TÜRK LOYDU

RULES FOR THE CLASSIFICATION OF NAVAL SHIPS

Part E

Chapter 106 - Automation 2015

This latest edition incorporates all rule changes. The latest revisions are shown with a vertical line. The section title is framed if the section is revised completely. Changes after the publication of the rule are written in red colour.

Unless otherwise specified, these Rules apply to ships for which the date of contract for construction is on or after 01st of January 2015.

If there is a difference between the rules in English and in Turkish, the rule in English is to be considered as valid. This publication is available in print and electronic pdf version. Once downloaded, this document will become UNCONTROLLED. Please check the website below for the valid version.

http:/www.turkloydu.org

TÜRK LOYDU

Head Office Postane Mah. Tersaneler Cad. No:26 Tuzla 34944 İSTANBUL / TÜRKİYE
Tel : (90-216) 581 37 00
Fax : (90-216) 581 38 00
E-mail : info@turkloydu.org
http://www.turkloydu.org

Regional Offices

Ankara Eskişehir Yolu Mustafa Kemal Mah. 2159. Sok. No : 6/4 Çankaya – ANKARA / TÜRKİYE
Tel : (90-312) 219 56 34 - 219 68 25
Fax : (90-312) 219 69 72
E-mail : ankara@turkloydu.org

İzmir Atatürk Cad. No :378 K.4 D.402 Kavalalılar Apt. 35220 Alsancak - İZMİR / TÜRKİYE
Tel : (90-232) 464 29 88
Fax : (90-232) 464 87 51
E-mail : izmir@turkloydu.org

Adana Çınarlı Mah. Atatürk Cad. Aziz Naci İş Merkezi No:5 K.1 D.2 Seyhan - ADANA / TÜRKİYE
Tel : (90- 322) 363 30 12
Fax : (90- 322) 363 30 19
E-mail : adana@turkloydu.org

Marmaris Atatürk Cad. 99 Sok. No:1 Ketenbaş Apt. Kat:4 Daire 6 Marmaris - MUĞLA / TÜRKİYE
Tel : (90- 252) 412 46 55
Fax : (90- 252) 412 46 54
E-mail : marmaris@turkloydu.org

Chapter 106 - Automation

SECTION 1

GENERAL RULES AND INSTRUCTIONS

A. General

1. These Rules apply to automated equipment on naval ships which is relevant for these ships as platform for military tasks and which is defined in these rules. Special requirements for weapon and tactical command systems should be defined in the building specification.

2. These Rules apply in addition to those of Chapter 105 - Electrical Installations, with particular reference to Section 10 - Computer Systems.

3. Design

3.1 The requirements laid down for each unit and system depend on their intended use and the process related conditions.

3.2 In all circumstances the operation of the ship using automated machinery installations shall be at least as safe as the operation with a manned machinery installation.

3.3 If special operating conditions call for a particular system design, TL reserve the right to impose additional requirements depending on the operational and system-specific considerations.

3.4 Systems shall be intelligible and user-friendly and shall follow ergonomic principles.

3.5 The design of safety measures, open and closed loop controls and monitoring equipment shall limit any potential risk in the event of breakdown or defect to a justifiable level of residual risk.

As far as applicable in a specific case, the following following basic requirements shall be observed:

- Compatibility with the environmental and operating conditions
- Compliance with accuracy requirements
- Recognizability and constancy of the parameter settings, limiting- and actual values
- Compatibility of the measuring, open and closed loop controls and monitoring systems with the process and its special requirements
- Immunity of system elements to reactive effects in overall system operation
- Non-critical behaviour in the event of power failure, restoration and of faults
- Unambiguous operation
- Maintainability, the ability to recognize faults and test capability
- Reproducibility of values.

3.7 Systems shall operate with sufficient speed to allow automatic open and closed loop controls to be carried out promptly in all operating conditions, to provide the user with accurate information in time and to allow commands given by the user to be executed at the right time.

3.8 Automatic interventions shall be provided where damage cannot be avoided by manual intervention.

For machinery and systems which are controlled remotely or automatically, control and monitoring facilities shall be provided to permit independent local operation.

3.9 If danger to persons or regarding the safety of the ship arising from normal operation or from faults or malfunctions in machinery, plant, control, monitoring and measuring systems cannot be ruled out, safety devices or safety measures are required.

3.10 If danger to machinery and systems arising from faults or malfunctions in control, monitoring and measuring systems cannot be ruled out, protective devices or protective measures are required.

3.11 Where mechanical systems or equipment are either completely or partly replaced by electric/ electronic equipment, the requirements relating to mechanical systems and equipment defined in Chapter

3.12 104 - Propulsion Plants and Chapter 107 - Ship Operation Installations and Auxiliary Systems shall be met accordingly.

4. Equivalence

4.1 Naval ships deviating from the TL Rules in their type, equipment or in some of their parts may be classed, provided that their structures or equipment are found to be equivalent to the TL requirements for the respective Class.

4.2 In this respect, **TL** can accept alternative design, arrangements and calculation/analyses (FE, FMEA, etc.) which are suitable to satisfy the intent of the respective **TL** requirements and to achieve the equivalent safety level.

B. Definitions

1. Alarms

An alarm gives optical and acoustical warning of abnormal operating conditions.

2. Protective devices

Protective devices detect actual values, activate alarms in the event of limit-value violation and prevent machinery and equipment being endangered. They automatically initiate curative measures or call for appropriate ones.

3. Safety devices

Safety devices detect critical limit value violations and prevent any immediate danger to persons, ship or machinery.

4. Safety systems

Combination of several safety devices and/or protective devices in one functional unit.

5. Systems

Systems contain all equipment necessary for monitoring, control or safety including the in- and output devices. Systems cover a defined function including behaviour under varying operation conditions, cycles and running.

6. Integrated Systems

Integrated systems contain more than one of the equipment components that are necessary for monitoring, control and safety, including the input and output devices. Integrated systems cover several defined functions, including the behaviour under varying operating conditions.

7. Operating and Monitoring Equipment

7.1 Machinery Control Centre (MCC)

7.1.1 It shall be possible to perform the following tasks from the machinery control centre:

- Control and monitoring of the propulsion plant
- Control and monitoring of the electrical installation
- Control and monitoring of the ship operation equipment for flooding control, fire fighting and NBC defence
- Monitoring of all other ship operation equipment

7.1.2 To fulfill the tasks mentioned above, the required control and monitoring equipment components shall be arranged in the machinery control centre, grouped in accordance with their functionalities into

- Propulsion plant
- Electrical installation
- Ship operation and damage control equipment

7.2 Bridge operating station

The bridge operating station is used to control the propulsion plant with simultaneous monitoring at the machinery control centre. If tasks of the machinery

control centre can be performed at the bridge operating station, the equipment prescribed under 7.1 shall be provided.

7.3 Auxiliary control positions

In the service spaces, auxiliary control positions shall be provided for operating the

- Propulsion engine(s) including gear(s) and coupling(s)
- Adjustment device(s) for propellers
- Prime movers for the generators
- Electrical installations
- Steering gear unit(s)

The power station switchboards serve as auxiliary control positions for the associated generators (without prime movers), switchgear and distributing arrangements.

7.4 Damage control centre (DCC)

The damage control group is deployed from the damage control centre. It shall be adequately equipped for the monitoring and control of the ship operation equipment, insofar as this is of importance for damage control.

C. Documents for Approval

The following documents are to be submitted for examination in triplicate and in good time so that they can be approved and made available to the Surveyor at the start of manufacture or installation of the systems, see also Chapter 105 - Electrical Installations, Section 1, C.

1. For each of the systems listed in Section 2 the following documents are to be submitted:

- System overview/layout
- Wiring diagrams
- Power supply concept
- Description of functional relationships
- General arrangement
- Functional description
- Documentation for computer systems according to Chapter 105 - Electrical Installations, Section 1, C.2.9

2. The list of measure points is to be submitted, see also Section 11.

3. A safety protection concept giving details of limit values which result in shutdown or reduction is to be submitted for the main propulsion plant and also for other equipment where necessary.

4. For the bridge equipment, the following documents of the automation plant shall be submitted for approval:

- Installation drawing of the bridge with the devices, components and systems
- Arrangement drawings with the devices in the bridge consoles
- List of devices with details of the type, manufacturer and approval body
- Block diagrams showing the functional interrelationship of the devices and their power supply

5. Test and trial schedules shall be compiled for the alarm-, monitoring-, safety-, protection- and control systems as specified in these Rules to cover the following steps:

- Tests of components and systems in the manufacturer's factory (FAT)
- Installation and integration tests of components, installations and systems on board at harbour (HAT)

- Functional tests of systems on board during the sea trials (SAT)

6. TL reserve the right to demand other documents where those submitted are not adequate or sufficient to provide an evaluation of the system.

D. Maintenance

1. Access shall be provided to automation systems to allow measurements and repairs to be carried out. Facilities such as simulation circuits, test jacks, pilot lamps etc. are to be provided to allow functional checks to be carried out and faults to be located.

2. The operational capability of other system shall not be impaired as a result of maintenance procedures.

3. Where the replacement of circuit boards in equipment which is switched on may result in the failure of components or in the critical condition of systems, a warning sign shall be fitted to indicate the risk.

4. Circuit boards and plug-in connections shall be protected against unintentional mixing up. Alternatively they shall be clearly marked.

SECTION 2

RANGE OF CONTROL AND MONITORING EQUIPMENT

A. General

1. The scope of equipment for automation, the required controls, regulating circuits and safety, alarm and monitoring equipment shall be provided to the extent needed to ensure safe operation of the engines and systems without any intervention by the crew over a period of 24 h or for a shorter period nh as defined in the building specification.

2. Ships which are designed according to these Rules are assigned the Class Notation **AUT-N** or **AUT-Nnh,** see also Chapter 101 - Classification and Surveys, Section 2, C.

3. Within the machinery control centre a central control station shall be provided from which the automated equipment can be controlled and monitored.

B. Scope of Equipment

1. For the ship installations, the following automatic control and monitoring systems shall be provided as a minimum:

1.1 Fire detection and alarm systems, see Chapter 105 - Electrical Installations, Section 9, C.

1.2 Monitoring, alarm and logging equipment, see Section 3, C.

1.3 Control and regulating systems, see Section 3, H.

1.4 Safety devices, systems and protective equipment, see Section 3, D., E., F. and G.

1.5 Stand-by units, see Section 3, I.

1.6 Remote control for the propulsion plant, see Section 6, A.

1.7 Automation of auxiliary machinery systems, see Section 7.

1.8 Power management system for the electrical power supply, see Section 8, A.

2. Depending on the ship type and deployment profile, any automation and monitoring equipment extending beyond this scope shall be stipulated in the building specification. However, the general principles defined shall also be observed in such cases.

SECTION 3

BASIC SYSTEM REQUIREMENTS

A. Layout and Performance

1. The installations shall take due account of the operational conditions "combat", "wartime cruising", "peacetime cruising" and "peacetime in-port readiness".

2. The adaptation of the installations should take place automatically after the operational condition has been selected.

3. Redundant systems shall be separately protected against short circuits and overloads, and shall be selectively fused.

4. To prevent unnecessary interruptions in operation, it shall be ensured that the triggering of standby circuits, alarm system, protective devices, safety system and safety devices shall take place in that order.

5. Disturbed units which are automatically shut down shall be restarted only directly at the unit after a manual release.

6. If approved systems are extended, renewed proof of trouble-free operation shall be provided for the complete system.

7. It shall be ensured that, on failure of the main electrical power supply, the automation systems are supplied by an uninterruptible power supply for at least 1 h. Failure of the supply from the main source of electrical power shall trigger an alarm.

8. The uninterruptible power supply shall be monitored so that, towards the end of the stored energy period, an automatically controlled shutdown of the system is ensured.

B. Man-Machine Interfaces

1. General requirements

1.1 Together with the display units in the operating stations and control stations (operating station in the auxiliary control position/damage control centre/ machinery control centre), the controls form the interface between man and machine. Attention shall be paid to ergonomic design and arrangement of the devices.

1.2 Controls shall correspond to the system being controlled with regard to their position and direction of operation.

1.3 The controls for essential equipment shall be installed at or near the equipment concerned (manual local operation), and it shall be possible to operate the essential equipment locally by hand in the event of failure of the automation system.

1.4 The control elements, comprising input and output units, shall be operable in accordance with their prescribed environmental conditions (daylight/artificial light) without any limitations.

1.5 Colours, symbols and texts for the inputs and outputs of a system shall be so chosen that they are uniform (standardized).

2. Input units

2.1 The consequences of control commands shall be indicated at the respective control station.

2.2 Where controls are possible from several control stations, the following shall be observed:

2.2.1 Competitive commands shall be prevented by suitable interlocks.

2.2.2 The control station in operation shall be recognizable as such.

2.2.3 Taking over of command shall only be possible with the authorization of the user of the control station which is in operation.

2.2.4 Precautions shall be taken to prevent changes to desired values due to a change-over in command station.

2.2.5 If the operating authorization is withdrawn from an active operating station, this shall be indicated on location.

2.2.6 If several controllable facilities are grouped together at one operating station, e.g. through a process display, the operating authorizations shall be assigned with regard to the relevant functional unit.

2.2.7 The transfer of the active operation station to another location shall be recorded.

2.3 Operating keyboards shall comply with the following conditions:

2.3.1 Structure and markings shall conform to a recognized and standardized system.

2.3.2 It shall be possible to operate the keys reliably, and there shall be confirmation of the entry.

2.3.3 If multiple functions are assigned to keys, it shall be possible to recognize which of the assigned functions are active.

2.4 Provided that sufficient operating and functional reliability is verified under all operating conditions, other types of input devices, e.g. lightpen, touchscreen, trackball, joystick, are also permissible.

2.5 Password protection is deemed equivalent to protection by a lockable switch.

3. Output units

3.1 Representation of information

3.1.1 The operational readiness of a system shall be indicated.

3.1.2 A generally understandable operator-guidance system shall be provided. Such operator guidance can consist of, for example, function keys, menu screens or computer-supported dialog steps.

3.1.3 Suitable search strategies shall ensure rapid access to data.

3.1.4 Alarms and information shall be presented clearly according to their functional significance and interrelationship. These presentations can be provided in alphanumeric form or as graphic images/diagrams.

3.1.5 In every operating mode of the system, alarms shall be presented visually and acoustically with higher priority compared to other information, such as the controlling or printing of lists. They shall be clearly distinguishable from other information.

3.1.6 If other information and displays are also shown in addition to alarms, an alarm list shall be created that can be called up with only one operating step.

3.1.7 If alarms can be disabled, a list of disabled alarms shall be created that can be called up as and when required.

3.1.8 A maximum period of 2 seconds should not be exceeded for refreshing the display of time-critical measuring points, and especially of their alarms.

3.1.9 If symbols are used for the representation of alarms and information, an explanation (key) of these symbols shall be provided. Uniform symbols should be used.

3.2 Technical requirements

3.2.1 Measures shall be taken to ensure satisfactory presentation of information, even in daylight, e.g. through antireflection coatings on displays or the use of filters.

3.2.2 It shall be possible to adapt the brightness of output units in order to suit the ambient conditions in each case. No inadmissible colour distortions shall occur. Proper legibility shall be ensured at all times.

3.2.3 The size, colour and density of text, graphic information and alarm signals displayed on a screen shall be such that they may be easily read from a

distance of 1 m under all lighting conditions.

3.2.4 The use of monochrome displays is permissible, provided that clear recognition of the signals is guaranteed.

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

3.2.6 If required alarms or displays are shown on a video display or line display, a second independent output unit shall be available.

C. Machinery Alarm Systems

1. General requirements

1.1 The machinery alarm system shall provide an alarm for unacceptable deviations from operating figures.

1.2 At least the alarms specified in Section 11 shall be provided.

1.3 Alarm delays shall be kept within defined time limits to prevent any risk to the monitored system in the event of exceeding the limit value.

1.4 Optical signals shall be individually indicated at a central position. The meaning of the individual indications shall be clearly identifiable by text or symbols.

If a fault is indicated, the optical signal shall remain visible until the fault has been eliminated. It shall be possible to distinguish between an optical signal which has been acknowledged and one that has not been acknowledged.

1.5 It shall be possible to acknowledge acoustic signals and optical messages separately. The acknowledgement shall first be performed for the acoustic signals and then for the optical messages.

The acknowledgement of an alarm shall not inhibit an alarm which has been generated by new causes.

1.6 An acknowledgement shall only be possible where the fault is indicated as a single indication and sufficient information is available for the assessment of the relevant process.

1.7 Alarms shall be discernible under all operating conditions. Where this cannot be guaranteed, for example due to the noise level, additional optical signals, e.g. flashing lights shall be installed.

1.8 Even an alarm which is triggered by a transient fault shall only be reset after the alarm has been acknowledged.

1.9 The audible signal in the machinery space may be switched off during unmanned operation, if the operational readiness of the audible signaling equipment is ensured by appropriate measures during the remaining time.

1.10 Alarms shall also be indicated at another manned control centre if the installation to which the alarm refers is not manned.

1.11 During port operation, the alarms in the machinery space shall be signalled at least in the form of a collective alarm at a permanently-manned station.

1.12 Alarm systems shall be designed according to the closed-circuit principle or the monitored open circuit principle. Equivalent monitoring principles are permitted.

1.13 All prescribed alarms shall be logged with simultaneous recording of the date and time. The beginning and end of a fault shall be clearly discernible.

1.14 The automatic suppression of alarm signals shall be monitored for correct function or designed as a redundant function.

1.15 Failure of the machinery alarm system shall be signalled at a permanently-manned station.

1.16 Collective alarms

1.16.1 If alarms of autonomous essential equipment are grouped together and signalled to the machinery alarm system as collective alarms, the individual alarms shall be recognizable at the corresponding installation.

1.16.2 Retriggering of the collective alarm by a new individual alarm shall be possible at all times, irrespective of the alarm state of the collective alarm.

1.16.3 The transmission of collective alarms shall be monitored for possible failure.

2. Alarms on the bridge

2.1 The alarms on the bridge shall be prepared in form of collective alarms divided into three groups according to their urgency. Individual alarms specified in Section 11 shall be provided. The groups are:

2.1.1 "Stop" group: alarms signalling faults which require the propulsion system to be shut down immediately.

2.1.2 "Reduce" group: alarms signalling faults which require a reduction in power of the propulsion system.

2.1.3 "Common" group: alarms signalling faults which do not require actions as described in 2.1.1 or 2.1.2.

2.1.4 The collective alarms shall be generated independently of the safety system.

2.2 The acknowledgement or non-acknowledgement of the machinery alarms shall be recognizable independently of the acknowledgement of the collective and individual alarms on the bridge.

3. Alarms at the main operating centres

3.1 If the alarms of a functional unit are not acknowledged at the associated active operating station after a specified time, this shall be indicated at another active control centre.

3.2 The filtering and grouping of alarms shall be performed in relation to the selected operational condition and shall be possible in accordance with at least one of the following rules for reducing alarm bursts:

3.2.1 Hierarchical group formation, e.g. according to compartments, or deck and system components, e.g. electrical installation, propulsion.

3.2.2 Exceeding of a prescribed threshold by simultaneous fault signals for installations and systems or compartments and decks.

4. Wireless duty alarm systems

Where the alarms according to C. 1.10 for the engineer officers or for those crew members responsible for the machinery plant are designed as a wireless duty alarm system, the following requirements are to be observed:

4.1 The function of the system has to be proved in all areas of the ship.

4.2 The minimum operation time of the mobile units shall be at least 12 hours without intermediate charging. An alarm shall be given in time before the automatic switch off.

4.3 At least two charged reserve units shall be available.

4.4 Alarms shall be set above personnel calls. Calls to persons shall not suppress alarms.

4.5 The fixed stations shall be supplied at least for 15 minutes in case of a failure of the ship's mains.

4.6 Watch and alarm functions shall be realized as in standard hardwired systems.

4.7 Radio contact between the fixed and mobile units shall be checked regularly and automatically. The loss of the contact has to be alarmed.

D. Safety Systems

1. Safety systems shall be independent of open

and closed loop control and alarm systems. Faults in one system shall not affect other systems.

Deviations from this requirement may be allowed for redundant equipment with the agreement of TL, where this would entail no risk to human life and where ship safety would not be endangered.

2. Safety systems shall be assigned to systems which need protection.

3. The monitored open-circuit principle is to be applied to safety systems. Alternatively, the closed circuit principle may be applied where it is demanded by the provisions of national regulations, e.g. boiler and oil-fired systems.

Equivalent monitoring principles are permitted.

4. Faults, and also the activation of safety systems shall be alarmed and recorded.

5. Faults of the safety system shall not have any effects on the function of the system being monitored.

6. The power supply is to be monitored and loss of power is to be indicated by an alarm and recorded.

E. Protective Devices

1. When reaching dangerous limits, protective devices shall automatically adapt the operation temporarily to the remaining technical capabilities or demand adaptation.

The protective measure may be a function of the machinery alarm system.

2. Faults of the protective devices shall not have any effects on the function of the system being monitored.

F. Safety Devices

1. The design of safety devices shall be as simple as possible and the devices shall be reliable and inevitable in operation. Proven safety devices which are not depending on a power source are to be preferred.

2. The suitability and function of safety devices shall be demonstrated in the given application.

3. Safety devices shall be so designed that potential faults such as loss of voltage or a broken wire shall not create a hazard to human life, ship or machinery.

These faults and also the tripping of safety devices shall be signalled by an alarm.

4. Where faults which affect the operation of the devices cannot be identified, appropriate test facilities shall be provided and actuated periodically.

5. Faults of the safety devices shall not have any effects on the function of the system being monitored.

6. The adjustment facilities for safety devices shall be so designed that the last setting can be detected.

7. Safety devices shall be designed preferably using conventional (hard wired) technology. Alternative technical solutions shall be agreed with TL.

8. Where auxiliary energy is required for the function of safety devices, this has to be monitored and a failure has to be alarmed.

G. Override

1. Override possibilities for propulsion plants and generator sets shall be provided. They may only be activated from the currently active operating station.

2. Override possibilities shall be secured against unintentional activation. The activation of overriding arrangements shall be indicated and recorded.

3. If override possibilities have been activated and a shutdown or reducing function is triggered, an alarm shall signal that the triggering has been disabled. The triggering criterion shall be recognizable.

4. It shall not be possible to override any over-speed protection functions or other time-critical functions.

5. An alarm shall be triggered if installations are started with the override function activated.

H. Open-Loop and Closed-Loop Control

1. Open-loop control

1.1 Main propulsion engines and essential equipment shall be provided with effective means for the control of their operation. All controls for essential equipment shall be independent or so designed that failure of one system does not impair the performance of other systems.

1.2 Control equipment shall have built-in protection features wherever incorrect operation would result in serious damage or in the loss of essential functions.

1.3 If user-related authorizations are assigned for control equipment, suitable measures shall be taken to prevent unintentional or unauthorized operating actions.

1.4 These measures shall consider the possible incapability of an authorized operator or his operating workplace (hardware/software) and include a suitable hand-over procedure.

1.5 The changing of active operating workplaces and operators with their corresponding operator authorizations shall be recorded.

2. Closed-loop control

2.1 Under normal conditions, closed-loop controls shall keep the process variables within the specified limits.

2.2 Closed-loop controls shall maintain the reaction specified for the installation over the full control range. Anticipated variations of the parameters shall be considered during planning.

2.3 Defects in a control loop shall not impair the function of other essential control loops.

2.4 The power supply of essential control loops shall be monitored, and power failure shall be signalled by an alarm.

I. Stand-by Circuits / Automatic Controls

1. General

1.1 Stand-by circuits shall automatically start stand-by units:

- in the case of failure of units in operation
- to meet the demand of auxiliary machinery with staggered operation

1.2 Automatic controls shall automatically start units as described in Section 8, A.:

- to maintain stored energy, e.g. compressed air
- following restoration of the power supply after black-out, due to a failure of the ship's mains

1.3 There shall be a possibility for switching off the automatic controls.

2. Design

2.1 For similar units, the possibility of reciprocal operation shall be provided.

2.2 Faults in the active unit shall lead to the automatic starting of the stand-by unit. The start-up of a stand-by unit as well as faults in a control unit shall trigger an alarm.

2.3 If auxiliary machinery as pumps, auxiliary blowers, are driven mechanically by the propulsion plant, the spare machinery shall be designed for automatic start-up when manoeuvring at low speed ranges, in the event that the performance of the mechanically driven auxiliary machinery does not suffice under these conditions. There shall be no alarm

for operation in the case of automatic start-up due to the operating conditions.

2.4 Separate sensors shall be used for stand-by circuits and machinery alarms. The function of the machinery alarms shall also be ensured even if the control unit for the stand-by circuit should fail.

2.5 If stand-by circuits are grouped together in a control unit, no more than one item of essential equipment shall be affected by a fault in that control unit.

2.6 Stand-by circuits shall preferably be arranged decentrally and assigned directly to the corresponding units.

2.7 A fault in the control unit shall not lead to failure of the units in operation

2.8 Staggered starting of stand-by units shall be ensured in the event of failure of the ship's mains and restoration of the electrical supply.

2.9 If control units should fail, manual local control shall be possible, independently of the operating condition of the plant.

SECTION 4

EQUIPMENT ON THE BRIDGE

A. General

1. The steering positions on the bridge shall include all arrangements required to command the ship and to operate the ship installations under all operating conditions.

2. The workplaces shall be designed for a condensed presentation of information. From here it shall be possible to control the ship, especially in critical situations.

3. The various functions shall be assigned to appropriate workplaces, to ensure that the tasks and activities arising therefrom can be performed safely and reliably. It is permissible for workplaces to be combined.

The following workplaces shall be provided:

- Ship propulsion/ ship operation
- Steering gear
- Navigation
- Communication

4. The devices shall be arranged in accordance with ergonomic principles and shall be adaptable to the ambient conditions as regards operability, legibility and free of glare.

B. Ship Propulsion /Ship Operation

1. The "ship propulsion/ship operation" workplace shall be equipped with the remote-control facilities for the propulsion plant and the required indicators and displays.

2. For setting the rates of speed of the prime movers, the same operating elements as for the machinery control centre should be used, see Section 6, A.2.

3. Alarms from the machinery alarm system shall be provided, see Section 3, C.2.

4. The remote-control and monitoring devices for navigation lights, signalling system, upper deck lighting etc. shall be provided.

C. Steering Gear

The "steering gear" workplace shall be equipped with the remote-control and monitoring devices for the steering gear installation.

D. Navigation

The "navigation" workplace shall be equipped with nautical devices which permit route planning, position-fixing and location documentation.

E. Communication

The "communication" workplace shall be equipped with the devices required for

- Emergency and safety-related radio communications using GMDSS (Global Maritime Distress and Safety System)
- External communications
- Internal communications, see Chapter 105 - Electrical Installations, Section 9, B. and C.

SECTION 5

INTEGRATED SYSTEMS

A. General

1. The reliability of the functions of integrated systems shall be equivalent to the reliability of the functions of the individual systems.

2. Networks shall be designed according to an international standard.

3. The implementation and configuration of a network with regard to the use of the

- Transmission media
- Topologies
- Access procedures
- Access speeds
- Network systems
- Interfaces
- Possible redundancies

shall be adapted to meet the corresponding demands on the system.

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

B. Integration of Monitoring, Control and Safety Functions

The required independence of monitoring, control and safety functions which is implemented in conventionally implemented installations shall, for the combination of two or more functions, be replaced by other suitable measures, for example by:

- Coupling of otherwise autonomous systems, involving an exchange of information and data correction
- Multichannel technology
- Fault-tolerant systems

C. Integrated Ship Control System

1. The system comprises functions for the open-loop and closed-loop control, the monitoring and the safety of the installations required for ship operation.

2. The system shall be designed to have a hierarchical structure.

The following structural levels shall be provided as a minimum:

- Process level
- Control-loop level
- Control / command level

2.1 On the process level, the sensory capture of process data and the local information and control outputs take place.

2.2 On the control-loop level, the data belonging to a subprocess are collected and processed. The local sensors, actuators and indicators are served.

A local operating possibility shall be provided.

2.3 On the control/command level, the subprocesses are displayed and operated via control positions.

3. In the event of faults, the structural levels shall be free of reactive effects.

4. Central functions on the control/command level shall be covered by a redundancy concept.

5. For an essential subprocess, the relevant data shall only be captured locally. Data from other local process control components shall only be used for verifying data of the subprocess in question.

6. On the control/command level, no essential process tasks shall be performed. Only the display of actual values and the handing-over of setpoint values shall occur.

7. On failure of the control/command level or the connection to the higher-ranking control stations, manual operating of the subprocesses shall continue to be possible on the closed-loop control level by means of local control elements.

8. A defect in one of the subsystems, i.e. an individual module, unit or subsystem of the integrated system shall not affect the function of other subsystems.

9. A failure of the data transfer between connected autonomous subsystems shall not impair their independent essential functions.

10. Diagnosis functions

An integrated ship control system shall be equipped with self-diagnosis functions as follows:

10.1 The system shall offer installation-specific instructions for support with the diagnosis, elimination and prevention of faults in the installation.

10.2 All relevant components shall be monitored with the aid of suitable "watchdog" functions.,

10.3 The effect of faults on the process and on the scope of failures of functions shall be detectable by the system itself or made evident through suitable documentation.

10.4 For analogous signal transducers, a "live zero" is required, e.g. as per NAMUR.

Defined minimum and maximum values for sensors shall trigger an alarm on being infringed, i.e. leaving the valid measurement range.

10.5 Open-loop and closed-loop control components of self-contained installations shall pass on the diagnosis results allocated to them to the control system. This includes plausibility checks on the function of the connected installations and systems.

10.6 Actuators to be driven shall be provided with self-monitoring functions. If this is not possible, the motion shall be monitored additionally via plausibility checks through the ship control system.

D. Bus Systems

1. Simple bus links can be used in systems if the conventional implementation relies on a power supply.

2. If autonomous systems are centrally displayed and served via a bus, at least one collective alarm as per Section 3, C.1.16 shall be provided for each system in case of failure of the bus.

3. Essential equipment of different types shall not fail together as a result of the simple failure of a bus system.

4. If a redundant bus system is stipulated, it shall be fault-tolerant for a single-fault event. A fault shall trigger an alarm, and a changeover to the operable bus shall take place.

The standby bus shall also be monitored for operational readiness.

The individual bus cables shall be routed separately or protected in a suitable manner.

5. If a ring-bus system is stipulated, it shall be fault-tolerant in the event of short circuits and line breaks. Such faults shall trigger an alarm.

Forward and return cables shall be routed separately or protected in a suitable manner.

6. Any failure of a bus link shall lead to an unambiguous and safe condition.

7. In the case of active bus couplers, it shall be ensured that on failure/shutdown of the computer the data transport on the network is not affected.

E. Shipboard Training System

If a shipboard training system is provided, the following shall be observed:

1. With a shipboard training system, the possibility of conducting training courses during normal operation of the ship shall be created.

2. The training courses shall permit training in the areas of electrical installation, propulsion plant, ship operation and damage control and their interaction.

The ship engineering processes shall be simulated by models.

3. As training functions, the programming of courses using excerpts from recorded real and simulated scenarios as well as selection, start, stop, pause, restart and manipulation shall be possible.

4. Training operation, and the transition from training to normal operation and vice versa, shall not exert any effect on the normal operation.

5. The training mode shall be clearly recognizable

SECTION 6

MAIN PROPULSION PLANT

A. Remote Controls

1. General requirements

1.1 The remote control shall be capable to control speed, direction of thrust and, as appropriate, torque or propeller pitch without restriction under all navigating and operating conditions.

1.2 Single lever control is to be preferred for remote control systems. Lever movement shall be in accordance to the desired course of the ship.

Commands entered into the remote control system from the bridge shall be recognizable at all control stations.

1.3 The remote control system shall carry out commands including emergency manoeuvres which are ordered, in accordance with the propulsion plant manufacturer's specifications.

Where critical speed ranges are incorporated, their quick passing is to be guaranteed and a set point value within these ranges has to be inhibited.

1.4 With each new command, stored commands shall be erased and replaced by the new input.

1.5 In the case of set speed stages, a facility shall be provided to change the speed in the individual stages.

1.6 An overload limitation facility is to be provided for the propulsion machinery.

1.7 On ships with shaft-driven generators, it shall be ensured in case of manoeuvres which would prevent operation of the shaft-driven generator system, that the supply of the equipment in accordance with Section 8 is maintained without interruption.

1.8 Following emergency manual shutdown or automatic shutdown of the main propulsion plant, a restart shall only be possible via the stop position of the command entry.

1.9 For the entry of commands at monitor work places the requirements in 1.1 to 1.8 shall also be fulfilled. In the event of malfunctions or failure of the computer system, it shall be possible to change over to the mode using the conventional control-lever system, whereby at least one control lever shall be located on the bridge and one in the machinery space.

1.10 When the turning gear is engaged or automatic shutdown has not been acknowledged, any start attempts are to be prevented.

1.11 The failure of the remote control system and of the control power shall not result in any sudden change in the propulsion power nor in the speed and direction of rotation of the propeller.

In individual cases, TL may approve other failure conditions, where it is assumed that

- there is no increase in ship's speed
- there is no course change
- no unintentional start-up processes are initiated

1.12 The failure of the remote control system and of the control power is to be signalled by an alarm.

1.13 Should the remote control system fail, local operation shall be possible.

1.14 The transfer of control between the navigation bridge and machinery space shall be possible only in the machinery area.

1.15 At least all the stopping and reduction criteria mentioned in Section 11 shall lead to a stopping or reduction of the main propulsion automatically, or shall request these actions. Override possibilities are permissible, with the exception of the overspeed protection, see also Section 3, G.

2. Facilities on the bridge

2.1 An engine telegraph with feedback facility is to be fitted. The engine telegraph may be mechanically linked to the operation of the remote control system. Remote control and telegraph shall be mutually independent from each other and shall have separate

supplies.

2.2 In the event of failure of the remote control system, the main machinery shall be capable of being shutdown with an emergency manual shutdown facility from the bridge and the machinery control centre.

This device shall be independent of the remote control system and it's power supply.

2.3 The emergency shutdown facility shall not be automatically cancelled and shall be protected against unintentional operation.

2.4 With the consent of TL, for systems with clutch couplings, the shafting may be disconnected as an emergency stop facility from the bridge. The state of the coupling shall be indicated.

2.5 The following indications shall be provided for the main control stand, if there are any:

- Control from the machinery control centre
- Control from the bridge
- Control from the local control station

2.6 An indicator for the propeller shaft speed and the direction of rotation shall be provided for propulsion systems with fixed propellers.

2.7 In the case of controllable pitch propeller systems, an indicator shall be provided to display the speed of the propeller shaft and the pitch of the propeller.

2.8 For drives with gas turbines, speed indicators shall be provided for the free turbine and the gas generator.

2.9 In the case of systems which have reversing gears, indicators shall be provided to display the speed and direction of rotation of the propeller shaft and also the speed of the propulsion machinery.

2.10 For a propulsion plant with several shafts or several gearboxes, an indicator showing the current state of the various clutches shall be provided.

2.11 For electrical propulsion plants, the following indicators shall be provided:

- Revolution indicator for each propeller
- Indication of the power remaining available for the propulsion plant in relation to the total available ship's electrical power
- Plant ready for switching on
- Plant ready for operation
- Plant disturbed
- Power reduced
- Request to reduce

2.12 Change-over to other control stations in the bridge area may be done from the bridge.

It shall be ensured that control is only possible from one control station at any time. Transfer of command from one control station to another shall only be possible when the respective control levers are in the same position and when a signal to accept the transfer is given from the selected control station.

A display at each control station shall indicate whether the control station in question is in operation.

2.13 Change-over is not required where the control levers at the control stations are mechanically or electrically connected and with the control unit of the remote control system so that they automatically adopt the same position.

2.14 A malfunction in a system for synchronizing the lever control at several control positions shall not result in the failure of the remote control at the main operating station.

3. Facilities in the machinery control centre

3.1 If remote control of the propulsion plant is provided from a machinery control centre, the equipment listed under 2. shall also be fitted in the machinery control centre.

3.2 For electrical propulsion plants, a power meter and an indication of the generators connected to the drive shall be provided in addition.

4. Facilities at the engine manoeuvring platform

4.1 A manual operating facility for the engine which is independent of the remote control system is to be installed at the local machinery control station.

4.2 For a propulsion plant with several shafts or several gearboxes, an emergency operating possibility shall be provided for the clutches.

4.3 The indicators listed in 2.5 to 2.10 shall be fitted at the control station.

4.4 For electrical propulsion plants, the following measurement and display facilities shall be provided, differing from 2.11:

- Ammeter and voltmeter for each supply and each load component
- Ammeter and voltmeter for each exciter circuit
- Revolution indicator per shaft
- Plant ready for switching on
- Plant ready for operation
- Plant disturbed
- Power reduced

4.5 If several operating stations are needed for the local control of the propulsion plant, suitable communication possibilities shall be provided between them and the machinery control centre.

4.6 For the local indicators required according to Chapter 104 - Propulsion Plants, the following applies:

4.6.1 The indicators shall permit conventional operation that is independent of the automation system.

4.6.2 A fault shall only lead to failure of one indicator. The same applies for electrically powered indicators and their supply.

4.6.3 If these indicators are an integral element of an automation system, precautionary measures shall be taken to prevent failure of the indicators in the event of a fault in the automation system.

4.6.4 The same sensors can be used for both indicators and automation systems, if it is ensured that the indicator is still supplied with the measurement value in the event of failure of the automation system and vice versa.

5. Facilities at the operating station

If the entire propulsion plant is to be controlled locally by an automatic system, the same requirements as for a machinery control centre shall apply, as and where appropriate, see 3.

B. Speed/Performance Control of Main Propulsion Machinery

1. General requirements

1.1 The controller and the actuator shall be suitable for controlling the corresponding main propulsion machinery under the operating conditions laid down in the Rules and shall also be in line with the requirements specified by the engine manufacturer, see also Chapter 104 - Propulsion Plants.

1.2 In the event of faults in the regulator system, the operating condition of the aggregate shall not become dangerous.

Faults in the regulator system shall cause an alarm.

There shall be no resulting increase in speed and output.

2. Power supply

2.1 Control systems with an independent back-up system shall be supplied from the main source of electrical power.

2.2 Where main propulsion machinery can be operated without a supply of electrical power, e.g. pumps driven from the main engine, their control systems shall be fed from the main source of electrical power, if they have no mechanical back-up system.

In the event of failure of the main electrical power supply, the control systems shall be supplied by an uninterruptible power supply.

2.3 Where main propulsion machinery can only be operated with a supply of electrical power, e.g. electrically driven pumps, their control systems shall be supplied separately from each power station or from different main groups.

2.4 Dedicated power supplies shall be provided for each control system of plants comprising a number of main propulsion engines.

2.5 If an aggregate is out of service its control system shall not discharge batteries.

C. Diesel Engines

1. General requirements

For the monitoring, protection and control concept, Section 11 shall be observed

2. Starting operations

2.1 The number and duration of automatic start attempts shall be limited.

2.2 The number of starting operations prescribed according to Chapter 104 - Propulsion Plants shall also be verified for operations with the remote control system.

2.3 Electrical starting equipment

2.3.1 The starter batteries shall only be used for starting and preheating, where applicable and for the monitoring equipment and controller associated with the engine.

Maintaining and monitoring of the charge condition of the batteries shall be ensured.

2.3.2 If main engines are started electrically, two mutually independent starter batteries shall be provided. They shall be so arranged that they cannot be connected in parallel. Each battery shall be capable of starting the main engine from the cold condition.

2.3.3 The total capacity of the starter batteries shall be sufficient for a number of starting operations to be carried out within 30 minutes without recharging. For non-reversible main engines 6 starting operations must be possible.

3. Governors and overspeed protection

3.1 Each diesel engine shall be fitted with a safety governor or speed governor that is so adjusted that the speed of the engine cannot exceed its rated speed by more than 15 %.

3.2 Each main engine with a rated output of 220 kW or more which can be uncoupled during operation or which drives a variable-pitch propeller shall be fitted, in addition to the normal governor, with an independent overspeed protection that ensures that the speed of the engine cannot exceed the rated speed of the engine by more than 20%.

4. Safety devices

4.1 Each engine with a rated output of 220 kW or more shall be fitted with devices which automatically shut down the engine on failure of the lubricating oil supply.

4.2 If necessary, the engine shall be stopped if the cooling water pressure is too low.

4.3 An automatic reduction shall be triggered for the following cases:

- Oil mist concentration or engine bearing temperatures too high (only for engines of more than 2250 kW or a cylinder diameter of more than 300 mm)
- Lubricating oil temperature too high
- Cooling water temperature too high
- Exhaust gas temperature too high

4.4 Where a reduction is not sufficient to protect the engine, an automatic shutdown facility shall be provided.

D. Gas Turbine Plants

1. General requirements

For the monitoring, protection and control concept, Section 11, C. shall be observed.

2. Governors and overspeed protection

2.1 Main propulsion gas turbines shall be fitted with an overspeed protection which ensures that the speed of the engine cannot exceed the maximum continuous rating by more than 15 %.

2.2 If a main propulsion gas turbine is coupled to a reversing gear, an electrical power transmission, a variable-pitch propeller or a clutch coupling, an independent speed governor shall be provided that is suitable for controlling the speed of the unloaded gas turbine without the overspeed protection being triggered.

3. Safety devices

3.1 Main propulsion gas turbines shall be fitted with a quick-action turbine stopping device which automatically interrupts or stops the fuel feed to the turbine for at least the following cases:

- Overspeed
- Lubricating oil pressure too low
- Extinguishing of combustion during operation
- Inadmissible vibration
- Inadmissible axial shifting of a rotor
- Inadmissible exhaust gas temperature
- Lubricating oil pressure in the reduction gearbox too low
- Inadmissible low pressure at the compressor intake

3.2 The following auxiliary systems for auxiliary turbines shall be fitted with an automatic temperature control system, which is able to keep the normal operating values over the entire output range:

- Lubricating oil supply
- Fuel supply, or alternatively fuel viscosity
- Exhaust gas

3.3 There shall be facilities or interlocks which purge accumulations of liquid fuel, or blow out gaseous fuel, from all parts of the main-propulsion gas turbine before the ignition sequence can begin or reignition after a misfire can take place.

3.4 An emergency manual quick-closing device for the fuel feed shall be provided at the control position.

3.5 In the event of misfire, the starting device of the gas turbine shall be capable of aborting the ignition sequence and of shutting off the fuel feed within a specified period of time.

3.6 Safety devices prescribed in addition by the manufacturer with the purpose of preventing dangerous situations in the event of a malfunction in the turbine plant shall be submitted for approval.

E. Electric Motors

1. General requirements

1.1 For additional rules concerning electrical propulsion plants, see Chapter 105 - Electrical Installations, Section 13.

1.2 For the monitoring, protection and control concept, Section 11, D. shall be observed.

2. Control and regulating

2.1 An automatic power limitation of the propulsion motors shall ensure that the ship mains will not be overloaded.

2.2 The reverse power during reversing or speed-reducing manoeuvres shall be limited to the acceptable maximum values.

3. Safety devices

3.1 Automatic shutdown of the propulsion plant, which impairs the ship's manoeuvring capability, shall be limited to such failures which result in serious damage within the plant.

3.2 Safety devices shall be set to such values that they do not respond to overload occurring during normal operation, e.g. while manoeuvring, or if there are heavy seas.

3.3 Defects in reducing and stopping devices shall not impair the limited operation in accordance with Chapter 105 - Electrical Installations.

3.4 In the event of failure of an actual or reference value, it shall be ensured that the propeller speed does not increase unacceptably, the propulsion will not be reversed, or dangerous operating conditions arise. The same applies to failure of the power supply for control and regulating.

3.5 The following additional safety devices shall be provided:

- Protection of the drives in the event of uncontrolled mechanical blocking
- Overspeed protection
- Protection against overcurrent and short circuit
- Differential protection and earth fault monitoring (only for a single generator with more than 1500 kW)

F. Multi-Shaft Systems, Systems with Several Propulsion Machines

1. Drive types

1.1 All possible operating modes and drive types, including the emergency operating possibilities, shall be presented in tabular form with all the possible combinations.

1.2 The planned subdivision of the functionality for the controls, subgroup controls and their actuators shall be presented in an overall schematic diagram.

1.3 A hazard analysis (HAZAN) and a failure mode and effects analysis (FMEA) for the possible operating modes and drive types mentioned under 1.1 and for the controls and actuators mentioned under 1.2 shall be submitted for approval.

1.4 The various control curves and operating instructions shall be specified in relation to the different drive types.

1.5 If the availability is to be increased through the use of multi-shaft systems or systems with several propulsion machines, the TL Rules Chapter 23 – Redundant Propulsion and Steering Systems shall be observed.

2. Control and regulating

2.1 In the case of multi-shaft systems, there shall be a possibility of controlling and switching off each individual propulsion plant from the bridge.

2.2 Dedicated power supplies shall be provided for each control system of plants comprising a number of main engines or gas turbines.

3. Safety systems

Safety systems shall be divided up so that the failure of any plant component does not impair the function of the other plant components, or the proper functioning can be restored by simple measures.

4. Alarms

Alarms on the bridge shall be provided separately for each propulsion plant.

5. Stand-by circuits

The stand-by circuits prescribed for these plants can be omitted if a multi-engine propulsion plant is provided with separate systems and with automatic and individual stopping (uncoupling).

The autarky of the compartments has to be observed, if applicable.

SECTION 7

AUXILIARY MACHINERY SYSTEMS

A. General

1. Means shall be provided for auxiliary machines which are started automatically or by remote control to prevent undesired remote and automatic start-up.

2. For the scope of stand-by circuits and remote control facilities for essential auxiliary machinery as well as for the scope of the alarm and registrating locations, see Section 11.

3. With regard to the individual local alarms listed in Section 11, a collective alarm which indicates a fault in the system concerned is sufficient in the machinery alarm system.

3.1 The individual alarms shall be recognizable at the system concerned.

3.2 Specifications for collective alarms are given in Section 3, C.1.16.

B. Remote Controlled Valves, Units and Processes

1. If valves, units and processes are remote controlled, all the necessary elements shall be operable by remote control.

2. If a certain type of valve, aggregate or process is remote-controlled, then all other units of the same type shall, as far as is possible, also be remote-controlled.

3. Manual control shall be possible.

4. The option for manual control, even of individual elements, shall be recognizable on the remote control unit.

5. Manual control shall have priority. The remote control shall not have any capability for overriding the manual control.

6. Failure of the remote control facilities shall not result in any control outputs. Elements shall preferably be driven by pulse signals.

7. An acknowledgement message shall be sent back to confirm control commands. If no acknowledgement message that matches the command is received after a process-dependent delay, this condition shall be signalled.

C. Source/Target Control

If a source/target control is envisaged, the following shall be observed, see also P.2.4:

1. The possibility of rerouting a certain quantity shall be provided.

2. The release of the pipe route and the starting of the necessary feed pumps shall occur automatically.

3. The feed pumps shall only be started after positive confirmation of the valve positions has been received.

4. If manual interventions are made in the automatism of the source/target control, or if an aggregate or valve needed for the source/target process is manually remote-controlled or remote-actuated, or if an acknowledgement message is not clear, the procedure shall be terminated automatically and the installation shall be brought into a safe operating condition.

D. Ship Stabilizer Plants

1. General requirements

1.1 The provisions relating to mechanical equipment in Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 2, B. shall be observed.

1.2 Under all operating conditions, even in the event of a fault, the stabilizer plant shall not cause any hazardous conditions for the ship.

1.3 The failure condition of the plant shall ensure the neutral position of the ship.

2. Rudder roll stabilization

2.1 The roll stabilization by the rudder is a function of the steering gear control system.

2.2 It shall be possible to select the normal steering gear control system reliably at all times.

2.3 The maximum rudder angle shall be limited for the rudder roll stabilization mode.

E. Auxiliary Diesel Engines

1. Automatic or remotely controlled start attempts shall be limited in duration and number.

For the remotely controlled or automatic starting of engines, only systems are permitted which allow starting for any position of the crankshaft.

2. Electrical starting devices

2.1 The starter batteries shall only be used for starting (and preheating, where applicable) and for the monitoring equipment and controller associated with the engine.

2.2 Maintaining and monitoring of the charge condition of the batteries shall be ensured.

2.3 If several auxiliary engines are started electrically, at least two mutually independent batteries shall be provided. The use of the main engine starter batteries, if there are any, is permitted.

2.4 The capacity of the batteries shall be sufficient for at least three starting operations per engine.

2.5 If only one of the auxiliary engines is started electrically, one battery is sufficient.

3. In the event of overspeed or a failure of the lubricating oil supply of diesel engines, automatic stopping of the engine shall be ensured.

4. Regulators

4.1 Electrical regulators and the associated actuators are subject to mandatory type-testing.

4.2 In the event of faults in the regulator system, the operating condition of the engine shall not become dangerous.

4.3 In the case of malfunctions in the regulator system, the fuel admission in the injection pumps shall be set to "0". Faults in the regulator system shall cause an alarm.

4.4 Batteries shall not be discharged by the regulator system following an engine shutdown.

5. Starting and stopping operations

5.1 The starting and stopping operations for the individual automated generators should also be possible through manual actuation in the corresponding section of the power station switchboard.

5.2 It shall be ensured that the starting operation for a generator can only take place if all start interlocks have been released.

5.3 The start interlocks shall be fitted with an override possibility.

5.4 For each aggregate, an emergency stop pushbutton shall be provided locally at the machine.

F. Auxiliary Turbines

1. Remotely controlled or automatic start-up of auxiliary turbines and acceleration to rated speed are to be accomplished in such a way that the load applied is without risk to the turbines.

2. Safety system

For the safety devices, see gas turbines, Section 6, D.

G. Auxiliary Steam Plants

The requirements according to Section 11, Table 11.6 and Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 15 are to be observed.

H. Purifier Systems

1. The temperature of the separating medium shall be automatically controlled and monitored.

2. Malfunctions in the purifying process shall cause the flow to the purifier to be cut off automatically.

3. Depending upon type and method of separation, the unintentional opening of the drum and the loss of the water seal and water in the medium to be separated shall trip an alarm, see Section 11, Table 11.6.

4. The heating system of the preheater is to be so designed that an interruption of the flow to the purifier does not result in overheating of the preheaters.

I. Air Compressor Systems

In the event of failure of the pressurized lubrication system, independently driven compressors shall shut down automatically. A suitable automatic drain facility shall be provided for the cooler and water traps, also during operation, where appropriate.

J. Hydrophor Facility / Fresh Water Conditioning

1. The filling level in the fresh water storage tanks shall be monitored.

2. When 95 % of the storage volume is reached, the conditioning plant shall stop automatically.

3. If the level falls below 15 % of the storage volume, an alarm shall be triggered.

4. Two pressure pumps shall be provided as standby units.

5. The pressure in the booster tank shall automatically be kept within the working range.

6. If the working pressure is not attained after a certain operating time of the pressure pump, this status shall trigger an alarm and the pump shall be stopped.

7. The temperature of the hot water circuit shall be regulated automatically.

8. The operating temperature shall be supervised against maximum and minimum temperature and trigger an alarm.

K. Main Fire Extinguishing Pumps

1. The fire extinguishing system shall be kept under constant pressure.

2. A pressure drop shall trigger an alarm.

3. In the event of a pressure loss during peacetime in-port readiness, the pressure pumps can be started automatically.

4. A pressure loss without any demand from fire-extinguishing water consumers shall trigger an alarm.

5. Rising mains shall be shut off automatically during the operating conditions "combat / action stations" and "wartime cruising", and may only be opened again after being selected.

L. Valves at the Shell

Valves at the outer shell which are open during operation of the machinery shall be accessible, and it shall be possible to operate them from a safe position above the floor plates.

M. Measuring System for Tank Contents

1. If an electrical system for measuring tank contents is envisaged, the following requirements shall be observed:

2. The tank levels shall be indicated in volume and mass.

3. The position of the tanks within the ship shall be clearly recognizable.

4. The measurement tolerance shall not exceed 5 % on even keel.

5. Sensor values lying outside the plausible range shall trigger an alarm. If the sensor is defective, the corresponding indication shall be marked as invalid.

6. The alarms required for fuel or lubricating oil tanks shall not be derived from the signals supplied by the filling level sensors. Separate sensors shall be provided.

7. As far as possible, sensors shall not be arranged in the pressure and suction funnel of the tanks.

N. Bilge and Drain Facilities

1. Bilge wells shall be located and monitored in such a way that the accumulation of liquid is detected at normal angles of trim and heel, and shall be large enough to accommodate easily the normal drainage during the unattended period.

2. Where devices are fitted to provide automatic drainage of engine room bilges or bilge wells, an alarm shall be tripped to indicate when the bilge pump is running too often or too long.

3. Where, as a result of the **MARPOL** convention, a facility is specified for monitoring the residua oil content in the bilge water and, where appropriate, an automatic interruption in the drain process, an alarm is to be tripped when the limit value is exceeded and - where specified - the drainage process is to be stopped.

4. The water level in each watertight space/ section shall be monitored.

5. Sluice valves and nozzle valves between the spaces/sections shall close automatically during the operational conditions "combat/action stations" and "wartime cruising".

6. The fault and failure position of these valves shall be "closed".

O. Chilled Water Units

1. The temperature of the chilled water system and the capacity of the refrigerating compressors shall be controlled automatically, see also Chapter 107 – Ship Operation Installations and Auxiliary Systems, Section 12, G.4.

2. Chilled water circuits are to be monitored for the danger of frost in the range of immediate vicinity to water chillers. The monitoring device shall be set so that it is activated before the freezing point of the cooling medium is reached.

3. Chilled water circuits shall be provided with flow monitors. Starting of the compressor shall only be possible at given chilled water flow.

A starting delay shall be provided.

4. Refrigerating plants shall be fitted with low pressure cutout which shut down the compressor set if the condensing pressure is too low.

5. Compressors, whose oil circuit is not maintained by splash lubrication but by pressure lubrication, shall be fitted with a differential pressure switch which shuts down the compressor unit in case the difference pressure between oil - and refrigerant suction pressure exceeds the lower threshold value. Restart of the compressor shall be possible only after manual re-set.

6. The following operating parameters shall be indicated and any deviation of the limit values shall trigger an alarm:

- Current of the compressor drive motor
- Differential pressure of lubricating oil

- Suction pressure

- Discharge pressure

7. Water loss shall trigger an alarm.

8. Indication and operating equipment in the damage control centre shall be provided as follows:

8.1 It shall be possible to switch the plant on and off,

8.2 Centralized shutdown of the plants separated for each damage control area (main fire zone) shall be provided.

8.3 Alarms and operating conditions shall be indicated for each refrigerating plant.

8.4 Temperature indications for the refrigerating plants and the related refrigeration spaces shall be provided.

9. An approved refrigerant warning device shall be provided.

10. All the necessary switching, open-loop and closed-loop control equipment shall only be structurally combined for installations belonging to the same damage control area.

11. If several chilled water units are operated in sequential mode, the following shall be observed:

11.1 When the active unit has attained a predetermined maximum capacity, a starting signal shall be sent to the next stand by unit.

11.2 The failure of any unit shall not affect the functioning of the others.

11.3 In the event of water loss, the affected section shall be isolated from the others.

11.4 The connection and disconnection of additional units shall be such that, as far as possible, the active units are utilized with full capacity before additional units are connected.

11.5 If all units are in operation, an alarm shall be triggered when a prescribed absolute maximum value is reached.

P. Fuel System

The fuel system comprises the inward and outward fuel transfer, the storage, the fuel feed and the distribution of fuels.

1. Surveillance of tank content

1.1 The requirements set out in M. shall be observed

1.2 Trim and heel shall be considered for the content calculation if required by building specification.

1.3 Inadmissible changes in the contents of tanks shall trigger an alarm.

2. Remote control of pumps and valves

2.1 The requirements set out in B. shall be observed.

2.2 The desired/actual-value condition of the controlled valves and pumps shall be monitored constantly for deviations.

2.3 In the event of a fault, no dangerous condition shall arise, e.g. pressure wave through valve falling closed.

2.4 Level alarms shall be triggered by independent maximum-value sensors. In case of source/target control such an alarm shall lead to an interruption of a filling operation.

SECTION 8

ELECTRICAL SYSTEMS

A. Power management system

1. General

1.1 The power management system has the task of autonomously safeguarding the adequate supply of the electrical installations with due regard to the operating condition of the ship; see Chapter 105 – Electrical Installations, Section 3, A.

1.2 The electrical power supply shall be automated with respect to the starting and stopping of the generators, as well as the synchronization, paralleling and load sharing.

1.3 Through suitable measures, it shall be ensured that the ship's electrical supply remains available to an adequate degree, even in the event of a single failure.

1.4 The assemblies needed for generator protection shall be mutually independent and located in the section of the power station switchboard belonging to the generator. See also Chapter 105 - Electrical Installations, Section 4.

1.5 In the event of a single failure in the power management system, the independent operation of each generator and manual synchronization of the generators shall be possible.

1.6 The operational readiness and priority of each generator shall be selectable.

2. Synchronizing and paralleling

2.1 The automation system shall be so designed that any generator can be connected first to a de-energized network. After this, it shall be possible to automatically synchronize and connect all the other generators as required to commence parallel operation after the start procedure has been completed.

2.2 The synchronizing device shall harmonize the frequency and phase relation of the voltage of the generator with that of the network so precisely that the parallel connection can be made without impairment of the generators and switchgear, see Chapter 105 - Electrical Installations, Section 4.

2.3 If the synchronizing process is not successful, an alarm shall be triggered.

3. Sharing of active load

After completion of paralleling, the automatic system shall distribute the active load.

4. Load-dependent connection and disconnection

4.1 Depending on the current mains' load, it shall be possible to automatically connect or disconnect stand-by generating sets to or from a base-load set. If the base-load generator is connected to the network, further generators shall then start in a specified sequence and in the number determined by the demand of the ship's mains. The disconnection is then performed in the reverse order.

4.2 It shall be possible to select the reference generator, i.e. the base-load generator, manually.

4.3 A faulty stand-by generator shall automatically be removed from the add-on sequence, and an alarm shall then be triggered.

4.4 The selection of suitable load conditions for the connection and disconnection of generators depends on the size and number of installed units and consumers.

4.5 Operational disconnection at reduced load should be performed with a time delay. A generator that has been disconnected in this way is not locked out and remains ready for operation.

4.6 The automatic system shall be so designed that prolonged parallel operation with less than 40% load per generator is avoided.

4.7 The connection of high-power consumers shall be delayed until sufficient generator output is available.

B. Automation of the Shipboard Supply System (Electrical Distribution / Main Groups)

1. An automatic changeover of the power supply shall be provided, taking into consideration the available

supply voltage and the loading of the power stations.

2. Automatic restarting after a power failure shall be provided for specified essential equipment according to Section 11, I.

3. The interconnected operation of several power stations shall be controlled automatically, taking account of the operating conditions.

4. It shall be possible to actuate the bus-tie breakers between the feed points of the busbars in the power station switchboards either manually or by remote control.

SECTION 9

SHIP PROTECTION MANAGEMENT

A. Damage Control

1. Application

The ship protection management is used for rapid and targeted damage control. The ship control system shall support the ship operation technology, especially in the task areas of damage prevention, damage detection, damage limitation and damage control.

2. General requirements

If a ship protection management is envisaged, the following shall be observed:

2.1 The functions shall be provided on the control level of the integrated ship control system.

2.2 The database of the open-loop control and monitoring system shall be used.

2.3 The spatial arrangement of the elements to be controlled and monitored on the ship or within a sec tion shall be clearly recognizable. If necessary, e.g. for the representation of several decks, the isometric view shall be preferred.

3. Killcards and automatic sequential circuits

3.1 Killcards, if applicable shall be made available to the operator.

3.2 For each space, a killcard comprises the measures and information required for battle damage control. The detailed scope for each specific project shall be defined in the building specification.

3.3 Killcards are offered automatically by the systems.

3.4 Each killcard contains complete information how to react on a specific damage, e.g. fire or leakage, considering the different systems and conditions of the ship's compartment.

3.5 Switching actions for damage control are either carried out manually on the basis of information of the "static" killcards in the local process displays or as an automatic sequential circuit through confirmation (acknowledgement) of a control panel.

3.6 Following confirmation, the automatic sequential circuits shall run automatically as far as possible.

3.7 Steps which shall be initiated manually shall be clearly recognizable.

3.8 The execution of an automatic sequential circuit shall be monitored, and faulty execution shall trigger an alarm.

4. Switchover of operating conditions

4.1 For a change in operational conditions, the ship protection management performs, after acknowledgement by the operator at the corresponding control station, the various connections, disconnections and changeover actions specified in the building specification.

4.2 The switchovers of operational conditions are performed as automatic sequential circuits.

4.3 For example, for the following operational conditions switchovers shall be provided:

4.3.1 connection of all generators and opening of the interconnection feeder

4.3.2 closing of the rising mains in the fire extinguishing system

4.3.3 opening of the gates of the flood pump spaces in the compartments

4.3.4 separation of the compressed air system in solitary mode

4.3.5 complete or partial shutdown of diverse installations and devices, e.g. fans, fuel oil pumps, in the related compartments and service spaces for a confirmed and locally identifiable fire alarm

4.3.6 adding-on of defined fire pumps in the event of pressure loss

4.3.7 pumping-out during the sprinkling of ammunition rooms

4.3.8 pumping procedures in the bilge water collecting tank

4.3.9 damage limitation after hit damages, e.g. changeover to redundant infeed from the cold water system for essential consumers

4.3.10 switching-off of source/target control in the fuel system in the event of fire in the ship, e.g. aborting of the fuel transfer process during underway replenishment at sea.

4.4 Only manual enabling of overside pumping procedures following damage to the ship shall be possible.

B. Camera Surveillance

If camera surveillance is prescribed in the building specification for certain zones, the following shall be observed:

1. The images shall be clear and without distortion.

The possibility of still pictures shall be excluded, or still pictures shall be recognizable as such.

2. If images originating from several cameras can be shown on one monitor, the current camera location shall be identified.

3. If the images are to be shown via the visualizations of stipulated installations, e.g. the alarm system, the information which shall always be visible shall be superimposed over or inserted into the image.

4. Whether the use of the camera system is able to replace the prescribed alarm, signalling and display systems shall be considered in each individual case.

The requirements for the camera system, such as:

- Redundancies
- Colour display
- Sensitivity to low light levels
- Sound track transmission, and
- Capability of panning / zooming

shall be coordinated.

SECTION 10

TESTS

A. General

1. The testing of systems, equipment and assemblies demanded according to Section 2 are subject to the following rules.

2. As part of the general quality assurance system, the manufacturer shall ensure that the products which he manufactures meet the requirements as specified.

Records of the measures adopted and tests carried out as part of the quality assurance procedure shall be prepared.

3. For certain systems, equipment and components specified in the rules, tests are to be carried out in the presence of a TL Surveyor.

The tests and test specimen specified represent the minimum requirement.

Tests in the manufacturer's works or on board may also be required for other test objects, if the particular design of the test object makes this necessary. This applies in particular to integrated systems.

4. In the case of new systems, additional tests and trials are to be agreed, as required.

5. The purpose of the tests is to demonstrate compliance with the requirements as laid down in the building specification and the suitability of the test specimen for their intended use.

6. Where computer systems are used for functions which are essential to the safety of ship, crew and supply goods or to the fulfillment of the ship's tasks, records, test results and assessments are to be provided for the hardware and software in accordance with Chapter 105 - Electrical Installations, Section 10.

7. Tests are divided in:

- examination of technical documentation, see B.
- tests in manufacturer's factory (FAT), see C.
- tests on board (HAT and SAT), see D.
- tests for type approvals, see E.

The test procedures for FAT, HAT, SAT and type approvals are to be laid down in documents and are subject for approval by TL, see Section 1, C.5.

B. Examination of Technical Documents

1. The list of documents which are subject to approval is specified in Section 1, C.

2. Documents which have been examined and marked accordingly are to be submitted to the TL Surveyor on request.

C. Conducted at the Manufacturer's Factory (FAT)

1. Tests conducted in the presence of a TL Surveyor

The tests shall be carried out on the basis of the TL Rules for Classification of Steel Ships and the approved documents. They shall take place in accordance with a recognised standard.

2. Additional tests

TL reserve the right to demand additional tests for systems which have safety implications, or in case of extensive automation systems or where individual systems are integrated.

D. Tests on Board

1. General

Tests comprise:

- Tests during construction/installation
- Tests during commissioning

2. Tests during construction/ installation and system integration

2.1 During the period of construction of the ship, installations are to be checked for compliance with the documents which have been approved by TL and with the TL Rules for Classification and Construction.

2.2 Test certificates relating to tests which have already been carried out are to be submitted to the Surveyor on request.

2.3 The satisfactory condition and the proper functioning of all automation facilities shall be verified including their power supply.

2.4 Where not specified in the TL Rules for Construction, the tests to be conducted are to be agreed in accordance with the system requirements.

3. Tests during commissioning (SAT)

3.1 The satisfactory condition and correct operation of all automation equipment are to be demonstrated.

3.2 Corresponding proof shall be provided during sea service - without manual intervention - over a period of at least 6 hours.

E. Type Tests

1. The following installations, equipment and assemblies are subject to mandatory type testing:

- Computer systems
- Open-loop and closed-loop controls, and monitoring circuits, of essential equipment and of facilities serving the primary duty of the ship
- Integrated systems
- Remote control systems for the main propulsion plant
- Sensors and actuators for specified automation equipment
- Machinery alarm systems
- Duty alarm systems
- Safety devices
- Safety systems
- Power supply automation
- Measuring systems for tank content

2. As an alternative to the type tests specified, particular tests may be carried out, where justified in individual cases, with the prior consent of TL.

SECTION 11

SENSORS, STAND-BY CIRCUITS AND REMOTE-CONTROL FACILITIES

A. General

1. The monitoring, protection, open-loop and closed-loop control concept for equipment and installations shall ensure safe operation under all operating conditions.

2. The alarm, reduction- and shutdown criteria listed below represent the minimum requirement.

3. Dependent upon the design of the machinery plant, it may be necessary to adapt the range and details given in the Tables.

4. If more than one sensor is required for a criterion according to the Tables 11.1 to 11.8, it shall be ensured that the evaluation of the data from sensors takes place independently. If designed suitably, redundancy concepts can replace the need for independent evaluation.

5. For the design of the alarm devices, the provisions set out in Section 3, C. shall apply. Reductions of the operation parameters shall be in accordance with Section 3, E.

6. For the design of the stand-by circuits, the provisions set out in Section 3, H. and I. shall apply.

7. For the design of safety systems and safety devices, the provisions set out in Section 3, D. shall apply.

B. Sensors for Main Propulsion Diesel Engines (Medium and High Speed)

Table 11.1 Sensors for main propulsion diesel engines: Lubricating oil, coolant, fuel

Meaning of symbols: I = indication of cause of alarm U = low limit O = high limit R = reduce S = shut down B = start standby aggregate	Sensor for alarms	Sensor for controls	Sensor for safety functions	Individual alarm at the bridge
Lubricating oil				
Lubricating oil pressure at engine inlet **(1)(2)**	U	U/B	U/S	
Lubricating oil filter differential pressure	O			
Temperature of lubricating oil at engine inlet	O/R			
Concentration of oil mist or temperature of engine bearings for engines with power above 2250 kW or with cylinder diameters above 300 mm **(3)(4)**	O/R			
Failure in cylinder lubrication	R			
Level in lubrication oil sump tanks **(1)**	U			
Fault at lubricating oil automatic filter	I			
Coolant				
Cylinder cooling water pressure	U		U/S	
Temperature of cylinder cooling water at each cylinder outlet **(5)**	O/R			
Level in coolant expansion tanks	U			
Oil contamination in cylinder cooling water system **(6)**	I			
Pressure of seawater for cooling	U	U/B		
Pressure of LT (low temperature) freshwater cooling circuit	U			
Temperature of LT (low temperature) freshwater cooling circuit	O			
Fuel				
Fuel oil pressure to injection pumps	U			
Heavy fuel oil viscosity or temperature	U+O			
Leakage fuel injection pipe	I			
Fuel level (gas blanket) **(7)** in closed stand pipe	U			
Fault in automatic fuel oil filter	I			
Level in fuel oil service tank	U			

Table 11.1 Sensors for main propulsion diesel engines: Turbochargers, exhaust gas, air *(continued)*

Meaning of symbols: I = indication of cause of alarm U = low limit O = high limit R = reduce S = shut down B = start standby aggregate	Sensor for alarms	Sensor for controls	Sensor for safety functions	Individual alarm at the bridge
Turbocharger				
Lubricating oil pressure turbocharger **(9)**	U			
Lubricating oil temperature turbocharger outlet **(9)**	O			
Charging air temperature **(8)**	U+O			
Exhaust gas				
Exhaust gas temperature turbocharger inlet and outlet	O			
Exhaust gas temperature or deviation from exhaust gas mean temperature	(U+O)/R			
Air				
Control air pressure	U			
Starting air pressure **(10)**	U			
Overspeed trip (2)	O		O/S	

(1) *Individual alarms are to be provided for separate circuits*

(2) *Shut down only for engines from 220 kW upwards*

(3) *Shut down where necessary*

(4) *For high speed engines also other surveillance methods may be agreed with TL*

(5) *Where all cylinders have a common cooling water chamber with no individual shut-offs, individual monitoring may be dispensed*

(6) *With where cooling water is used for preheating or cooling fuel, lubricating oil*

(7) *Not applicable in the case of automatic gas-venting*

(8) *As an alternative, "Water in charge air-duct" instead of low limit*

(9) *Not applicable for selfcontained lubricating oil circuits*

(10) *For engines with direct reversing capability and also all engines with remote start from the bridge, individual alarm*

C. Sensors for Propulsion Gas Turbines

Table 11.2 Sensors for propulsion gas turbines

Meaning of symbols: I = indication of cause of alarm U = low limit O = high limit R = reduce S = shut down B = start standby aggregate	Sensor for alarms	Sensor for controls	Sensor for safety functions	Individual alarm at the bridge
Level in lubrication oil sump tank	U			
Level in lubrication oil gravity tank	U			
Lubricating oil pressure before turbine **(1)**	U	U/B	U/S	
Lubricating oil filter differential pressure	O			
Lubricating oil temperature before turbine	O			
Cooling water pressure	U	U/B		
Fuel pressure	U			
Coolant temperature	O			
Bearing temperature	O			
Failure of flames / igniting flame	I		S	
Vibrations **(1)**	O		O/S	
Axial displacement of the rotor	O		O/S	
Exhaust gas temperature **(1)**	O			
Low pressure before compressor **(1)**	U		U/S	
Speed free turbine	(U+O)		(U+O)/S	
Speed gas generator	O		O/S	

(1) *Limits must be reachable, without achieving a critical condition leading to a shut-down*

D. Sensors for Electric Propulsion Plants

Table 11.3 Propulsion motors, motor exciters

Meaning of symbols: I = indication of cause of alarm U = low limit O = high limit R = reduce S = shut down B = start standby aggregate	Sensor for alarms	Sensor for controls	Sensor for safety functions	Individual alarm at the bridge
Propulsion motor				
Excess current	O			
Short-circuit	I/S			
Overspeed	O			
Undervoltage	U			
Underfrequency	U			
Earth-fault at stator/rotor winding	I			
Protection of differential relais	I			
Stator winding temperature	O			
Bearing temperature	O			
Lubricating oil temperature	O			
Coolant temperature at inlet	O			
Coolant temperature at outlet	O			
External ventilation failure	I			
Exciter failure	I			
Motor exciter				
Current in power circuit	O			
Voltage in power circuit	O			
Short-circuit in power circuit	I			
Feeding failure	I			
Control voltage failure	I			
Ventilation failure	I			
Exciter thyristors temperature	O			
Exciter transformer temperature	O			
Failure of fuses	I			
Failure of regulator	I			
Earth-fault	I			

Table 11.3 Sensors for electric propulsion plants: Frequency converters, equipment for intermediate circuits *(continued)*

Meaning of symbols: I = indication of cause of alarm U = low limit O = high limit R = reduce S = shut down B = start standby aggregate	Sensor for alarms	Sensor for controls	Sensor for safety functions	Individual alarm at the bridge
Frequency converter				
Failure of main feeding	I			
Current in power circuit	O			
Feeding voltage	U+O			
Internal short-circuit	I			
Failure of control voltage	I			
Earth fault in power circuit	I			
Failure of ventilation	I			
Converter cubicle temperature	O			
Thyristor temperature	O			
Failure of thyristors / fuses	I			
Impulse mistake	I			
Computer mistake	I			
Deviations of set and actual values	O			
Equipment for intermediate circuits				
Choke winding temperature	O			
Mistake in intermediate circuit	I			
Converter transformer				
Short-circuit / differential protection	I			
Earth-fault	I			
Transformers windings temperature	O			
Generators				
Stator current	O			
Stator short-circuit	I			
Overspeed	O			
Voltage	U			
Frequency	U			
Stator earth-fault	I			
Stator windings temperature	O			
Bearing temperature	O			
Lubricating oil temperature	O			
Air intake temperature	O			
Air outlet temperature	O			
Failure of external ventilation	I			

E. Sensors for Propulsion Shafting and Steering Gear

Table 11.4 Sensors for propulsion shafting and steering gear

Meaning of symbols: I = indication of cause of alarm U = low limit O = high limit R = reduce S = shut down B = start standby aggregate	Sensor for alarms	Sensor for controls	Sensor for safety functions	Individual alarm at the bridge
Propulsion shafting				
Lubricating oil pressure before gear	U/R		U/S	
Lubricating oil temperature in gear **(1)**	O/R			
Lubricating oil filter differential pressure	O			
Level of lubricating oil in gear	U			
Level in tank for stern tube oil	U			
Temperature of aft stern tube bearing **(2)**	O			
Temperature of each radial bearing **(3)**	O			
Temperature of aft shaft bearing	O			
Temperature of thrust bearing or lubricating oil temperature at the thrust bearing	O/R			
Pressure of hydraulic oil for controllable pitch propeller	U			X
Level of hydraulic oil for controllable pitch propeller	U			
Steering gear				
Failure of power unit **(4)**	I			X
Overload and failure of one phase of electric drive	I			X
Low level hydraulic oil tank	U			X
Voltage failure rudder control **(4)**	I			X
Functional failure of hydraulic system (hydraulic lock alarm)	I			X

(1) *Above 1500 kW for antifriction bearing*

(2) *For shaft diameter below 400 mm temperature of oil for stern tube near to the aft bearing instead*

(3) *Not valid for antifriction bearing*

(4) *Alarms on the bridge may be continued, if there is fixed relation between control system and power unit*

F. Sensors for Auxiliary Diesel Engines

Table 11.5 Sensors for auxiliary diesel engines

Meaning of symbols: I = indication of cause of alarm U = low limit O = high limit R = reduce S = shut down B = start standby aggregate	Sensor for alarms	Sensor for controls	Sensor for safety functions	Individual alarm at the bridge
Auxiliary diesel engines				
Pressure of lubricating oil **(1)**	U		U/S	
Differential pressure of lubricating oil indicator filter	O			
Coolant pressure or flow	U			
Temperature of cooling water or cooling air	O			
Level of cooling water equalizing tank, if separate circuit	U			
Pressure of starting air	U			
Pressure of fuel	U			
Heavy fuel oil viscosity or -temperature	U+O			
Failure of fuel automatic filter	I			
Differential pressure of fuel indicator filter	O			
Leakage in fuel injection pipes	I			
Overspeed **(1)**	O		O/S	
Level of fuel operating tank(s)	U			
Concentration of oil mist or temperature of engine bearings for engines with power above 2250 kW or with cylinder diameters above 300 mm. **(2)**			O/S	

(1) *Shut-down only for engines from 220 kW upwards*

(2) *For high speed engines other methods of surveillance may be agreed with TL*

G. Sensors for Generation and Utilization of Heat

Table 11.6 Sensors for generation and utilization of heat

Meaning of symbols: I = indication of cause of alarm U = low limit O = high limit R = reduce S = shut down B = start standby aggregate	Sensor for alarms	Sensor for controls	Sensor for safety functions	Individual alarm at the bridge
Purifier Systems				
Temperature of separating medium	U+O			
Unintentional opening of drum	I			
Loss of water seal	I			
Sludge tank level	O			
Oil fired heaters				
Temperature at heater	O			
Circulation	U			
Temperature of flue gas	O			
Leakage	I			
Exhaust gas fired heaters				
Temperature at header	O			
Circulation	U/R			
Exhaust gas temperature at heater outlet	O			
Fire in heater	I			
Leakage	R			
Auxiliary steam plant				
Condensate, feed water and steam system				
Level in condensate tank	U			
Salt content	O			
Oil penetration	I			
Oil fired boiler				
Level of water	U+O			
Pressure of steam	O			
Circulation	U			
Exhaust gas boiler				
Level of water	U+O			
Pressure of steam	O			
Fire in exhaust gas boiler (boiler with framed tubes)	I			
Evaporator plant				
Salt content of the produced distillate	O			

.

H. Sensors for Fire Alarm Systems, Electrical Plants and Others

Table 11.7 Sensors for fire alarm systems, electrical plants and others

Meaning of symbols: I = indication of cause of alarm U = low limit O = high limit R = reduce S = shut down B = start standby aggregate	Sensor for alarms	Sensor for controls	Sensor for safety functions	Individual alarm at the bridge
Fire alarm system				
Fire alarm**(1)**	I			X
Fault	I			
Electrical plant				
Failure of ship's main	I			
Shut-down of unimportant consumers	I			
Generator switch activated	I			
Low frequency	U			
Excess voltage	O			
Failure 24 V main charger	I			
Fault in energy supply automation	I			
Cold water system				
Frost controller (temperature)	U			
Circulation flow	U			
Difference of oil pressure to suction pressure of refrigerant	U			
Current of compressor drive motor	O			
Suction pressure	U			
Outlet pressure	U			
Hydrophor plant				
Volume of reserves	U			
Working pressure	U			
Operation temperature	U/O			
Others				
Failure of bus system	I			
Failure of remote control	I			X
Failure of alarm system	I			X
No acknowledgement of an alarm	I			
Failure of safety system	I			
Activation of the safety system	I			

Table 11.7 Sensors for fire alarm system, electrical plants and others *(continued)*

Meaning of symbols: I = indication of cause of alarm U = low limit O = high limit R = reduce S = shut down B = start standby aggregate	Sensor for alarms	Sensor for controls	Sensor for safety functions	Individual alarm at the bridge
Override of safety system is activated	I			
Failure control system	I			
Set/actual values deviation of a remote control	I			
Start of an aggregate with override	I			
Automatic start of an auxiliary device	I			
Fault of a stand-by control unit	I			
Automatic sequence circuit unsuccessful (only ships with safety management system)	I			
Tank measuring system, filling levels	O			
Fuel tank, impermissible change of content	I			
Level of engine room bilge, bilge suction pipe **(3)**	O			
Oil content of bilge water after separator	O			
Switching-on time and frequency of automatic bilge pumps	O			
Level of fuel overflow tank	O			
Level leakage oil tank	O			
Failure of CO_2 -low pressure system	I			
Failure of compressor for starting air **(2)**	I			
System pressure of fire extinguishing system	U			
Activation of automatic fire extinguishing system	I			

(1) *Alarm to be distinguished from other alarms*

(2) *Only if main engine is directly reversible*

(3) *At minimum two separate sensors for alarms at each engine room or department*

I. Stand-by Circuit and Remote Control of Essential Equipment

Table 11.8 Stand-by circuit and remote control of essential equipment

Plant/System		Stand-by circuit	Starting after shut-down and return of the ship's main	Remote control
Diesel engine for propulsion	Lubricating oil pumps **(1)**	X	X	X
	Piston coolant pumps	X	X	X
	HT (high temperature) fresh cooling water pumps	X **(2)**	X	X
	LT (low temperature) fresh cooling water pumps	X	X	X
	Sea water cooling pumps	X**(3)**	X	X
	Nozzle coolant pumps	X**(2)**	X	X
	Fuel feeding pumps	X**(2)**	X	X
	Fuel pressure increasing pumps	X	X	X
Gas turbine	Lubricating oil pumps	X	X	X
	Coolant pumps	X	X	X
	Fuel feeding pumps	X	X	X
	Fuel pressure increasing pumps	X	X	X
Diesel generator	Cylinder cooling water pumps	X	X	X
	Lubricating oil pumps	X	X	X
	Fuel feeding pumps	X	X	X
Pump for gear lubricating oil		X	X	X
Pump for power oil of con-trollable pitch propeller		X	X	X
Pump for hydraulic oil of steering gear		X**(4)**		X**(4)**
Compressor for starting air		X**(5)**		X**(5)**
Compressor for control air		X**(5)**		X**(5)**
Main fire extinguishing pump		X**(5)**		X**(4)**
Electrical ship's main **(6)**		X	X	X
Static/rotating converter			X	

(1) *Valid for separated circuit*

(2) *If these pumps are driven by the main engine or gear, stand-by circuit not necessary*

(3) *For scoop operation automatic switch-on/ switch-off of main coolant pump as a function of the rate of speed as substitution*

(4) *Starting by remote control from bridge*

(5) *Automatic switching on or off depending on pressure*

(6) *Automatic power supply is prescribed. Ship's main must return independently*

SECTION 12

SPARE PARTS

A. General Requirements

1. In order to be able to restore machinery operation and manoeuvring capability of the ship in the event of a damage at sea electronic spare parts for the main propulsion plant and the essential equipment shall be available aboard of each ship together with the necessary tools.

2. The detailed scope of the spare parts shall be defined between shipyard and Naval authority considering the operational experience. In addition allowance is to be made for the manufacturer's recommendations.

3. The actual amount of spare parts shall be documented and a corresponding list shall be carried on board.

ANNEX

INTEGRATED COMPUTER CONTROL (ICC)

A. General

1. Integrated Computer Control (ICC) class notation may be assigned where an integrated computer system is in compliance with A. to C. provides fault tolerant control and monitoring functions at least for the services stated at below:

- Propulsion plant
- Cargo and ballast
- Electrical installation (power management system)

2. A FMEA (Failure Mode Effect Analysis) is to be carried out in accordance with IEC 60812: Analysis techniques for system reliability – Procedure for failure mode and effect analysis and the analysis document as specified in Chapter 105, Section 10, B.1.1 submitted for evaluation. The FMEA is to demonstrate that control and monitoring functions required by B. (alarm, safety and control systems) will remain available at each operator station in case of a single failure of the ICC, input error included, without adverse effect on the service(s).

3. Special consideration will be given to ICC systems for other applications, except for requirements of the additional class notation NAV-INS (Integrated Bridge Navigation Systems).

B. General Requirements

1. ICC system is to comply with computer system requirements of Chapter 105 and control and monitoring requirements of the rules applicable to particular systems, machinery or equipment.

2. Alarm displays are to be provided, in compliance with this chapter that ensure ready identification of faults in the equipment under control.

3. Alarm and indication functions required by this chapter are to be provided by the computer controlled automation system in response to any safety function for associated machinery. Systems providing the safety functions are in general to be independent of the computer controlled automation system. See also Chapter 5, Section 10, C.2.1.

4. Controls are to be provided, in compliance with Section 3, H. to ensure the safe and effective operation of equipment and response to faults, e.g., stopping, starting, adjustment of parameters, etc. Indication of operational status and other such parameters necessary to satisfy this requirement, is to be provided for all equipment under contol by the computer controlled automation system.

C. Operator Stations

1. The control of the equipment is to be possible with a minimum of two multi-function display and control units at each operator station. The number of units is to be sufficient to allow simultaneous access to control and monitoring functions required by B.2 to B.4. Back-up power supplies are to be rated to supply the connected load for a defined period of time that allows sufficient time to restore the supply in the event of loss of the normal power supply as a result of failure of a main source of electrical power. This period is not to be less than 30 minutes.

2. Each multi-function display and control unit is to include a monitor, keyboard and tracker ball. Alternative arrangements may be accepted only if enabling each unit to be configured by the user to provide required control and/or monitoring functions.

3. Where the computer controlled automation system is arranged such that control and monitoring functions may be accessed at more than one operator stations, the selected mode of operation of each station (e.g., in control, standby, etc.) is to be clearly indicated. See also Section 3, H.

4. Means of communication are to be provided between operator stations and any other stations from which the equipment may be controlled. The arrangements are to be permanently installed and are to remain operational in case of failure of the main electrical power supply to the computer controlled automation system.