermore, provision shall be made for an independent back-up dynamic positioning control system arranged in a special space separated by "A-60" class bulkhead from the main control station. During normal dynamic positioning control, the back-up system shall be in "hot back-up" state in "on" condition and shall be automatically updated by data input from the position reference system and external force sensors, thruster system feedback sensors, etc. Change-over of control to the back-up system shall be possible at all times and shall be effected manually from the back-up control station.

8.9.4 Independent joystick system with automatic ship heading keeping function shall be provided for DP systems irrespective of their Class.

8.9.5 In computer-based systems of Class 2 and 3 DP systems the software function of continuous analysis shall be implemented to verify that heading will be maintained and/or the ship will remain in position if the worst-case failure occurs. The analysis shall verify that, following the worst-case failure, the remaining in operation thrusters, propulsion plants and rudders, if involved in DP system operations, can generate the same resultant thrust and yawing moment as required prior to the accident under current environmental conditions.

8.9.6 The control systems with the software function of failure consequence analysis according to 8.9.5 shall actuate warning alarm where the analysis outcome establishes DP system's inability to maintain position and/or heading of the ship after the worst-case failure under current environmental conditions.

8.9.7 For DP system operations, which will take a long time to safely terminate, the failure consequence analysis shall be capable of simulating the DP system behaviour after the worst-case failure based on manual inputs of weather trend.

8.9.8 If the ship's equipment and/or systems (e.g. processing facilities for sea cable or pipe laying, etc.) are capable of generating disturbances with direct impact on DP performance, required data inputs shall be submitted automatically to the DP control system from such equipment/systems. Additionally, provisions shall be made for such data inputs into the DP control system manually.

8.9.9 Redundant computer-based systems shall be arranged with automatic transfer of control after a failure in one of the computer-based systems. The automatic transfer of control from one computer-based system to another shall be smooth, without significant disturbing effects on the thruster system. The alarm and monitoring system shall give the signal if the system, which take over control, is for whatever reason unable to provide automatic control during the transfer of systems.

8.9.10 A dedicated uninterruptible power source (UPS) shall be provided for each DP control system, including independent joystick system. The UPS battery capacity shall be sufficient for servicing the computer-based DP control system and external force sensors

connected to it as well as position reference system for 30 minutes following a main supply failure. For Class 2 and 3 DP systems, UPS shall be connected to independent power supply systems as indicated in 8.6.3 and 8.6.4. UPS for Class 3 back-up dynamic positioning control system shall be arranged considering 8.9.3. During change-over from the main supply to the battery supply, the alarm and monitoring system signal shall be given. The alarm and monitoring system signal shall also be given when the accumulator battery is discharged.

8.9.11 Application programs and database of dynamic positioning control system programmable devices shall be protected against destruction or data loss due to faults in the equipment power supply system.

8.10 POSITION REFERENCE SYSTEMS

8.10.1 Position reference systems shall be based on the operating requirements with due regard to the acceptable performance characteristics. The systems shall be simultaneously and coordinately available to the DP control system during operation. The position reference systems shall produce data with adequate accuracy. Provision shall be made for visual and audible alarm to indicate deviations from true data or excessive degradation of the signals from the position reference systems.

8.10.2 For Class 1 DP systems, at least two independent position reference systems shall be installed.

8.10.3 For Class 2 and 3 DP systems, at least three independent position reference systems shall be installed.

8.10.4 When two or more position reference systems are required, they shall not all be of the same type, but jointly such systems shall involve at least two different principles for position reference.

For Class 1 DP systems, the use of two independent position reference systems based on global navigation satellite systems (GNSS) with a differential subsystem (DGNSS) is allowed under the following conditions:

systems shall not be of the same type;

systems shall use different constellations of available satellites with different augmentation methods available;

operation of the ship in the DP mode is excluded in the 500 m area relative to other ships and offshore installations. Appropriate restrictions shall be entered in the Classification Certificate and in the Certificate of Compliance for Dynamic Positioning System of the Ship.

8.10.5 For Class 3 DP systems, one of the position reference systems shall be connected to the back-up control system and located in a space separated by "A-60" class bulkhead from the spaces containing other position reference systems.

8.11 EXTERNAL FORCE SENSORS

8.11.1 For the DP systems, provision shall be made for at least the following external force sensors determining:

heading;

magnitude of ship motions;

wind speed;

wind direction.

The sensors shall be selected on the basis of the operating requirements with due regard to the acceptable performance characteristics.

8.11.2 For Class 2 or 3 DP systems where required accuracy of keeping ship's position or heading is fully dependent on correct signals from external force sensors, at least three independent external force sensor systems shall be available for each parameter (e.g. three gyro compasses or three heading sensors engaging other physical principles, but in compliance with 8.11.1, shall be provided for heading).

8.11.3 For Class 3 DP systems, one group of sensors of each type, in addition to the requirements set forth in 8.11.2, shall comply with the requirement for separation thereof by "A-60" class bulkhead from other sensors.

8.12 ALARM AND MONITORING SYSTEM

8.12.1 In addition to the requirements set forth in 2.4, the alarm and monitoring system shall be arranged with facilities to preserve and indicate the data on failure alarms and change in their state.

8.12.2 Parameters monitored by the alarm and monitoring system shall be subdivided structurally into parameters, which to a certain degree are informative, and parameters, which when alarmed require immediate actions to be taken by the personnel.

8.13 CABLE ROUTEING AND PIPING OF DP-SYSTEM MACHINERY AND DEVICES

8.13.1 For Class 1 and 2 DP systems cable routes of electrical equipment and control systems, as well as hydraulic, fuel and lubricating oil and other piping shall be installed with due regard to the requirements set forth in 16.8.4, Part XI "Electrical Equipment" and Section 5, Part VIII "Systems and Piping".

8.13.2 For Class 3 DP systems, cables of stand-by electric and electronic equipment and piping of stand-by support systems and control systems shall not be routed together with cables and piping systems of the main equipment through the same spaces (compartments). Such installation may be only accepted in cases when the cables of stand-by equipment and, in turn, piping of stand-by systems run in "A-60" class fire-protective ducts. Use of cable connection boxes is not allowed in fire-protective ducts.

8.14 REQUIREMENTS FOR NON-DP SHIP SYSTEMS

8.14.1 Single failure in ship systems not directly part of the DP system (e.g. fire-extinguishing systems, engine-room ventilation systems, air heating and conditioning in ship spaces and accommodations, emergency stop systems of fuel, lubricating oil transfer pumps, ship ventilation, etc.) shall not affect DP system operation, exceeding criteria as specified in 8.5.5 and 8.5.6.

8.15 REQUIREMENTS FOR DEVELOPMENT OF FAILURE MODES AND EFFECTS ANALYSIS (FMEA) FOR DYNAMICALLY POSITIONED VESSELS

8.15.1 The purpose of the FMEA for dynamically positioned vessels is to verify that the dynamic positioning system TSC complies with the RS requirements regarding the effects of a single failure.

To develop an FMEA, the following documents are required:

worst-case failure design intent for a specific TSC;

drawings, specifications, and installation and operating manuals that contain information for each component regarding performance, protection and methods for detecting failures;

drawings showing separation of systems by compartments (for Class 3 DP system).

8.15.2 The DP FMEA shall be developed taking into account the following requirements:

.1 FMEA shall be developed in a top-to-bottom approach starting from the global automatic DP function and leading to the subsystem's function at a local level;

.2 at least one TSC shall be defined in the DP FMEA for the Register approval;

.3 every TSC shall be validated by proving trials. Test omissions, where several TSCs overlap in systems with the same setup, shall be stated and explained;

.4 FMEA shall be based on the ship's drawings and manuals, all of which shall be referenced in the applicable sections of FMEA;

.5 worksheets shall be included in FMEA to record the failures modes and their effects at the global station-keeping function level and at the local subsystem's function level. Table 8.15.2.5 provides an example of the format;

Table 8.15.2.5

DP FMEA worksheet

Main system				TSC				
Sub-system				Drawing reference				
FMEA ID	Component name, location and ID	Failure mode and cause	Immediate local effect	Effect on other redundant groups and other systems	Global effect on station-keeping	Detection and indication to operator	Means of protection and mitigation	Reference to proving trial test report

.6 any common elements and cross connections identified shall be analysed for a failure propagation. Table 8.15.2.6 provides an example of the format for recording the commonality analysis results;

Table 8.15.2.6

Cross connection worksheet

Main system				TSC				
Sub-system				Drawing reference				
FMEA ID	Component name, location and ID	Failure mode	Redundancy groups impacted	Cross connection with ID	Type of cross connection	Location	Accepted configuration (connected/isolated, closed, open, etc.)	Reference to proving documentation

.7 the DP FMEA shall provide an analysis of every system relevant for DP in a separate chapter with a summary table concluding on the following:

system's worst-case single failure;

possible causes of the worst-case single failure;

potential hidden failures;

common point failures;

cross connections;

interfaces to other systems within DP perimeter;

potential configuration errors and setups defeating the redundancy concept;

status of validation by proving trials;

any deviations from the Register requirements including the effects of a single point failure.

Each item of the summary shall be explicitly stated, including where no instances are found to report;

.8 if the cross connections are identified, they shall be addressed by:

isolation by removal of any physical link between the redundant groups traceable in the list of isolation points from FMEA appendices;

verification and validation of being safe by design based on the studies and testing;

.9 for the mark **DYNPOS-1**, Table 8.15.2.5 shall include columns for severity, probability of a failure and the final criticality for a DP system's station-keeping function. Such document can be referred to as Failure Mode, Effects and Criticality Analysis (FMECA). FMECA and FMEA are not mandatory conditions for assigning the mark **DYNPOS-1** and are submitted to the Register for familiarization and review on request of the shipowner;

.10 for the marks **DYNPOS-2** and **DYNPOS-3**, the criticality analysis is not required in FMEA;

.11 traceable version and document modification control shall be implemented for the DP FMEA and Proving Trials Report.

8.15.3 The FMEA is a ship specific document and shall be updated after any changes in the equipment and functions of the DP system.

8.15.4 The DP system proving trials document and Proving Trials Report are objective evidence of the FMEA confirmation and are subject to updating together with the FMEA.

9 POSITION MOORING SYSTEMS

9.1 SCOPE OF APPLICATION

9.1.1 The requirements of this Section apply to the automated control systems of power equipment of position mooring systems.

9.2 DEFINITIONS AND EXPLANATIONS

9.2.1 Position mooring system means a complex of systems, machinery and equipment intended for the ship's position keeping at predetermined accuracy when exposed to external disturbing forces by means of tensile anchor lines.

9.2.2 Auxiliary thrusters-assisted position mooring means the use the ship's main propulsion plant and thrusters together with the position mooring system.

9.3 CONTROL SYSTEMS

9.3.1 Each anchor winch shall be provided with the independent control system supplied by its own feeder with an individual protective device.

9.3.2 Each winch shall have a control station located so as to provide a good view of the anchoring operations having regard to the laying-out of the anchor by an anchor handling vessel.

9.3.3 Means shall be provided at each anchor winch control station to monitor chain cable/rope tension, the winch load (current) and the length of the chain cable/rope paid out, the chain cable/rope paying out speed.

9.3.4 A manned anchoring operations control station shall be provided with means to indicate chain cables tension, wind speed and direction. Besides, it shall be provided with means of communication between all control stations critical to anchoring operations.

9.3.5 The local and remote control stations shall be provided with the emergency anchor release arrangements that remain operable at the loss of power supply from the main source of electrical power by automatic switching to the standby source of power. The above controls need not be supplied from the independent source of power.

9.3.6 The emergency release arrangements shall actuate at a load equal to the minimum design tensile strength of the chain cable/rope, as well as at the maximum possible angles of heel and trim as regards damage stability and flooding conditions.

9.3.7 The following alarm signals shall be provided at the central and local anchoring operations control stations: on excessive chain cable/rope tension, on decrease of the chain cable/rope tension below the permissible limits.

9.3.8 Alarms shall be provided at the central anchoring operation control station on the ship's leaving the positioning point and on the ship's deviations from the set course.

The possibility shall be provided of the settings adjustment of the alarms actuation within the specified limits. Actuation settings shall be clearly identified. Measures shall be taken against inadvertent/unintended resetting.

9.4 AUXILIARY THRUSTERS FOR ANCHORING SYSTEMS

9.4.1 Where the anchoring systems are used in conjunction with auxiliary thrusters to keep the ship position, the latter shall comply with the requirements of Chapter 8.7.

9.4.2 Applicable requirements for dynamic positioning systems set forth in 8.7 and 8.8 cover also auxiliary thrusters control systems including centralized microprocessor control units.

9.4.3 Input signals fidelity of the auxiliary thrusters control system shall be provided by the signals relevant processing. All errors revealed during the fidelity check shall actuate alarms.

Russian Maritime Register of Shipping

Rules for the Classification and Construction of Sea-Going Ships
Part XV
Automation

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