CHINA CLASSIFICATION SOCIETY

RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS

2015

PART SEVEN AUTOMATION SYSTEMS

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CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 General requirements

1.1.1.1 This PART applies to automated systems for machinery and electrical installations installed on sea-going ships.

1.1.1.2 The automated system in this PART covers control, safety and alarm systems (including displays).

1.1.1.3 Ships with different levels of automation complying with the requirements of this PART may be assigned the following class notations:

(1) AUT−0 — indicating that the ship's propulsion plant can be remotely controlled from the bridge control station with the machinery spaces (including engine room centralized control station or room) periodically unattended;

(2) MCC — indicating that the machinery and electrical installations are capable of being operated with continuous supervision by watch-keepers from a centralized control station or room in the engine room;

(3) BRC — indicating that the ship's propulsion plant can be remotely controlled from the bridge control station with the engine room attended by watch-keepers.

1.1.1.4 Ships with automated systems complying with the requirements of this PART are to be adaptable to all sailing conditions, including maneuvering.

1.1.1.5 The safety of the ships with automated systems complying with the requirements of this PART is to be same as that of the ships with machinery spaces being attended. Means are to be provided to ensure that the machinery and electrical equipment can be manually and effectively operated from a local position in case of failure of the automated systems.

1.1.2 Definitions

1.1.2.1 For the purpose of this PART:

(1) *Automatic control* means self-regulating control carrying out predetermined orders to operate the machinery without action by an operator.

(2) *Remote control* means control of a device by an operator from a distance through mechanical, electrical, electronic, pneumatic, hydraulic, electromagnetic (radio) or optical means or combination thereof.

(3) *Local control* means direct manual control by an operator of machinery through a device located on or adjacent to the controlled machinery.

(4) *Control stations* (*rooms*) means spaces fitted with monitoring means capable of controlling the machinery and electrical installations. They are mainly divided into four categories as follows in this PART:

① *centralized control station* (*room*) *of engine room* (abbreviated to CCS) means a control station (room) in which all monitoring means for automated equipment in engine room are concentrated;

② *bridge control station* (abbreviated to BCS) means a control station monitoring the propelling plant and other equipment in bridge;

③ *local control station* (abbreviated to LCS) means a control station where machinery and electrical installations are locally controlled;

④ *other control stations* mean control stations except the above-mentioned three ones.

(5) *Safety systems* mean systems which will operate automatically for safeguarding the machinery or electrical equipment in question in the following three modes of operation in case of serious faults endangering the main propulsion machinery, boilers, electric generating plants and other essential machinery or electrical equipment:

Mode a: immediate shutdown, e.g. emergency stop of main engines, emergency cutoff of boiler fuel oil supply and emergency cutoff of electric power supply to consumers. And such machinery or equipment is not to be put into operation again if without the manual resetting;

Mode b: the operation of the machinery is temporarily adjusted to the prevailing conditions, e.g., by reducing the output or rotation speed of the machinery;

Mode c: the normal operating conditions are restored by starting of standby machinery.

(6) *Alarm* means a visual and audible signal of a predetermined out-of-limits parameter for the monitored machinery or system, which can identify the particular fault condition and its location within the machinery spaces, which can identify the particular fault condition and its location within the machinery spaces.

(7) *Group alarm* means a common alarm activated by any abnormal conditions of the monitored machinery or system.

(8) *Fail-safe principle* means that upon failure or malfunction of a component or system, the output automatically reverts to a predetermined design state of least critical consequence.

(9) *Override* means the special control measures for the skipping of a certain procedure or a certain safeguard action so as to effect compulsory operation to the machinery or electrical equipment for a short period to ensure the safety of the ship.
(10) *Emergency shutdown device* means a device independent of any control system and intended for manual activation in an emergency to stop the operation of machinery and electrical installations, e.g. emergency stop button of main engines, emergency cutoff button of boiler fuel oil supply and emergency cutoff button of electric power supply to consumers.
(11) *Redundancy design* means standby technical means to be used in case of system or equipment fault, by which a corresponding function can be taken over to continue an action or an original function is restored to continue the operation condition.
(12) *Node* means a point of interconnection to a data communication link.
(13) *Network* means a communication net for data transfer and exchange between computers.
(14) *Major modification* means one of the following cases or a combination thereof which will cause a substantial change to functions or safety features of an onboard computer system (excluding peripherals):
① change of hardware configuration;
② update of software;
③ alteration of network (including topology structure).

1.1.3 Plans and documents

1.1.3.1 Where a ship is intended to be assigned a machinery notation, the following plans and documents associated with control, alarm (display) and safety systems covered by this PART are to be submitted for approval:
(1) List of monitored and display points;
(2) List of alarm points (including display position and mode of alarms in the control station/room);
(3) Items of safety systems;
(4) Schematic diagrams of (electric, pneumatic, hydraulic) power supply to automated systems.
1.1.3.2 Plans and technical documents for computer systems of categories II and III (refer to 2.6.2 of this PART) are to be submitted in accordance with (1) to (4) below.
(1) Computer systems, for which an inspection is requested:
① The following plans and technical documents are to be submitted for approval:
(a) System description, covering at least detailed description of hardware configuration, description of system function, description of data communication, description of redundancy system conversion, description of system self-monitoring and data storage means;
(b) Block diagram of hardware and peripheral configuration, showing internal connection of main unit/module of system and interface with other system;
(c) System wiring connection diagram;
(d) Diagram of power source supply;
(e) Details of input and output devices;
(f) Software description, including at least description of the basic software installed in each hardware unit, the communication software installed on nodes in a network and application software;
(g) Block diagram of software functions;
(h) Failure analysis for safety related functions (only applicable to computer systems of category III) by adequate methods (such as failure tree analysis, risk analysis, FMEA or FMECA);
(i) Technical specifications of hardware and peripherals;
(j) Type test information for wireless data communication equipment (if applicable);
(k) Test program, including type test and routine test. Test procedure is to describe test configuration and simulation method. Each test is to stipulate initial state of equipment/system, test method, test result analysis and acceptance criteria. Each test is to cover normal mode and failure mode as well as power supply and communication failure.
② The following plans and technical documents are to be submitted for information:
(a) Operating manual (including troubleshooting instructions);
(b) Software quality control plan;
(c) Information related to wireless data communication (if applicable), which is to include details of manufacturers recommended installation and maintenance practices, network plan with arrangement and type of antenna and identification of location, specification of wireless communication system protocols and management functions, details of radio frequency and power levels.

(2) For computer systems, of which new installation or major modification is requested, the system description is to be submitted for information and the following plans and technical documents are to be submitted for approval:

① Plan of onboard power supply system;

② Arrangement of onboard systems;

③ Test program (including system function tests and onboard test procedures).

(3) For computer systems on board existing ships, of which an initial survey is requested, the system description and operation manual are to be submitted for information and the following plans and technical documents are to be submitted for approval:

① Plan of onboard power supply system;

② Arrangement of onboard systems (if necessary).

(4) For inspections after construction, description of any major modification of hardware and software, if applicable, is to be submitted for information.

1.1.3.3 Upon request of CCS, for computer systems of category I, necessary plans and documents may be submitted for information according to the requirements of 1.1.3.2.

1.1.3.4 Additional plans and documents are to be submitted for approval as deemed necessary by CCS.

1.1.4 Certification of products

1.1.4.1 For certification requirements for the equipment and installations used in automated systems of a ship, see for details in Appendix 1A — List of Certification Requirements for Classed Marine Products, of Chapter 3, PART ONE of the Rules.

1.1.5 Trials

1.1.5.1 The automated systems together with the associated machinery and electrical equipment are to be subject to mooring and sea trails in accordance with a test program approved by CCS for ascertaining the normal working of the whole system.

1.1.5.2 The setting of alarm points of automated systems and the preset parameters of safety systems which are determined in compliance with the requirements of the Rules as shown by the trials are to be recorded and maintained onboard for information.

CHAPTER 2 BASIC REQUIREMENTS

Section 1 GENERAL PROVISIONS

2.1.1 Environmental conditions

2.1.1.1 The automated systems are to operate satisfactorily within the ambient air temperatures as specified in 1.2.1.1(1) of Chapter 1, PART FOUR of the Rules.

2.1.1.2 The automated systems are to operate satisfactorily under the following conditions of relative humidity:

95% ± 3% at temperatures up to +45℃;

70% ± 3% at temperatures higher than +45℃.

2.1.1.3 The automated systems are to operate satisfactorily under the vibration conditions listed in Table 2.1.1.3. Where resonance occurs in the following frequency ranges and exceeds the required values, suitable means are to be provided for vibration damping.

Vibration **Table 2.1.1.3**

Location of installation	Parameters of vibration	
General space	2.0 ~ 13.2 Hz Amplitude ±1 mm	13.2 ~ 100 Hz Acceleration ±0.7 g
On reciprocating engines (e.g. diesel engines, air compressors) and other similar spaces	2.0 ~ 25 Hz Amplitude ±1.6 mm	25 ~ 100 Hz Acceleration ±4.0 g
Other special locations, e.g. exhaust pipes for (particularly medium or high speed) diesel engines	40 ~ 2,000 Hz Acceleration ±10.0 g (temperature 600℃)	

2.1.1.4 The automated systems are to operate satisfactorily under inclination and rolling conditions in all directions from the mounting position up to 22.5° (period 10 s) and under linear vertical acceleration of $\pm 9.8\ m/s^2$.

2.1.1.5 The automated systems are to be suitable for the normal conditions encountered on board ships, e.g. salt air, oil-laden atmosphere, mould and dust.

2.1.2 Other working conditions

2.1.2.1 The automated system is to comply with the requirements of paragraphs 1.2.2 and 1.2.3 of Section 2, Chapter 1 of PART FOUR of the Rules.

2.1.2.2 The automated system is to have necessary electromagnetic compatibility.

2.1.2.3 The hydraulic and pneumatic equipment of automated systems is to operate satisfactorily under pressure variations in the system by ±20% of the rated values and is not to be damaged by transient pressure rise up to 1.5 times the rated pressure.

2.1.3 Fail-safe

2.1.3.1 Control systems, alarm systems and safety systems are to be designed on the fail-safe principle. The fail-safe principle is to be applied on the basis not only of the automated system itself and its associated machinery, but also of the whole machinery installation and the safety of the ship and personnel.

2.1.3.2 The design of the control system, alarm system and safety system is to be such that a failure in the operation will not cause other failures and will, so far as possible, lead to the least dangerous condition of the controlled process.

2.1.3.3 The automatic control and remote control systems are to ensure continuous, effective and reliable operation.

2.1.4 Independence

2.1.4.1 Control, safety and alarm systems are to be designed or rendered to function independently of each other so that a failure or malfunction in one or two of these systems will not prevent the other system(s) from operating.

2.1.4.2 In any case, a safety system of mode a is to function independently of control and alarm systems so that a failure or malfunction in these systems will not prevent the safety system from operating. For the safety systems of modes b and c, complete independence of other control and alarm systems is not required.

2.1.4.3 Safety systems of different units of the machinery plant are to be independent. Failure in the safety system of one part of the plant is not to interfere with the operation of the safety system in another part of the plant.

2.1.5 Examination and lock-in

2.1.5.1 The functions of control, safety and alarm systems are to be capable of being examined. Where the settings, e.g. sensitivity and limiting values of the control, safety and alarm equipment may be regulated, these regulated values are to be such that they may be easily examined, identified and locked-in.

2.1.6 Power supply

2.1.6.1 The safety and alarm systems and control systems (e.g. automated systems of an electric generating plant) requiring continuous use in the event of a failure of normal power supply are to be capable of being automatically changed over to an independent standby power supply. The standby power supply may be an accumulator battery, with a capacity at least sufficient for a period of supply of 30 min. Where such systems could be adversely affected by an interruption in power supply, change-over to the standby power supply is to be achieved without a break.

2.1.6.2 A visual and audible alarm is to be given in the event of a failure of power supply① for safety system, alarm system and control system.

2.1.6.3 Control system, safety system and alarm system are to be supplied by independent final sub circuit and protected against short circuit and overload.

Section 2 CONTROL SYSTEMS

2.2.1 General requirements

2.2.1.1 Control systems include automatic and remote control systems.

2.2.1.2 Control systems are to have good control properties. Control systems for the operation of machinery and electrical equipment are to have satisfactory characteristics, i.e., to be stable throughout their operating range so that the operation of the controls will not induce detrimental mechanical or thermal loads. Control systems are also to have necessary accuracy of control.

2.2.1.3 The design of the control system is to be such that a failure in the control system will lead to the least dangerous condition of the controlled process and furthermore, such failure is not to render any reserved automatic or manual control, or both, inoperative.

2.2.1.4 All machinery and electrical installations essential for the safe operation of the ship are, in the case of failure in or out-of-action of any part of automatic or remote control system including failure of power supply, to be capable of:

(1) sending out alarm signals;

(2) replacing immediately faulty component(s) or putting the back-up arrangements into service in time for recovering normal operation (if applicable);

(3) transferring to local manual control, and the transfer of control is not to seriously affect the operating conditions of the machinery and electrical equipment.

2.2.1.5 Control systems for the main propulsion machinery (including main engine and controllable pitch propeller), boilers and electric generating plant are to be independent of each other unless necessary for operation. The control system for each independent propulsion engine is to be provided separately.

2.2.1.6 Where necessary measures are taken to ensure effective monitoring of the partly common equipment in the systems mentioned in 2.1.4.1 above and an alarm is given in case of any failure in such equipment, a partly common use of the equipment may be permitted (see also 2.7.1.4 of this Chapter).

2.2.2 Hydraulic and pneumatic power sources

2.2.2.1 The hydraulic power source and piping of control systems are to comply with the relevant requirements of Chapter 2 and Section 7 of Chapter 4 of PART THREE of the Rules, and the following requirements:

(1) The standby hydraulic pump is to start and operate automatically when the discharge pressure from the working pumps falls below a predetermined value and an alarm is to be given.

(2) Where the hydraulic pressure is lower than the required normal working pressure, an alarm is to be given.

2.2.2.2 The pneumatic power source and piping of control systems are to comply with the relevant requirements of Chapter 2 of PART THREE of the Rules and the following requirements:

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① A visual and audible alarm is to be given in the event of a failure of power supply for engine room centralized monitoring and alarm system. For alarms of safety system, alarm system and control system of other equipment in the event of a failure of power supply, refer to Table 3.10.1.1 of Chapter 3 of this PART.

(1) Air vessels for pneumatic controls may be supplied from the main engine starting air vessels or from exclusive air compressors.
(2) Where air vessels are supplied from the exclusive air compressors, at least two compressors are to be provided, one of which is standby, or from one exclusive air compressor and the main air vessel. The air compressors are to start and operate automatically when the air pressure falls below a predetermined value.
(3) Relief valves are to be fitted in the pneumatic control piping, which are to be set to open at a pressure not greater than 1.1 times the normal working pressure.
(4) Reducing valves, filters, oil separators and driers are to be provided in the pneumatic control piping so as to ensure dry, clean and oil-free air to the pneumatic controls. The reducing valves, filters and driers are to be, in general, fitted each in duplicate and in parallel. The provision of a single filter and a single drier may be permitted, provided that means are provided to ensure quick maintenance and renewal of the above-mentioned devices without interrupting the normal operation of the pneumatic control system.

Section 3 SAFETY SYSTEMS

2.3.1 General requirements

2.3.1.1 In case of serious faults endangering the main propulsion engines, boilers, electric generating plants and other essential machinery and electrical equipment, the safety systems are to operate automatically for safeguarding the machinery or electrical equipment in question in the three modes of operation required in 1.1.2.1(5) of this PART and alarms are to be given.
2.3.1.2 When the system has stopped a unit, the unit is not to be restarted automatically before a manual reset has been made.
2.3.1.3 In order to avoid undesirable interruption in the operation of machinery, the system is to intervene sequentially after the operation of alarm system by:
(1) starting of standby units;
(2) load reduction or shutdown, such that the least drastic action is taken first.
2.3.1.4 When the system has been activated, audible and visual alarms are to be given in control station to trace the cause of the safety action.

2.3.2 Means of overriding

2.3.2.1 For the purpose of ensuring the safety of ships, main propulsion machinery systems, such as main diesel engines, steam turbines, gas turbines and electric propulsion systems, are in general to be provided with arrangements for overriding.
2.3.2.2 An indication is to be given and a suitable alarm is to be activated when an overriding action is operated.
2.3.2.3 Means are to be provided to preclude inadvertent operation of the overriding function.

2.3.3 Pneumatic power source and piping

2.3.3.1 The pneumatic power source and piping of safety systems are to be in compliance with the requirements of 2.2.2 of this Chapter, and the pneumatic pipelines are to be as far as practicable separated from the control systems.

Section 4 ALARM SYSTEMS (INCLUDING DISPLAYS)

2.4.1 General requirements

2.4.1.1 All faults of the controlled and monitored machinery or electrical equipment and their control and monitoring systems are to be indicated with alarm signals at the relevant control stations (rooms) so that the engineering personnel on duty are made aware that a machinery fault has occurred.
2.4.1.2 All alarms are to be both audible and visual. According to the nature of faults, the colors used for visual signals are to be, in general, red for vital faults and yellow for general ones. Audible signal is to be of an adequate sound level and to be clearly distinguishable from the fire alarms, telephones and other sound signals (e.g. CO_2 flooding).
2.4.1.3 The alarm system is to be capable of indicating all faults occurred at the same time, and the operation and/or acknowledgement of any alarm is not to inhibit the operation and/or acknowledgement of other alarms occurred at the same time.

2.4.1.4 Arrangements may be fitted to extinguish (silence) audible alarm signals. When alarms are acknowledged and the silencing button is pressed, visual alarm signals are not to be extinguished, but may be altered, for example, from flashing to a steady light, and remain clearly visible. The local silencing of bridge or accommodation alarms is not to stop the audible machinery space alarm. The silencing button for the audible alarms in machinery spaces is permitted to be arranged only in the machinery space or at the engine room centralized control station and the visual alarm signals are to be retained until the fault has been rectified. When the fault has been rectified, the alarm system is to be automatically reset to its normal operating condition.
2.4.1.5 Where a single alarm has been shown in the local control station of engine room, the alarm signal is also to be shown in other relevant remote control stations and may be displayed by means of group alarm.

2.4.2 Inspection and self-monitoring of alarm systems
2.4.2.1 The alarm system is to be designed with self-monitoring properties, i.e., any fault in the alarm system should cause it to detect itself automatically and fall into the alarm (or indication) condition. The extent and depth of self-monitoring is to be determined in connection with the measures taken for maintenance and renewal.
2.4.2.2 The alarm system is to be capable of blockading meaningless signals during certain processes. Manual blockading is to be indicated.

2.4.3 Displays
2.4.3.1 Parameters may be clearly displayed by instrumentation or display units. Parameter displays may be performed separately or selectively, and may be alphanumeric or in the form of graphics or diagrams. But all displays or indications are to be clearly distinguishable. The color of indicating lamps is normally to be green or white. For display units incorporating with computers and the specific requirements for display, refer to 2.6.6.3 and 2.6.6.4 of this Chapter.

Section 5 CONTROL STATIONS (ROOMS)

2.5.1 Arrangement of control stations (rooms)
2.5.1.1 The engine room centralized control station (room) (abbreviated to CCS) is generally to be located within the machinery spaces.
2.5.1.2 The CCS is to be located as far as possible in a position of least vibrations and of low noise level while the ship operates at sea.
2.5.1.3 The CCS within the machinery spaces is to be of the sound-proof construction, with the window glass of the shatter-resistant type. The CCS is to have two means of access located as far remote from each other as practicable, and one of which is to be as far as possible situated near the escape trunk of the machinery spaces or the special purpose escape trunk.
2.5.1.4 The control and monitoring equipment, signal displays, control levers, switches and push buttons within the control stations (rooms) are to be arranged with due attention to thorough ergonomics for the convenience of operation, surveillance, maintenance and the safety of the operators.
2.5.1.5 The local control stations are to comply with the relevant requirements of 1.1.1.5 and 2.5.2 of this PART. It is to be possible for the propulsion machinery to be controlled from a local position even in the case of failure or malfunction in any part of the automatic or remote control systems of any other control station or the propulsion machinery.

2.5.2 Transfer of control
2.5.2.1 Transfer of control between control stations is to be possible to the machinery and electrical equipment under common control from such stations, either when these machinery and electrical equipment are in normal operation or in case of their failures. Such changeover is not to seriously affect the operating conditions of the machinery and electrical equipment.
2.5.2.2 The transfer of control between the CCS and BCS is to be possible only at the CCS, and the transfer of control between the LCS and CCS or BCS is to be possible only at the LCS.
2.5.2.3 Changeover between control stations is to be so arranged that it may be effected only with the acceptance of the station taking control.
2.5.2.4 Provision is to be made at all control stations (rooms) to indicate which station is in control.
2.5.2.5 Where machinery and electrical equipment may be controlled from two or more control stations (rooms), control is to be possible only from one control station at one time. At all control stations, interconnected control positions for the controllers for main propulsion machinery are permitted.

2.5.2.6 Propulsion machinery orders from the navigating bridge are to be indicated at all control positions for the machinery.
2.5.2.7 Where the manual control gear of the main engine or other machinery and electrical equipment is extended directly to the CCS by means of mechanical linkage, the provision of corresponding LCS may be exempted.

2.5.3 Other control stations

2.5.3.1 For the arrangement of other control stations which are in close relation to the safety of machinery and electrical equipment or the safety of the ship, relevant technical information (e.g. arrangement plan, specification of monitoring properties) are to be provided and the relevant requirements of this PART are to be complied with.

Section 6 COMPUTER SYSTEMS

2.6.1 General requirements

2.6.1.1 This Section applies to onboard computer systems which provide control, alarm, monitoring or safety functions which are subject to classification requirements, including programmable electronic systems. This Section does not apply to loading instruments① and radio communication and navigation equipment with detailed performance standard by IMO.
2.6.1.2 Computer systems are to fulfill the functional requirements of the system under control for all operating conditions including emergency conditions, taking into account in particular that they are:
(1) not to cause danger to persons;
(2) not to cause damage to ship and its equipment;
(3) not to affect operability of non-computer devices and systems (e.g. main and auxiliary engines);
(4) not to cause damage to the environment;
(5) not to affect system usability;
(6) easy to maintain.
2.6.1.3 When an alternative design or arrangement deviating from the requirements of this Section are proposed, an engineering analysis carried out in accordance with a relevant International② or National Standard is to be submitted to CCS for approval. As a failure of a category III system may lead to an accident with catastrophic severity, the use of unconventional technology (e.g. radio communication technology) for such applications will only be permitted exceptionally in cases where evidence is presented that demonstrates acceptable and reliable system performance to the satisfaction of CCS.
2.6.1.4 Computer systems of categories II and III are to be protected against unintentional or unauthorized modification of programs. Any modification made after performance tests witnessed by CCS surveyor is to be documented and traceable. Any major modification③ is to be resubmitted to CCS for approval.
2.6.1.5 Modification of characteristic values and set values of computer systems of category III is to be confirmed by CCS.

2.6.2 System categories

2.6.2.1 Computer systems may be divided into categories I, II and III according to the possible extent of the damage caused by a single failure, as shown in Table 2.6.2.1. The damage considered is not an indirect one, but directly incurred by an event. Identical redundancy will not be taken into account for the assignment of a system category.

Computer System Categories **Table 2.6.2.1**

Category	Effect	Function	Example
I	System fault will not endanger personnel safety, ship safety and environment	— Monitoring and routine management	— Maintenance and support system — Routine information processing
II	System fault will finally endanger personnel safety, ship safety and environment	— Monitoring and alarming — Control necessary for maintaining normal operation and living conditions of the ship	— Monitoring and alarm devices — Sounding means for tank capacity — Control system of auxiliary machinery — Remote control system of main propulsion machinery

① Refer to the requirements of Appendix 1 “Loading Instruments” of Chapter 2, PART TWO of the Rules.
② Refer to Reg.II-1/55 of SOLAS Convention.
③ Major modification means modification affecting system function and safety.

Category	Effect	Function	Example
			— Fire detection and extinction system — Bilge system — Speed adjuster
III	System fault will immediately endanger personnel safety, ship safety and environment	— Control necessary for maintaining propulsion and steering — Safety	— Protective system or means of machinery — Control system of burners — Electronic oil injector of internal combustion engines — Control system for propulsion and steering — Synchronizing units for generators

2.6.2.2 The categorization of computer systems varies depending on different types and dimensions of ships, duration and frequency of working of personnel in dangerous zones, complexity of systems and possibility of preventing damage.
2.6.2.3 Where independent effective backup or other means of averting danger is provided, the system category III may be decreased by one category.

2.6.3 System design
2.6.3.1 A computer system is to have sufficient capability to:
(1) perform necessary autonomous operations,
(2) accept user commands,
(3) inform the user correctly,
under all operating conditions including emergency.
2.6.3.2 The system is to be designed to 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.
2.6.3.3 Computer systems are to be designed in such a way that they can be used without special previous knowledge, otherwise operators are to be provided with relevant training.
2.6.3.4 The failure and restarting of computer systems are not to cause processes to enter undefined or critical states. When the power supply is recovered after failure, the computer system is to be capable of restarting to operate in accordance with the predetermined procedures in a short time and its function is also to be recovered rapidly.
2.6.3.5 The system is to be so designed that failure of one part will not induce failure of other parts or the entire system; such failure is to be restricted to the failing module. Where necessary, redundancy design (e.g. standby means) may be used and the equipment is to be capable of restoring its functionality.
2.6.3.6 For ease of maintenance and renewal, the hardware is to consist of replaceable modules and is to be standardized and modularized so far as possible. The use of different modules is to be minimized to reduce quantity of spares. Each replaceable part is to be constructed for easy and safe handling. Plug-in modules and joints (including electrical connection means) are to be marked for identification and so designed that they will not be incorrectly plugged in.
2.6.3.7 Systems performing essential functions are to store data in permanent storage units so as to ensure that power breakdown will cause no loss or error to programs, characteristic curves and limit values in use.
2.6.3.8 The design of software of computer system of categories II and III is to comply with following requirements:
(1) The software is to be capable of being kept in privacy and closed.
(2) The operating system program is to be suitable for development, installation and subsequent modification during all phases of the software life cycle.
(3) System tests are to be performed and documented. These tests are to include all software functions and important combinations of functions, performance, dependability and usability requirements under all modes of operation including emergency conditions and behavior under failure conditions. Upon modification of the software, the tests are to be changed accordingly.
(4) The software is to be designed such that the operator cannot modify programs and fixed ship-related data.
2.6.3.9 Computer systems are to be self-checking and all faults inducing loss of essential functions are to give visual and audible alarms.
2.6.3.10 All faults of the computer system, which affect its essential functions and cannot be displayed by itself, are to be displayed by a unit independent of it.

2.6.3.11 The external power supply of computer system is to be provided with failure monitoring and visual and audible alarms are to be given in case of failure. If redundancy system is adopted, each system is to be supplied by independent final sub circuit.
2.6.3.12 In the computer-based systems performing programmed control and monitoring, the control system, alarm system and safety system are to be in compliance with the requirements for independence in 2.1.4 of this Chapter.
2.6.3.13 When the computer system is used for important functions related to propulsion, steering and ship safety, standby or emergency measures are to be provided, which are to be independent of computer system as far as possible.

2.6.4 Data communication
2.6.4.1 The reliability of data communication is to be determined according to categories of computer systems and their specific application. Systems of categories II and III are to comply with the requirements of 2.6.4.2 to 2.6.4.10 below.
2.6.4.2 The data communication link is to be continuously self-checking, for detecting failures on the link itself and data communication failure on nodes and is to give an alarm in the event of an abnormal condition.
2.6.4.3 System is to automatically initiate transition to the least hazardous state in the event of data communication failure.
2.6.4.4 When the same data communication link is used for two or more essential functions, this link is to be redundant.
2.6.4.5 Switching between redundant links is not to disturb data communication or continuous operation of functions.
2.6.4.6 To ensure that data can be exchanged between various systems, standardized interfaces are to be used.
2.6.4.7 Where a single component failure results in loss of data communication, means are to be provided to automatically restore data communication.
2.6.4.8 Loss of a data communication link is not to affect the ability to operate essential services by alternative means.
2.6.4.9 Means are to be provided to ensure the integrity of data and provide timely recovery of corrupted or invalid data.
2.6.4.10 The characteristics of the data communication link are to be such as to transmit all necessary information in adequate time and overloading is prevented.

2.6.5 Additional requirements for wireless data links
2.6.5.1 In addition to complying with the requirements of 2.6.4 of this Section, the requirements of 2.6.5.2 to 2.6.5.4 below are to be complied with for system category II using wireless data communication links. For system category III, the use of wireless data communication links is to comply with 2.6.1.3 of this Section.
2.6.5.2 Functions that are required to operate continuously to provide essential services dependent on wireless data communication links are to have an alternative means of control that can be brought in action within an acceptable period of time.
2.6.5.3 Wireless data communication is to 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. It is only to permit connection of devices that are included in the system design.
(3) Message encryption: Protection of the confidentiality and/or criticality of the data content.
(4) Security management: Protection of network assets, prevention of unauthorized access to network assets.
2.6.5.4 The wireless system is to comply with the radio frequency and power level requirements of International Telecommunications Union and of the flag Administration①.

2.6.6 Input and output devices
2.6.6.1 Input and output devices of computer systems are to be designed for ease of handling and user-friendliness and are so far as possible to follow ergonomic principles.

① Consideration is to 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.

2.6.6.2 The keyboard of a computer is to meet the following requirements:
(1) Where equipment operations or functions may be changed via keyboards, appropriate measures (such as setting password) are to be employed so as to limit access of such operations to authorized personnel only.
(2) If the operation of a key is able to cause dangerous operating conditions, measures are to be taken to prevent the instruction in question from being executed by a single action such as use of a special key lock, or use of two or more keys.
2.6.6.3 The computer displays are to comply with following requirements:
(1) The size, color and density of text and graphic information displayed on a visual display unit is to be such that it may be easily read from the normal operator position under all operational lighting conditions. The brightness and contrast are to be capable of being adjusted to the prevailing ambient conditions.
(2) Information is to be displayed in a logical priority.
(3) If alarm messages are displayed on color monitors, the distinctions in the alarm status are to be ensured even in the event of a failure of a primary color.
2.6.6.4 Where a display unit is used for alarm in place of a general indicating lamp in computer systems of categories II and III, the following requirements are to be satisfied:
(1) The indication of the display unit is to be clear under the bright environmental condition. Data and information shown on the display unit are to be capable of being easily read by an operator in a normal working position.
(2) The display unit is to be capable of clearly indicating all the alarm signals.
(3) The display unit is to be capable of distinguishing the status of fault alarms, i.e., the status before and after acknowledgment; but this distinction is not to be shown by means of different colors only.
(4) A storage device and an output interface are to be provided in order to record and output the faults and their time.
(5) For the centralized monitoring and alarm system in the engine room, at least a standby display unit or lamp panel is to be provided, or a printer is to be provided in order to record the faults and their time.
(6) The display unit is to be capable of normal operation in the event of a failure of the normal power supply.
(7) Where a display unit is common to parameter and alarm displays, the parameter display is not to interfere with the initiation of alarm signals.

2.6.7 Graphical user interface

2.6.7.1 Information is to be presented clearly and intelligibly according to its functional significance and association. Screen contents are to be logically structured and their representation is to be restricted to the data which is directly relevant for the user.
2.6.7.2 When using general purpose graphical user interfaces, only the functions necessary for the respective process are to be available.
2.6.7.3 Alarms are to be visually and audibly presented with priority over other information in every operating mode of the system; they are to be clearly distinguishable from other information.

2.6.8 Tests and evidence

2.6.8.1 Tests and evidence are to be in accordance with Table 2.6.8.1. Definitions and notes relating to Table 2.6.8.1 are given in Appendix 1 of this Chapter.

Tests and Evidence of Computer Systems **Table 2.6.8.1**

No.	Tests and evidence	System category		
		I	II	III
1.	**Evidence of quality system**			
	Quality plan for software		M	M
	Inspection of components (only Hardware) from sub-suppliers		M	M
	Quality control in production		M	M
	Final test reports	M	M	S
	Traceability of software	M	M	S
2.	**Hardware and software description**			
	Software description		M	S
	Hardware description		M	S
	Failure analysis for safety related functions only			S
3.	**Evidence of software testing**			
	Evidence of software testing according to quality plan		M	S
	Analysis regarding existence and fulfilment of programming procedures for safety related functions			S
4.	**Hardware tests**			

No.	Tests and evidence	System category		
		I	II	III
	Tests according to CCS Guidelines for Type Approval Test of Electric and Electronic Products, 2006		W	W
5.	**Software tests**			
	Module tests		M	S
	Subsystem tests		M	S
	System test		M	S
6.	**Performance tests**			
	Integration test		M	W
	Fault simulation		W	W
	Factory Acceptance Test (FAT)	M	W	W
7.	**On-board test**			
	Complete system test	M	W	W
	Integration test		W	W
	Operation of wireless equipment to demonstrate electromagnetic compatibility		W	W
8.	**Modifications**			
	Tests after modifications	M	S/W	S/W

Notes: M = Evidence kept by manufacturer and submitted on request.
S = Evidence checked by CCS.
W = To be witnessed by CCS.

Section 7 SENSORS

2.7.1 General requirements

2.7.1.1 The sensors are to give stable and normal operational performance over a long period of time. The measuring range and frequency characteristics (if applicable) of sensors are to be consistent with the expected maximum variation range and variation of velocity of the parameters being detected. The sensors are to possess suitable accuracy and sensitivity.

2.7.1.2 The sensors are to have good compatibility with the environmental conditions at their positions. The sensors are to be mechanically robust and durable, having good mechanical protection, reliable electrical connections and good insulated property.

2.7.1.3 The sensors are to be so sited that they can properly reflect the monitored parameters and are readily accessible for testing and renewal. In order that maintenance and renewal can be carried out easily, a protective cover is to be fitted for sensors. Where the sensors are sited in positions inaccessible for renewal, a standby sensor is to be fitted.

2.7.1.4 An independent sensor is to be provided for Mode a protective action; if not specially required, for Mode b protective action, the use of a common sensor with display and alarm is permitted; for Mode c protective action, the use of a common sensor with alarm is permitted.

Section 8 MAIN PROPULSION MACHINERY REMOTELY CONTROLLED FROM NAVIGATION BRIDGE

2.8.1 General requirements

2.8.1.1 If main propulsion machinery is remotely controlled from navigation bridge, the requirements of 2.8.1.2 to 2.8.1.12 of this Chapter are to be complied with.

2.8.1.2 Under all sailing conditions, including manoeuvring, the speed and direction of main propulsion machinery and, if applicable, pitch of the propeller are to be fully controllable from the navigating bridge.

2.8.1.3 The remote control of main propulsion machinery from navigation bridge is to be performed by a single control device for each independent propeller, with automatic performance of all associated services including, where necessary, means of preventing overload and prolonged running in critical speed ranges of the propelling machinery. Where multiple propellers are designed to operate simultaneously, they may be controlled by one control device.

2.8.1.4 The bridge control system is to be independent from the other transmission system, however, one control lever for both system may be accepted.

2.8.1.5 Operations following any setting of the bridge control device including reversing from the maximum ahead service speed in case of emergency are to take place in an automatic sequence and with time intervals acceptable to the machinery.

2.8.1.6 The main propulsion machinery is to be provided with an emergency stopping device on the navigating bridge and independent from the bridge control system, but its actuating unit may not be independent and the arrangement of which is to be such as to preclude inadvertent operation.

2.8.1.7 Main propulsion machinery orders from the navigation bridge are to be indicated in the engine room centralized control station (if fitted) or at the main propulsion machinery local control station.

2.8.1.8 Remote starting of the propulsion machinery is to be automatically inhibited if conditions exist which may hazard the machinery, e.g. shaft turning gear engaged, drop of lubricating oil pressure.

2.8.1.9 The design of the bridge control system is to be such that in case of its failure, an alarm is given. In this case, the speed and direction of the propeller thrust is to be maintained until local control is in operation, unless this is considered impracticable. In particular, lack of power (electric, pneumatic, hydraulic) is not to lead to major and sudden change in propulsion power or direction of propeller rotation.

2.8.1.10 If the remote control system of the main propulsion machinery is designed for automatic starting, the number of automatic consecutive is to be limited to not more than 3. Visual and audible alarms are to be given on the navigation bridge at the third failure and an alarm is to be provided on the navigation bridge and in the machinery space to indicate low starting air pressure which is to be set at a level to permit main propulsion machinery starting operations.

2.8.1.11 Bridge control station, engine room centralized control station (room) and main propulsion machinery local control station are to indicate:

(1) main engine speed or propeller speed;

(2) the direction of rotation of fixed pitch propellers or the blade angle (or the pitch) for controllable pitch propellers;

(3) clutch position and shaft brake position (where applicable);

(4) starting air pressure or voltage of starting storage batteries for main engines;

(5) the control station in control;

(6) the power supply to control and monitoring systems relating to the control station.

2.8.1.12 If main propulsion machinery is remotely controlled from navigation bridge, automation systems are to be designed in a manner which ensures that threshold warning of impending or imminent shutdown or shutdown of the main propulsion machinery is given to the officer in charge of the navigational watch in time to assess navigational circumstances in an emergency. In particular, the systems are to control, monitor, report, alert and take safety action to slow down or stop propulsion while providing the officer in charge of the navigational watch an opportunity to manually intervene (such as overriding), except for those cases where manual intervention will result in total failure of the engine and/or main propulsion machinery within a short time, for example in the case of overspeed.

Appendix 1 DEFINITIONS AND NOTES RELATING TO TESTS AND EVIDENCE OF COMPUTER SYSTEMS

1.1 Evidence of quality system

1.1.1 Quality plan for software: a plan for software lifecycle activities is to be produced which defines relevant procedures, responsibilities and system documentation, including configuration management.

1.1.2 Inspection of components (only Hardware) from sub-suppliers: proof that components and/or subassemblies conform to specification.

1.1.3 Quality control in production: evidence of quality assurance measures on production.

1.1.4 Final test reports: reports from testing of the finished product and documentation of the test results.

1.1.5 Traceability of software: modification of program contents and data, as well as change of version has to be carried out in accordance with a procedure and is to be documented.

2.1 Hardware and software description

2.1.1 Software description: software is to be described, e.g.:

— Description of the basic and communication software installed in each hardware unit;
— Description of application software (not program listings);
— Description of functions, performance, constraints and dependencies between modules or other components.

2.1.2 Hardware description: hardware is to be described, e.g.:

— System block diagram, showing the arrangement, input and output devices and interconnections;
— Connection diagrams;
— Details of input and output devices;
— Details of power supplies.

2.1.3 Failure analysis for safety related functions only (e.g. FMEA): the analysis is to be carried out using appropriate means, e.g.:

— Fault tree analysis;
— Risk analysis;
— FMEA or FMECA.

The purpose is to demonstrate that for single failures, systems will fail to safety and that systems in operation will not be lost or degraded beyond acceptable performance criteria when specified by CCS.

3.1 Evidence of software testing

3.1.1 Evidence of software testing according to quality plan: procedures for verification and validation activities are to be established, e.g.:

— Methods of testing;
— Test programs producing;
— Simulation.

3.1.2 Analysis regarding existence and fulfilment of programming procedures for safety related functions: specific assurance methods are to be planned for verification and validation of satisfaction of requirements, e.g.:

— Diverse programs;
— Program analysis and testing to detect formal errors and discrepancies to the description;
— Simple structure.

4.1 Hardware tests

4.1.1 Tests according to CCS Guidelines for Type Approval Test of Electric and Electronic Products, 2006 will normally be a type approval test. Special consideration may be given by CCS to tests witnessed and approved by another IACS member society.

5.1 Software tests

5.1.1 Module tests: software module tests are to provide evidence that each module performs its intended function and does not perform unintended functions.

5.1.2 Subsystem tests: subsystem testing is to verify that modules interact correctly to perform the intended functions and do not perform unintended functions.

5.1.3 System test: system testing is to verify that subsystems interact correctly to perform the functions in accordance with specified requirements and do not perform unintended functions.

6.1 Performance tests

6.1.1 Integration tests: programmable electronic system integration testing is to be carried out using satisfactorily tested system software, and as far as practicable intended system components.

6.1.2 Fault simulation: faults are to be simulated as realistically as possible to demonstrate appropriate system fault detection and system response. The results of any required failure analysis are to be observed.

6.1.3 Factory Acceptance Test (FAT): factory acceptance testing is to be carried out in accordance with a test program accepted by CCS. Testing is to be based on demonstrating that the system fulfils the requirements specified by CCS.

7.1 On-board tests

7.1.1 Complete system test: testing is to be performed on the completed system comprising actual hardware components with the final application software, in accordance with an approved test program.

7.1.2 Integration tests: on board testing is to verify that correct functionality has been achieved with all systems integrated.

7.1.3 For wireless data communication equipment, tests during harbour and sea trials are to be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not its self fail as a result of electromagnetic interference during expected operating conditions. Where electromagnetic interference caused by wireless data communication equipment is found to be causing failure of equipment required for Category II or III systems, the layout and/or equipment is to be changed to prevent further failures occurring.

8.1 Modifications

8.1.1 Tests after modifications: modifications to approved systems are to be notified in advance and carried out to the satisfaction of CCS, see 2.6.1.4 of this Chapter.

CHAPTER 3 REQUIREMENTS FOR CLASS NOTATION AUT-0 OF PERIODICALLY UNATTENDED MACHINERY SPACES

Section 1 GENERAL PROVISIONS

3.1.1 Application

3.1.1.1 This Chapter applies to ships of which the main propulsion machinery is remotely controlled from the BCS and the machinery space including CCS is periodically unattended. In this connection, the class notation is AUT-0.

3.1.1.2 Ships with the class notation AUT-0 are, in addition to complying with the requirements of this Chapter, to be in compliance with the requirements of Chapters 1 and 2 of this PART.

3.1.1.3 For passenger ships with the class notation AUT-0, attention is to be paid to the requirements of the flag Administration, if any.

3.1.1.4 In the unattended period, automated systems are to ensure the normal continuous operation of the following machinery and electrical equipment:

(1) main propulsion machinery, including main engines (such as main diesel engine, main steam turbine, main gas turbine and electric propulsion installations), gearing (including clutches and reduction gearboxes) and propellers (including controllable pitch propellers);

(2) essential auxiliary machinery serving the main propulsion machinery;

(3) main and auxiliary boilers;

(4) electric generating plant;

(5) other machinery and electrical equipment, such as air compressors, bilge systems (including oily water separators), valves associated with remote control, fuel oil systems as well as others of which automated control and monitoring is deemed necessary by CCS.

Section 2 MAIN PROPULSION MACHINERY

3.2.1 General requirements

3.2.1.1 The starting, speed regulating, reversing (including shaft reversing) and stopping of the main propulsion machinery are to be capable of being remotely controlled or automatically, sequentially controlled from the CCS. In the case of failure of any part of the control systems, it is to be possible for the main propulsion machinery to be manually controlled from the LCS with regard to the above-mentioned operations.

3.2.2 Main diesel engines

3.2.2.1 The main diesel engines are to comply with the relevant requirements of Chapter 9 of PART THREE of the Rules.

3.2.2.2 The control systems of main diesel engines are to comply with the following requirements:

(1) The control system is to ensure that under all operational conditions the engines and shafting will not be subjected to detrimental mechanical and thermal overloads.

(2) The automatic sequential control of main diesel engines is to be provided with necessary interlocks so as to prevent any mechanical damage.

(3) The number of unsuccessful automatic consecutive starts of main diesel engines is not to be more than 3. The main engine is to stop starting at the third failure, and an audible and visual alarm is to be given and the single alarm is to be extended to the BCS.

(4) The control system of main diesel engines is to be so designed that a critical speed range will be automatically crossed over promptly.

(5) Where the main diesel engine is used for main propulsion, means are to be provided to keep the starting air pressure within the required pressure range.

3.2.2.3 The safety system of main diesel engines is to comply with the following:

(1) Safeguards

① A suitable alarm is to be activated at the starting of standby pumps for which the automatic starting is required.

② If an overriding function of the required automatic reduction of power is provided, means are to be provided to preclude inadvertent operation of the overriding function, and a suitable alarm is to be activated by the operation.

③ If an overriding function of the required automatic stops is provided (with the exception of overspeed), means are to be provided to preclude inadvertent operation of the overriding function, and a suitable alarm is to be activated by the operation. When the main engine is stopped automatically, restarting after restoration of normal operating conditions is to be possible only after manual reset, e.g. by-passing the control lever through the 'stop' position. Otherwise, automatic restarting is not permissible.

(2) For the requirements for the safety system of main diesel engines, refer to column 4 of Table 3.10.1.1 of this Chapter.

(3) In addition, emergency shutdown devices are to be provided at the BCS and CCS (see also 2.8.1.6 of this PART and 3.7.3.5 of this Chapter).

3.2.2.4 The alarm system (including displays) of main diesel engines is to satisfy the following requirements:

(1) Remote indications required in Table 3.10.1.1 of this Chapter are only for items to be displayed and alarmed at the CCS, see columns 2 and 3 of that Table.

(2) For items to be alarmed and the mode of alarms at the BCS, refer to column 5 of Table 3.10.1.1 of this Chapter. The items to be displayed are specified in 2.8.1.11, Chapter 2 of this PART.

3.2.2.5 Where vibration dampers are fitted for main engines:

For torsional or axial vibration dampers oiled by circulating lubrication from main engines and based on amortization thereof, the requirements for the items to be automatically controlled and monitored are to be in compliance with Table 3.10.1.1 of this Chapter as appropriate.

3.2.3 Main steam turbines

3.2.3.1 The main steam turbines are to comply with the relevant requirements of Chapter 7 of PART THREE of the Rules.

3.2.3.2 The control system of main steam turbines is to comply with the following requirements.

(1) Means are to be provided, by automatic steam spinning, to prevent the risk of thermal distortion of the main steam turbine, when the shaft has been stopped for a period exceeding the predetermined time in the maneuvering mode. However, device capable of stopping such automatic spinning is to be provided in the bridge.

(2) The control system is to be so designed that a critical speed range will be automatically crossed over promptly. Or alternatively, audible and visual alarms are to be given automatically when the turbine is running in the critical speed range, so as to warn the man-on-watch to cross over the critical speed range by manual control.

3.2.3.3 For the requirements for the safety system of main steam turbines, refer to column 4 of Table 3.10.1.1 of this Chapter.

3.2.3.4 The alarm system (including displays) of main steam turbines is to comply with the following requirements.

(1) For items to be displayed and alarmed at the CCS, refer to columns 2 and 3 of Table 3.10.1.1 of this Chapter.

(2) For items to be alarmed and the mode of alarms at the BCS, refer to column 5 of Table 3.10.1.1 of this Chapter. The items to be displayed are specified in 2.8.1.11, Chapter 2 of this PART.

3.2.4 Main gas turbines

3.2.4.1 The main gas turbines are to comply with the relevant requirements of Chapter 8 of PART THREE of the Rules.

3.2.4.2 The control system of main gas turbines is to comply with the following requirements.

(1) When the gas turbine increases power from starting to rated condition or decreases power from rated condition to stop running, provision is to be made so that dangerous thermal and/or mechanical stresses will not occur in any part of the turbine due to the control of oil fuel supply, except in case of emergency control. Gas turbine remote control systems are to be so designed that the turbine exhaust gas temperature and the rotor speed can be maintained within a predetermined range and that the combustion in combustion chamber can be maintained in a steady state under normal operations.

(2) The remote control system of gas turbines is to be so designed that the lubricating oil system, oil fuel system and cooling system are interlocked as appropriate in order that the starting and stop of gas turbine operation can be carried out according to the predetermined procedure with sequential control complying with the following requirements:

① the lubricating oil pumps are to be kept in operation both before starting and after stopping the gas turbine. However, special consideration may be given to gas turbines fitted with roller bearings and attached lubricating oil pumps;

② the combustion chambers are to be sufficiently purged with air before ignition;
③ main oil fuel valves are not to open prior to ignition spark;
④ the ignition of each burner is not to exceed the predetermined duration. And if the gas turbine cannot achieve starting within the predetermined period, it is not to repeat the starting;
⑤ no excessive fuel is to be supplied into the combustion chamber during ignition.

(3) The remote control system for single-screw multi-turbine unit is to be so designed that the load on each turbine will not be abnormally distributed.

3.2.4.3 For the requirements for the safety system of main gas turbines, refer to column 4 of Table 3.10.1.1 of this Chapter.

3.2.4.4 The alarm system (including displays) of main gas turbines is to comply with the following requirements:

(1) For items to be displayed and alarmed at the CCS, refer to columns 2 and 3 of Table 3.10.1.1 of this Chapter.

(2) For items to be alarmed and the mode of alarms at the BCS, refer to column 5 of Table 3.10.1.1 of this Chapter. The items to be displayed are specified in 2.8.1.11, Chapter 2 of this PART.

3.2.5 Controllable pitch propellers

3.2.5.1 Controllable pitch propellers are to comply with the relevant requirements in Section 3, Chapter 11 of PART THREE of the Rules.

3.2.5.2 Blade angle (or pitch) is to be capable of being remotely controlled or automatically, sequentially controlled from the BCS.

3.2.5.3 The remote control is to be performed by a single control device for each independent propeller, with automatic performance of all associated services. The control of a multi-propeller system where the propellers will possibly be in operation simultaneously may be preformed by one device.

3.2.5.4 The combined control system of main engines and controllable pitch propeller for main propulsion is to be capable of preventing the engines and shafting from being overloaded and stopped due to overloading or overspeed.

3.2.5.5 For the hydraulic remote control system of controllable pitch propellers for main propulsion, a standby power source is to be provided. The standby pump supplying hydraulic power for pitch control is to be capable of automatically starting when the pressure of the hydraulic system is below the predetermined value.

3.2.5.6 The blade angle (or pitch) and shaft speed of controllable pitch propellers is to be indicated at each control station from which it is possible to control the propeller pitch (see 2.8.1.11, Chapter 2 and Table 3.10.1.1 of this PART).

3.2.5.7 For the items to be alarmed with regard to controllable pitch propellers, refer to Table 3.10.1.1 of this Chapter.

3.2.6 Electric propulsion installations

3.2.6.1 The function of control and monitoring of the electric propulsion installations is to comply with the requirements in Section 2, Chapter 15 of PART EIGHT of the Rules.

3.2.6.2 The electric propulsion installations are to be capable of being controlled at the BCS, and there are to be provided with instruments for indicating the direction of rotation and speed of the propeller shaft, as well as those for indicating other necessary operational parameters.

3.2.7 Clutches

3.2.7.1 The requirements for the items to be automatically controlled and monitored for clutches are to be in compliance with Table 3.10.1.1 of this Chapter as appropriate.

3.2.8 Gearboxes

3.2.8.1 The requirements for items to be automatically controlled and monitored for gearboxes are to be in compliance with Table 3.10.1.1 of this Chapter as appropriate.

Section 3 BOILERS

3.3.1 Main boilers

3.3.1.1 The main boilers are to comply with the relevant requirements of Chapter 6 of PART THREE of the Rules.

3.3.1.2 The control system of main boilers is to comply with the following requirements.

(1) Water level control
① The automatic control system is to ensure that the boiler water level is maintained within the predetermined range under all working conditions.
② Each boiler is to be provided with two independent low-water-level sensors (one of which is used in the safety system to detect the limited low water level) and one high-water-level sensor. Water level sensors are to be so located as to prevent the release of malfunction signals due to the rolling and pitching of the ship.
(2) Combustion control
① The automatic combustion control system is to be capable of maintaining the predetermined amount of steam generation, steam pressure, steam temperature and a stable combustion of the main steam turbine under all working conditions.
② The sequentially controlled boilers with an automatic ignition system are to satisfy the following requirements:
(a) prior to the initial ignition of the burner, the combustion chamber and flue passes are to be prepurged. The purging time is to be appropriate to a minimum of four air changes in the combustion chamber. During boiler purge, the air registers and dampers are to be kept widely open;
(b) ignition can only be initiated after the air entry into and on completion of prepurging of the combustion chamber. The burner fuel valves are not to open prior to ignition spark. In the event of ignition failure, the ignition devices and burner fuel supply valves are to be automatically shut off. The time from fuel supply valve opening to closing is not to be greater than 15 s;
(c) each burner is to be fitted with a flame scanner designed to automatically shut off the fuel oil supply valve in the event of flame failure, and the action of shutoff is to be capable of closing the valve within 6 s following the flameout.

3.3.1.3 The safety system of main boilers:
(1) Where any one of the following faults takes place, the boiler fuel oil supply is to be automatically shut off, or alternatively, equivalent means are to be adopted for the emergency shutdown of the boiler:
① flame failure (i.e. flameout on all burners) in the combustion chamber or ignition failure;
② the water level in the boiler is below the limited low water level (the limited low water level is not to be lower than the lowest permissible water level or the level visible in the gauge glass);
③ loss of the pressure of combustion air in the forced draft to boiler.
(2) In addition to those mentioned in (1) above, separate emergency manual shutoff devices for each boiler fuel oil supply are to be provided at CCS (see also 3.7.3.5 of this Chapter).
(3) The standby pumps for boiler fuel oil are to start automatically when the discharge pressure from the working pumps falls below a predetermined value.
(4) The standby pumps for boiler feed water are to start automatically when the pressure or flow rate from the working pumps falls below a predetermined value.
3.3.1.4 The alarm system of main boilers (including displays)
(1) The items to be displayed and alarmed at the CCS are indicated in columns 2 and 3 of Table 3.10.1.1 of this Chapter.
(2) The items to be alarmed and the mode of alarms at the BCS are indicated in column 5 of Table 3.10.1.1 of this Chapter.

3.3.2 Auxiliary boilers
3.3.2.1 Auxiliary boilers are to comply with the relevant requirements of Chapter 6 of PART THREE of the Rules.
3.3.2.2 The combustion control of auxiliary boilers is in general to comply with the requirements of 3.3.1.2(2) of this Section.
3.3.2.3 The safety system of auxiliary boilers is to comply with the requirements of 3.3.1.3(1), 3.3.1.3(2) and 3.3.1.3(3) of this Section. And the standby pumps for boiler feed water are to be started and put into service automatically in case the water level in the boiler is lower than the predetermined value.
3.3.2.4 The items to be automatically controlled and monitored for auxiliary boilers are to be in compliance with Table 3.10.1.1 of this Chapter as appropriate.

3.3.3 Exhaust gas boilers
3.3.3.1 Exhaust gas boilers are to comply with the relevant requirements of Chapter 6 of PART THREE of the Rules.
3.3.3.2 The items to be automatically controlled and monitored for exhaust gas boilers are to be in compliance with Table 3.10.1.1 of this Chapter as appropriate.

3.3.3.3 Indicating lights for the operation of boiler water pumps are to be provided at the CCS.
3.3.3.4 It is to be ensured that the safety system of exhaust gas boilers is capable of starting the action of by-pass of exhaust gas or the mechanism of vapour release in case steam drum outlet pressure/temperature of steam boilers is excessively high.

3.3.4 Thermal oil heaters
3.3.4.1 The thermal oil heaters are to comply with the relevant requirements in Section 8, Chapter 4 of PART THREE of the Rules.
3.3.4.2 The items to be automatically controlled and monitored for thermal oil heaters are to be in compliance with Table 3.10.1.1 of this Chapter as appropriate.
3.3.4.3 The standby pumps are to be started automatically when outlet pressure of circulating pumps for transfer of fuel oil is lower than the predetermined value.
3.3.4.4 For ensuring stable working conditions throughout the operating range of the heater, automatic control is to be provided for the following:
(1) combustion system;
(2) temperature or viscosity of fuel oil (only for heavy oil);
(3) temperature of thermal oil.

Section 4 ELECTRIC GENERATING PLANT

3.4.1 General requirements
3.4.1.1 In addition to complying with the requirements of this Section, the electric generating plant is to be in compliance with the relevant requirements of Chapter 2, PART FOUR of the Rules.
3.4.1.2 The items to be automatically controlled and monitored for electric generating plant are to be in compliance with Table 3.10.1.1 of this Chapter as appropriate.

3.4.2 Continuity of power supply
3.4.2.1 Where electrical power is normally supplied by one generating set, arrangements, such as load shedding referred to in 3.4.2.6 of this Section or automatic starting of a standby generating set, etc. are to be provided to ensure that the safety of the ship under all sailing conditions, including maneuvering, is at least equivalent to that of a ship having the machinery space manned.
3.4.2.2 If the electrical power is normally supplied by more than one generator operating in parallel, provision is to be made by means such as load shedding referred to in 3.4.2.6 of this Section, or by appropriate separation of the switchboard bus-bars to ensure that, in the event of loss of one of the generating sets, the remaining set(s) are kept in operation without overload to permit propulsion and steering, and to ensure the safety of the ship.
3.4.2.3 In the event of a failure of the generating set in service, a standby generating set is to be capable of automatically starting and connecting to the main switchboard, with a sufficient capacity to supply those services necessary to ensure that the safety of the ship under all sailing conditions, including maneuvering, is at least equivalent to that of a ship having the machinery spaces manned.
3.4.2.4 All motor-driven essential auxiliaries serving the main propulsion machinery are to be capable of automatically re-starting in a sequence upon restoration of power after interruption.
3.4.2.5 The automatic starting system and characteristics of the standby generating set are to be such as to permit the standby generator to carry its full rated load as quickly as is safe and practicable, subject to a maximum period of 45 s.
3.4.2.6 For the safety of power supply to essential equipment, suitable load shedding devices are to be provided to automatically cut off the non-essential loads:
(1) when the total load exceeds the rated output power of generator caused by automatic switch-on of additional loads;
(2) when the total load exceeds the sum of rated powers of other generating sets which are still in service in case of the failure of one of generators as more than one generating sets are operating in parallel.

Section 5 AUXILIARY MACHINERY

3.5.1 General requirements
3.5.1.1 The auxiliary machinery referred to in this Section means the prime mover of electric generators, all kinds of pumps and air compressors serving the main propulsion machinery, etc.

3.5.1.2 During the unattended period of machinery spaces, all the auxiliary machinery are to be capable of being normally operated automatically.

3.5.2 Auxiliary diesel engines

3.5.2.1 The items to be automatically controlled and monitored for the auxiliary diesel engines are to be in compliance with Table 3.10.1.1 of this Chapter as appropriate.

3.5.3 Pumps

3.5.3.1 The motor-driven pumps serving the main propulsion machinery are to be capable of being automatically started in sequence upon restoration of power after interruption. For the requirements for automatic changeover of standby pumps, see items marked with "c" in column 4 of Table 3.10.1.1 of this Chapter.

3.5.4 Air compressors

3.5.4.1 The items to be automatically controlled and monitored for air compressors are to be in compliance with Table 3.10.1.1 of this Chapter as appropriate.

Section 6 OTHER EQUIPMENT

3.6.1 Bearings of tail pipes

3.6.1.1 The items to be automatically controlled and monitored for bearings of tail pipes are to be in compliance with Table 3.10.1.1 of this Chapter as appropriate.

3.6.2 Valves

3.6.2.1 The valves covered by this Section mean the valves used in bilge and sea water systems (including ballast water system).

3.6.2.2 Failure of actuator power is not to put the valve and the whole ship to an unsafe condition.

3.6.2.3 Positive indication is to be provided at the station for valve control to show the actual valve position or alternatively, whether the valve is fully open or closed.

3.6.2.4 Operating equipment located in places which may be flooded is to be capable of normal operation when submerged.

3.6.2.5 In the event of a failure of the remote or automatic control the valves are to be capable of being operated manually.

3.6.3 Oil purifiers, etc.

3.6.3.1 The items to be automatically controlled and monitored for oil purifiers, oil return tanks of main and auxiliary engines and incinerators are to be in compliance with Table 3.10.1.1 of this Chapter as appropriate.

3.6.4 Oil tanks

3.6.4.1 The capacities of fuel oil daily service and settling tanks are to be appropriate to the consumption necessary for the unattended period (such as 8 h, 16 h, 24 h) plus 10% at least. A low level alarm is to be provided for the daily service fuel oil tanks (see Table 3.10.1.1 of this Chapter) and high and low level alarms are to be provided for the settling tanks.

3.6.4.2 Where the daily service fuel oil tanks are replenished automatically or remotely, means are to be provided to eliminate the possibility of overflow, and high and low level alarms are to be provided and extended to the BCS. In this case, the tanks may be exempted from the requirements for capacity as specified in 3.6.4.1 above.

Section 7 ADDITIONAL REQUIREMENTS FOR CONTROL STATIONS (ROOMS)

3.7.1 Provision of control stations (rooms)

3.7.1.1 Bridge control station (BCS), engine room centralized control station (CCS) and local control stations (LCS) are in general to be provided on ships with machinery spaces periodically unattended.

3.7.2 Functions of bridge control stations (BCS)

3.7.2.1 Under all sailing conditions including maneuvering, the speed and direction of thrust of main propulsion machinery as well as other associated installations (if fitted) are to be effectively controlled from the BCS. When necessary, the control is to be capable of being changed over to other control stations at any time and the changeover is to comply with the relevant requirements of 2.5.2 of this PART. The design and arrangement of bridge control station are to comply with the requirements in Section 8, Chapter 2 of this PART.

3.7.2.2 Alarms at the BCS

(1) For the items to be alarmed at the BCS and the mode of alarms, see column 5 of Table 3.10.1.1 of this Chapter. Alarms indicating the faults in the machinery and electrical equipment as well as the automated control and monitoring systems are, in general, to be relayed to the BCS in the following modes: group alarms for the protective actions of safety systems; separate alarms; group alarms for serious faults and group alarms for general faults.

(2) The audible alarms at the BCS are permitted to be silenced after acknowledgment, but the visual alarms are to be extinguished only after the rectification of faults, and furthermore, the visual signals are to be capable of being clearly distinguishable before and after acknowledgment.

3.7.3 Functions of centralized control stations (rooms) of engine room (CCS)

3.7.3.1 The CCS is to be capable of performing functions of control and changeover of the main propulsion machinery as specified in 3.7.2.1 of this Section, and besides, it is also to be capable of controlling and monitoring the other equipment as specified in 3.1.1.4 of this Chapter.

3.7.3.2 Instruments or display units are to be provided at the CCS to indicate the essential parameters for ensuring the safe and reliable operation of the machinery and electrical equipment. The items to be displayed are given in column 2 of Table 3.10.1.1of this Chapter.

3.7.3.3 All faults including several faults occurred at the same time in the machinery and electrical equipment and in the control and monitoring systems are to be capable of being alarmed at the CCS. The items to be alarmed are given in column 3 of Table 3.10.1.1of this Chapter.

3.7.3.4 Audible alarms at the CCS are to be capable of being silenced only after being acknowledged at the station.

3.7.3.5 The emergency button for stopping main propulsion machinery and the emergency buttons for cutting off oil supply to boilers and incinerators provided at the CCS are to be independent of the automated systems of the station, but their actuating units may not be required to be independent and are to be arranged so as to preclude inadvertent operation.

3.7.3.6 Where overriding function as prescribed in 1.1.2.1(9) of this PART is provided for main engines, the overriding function is also to be provided at the CCS, and is to be so arranged as to preclude inadvertent operation.

3.7.4 Functions of local control stations (LCS)

3.7.4.1 The LCS is to comply with the requirements of 2.5.1.5 of this PART.

3.7.5 Communication

3.7.5.1 In addition to complying with the relevant requirements of PARTs THREE and FOUR of the Rules, reliable means of vocal communication are to be provided between the CCS or the LCS (if applicable), the BCS and the engineers' accommodation.

Section 8 ADDITIONAL REQUIREMENTS FOR CONTROL AND MONITORING SYSTEMS

3.8.1 Safety systems

3.8.1.1 The safety systems in all controlled and monitored machinery and electrical equipment are to be in compliance with the requirements of Section 3, Chapter 2 of this PART.

3.8.2 Alarm systems

3.8.2.1 The arrangement of the alarm display is to assist in identifying the particular fault condition and its location within the machinery space.

3.8.2.2 If the bridge navigating officer of the watch is the sole watch-keeper then, in the event of a machinery fault being monitored at the control location for machinery, the alarm system is to be such that this watch-keeper is made aware when:

(1) a machinery fault has occurred;

(2) the machinery fault is being attended to (e.g. acknowledging, silencing);

(3) the machinery fault has been rectified. Alternative means of communication between the bridge area, the accommodation for engineering personnel and the machinery spaces (CCS or local control stations) may be used for this function.

3.8.2.3 Group alarms may be arranged on the bridge to indicate machinery faults. Alarms associated with faults requiring speed reduction or automatic shutdown of propulsion machinery are to be separately identified (see column 5 in Table 3.10.1.1 of this Chapter).

3.8.2.4 The alarm system is to be capable of being tested during normal machinery operation. Where practicable, means are to be provided at convenient and accessible positions to permit the sensors to be tested without affecting the operation of the machinery.

3.8.2.5 If an alarm has been acknowledged and a second fault occurs before the first is rectified, then audible and visual alarms are to operate again. Alarms due to temporary failures are to remain activated until acknowledged.

3.8.2.6 Automatic recording devices are to be provided at the CCS for recording the important parameters and faults. Where a computer system is used, its recording device may be adopted instead.

3.8.2.7 A changeover switch is to be provided to relay all the fault alarms to the engineers' accommodation and each engineer's cabin by group alarms so as to ensure that the alarm signal is relayed at least to one cabin of the engineer on watch.

Acknowledgment of alarms at positions outside a machinery space (including the CCS) is not to silence the audible alarm or extinguish the visual alarm in that machinery space (including the CCS).

Where an alarm has not been acknowledged in a certain time in the machinery space (including the CCS), the alarm system referred to in 2.8.4, Chapter 2 of PART FOUR of the Rules is to be activated automatically, and the alarm is to be clearly audible within the engineers' accommodation and related public spaces.

Section 9 FIRE PRECAUTIONS AND PROTECTION AGAINST FLOODING

3.9.1 Fire precautions

3.9.1.1 The fire precautions for periodically unattended machinery spaces (including the CCS) are to comply with the relevant requirements of PART SIX of the Rules, inter alia, the requirements for the special arrangements in machinery spaces, fire detection and alarm systems, and water fire-extinguishing systems. There is to be immediate water delivery from the fire main system at a suitable pressure, either by remote starting of one of the main fire pumps with remote starting from the navigating bridge or fire control station, if any, or permanent pressurization of the fire main system by one of the main fire pumps, except that this requirement need not be complied with for cargo ships of less than 1,600 gross tonnage if the fire pump starting arrangement in the machinery space is in an easily accessible position.

3.9.1.2 In addition to complying with the requirements for engine rooms given in PART THREE of the Rules, the fire precautions for periodically unattended machinery spaces are to comply with the following.

(1) Fuel oil, lubricating oil and hydraulic oil pipelines are to be so constructed and arranged as to avoid excessive stresses due to vibration and expansion. Flange joints are to be minimized as far as practicable in the above pipelines.

(2) Equipment for the automatic treatment of flammable oils, such as oil purifiers, oil heaters, oil filters, oil pumps, etc., are to be provided with means to prevent oil spillage, for instance, drip trays fitted below the equipment for collecting oil leakage and draining it to a sludge tank. The above-mentioned equipment is to be centralized as far as practicable in a special space.

(3) The high pressure fuel oil pipelines are to be screened or otherwise suitably protected to prevent leaks from dripping or spraying onto hot surfaces or into machinery air intakes, for instance, the fitting of metal sheathing to the high pressure fuel injection pipes of diesel engines.

(4) Leakage from high pressure fuel pipes are to be, as far as practicable, collected and led to a collector tank(s) fitted in a safe position and arrangements are to be provided for an alarm to be given in the event of leakage, see Table 3.10.1.1 of this Chapter.

(5) Fuel oil or lubricating oil heaters are to comply with the following:

① high temperature alarm is to be provided;

② in addition to the temperature control, an independent safeguard is to be fitted which will automatically cut off the heating supply in the event of excessively high temperatures or loss of flow, except where the maximum temperature of the heating media remains limited to a value below 220℃;

③ where electric heaters are adopted, an independent safeguard is to be fitted which will automatically cut off the heating supply in the event of excessively high temperatures, except that all live heating components are soaked in oil and the surface temperature of the heating components remains below 220℃.

3.9.1.3 Special requirements for fire detection systems

(1) An automatic fire detection system is to be fitted in the machinery spaces.

(2) The system is to be designed with self-monitoring properties. Power or system failures are to initiate an audible alarm distinguishable from the fire alarm.

(3) The fire detection indicating panel is to be located on the navigation bridge, fire control station, or other accessible place where a fire in the machinery space will not render it inoperative.

(4) The fire detection indicating panel is to indicate the place of the detected fire in accordance with the arranged fire zones by means of a visual signal. Audible signals clearly distinguishable in character from any other audible signals are to be audible throughout the navigation bridge and the accommodation area of the personnel responsible for the operation of the machinery space.

(5) Fire detectors are to be of such types, and so located, that they will rapidly detect the onset of fire in conditions normally present in the machinery space. Consideration is to be given to avoiding false alarms. The type and location of detectors are to comply with the relevant requirements of the International Convention for the Safety of Life at Sea, 1974 (hereinafter referred to as SOLAS Convention) and the International Code for Fire Safety Systems (hereinafter referred to as FSS Code) and a combination of detector types is recommended in order to enable the system to react to more than one type of fire symptom.

(6) Fire detector zones are to be arranged in a manner that will enable the operating staff to locate the seat of the fire. The arrangement and the number of loops and the location of detector heads are to comply with the relevant requirements of SOLAS Convention and FSS Code. Air currents created by the machinery are not to render the detection system ineffective.

(7) When fire detectors are provided with the means to adjust their sensitivity, necessary arrangements are to be ensured to fix and identify the set point.

(8) When it is intended that a particular loop or detector is to be temporarily switched off, this state is to be clearly indicated. Reactivation of the loop or detector is to be performed automatically after a preset time.

(9) The fire detection indicating panel is to be provided with facilities for functional testing.

(10) The fire detection system is to be fed automatically from the emergency source of power if the main source of power fails, and to comply with the requirements of 2.9.6 of PART FOUR.

(11) Facilities are to be provided in the fire detection system to release manually the fire alarm from the passageways having entrances to engine and boiler rooms, navigation bridge and control station in engine room.

(12) The fire detection system is to be tested upon installation on board to confirm compliance with the rule requirements for function.

3.9.2 Protection against flooding

3.9.2.1 An alarm system is to be provided to warn high bilge water level in machinery spaces. The alarm level is to be sufficiently low to prevent liquid overflowing from the bilge onto the tank top of double bottom tanks.

3.9.2.2 The number and location of bilge water level detectors are to be such as to prevent false alarms at normal angles of trim and heel.

3.9.2.3 The location of the controls of any valve serving a sea inlet, a discharge below the waterline or a bilge injection system, for controlling flooding upon damage, is to be such as to allow adequate time for operation in case of influx of water to the space, having regard to at least 10 min which could be required to reach and close the valve. Arrangements are to be made to operate the controls from a position above the level to which the space could become flooded due to any broken pipe with the ship being in the fully loaded condition.

3.9.2.4 Bilge wells are to be large enough to accommodate normal drainage during the unattended period. Where the bilge pumps are arranged to start automatically, smaller bilge wells may be permitted to accommodate the normal drainage for a suitable time, provided that an alarm is provided to indicate if the influx of liquid is greater than the pump capacity or if the pump is operating more frequently than would normally be expected and that the discharge complies with the relevant requirements for pollution prevention. The items to be controlled and monitored are indicated in Table 3.10.1.1 of this Chapter as appropriate.

3.9.2.5 Alarms required by 3.9.2.1 and 3.9.2.4 above are to be given at the CCS, BCS and engineers' accommodation area.

Section 10 AUTOMATIC CONTROL AND MONITORING ITEMS

3.10.1 Table of automatic control and monitoring items

3.10.1.1 The automatic control and monitoring items (if fitted) for all ships with the class notation AUT-0 are to comply with Table 3.10.1.1.

3.10.1.2 The designations used in Table 3.10.1.1 of this Section are defined as follows:

–: not required;
*: only required for trunk piston diesel engines;
a: Mode a protective action, such as emergency shutdown of the engine, fuel oil cutoff of boiler and cutoff of electric power supply, etc.;
b: Mode b protective action, such as reducing the speed of rotation or the output of machinery;
c: Mode c protective action, such as starting and putting into operation of standby pump or standby unit;
S: single alarm;
G_a: group alarm activated by Mode a protective action;
G_b: group alarm activated by Mode b protective action;
R: group alarm for serious faults;
Y: group alarm for general faults.

3.10.1.3 Where "per cylinder" appears in the column "Remarks" of Table 3.10.1.1 of this Section, it applies only to crosshead diesel engines, and for trunk piston diesel engines, "fitted on manifold outlet" may be used to replace the "per cylinder".

3.10.1.4 For the equipment marked with "▲" in Table 3.10.1.1 of this Section, if all of the single alarms and display items provided locally or in the vicinity of the engine are confirmed by CCS, the engine room central control station and the BCS may be exempted from the single alarms and display items as required in Table 3.10.1.1. Only one group alarm for general faults and one fault display are to be provided in this case.

Automatic Control and Monitoring Items for Ships with Class Notation AUT-0

Table 3.10.1.1

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
1. Main diesel engine **1.1 Fuel oil system**					
Fuel oil inlet pressure	Pressure	Low	c	*R*	Fitted after filter
Fuel oil temperature or viscosity (before injection pumps)	Temp. or viscosity	Low and high	–	*Y*	Only for heavy oil
Leakage from high pressure fuel pipes	–	Leakage	–	*Y*	
Level of fuel oil in daily service tanks	–	Low	–	*Y*	High-level alarm also required, if no suitable overflow arrangement provided
Common rail fuel oil pressure	–	Low	–	*Y*	
1.2 Lubricating oil system					
Lub-oil inlet pressure to main bearing & thrust bearing	Pressure	Low	c	*R*	
			b	G_b	Necessary for crosshead diesel engines
		Excessively low	a	G_a	
Lub-oil inlet pressure to crosshead bearing	Pressure	Low	c	*R*	Required if separate lub-oil system installed for crosshead diesel engines
			b	G_b	
		Excessively low	a	G_a	
Lub-oil inlet pressure to camshaft	Pressure	Low	c	*R*	
		Excessively low	a	G_a	
Lub-oil inlet temperature to camshaft	Temp.	High	–	*Y*	
*Lub-oil filter differential pressure	Pressure	Great	–	*Y*	
Lub-oil inlet temperature	Temp.	High	–	*Y*	

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
Thrust bearing pad temperature or bearing temperature	Temp.	High	b	G_b	Necessary for crosshead diesel engines
		Excessively high	a	G_a	
Main, crank, crosshead bearing oil outlet temperature or oil mist concentration in crankcase	–	High	b	G_b	Applicable to low speed diesel engines specified in 9.7.6, Ch.9, Pt.3
*Oil mist concentration in crankcase	–	High	a	G_a	Applicable to medium and high speed diesel engines specified in 9.7.6, Ch.9, Pt.3; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Flow rate of cylinder lubricator (each apparatus)	–	Small	b	G_b	Required for trunk piston diesel engines if necessary for safe operation of the engines
Oil level in lub-oil circulating tank	–	Low	–	*Y*	Necessary for crosshead diesel engines; individual level alarms required for the tanks if separate lub-oil systems installed (e.g. camshaft, rocker arms, etc.) for crosshead diesel engines
Common rail servo oil pressure	–	Low	–	*Y*	
1.3 Turbocharger system					
Turbocharger lub-oil inlet pressure	Pressure	Low	–	*Y*	Unless provided with a self-contained lubricating oil system integrated with the turbocharger
Turbocharger lub-oil outlet temp each bearing	Temp	High	–	*Y*	Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design, alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
Speed of turbocharger	Speed	–	–	–	Necessary for crosshead diesel engines
1.4 Piston cooling system (Necessary for crosshead diesel engines)					
Piston coolant inlet pressure	Pressure	Low	c	*Y*	The slowdown is not required if the coolant oil taken from the main cooling system of the engine
		Excessively low	b	G_b	
Piston coolant outlet flow	–	Low	b	G_b	Per cylinder; where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted
Piston coolant outlet temperature	Temp.	High	b	G_b	Per cylinder

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
Level of piston coolant in expansion tank	–	Low	–	*Y*	
1.5 Seawater cooling system					
Pressure of cooling seawater	Pressure	Low	c	*Y*	
1.6 Cylinder fresh cooling water system					
Cylinder water inlet pressure or flow	Pressure or flow	Low	c	*Y*	Only cylinder coolant inlet pressure required for crosshead diesel engines
		Excessively low	b	G_b	
Cylinder water outlet temperature (from each cylinder) Cylinder water outlet temperature (general)	Temp.	High	b	G_b	Required for crosshead diesel engines where one common cooling space without individual stop valves is employed for all cylinder jackets. For trunk piston diesel engines, alarm and slowdown only for cylinder water outlet temperature (general) and two separate sensors required
Oily contamination of main engine cooling water system	–	Contaminated	–	–	Necessary for crosshead diesel engines; required where main engine cooling water is used in fuel and lubricating oil heat exchangers
Level of cylinder cooling water in expansion tank	–	Low	–	*Y*	
1.7 Starting and control air systems					
Starting air pressure before main shut-off valve	Pressure	Low	–	*S*	
Control air pressure	Pressure	Low	–	*S*	
Safety air pressure	Pressure	Low	–	*S*	Necessary for crosshead diesel engines
1.8 Scavenge air system					
Scavenge air receiver pressure	Pressure	–	–	–	Necessary for crosshead diesel engines
Scavenge air box temperature (fire)	Temp.	High	b	G_b	
Scavenge air receiver water level	–	High	–	*Y*	
*Scavenge air receiver temperature	Temp.	High	–	*Y*	
1.9 Exhaust gas system					
Exhaust gas temp. after each cylinder	Temp.	High	b	G_b	For trunk piston diesel engines having a power of more than 500 kW per cylinder only
Exhaust gas temperature after each cylinder. Deviation from average	–	Great	–	*R*	
Exhaust gas temperature before each turbocharger	Temp.	High	–	*R*	Necessary for crosshead diesel engines
Exhaust gas temperature after each turbocharger	Temp.	High	–	*R*	
1.10 Fuel valve coolant					
Pressure of fuel valve coolant	Pressure	Low	c	*R*	The requirement is to be complied with if the crosshead diesel engine is fitted with a separate fuel valve cooling system
Temperature of fuel valve coolant	Temp.	High	–	*Y*	
Level of fuel valve coolant in expansion tank	–	Low	–	*Y*	
1.11 Engine speed/direction of rotation					
Speed	Speed	Overspeed	a	G_a	
Direction of rotation	Direction of rotation	Wrong way	–	*S*	Necessary for crosshead diesel engines
1.12 Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
	hydraulic pressure				
2 Auxiliary diesel engines▲					
Lub-oil inlet pressure	Pressure	Low	–	*Y*	
		Excessively low	a		
Fuel oil temperature or viscosity (before injection pumps)	Temp. or viscosity	Low or high	–	*Y*	Only for heavy oil
Exhaust gas temp. after each cylinder	Temp.	High	–	*Y*	For engine power > 500 kW per cylinder only
Lub-oil inlet temperature	–	High	–	*Y*	
Temperature of cooling water or cooling air outlet	Temp.	High	–	*Y*	
Pressure or flow of cooling water	–	Low	–	*Y*	
Speed	–	Overspeed	a	*Y*	
Starting air pressure	Pressure	Low	–	*Y*	
Fuel oil leakage from pressure pipes	–	Leakage	–	*Y*	
Oil mist concentration in crankcase	–	High	a	*Y*	Applicable to diesel engines specified in 9.7.6, Ch.9, Pt.3; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Level in fuel oil daily service tank	–	Low	–	*Y*	
Level in cooling water expansion tank	–	Low	–	*Y*	If not connected to main system
Common rail fuel oil pressure	–	Low	–	*Y*	
Common rail servo oil pressure	–	Low	–	*Y*	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp
3 Electric generating plant▲					
Bus bar voltage	Voltage	High and low	–	*Y*	
Bus bar frequency	Frequency	High and low	–	*Y*	
Load shedding	–	When in operation	–	*Y*	
Automatic switch-on of circuit breaker	–	Failure	–	*Y*	
Tripping of automatic circuit breaker	–	When in operation	–	*Y*	
Failure of load distribution	–	Failure		*Y*	Fitted if automatic load distribution is adopted
4 Main gas turbines					
Lub-oil inlet pressure to gas turbine and gearing	Pressure	Low	c	*R*	
		Excessively low	a	G_a	
Lub-oil inlet temperature to gas turbine and gearing	Temp.	High	–	*Y*	
Lub-oil filter differential pressure	–	Great	c	*Y*	
Oil level in lub-oil circulating tank	–	Low	–	*Y*	For gravity and circulating oil tanks

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
Turbine main bearing temperature	Temp.	High	–	*Y*	
Coolant pressure or flow	–	Low	–	*Y*	
Coolant temperature	Temp.	High	–	*Y*	
Fuel oil temperature or viscosity	Temp. or viscosity	Low or high	–	*Y*	Only for heavy oil
Fuel oil pressure or flow	Pressure or flow	Low	c	*Y*	
Level in fuel oil daily service tank	–	Low	–	*Y*	When it is replenished automatically, high and low level alarms are to be fitted
Gas inlet or outlet temperature of turbine	Temp.	High	–	*Y*	
		Excessively high	a	G_a	
Deviation of exhaust gas temperature from average	–	High	–	*Y*	
Gas turbine combustion chamber flame and ignition	–	Failure	a	G_a	
Gas turbine vibration	–	High	–	*Y*	
		Excessively high	a	G_a	
Axial displacement of turbine rotor	–	Great	–	*R*	
Turbine speed	–	Overspeed	a	G_a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp
5 Auxiliary gas turbines▲					
Lub-oil inlet pressure for turbine and gearing	Pressure	Low	–	*Y*	
		Excessively low	a		
Exhaust gas temperature	Temp.	High	a	*Y*	
Combustion chamber flame	–	Extinguished	a	*Y*	
Gas turbine vibration	–	Excessive	a	*Y*	
Gas turbine speed	–	Overspeed	a	*Y*	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp
6 Main steam turbines					
Lub-oil inlet pressure for turbine and gearing	Pressure	Low	c	*R*	
		Excessively low	a	G_a	
Lub-oil inlet temperature for turbine and gearing	Temp.	High	–	*Y*	
Lub-oil filter differential pressure	–	Great	–	*Y*	
Level of lub-oil tank	–	Low	–	*Y*	For gravity and circulating oil tanks
Bearing temperature or bearing lub-oil outlet temperature of turbine and gearing	Temp.	High	–	*Y*	
Thrust bearing temperature or lub-oil outlet temperature	–	High	–	*Y*	
Astern turbine exhaust steam temperature	Temp.	High	–	*Y*	
Gland steam pressure	Pressure	High and low	–	*Y*	
Circulating seawater pressure or flow	Pressure	Low	c	*Y*	

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
	or flow				
Main condenser vacuum	Vacuum	Low	b	G_b	
Main condenser condensate level	–	High and low	b	G_b	
Condensate pump	–	Stop/failure	–	*Y*	
Condensate salinity	–	High	–	*Y*	
Steam turbine vibration	–	Excessive	b	G_b	
Axial displacement of turbine rotor	–	Excessive	a	G_a	
Turbine speed	–	Overspeed	a	G_a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp
7 Auxiliary steam turbines▲					
Lub-oil inlet temperature for turbine and gearing	–	High	–	*Y*	
Lub-oil inlet pressure for turbine and gearing	Pressure	Low	–	*Y*	
		Excessively low	a		
Condenser vacuum	–	Low	a	*Y*	
Axial displacement of turbine rotor	–	Excessive	a	*Y*	
Turbine speed	–	Overspeed	a	*Y*	
Power supply for control-safety-alarm systems (electric, pneumatic, hydraulic)	Electric, pneumatic and hydraulic pressure	Loss	—	*Y*	Indication of voltage may be replaced by indicating lamp
8 Main steam boilers					
Steam drum or superheater outlet pressure	Pressure	High and low	–	*R*	
Superheated steam outlet temperature	Temp.	High	–	*R*	
De-superheated steam outlet temperature	Temp.	High	–	*R*	
Boiler feed water level	Level	High	–	*R*	At least 3 sensors fitted. See 3.3.1.2(1)② and 3.3.1.3(1)② of this Chapter
		Low	c	*R*	
		Excessively low	a	G_a	
Temperature or viscosity of oil fuel to burners	Temp. or viscosity	Low or high	–	*Y*	Only for heavy oil Protective action with cutoff of boiler fuel oil supply in case of excessively high temperature or excessively low viscosity may be carried out by cutoff of fuel oil heating supply
		Excessively low or high	a	G_a	
Fuel oil pressure to burners	Pressure	Low	c	*Y*	See 3.3.1.3(3) of this Chapter
Forced draft pressure	Pressure	Loss	a	G_a	2 sensors fitted
Burner flame and ignition	–	Extinguished / ignition failure	a	G_a	Each burner is to be monitored
Fuel oil atomizing steam (air) pressure	Pressure	Low	–	*Y*	
Feed pump discharge pressure or flow	Pressure or flow	Low	c	*R*	See 3.3.1.3(4) of this Chapter
Feed water forced circulation flow	Flow	Low	a	G_a	Required for forced circulating boilers only
Level of feed water tank	–	Low	–	*Y*	Required for daily feed water

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
					tanks only
Feed water salinity	–	High	–	*Y*	
Water level of deaerator	–	High and low	–	*Y*	
Boiler air supply casing and exhaust pipe (smoke uptake)	–	Fire	–	*Y*	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp
9 Auxiliary steam boilers▲					
Steam drum or superheater outlet pressure	Pressure	Low	–	*Y*	
Boiler feed water level	–	High	–	*Y*	See 3.3.2.3, 3.3.1.2(1)② and 3.3.1.3(1)② of this Chapter
		Low	c	*Y*	
		Excessively low	a	*Y*	
Temperature or viscosity of oil fuel to burners	Temp. or viscosity	Low or high	–	*Y*	Only for heavy oil Protective action with cutoff of boiler fuel oil supply in case of excessively high temperature or excessively low viscosity may be carried out by cutoff of fuel oil heating supply
		Excessively low or high	a	*Y*	
Fuel oil pressure to burners	Pressure	Low	c	*Y*	See 3.3.1.3(3) of this Chapter
Forced draft pressure	–	Loss	a	*Y*	
Burner flame and ignition	–	Extinguished / ignition failure	a	*Y*	
Feed water salinity	–	High	–	*Y*	Only applicable to auxiliary steam boiler for driving turbine-generator set
Boiler air supply casing and exhaust pipe (smoke uptake)	–	Fire	–	*Y*	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp
10 Controllable pitch propeller					
Pitch or blade angle of controllable pitch propeller	Pitch or blade angle	—	—	—	See 2.8.1.11 of this PART
Propeller shaft speed	Speed	—	—	—	See 2.8.1.11 of this PART
Hydraulic system pressure for controlling propeller pitch	Pressure	Low	c	*S*	
Hydraulic oil tank level	–	Low	–	*Y*	
Hydraulic oil temp. (if oil cooler is fitted)	–	High	–	*Y*	
Electric power supply for electrohydraulic control system	Voltage	Loss	–	*Y*	
11 Vibration damper					
Oil inlet pressure or amplitude for vibration damper	Pressure or amplitude	Low or great	–	*Y*	See 3.2.2.5 of this Chapter and 12.1.4.3, Chapter 12, PART THREE of the Rules
12 Gearbox (for main propulsion machinery)					
Lub-oil inlet pressure of gearbox	Pressure	Low	c	*R*	

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
		Excessively low	a	G_a	
Lub-oil inlet temperature of gearbox	Temp.	High	–	*Y*	
Gear oil pressure	Pressure	Low	–	*Y*	
13 Clutches					
Clutch position	Position	–	–	–	
Power supply for control of clutches (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	See 2.8.1.11 of this PART
14 Stern tube bearing					
Oil lubricated stern tube bearing temp.	–	High	–	*Y*	
Level of stern tube lubricating oil tank	–	Low	–	*Y*	
15 Exhaust gas boilers					
Circulating feed pump outlet pressure or flow	Pressure or flow	Low	c	*Y*	Only applicable to water tube exhaust gas boiler with forced circulation
Fire in exhaust gas pipelines	–	Fire	–	*Y*	
Steam pressure	Pressure	High	–	*Y*	
16 Air compressors▲					
Air compressor lubricating oil pressure	–	Low	a	*Y*	Except for splash lubrication
17 Thermal oil heaters▲					
(1) Oil-fired					
Thermal oil expansion tank level	–	Low	a	*Y*	
Thermal oil flow or pressure	–	Low	a	*Y*	
Thermal oil outlet temperature	–	High	a	*Y*	
Combustion air pressure or forced ventilation	–	Low or shutoff	a	*Y*	
Fuel oil pressure	—	Excessively low	c	*Y*	
Fuel oil temperature or viscosity	—	Low and high	—	*Y*	Only for heavy oil
Uptake temperature	–	High	a	*Y*	
Burner flame and ignition	–	Extinguished / ignition failure	a	*Y*	Each burner is to be monitored
(2) Exhaust-fired					
Thermal oil expansion tank level	–	Low	a	*Y*	
Thermal oil flow or pressure	–	Low	a	*Y*	
Thermal oil outlet temperature	–	High	a	*Y*	
Exhaust temperature	–	High	–	*Y*	
18 Computer systems					
Computers under operating status	–	Failure	c	*R*	
Computer systems	–	Failure	–	*R*	Including ineffectiveness of local area network control, overload of local area network, running stop due to overflow, etc.
Electrical power of computer systems	Voltage	Failure	–	*Y*	Indication of voltage may be replaced by indicating lamp
19 Oil purifier▲					
Purifier oil outlet pressure	Pressure	Low	–	*Y*	
Purifier oil inlet temperature	–	High	–	*Y*	

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
20 Sludge tank					
Level of sludge tank	–	High	–	*Y*	
21 Bilge					
Bilge level	–	High	–	*S*	See 3.9.2.1 of this Chapter
Bilge pumps	Indication for operation time	Too long or more frequently	–	*Y*	For automatically controlled bilge pumps only, see 3.9.2.4 of this Chapter
22 Incinerator▲ (only for unattended operation during incinerating)					
Fuel oil viscosity or temperature	–	Low or high	–	*Y*	Only for heavy oil
Fuel oil pressure	–	Low	–	*Y*	
Combustion air pressure	–	Low	a	*Y*	
Burner flame and ignition	–	Extinguished / ignition failure	a	*Y*	
Furnace temperature	–	High	a	*Y*	
Exhaust gas temperature	–	High	–	*Y*	
23 Diesel engines driving propulsion generators					
Fuel oil inlet pressure	Pressure	Low	c	*R*	Fitted after filter
Fuel oil temperature or viscosity (before injection pumps)	Temp. or viscosity	Low or high	–	*Y*	Only for heavy oil
High pressure fuel pipes	–	Leakage	–	*Y*	
Level of fuel oil in daily service tank	–	Low	–	*Y*	
Common rail fuel oil pressure	–	Low	–	*Y*	
Common rail servo oil pressure	–	Low	–	*Y*	
Lub-oil inlet pressure	Pressure	Low	c	*R*	
		Excessively low	a	G_a	
Lub-oil filter differential pressure	Pressure	Great	–	*Y*	
Lub-oil inlet temperature	–	High	–	*Y*	
Oil mist concentration in crankcase	–	High	a	*S*	Applicable to diesel engines specified in 9.7.6, Ch.9, Pt.3; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Flow rate of cylinder lubricator. Each apparatus	–	Small	–	*Y*	Required if necessary for safe operation of the engines
Pressure of cooling seawater	Pressure	Low	c	*R*	
Cylinder cooling water pressure or flow	Pressure or flow	Low	c	*R*	
Cylinder cooling water outlet temperature	Temp.	High	–	*Y*	
Level of cylinder cooling water in expansion tank	–	Low	–	*Y*	
Starting air pressure	Pressure	Low	–	*S*	
Control air pressure	Pressure	Low	–	*S*	
Exhaust gas temp. after each cylinder	Temp.	High	–	*Y*	For diesel engines having a power of more than 500 kW per cylinder only
Speed	–	Overspeed	a	G_a	
Power supply for control-safety-alarm systems (electrical, pneumatic	Electrical, pneumatic	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
and hydraulic pressure)	and hydraulic pressure				
24 Gas turbines driving propulsion generators					
Fuel oil pressure or flow	Pressure or flow	Low	c	*R*	
Fuel oil temperature or viscosity	Temp. or viscosity	Low or high	–	*Y*	Only for heavy oil
Lub-oil inlet pressure to gas turbine and gearing	Pressure	Low	c	*R*	
		Excessively low	a	G_a	
Lub-oil inlet temperature to gas turbine and gearing	Temp.	High	–	*Y*	
Turbine main bearing temperature	Temp.	High	–	*Y*	
Lub-oil filter differential pressure	–	Great	–	*Y*	
Level in lub-oil circulating tank	–	Low	–	*Y*	For gravity and circulating oil tanks
Coolant pressure or flow	–	Low	–	*Y*	
Coolant temperature	Temp.	High	–	*Y*	
Level in fuel oil tank for ignition and starting	–	Low	–	*S*	When it is replenished automatically, high and low level alarms are to be fitted
Gas turbine ignition	–	Failure	a	G_a	
Combustion chamber flame	–	Extinguished	a	G_a	
Exhaust gas temperature	Temp.	High	a	G_a	
Gas turbine vibration	–	Excessive	a	G_a	
Axial displacement of turbine rotor	–	Great	a	G_a	Automatic shutdown not required if fitted with roller bearings
Gas turbine speed	–	Overspeed	a	G_a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp
25 Miscellaneous					
Overriding function	–	When overriding is initiated	–	*S*	
Controlled environmental conditions	–	Abnormal	–	*Y*	Where controlled environment is required for equipment, this requirement is to be complied with
Automatic systems	–	Failure	–	*Y*	Including electric power fault

CHAPTER 4 REQUIREMENTS FOR MACHINERY NOTATIONS OF CONSTANTLY ATTENDED MACHINERY SPACES

Section 1 GENERAL PROVISIONS

4.1.1 Application

4.1.1.1 This Chapter applies to ships with machinery spaces (including the CCS) constantly attended by watch-keepers, and intended to be assigned machinery notations MCC and/or BRC.

4.1.1.2 In addition to this Chapter, ships intended to be assigned the above-mentioned machinery notations are to comply with the applicable requirements of Chapters 1 and 2 of this PART.

Section 2 REQUIREMENTS FOR AUTOMATION OF SHIPS WITH CLASS NOTATION MCC

4.2.1 Provision of control stations (rooms)

4.2.1.1 Ships with the class notation MCC are to be provided with the CCS and the LCS. When the machinery and electrical equipment are in normal operation, the CCS is to be constantly attended by watch-keepers.

4.2.2 Functions of the CCS

4.2.2.1 The control and monitoring functions of the CCS is to be in compliance with the following requirements:

(1) The starting, speed regulating, reversing (including shaft reversing) and stopping as well as blade angle (or pitches) of the main propulsion machinery are to be capable of being remotely controlled or automatically, sequentially controlled from the CCS. When necessary, the control is to be capable of being changed over to other control stations (rooms) at any time and the changeover is to comply with the relevant requirements of 2.5.2 in this PART. In addition, the other machinery and electrical equipment mentioned in 3.1.1.4 of this PART are to be controlled and monitored automatically.

(2) The design and arrangement of centralized control station of engine room are to comply with the following requirements:

① in principle, the remote control from the CCS to main propulsion machinery is to be performed by a single control device for each independent propeller, with automatic performance of all associated services including, where necessary, means of preventing overload and prolonged running in critical speed ranges of the propelling machinery;

② the control system of the CCS is to be independent from the other communication system, however, one control lever for both systems may be accepted;

③ operations following any setting of the CCS including reversing from the maximum ahead service speed in case of emergency are to take place in an automatic sequence and within time intervals acceptable to the machinery;

④ remote starting of the propulsion machinery in the CCS is to be automatically inhibited if conditions exist which may hazard the machinery, e.g., shaft turning gear engaged, drop of lubricating oil pressure;

⑤ the design of the control system in the CCS is to be such that in case of its failure an alarm is given. In this case, the speed and direction of the propeller are to be maintained until local control is in operation, unless this is considered impracticable. In particular, lack of power (electric, pneumatic, hydraulic) or changeover of control is not to lead to major and sudden change in propulsion power or propulsion direction.

(3) Instruments and display units are to be provided at the CCS to indicate the essential parameters for ensuring the safe and reliable operation of the machinery and electrical equipment. The items to be displayed are given in column 2 of Table 4.2.6.1 of this Chapter.

(4) All faults, including several faults occurred at the same time in the machinery and electrical equipment and in the control and monitoring systems are to be capable of being alarmed at the CCS. The items to be alarmed are given in column 3 of Table 4.2.6.1 of this Chapter.

(5) Audible alarms at the CCS are to be capable of being silenced only after being acknowledged at the station.

(6) The emergency button for stopping the main propulsion machinery and the emergency button for cutting off oil supply to boilers are to be provided at the CCS and independent of the control system, but their actuating units may not be independent, and are to be so arranged as to preclude inadvertent touching.

(7) Where overriding function is provided for the main engine, such function is also to be provided at the CCS, and is to be so arranged as to preclude inadvertent touching.

4.2.2.2 The functions of automatic and remote control of all the machinery and electrical equipment specified in 3.1.1.4 of this PART are to be, in general, in compliance with the requirements of Sections 2, 3, 5 and 6 of Chapter 3 of this PART. However, the intervention of some control processes by the attendant in the CCS is permitted, provided that the attendant is competent to perform such control, such as the employment of remote control to substitute some items in the automatic control.

4.2.2.3 For the safety system, Mode a protective action is to be carried out automatically, Modes b and c protective actions may be carried out automatically or by manual operation in the CCS.

4.2.3 Functions of the local control station (LCS)

4.2.3.1 The LCS is to comply with the requirements of 2.5.1.5 of this PART.

4.2.4 Fire precautions

4.2.4.1 The fire precautions are in general to comply with the requirements for fire detection and fire alarm systems in 3.9.1.1 of this PART (the areas of an engine room which can be seen from the CCS may be exempted from the required sensors) and the requirements in 3.9.1.2 (except (4)) of this PART.

4.2.5 Protection against flooding

4.2.5.1 A bilge high level alarm system is to be provided.

4.2.5.2 The overboard discharge of bilge is to comply with the relevant requirements for pollution prevention.

4.2.6 Table of automatic control and monitoring items

4.2.6.1 The automatic control and monitoring items (if fitted) for all ships with the class notation MCC are to comply with Table 4.2.6.1.

4.2.6.2 The designations used in Table 4.2.6.1 of this Section are defined as follows:

−: not required;

*: only required for trunk piston diesel engines;

a: Mode a protective action, such as emergency shutdown of the engine, fuel oil cutoff of boiler and cutoff of electric power supply, etc.;

b: Mode b protective action, such as reducing the speed of rotation or the output of machinery;

c: Mode c protective action, such as starting and putting into operation of standby pump or standby unit.

4.2.6.3 Where “per cylinder” appears in the column “Remarks” of Table 4.2.6.1 of this Section, it applies only to crosshead diesel engines, and for trunk piston diesel engines, “fitted on manifold outlet” may be used to replace “per cylinder”.

4.2.6.4 For the equipment marked with “▲” in Table 4.2.6.1 of this Section, if all of the single alarms and display items provided locally or in the vicinity of the engine are confirmed by CCS, the engine room central control station may be exempted from the single alarms and display items as required in Table 4.2.6.1. Only one group alarm for general faults and one fault display are to be provided in this case.

Automatic Control and Monitoring Items for Ships with Class Notation MCC

Table 4.2.6.1

Item	CCS		Mode of protective control action	Remarks
	Display	Limit alarm		
1	2	3	4	5
1 Main diesel engine **1.1 Fuel oil system**				
Fuel oil inlet pressure	Pressure	Low	c	Fitted after filter
Fuel oil temperature or viscosity (before injection pumps)	Temp. or viscosity	Low or high	–	Only for heavy oil
Leakage from high pressure fuel pipes	–	Leakage	–	
Level of fuel oil in daily service tanks	–	Low	–	High-level alarm also required, if no suitable overflow arrangement provided
Common rail fuel oil pressure	–	Low	–	

Item	CCS		Mode of protective control action	Remarks
	Display	Limit alarm		
1	2	3	4	5
1.2 Lubricating oil system				
Lub-oil inlet pressure to main bearing & thrust bearing	Pressure	Low	c	
			b	Necessary for crosshead diesel engines
		Excessively low	a	
Lub-oil inlet pressure to crosshead bearing	Pressure	Low	c	Required if separate lub-oil system installed for crosshead diesel engines
			b	
		Excessively low	a	
Lub-oil inlet pressure to camshaft	Pressure	Low	c	
		Excessively low	a	
Lub-oil inlet temperature to camshaft	Temperature	High	–	
*Lub-oil filter differential pressure	Pressure	Great	–	
Lub-oil inlet temperature	Temperature	High	–	
Thrust bearing pad temperature or bearing temperature	Temperature	High	b	Necessary for crosshead diesel engines
		Excessively high	a	
Main, crank, crosshead bearing oil outlet temperature or oil mist concentration in crankcase	–	High	b	Applicable to low speed diesel engines specified in 9.7.6, Ch.9, Pt.3
*Oil mist concentration in crankcase	–	High	a	Applicable to medium and high speed diesel engines specified in 9.7.6, Ch.9, Pt.3; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Flow rate of cylinder lubricator. Each apparatus	–	Small	b	Required for trunk piston diesel engines if necessary for safe operation of the engines
Oil level in lub-oil circulating tank	–	Low	–	Necessary for crosshead diesel engines; individual level alarms required for the tanks if separate lub-oil systems installed (e.g. camshaft, rocker arms, etc.) for crosshead diesel engines
Common rail servo oil pressure	–	Low	–	
1.3 Turbocharger system				
Turbocharger lub-oil inlet pressure	Pressure	Low	–	Unless provided with a self-contained lubricating oil system integrated with the turbocharger
Turbocharger lub-oil outlet temp each bearing	Temp	High	–	Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design, alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative
Speed of turbocharger	Speed	–	–	Necessary for crosshead diesel engines

Item	CCS		Mode of protective control action	Remarks
	Display	Limit alarm		
1	2	3	4	5
1.4 Piston cooling system (Necessary for crosshead diesel engines)				
Piston coolant inlet pressure	Pressure	Low	c	The slowdown is not required if the coolant oil taken from the main cooling system of the engine
		Excessively low	b	
Piston coolant outlet flow	–	Low	b	Per cylinder; where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted
Piston coolant outlet temperature	Temp.	High	b	Per cylinder
Level of piston coolant in expansion tank	–	Low	–	
1.5 Seawater cooling system				
Pressure of cooling seawater	Pressure	Low	c	
1.6 Cylinder fresh cooling water system				
Cylinder water inlet pressure or flow	Pressure or flow	Low	c	Only cylinder coolant inlet pressure required for crosshead diesel engines
		Excessively low	b	
Cylinder water outlet temperature (from each cylinder) Cylinder water outlet temperature (general)	Temperature	High	b	Required for crosshead diesel engines where one common cooling space without individual stop valves is employed for all cylinder jackets. For trunk piston diesel engines, alarm and slowdown only for cylinder water outlet temperature (general) and two separate sensors required
Oily contamination of main engine cooling water system	–	Contaminated	–	Necessary for crosshead diesel engines; required where main engine cooling water is used in fuel and lubricating oil heat exchangers
Level of cylinder cooling water in expansion tank	–	Low	–	
1.7 Starting and control air systems				
Starting air pressure before main shut-off valve	Pressure	Low	–	
Control air pressure	Pressure	Low	–	
Safety air pressure	Pressure	Low	–	Necessary for crosshead diesel engines
1.8 Scavenge air system				
Scavenge air receiver pressure	Pressure	–	–	Necessary for crosshead diesel engines
Scavenge air box temperature (fire)	Temperature	High	b	
Scavenge air receiver water level	–	High	–	
*Scavenge air receiver temperature	Temperature	High	–	
1.9 Exhaust gas system				
Exhaust gas temp. after each cylinder	Temperature	High	b	For trunk piston diesel engines having a power of more than 500 kW per cylinder only
Exhaust gas temperature after each cylinder. Deviation from average	–	Great	–	
Exhaust gas temperature before each turbocharger	Temperature	High	–	Necessary for crosshead diesel engines
Exhaust gas temperature after each turbocharger	Temperature	High	–	
1.10 Fuel valve coolant				
Pressure of fuel valve coolant	Pressure	Low	c	The requirement is to be complied with if the crosshead diesel engine is fitted with a separate fuel valve cooling system
Temperature of fuel valve coolant	Temperature	High	–	
Level of fuel valve coolant in expansion tank	–	Low	–	

Item	CCS		Mode of protective control action	Remarks
	Display	Limit alarm		
1	2	3	4	5
1.11 Engine speed/direction of rotation				
Speed	Speed	Overspeed	a	
Direction of rotation	Direction of rotation	Wrong way	–	Necessary for crosshead diesel engines
1.12 Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	Indication of voltage may be replaced by indicating lamp
2 Auxiliary diesel engines▲				
Lub-oil inlet pressure	Pressure	Low	–	
		Excessively low	a	
Fuel oil temperature or viscosity (before injection pumps)	Temperature or viscosity	Low or high	–	Only for heavy oil
Exhaust gas temp. after each cylinder	Temperature	High	–	For engine power > 500 kW per cylinder only
Lub-oil inlet temperature	–	High	–	
Temperature of cooling water or cooling air outlet	Temperature	High	–	
Pressure or flow of cooling water	–	Low	–	
Speed	–	Overspeed	a	
Starting air pressure	Pressure	Low	–	
Fuel oil leakage from pressure pipes	–	Leakage	–	
Oil mist concentration in crankcase	–	High	a	Applicable to diesel engines specified in 9.7.6, Ch.9, Pt.3; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Level in fuel oil daily service tank	–	Low	–	
Level in cooling water expansion tank	–	Low	–	If not connected to main system
Common rail fuel oil pressure	–	Low	–	
Common rail servo oil pressure	–	Low	–	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	Indication of voltage may be replaced by indicating lamp
3 Main gas turbines				
Lub-oil inlet pressure to gas turbine and gearing	Pressure	Low	c	
		Excessively low	a	
Lub-oil inlet temperature to gas turbine and gearing	Temperature	High	–	
Lub-oil filter differential pressure	–	Great	c	
Oil level in lub-oil circulating tank	–	Low	–	For gravity and circulating oil tanks
Turbine main bearing temperature	Temperature	High	–	
Coolant pressure or flow	–	Low	–	
Coolant temperature	Temperature	High	–	
Fuel oil temperature or viscosity	Temperature or viscosity	Low or high	–	Only for heavy oil
Fuel oil pressure or flow	Pressure or flow	Low	c	

Item	CCS		Mode of protective control action	Remarks
	Display	Limit alarm		
1	2	3	4	5
Level in fuel oil daily service tank	–	Low	–	When it is replenished automatically, high and low level alarms are to be fitted
Gas inlet or outlet temperature of turbine	Temperature	High	–	
		Excessively high	a	
Deviation of exhaust gas temperature from average	–	High	–	
Gas turbine combustion chamber flame and ignition	–	Failure	a	
Gas turbine vibration	–	High	–	
		Excessively high	a	
Axial displacement of turbine rotor	–	Great	–	
Turbine speed	–	Overspeed	a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	Indication of voltage may be replaced by indicating lamp
4 Auxiliary steam turbines▲				
Lub-oil inlet pressure for turbine and gearing	Pressure	Low	–	
		Excessively low	a	
Exhaust gas temperature	Temperature	High	a	
Combustion chamber flame	–	Extinguished	a	
Gas turbine vibration	–	Excessive	a	
Gas turbine speed	–	Overspeed	a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	Indication of voltage may be replaced by indicating lamp
5 Main steam turbines				
Lub-oil inlet pressure for turbine and gearing	Pressure	Low	c	
		Excessively low	a	
Lub-oil inlet temperature for turbine and gearing	Temperature	High	–	
Lub-oil filter differential pressure	–	Great	–	
Level of lub-oil tank	–	Low	–	For gravity and circulating oil tanks
Bearing temperature or bearing lub-oil outlet temperature of turbine and gearing	Temperature	High	–	
Thrust bearing temperature or lub-oil outlet temperature	–	High	–	
Astern turbine exhaust steam temperature	Temperature	High	–	
Gland steam pressure	Pressure	High and low	–	
Circulating seawater pressure or flow	Pressure or flow	Low	c	
Condenser vacuum	Vacuum	Low	b	
Condenser condensate level	–	High and low	b	
Condensate pump	–	Stop/failure	–	
Condensate salinity	–	High	–	
Steam turbine vibration	–	Excessive	b	
Axial displacement of turbine rotor	–	Excessive	a	

Item	CCS		Mode of protective control action	Remarks
	Display	Limit alarm		
1	2	3	4	5
Turbine speed	–	Overspeed	a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	Indication of voltage may be replaced by indicating lamp
6 Auxiliary steam turbines▲				
Lub-oil inlet temperature for turbine and gearing	–	High	–	
Lub-oil inlet pressure for turbine and gearing	Pressure	Low	–	
		Excessively low	a	
Condenser vacuum	–	Low	a	
Axial displacement of turbine rotor	–	Excessive	a	
Turbine speed	–	Overspeed	a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	Indication of voltage may be replaced by indicating lamp
7 Main steam boilers				
Steam drum or superheater outlet pressure	Pressure	High and low	–	
Superheated steam outlet temperature	Temperature	High	–	
De-superheated steam outlet temperature	Temperature	High	–	
Boiler feed water level	Level	High	–	At least 3 sensors fitted. See 3.3.1.2(1)② and 3.3.1.3(1)② of this PART
		Low	c	
		Excessively low	a	
Temperature or viscosity of oil fuel to burners	Temperature or viscosity	Low or high	–	Only for heavy oil. Protective action with cutoff of boiler fuel oil supply in case of excessively high temperature or excessively low viscosity may be carried out by cutoff of fuel oil heating supply
		Excessively low or high	a	
Fuel oil pressure to burners	Pressure	Low	c	See 3.3.1.3(3) of this PART
Forced draft pressure	Pressure	Loss	a	2 sensors fitted
Burner flame and ignition	–	Extinguished/ ignition failure	a	Each burner is to be monitored
Fuel oil atomizing steam (air) pressure	Pressure	Low	–	
Feed pump discharge pressure or flow	Pressure or flow	Low	c	See 3.3.1.3(4) of this PART
Feed water forced circulation flow	Flow	Low	a	Required for forced circulating boilers only
Level of feed water tank	–	Low	–	Required for daily feed water tanks only
Feed water salinity	–	High	–	
Water level of deaerator	–	High and low	–	
Boiler air supply casing and exhaust pipe (smoke uptake)	–	Fire	–	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	Indication of voltage may be replaced by indicating lamp

Item	CCS		Mode of protective control action	Remarks
	Display	Limit alarm		
1	2	3	4	5
8 Auxiliary steam boilers▲				
Steam drum or superheater outlet pressure	Pressure	Low	–	
Boiler feed water level	–	High	–	See 3.3.1.2(1)② and 3.3.1.3(1)② of this PART
		Low	c	
		Excessively low	a	
Temperature or viscosity of oil fuel to burners	–	Low or high	–	Only for heavy oil. Protective action with cutoff of boiler fuel oil supply in case of excessively high temperature or excessively low viscosity may be carried out by cutoff of fuel oil heating supply
		Excessively low or high	a	
Fuel oil pressure to burners	Pressure	Low	c	See 3.3.1.3(3) of this PART
Forced draft pressure	–	Loss	a	
Burner flame and ignition	–	Extinguished/ ignition failure	a	
Feed water salinity	–	High	–	Only applicable to auxiliary steam boiler for driving turbine-generator set
Boiler air supply casing and exhaust pipe (smoke uptake)	–	Fire	–	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	Indication of voltage may be replaced by indicating lamp
9 Controllable pitch propeller				
Pitch or blade angle of controllable pitch propeller	Pitch or blade angle	–	–	See 2.8.1.11 of this PART
Propeller shaft speed	Speed	–	–	See 2.8.1.11 of this PART
Hydraulic system pressure for controlling propeller pitch	Pressure	Low	c	
Hydraulic oil tank level	–	Low	–	
Hydraulic oil temp. (if oil cooler is fitted)	–	High	–	
Electric power supply for electrohydraulic control system	Voltage	Loss	–	
10 Vibration damper				
Oil inlet pressure or amplitude for vibration damper	Pressure or amplitude	Low or great	–	See 3.2.2.5 of this PART and 12.1.4.3 of PART THREE
11 Gearbox (for main propulsion machinery)				
Lub-oil inlet pressure of gearbox	Pressure	Low	c	
		Excessively low	a	
Lub-oil inlet temperature of gearbox	Temperature	High	–	
Gear oil pressure	Pressure	Low	–	
12 Clutches				
Clutch position	Position	–	–	
Power supply for control of clutches (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	See 2.8.1.11 of this PART
13 Stern tube bearing				

Item	CCS		Mode of protective control action	Remarks
	Display	Limit alarm		
1	2	3	4	5
Oil lubricated stern tube bearing temp.	–	High	–	
Level of stern tube lubricating oil tank	–	Low	–	
14 Air compressors▲				
Air compressor lubricating oil pressure	–	Low	a	Except for splash lubrication
15 Thermal oil heaters▲				
(1) Oil-fired				
Thermal oil expansion tank level	–	Low	a	
Thermal oil flow or pressure	–	Low	a	
Thermal oil outlet temperature	–	High	a	
Combustion air pressure or forced ventilation	–	Low or shutoff	a	
Fuel oil pressure	–	Excessively low	c	
Fuel oil temperature or viscosity	–	Low or great	–	Only for heavy oil
Uptake temperature	–	High	a	
Burner flame and ignition	–	Extinguished/ ignition failure	a	Each burner is to be monitored
(2) Exhaust-fired				
Thermal oil expansion tank level	–	Low	a	
Thermal oil flow or pressure	–	Low	a	
Thermal oil outlet temperature	–	High	a	
Exhaust temperature	–	High	–	
16 Oil purifier▲				
Purifier oil outlet pressure	Pressure	Low	–	
Purifier oil inlet temperature	–	High	–	
17 Sludge tank				
Level of sludge tank	–	High	–	
18 Bilge				
Bilge level	–	High	–	See 3.9.2.1 of this PART
Bilge pumps	Indication for operation time	Too long or more frequently	–	For automatically controlled bilge pumps only, see 3.9.2.4 of this PART
19 Diesel engines driving propulsion generators				
Fuel oil inlet pressure	Pressure	Low	–	Fitted after filter
Fuel oil temperature or viscosity (before injection pumps)	Temp. or viscosity	Low or high	–	Only for heavy oil
High pressure fuel pipes	–	Leakage	–	
Level of fuel oil in daily service tank	–	Low	–	
Common rail fuel oil pressure	–	Low	–	
Common rail servo oil pressure	–	Low	–	
Lub-oil inlet pressure	Pressure	Low	–	
		Excessively low	a	
Lub-oil filter differential pressure	Pressure	Great	–	
Lub-oil inlet temperature	–	High	–	
Oil mist concentration in crankcase	–	High	a	Applicable to diesel engines specified in 9.7.6, Ch.9, Pt.3; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems

Item	CCS		Mode of protective control action	Remarks
	Display	Limit alarm		
1	2	3	4	5
Flow rate of cylinder lubricator. Each apparatus	–	Small	–	Required if necessary for safe operation of the engines
Pressure of cooling seawater	Pressure	Low	–	
Cylinder cooling water pressure or flow	Pressure or flow	Low	–	
Cylinder cooling water outlet temperature	Temp.	High	–	
Level of cylinder cooling water in expansion tank	–	Low	–	
Starting air pressure	Pressure	Low	–	
Control air pressure	Pressure	Low	–	
Exhaust gas temp. after each cylinder	Temp.	High	–	For diesel engines having a power of more than 500 kW per cylinder only
Speed	–	Overspeed	a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	Indication of voltage may be replaced by indicating lamp
20 Gas turbines driving propulsion generators				
Fuel oil pressure or flow	Pressure or flow	Low	–	
Fuel oil temperature or viscosity	Temp. or viscosity	Low or high	–	Only for heavy oil
Lub-oil inlet pressure to gas turbine and gearing	Pressure	Low	–	
		Excessively low	a	
Lub-oil inlet temperature to gas turbine and gearing	Temp.	High	–	
Turbine main bearing temperature	Temp.	High	–	
Lub-oil filter differential pressure	–	Great	–	
Level in lub-oil circulating tank	–	Low	–	For gravity and circulating oil tanks
Coolant pressure or flow	–	Low	–	
Coolant temperature	Temp.	High	–	
Level in fuel oil tank for ignition and starting	–	Low	–	When it is replenished automatically, high and low level alarms are to be fitted
Gas turbine ignition	–	Failure	a	
Combustion chamber flame	–	Extinguished	a	
Exhaust gas temperature	Temp.	High	a	
Gas turbine vibration	–	Excessive	a	
Axial displacement of turbine rotor	–	Great	a	Automatic shutdown not required if fitted with roller bearings
Gas turbine speed	–	Overspeed	a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and Hydraulic pressure	Loss	–	Indication of voltage may be replaced by indicating lamp
21 Miscellaneous				
Overriding function	–	When overriding is initiated	–	
Automatic systems	–	Failure	–	Including electric power fault

Section 3
REQUIREMENTS FOR AUTOMATION OF SHIPS WITH CLASS NOTATION BRC

4.3.1 General requirements
4.3.1.1 Ships with the class notation BRC are to be provided with the remote control of the main propulsion machinery and other related installations from the BCS. The machinery spaces are to be constantly attended by watch-keepers to look after the machinery and electrical equipment as described in 3.1.1.4 of this PART.

4.3.2 Functions of the BCS
4.3.2.1 Under all sailing conditions including maneuvering, the speed and direction of thrust of main propulsion machinery as well as other installations (if fitted) are to be effectively controlled from the BCS. The design and arrangement of BCS are to comply with the requirements of Section 8 of Chapter 2 of this PART.
4.3.2.2 Where necessary, the control of propulsion machinery from the BCS is to be capable of being changed over to the local control station at any time and the changeover of the control is to comply with the relevant requirements of 2.5.2 of this PART.
4.3.2.3 The automatic and remote control of main engines, clutches, controllable pitch propeller, etc. is to be, in general, in compliance with the relevant requirements of Section 2 and Section 6 of Chapter 3 of this PART.
4.3.2.4 The Mode a protective action of main engines is to be capable of being carried out automatically, the other actions (Mode b and Mode c) may be carried out by manual operation.
4.3.2.5 The bridge control of main steam turbines is to comply with the requirements in 3.2.3.2 of this PART. If the slow-turning device is arranged to be operated manually, automatic operation will not be required.
4.3.2.6 Alarms at the BCS:
(1) For the items to be alarmed at the BCS and the mode of alarms, see column 3 of Table 4.3.4.1 of this Section. Alarms indicating the faults in the machinery and electrical equipment as well as the automated control and monitoring systems are, in general, to be relayed to the BCS in the following modes: group alarms for the protective actions of safety systems; separate alarms; group alarms for serious faults and group alarms for general faults.
(2) The audible alarms at the BCS are permitted to be silenced after acknowledgment, but the visual alarms are to be extinguished only after the rectification of faults, and furthermore, the visual signals are to be capable of being clearly distinguishable before and after acknowledgment.

4.3.3 Functions of the LCS
4.3.3.1 The LCS is to comply with the requirements in 2.5.1.5 of this PART.
4.3.3.2 The items to be displayed and alarmed, as required in columns 2 and 3 of Table 4.3.4.1 of this Section for the propulsion machinery (such as main engines, clutches, controllable pitch propeller, etc.), are to be provided at the LCS.

4.3.4 Table of automatic control and monitoring items
4.3.4.1 The automatic control and monitoring items (if fitted) for all ships with the class notation BRC are to comply with Table 4.3.4.1.
4.3.4.2 The designations used in Table 4.3.4.1 of this Section are defined as follows:
−: not required;
*: only required for trunk piston diesel engines;
S: single alarm;
G_a: group alarm activated by Mode a protective action;
G_b: group alarm activated by Mode b protective action;
R: group alarm for serious faults;
Y: group alarm for general faults.
4.3.4.3 Where “per cylinder” appears in the column “Remarks” of Table 4.3.4.1 of this Section, it applies only to crosshead diesel engines, and for trunk piston diesel engines, “fitted on manifold outlet” may be used to replace “per cylinder”.

Automatic Control and Monitoring Items for Ships with Class Notation BRC

Table 4.3.4.1

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
1 Main diesel engine					
1.1 Fuel oil system					
Fuel oil inlet pressure	Pressure	Low	c	*Y*	Fitted after filter
Fuel oil temperature or viscosity (before injection pumps)	Temp. or viscosity	Low or high	–	*Y*	Only for heavy oil
Leakage from high pressure fuel pipes	–	Leakage	–	*Y*	
Level of fuel oil in daily service tanks	–	Low	–	*Y*	High-level alarm also required, if no suitable overflow arrangement provided
Common rail fuel oil pressure	–	Low	–	*Y*	
1.2 Lubricating oil system					
Lub-oil inlet pressure to main bearing & thrust bearing	Pressure	Low	c	*Y*	
			b	G_b	Necessary for crosshead diesel engines
		Excessively low	a	G_a	
Lub-oil inlet pressure to crosshead bearing	Pressure	Low	c	*Y*	Necessary for crosshead diesel engines
			b	G_b	
		Excessively low	a	G_a	
Lub-oil inlet pressure to camshaft	Pressure	Low	c	*Y*	
		Excessively low	a	G_a	
Lub-oil inlet temperature to camshaft	Temp.	High	–	*Y*	
*Lub-oil filter differential pressure	Pressure	Great	–	*Y*	
Lub-oil inlet temperature	Temp.	High	–	*Y*	
Thrust bearing pad temperature or bearing temperature	Temp.	High	b	G_b	Necessary for crosshead diesel engines
		Excessively high	a	G_a	
Main, crank, crosshead bearing oil outlet temperature or oil mist concentration in crankcase	–	High	b	G_b	Applicable to low speed diesel engines specified in 9.7.6, Ch.9, Pt.3
*Oil mist concentration in crankcase	–	High	a	G_a	Applicable to medium and high speed diesel engines specified in 9.7.6, Ch.9, Pt.3; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Flow rate of cylinder lubricator. Each apparatus	–	Small	b	G_b	Required for trunk piston diesel engines if necessary for safe operation of the engines
Oil level in lub-oil circulating tank	–	Low	–	*Y*	Necessary for crosshead diesel engines; individual level alarms required for the tanks if separate lub-oil systems installed (e.g. camshaft, rocker arms, etc.) for crosshead diesel engines
Common rail servo oil pressure	–	Low	–	*Y*	
1.3 Turbocharger system					
Turbocharger lub-oil inlet pressure	Pressure	Low	–	*Y*	Unless provided with a self-contained lubricating oil

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
					system integrated with the turbocharger
Turbocharger lub-oil outlet temp each bearing	Temp.	High	–	*Y*	Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative
Speed of turbocharger	Speed	–	–	–	Necessary for crosshead diesel engines
1.4 Piston cooling system (Necessary for crosshead diesel engines)					
Piston coolant inlet pressure	Pressure	Low	c	*Y*	The slowdown is not required if the coolant oil taken from the main cooling system of the engine
		Excessively low	b	G_b	
Piston coolant outlet flow	–	Low	b	G_b	Per cylinder; where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted
Piston coolant outlet temperature	Temp.	High	b	G_b	Per cylinder
Level of piston coolant in expansion tank	–	Low	–	*Y*	
1.5 Seawater cooling system					
Pressure of cooling seawater	Pressure	Low	c	*Y*	
1.6 Cylinder fresh cooling water system					
Cylinder water inlet pressure or flow	Pressure or flow	Low	c	*Y*	Only cylinder coolant inlet pressure required for crosshead diesel engines
		Excessively low	b	G_b	
Cylinder water outlet temperature (from each cylinder) Cylinder water outlet temperature (general)	Temp.	High	b	G_b	Required for crosshead diesel engines where one common cooling space without individual stop valves is employed for all cylinder jackets. For trunk piston diesel engines, alarm and slowdown only for cylinder water outlet temperature (general) and two separate sensors required
Oily contamination of main engine cooling water system	–	Contaminated	–	–	Necessary for crosshead diesel engines; required where main engine cooling water is used in fuel and lubricating oil heat exchangers
Level of cylinder cooling water in expansion tank	–	Low	–	*Y*	
1.7 Starting and control air systems					
Starting air pressure before main shut-off valve	Pressure	Low	–	*Y*	
Control air pressure	Pressure	Low	–	*Y*	
Safety air pressure	Pressure	Low	–	*Y*	Necessary for crosshead diesel engines
1.8 Scavenge air system					

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
Scavenge air receiver pressure	Pressure	–	–	–	Necessary for crosshead diesel engines
Scavenge air box temperature (fire)	Temp.	High	b	G_b	
Scavenge air receiver water level	–	High	–	*Y*	
*Scavenge air receiver temperature	Temp.	High	–	*Y*	
1.9 Exhaust gas system					
Exhaust gas temp. after each cylinder	Temp.	High	b	G_b	For trunk piston diesel engines having a power of more than 500 kW per cylinder only
Exhaust gas temperature after each cylinder. Deviation from average	–	Great	–	*Y*	
Exhaust gas temperature before each turbocharger	Temp.	High	–	*Y*	Necessary for crosshead diesel engines
Exhaust gas temperature after each turbocharger	Temp.	High	–	*Y*	
1.10 Fuel valve coolant					
Pressure of fuel valve coolant	Pressure	Low	c	*Y*	The requirement is to be complied with if the crosshead diesel engine is fitted with a separate fuel valve cooling system
Temperature of fuel valve coolant	Temp.	High	–	*Y*	
Level of fuel valve coolant in expansion tank	–	Low	–	*Y*	
1.11 Engine speed/direction of rotation					
Speed	Speed	Overspeed	a	G_a	
Direction of rotation	Direction of rotation	Wrong way	–	*Y*	Necessary for crosshead diesel engines
1.12 Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp
2 Main gas turbines					
Lub-oil inlet pressure to gas turbine and gearing	Pressure	Low	c	*R*	
		Excessively low	a	G_a	
Lub-oil inlet temperature to gas turbine and gearing	Temp.	High	–	*Y*	
Lub-oil filter differential pressure	–	Great	c	*Y*	
Oil level in lub-oil circulating tank	–	Low	–	*Y*	For gravity and circulating oil tanks
Turbine main bearing temperature	Temp.	High	–	*Y*	
Coolant pressure or flow	–	Low	–	*Y*	
Coolant temperature	Temp.	High	–	*Y*	
Fuel oil temperature or viscosity	Temp. or viscosity	Low or high	–	*Y*	Only for heavy oil
Fuel oil pressure or flow	Pressure or flow	Low	c	*Y*	
Level in fuel oil daily service tank	–	Low	–	*Y*	When it is replenished automatically, high and low level alarms are to be fitted
Gas inlet or outlet temperature of turbine	Temp.	High	–	*Y*	
		Excessively high	a	G_a	
Deviation of exhaust gas temperature from average	–	High	–	*Y*	
Gas turbine combustion chamber flame and ignition	–	Failure	a	G_a	
Gas turbine vibration	–	High	–	*Y*	
		Excessively high	a	G_a	
Axial displacement of turbine rotor	–	Great	–	*R*	

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
Turbine speed	–	Overspeed	a	G_a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp
3 Main steam turbines					
Lub-oil inlet pressure for turbine and gearing	Pressure	Low	c	*R*	
		Excessively low	a	G_a	
Lub-oil inlet temperature for turbine and gearing	Temp.	High	–	*Y*	
Lub-oil filter differential pressure	–	Great	–	*Y*	
Level of lub-oil tank	–	Low	–	*Y*	For gravity and circulating oil tanks
Bearing temperature or bearing lub-oil outlet temperature of turbine and gearing	Temp.	High	–	*Y*	
Thrust bearing temperature or lub-oil outlet temperature	–	High	–	*Y*	
Astern turbine exhaust steam temperature	Temp.	High	–	*Y*	
Gland steam pressure	Pressure	High and low	–	*Y*	
Circulating seawater pressure or flow	Pressure or flow	Low	c	*Y*	
Condenser vacuum	Vacuum	Low	b	G_b	
Condenser condensate level	–	High and low	b	G_b	
Condensate pump	–	Stop/ failure	–	*Y*	
Condensate salinity	–	High	–	*Y*	
Steam turbine vibration	–	Excessive	b	G_b	
Axial displacement of turbine rotor	–	Excessive	a	G_a	
Turbine speed	–	Overspeed	a	G_a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp
4 Controllable pitch propeller					
Blade angle (or pitch) of controllable pitch propeller	Blade angle or pitch	–	–	–	See 2.8.1.11 of this PART
Propeller shaft speed	Speed	–	–	–	See 2.8.1.11 of this PART
Hydraulic system pressure for controlling propeller pitch	Pressure	Low	c	*Y*	
Hydraulic oil tank level	–	Low	–	*Y*	
Hydraulic oil temp. (if oil cooler is fitted)	–	High	–	*Y*	
Electric power supply for electrohydraulic control system	Voltage	Loss	–	*Y*	
5 Vibration damper					
Oil inlet pressure or amplitude for vibration damper	Pressure or amplitude	Low or great	–	*Y*	See 3.2.2.5 of this PART and 12.1.4.3 of PART THREE of the Rules
6 Gearbox (for main propulsion machinery)					
Lub-oil inlet pressure of gearbox	Pressure	Low	c	*Y*	

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
		Excessively low	a	G_a	
Lub-oil inlet temperature of gearbox	Temp.	High	–	*Y*	
Gear oil pressure	Pressure	Low	–	*Y*	
7 Clutches					
Clutch position	Position	–	–	–	
Power supply for control of clutches (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	See 2.8.1.11 of this PART
8 Stern tube bearing					
Oil lubricated stern tube bearing temp.	–	High	–	*Y*	
Level of stern tube lubricating oil tank	–	Low	–	*Y*	
9 Diesel engines driving propulsion generators					
Fuel oil inlet pressure	Pressure	Low	–	*Y*	Fitted after filter
Fuel oil temperature or viscosity (before injection pumps)	Temp. or viscosity	Low or high	–	*Y*	Only for heavy oil
High pressure fuel pipes	–	Leakage	–	*Y*	
Level of fuel oil in daily service tank	–	Low	–	*Y*	
Common rail fuel oil pressure	–	Low	–		
Common rail servo oil pressure	–	Low	–		
Lub-oil inlet pressure	Pressure	Low	–	*Y*	
		Excessively low	a	G_a	
Lub-oil filter differential pressure	Pressure	Great	–	*Y*	
Lub-oil inlet temperature	–	High	–	*Y*	
Oil mist concentration in crankcase	–	High	a	G_a	Applicable to diesel engines specified in 9.7.6, Ch.9, Pt.3; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Flow rate of cylinder lubricator. Each apparatus	–	Small	–	*Y*	Required if necessary for safe operation of the engines
Pressure of cooling seawater	Pressure	Low	–	*Y*	
Cylinder cooling water pressure or flow	Pressure or flow	Low	–	*Y*	
Cylinder cooling water outlet temperature	Temp.	High	–	*Y*	
Level of cylinder cooling water in expansion tank	–	Low	–	*Y*	
Starting air pressure	Pressure	Low	–	*Y*	
Control air pressure	Pressure	Low	–	*Y*	
Exhaust gas temp. after each cylinder	Temp.	High	–	*Y*	For diesel engines having a power of more than 500 kW per cylinder only
Speed	–	Overspeed	a	G_a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp

Item	CCS		Mode of protective control action	Mode of alarm at BCS	Remarks
	Display	Limit alarm			
1	2	3	4	5	6
10 Gas turbines driving propulsion generators					
Fuel oil pressure or flow	Pressure or flow	Low	–	*Y*	
Fuel oil temperature or viscosity	Temp. or viscosity	Low or high	–	*Y*	Only for heavy oil
Lub-oil inlet pressure to gas turbine and gearing	Pressure	Low	–	*Y*	
		Excessively low	a	G_a	
Lub-oil inlet temperature to gas turbine and gearing	Temp.	High	–	*Y*	
Turbine main bearing temperature	Temp.	High	–	*Y*	
Lub-oil filter differential pressure	–	Great	–	*Y*	
Level in lub-oil circulating tank	–	Low	–	*Y*	For gravity and circulating oil tanks
Coolant pressure or flow	–	Low	–	*Y*	
Coolant temperature	Temp.	High	–	*Y*	
Level in fuel oil tank for ignition and starting	–	Low	–	*Y*	When it is replenished automatically, high and low level alarms are to be fitted
Gas turbine ignition	–	Failure	a	G_a	
Combustion chamber flame	–	Extinguished	a	G_a	
Exhaust gas temperature	Temp.	High	a	G_a	
Gas turbine vibration	–	Excessive	a	G_a	
Axial displacement of turbine rotor	–	Great	a	G_a	Automatic shutdown not required if fitted with roller bearings
Gas turbine speed	–	Overspeed	a	G_a	
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	–	*Y*	Indication of voltage may be replaced by indicating lamp
11 Miscellaneous					
Overriding function	–	When overriding is initiated	–	*S*	
Automatic systems	–	Failure	–	*Y*	Including electric power fault

4.3.5 Requirements for automation of small ships with class notation BRC

4.3.5.1 For small ships of less than 500 gross tonnage with the class notation BRC, only group alarms activated by Mode a and Mode b protective actions as defined in Table 4.3.4.1 of this Section are to be provided in the BRC.