RUSSIAN MARITIME REGISTER OF SHIPPING

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RULES

FOR THE CLASSIFICATION AND CONSTRUCTION OF MOBILE OFFSHORE DRILLING UNITS

PART XIV

AUTOMATION

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RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF MOBILE OFFSHORE DRILLING UNITS

Rules for the Classification and Construction of Mobile Offshore Drilling Units (the MODU Rules) 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 September 2023.

The present Rules are based on the latest version of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms, 2022, 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 set down specific requirements for MODU, consider the recommendations of the Code for the Construction and Equipment of Mobile Offshore Drilling Units, 2009 (2009 MODU Code) (IMO resolution A.1023(26), as amended) and supplement the Rules for the Classification and Construction of Sea-Going Ships and the Rules for the Equipment of Sea-Going Ships.

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 and Machinery";
Part VIII "Systems and Piping";
Part IX "Boilers, Heat Exchangers and Pressure Vessels";
Part X "Electrical Equipment";
Part XI "Refrigerating Plants";
Part XII "Materials";
Part XIII "Welding";
Part XIV "Automation";
Part XV "Safety Assessment";
Part XVI "Signal Means";
Part XVII "Life-Saving Appliances";
Part XVIII "Radio Equipment";
Part XIX "Navigational Equipment";
Part XX "Equipment for Prevention of Pollution".

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

For this version, there are no amendments to be included in the Revision History.

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of Sections 1 to 5 and 8 to 10 apply to automation equipment subject to technical supervision irrespective of whether the MODU has an automation mark in its class notation or not.

The requirements of Sections 6, 7 apply to units which, in conformity with 2.4, Part I "Classification", have the automation mark **AUT** and/or one of the marks **DYNPOS** added to the character of classification, with indication of the appropriate class of the dynamic positioning system according to 7.1.2.

The requirements of Section 6 are applicable also to the units which have no automation mark in the class notation but provided main machinery control room and remote control and monitoring systems of the machinery and devices.

1.1.2 The present Part contains technical requirements for the automation equipment listed in 1.1.1 and defines the minimum needed extent of remote automated control, protection, alarm and indication.

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 this Part the following definitions have been adopted.

Automated machinery plant is a complex of machinery and equipment fitted up with automation systems or devices to enable a remote automatic or automated control and monitoring of the plant.

Uninterruptible power supply is a mode of the electrical power supply achieved through combined operation of the main, emergency and standby sources of electrical power, to enable the continuity of power supply to be maintained in case of the main power source failure.

Acknowledgement is a confirmation of receipt of an alarm or call by the personnel.

Automation equipment includes instrumentation, sensors, actuators and other equipment intended for the automatic or remote automated control, protection and alarm, i.e. for remote monitoring of machinery and installations.

Control and monitoring station is a special space or area containing control and/or monitoring means intended for control and monitoring of:

propulsion plant or dynamic positioning system of the MODU;

electric power plant;

emergency electric power plant;

other machinery, systems and facilities supporting functioning of the MODU under normal or emergency conditions, for example, shut-down system of the process equipment, remote and emergency shut-down system of the machinery, radio communication and internal loudspeaking communication systems and command telephony system, etc.

Standby power source is a source of electrical power independent of the main and emergency power sources. The standby power source may be used to provide uninterrupted power supply to certain kinds of essential equipment.

Remote automated control system is automation 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 actuating devices realizing the mode of the machinery functioning set up by the operator.

Alarm system is an apparatus to release visual and audible signals simultaneously in order to attract attention of the personnel and oblige them to take certain actions. The alarm system of a machinery plant is intended to inform the personnel whenever the monitored parameters reach the preset limits and deviations of machinery and associated systems from normal working ranges occur.

Group alarm subsystem is the structural part of the centralized alarm 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. Each common signal shall have a notation to describe the common signals, for example, "Parameters of the electric generating plant", "Parameters of the boiler plant", etc.

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 or on the fluctuations of certain conditions in machinery and devices

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

A u t o m a t i o n c o m p o n e n t is a structurally independent item (e.g. amplifier, sensor, relay, logic element) forming part of automation devices and systems.

1.3 SCOPE OF TECHNICAL SUPERVISION

1.3.1 General provisions concerning classification procedure, technical supervision of MODU during design or construction, manufacture of equipment and component thereof, surveys and requirements for technical documentation to be submitted to the Register for review and approval on the MODU as a whole shall be found in Part I "Classification" of the MODU Rules and General Regulations for the Classification and Other Activity.

1.3.2 Subject to technical supervision during manufacture as well as on board the MODU are automated control and monitoring systems and devices of the following:

.1 machinery and propellers of the propulsion plant, thrusters and steering gears of self-propelled MODU;

.2 apparatus and other equipment of electric generating plants;

.3 driving machinery of generators and converters;

.4 driving machinery of jacking systems of self- elevating MODU;

.5 ballast systems for raising and submersion of submersible and semi-submersible MODU;

.6 windlasses, winches and other deck machinery;

.7 auxiliary machinery (pumps, compressors, etc);

.8 main and auxiliary boilers;

.9 refrigerating plants;

.10 alarm system, fire detection system, etc;

.11 MODU draught, heel, trim, measuring and logging systems, etc.;

.12 other systems as required by the Register.

1.4 TECHNICAL DOCUMENTATION

1.4.1 For each item of automation equipment listed under 1.3.2, the following technical documentation shall be submitted to the Register:

.1 functional description including technical parameters and operating conditions (explanatory note);

.2 block diagrams of control and monitoring systems;

.3 plans of front panels of control consoles with indication of functional components;

.4 general view drawing (layout of basic components);

.5 list of monitored parameters of the unit for alarm system, as well as group alarm subsystem for MODU;

.6 description of power supply sources for automation system and their connection diagram;

.7 guidelines for installation and operation;

.8 cable routing layout drawing and means of protection against electromagnetic interference;

.9 test program and test standards;

.10 failure mode-and-effects analysis (for complicated automation systems, such as Class 2 and 3 dynamic positioning control systems or integrated computer-based systems);

.11 documentation on software and information on testing thereof by the builder.

2 DESIGN OF AUTOMATION SYSTEMS

2.1 GENERAL

2.1.1 The design of automation components and control devices shall ensure an average operating life of automation systems between repairs of at least 5000 h.

2.1.2 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 decks.

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

No damage to components and 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 2.1.2-1.

Table 2.1.2-1

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 2.1.2-2.

Table 2.1.2-2

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.		

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

2.1.4 Depending on the category of equipment, reliable operation of automation systems shall be ensured at vibrations conditions specified in Table 2.1.4-1.

Table 2.1.4-1

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.
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.).

Category of equipment	Vibration conditions	Description
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, automation equipment shall also operate reliably at shocks with the parameters specified in Table 2.1.4-2.

T a b l e 2.1.4-2

Category of equipment	Shock parameters	Description
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 intended for installation on MODU without ice class assigned.
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 **Ice-resistant** class MODU.
N o t e . Equipment falling into a higher category meets the requirements for all lower categories of equipment.		

2.1.5 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.

2.1.6 The protection of enclosures of the automation systems, automation components and control devices shall be chosen in accordance with 2.4, Part X "Electrical Equipment".

2.1.7 Electrical and electronic components and devices shall operate reliably in case of deviation of the power parameters listed in Table 2.1.7-1 from nominal values.

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

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

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

T a b l e 2.1.7-1

Parameter	Deviation from nominal value		
	long-term	short-term	
	%	%	s
Voltage	+ 6 to –10 [1]	± 20	1,5
Frequency	±5	±10	5
[1] For direct current: ± 10 %.			

Categories of the equipment depending on type of power supply are given in Table 2.1.7-2.

T a b l e 2.1.7-2

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 with 30 s intervals.

2.1.8 Pneumatic and hydraulic components and devices shall be operable under fluctuations of the working medium pressure within ± 20 per cent of the nominal value.

2.1.9 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 2.1.9.

Table 2.1.9

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

2.1.9.1 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.

2.1.9.2 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.

2.1.9.3 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.

2.1.9.4 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.

2.1.10 Automation equipment shall operate reliably in the event of harmonic distortions of the supply voltage curve as specified in 3.2.1.4, Part X "Electrical Equipment".

2.1.11 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 for these conditions.

2.1.12 For sensors intended to measure the temperature of media under pressure, provision shall be made for pockets the strength of which shall be designed for the maximum pressure like the casing or piping of the equipment where the sensor is fitted.

2.1.13 Three-way valves or similar devices shall be fitted on the measuring pipes before the sensors to enable functional check of the sensors without dismounting thereof and for blowing off. Access to operations with these valves shall be possible only for authorized personnel with the use of special tool.

2.1.14 Provision shall be made that in case of failure of visual or audible alarm devices in one circuit the functioning of the remaining circuits would not be affected.

2.1.15 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 2.1.15.

Table 2.1.15

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.
Note. Equipment falling into a higher category meets the requirements for all lower categories of equipment.	

2.2 REQUIREMENTS FOR COMPONENTS AND DEVICES

2.2.1 The components and devices used in the automation systems shall be so constructed as to permit easy mounting, adjustment and replacement thereof. Screwed joints shall be provided with means to prevent them from being worked loose. No mechanical resonance with an amplification factor in excess of 5 is permitted.

2.2.2 Pneumatic and hydraulic components and devices shall not be damaged by momentary overloads due to a working medium pressure rise equal to 1,5 times the working pressure.

2.2.3 The contacting surfaces of electric plug-in-socket connections shall be so designed and positioned as to prevent the increase of contact resistance restricting their performance.

2.2.4 Cable inlets to cabinets or connection boxes in machinery spaces shall be arranged on the underside or side of the cabinets or boxes. Where cable inlets are arranged on the side, the cable shall have a loop directed downwards. Cable inlet from above is only permitted through tight glands or special arrangements to prevent penetration of liquids into the item concerned. At cable inlets, especially in way of connection to movable components and devices, provision shall be made to avoid tension effects.

2.2.5 Printed circuit boards shall be coated with insulating varnish over the connecting wire line.

2.2.6 Regulating components intended for initial setting shall be protected against spontaneous change of setting.

A reset and fixing of the regulating components shall be possible.

2.2.7 Servomotors shall be so constructed that no spontaneous uncontrolled change of their setting is possible.

2.2.8 All units, terminal boards, cable connections and test points on the components and devices shall be clearly marked. The marking of sensors, logic units and actuators shall contain information on their functionality so that they can be identified on the drawings and in the lists of devices and systems.

2.2.9 Information (signalling) circuits shall be so constructed as to preclude damage to the unit or associated components in case of their malfunction. No damage to the unit or adjacent component shall occur in case of short-circuit, earth fault or break-off of line transmitting signal from the measuring element to other devices. Such malfunctions shall result in relatively safe condition of the module or component with an alarm signal being released.

2.2.10 Pipes of the hydraulic and pneumatic automation devices shall be of metal. Plastic pipes are accepted in the pneumatic devices provided they meet the following requirements. Pipes and other equipment made of plastic materials shall have satisfactory mechanical strength, low thermoplasticity, high oil and fire resistance. These properties shall be supported by appropriate tests.

2.3 GENERAL REQUIREMENTS FOR AUTOMATED CONTROL SYSTEMS OF MACHINERY AND PLANTS

2.3.1 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.

2.3.2 Provision shall be made to prevent incorrect mounting while replacing removable items (moduli) having plug-in-socket connections and to ensure their efficient fixing in the working position. Where necessitated by the operating or structural features of components and 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.

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

2.3.4 The automation control systems shall be so constructed that the replacement of components and devices by others of the same type would not affect the operation of the systems or require additional adjustment. The adjustment, if necessary, shall be possible with simple means.

2.3.5 Electrical and electronic automation systems shall be fitted up with safety devices capable of selective disconnection of that part of the system where a fault occurs.

2.3.6 Automation control systems shall be based on "fail-to-safe" principle.

2.3.7 Where machinery or plants are stopped by safety devices, they shall not be restarted automatically or remotely before a manual reset has been carried out. Any other solution is subject to special consideration by the Register.

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

2.3.9 It shall be possible to clean the filters while in operation.

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

2.3.11 The feeding pipes from the tanks for hydraulic devices shall be located in the lower parts of the tanks to allow for a level variation due to consumption of fluid and motions of the units in order to avoid formation of air locks.

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

2.3.13 Pneumatic automation systems of the main propulsion plants and electrical power plants shall generally have two devices for cleaning and drying the air so interconnected 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 interrupting the air supply.

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

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

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

2.3.16 A full or partial loss of power in automated or remote control circuits shall not result in dangerous situations.

2.3.17 The operation of air-cooled control devices shall not be impaired owing to an eventual contamination of cooling air. Where forced cooling is applied, provision shall be made to prevent failure of the air-cooled equipment in case the cooling system fails and to give a proper alarm signal.

2.4 ALARM, SAFETY, INDICATION AND LOGGING SYSTEMS

2.4.1 Alarm system.

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

Partial integration of alarm system with control systems may be allowed for the integrated systems, provided the applicable requirements of 5.6 are met, including the appropriate backup of data transmission channels and power supply systems.

The alarm system on MODU with its central information panels generally located in the main machinery control room shall structurally include a group common 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 (indicator columns);

on the navigating bridge (in the wheelhouse);

in service and public spaces of the ship;

in accommodation spaces for essential 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.

The information panels of the alarm system shall provide visual and audible alarms to indicate malfunctions, parameters reaching predetermined limit values, deviations of equipment from normal working ranges, and shall be located in places where continuous watch is kept by the operating duty personnel (at control stations).

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

2.4.1.3 The alarm 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 acknowledgement of another. Failure of one component (device) of the system shall not cause failure of the alarm system in general. When common monitors are applied instead of individual light signalling devices, at least two such monitors shall be provided.

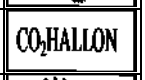
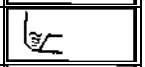
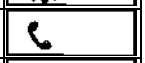
2.4.1.4 The visual signals in the main machinery control room and at the local control stations shall be individual and indicate the fault condition. They shall be generally given as flashing lights. After being accepted (acknowledged), the flashing light shall change to steady condition.

Cancelling of a visual signal shall be only possible after the fault has been repaired or the faulty part of the system disconnected.

2.4.1.5 For all alarm systems, common audible signal devices may be used but not less than two. Once acknowledged, the audible signal shall be silenced, whereupon the system shall be immediately open to forthcoming signals even though the previous faults might not yet be attended to. Simultaneously with acknowledgement of the audible signal in the main machinery control room on MODU audible and visual signals in machinery spaces and on the common signal units in the accommodation and public spaces shall be silenced. However, acknowledgement of the alarm signal on the common signal units at the main control and monitoring station and in the accommodation spaces of MODU shall not bring about silencing of the audible signal in the main machinery control room and/or in the machinery space. In MODU machinery spaces along with the audible signal devices of the alarm system provision shall be made for visual display units (indicator columns) for the identification of the signal, for which colours and symbols shown in Table 2.4.1.5 shall be used. The flashing alarm shall be illuminated for at least 50 per cent of the cycle and have a

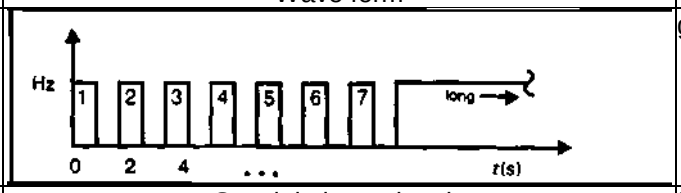
pulse frequency in the range of 0,5 and 1,5 Hz. The audible signal of the alarm system in machinery spaces shall be clearly heard even though one of signal display units fails.

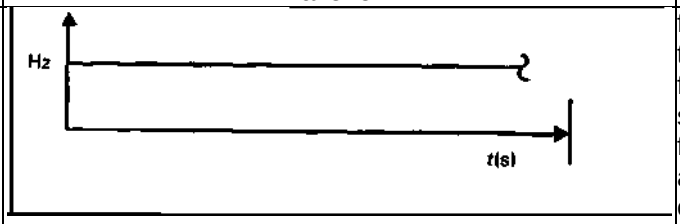
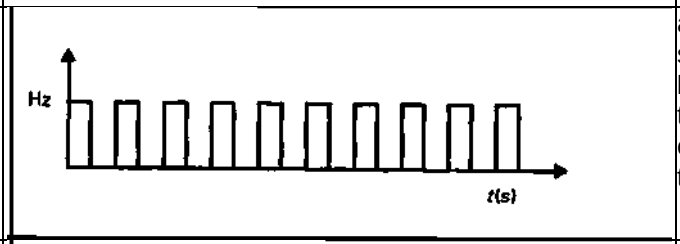
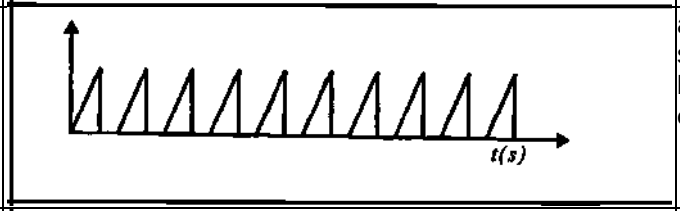
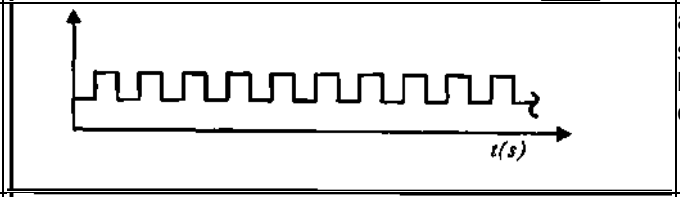
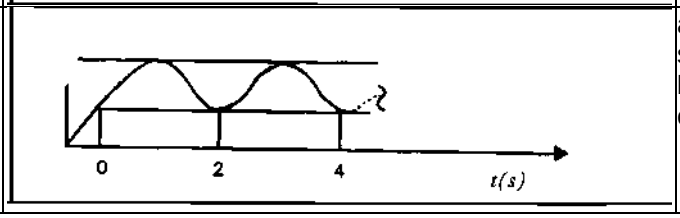
Table 2.4.1.5

Signal	Colour	Symbol
Fire detection alarm in spaces other than machinery spaces	Red	
Fire detection alarm in machinery spaces	Red	
Fire extinguishing medium release alarm	Red	
Machinery alarm	Yellow	
Steering gear alarm	Yellow	
Bilge alarm	Yellow	
Engineer's alarm	Yellow	
Telephone	White	
Engine room telegraph. Command transmission	White	

2.4.1.6 Self-eliminating faults shall be indicated by the alarm system in such a way that the signal remains applied until it is accepted (acknowledged). The audible signals of the alarm system shall be readily distinguishable from audible signals of other systems. The audible signals (except for the bell) 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 system shall correspond to the one of the waveforms shown in Table 2.4.1.6. 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 in the engine room. 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.

Table 2.4.1.6

Nos	Wave form	Comments
1.1		general alarm
1.2	Special alarm signals	fire detection alarm in spaces other than machinery spaces

Nos	Wave form	Comments
2		fire detection alarm in spaces other than machinery spaces; fire detection alarm in machinery spaces; fire extinguishing medium release alarm; engine room telegraph (command transmission)
3.1		alarm system signal; steering gear alarm; bilge alarm; engineer's alarm; telephone; engine room telegraph (command transmission);
3.2		alarm system signal; steering gear alarm; bilge alarm; engineer's alarm;
3.3		alarm system signal; steering gear alarm; bilge alarm; engineer's alarm;
3.4		alarm system signal; steering gear alarm; bilge alarm; engineer's alarm;

2.4.1.7 The signal indicating a complete or partial disablement of the alarm system shall be readily distinguishable in the main machinery control room from other signals. Visual signals and/or indication of parameters in computer-based alarm systems shall not be lost due to instantaneous supply voltage drops or mains voltage and frequency fluctuations.

Provision shall be made for structural means of protection against unpredictable or unauthorised intervention that can result in changes to the programs or the limiting values of the controlled parameters (settings).

2.4.1.8 Checking of the alarm system shall be possible while machinery is in operation.

2.4.1.9 Momentary power failure in the alarm system shall not bring about the loss of signals applied at the moment.

2.4.1.10 Irrespective of the extent of automation and the monitoring order using for the machinery, the alarm 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.

Alarms for machinery faults shall be provided on the panels from which the machinery is remotely controlled.

2.4.1.11 The alarm system on MODU shall be so arranged that signals pertinent to machinery or electric power plant are in the first place relayed to the panels (consoles) 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 relayed to the main control and monitoring station of the MODU.

2.4.1.12 Alarm systems shall comprise arrangements to preclude false alarms from momentary changes of parameters due to motions of the unit, starts and stops of machinery, etc.

2.4.1.13 MODU engineers' alarm.

Provision shall be made for an alarm system to call the members of machinery crew in the engine room or main machinery control room, which shall be put into operation:

.1 manually from the main machinery control room or from a local control station of main machinery;

.2 automatically where an alarm for the machinery plant is not acknowledged on the panel in the engine room or in the main machinery control room within a specified period of time (e.g. 2 min). This signalling system shall be led to the group alarm subsystems in the accommodation, service and public spaces in which the members of machinery crew might be staying.

2.4.1.14 Alarm "Personnel in machinery space" of MODU.

For periodically unattended machinery spaces of MODU provision shall be made for an alarm "Personnel in machinery space" by which the safe and efficient condition of the engineer on duty who is in the machinery space alone is confirmed at the main control and monitoring station.

Unless reset in a period not exceeding 30 min, this alarm system shall be put in operation:

.1 manually by the engineer on duty when attending machinery spaces on routine checks and shall be disabled after leaving the machinery space;

.2 automatically when the engineer on duty shall attend machinery space in case of a machinery alarm. Disablement of the alarm "Personnel in machinery space" shall not be possible before the engineer has acknowledged the alarm in the machinery space.

A pre-warning signal shall be provided in the machinery space, which operates 3 min before the above alarm is given to the main control and monitoring station, concerning the necessity of early acknowledgement of the above alarm to be effected by the end of specified (e.g. 30 min) period during the whole time the engineer on duty is staying in the machinery space.

2.4.2 Safety systems.

2.4.2.1 The safety systems of automated machinery shall be provided for those parameters only the deviation of 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 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.

2.4.2.3 Where arrangements for overriding the shut down machinery are provided for certain parameters, 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.

2.4.2.4 Provision shall be made for self-monitoring of the safety systems. An alarm signal shall be activated at least at such faults as short-circuit, open- circuit failure and earth fault.

2.4.2.5 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 or plants.

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

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

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

.3 protect machinery or plants from emergency condition by shutdown the machinery or plants and stopping fuel supply thereto.

An alarm signal shall be given before the safety system has been automatically activated.

2.4.2.7 After activation, the safety system shall be brought again to the state of readiness by the personnel.

2.4.2.8 Pressure vessels, boilers and similar installations the breakdown of which can result in explosions, fires, etc, shall have two-level protection from excessive pressure. Such protection shall be provided by various types of safety devices; for example, the first level may be provided by an electrical safety system and the second level – by a safety valve.

2.4.3 Indication and logging systems.

2.4.3.1 Indication and logging systems shall be independent of control, alarm and safety systems so that their failure would not affect such other systems.

2.4.3.2 When logging systems fail, an alarm signal shall be activated.

2.4.3.3 Provision shall be made for easy reading of indicated data with regard to the illumination at the indicator positions.

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

2.4.3.5 The number of devices and displays of the indication system shall be sufficient to enable safe control of the machinery and plants.

3 SUPPLY OF AUTOMATION SYSTEMS

3.1 GENERAL

3.1.1 Where the essential machinery or plants are supplied from both main and emergency power sources, the automation systems or devices of these machinery or units shall be also supplied from the said two power sources. Consumers differing in voltage shall be supplied by separate feeders.

3.1.2 The control systems of propulsion plants 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 sections 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 Where the automation systems of particular auxiliary machinery are supplied by the same feeders as the corresponding electric motors, provision shall be made for a start of standby auxiliary machinery and for connection of the automation system to its feeder in the event of a loss of power at the running machinery.

3.1.4 Hydraulic and pneumatic automation systems shall be supplied from two sources. The second source shall be connected automatically upon pressure loss with release 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 2.3.15 and 2.3.16 are complied with.

3.1.5 Air used for the automation system shall be free from oil, moisture and other contamination. To avoid condensate formation, provision shall be made for heating arrangements or other means to preclude formation of condensate over the entire range of working temperatures.

3.1.6 Alarm and safety systems shall be supplied from both main and standby sources. The standby power source shall be an independent source (e.g. an accumulator battery) which shall come into operation automatically when the main source fails, with an alarm activated upon change-over.

The capacity of the accumulator battery of the standby source of power shall be sufficient for powering the alarm and safety systems during 30 min.

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

4 AUTOMATED MACHINERY AND PLANTS

4.1 GENERAL

4.1.1 Machinery and plants shall be constructed in conformity with the applicable requirements of the relevant Parts of the MODU Rules, and provision shall be made for local stations and alarm devices and indicators.

4.1.2 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 shall be still possible.

4.1.3 Change over from local control to automatic or remote control shall be possible from local control stations only. Change over from remote to automatic control may be effected from remote control stations.

4.1.4 If the preset sequence of operations is disturbed, the programmed automatic control system shall stop performing the program and shall bring the machinery to a safe condition with an alarm released in all cases at the control station where continuous watch is kept.

4.1.5 Where a fuel gas system is provided to feed the electric power plant, provision shall be made for an interlocking between the gas supply system and the ventilation system of the gas pipeline protective casing. When gas is supplied to the gas pipeline, the ventilation of the protective casing shall be switched on and a gas concentration sensor shall be provided at the ventilation duct outlet to detect possible leakages.

4.1.6 Gas fuel supply shall be automatically terminated when:

gas with a concentration of 60 per cent of the lower explosive limit (LEL) is detected in the casing to be ventilated;

gas with a concentration of 25 per cent of the lower explosive limit (LEL) is detected in the machinery space;

ventilation of the gas pipeline protective casing is stopped;

a fire is detected in the machinery space.

4.2 AUTOMATED PROPULSION PLANTS

4.2.1 The remote automated control system of the propulsion plant of the MODU shall provide start and stop, as well as the control of the propeller speed, thrust value and direction of rotation within the whole permissible operating range of the propulsion plant.

4.2.2 The remote automated control system shall meet the following requirements:

.1 in case of quickly alternating commands, the last one in a sequence shall be executed irrespective of the operating condition;

.2 setting of the speed or of the thrust value and direction of rotation shall be effected by means of a single control unit;

.3 when setting the speed of the propulsion plant, provision shall be made for an automatic passing of the critical rotational speed ranges irrespective of the preset operating mode;

.4 remote control systems and engine telegraph systems shall be independent of each other so that faults in one of the systems would not affect the operation of the other; for both systems common control lever may be used;

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

.6 for propulsion machinery which are served by independent auxiliary electric machinery and which stop upon power loss on the main switchboard, provision shall be made for remote or automatic programmed starting of the machinery when the power supply is restored;

.7 if the remote automated control system fails, the preset mode of operation of the propulsion machinery and propellers shall be maintained until change-over to local control or until the plant is brought to fail-safe condition (stoppage of propellers), if the maintenance of the preset mode is impracticable or unreasonable;

.8 remote automated control system shall ensure emergency manoeuvring whereby a change in speed of a self-propelled MODU and in direction of its movement for the opposite shall be achieved within the shortest time possible. Besides, power limitations, if set below the nominal value, shall be automatically removed.

4.2.3 Where there are several control locations of the propulsion plant, the one in the main machinery control room shall predominate over the one on the navigating bridge (main control station).

The same is true in respect of the control location in the main machinery space as compared to that in the main machinery control room.

The transfer of control to a predominant control location and back shall be possible from a predominant location only, in any moment and irrespective of the position of the remote controls (the transfer of control shall be effected by the personnel, wherever possible, without substantial alteration of the rotational speed and thrust of the propulsion plant).

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

The possibility of simultaneous control from different locations shall be eliminated. Where several controls are provided at the locations (e.g. at bridge wings and in the centre), they shall be either mechanically or electrically synchronized.

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

4.2.4 The propulsion machinery emergency stop device, if electrically operated, shall be independent of remote automated control system, alarm and safety systems, and of the unit's mains.

4.2.5 With regard to the safety system, provision shall be made for an automatic power reduction in case of faults not involving direct damage to the propulsion plant.

4.2.6 In case of main internal combustion engine at 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 propulsion plants having main machinery of other types are concerned, the automatic regulation of working medium temperature shall be agreed with the Register.

4.2.7 The number of successful automatic starts made by the remote automated control system from a non-replenishable power source for starting shall not be less than required in 3.2.4, Part VIII "Systems and Piping", and the normal functioning of the remote control system shall not be limited in case of the starting air pressure drop or the capacity of starting accumulator batteries decrease lower than the limits of alarm actuation.

The number of ineffective attempts of automatic starting shall be limited by two or three attempts so that after the last ineffective attempt made by the remote control system, the starting air quantity or accumulator battery capacity is sufficient to provide manually a half number of starting attempts as required in 3.2.4, Part VIII "Systems and Piping" or 13.7.2, Part XI "Electrical Equipment".

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

4.2.9 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 4.2.9-1 — 4.2.9-4.

Table 4.2.9-1

Nos.	Monitored parameters for medium and high speed diesel engines	Group 1 Remote indication, alarm, automatic slowdown with alarm	Group 2 Automatic start of standby pumps with alarm	Group 3 Automatic shutdown of engine with alarm
1.0	**Fuel oil system**			
1.1	Fuel oil pressure after filter (engine inlet)	Ind./Min.	Start	–
1.2	Fuel oil viscosity (temperature) before injection pumps[1]	Max. (Min)	–	–
1.3	Leakage from high pressure pipes	Alarm	–	–
1.4	Level of fuel oil in daily service tank[2]	Min.	–	–
1.5	Common rail fuel oil pressure	Min.	–	–
2.0	**Lubricating oil system**			
2.1	Lub. oil to main bearing and thrust bearing pressure	Ind./Min.	Start	Shutdown
2.2	Lub. oil filter differential pressure	Ind./Max.	–	–
2.3	Lub. oil inlet temperature	Ind./Max.	–	–
2.4	Oil mist concentration in crankcase[3]	Max.	–	Shutdown
2.5	Flow rate cylinder lubricator. Each apparatus.	Min.	–	–
2.6	Common rail servo oil pressure	Min.	–	–
3.0	**Turbocharger system**	Ind./Min.	–	–
3.1	Turbocharger lub. oil inlet pressure[4]	Ind./Min.	–	–
4.0	**Sea water cooling system**			
4.1	Sea water pressure	Ind./Min.	Start	–

Nos.	Monitored parameters for medium and high speed diesel engines	Group 1 Remote indication, alarm, automatic slowdown with alarm	Group 2 Automatic start of standby pumps with alarm	Group 3 Automatic shutdown of engine with alarm
5.0	**Cylinder fresh cooling water system**			
5.1	Cylinder water inlet pressure or flow	Ind./Min./ Slowdown	–	–
5.2	Cylinder water outlet temperature (general)[5]	Ind./Max./ Slowdown	Start	–
5.3	Level of cylinder cooling water in expansion tank	Min.	–	–
6.0	**Starting and control air system**			
6.1	Starting air pressure before main shut-off valve	Ind./Min.	–	–
6.2	Control air pressure	Ind./Min.	–	–
7.0	**Scavenge air system**			
7.1	Scavenge air box temperature	Max.	–	–
8.0	**Exhaust gas system**			
8.1	Exhaust gas temperature after each cylinder[6]	Ind./Max./Slowdown	–	–
8.2	Exhaust gas temperature after each cylinder. Deviation from average[6]	Max.	–	–
9.0	**Engine speed**	Ind.	–	–
10.0	**Engine overspeed**	Alarm	–	Shutdown
11.0	**Gas concentration in machinery spaces[7]**	Max.	–	–
12.0	**Control - safety - alarm system power supply failure**	Alarm	–	–

Group 1: Common sensor for indication, alarm and slowdown.
Group 2: Sensor for automatic start of standby pumps.
Group 3: Sensor for shutdown.
Ind. - remote indication (continuous or on call).
Max. - alarm for high value.
Min. - alarm for low value.
Alarm - alarm activated.
Start - automatic start of standby pumps.
Slowdown - load reduction.
Shutdown - engine shutdown.

[1] For heavy fuel oil burning engines only.

[2] High-level alarm is required if no suitable overflow arrangement is provided.

[3] Only for medium-speed engines of 2250 kW and above or having cylinders of more than 300 mm bore. One oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement of independence between alarm and shutdown system.

[4] Unless provided with a self-contained lubricating oil system integrated with the turbocharger.

[5] Two separate sensors are required for alarm and slowdown.

[6] For engine power > 500 kW/cyl.

[7] Required, where installations with dual-fuel (gas - oil fuel) engines are used.

Table 4.2.9-2

Nos	Monitored parameter for main steam turbines	Group 1 Remote indication, alarm	Group 2 Automatic start of standby pumps with alarm	Group 3 Automatic shutdown of turbine with alarm
1.0	Lubricating oil pressure after oil cooler	Ind./Min.	Start	Shutdown
2.0	Lub. oil differential pressure across filter	Ind./Max.	–	–
3.0	Lub. oil temperature at each bearing outlet	Ind./Max.	–	–

Nos	Monitored parameter for main steam turbines	Group 1 Remote indication, alarm	Group 2 Automatic start of standby pumps with alarm	Group 3 Automatic shutdown of turbine with alarm
4.0	Lub. oil level in gravity tank	Ind./Min.	–	Shutdown
5.0	Steam temperature before maneuvering valves[1]	Ind./Min./Max.	–	–
6.0	Steam pressure before maneuvering valves	Ind./Max.	–	–
7.0	Steam pressure in condenser	Ind./Max.	–	Shutdown
8.0	Pressure in deaerator	Ind./Min./Max.	–	–
9.0	Water level in deaerator	Ind./Min./Max.	–	–
10.0	Water level in condenser	Ind./Min./Max.	–	Shutdown
11.0	Water pressure after condensate pump	Ind./Min.	Start	–
12.0	Condensate salinity	Max	–	–
13.0	Turbine vibrations	Max.	–	Shutdown
14.0	Axial displacement of rotor	Max.	–	Shutdown
15.0	Steam pressure in end glands	Ind./Max.	–	–
16.0	Sea water pressure at circulation pump outlet	Ind./Min	Start	–
17.0	Steam turbine control system power supply-failure	Alarm	–	–

Group 1: Common sensor for indication, alarm and slowdown.
Group 2: Sensor for automatic start of standby pumps.
Group 3: Sensor for shutdown.
Ind. - remote indication (continuous or on call).
Max. - alarm for high value.
Min. - alarm for low value.
Alarm - alarm activated.
Start - automatic start of standby pumps.
Shutdown - turbine load reduction.
[1] When re-heating is used, an additional alarm is required at turbine inlet.

Table 4.2.9-3

Nos	Monitored parameter for main gas turbines	Group 1 Remote indication, alarm	Group 2 Automatic start of standby pumps with alarm	Group 3 Automatic shutdown of gas turbine with alarm
1.0	Lub. oil inlet pressure	Ind./Min.[4]	Start	Shutdown
2.0	Lub. oil inlet temperature	Ind./Max.	–	–
3.0	Bearing temperature	Ind./Max.	–	–
4.0	Gas temperature at high-pressure turbine outlet	Ind./Max.	–	Shutdown
5.0	Flame failure or ignition system failure or stratification of temperatures over flame tubes	Alarm	–	Shutdown
6.0	Automatic start system failure	Alarm	–	–
7.0	Fuel oil pressure at gas turbine engine inlet[1]	Ind./Min	–	Shutdown
8.0	Fuel oil pressure before burners[1]	Ind./Min.	–	Shutdown
9.0	Fuel oil temperature before burners[2]	Ind./Min./Max.	–	–
10.0	Pressure differential across air cleaner	Ind./Max.	–	–
11.0	Gas turbine vibration at each support	Ind./Max.[4]	–	Shutdown
12.0	Axial displacement of rotor	Max.	–	Shutdown
13.0	Gas turbine speed (at each rotor)[3]	Ind./Max.	–	Shutdown
14.0	Oil level in lubricating oil tank	Ind./Min.	–	–

Nos	Monitored parameter for main gas turbines	Group 1 Remote indication, alarm	Group 2 Automatic start of standby pumps with alarm	Group 3 Automatic shutdown of gas turbine with alarm
15.0	Automatic gas turbine shutdown	Alarm	–	–
16.0	Gas concentration in machinery space	Ind./Max.	–	Shutdown
17.0	Temperature under gas turbine sheath	Ind./Max.	–	–
18.0	Gas temperature after gas turbine	Ind./Max.[4]	–	Shutdown
19.0	Control-safety-alarm system power supply failure	Alarm	–	–
20.0	Coolant temperature	Ind./Max.	–	–
21.0	Pressure differential across lubricating oil filter	Max.	–	–
22.0	Vacuum pressure at the compressor inlet	Max.[4]	–	Shutdown

Group 1: Common sensor for indication, alarm and slowdown.
Group 2: Sensor for automatic start of standby pumps.
Group 3: Sensor for shutdown.
Ind. - remote indication (continuous or on call).
Max. - alarm for high value.
Min. - alarm for low value.
Alarm - alarm activated.
Start - automatic start of standby pumps.
Shutdown - gas turbine load reduction.

[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 4.2.9-4

Nos	Monitored parameters for shafting, CPP, reduction gear and couplings (if provided)	Group 1: Remote indication, alarm, automatic slowdown with alarm	Group 3: Automatic shutdown of engine (turbine) with alarm
	Shafting		
1.0	Temperature of thrust bearing (or lubricating oil),	Max/Slowdown	Shutdown
2.0	including those built- in in engine and reduction gear Temperature of shaft bearings (or lubricating oil)	Max.	–
3.0	Temperature of sterntube bearing (or lubricating oil)[1]	Max.	–
4.0	Lub. oil level in sterntube lubrication tank[2]	Min.	–
5.0	Water flow at sterntube inlet[3]	Min.	–
	CPP		
6.0	Hydraulic oil pressure downstream of filter	Min.	–
7.0	Hydraulic oil level in header tank	Min.	–
8.0	Control system (or power supply) failure[4]	Alarm	–

Nos	Monitored parameters for shafting, CPP, reduction gear and couplings (if provided)	Group 1: Remote indication, alarm, automatic slowdown with alarm	Group 3: Automatic shutdown of engine (turbine) with alarm
	Reduction gear and couplings		
9.0	Lubricating oil pressure at reduction gear inlet[5]	Ind./Min.	Shutdown
10.0	Lub. oil temperature in reduction gear	Ind./Max./Slowdown	–
11.0	Temperature of each sliding bearing[6]	Max.	–
12.0	Hydraulic oil pressure at coupling inlet	Ind./Min.	–

Group 1: Common sensor for indication, alarm and safety systems (for slowdown).
Group 3: Sensor of safety system (shutdown of engine (turbine)).
Ind. - remote indication (continuous or on call).
Max. - alarm for high value.
Min. - alarm for low value.
Shutdown - engine (turbine) load reduction.
Alarm - alarm activated.

[1] Refer to 5.6.3, Part VII "Machinery Installations" of the Rules for the Classification and Construction of Sea-Going Ships.

[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 a power of more than 2250 kW.

4.3 AUTOMATED BOILER PLANTS

4.3.1 The requirements of this Chapter cover boiler plants with oil-burning installations.

4.3.2 Steam boilers shall be fitted up with automatic water level regulators and combustion controls to maintain automatically the steam pressure within pre-set range.

4.3.3 Automated boilers shall have at least two low water level detectors independent of each other and connected to output devices located at different heights, one of which shall be used solely for low water level protection.

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

4.3.4 Provision shall be made for a remote shutdown of automated boiler plants from the main machinery control room or from the control station where continuous watch is kept.

4.3.5 Automated oil-burning installations shall be fitted with interlocking devices to permit fuel oil

being fed into the boiler furnace only when the requirements listed below are complied with:

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

.2 boiler furnace is so pre-purged that normal ignition of flame-jet and sufficient air changes are ensured therein;

.3 fuel oil supply to burners is set to minimum permissible quantity to ensure steady combustion.

4.3.6 As far as the automated oil-burning installations are concerned, the oil supply to the burners shall be cut off automatically under the following circumstances:

.1 absence of flame for not more than 5 s from the moment the oil supply begins;

.2 fuel oil viscosity (temperature) being insufficient for atomization;

.3 degradation of parameters of vapour or air intended for fuel oil atomization;

.4 fuel oil supply decreases below the level at which the flame-jet burns steadily.

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

4.3.8 If the ignition of fuel oil fails, re-starting of the burner shall be possible from the local control station only after the boiler furnace has been appropriately pre-purged.

4.3.9 Monitored parameters of automated boiler plants, measuring points, limiting parameter values and types of automatic protection and indication are given in Table 4.3.9.

Table 4.3.9

Nos.	Monitored parameter	Alarms for limited values of parameters	Automatic protection	Indication in main machinery control room	Comments
1	**Main boilers**				
1.1	Steam pressure in boiler drum	Max.	Shutdown	Continuous	–
1.2	Steam temperature after superheater	Max.		On call	–
1.3	Steam temperature after steam cooler	Max.		On call	–
1.4	Water level in boiler drum	Min.	Shutdown	Continuous	–
1.5	Feed water pressure after pump	Min.	Shutdown	Continuous	–
1.6	Fuel oil pressure before burner	Min.	Shutdown	On call	–
1.7	Pressure of steam or air used for atomization	Min.	Shutdown	–	–
1.8	Fuel oil viscosity (temperature) before burner	Min.	–	–	–
1.9	Air pressure before furnace	Min.	Shutdown	–	–
1.10	Feed water salinity	Max.	–	–	–

Nos.	Monitored parameter	Alarms for limited values of parameters	Automatic protection	Indication in main machinery control room	Comments
1.11	Flame	Flame failure	Shutdown	–	–
1.12	Fuel oil level in daily service tank	Min.	–	–	–
1.13	Fuel oil temperature in daily service tank	Min.	–	–	–
1.14	Electric power supply to boiler controls	Power loss	Shutdown	–	–
2	**Thermal oil boilers**				
2.1	Thermal oil pressure at boiler outlet	Max.	Shutdown	–	–
2.2	Thermal oil temperature at boiler outlet	Max.	Shutdown	–	–
2.3	Thermal oil flow at boiler outlet	Min.	Shutdown	Continuous	–
2.4	Thermal oil level in expansion tank	Min.	Shutdown	Continuous	–

N o t e . In the main machinery control room, group alarms may be used provided identification is possible at the local control station.

4.4 AUTOMATED ELECTRIC POWER PLANTS

4.4.1 The electric power plants on MODU shall ensure electric power supply for the consumers in conformity with the following requirements:

4.4.1.1 On MODU where electrical power is normally supplied from one generator, the control devices shall be provided to ensure:

.1 automatic starting of standby generator, the automatic synchronization, taking over and sharing of load in case:

maximum permissible load is reached by the generator during operation (85 per cent, for instance); or

there is malfunction of the operating unit which enables an automatic synchronization of generators to be carried out and the load to be transferred to the standby generator without any loss of voltage on the main switchboard busbars;

.2 automatic starting of standby generator and its connection to the main switchboard busbars within 30 s if the running generator fails and the main switchboard is in "black-out" position.

When the voltage on the switchboard busbars is restored, essential auxiliary machinery shall be restarted automatically as specified in 4.4.2.

4.4.1.2 On MODU, where electrical power is normally supplied from two or more generators operating in parallel, means shall be provided (automatic disconnection of less important services, for instance) to prevent overload of the remaining generators and deenergizing of the main switchboard busbars in case one of the generators fails in order to ensure safe functioning of the unit.

4.4.2 When the voltage on the main switchboard busbars is restored after black-out, the start of key machinery essential for normal functioning of the MODU shall be effected automatically in accordance with a specified program and in such a way that the electric power plant is not overloaded.

4.4.3 When, at load reduction on the electric power plant, the generators shall be disconnected automatically, provision shall be made to the effect this would not also happen at momentary load variations.

4.4.4 The drives of generators started automatically shall be ready to start immediately. A visual signal shall be provided to indicate readiness.

When the drives are not ready to be started immediately, an indicator shall be provided to warn that automatic starting is impossible.

4.4.5 When the standby generators shall start automatically if the running ones are overloaded, provision shall be made for the following:

.1 automatic synchronization and connection;

.2 automatic load sharing;

.3 preliminary determination of sequence in which the generators shall be started and connected to the collecting busbars of the main switchboard.

4.4.6 Where a water pump or independently driven fan is used to cool the generators, provision shall be made for an alarm system to indicate when the cooling system fails, as well as for an automatic protection of the generators against overheating by way of disconnection of non-essential consumers.

4.4.7 Automated electric power plants shall ensure automatic and remote connection of electric generators including automatic synchronization, taking over and sharing of load.

4.4.8 Monitoring parameters of automated electric power plants (except emergency ones), measuring points, limiting values of parameters and types of automatic protection and parameter indication are given in Table 4.4.8.

Table 4.4.8

Nos.	Monitored parameter	Measuring point	Alarms For limited values of parameters	Automatic protection	Indication in main machinery control room	Comments
1	**Ship mains**					
1.1	Voltage on main switchboard	–	Min.	Tripping of generator's circuit-breaker	Continuous	Where the main switchboard is installed in main machinery control room no additional indication is required
1.2	Current frequency on main switchboard	–	Min.	–	Continuous	
1.3	Insulation resistance on main switchboard	–	Min.	–	Continuous	
2	**Generators**					
2.1	Load (current) on main switchboard		Max	a) Alarm signal		Effected by the protection system of generators
		–	Max	b) Disconnection of nonessential consumers	–	
		–	Max.	c) Disconnection of generator	–	
2.2	Reverse power (current) on main switchboard	–	Max.	Tripping of generator's circuit-breaker	–	
2.3	Generator winding temperature	–	Max.	–	–	When the power is 5000 kW and over
3	**Internal combustion engines for driving generators**					
3.1	Lubricating oil pressure	At engine inlet	Min.	Engine shutdown	Continuous	–
3.2	Lubricating oil temperature	At engine inlet	Max.	–	On call	–
3.3	Oil mist concentration or bearing temperature	–	Max.	Engine shutdown	–	Automatic stop of diesel generators at such parameter may be permissible where high certainty of signal is provided
3.4	Cooling water pressure or flow	At engine inlet	Min.	–	–	–
3.5	Cooling water temperature	At engine outlet	Max.	–	On call	–
3.6	Sea water pressure or flow	At engine inlet	Min.	–	–	–
3.7	Fuel oil pressure	At engine inlet	Min.	–	–	–
3.8	Fuel oil viscosity (temperature)	At engine inlet	Max. (Min.)	–	–	–
3.9	Fuel oil leakage from HP piping	After fuel oil injection pump	Presence of fuel oil	–	–	–
3.10	Exhaust gas temperature	At engine outlet	Max.	–	On call	–
3.11	Fuel oil level in daily service tank	–	Min.	–	–	–
3.12	Cooling water level in expansion tank	–	Min.	–	–	–

Nos.	Monitored parameter	Measuring point	Alarms For limited values of parameters	Automatic protection	Indication in main machinery control room	Comments
3.13	Starting air pressure before starting valve	–	Min.	–	–	–
3.14	Speed (racing)	–	Max.	Engine shutdown	–	–
4	**Steam turbines for driving generators**					
4.1	Lubricating oil pressure	At inlet	Min.	Turbine shutdown	Continuous	–
4.2	Lubricating oil temperature	At bearings	Max.	–	On call	–
4.3	Steam pressure before turbine	–	Min.	–	Continuous	–
4.4	Steam pressure in condenser	–	Max.	Turbine shutdown	On call	–
4.5	Water level in condenser	–	Max.	–	–	–

4.5 AUTOMATED COMPRESSOR PLANTS

4.5.1 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 per cent, 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 per cent, a second compressor turned on automatic mode shall be automatically started, and both compressors shall keep operating until the nominal pressure is reached.

4.5.2 For compressors, provision shall be made for regulating the starting pressure.

4.5.3 Compressed air systems shall be fitted up with automatic drainage devices.

4.5.4 Automated compressor plants shall keep up the starting and operational air vessel pressure at a level which would suffice at least to comply with the requirements stated in Part VIII "Systems and Piping".

4.5.5 Monitored parameters of automated compressor plants, measuring points, limiting values of parameters and types of automatic protection and indication are given in Table 4.5.5.

Table 4.5.5

Nos.	Monitored parameter	Measuring point	Alarms for limited values of parameters[1]	Automatic protection	Indication in machinery control room	Comments
1	Lubricating oil pressure	At compressor inlet	Min.	Compressor shutdown	Continuous	–
2	Coolant flow	At compressor inlet	Min.	Compressor shutdown	–	–
3	Air temperature	At compressor outlet	Max.	–	–	–
4	Starting air pressure	Air receiver	Min.	–	Continuous	–
5	Control air pressure	After reducing valve	Min.	–	Continuous	–

[1] Group alarms are permitted in the main machinery control room on condition that provision is made for identification at the local control station.

4.6 AUTOMATED PUMPING PLANTS

4.6.1 Automated pump control system shall ensure automatic starting of standby pumps and change over as necessary in systems in case of pump failure or upon reaching the highest permissible deviations of parameters in essential circulation systems. 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.

4.6.3 It is advisable that the fire pumps be automatically started upon operation of the following signals:

from the fire detection and fire alarm system, in case of a true signal "Fire";

in case of pressure drop in the fire main which is kept permanently under pressure.

4.6.4 Remote starting of the fire pumps shall be effected:

from the main machinery control room;

from the standby control station;

from the emergency control station.

4.7 AUTOMATED BILGE PLANTS

4.7.1 Depending on the water level in the wells, the automated bilge plants shall put relevant bilge pump in operation. Indication for pump operation shall be provided.

4.7.2 If, after the bilge pumps have been started, the water goes on rising or does not fall within a specified period of time, an alarm shall be activated.

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 The arrangement of sensors shall make it possible to determine the water level under normal and emergency conditions of heel and trim of the unit.

4.7.5 Monitored parameters of automated bilge plants measuring points, limiting values of parameters, types of automatic protection and parameter indication are given in Table 4.7.5.

Table 4.7.5

Monitored parameters	Measuring point	Alarms for limiting values of parameters	Automatic protection	Indication of parameters in main machinery control room	Comments
Water level	Bilge wells	Max.	–	–	–
Water level in emergency	Bilge wells, shaft passages	Max.	–	–	–

4.8 AUTOMATED REFRIGERATING PLANTS

4.8.1 In accordance with 1.1, Part XI "Refrigerating Plants" the automated refrigerating plants shall comply with the requirements of 7.2, Part XII "Refrigerating Plants" of the Rules for the Classification and Construction of Sea-Going Ships.

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

4.8.3 Monitored parameters of automated refrigerating plants, measuring points, limiting values of parameters, types of automatic protection and parameter indication are given in Table 4.8.3.

Table 4.8.3

Monitored parameters	Measuring point	Alarms for limiting values of parameters	Automatic protection	Indication of parameters in main machinery control room	Comments
Condition of refrigerating plant	Compressor	Malfunction Failure	Compressor shutdown	Group alarm	–

5 COMPUTERS AND COMPUTER-BASED AUTOMATION SYSTEMS

5.1 APPLICATION

5.1.1 The present requirements apply to computers and computer-based systems used for monitoring and control of essential machinery and arrangements:

propulsion plant of MODU;

steering system (autopilot);

electric power plant;

fire detection and alarm systems, and gas detection and alarm systems;

general alarm systems;

alarm systems of machinery installation or integrated control and monitoring systems;

systems used to ensure stability of MODU and to carry out procedures of submersion and emersion of the submersible and semi-submersible MODU;

position mooring and dynamic positioning systems of MODU;

other similar automation systems.

5.1.2 The present requirements apply also to computer-based systems used for control of non- essential machinery and devices where loss of control may result in serious damage to the MODU, to machinery or serious injury to personnel, e.g. explosion of domestic water boilers.

5.2 DEFINITIONS AND EXPLANATIONS

5.2.1 For the purpose of this Section the following definitions have been adopted:

Integrated system is a combination of computer or computer-based systems, which are interconnected by a data communication link, in order to allow centralised access to information with the aim of implementing control and monitoring functions of machinery and equipment.

Interface is a transfer point at which information in digital form is exchanged.

Computer is a programmable electronic device for mathematical processing and storing data in the digital form, making calculations and/or producing the logic for control functions.

Computer-based system is a system of one or more computers, associated software, peripherals and interfaces which implement links with set- point devices, sensors and actuators.

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

Node is a device (a computer) of interconnection to a data communication link.

5.3 DESIGN OF COMPUTER-BASED SYSTEMS USED FOR CONTROL AND MONITORING

5.3.1 The computers and 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.

5.3.2 If the process time for functions of the computer-based control system is shorter than the reaction time of the operator and therefore damage cannot be prevented by manual intervention, means of automatic intervention shall be provided.

5.3.3 A computer-based system shall have sufficient capability (hardware and software ones) to:

perform necessary autonomous operations;

accept operator (user) commands;

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

5.3.4 System capability shall provide adequate response time 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.

5.3.5 Computer-based systems shall be designed in such a way that they can be used without special previous knowledge. To handle particularly complicated systems the manufacturer shall provide appropriate technical assistance for the user and training of the personnel.

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

5.4 HARDWARE

5.4.1 Hardware of computers and peripherals shall be suitably designed to withstand supply voltage variations and transients, ambient temperature changes, humidity, vibration, electromagnetic interference, corrosion, etc, normally encountered on board, as specified in 2.1.

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

5.4.3 Each replaceable part (printed circuit board, unit) shall be simple to replace and shall be constructed for easy and safe handling. All replaceable parts shall be so arranged 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.

5.4.4 The computer-based systems shall be, wherever possible, so constructed that no fans for forced cooling of processors and thermally stressed elements need to be provided. Where forced ventilation is used, an alarm shall be provided to operate when the temperature exceeds the limiting value permissible in case of the fan failure.

5.5 SOFTWARE REQUIREMENTS

5.5.1 General.

5.5.1.1 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.

5.5.2 Quality Management Systems Requirements.

5.5.2.1 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.

5.5.2.2 The quality management system specified in 5.5.2.1 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 5.10.3) 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 5.10.8;

.4 having a specific procedure for software installation and amendments thereto on board MODU and drilling ships including interactions with owners.

5.5.3 Software lifecycle.

5.5.3.1 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 5.10.3) 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 functions provided by the operating system, function libraries, software shell, etc. and used by the inspected software.

5.5.3.2 Integration testing before installation on MODU and drilling ships.

Intra-system integration testing shall be carried out between system and sub-system software modules before being integrated on drilling ships and MODU. 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.

5.5.3.3 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 of this Part, as well as the list of relevant tests and checks is specified in 5.10.8. Technical documentation shall address the compatibility of the programmable device with the relevant computer-based systems, list of necessary tests to be carried out on MODU and drilling ships during integration into the computer-based systems and it shall identify the programmable device scope of application as well as the computer-based system components using, if possible, such a device.

5.5.3.4 Final integration and testing on MODU and drilling ships.

.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 drilling ships and MODU 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 MODU and drilling ships.

The list of relevant tests and checks is given in 5.10.8.

5.5.3.5 Software modifications during operation.

5.5.3.5.1 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 5.5.1, 5.5.2, 5.5.3.1 to 5.5.3.4;

.2 during the drilling ship and MODU 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 5.5.3.6.

5.5.3.5.2 Change management.

The owner shall ensure that necessary procedures for software and hardware change management exist on drilling ship and MODU, 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 of drilling ship and MODU shall be recorded in accordance with 5.5.3.5.1.2.

5.5.3.6 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 MODU and drilling ships the software code, executables and physical medium used for installation shall be scanned for viruses and malicious software. Results of the scan shall be documented and kept with the software registry.

5.6 SYSTEM CONFIGURATION

5.6.1 General.

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

5.6.1.2 The selection of the computer equipment shall be made to provide completeness and sufficiency of the functions to be implemented, consistent with safe operation of the system under control.

5.6.2 Self-test.

5.6.2.1 Computer based systems shall have a built-in self-test capability to monitor for correct operation and an alarm shall be released at the desks of the control and monitoring stations to indicate an abnormal condition

5.6.3 Power supply.

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

5.6.3.2 Programs and data held in the system shall be protected against damage and corruption by loss of power.

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

5.6.4 Installation.

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

5.6.5 Cables.

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

5.6.6 Data communication.

5.6.6.1 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.

5.6.6.2 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.

5.6.6.3 Switching between redundant links shall not disturb data communication or continuous operation of functions.

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

5.6.7 Fail-to-safe principle.

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

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

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

5.6.8 Integration of systems.

5.6.8.1 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.

5.6.8.2 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.

5.6.8.3 Complete failure in connectivity between parts of the integrated system shall not affect their independent functionality.

5.6.8.4 Alternative or standby means of operation, independent of the integration, shall be available for all the particularly essential control and monitoring functions.

5.6.8.5 When systems under control (e.g. power units) are required to be duplicated and located in separate compartments this shall be also applied to computer based systems used for control and monitoring.

5.7 USER INTERFACE

5.7.1 General.

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

5.7.1.2 The operational status of a computer-based system (on, off, non-failed, failed, etc.) shall be easily recognizable at the control and monitoring stations.

5.7.1.3 A user guide shall be provided. The user guide shall describe at least:

function keys;

menu displays;

computer-guided dialogue steps, etc.

5.7.1.4 An alarm shall be displayed at relevant visual display units or operator stations for failure or shutdown of a subsystem.

5.7.2 Input devices.

5.7.2.1 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 easily recognizable.

5.7.2.2 Dedicated function keys or special controls 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.

5.7.2.3 Control panels on the navigating bridge shall be provided with separate lighting. Visual display units shall be controllable dimmer system provided.

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

5.7.2.5 If operation of a key is able to cause dangerous operating conditions for the equipment (systems under control), at least the following measures shall be taken to prevent the instruction in question from being executed by unauthorized personnel:

use of a special key lock; or

use of two or more keys, or

use of special password for access.

5.7.2.6 Conflicting control interventions shall be prevented by means of interlocks or warnings. The active control status shall be displayed on a visual display by text or symbols recognizable to the operator.

5.7.3 Output devices.

5.7.3.1 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.

5.7.3.2 Information shall be displayed in logical priority, that is, the most important information shall be focussed in those portions of the screen where it is most clearly visible to the operator.

5.7.3.3 If alarm messages are displayed on colour monitors, they shall be distinguished in red and the information shall be clear and intelligible even in the event of failure of a primary colour.

5.7.4 Graphical user interface.

5.7.4.1 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 are directly relevant to the operator who is given appropriate authority.

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

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

5.7.4.4 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 mandatory identity of the following:

symbols;
colours;
controls;
information priorities;
layout.

5.8 TRAINING

5.8.1 For complicated computer-based systems used for control and monitoring, 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.

5.8.2 Documentation shall be provided to support the training and shall be available for repeated use on board the MODU.

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

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

5.9 TESTING

5.9.1 The computer-based systems shall be designed, manufactured and tested in accordance with the requirements of this Section and other requirements of the MODU Rules, which shall be confirmed by an appropriate Certificate of the Register. In case of any integrated systems the evidence that the computer-based system conforms fully to the functional requirements shall be indicated in the technical documentation and Certificate of the integrated system.

5.9.2 In addition to the requirements of this Section manufacturers shall ensure by means of quality control system surveyed by the Register or another classification society that their products meet their quality specifications.

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

5.9.4 Modifications of program contents and data, as well as change of version, shall be checked and tested before the system is put into operation.

5.10 PROGRAMMABLE ELECTRONIC SYSTEMS

5.10.1 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 of drilling ships and MODU is excluded.

5.10.2 General.

5.10.2.1 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 drilling ships, MODU as well as equipment, usability of programmable electronic systems and operability of non computer devices and systems, etc.

5.10.2.2 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.

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

5.10.3 System categories.

5.10.3.1 Programmable electronic systems shall be assigned into three system categories as shown in Table 5.10.3.1 according to the potential (possible) extent of the damage caused by a single failure within the programmable control and monitoring electronic systems.

Table 5.10.3.1

System categories

Category	Effects	System functionality
I	Those systems, failure of which will not lead to dangerous situations for human safety, safety of drilling ship, MODU 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 drilling ship, MODU and/or threat to the environment	Alarm and monitoring functions; control functions which are necessary to maintain drilling ship, MODU in normal operational and habitable conditions
III	Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of drilling ship, MODU and/or threat to the environment	Control functions for maintaining the drilling ship, MODU 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.

5.10.3.2 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 MODU or drilling ship specified in 3.1.2, Part X "Electrical Equipment".

The relevant examples of the assignment of a programmable electronic system to the appropriate categories are given in Table 5.10.3.2. The list of the examples given is not exhaustive.

Table 5.10.3.2

Examples of assignment to system categories

System category	Examples
I	Maintenance support system Information system Diagnostic 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, meaning the means to generate and control mechanical thrust in order to move the MODU. 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 if a winch is provided

5.10.4 Data communication links.

5.10.4.1 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.

5.10.4.2 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, means shall be provided to automatically restore data communication link.

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

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

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

5.10.4.5 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.

5.10.4.6 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.

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

5.10.4.8 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.

5.10.5 Additional requirements for wireless data communication links.

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

5.10.5.2 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.

5.10.5.3 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 criticality of the data content;

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

5.10.5.4 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.

5.10.5.5 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 self-fail as a result of electromagnetic interference via wireless data communication links during expected operating conditions.

5.10.6 Protection against modifications.

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

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

5.10.6.3 Any modifications in software or hardware made after performance of the tests witnessed by the Register as per item 6 of Table 5.10.8 shall be documented and submitted to the Register for approval.

5.10.7 Technical documentation.

5.10.7.1 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 5.10.2.2).

For MODU and drilling ships with the distinguishing marks **AUT1-ICS**, **AUT2-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, drilling ship and MODU 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.

5.10.7.2 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).

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

5.10.7.4 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 5.10.5.3);

.4 details of radio frequency and power levels;

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

.6 on-board test program for MODU and drilling ships (mooring and sea trials).

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

5.10.7.6 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.

5.10.8 Tests and evidence.

Tests and appropriate documents (reports, certificates) shall be issued in accordance with Table 5.10.8.

T a b l e 5.10.8

Tests and evidence according to system category

Nos.	Requirement	Supplier involved	System integrator involved	Owner involved	Category I[1]	Category II	Category III
1	Quality Plan	×	×		Ⓐ[2]	Ⓐ	Ⓐ
2	Risk assessment report		×		Ⓘ[2]	Ⓘ[2]	Ⓘ[2]
3	Software modules functional description and associated hardware description	× (if necessary)	×			Ⓘ	Ⓘ
4	Evidence of verification of software code	× (if necessary)	×			Ⓘ	Ⓘ

Nos.	Requirement	Supplier involved	System integrator involved	Owner involved	Category I[1]	Category II	Category III
5	Evidence of functional tests for elements included in systems of Category II and III at the level of software module, sub-system and system	×	×			Ⓘ	Ⓘ
6	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		×			Ⓐ	Ⓐ
7	Factory acceptance test including functional and failure tests	×	×			Ⓦ	Ⓦ
8	Test program for simulation tests for final integration of the system		×			Ⓐ	Ⓐ
9	Simulation tests for final integration of the system		×			Ⓦ	Ⓦ
10	Test program for on-board tests (includes wireless data communication testing)		×			Ⓐ	Ⓐ
11	Mooring and sea trials tests (includes wireless data communication testing)		×			Ⓦ	Ⓦ
12	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		×			Ⓘ	Ⓘ
13	Updated software registry		×	×		Ⓘ	Ⓘ
14	Procedures and documentation related to security policy		×	×		Ⓘ	Ⓘ
15	Test program for compliance with the shipboard service conditions	×	×		Ⓐ[3]	Ⓐ	Ⓐ
16	Tests for compliance with the shipboard service conditions	×	×			Ⓦ	Ⓦ
17	Test reports according to the shipboard service conditions	×	×		Ⓐ[3]	Ⓐ	Ⓐ

Nos.	Requirement	Supplier involved	System integrator involved	Owner involved	Category I[1]	Category II	Category III
Symbols: × — 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 5.5.3.1.1. [3] If relevant requirements are available in the RS rules.							

6 UNITS HAVING AN AUTOMATION MARK IN THEIR CLASS NOTATION

6.1 GENERAL

6.1.1 The requirements of the present Section apply to MODU which are assigned in compliance with 2.4.1, of Part I "Classification", one of the automation marks (**AUT1, AUT2, AUT1-C, AUT2-C, AUT1-ICS, AUT2-ICS**) in their class notation.

Such MODU shall be equipped with automation systems of their electric power plants and/or machinery (propulsion) plants to the extent sufficient to ensure their safety under all sailing (operational) conditions without permanent attendance of machinery spaces.

The requirements of the present Section may also apply to MODU without automatic mark in their class notation, but which are provided with a main machinery control room, remote automated control systems of propulsion plants, as well as an automated electrical power plant and a centralized alarm system.

6.1.2 The automation systems and devices installed shall comply with the requirements of relevant Sections of the present Part, as well as with the applicable requirements of other Parts of the MODU Rules.

6.1.3 To be automated are at least the following plants:

propulsion plant, if provided, complying with the requirements of 4.2;

electric power plant, complying with the requirements of 4.4;

boiler plant complying with the requirements of 4.3;

compressor plant complying with the requirements of 4.5;

pumping plants complying with the requirements of 4.6, 4.7;

other essential plants used to support the main operating practices on the MODU.

6.1.4 Provision shall be made for an alarm system to cover all the parameters and working conditions controlled, as mentioned in Section 4 and in this Section.

6.1.5 All equipment installed in a machinery space shall be adapted to unattended service. Some operations (replenishment of tanks, cleaning of filters, etc) may be effected manually if carried out at certain intervals (not more than once every 12 h).

6.1.6 Provisions concerning fire protection are specified in Part VI "Fire Protection".

6.2 DEVICES AT THE MODU MAIN CONTROL STATION

6.2.1 The main control station shall be equipped with controls of the propulsion plant, if provided, as well as with a group alarm subsystem of the machinery (electric power) plant providing the following separate alarms:

"Water in machinery space";

"Fire in machinery space";

"Alarm system failure".

6.2.2 Provision shall be made for an alarm system to pre-warn (5 to 10 s in advance) of the development of a fault, which brings about shut-down of the propulsion plant.

6.2.3 A "Dead man" alarm system shall be provided.

6.2.4 Provision shall be made for arrangements for emergency shut-down of machinery and devices as required by 9.6, Part X "Electrical Equipment".

6.3 DEVICES IN MODU MACHINERY SPACES

6.3.1 Provision shall be made for an enclosed main machinery control room fitted up with the following:

controls and devices stated in 3.2 of Part VII "Machinery Installations";

centralized alarm, indication and logging system, as well as signal devices to indicate operation of the safety system of the machinery units;

visual signal devices (indicators) to indicate the operation modes of machinery and plants;

disconnecting devices of the oil-burning installations of boilers, fans of machinery spaces, fuel and lubricating oil transfer pumps;

separate alarms "Water in machinery space" and "Fire in machinery space";

as well as the following additional devices:

.1 remote controls of auxiliaries serving the propulsion machinery if the latter are not automated;

.2 signalling devices to indicate which machinery and plants were in operation when the main switchboard became deenergized that shall be started remotely as the voltage is restored;

.3 indicators and alarms of the automated refrigerating plant;

.4 indicators and alarms of the automated process machinery and devices.

6.3.2 A personnel call device shall be fitted connected to particular sections of machinery spaces.

6.3.3 Safety signboards bearing the inscription "Attention! Machinery is started automatically" shall fitted at the entrances to periodically unattended machinery spaces.

6.4 DEVICES IN MODU ENGINEERS' ACCOMMODATION

6.4.1 In engineers' accommodation and public spaces group alarm devices (units) shall be fitted to warn of the malfunctions of machinery and plants in machinery spaces and also separate alarms: "Water in the engine room" and "Fire in the engine room". The acknowledgement of each signal of these devices shall be indicated at the main control station by muting the audible signal only.

6.4.2 Devices mentioned in 6.4.1 may be switched to inoperable condition, but at least one of the devices (for the personnel on duty) shall remain in "on" condition.

6.4.3 The group alarm devices shall be also fitted in other spaces where the members of machinery crew may be staying.

6.5 ELECTRIC POWER PLANT

6.5.1 Where no provision is made for an automated electric power plant in compliance with 4.4, the following shall be provided:

.1 inoperative prime movers of generators shall be kept ready to immediate start;

.2 prime movers of generators shall be remotely started and shut down from the main machinery control room;

.3 remote synchronizing, connection and load sharing from the main machinery control room. Synchronizing, connection and load sharing may be effected from the main switchboard if installed in the main machinery control room.

6.5.2 Where particular functions of the electric power plant are automated, the relevant requirements of 4.4 shall be complied with.

6.6 PROPULSION PLANTS

6.6.1 The remote automated control systems of the propulsion plants of self-propelled MODU shall ensure necessary speed, manoeuvrability and safety of a MODU under all sailing (operating) conditions without permanent attendance of personnel in machinery spaces.

6.6.2 The propulsion plants shall meet the requirements set forth in 4.2 and other applicable requirements set forth in other Sections of this Part and other parts of the MODU Rules.

6.7 BOILER PLANTS

6.7.1 The extent of automation of the boiler plant functions and the scope of its controlled parameters to be read out in the main machinery control room shall comply with the requirements set forth in 4.3.

6.7.2 Where there is a local control station with full scope of required functions to control and monitor the boiler plant, group alarms (grouped together according to the most important parameter groups of the same type) and remote emergency shutdown devices may be presented in the main machinery control room.

6.8 COMPRESSOR PLANTS

6.8.1 The automated control system of air compressors shall provide for local and remote (from the main machinery control room) as well as automatic control based on the compressed air parameters.

6.8.2 The scope of the compressors and compressed air alarms presented in the main machinery control room is to comply with the requirements set forth in 4.5.

6.9 PUMPING PLANTS

6.9.1 Automated control of electric motors driving the pumps of essential services on the unit shall comply with the requirements set forth in 4.6.

6.9.2 Provision shall be made for remote (from the main machinery control room) starting and stopping the pumps, as well as for remote control of valves of the essential systems with relevant indication of their open or closed position to be presented in the main machinery control room.

6.9.3 Automated pumping plants of the submersion/raising system of submersible and semi-submersible MODU shall meet the requirements set forth in 9.3.

6.10 BILGE SYSTEMS

6.10.1 Where no provision is made for an automated bilge system in conformity with 4.7, fittings of the bilge well drainage system in machinery spaces shall be remotely controlled from the main machinery control room.

6.10.2 For bilge systems of machinery spaces the requirements of 4.7.2 — 4.7.5 shall be complied with.

7 DYNAMIC POSITIONING SYSTEMS

7.1 APPLICATION AND MARKS IN CLASS NOTATION

7.1.1 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 7.5.12 and 7.14.1.

7.1.2 Observance of the requirements of this Section and applicable requirements of other sections of this Part is mandatory for MODUs and drilling ships, which are assigned in compliance with 2.4.2, Part I "Classification", one of the following marks: **DYNPOS-1**, **DYNPOS-2** or **DYNPOS-3**, added to the class notation.

7.2 DEFINITIONS AND EXPLANATIONS

7.2.1 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 MODU or drilling 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 MODU or drilling 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 MODU or drilling 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 MODU/drilling ship 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.

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

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 a 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 means, for the purposes of this Section, a drilling ship or a self-propelled mobile offshore drilling unit.

Single failure in dynamic positioning system means a failure in active components and/or passive elements of a dynamic positioning system, as defined in 7.5.5 and 7.5.6.

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 MODU or drilling 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 MODU or drilling 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 MODU or drilling 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.

7.3 SCOPE OF SURVEYS

7.3.1 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.

7.4 TECHNICAL DOCUMENTATION REVIEW

7.4.1 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 7.4.1

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 as well as the automatic system for the shutdown of non-explosion proof type electrical equipment (refer to 7.9.4, Part X "Electrical Equipment"); system performance (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**

Equipment/ system	Name of documentation	Description	Distinguishing mark in class notation
	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**
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**

Equipment/ system	Name of documentation	Description	Distinguishing mark in class notation
	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**

Equipment/ system	Name of documentation	Description	Distinguishing mark in class notation
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.			

7.4.2 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 7.4.1.

7.5 DESIGN OF THE DP SYSTEMS, CLASSES

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

7.5.2 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.

7.5.3 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.

7.5.4 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 7.5.8. In this case, the loss of position and/ or heading of the ship may occur in the event of a single failure.

7.5.5 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.

7.5.6 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 7.5.5, 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, fire or activation of the automatic system for the shutdown of non-explosion proof type electrical equipment (refer to 7.9.4, Part X "Electrical Equipment");

failure in all active and passive components located in any one fire subdivision, from fire, flooding or activation of the automatic system for the shutdown of non-explosion proof type electrical equipment (refer to 7.9.4, Part X "Electrical Equipment").

7.5.7 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.

7.5.8 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 7.9.4.

7.5.9 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.

7.5.10 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.

7.5.11 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.

7.5.12 For MODUs where dynamic positioning operations are required to maintain operational control over the integrity of the well, dynamic positioning systems not inferior to Class 3 shall be used.

7.6 POWER SUPPLY SYSTEM

7.6.1 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.

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

7.6.3 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.

7.6.4 For Class 3 DP systems, the power system shall have characteristics mentioned in 7.6.3, 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.

7.6.5 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 7.5.5 and 7.5.6.

7.6.6 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).

7.7 THRUSTER SYSTEM

7.7.1 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.

7.7.2 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.

7.7.3 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.

7.7.4 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 X "Electrical Equipment".

7.7.5 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 7.6.3 and 7.6.4. 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.

7.7.6 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 7.5.6.

7.8 CONTROL STATIONS

7.8.1 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.

7.8.2 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.

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

7.8.4 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.

7.8.5 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.

7.9 COMPUTER-BASED DYNAMIC POSITIONING CONTROL SYSTEMS

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

7.9.2 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.

7.9.3 Computer-based systems in Class 3 dynamic positioning control systems shall be duplicated as indicated in 7.9.2, 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.

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

7.9.5 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.

7.9.6 The control systems with the software function of failure consequence analysis according to 7.9.5 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.

7.9.7 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.

7.9.8 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.

7.9.9 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.

7.9.10 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 7.6.3 and 7.6.4. UPS for Class 3 back-up dynamic positioning control system shall be arranged considering 7.9.3. 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.

7.9.11 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.

7.10 POSITION REFERENCE SYSTEMS

7.10.1 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.

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

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

7.10.4 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 physical 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.

7.10.5 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.

7.11 EXTERNAL FORCE SENSORS

7.11.1 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.

7.11.2 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 7.11.1, shall be provided for heading).

7.11.3 For Class 3 DP systems, one group of sensors of each type, in addition to the requirements set forth in 7.11.2, shall comply with the requirement for separation thereof by "A-60" class bulkhead from other sensors.

7.12 ALARM AND MONITORING SYSTEM

7.12.1 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.

7.12.2 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.

7.13 CABLE ROUTEING AND PIPING OF DP SYSTEM MACHINERY AND DEVICES

7.13.1 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 X "Electrical Equipment" and Section 5, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

7.13.2 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.

7.14 REQUIREMENTS FOR NON-DP SHIP SYSTEMS

7.14.1 Single failure in ship systems not directly part of the DP system (e.g. fire-extinguishing systems, ventilation systems of engine-room and other spaces where the DP system equipment is installed (refer to 3.2.10, Part VIII "Systems and Piping"), air heating and conditioning in ship spaces and accommodations, emergency stop systems of fuel, lubricating oil transfer pumps, automatic system for the shutdown of non-explosion proof type electrical equipment, etc.) shall not affect DP system operation, exceeding criteria as specified in 7.5.5 and 7.5.6.

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

7.15.1 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).

7.15.2 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 7.15.2.5 provides an example of the format;

Table 7.15.2.5

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 7.15.2.6 provides an example of the format for recording the commonality analysis results;

Table 7.15.2.6

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 7.15.2.5 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.

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

7.15.4 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.

8 POSITION MOORING SYSTEMS

8.1 GENERAL

8.1.1 Anchoring arrangements, where fitted as the sole means for position keeping, shall be designed to maintain the unit on station in all operating conditions. The arrangements shall be such that a failure of any single component (device) shall not cause progressive failure of the remaining anchoring arrangements.

8.1.2 Each anchor winch shall serve only its own anchoring arrangement, with the exception of the passive mooring arrangements served by portable drives which take care of several winches.

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

8.1.4 The design of the winch shall provide for adequate dynamic braking capacity to control normal combinations of loads from the anchor, anchor cable and anchor handling vessel during the deployment of the anchors at the maximum design payout speed of the winch.

8.1.5 On loss of power to the anchor winch, the power-operated braking system shall be automatically applied and be capable of holding against at least 50 per cent of the total static braking capacity of the winch.

8.2 CONTROL SYSTEMS

8.2.1 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.

8.2.2 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.

8.2.3 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.

8.2.4 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. Operation of the changing-over device shall not cause faults in the power supply system.

8.2.5 The central anchoring operations control station (refer to 8.2.3) shall be provided with an alarm system comprising at least the following:

limiting MODU deviation from the positioning point;
limiting deviation from the set positioning course;
failure of the computer-based (microcontroller) anchor winch control system;
supply system failure;
anchor winch overload;
failure of particular anchor lines;
failure of the MODU position control system (according to each system).

8.3 AUXILIARY THRUSTERS FOR POSITION MOORING SYSTEMS

8.3.1 Where the position mooring systems are used in conjunction with auxiliary thrusters to keep the MODU position, then their power equipment and control systems shall comply with the applicable requirements in Section 7.

8.3.2 The central anchoring operations control station shall be provided with a panel (desk) of centralized remote and automated control system for thrusters that are part of auxiliary dynamic positioning system.

The auxiliary thruster control system shall comply with the applicable requirements specified in 7.8, 7.9, 7.10, 7.11, 7.12.

9 BALLAST SYSTEM OF SUBMERSIBLE AND SEMI-SUBMERSIBLE MODU

9.1 GENERAL

9.1.1 The semi-submersible MODU shall be provided with an effective ballast pumping system capable of ballasting and deballasting any ballast tanks in normal and extreme conditions.

9.2 BALLAST PUMPS

9.2.1 The electric motors of the ballast pumps shall comply with the requirements specified in 5.5, Part X "Electrical Equipment" and shall be supplied by two feeders: one from the main switchboard and the other from the emergency switchboard.

9.2.2 The ballast system shall be capable of operating after the damage of any one component (generator, transformer) in the power supply system.

9.2.3 The ballast system shall remain operational under conditions when the semi-submersible MODU is in damaged condition, has a heel and/or trim which reaches its limiting values as specified in 2.1.2.2, Part X "Electrical Equipment" and is supplied from the emergency source of electric power.

9.3 CONTROL AND INDICATING SYSTEMS

9.3.1 A central ballast control station shall be provided on the semi-submersible MODU. It shall be located above the worst damage waterline. The control console shall be of protection class not lower than IP-23 and shall be equipped with the following control, alarm and indication systems:

.1 ballast pump control system;

.2 ballast pump status-indicating system;

.3 ballast valve control system;

.4 ballast valve position-indicating system;

.5 tank level indicating system;

.6 draught indicating system;

.7 heel and trim indicators;

.8 power availability indicating system (main and emergency) for control, alarm and indicating systems;

.9 ballast system hydraulic/pneumatic pressure- indicating system.

9.3.2 In addition to remote control of the ballast pumps and valves from the central ballast control station, all ballast pumps and valves shall be fitted with independent local control operable in the event of remote control failure. The independent local control of each ballast pump and of its associated ballast tank valves shall be in the same location.

9.3.3 The ballast pump control and status- indicating systems shall function independently of one another, or have sufficient redundancy, such that a failure in one system does not jeopardize the operation of the other systems.

9.3.4 Each remotely operated ballast valve shall fail to the closed position upon loss of control power. An alternative ballast valve arrangements that do not fail to the closed position upon loss of power may be accepted only with the proviso that this does not result in uncontrolled overflow of ballast which can entail a dangerous situation.

9.3.5 The tank level indicating system required by 9.3.1.5 shall provide means to:

.1 indicate liquid levels in all ballast tanks. A secondary means of determining levels in ballast tanks, which may be a sounding pipe, shall be provided. Tank level sensors shall not be situated in the tank suction lines;

.2 indicate liquid levels in other (non-ballast) tanks, such as fuel oil, fresh water, drilling water or liquid storage tanks, the filling or emptying of which could affect the stability of the unit.

9.3.6 The draught indicating system shall indicate the draught at each comer of the unit or at representative positions.

9.3.7 Enclosures housing ballast system electrical control and monitoring components (units), the failure of which would cause unsafe operation of the ballast system upon liquid entry into the enclosure, shall comply with the requirements set forth in 2.4.4.2, Part X "Electrical Equipment".

9.3.8 Means to indicate whether a valve are open or closed shall be provided at each location from which the valve can be controlled. The indicators shall rely in their functioning on movement of the valve stem or spindle.

9.3.9 Means shall be provided at the central ballast control station to isolate or disconnect the ballast pump control and ballast valve control systems from their sources of electrical, pneumatic or hydraulic power.

9.4 INTERNAL COMMUNICATION

9.4.1 A permanently installed means of communication, independent of the unit's main source of electrical power, shall be provided between the central ballast control station and spaces that contain ballast pumps or valves, or other spaces that may contain equipment necessary for the operation of the ballast system.

9.5 PROTECTION AGAINST FLOODING

9.5.1 On all semi-submersible (column-stabilized) MODU and on all other units where the spaces containing the seawater valves are normally unattended and not provided with high bilge water level detection, each seawater inlet and discharge in spaces below the assigned load line shall be provided with valves operable from a position above the spaces containing the valves.

9.5.2 The control systems and open/shut indicators of watertight doors and hatch covers shall be operable in both normal conditions and in the event of main power failure. The power supply system of the above arrangements shall comply with the requirements set forth in 5.9.2.

9.5.3 The bilge pumping system shall be provided with a remote control system and its valve position (open/shut) indicators, as well as alarms to indicate high water level in the bilge wells or compartments of the unit. The alarms to indicate high water level in each bilge well shall be activated by two independent sensors. One of these sensors may be used also to activate an automated bilge pump.

10 JACKING SYSTEM OF SELF-ELEVATING MODU

10.1 GENERAL REQUIREMENTS FOR JACKING SYSTEM

10.1.1 The jacking system of self-elevating MODU shall be capable of raising, lowering the MODU hull and maintaining the self-elevating MODU in operating condition.

10.1.2 The jacking system shall be designed with sufficient redundancy in such a way that in the event of failure of any one component (unit, set, electric and hydraulic power system, control system) they remain capable to continue raising, lowering or keeping the self-elevating MODU in initial position.

10.2 DESIGN

10.2.1 The jacking system shall be so designed as to preclude overloading of their parts, assemblies and machinery during operations with self-elevating MODU hull. This is particularly true for the following electrical equipment components:

controllers (starting gear) of electric motors;

characteristics of electric motors (rating, torque);

characteristics of brakes;

interlocks between electric motors and fixing arrangements of self-elevating MODU legs.

10.2.2 The braking system shall be automatically applied upon loss of power to the jacking mechanisms.

10.3 FIXING ARRANGEMENTS

10.3.1 For a self-elevating MODU not provided with leg fixation system, calculation of the brake holding force shall be made with due regard for maximum load defined as a maximum interaction between the leg and self-elevating mechanism under storm conditions (maximum mass of self-elevating MODU plus the relevant component of storm action). The static braking torque shall be taken to be not less than 1,3 times the maximum load having regard to the mechanical transmission efficiency.

10.3.2 For a self-elevating MODU provided with leg fixation system, calculation of the brake holding force shall be made with due regard for the design load. The static braking torque shall be taken to be not less than 1,2 times the design load.

10.4 ELECTRIC MOTORS OF JACKING SYSTEMS

10.4.1 The power of electric motors driving the jacking system shall be chosen with consideration for the possible, within permissible limits, nonuniform distribution of the design load throughout the self-elevating MODU hull, having regard to the design permissible time of unit elevation, as well as having regard to the losses by friction between the legs and guides and to the reduction gear efficiency.

10.4.2 The characteristics of the electric motor torque (mechanical characteristics) shall be such as to render the electric motor incapable of causing damage to any part (component) of the reduction gear or gear rack of the jacking mechanism in the event of mechanical interlocking of the jacking system.

10.5 CONTROL AND MONITORING SYSTEMS

10.5.1 To ensure control of raising or lowering of the self-elevating MODU hull, the control stations shall be fitted up with appropriate monitoring system which shall provide for an alarm to be activated in the event of deviations from the permissible values and indication of at least the following parameters:

availability for elevation/lowering operation (power to all necessary equipment is turned on);
position of fixing arrangements (catches) of legs (if provided); load on legs;
deviation from horizontal position of the self- elevating MODU hull;
pressure of working fluid in hydraulic cylinders;
pressure of working fluid in control system;
temperature of working fluid in hydraulic system;
loading (current) of electric motors;
overloading of electric motors.

10.5.2 In order to equalize the loads between the jacking mechanisms of the legs, the torques developed by the electric motors shall be monitored and equalized whenever necessary. This procedure shall be carried out after raising of the self-elevating MODU hull as well as in storm conditions where the load distribution can be disturbed. Such procedure does not apply if an automatic load distribution system is available.

10.5.3 In the electric drives of each leg, one feeder is allowed to supply two or more motors. The feeder shall be provided with short-circuit protection set to operate at not more than ten-fold value of the total full load current of the motors jointly switched on.

10.5.4 Monitoring of the motor loading required by 10.5.1 shall be effected by three-phase wattmeters with a central scale. Such wattmeters may be installed not for each motor but for the feeder to which two or more jacking system motors are connected.

10.5.5 The seawater supply system shall provide for monitoring of at least the following parameters:

water pressure in system (minimum pressure alarm and pressure indication in the main machinery control room);
water level in intermediate tank;
submersible pump and pipe position indication;
automatic stoppage of mechanism for lifting and lowering submersible pumps in end positions.

10.5.6 Provision shall be made for automatic start of a standby submersible seawater pump in the event of water pressure drop with an alarm signal to be released in the main machinery control room.

10.5.7 The elevating (jacking) system shall be operable from a central jacking control station.

10.5.8 The jacking control station shall have the following:

.1 audible and visual alarms for jacking system overload and out-of-level. Units whose jacking systems are subject to rack phase differential shall also have audible and visual alarms for rack phase differential; and

.2 instrumentation to indicate:

.2.1 the inclination of the unit on two horizontal perpendicular axes;

.2.2 power consumption or other indicators for lifting or lowering the legs, as applicable; and

.2.3 bracke release status.

10.5.9 A communication system shall be provided between the central jacking control and a location at each leg.

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Part XIV
Automation

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