TÜRK LOYDU

RULES FOR THE CLASSIFICATION OF NAVAL SHIPS

Chapter 106 - Automation

January 2022

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 as defined in TL- PR 29 is on or after 1st of January 2022. New rules or amendments entering into force after the date of contract for construction are to be applied if required by those rules. See Rule Change Notices on TL website for details.

"General Terms and Conditions" of the respective latest edition will be applicable (see Rules for Classification and Surveys).

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Chapter 106 - Automation

AMENDMENTS

Revision	RCS No.	EIF Date*
Section 05	04/2023	01.01.2024

* Entry into Force (EIF) Date is provided for general guidance only, EIF dates given in Rule Change Summary (RCS) are considered valid. In addition to the above stated changes, editorial corrections may have been made.

SECTION 1

GENERAL RULES AND INSTRUCTIONS

A. Scope and Application

1. These Rules apply additionally to automated machinery systems on naval ships as platform for military tasks, classified by Türk Loydu (**TL**), which have one of the Class Notations in the Class Certificate relating to the machinery system as listed under E.

Special requirements for military sensors, weapons and tactical command systems are not subject of these Rules.

These Rules apply in addition to those of Electric (Chapter 105), with particular reference to Section 10.

2. Approval may be given for designs which differ from the Rules if they have been checked for suitability by **TL** and accepted as being of equivalent design.

3. **TL** reserves the right to specify additional requirements to the Rules where these are related to new systems or installations or where they are necessary due to new findings or practical experience.

Deviations from the Rules may be permitted in particularly justified instances.

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 for Machinery Plants

A protective device protects a machinery plant at a critical limit-value violation of one measuring point which could lead to complete breakdown, serious damage or explosion in a time so that manual intervention is still possible in case of attended machinery plant.

3. Safety Devices for Machinery Plants

A safety device protects a machinery plant at a critical limit-value violation of one measuring point which could lead to complete breakdown, serious damage or explosion rapidly so that manual intervention is not possible also in case of attended machinery plant.

4. Safety Systems for Machinery Plants

The safety system of a machinery plant is the subsumption of the protective and safety devices

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

1. Documents for submission

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.

2. Newbuildings

2.1 For each of the systems listed in Section 2:

- General plan

- Wiring diagrams

- Power supply plan

- Description of functional relationships

- General arrangement

- Functional description

- Documentation for computer systems according to Chapter 105 - Electric, Section 1, Table 1.1/9.

2.2 The list of measure points is to be submitted for the monitoring system, see also Section 9.
For integrated automation systems, Section 7A is to be observed additionally.

2.3 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.

2.4 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

- If Class Notation **RC** is assigned, list of indications located on the bridge for supervision of the machinery.

2.5 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)

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

2.7 Documents are to be marked with the ship's name or the shipyard's new building number and the date of issue.

3. Modifications and Additions

Major modifications which may affect the automation systems on a ship which is under construction or at sea are subject to approval. Documents are to be submitted in time before conversion.

4. Ship Documents

When a naval ship is commissioned or following major modifications and additions to the automated machinery installations, the documents listed under C. which show the final form of the system are to be provided for onboard use.

D. References to Other Rules and Regulations

1. TL Rules and Guidelines

1.1 The following **TL** Rules particularly apply:

- Propulsion Plants (Chapter 104)

- Ship Operation Installations and Auxiliary Systems (Chapter 107)

- Electric (Chapter 105)

1.2 Where requirements in respect of automated machinery systems are not covered by these Rules, the application of other rules and standards is to be agreed as necessary.

1.3 Further Rules and Guidelines, named in the Rules are to be observed.

2. National Regulations

If necessary, besides of the **TL** Rules for Construction national regulations are to be observed as well.

3. International Regulations and Codes

If international Regulations and Codes, like MARPOL, etc. are defined in the building specification **TL** may be ordered to verify compliance with.

E. Class Notations

Machinery installations which comply with **TL**'s Rules for automated and/or remotely controlled systems are given the following additions to the Class Notation:

1. AUT-N

The machinery installation has been designed to operate in an unattended machinery space so that no control and maintenance operations are required for at least 24 hours.
Equipment has to comply with the conditions laid down in Section 2, A.

2. AUT-Nnh

This denotes the period during which no control and maintenance operations are necessary, whereby nh means that the machinery installation may be left unattended for n hours (h).

Equipment has to comply with the conditions laid down in Section 2, B.

3. RC

Small naval vessels with a length **L** ≤ 48 m having machinery plants built, equipped, surveyed and tested for remote control of main engines may be assigned the Class Notation **RC** – Remote Control.

Equipment has to comply with the conditions laid down in Section 2, C.

F. Basic Technical Requirements and Guidance

1. Equipment on the Bridge

1.1 General

1.1.1 It is recommended that the steering positions on the bridge include all arrangements required to command the ship and to operate the ship installations under all operating conditions.

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

1.1.3 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 should be provided:

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

1.1.4 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.

1.2 Ship propulsion/ship operation

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

1.2.2 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 5, A.2.

1.2.3 Alarms from the machinery alarm system shall be provided, see Section 4, A.11.

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

1.3 Steering gear

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

1.4 Navigation

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

1.5 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 the **TL** Rules for Electric (Chapter 105), Section 9, C. and D.

2. Maintenance

2.1 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.

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

2.3 Where maintenance for 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. As an alternative a statement in the operator manual can be done in order to indicate the risk.

2.4 Circuit boards and plug-in connections shall be protected against unintentional mixing up. Alternatively they shall be clearly marked to show where they belong to.

3. Spare Parts

For spare parts see Section 10.

SECTION 2

RANGE OF CONTROL AND MONITORING EQUIPMENT

A. Machinery with Class Notation AUT-N

1. Applicable only for ships with a length **L** ≥ 24 m and a machinery space which can be manned.

2. The propulsion plant and the auxiliary equipment necessary for operation is to be prepared free of maintenance for 24 hours.

Within the machinery control centre (MCC) a central control station close to the machinery space shall be provided from which the automated equipment can be controlled and monitored.

3. Service tanks for propulsion machinery and at least one electrical power generation plant are to be refilled automatically or are to be so sized that they do not require topping up for 24 hours. A reserve capacity of 15 % is also to be provided. If not otherwise defined in the building specification, basis for the calculation of tank size is the continuous ahead cruising speed v_M.

4. A remote control system for the propulsion plant is to be installed on the bridge in accordance with Section 5, A.

5. A safety system for the propulsion plant is to be installed in accordance with Section 4, C. and Section 5, B. ÷ D. with regard to diesel engines.

6. A machinery alarm system is to be provided in accordance with Section 4, A. and a duty alarm system in accordance with Section 4, B.

7. An alarm point/data recording device is to be provided in accordance with Section 4, A.14. for propulsion output above 1500 kW; see Section 9.

8. Means of communication are to be installed in accordance with Section 4, G.

9. Auxiliary Boilers are to be equipped as described in Section 6, D.

10. Auxiliary diesels are to be equipped as described in Section 6, B.

11. Auxiliary gas turbines are to be equipped as described in Section 6, C.

12. Starting air and control air vessels have to be filled-up automatically.

13. Purifier systems are to be designed in accordance with Section 6, E.

14. Air compressors are to be designed in accordance with Section 6, F.

15. For essential auxiliary machinery, a stand-by circuit is to be provided in accordance with Section 4, I. and Section 9, I.

16. Where required for system operation, pressures and temperatures are to be controlled automatically.

17. Valves in the shell which are open during machinery operation are to be accessible and have to be capable of being operated from a safe height above the floor plates.

18. Engine room bilges and bilge wells are to be designed in accordance with Section 6, G.

19. Interruptions in the power supply are to be avoided or overcome in accordance with Section 4, I.2.

20. A fire alarm and detection system is to be provided in accordance with Section 4, H.

21. Approved fire-extinguishing equipment is to be provided in the engine and boiler spaces. See the **TL** Rules for Ship Operation Installations and Auxiliary Systems (Chapter 107), Section 9 for details of the design.

22. A remote start system for one of the main fire pumps is to be installed on the bridge and where applicable at the main fire control station. The associated valves are to be equipped with an instruction table:

"Keep valves open at all times!"

B. Machinery with Class Notation AUT-Nnh

1. Applicable only for ships with a length **L** ≥ 24 m and a machinery space which can be manned.

2. For the range of equipment see A.3. to 22.

Within the machinery control centre (MCC) close to the machinery space a central control station shall be provided from which the automated equipment can be controlled and monitored.

3. The propulsion plant and the auxiliary equipment necessary for operation is to be prepared free of maintenance for at least the length of time (n hours) in which the machinery spaces may be left unattended in accordance with their Class Notation.

4. Service tanks for propulsion machinery are to be refilled automatically or are to be designed so that they do not require topping up during the period in which the machinery space is left unattended. A reserve capacity of 15 % is also to be provided. If not otherwise defined in the building specification, basis for the calculation of tank size is the continuous ahead cruising speed v_M.

C. Machinery with Class Notation RC

1. Scope

Small naval vessels with a length **L** ≤ 48 m having machinery plants built, equipped, surveyed and tested for remote control of main engines according to these Rules may be assigned the Class Notation **RC** – Remote Control.

2. Extent, Design and Construction of the Equipment

2.1 Extent of automation

The extent of automation of the propulsion plant together with the auxiliary equipment necessary for operation and the safety of the ship is to be sufficient for an unattended engine room operation during normal sea service and normal manoeuvring.

The supervision of the machinery plant is done from the navigating bridge.

2.2 Starting

Automatic restart or manual start possibility from the bridge after a blackout is to be arranged for all components which are necessary for restoring of propulsion.

Exemptions may be granted for multi unit installations where stop of one unit does not cause loss of propulsion.

2.3 Manual operation

Each important automatic and/or remote controlled system shall also be capable of being operated manually. Where auxiliary machinery is started up automatically or by remote control, means shall be provided to secure them against remote controlled or automatic start-up, e.g. during repairs.

3. Monitoring Equipment

3.1 Machinery alarm system

3.1.1 The machinery alarm system shall provide an optical and an audible signal of unacceptable deviations from operating figures.

3.1.2 The alarms shall be presented on the navigating bridge.

3.1.3 Collective alarms are allowed for standalone systems except main propulsion machinery. The individual alarms shall be recognisable at the concerned system.

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

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

3.1.6 If a fault is indicated, the optical signal shall remain visible until the fault has been eliminated.

3.1.7 It shall be possible to distinguish between an optical signal which has been acknowledged and one that has not been acknowledged.

3.1.8 It shall be possible to acknowledge audible signals.

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

3.1.10 Acknowledgement of optical alarms shall only be possible where the fault has been indicated as an individual signal and a sufficient overview of the concerned process is been given.

3.1.11 Alarms have to 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 are to be installed.

3.1.12 Transient faults which are self-correcting without intervention shall be memorized and indicated by optical signals which shall only disappear when the alarm has been acknowledged.

3.1.13 Where an alarm has not been acknowledged within a preset time, an alarm shall be released in the accommodation and mess areas of the engineer officers.

3.1.14 Alarm systems shall be designed on the closed-circuit or the monitored open-circuit principle. Equivalent monitoring principles are permitted.

3.1.15 The alarm system is to be supplied from the power source with battery backup for at least 30 minutes.

The failure of the supply from the main power source is to be alarmed.

3.1.16 The automatic suppression of alarm signals is to be monitored for correct function or shall be of redundant type.

3.1.17 The failure of the machinery alarm system shall be alarmed.

3.1.18 Machinery alarm systems are subject to mandatory type approval.

3.2 Fire detection and alarm systems for machinery spaces

3.2.1 An automatic fire detection and alarm system with means of testing is to be provided which indicates the initial stage of fire in machinery spaces. The fire detection system has to be based on a self monitoring principle.

3.2.2 The fire alarm shall be given visually and audibly on the navigation bridge, in the machinery spaces, and in the accommodation.

The alarm shall be clearly distinguishable from other alarms.

3.2.3 Location and number of the detectors shall be such as to provide ample cover for all the endangered areas.

3.2.4 The fire detection system is to be fed automatically from at least two sources of electrical power.

3.2.5 Fire detection and alarm systems are subject to mandatory type approval.

3.3 Safety system

3.3.1 A safety system which is for all important parameters independent of the alarm system, is to be provided.

3.3.2 When abnormal operating conditions are reached or serious malfunction occur which cannot be dealt with in time by the crew members responsible for the machinery, the safety system has to safeguard machinery against critical conditions (automatic shut-down).

3.3.3 Where safety systems are provided with overriding arrangements, these shall be safeguarded against accidental operation. The actuation of overriding arrangements is to be indicated.

3.3.4 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.

3.3.5 The suitability and function of safety systems shall be demonstrated in the given application.

3.3.6 Safety systems shall be so designed that potential faults such as, for example, loss of voltage or a broken wire shall not create a hazard to human life, vessel or machinery.

3.3.7 Faults and also the tripping of the safety system shall be signalled by an alarm.

3.3.8 Where faults which affect the operation of the safety system cannot be identified, appropriate test facilities shall be provided which shall be actuated periodically.

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

3.3.10 Safety systems shall be designed preferably using conventional technology (hard wired). Alternative technical solutions shall be agreed with **TL.**

3.3.11 On failure of the ship's power supply, the function of a safety system has to be guaranteed as long as the supervised machinery is in operation.

3.3.12 Safety systems are subject to mandatory type approval.

3.4 Call systems for crew members responsible for the machinery

The officer of the watch on the bridge shall be able to call the crew members.
This equipment may take the form of a two-way intercommunication system. The system may consist of portable or permanently installed equipment and shall be capable of operation even if the power supply fails.

4. Remote Control From the Navigating Bridge

4.1 Type of remote control

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.

4.2 Control positions

It shall be ensured that control is only possible from one control station at any time.

4.3 Transfer of control positions

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 which control station is in operation.

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

4.4 Equipment on the bridge

The following equipment is to be provided on the bridge:

4.4.1 An indicator showing which control position is in use.

4.4.2 Emergency shut-down:

Should the remote control fail, it shall be possible to shut-down the main engine from the navigating bridge using a system independent of the remote control system and its power supply. Alternatively, where the installation is fitted with clutch couplings, means can be provided for disengaging the shaft from the bridge.

The emergency shut-down systems are to be backed-up by sufficient storage of control power and shall work

on the open-circuit principle, if electrical.

Measures are to be taken to ensure that the emergency shut-down system cannot be operated inadvertently.

4.4.3 For direct propulsion (fixed propeller):

An indicator showing the rotation speed and direction of rotation of the propeller shaft.

4.4.4 For controllable pitch propellers:

An indicator showing the rotation speed of the propeller shaft and the pitch of the blades.

4.4.5 For installations equipped with reversing gears:

Indicator showing the speed and direction of rotation of the propeller shaft and the rpm of the main engine.

4.4.6 For installations equipped with clutch couplings:

An arrangement is to be provided for remote controlled engagement/disengagement of the couplings. The engaged/disengaged position is to be indicated.

4.4.7 Additional necessary indications for the supervision of the machinery plant may be decided case by case.

4.5 Shaft-driven generators

On ships with shaft-driven generators, the remote control from the bridge shall be so designed that, with the shaft-driven generators in operation, manoeuvres can be performed without disturbing the main electrical power supply system (e.g. by the use of constant speed equipment with controllable pitch propellers or by arranging for the power supply system to be automatically transferred to an independent diesel generator).

5. Fire Protection / Fire-Extinguishing

5.1 Fire protection

One main fire pump is to be provided with a remote start arrangement from the navigating bridge.

6. Prevention Against Engine Room Flooding

6.1 Valves in the ship's shell plating which are open during operation of the engines have to be accessible and capable of operation from a safe height above the floor plates.

6.2 Engine room bilges and drain wells are to be large enough to accommodate normal drainage without tripping a level alarm during the unattended period.

6.3 In each machinery space bilge at least 2 high level sensors are to be provided.

7. Miscellaneous

7.1 Auxiliary boilers

The automatic controls of auxiliary boilers shall be capable of maintaining the desired values within the permissible limits of all possible load variations, independent of the kind of heating.

Should the permissible operating values be exceeded, individual alarm shall be given and the safety system has to act automatically. The intervention of the safety system is to be monitored.

7.2 Tests

After installation on board all automatic and remote controls are to be tested during trials at the shipyard and sea trials to the satisfaction of **TL**.

8. Alarm and Recording Points

The Tables 9.10 – 9.12 in Section 9 summarize the monitored parameters and define the limits for an alarm.

SECTION 3

BASIC REQUIREMENTS

A. Design and Performance

1. The requirements laid down for each unit and system depend on their intended use and the process-technological conditions. The Rules stipulate the minimum requirements for these.

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

The adaptation of the mode of the systems should take place automatically after the operational condition has been selected.

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

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

4. Systems have to be intelligible and userfriendly and have to follow ergonomic principles.

5. The potential risk in the event of breakdown of safety, protection and monitoring equipment, open and closed-loop controls is to be limited to a justifiable level of residual risk.

6. As far as required, the 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 recognise faults and test capability
- Reproducibility of values

7. Systems have to 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.

8. Redundant systems shall be individually protected against short-circuit and overload and selectively supplied with power.

9. The required drain facilities are either to be automated or of a type which requires no intervention during the period in which the machinery spaces are to be left unmanned in line with their Class Notation.

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

11. Machinery alarm systems, protection and safety systems, together with open- and closed-loop control systems for essential equipment shall be constructed in such a way that faults and malfunctions affect only the directly involved function.

This also applies to measuring facilities.

12. For machinery and systems which are controlled remotely or automatically, control and monitoring facilities have to be provided to permit manual operation.

12.1 The actual control mode shall be discernible at the concerned control stations.

12.2 The manual operation facilities shall have provisions to override the automated or remote controls. Failure of any part of the automatic or remote control system shall not prevent the manual operation.

12.3 At manual operation influence of the automated or remote mode shall be prevented by technical measures.

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

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

15. Where mechanical systems or equipment are either completely or partly replaced by electric / electronic equipment, the requirements relating to mechanical systems and equipment according to the **TL** Rules for Propulsion Plants (Chapter 104) and Ship Operation Installations and Auxiliary Systems (Chapter 107) shall be met accordingly.

16. To avoid unnecessary interruption of the operation the respond of stand-by functions and alarm systems shall occur before responding of safety systems.

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

18. Where approved systems are modified, the proper functioning of the system as a whole is to be demonstrated.

19. It shall be ensured that, on failure of the main electrical power supply, the automation systems are supplied by a UPS for at least 30 minutes. Failure of the supply from the main source of electrical power shall trigger an alarm.

20. The battery back up shall be monitored so that, towards the end of the stored energy period, an automatically controlled shut-down of the system is ensured and a failure has to be alarmed. See also the **TL** Rules for Electric (Chapter 105), Section 2, B.

B. Computer Systems

Where computer systems are used for systems according to Section 2, the requirements relating to hardware and software in accordance with the **TL** Rules for Electric (Chapter 105), Section 10 shall be fulfilled.

C. Input and Output Units

1. General Requirements

1.1 The input/output units represent the man/machine interface. 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.

1.4 The control elements, comprising input and output units, shall be operable in accordance with their prescribed environmental conditions and output units shall be clearly readable even in day light.

1.5 Colours, symbols and texts for the inputs and outputs of a system shall be standardized, see **TL** Rules for Electric (Chapter 105), Section 1, Table 1.9.

If symbols are used for the representation of alarms and information, an explanation (key) of these symbols shall be provided. Preferable IMO Resolution A.1021(26) - Code on Alerts and Indicators should be used.

2. Input units

2.1 Control commands shall be indicated at the respective control station.

2.2 Input units located on the bridge shall be individually illuminated, where the general lighting is not adequate. The lighting has to be adapted nonglare.

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 directly accesssible.

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

3.2 Technical requirements

3.2.1 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.

3.2.2 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.

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

3.2.4 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.

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

D. Open-/ Closed-Loop Control Equipment

1. Open-Loop Control Equipment

1.1 Main 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 designed that failure of one system does not impair the performance of other systems, see A.6 and Section 7,A.

1.2 Protection measures shall be provided where incorrect operation would result in serious damage or the loss of essential functions.

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

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

1.4.1 Competitive commands shall be prevented by suitable interlocks. The control station in operation shall be recognizable as such.

1.4.2 Taking over of command shall only be possible

with the authorization of the user of the control station which is in operation.

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

1.4.4 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.

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

1.5 Operating keyboards shall comply with the following conditions:

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

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

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

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

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

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

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

1.10 Special considerations shall be given to takeover philosophies in all operating conditions including damage.

2. Closed-Loop Control Equipment

2.1 Closed-loop control equipment shall keep the process variables within the specified limits under normal conditions.

2.2 Closed-loop controls have to show the specified reaction 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 control loops for essential equipment.

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

SECTION 4

AUTOMATION SYSTEMS

A. Machinery Alarm Systems

1. The machinery alarm system shall provide an optical and an audible signal for unacceptable deviations from operating figures, see Section 9.

2. For main engines, a system of alarm displays and controls is to be provided which readily ensures identification of faults in the machinery and satisfactory supervision of related equipment. This may be provided at a main control station or, alternatively, at subsidiary control stations. In the latter case, a master alarm display is to be provided at the main control station showing which of the subsidiary control stations is indicating a fault condition.

Alarms, remote indications and safeguards listed in Table 8.1 and 8.2 are respectively referred to trunk-piston and cross-head reciprocating internal combustion engines.

The detailed requirements covering communications of alarms from machinery spaces to the bridge area and accommodation for engineering personnel, are contained in TL- R M29 “Alarm systems for vessels with periodically unattended machinery spaces”.

3. For trunk-piston reciprocating internal combustion auxiliary diesel engines, all monitored parameters for which alarms are required to identify machinery faults and associated safeguards are listed in Table 8.7.

All these alarms are to be indicated at the control location for machinery as individual alarms; where the alarm panel with individual alarms is installed on the engine or in the vicinity, common alarm in the control location for machinery is required.

For communication of alarms from machinery space to bridge area and accommodation for engineering personnel detailed requirements are contained in IACS UR M29 “Alarm systems for vessels with periodically unattended machinery spaces”.

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

5. 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.

6. It shall be possible to acknowledge audible signals independent from visual signal.

7. Acknowledgement of optical alarms shall only be possible where the fault has been indicated as an individual signal and a sufficient overview of the relevant process is been given.

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

9. Alarms have to 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.

10. Transient faults which are self-correcting without intervention shall be memorized and indicated by optical signals which shall only disappear when the alarm has been acknowledged.

11. 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.

12. 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.

13. Alarms on the bridge

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 9 shall be provided.

13.1 "Stop" group: alarms signalling faults which require the propulsion system to be shut down immediately. This alarm is a summarization of the alarms, for which the measurand has to effect a shut-down in accordance with Section 9. This alarm has to be activated before the safety system shuts the engine down.

13.2 "Reduce" group: alarms signalling faults which require a reduction in power of the propulsion system. This alarm is a summarization of the alarms, for which the measurand has to effect a reduction in accordance with Section 9. In case of automatic reduction, the alarm has to be activated before the engine will be reduced.

13.3 "Common" group: alarms signalling faults which do not require actions as described in 11.1 or 11.2.

13.4 The group alarms shall be generated independently of the safety system.

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

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

15. The alarm system shall be supplied from the power source with battery backup for at least 30 minutes.

The failure of the supply from the power source is to be alarmed.

16. If limit values are exceeded, this is to be recorded with date and time relating to the occurrence and the clearing of the fault in chronological order. The beginning and end of a fault are to be clearly recognizable.

17. Collective alarms

In individual cases, **TL** may approve collective alarms from essential, stand-alone systems which are signalled to the machinery alarm system.

17.1 Each additional new single alarm has to retrigger the collective alarm.

17.2 The individual alarms have to be recognisable at the concerned system.

17.3 Collective alarms are to be recorded as described under 14.

18. The automatic suppression of alarm signals is allowed. The necessary signals are to be monitored for correct function or shall be of redundant type.

19. The failure of the machinery alarm system shall be signalled at a permanently manned station.

20. Machinery alarm systems are subject to mandatory type approval

21. Alarms at the main operating centres

21.1 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.

21.2 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:

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

B. Duty Alarm Systems

1. General

The duty alarm system sends alarms to the responsible persons in case of incorrect situations whenever the machinery spaces are unattended.

1.1 It shall be possible to choose the person on duty and this is to be indicated on the bridge and at the location where the choice was made.

1.2 Where an alarm has not been acknowledged within a preset time at the machinery alarm system, an alarm shall be released at a permanently manned station and/or the bridge respectively in the accommodation and mess areas of the engineering officers. Such an acoustic alarm can be acknowledged individually. The reset of the alarm will be done by acknowledging at the machinery alarm system.

1.3 Duty alarm systems are subject to mandatory type approval.

1.4 The duty alarm system shall be supplied from the power source with UPS for at least 30 minutes. The failure of the supply from the power source is to be alarmed.

1.5 Failures of the duty alarm system have to be alarmed at an attended location.

1.6 Where the duty alarm system is combined with the Engineers' alarm (Engineers' call), an additional means for communication between the engine room or the machinery control centre as a permanently manned station and/or the bridge respectively the accommodation and mess areas of the engineering officers has to be installed. This might be a telephone system.

2. Hard Wired Duty Alarm Systems

Alarms have to be given at a permanently manned station and/or the bridge respectively in the accommodation and mess areas of the engineering officers.

3. Wireless Duty Alarm Systems

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

3.2 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.

3.3 At least two charged reserve units shall be available.

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

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

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

3.7 The fixed stations shall be supplied at least for 30 minutes in case of a failure of the ship's mains.

C. Protective Devices for Machinery Plants

1. Protective devices shall be independent of open and closed-loop control and alarm systems and shall be assigned to systems which need protection.

2. When reaching dangerous limits, protective devices shall adapt the operation to the remaining technical capabilities.

3. Protective devices shall be supplied according to the **TL** Rules for Electric (Chapter 105), Section 4, H.9. For battery supply at least 30 minutes have to be safeguarded.

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

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

6. The monitored open-circuit principle is to be applied to protective devices which can activate an automatic shut-down. Equivalent monitoring principles are permitted.

7. The tripping of a protective device and faults shall be alarmed and recorded. The reason for the tripping shall be identifiable,

8. Disturbed units which are automatically shutdown shall be restarted only directly at the unit after a manual release.

9. The adjustment facilities for protective devices shall be so designed that the last setting is traceable.

10. Protective devices which can activate an automatic shut-down of the main propulsion plant shall be equipped with overriding facilities.

11. Protective devices are subject to mandatory type approval.

12. Reductions of the Main Propulsion Plant

12.1 For the protection of the main propulsion plant, reductions according to Section 9 have to be provided.

12.2 Reductions can be initiated automatically or by a request for manual reduction.

12.3 Reductions may be a function of the machinery alarm system.

12.4 Overriding capabilities have to be provided for automatic reductions.

13. Manual Emergency Stop

13.1 Manual emergency stops are to be protected against unintentional activation.

13.2 The manual emergency stop shall not automatically be cancelled.

13.3 It shall be recognizable which manual emergency stop has been activated.

13.4 The monitored open-circuit principle is to be applied to manual emergency stops. Equivalent monitoring principles are permitted.

D. Safety Devices for Machinery Plants

1. Safety systems shall be independent of open and closed loop control and alarm systems and shall be assigned to systems which need protection.

2. When reaching dangerous limits, safety devices shall initiate an automatic shut-down. See also Section 9.

3. Safety devices shall be supplied according to the **TL** Rules for Electric (Chapter 105), Section 4, H.9. For battery supply at least 30 minutes have to be safeguarded.

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

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

6. The monitored open-circuit principle is to be applied to safety devices. Equivalent monitoring principles are permitted.

7. The tripping of safety devices and faults shall be alarmed and recorded. The reason for tripping shall be identifiable.

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

9. The adjustment facilities for safety devices shall be so designed that the last setting is traceable.

10. Safety devices of the main propulsion plant may be equipped with overriding facilities. The overspeed protection is excluded.

11. Safety devices are subject to mandatory type approval.

E. Safety Systems for Machinery Plants

1. Only protective and safety devices of one system which needs protection are allowed to be combined.

2. The requirements according to C. and D. are to be observed.

3. Safety systems are subject to mandatory type testing.

F. Override Facilities

1. Override facilities according to C.10, C.12.4 and D.10. have to be provided.

2. The activation of the overriding facility is to be indicated at the concerned control station.

3. The activation of the overriding facility is to be recorded.

4. Overriding facilities are not permitted for overspeed protection or manual emergency stops.

G. Means of Communication

A reliable means of vocal communication shall be provided between the machinery control centre or the propulsion machinery control position, the navigating bridge and the accommodation and mess areas of the engineer officers or the crew members responsible for the machinery and other important functions of the ship.

The **TL** Rules for Electric (Chapter 105), Section 9, C.5.1. are to be observed for the layout.

H. Fire Detection Systems for Machinery Spaces

1. For general requirements relating to fire alarm systems, see **TL** Rules for Electric (Chapter 105), Section 9, D.3.

2. Fire detection systems shall signal a fire at an early stage.

3. The fire alarm shall be optical and audible recognized on the bridge, in the accommodation and mess areas of the engineer officers or the crew member responsible for the machinery plant and also in the machinery space without any time delay and it is to be distinguishable from other alarms.

4. Each detection loop shall not enclose more than one fire subdivision or one watertight compartment or, wherever possible, more than two superimposed decks. This applies only to non-addressable detectors, which do not allow the remote and individual identification of each detector. Separate detection loops shall be used where facilities are provided for the separate flooding of different machinery spaces with gas fire-extinguishing media (e.g. CO_2).

5. The position and number of detectors shall be specified under consideration of machinery space ventilation, so that all endangered areas are safely covered. This particularly applies to areas in which boilers, waste and sludge incinerators, generators, switchboards, refrigeration machinery and purifiers are installed and also in the engine casing and at the exhaust gas side in exhaust gas-fired auxiliary boilers with finned pipes.

6. In workshops and rooms where detectors are liable to be actuated, e.g. by welding, they may be temporarily ineffective.
The detectors shall automatically become operative again after a preset time.

7. For requirements relating to fixed waterbased local application fire-fighting systems (FWBLAFFS), see **TL** Rules for Electric (Chapter 105), Section 9, D.4.

I. Stand-by Circuits / Automatic Controls

1. General

1.1 Stand-by circuits as described in Section 9, I. shall automatically start stand-by units, if these are required according to the **TL** Rules for Propulsion Plants (Chapter 104):

- 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 9, I.:

- 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 A reciprocal operation capability is to be provided for similar units.

1.4 The automatic change-over to another unit is to be signalled by an alarm.

1.5 Where auxiliary machinery is mechanically driven from the propulsion system, stand-by units shall be provided for automatic start-up when carrying out manoeuvres in the lower speed range where the output of the mechanically-driven auxiliary machines is not adequate under these conditions.

1.6 An alarm shall not be tripped in the case of machinery installations with mechanically connected pumps, when the independent pumps start up due to normal operation.

1.7 The sensors for stand-by circuits have to be independent from other systems.

1.8 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, see Section 3, A.11.

1.9 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.

1.10 Stand-by circuits shall preferably be arranged decentrally and assigned directly to the corresponding units. The actual status shall be monitored at the respective control station.

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

2. Stand-by Circuits for Generators

2.1 For the stand-by circuits for generators see **TL** Rules for Electric (Chapter 105), Section 3, B.3.5.3

2.2 Following a black-out and restoration of the power supply, essential auxiliary machinery has to start up again automatically, possibly in staggered formation. See also Section 9, I.

SECTION 5

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 reference input within them have 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 4, I.2 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 When the turning gear is engaged or automatic shutdown has not been acknowledged, any start attempts are to be prevented.

1.10 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

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

1.12 Remote control systems for main propulsion plants are subject to mandatory type approval.

1.13 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 which control station is in operation.

1.14 The take of control independent of the accept signal, stated in 1.13, shall only be possible in the machinery space.

The loss of control (e.g. when control taken over by a local control station, due to a malfunction, and reboot one of the propulsion sides (PS or SB)) at the concerned control station is to be signalled audibly and visually.

2. Facilities on the bridge

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

2.2 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.

2.3 The main propulsion system shall be capable of being shutdown with an emergency manual shutdown n facility from the bridge. This device shall be independent of the remote control system and it's power supply.

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

2.5 Where the safety system of the main propulsion plant shall be equipped with an overriding arrangement, this has to be installed on the bridge.

2.6 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.

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

2.8 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.

2.9 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 Override opportunity is permitted for shutdown criteria, as required in Section 9, except for shutdown in case of overspeed.

2.11 Override opportunity shall be realized for slowdown criteria, as required in Section 9. It shall be also realized for additional shut-down and slow-down criteria, not listed in Section 9.

3. Facilities in the Machinery Control Centre

Remote control of the propulsion plant is to be provided from a machinery control centre. The equipment listed under 2.7 to 2.9 shall also be fitted in the machinery control centre.

In addition the required equipment is to be installed in accordance with the **TL** Rules for Propulsion Plants (Chapter 104), Section 3, H.

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 The indicators listed in 2.7 to 2.9 shall be fitted at the control station.

4.3 In addition the required equipment is to be installed in accordance with the **TL** Rules for Propulsion Plants (Chapter 104), Section 3, H.

4.4 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.

4.5 For the local indicators required according to the **TL** Rules for Propulsion Plants (Chapter 104), the following applies:

4.5.1 The indicators shall permit conventional operation that is independent of the remote control system.

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

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

4.5.4 The same sensors can be used for both indicators and remote control systems, if it is ensured that the indicator is still supplied with the measurement value in the event of failure of the remote control 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. Diesel Engines

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

Proof of the number of start attempts as specified in the **TL** Rules for Ship Operation Installations and Auxiliary Systems (Chapter 107), Section 6 is also to be provided for manoeuvring with the remote control system.

2. The controller and the actuator shall be suitable for controlling the engine under the operating conditions laid down in the Rules and also in line with the requirements specified by the engine manufacturer, see **TL** Rules for Propulsion Plants (Chapter 104), Section 3, F.

3. For details of the requirements relating to electronic governors and actuators, and also their power supplies, see **TL** Rules for Electric (Chapter 105), Section 9, B.8. and the **TL** Rules for Propulsion Plants (Chapter 104), Section 3, F.

4. At least those stop and reduce criteria listed in Section 9, Table 9.1 have to stop or reduce the main propulsion plant or have to request for reduction.

5. Where a reduction is not sufficient to protect the engine, an automatic shutdown facility shall be provided, see Section 9, Table 9.1.

6. For electrical starting equipment see the **TL** Rules for Electric (Chapter 105), Section 7, D.6.

C. Gas Turbine Plants

1. General requirements

The general requirements for gas turbines applied for:

- Essential main propulsion
- Non-essential propulsion
- Driving of auxiliaries

are summarized in the **TL** Rules for Propulsion Plants (Chapter 104), Section 4A.

2. Monitoring and Control

For the monitoring, protection and control concept, Section 9, Table 9.2 shall be observed.

D. Electrical Propulsion Plants

See **TL** Rules for Electric (Chapter 105), Section 13.

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

1.4 If the availability is to be increased through the use of multi-shaft systems or systems with several

1.5 propulsion machines, the **TL** Rules Chapter 23 – Redundant Propulsion and Steering Systems shall be observed.

2. Safety systems are to be divided so that in the event of failure of one part of the system, the function of the other system parts is still maintained or can be restored by adopting simple measures.

3. In the case of multi-shaft systems, there shall be a possibility of controlling and switching down the individual drive systems from the bridge.

4. Individual visual alarm displays for each drive system are to be provided on the bridge.

5. Separate supply facilities are to be provided for each control system where there is a multiple number of main engines.

6. The stand-by circuits prescribed for these plants can be omitted if a multiple drive system is provided with separate systems and automatic individual shut-down (uncoupling).

SECTION 6

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.

For the scope of stand-by circuits and remote control facilities for essential auxiliary machinery, see Section 9,I.

2. The alarms and recording points listed in Section 9 are to be observed.

B. Auxiliary Diesel Engines

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

With regard to the remotely controlled or automatic starting of engines, only systems permitted are those which allow starting in any position of the crankshaft.

2. For details of auxiliary engines with electric start-up, see **TL** Rules for Electric (Chapter 105), Section 7, D.6.

3. An automatic shut-down is to be provided for the event of overspeed, detection of oil mist and failure of the lubrication oil supply of diesel engines.

4. For details of the requirements relating to electronic governors and actuators, and also their power supplies, see **TL** Rules for Electric (Chapter 105), Section 9, B.8. and the **TL** Rules for Propulsion Plants (Chapter 104), Section 3, F.

C. Auxiliary Gas Turbines

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. See also **TL** Rules for Propulsion Plants (Chapter 104), Section 4A.

D. Auxiliary Steam Plants

The requirements according to **TL** Rules for Ship Operation Installations and Auxiliary Systems (Chapter 107), Section 15 and 17 are to be observed

E. Purifier Systems

1. Malfunctions in the purifying process have to cause the flow to the purifier to be cut off automatically.

2. The inrush of water in the discharge of the medium to be separated shall trip an alarm.

Depending upon type and method of separation, the unintentional opening of the drum and the loss of the water seal and water shall trip an alarm.

3. Fuel and lubrication oil purifiers are to be of self-cleaning type, unless no operation or maintenance is required to keep them in service during the period of which the machinery spaces are to remain unattended according to the Class Notation.

F. Air Compressor

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

G. 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. At least two level sensors are to be fitted in each machinery space and the tripping of these sensors is to be indicated by an individual alarm. See also the **TL** Rules for Ship Operation Installations and Auxiliary Systems (Chapter 107), Section 8.

4. Where, as a result of the **MARPOL** convention, a facility is specified for monitoring the residual 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.

5. If needed for damage control the water level in each watertight space/section shall be monitored.

6. If special autarky of compartments is asked for by the Naval authority it is recommended that sluice valves and nozzle valves between the spaces/sections close automatically during the operational conditions "combat/action stations" and "wartime cruising".

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

H. Remote Controlled Valves, Units and Processes

1. Failure of the remote control facilities shall not result in any control outputs.

2. 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.

I. Source/Target Control

If a source/target control is envisaged, the following shall be observed, see also O.7:

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 the procedure for achieving a certain target is disturbed (e.g. by manual intervention, remote control or system failure), the procedure shall be terminated automatically and the installation shall be brought into a safe operating condition.

J. Ship Stabilization Plants

If Class Notation **SEAKEEP** shall be assigned, the necessary requirements as defined in the **TL** Rules for Ship Operation Installations and Auxiliary Systems (Chapter 107), Section 2, C. to J. are to be applied.

K. 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. At least one pressure pump shall be provided as standby unit.

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.

L. Main Fire Extinguishing Pumps

1. The fire-extinguishing system shall either be kept under constant pressure or remote start of at least one fire pump shall be provided.

2. In case of systems under permanent pressure, a pressure drop shall trigger an alarm.

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

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 the same measuring unit for each tank.

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

4. The measurement tolerance of the complete system should not exceed 5 % on even keel.

5. Sensor values lying outside the plausible range shall trigger an alarm and 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 be situated only at representative tank sections.

N. 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 leak detection 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.

O. Fuel System

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

1. The requirements set out in M. shall be observed.

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

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

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

5. The given commands and the feed back of the controlled valves and pumps shall be monitored constantly for deviations.

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

7. 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.

8. Reference is made to **TL** Rules for Ship Operation Installations and Auxiliary Systems (Chapter 107), Section 7 and Section 8, G., H. and I.

SECTION 7

INTEGRATED SYSTEMS

A. General

1. The integration of functions of independent equipment shall not decrease the reliability of the single equipment.

2. The required independence of monitoring, conventional alarm, control and safety functions shall be secured by other sufficient measures where two or more of those functions are integrated in one system.
Such measures may be:

Coupling of otherwise autonomous systems, involving an exchange of information and data correction

Multichannel technology

Fault-tolerant systems

These measures have to be documented and suitable proofs have to be furnished.

3. The interruption of the transfer of data between connected autarkic sub-systems shall not impair their independent functions.

4. Operation of essential equipment shall be possible independently of integrated systems.

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

6. The creation and configuration of a network with regard to the use of the

- Transmission media
- Topologies
- Access procedures
- Access speeds
- Network systems
- Interfaces
- Any redundancy which may be required shall comply with the system requirement in each case.

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

B. Sub-systems of an Integrated Ship Control System

For naval ships the following sub-systems may be integrated:

Automation of propulsion plant

Automation of auxiliary systems

Power management for naval purposes according to the different operating conditions

Ship protection management for damage control

System for load line and stability calculations

Camera surveillance system

Navigation system

Maintenance system

On board training system

Other systems to be agreed

Depending on the type of naval ship and its operating conditions it is a decision of the Naval Authority if an integrated system shall be established and which sub-systems shall be integrated.

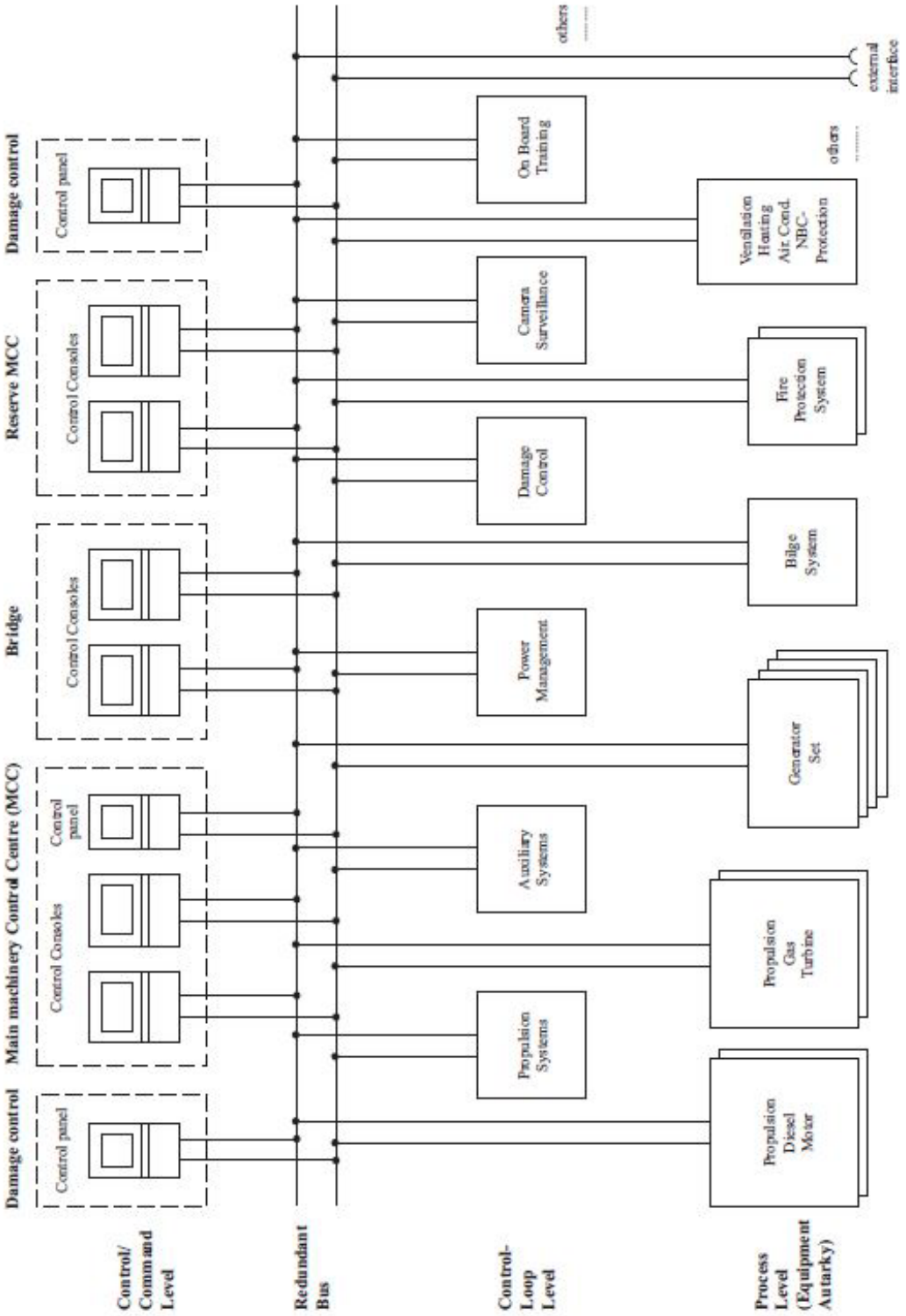

Figure 7.1 Hierarchical structure of integrated systems (example)

C. Structure of an Integrated Ship Control System

1. Scope

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

2. Structural Levels

The system shall be designed to have a hierarchical structure, see Figure 7.1.

The following structural levels shall be provided as a minimum:

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

These levels are connected for data exchange by a bus system.

3. Process Level

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

Any imposed equipment limitations shall be reflected in system design.

4. Control-Loop Level

4.1 On the control-loop level, the data belonging to a sub-process are collected and processed. The local sensors, actuators and indicators are served.A local operating possibility shall be provided.

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

5. Control/Command Level

5.1 On the control/command level, the sub-processes are displayed and operated via control positions.

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

5.3 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.

6. Data Collection

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

7. Failure Behaviour

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

7.2 A defect in one of the subsystems, i.e. an individual module, unit or sub-system of the integrated system shall not affect the function of other sub-systems. Exception may be those functions directly dependant on the defective part.

7.3 A failure of the data transfer between connected autonomous sub-systems shall not impair their independent essential functions.

8. Diagnosis Functions

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

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

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

8.3 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.

8.4 For analogous signal transducers, a "live zero" is required. Defined minimum and maximum values for sensors being exceeded shall trigger an alarm, i.e. leaving the valid measurement range.

8.5 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.

8.6 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 4, A.15 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. All types of bus systems have to undertake continuous self testing to recognize occurring faults. Any failure of a bus system shall lead to an unambiguous and safe condition.

1. 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.

8. External ship/ship and ship/land interfaces shall enable data exchange. For the operating condition of port readiness e. g. a transfer of alarms for fire detection, flooding, control of generators or other auxiliary machinery may be favourable. Failure or faults of the connected external systems shall not disturb the internal integrated ship control system.

E. Power Management in Case of Damage

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 and the actual damage situation; see **TL** Rules for Electric (Chapter 105), Section 3, B.

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

1.3 For damage condition and according to the input from the other sub-systems concerning actual damage, the electrical power supply shall be automated with respect to the starting and stopping of the still functioning generators, as well as the synchronization, paralleling and load sharing.

The operational readiness and priority of use of each generator shall be selectable also manually.

1.4 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.

2. Generator Protection

The assemblies needed for generator protection shall be mutually independent and located in the compartment of the switchboard of the electrical power generation plant belonging to the generator.

See also **TL** Rules for Electric (Chapter 105), Section 4.

3. Synchronizing and Paralleling

Synchronizing and paralleling of the electrical sources shall be done at process level, compare the **TL** Rules for Electric (Chapter 105), Section 3 and 4.

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

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

4. Load Sharing

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 generator.

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

4.3 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.

4.4 The automatic system shall be so designed that prolonged parallel operation with minimum load per generator is avoided.

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

F. Ship Protection Management for Damage Control

1. Application

The ship protection management is to be used for rapid and targeted damage control. This system shall support the crew 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/ command level of the integrated ship control system.

2.2 The database of the control and monitoring system at control-loop level should be used.

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

3. Killcards and Automatic Predefined Damage Control Procedures

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

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

3.2 Killcards, if applicable, shall be made available to the operator by offering them automatically by the systems to the respective operator.

3.3 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 automatically.

Steps which shall be initiated manually shall be clearly recognizable.

3.4 Following confirmation (acknowledgement) at a control panel, the automatic damage control procedures shall run automatically as far as possible with the option to stop the procedure and to continue actions manually.

The execution of an automatic damage control procedure shall be monitored, and faulty execution shall trigger an alarm.

4. Switchover of Operating Conditions

4.1 Principles

For a change of the operational conditions as defined in in the **TL** Rules for Electric (Chapter 105), Section 3, A., the ship protection management shall perform, after acknowledgement by the operator at the corresponding control station, the various connections, disconnections and changeover actions specified in the building specification.

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

4.2 Overboard pumping

Procedures for pumping liquids overboard following damage to the ship shall only be possible in manual mode.

4.3 Examples for switching operations

For example, the following operational conditions switchovers may 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 shut-down 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.

G. System for Load Line and Stability Calculations

If the other sub-systems are able to recognize if a compartment or room of the ship is flooded or if weights have changed considerably also a sub-system for load line and stability calculations should be integrated, compare the **TL** Rules for Hull Structures and Ship Equipment (Chapter 102), Section 2.

H. Camera Surveillance System

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.

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

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

shall be identified. It shall be possible to display every camera image on every monitor.

4. If the images are to be shown via the visualizations of stipulated installations, e.g. by the alarm system, the information shall always be visible by superimposing over or inserting it into the image. If an alarm in a certain compartment is triggered, automatically the relevant camera images of that compartment should be displayed at specific monitors.

5. 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.

I. Navigation System

Navigation systems are not subject to Classification. Such systems have to be selected by the Naval Authority or the Shipyard and all necessary interfaces to the integrated system shall be clearly defined.

J. Maintenance System

A sub-system to continuously check the service condition of all the actuators may be integrated. This may include online monitoring of vibration measuring systems and other specialized equipment and sensors, like accelerometers, tachometers, displacement probes, etc.

The detailed requirements have to be agreed for the actual project.

K. On-board 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. Switching especially from training to normal operation shall be possible without time delay.

5. The training mode shall be clearly recognizable. Not all control stations should be operable for training at the same time if the ship is cruising.

L. Testing

The integrated system shall undergo comprehensive testing before and during sea trials. The integrity of the sub-systems and essential machinery shall be demonstrated during normal operation and fault conditions.

A test program is to be submitted to **TL** in advance for approval. Systems and equipment are to be approved in accordance with agreed standards, criteria and/or procedures.

SECTION 8

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.

TL reserves the right to demand that tests also be carried out on other items either on the manufacturer's premises or on board. This applies in particular in integrated systems.

4. In the case of new systems or systems which are being used for the first time on ships classed by **TL**, additional tests and trials are to be agreed, as required, between the manufacturer and **TL.**

5. Where computer systems are used for functions which are essential for the safety of ship, crew and supply goods which are subject to classification, records, test results and assessments are to be provided for the hardware and software in accordance with Chapter 105 - Electric, Section 10.

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

7. Tests comprise :

- Examination of technical documentation, see B.
- Tests conducted at the manufacturer's works (FAT), see C.
- Tests on board (HAT and SAT), see D.
- Type approvals, see E.

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. Tests Conducted at the Manufacturer's Works (FAT)

TL reserve the right to demand tests for systems which have safety implications, or in case of extensive automation systems or where individual systems are integrated. This test might be a factory acceptance test (FAT) with presence of **TL.**

D. Tests on Board (HAT and SAT)

1. General

Tests comprise:

- Tests during construction/installation
- Tests during commissioning
- Tests during sea trial
- Repeated tests

2. Tests During Construction/ Installation

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.

3. Tests During Commissioning

The satisfactory condition and the proper functioning of all automation equipment are to be demonstrated.

Where not specified in the Rules, the tests to be conducted are to be agreed with the **TL** surveyor in accordance with the system requirements.

4. Tests During Sea Trials (SAT)

4.1 Scope

The purpose of the test is to prove that all systems are adjusted properly and that ship's machinery operation can be performed without manual intervention.

4.2 Preparation

4.2.1 A list has to be provided to the attending Surveyor which shows all equipment that is switched off with sufficient explanation.

4.2.2 It has to be agreed on representative persons who are allowed to enter engine room and engine control centre for checking and watch keeping during the test.

4.2.3 If applicable, the following is to be prepared:

4.2.3.1 All systems to be prepared for automatic control and adjusted to the correct settings.

4.2.3.2 Manual operated valves shall be completely closed or open.

4.2.3.3 All electric equipment is functioning and switched on.

4.2.3.4 Main propulsion control shall be on the bridge.

4.2.3.5 No alarms shall be manual inhibited.

4.2.3.6 The duty alarm system shall be switched to "Unattended machinery".

4.3 Execution

4.3.1 The start and completion of the test shall be clearly communicated between machinery control centre room and bridge. If appropriate, also announcement via the PA-system may be made.

4.3.2 The start and end of the test shall be marked on the alarm registration device.

4.3.3 Other tests which may be carried out during the endurance test shall be agreed before.

4.3.4 The minimum test time is four hours.

4.3.5 The test shall include at least two hours at 100 % main engine load.

4.3.6 The test shall include manoeuvres from full ahead to dead slow astern.

4.4 De-Briefing

4.4.1 The trials report is to be completed in accordance with the survey type "Unattended Machinery Spaces Initial".

4.4.2 Basically no alarms shall occur during the test.

4.4.3 If alarms come up which indicate malfunction of equipment or wrong system settings, the cause is to be rectified. This may result in repetition of the test.

E. Type Approvals

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

- Computer systems for open-loop and closed-loop controls and monitoring of essential equipment essential for ship operation
- Remote control systems for the main propulsion plant
- Fire detection systems and sensors

- Sensors and actuators for specified automation equipment
- Machinery alarm systems
- Duty alarm systems
- Protective devices
- Safety devices
- Safety systems
- Measuring systems for tank content, if sounding pipes are not available.

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

SECTION 9

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, 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 4, A. shall apply. Reductions of the operation parameters shall be in accordance with Section 4, C.12.

6. For the design of the stand-by circuits, the provisions set out in Section 3, D. and Section 4,I. shall apply.

7. For the design of safety systems and safety devices, the provisions set out in Section 4, E and D. shall apply.

8. In general, the alarms, reductions and shutdowns, as shown in the Tables 9.1 to 9.12, shall be indicated in the machinery alarm system as individual alarms. On the bridge the alarms shall be grouped as described in Section 4, A.11. If it is required to realize individual alarms on the bridge, a notation in the Tables 9.1 to 9.12 is made.

B. Sensors for Main Propulsion Diesel Engines

1. Medium and high speed engines (trunk piston engines)

Table 9.1 Main propulsion diesel engines (medium and high speed)

F = Fault L = Low limit H = High limit R = Reduction RI = Remote Indication S = Shut down T = Trigger Stand-by activation	Sensor for alarms	Sensor for stand-by aggregate	Sensor for safety functions	Individual alarm at the bridge
Fuel oil system				
Fuel oil pressure after filter (engine inlet)	RI, L	L, T		
Fuel oil viscosity before injection pumps or fuel oil temperature before injection pumps **(13)**	L, H			
Leakage from high pressure pipes	F			
Level of fuel oil in daily service tank **(14)**	L			
Common rail fuel oil pressure	L			
Lubricating oil system				
Lub oil to main bearing and thrust bearing, pressure	L, RI	L, T	L, S	
Lub oil pressure at engine inlet **(1) (2)**	L	L, T	L, S	
Lub oil filter differential pressure	H, RI			
Lub oil inlet temperature	H, RI			
Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: - the engine main and crank bearing oil outlet; or - the engine main and crank bearing) **(4)**	F		S	
Failure in cylinder lubrication	F, R			
Level in lubrication oil sump tanks **(1)**	L			
Fault at lubricating oil automatic filter	F			
Temperature thrust bearing	H, R			
Flow rate cylinder lubricator. Each apparatus	L, R			
Common rail servo oil pressure	L			
Turbocharger system				
Turbocharger lub oil inlet pressure **(8)**	L, RI			
Turbocharger lub oil temperature each bearing **(8), (12)**	H			
Speed of turbocharger **(15)**	H, RI			
Sea water cooling system				
Sea water pressure	L, RI	L, T		
Cylinder fresh water cooling system				
Cylinder water inlet pressure or flow	L, RI	L, T	L, S **(10)**	
Cylinder water outlet temperature (general) **(5)**	H R, RI			
Level of cylinder cooling water in expansion tanks	L			
Oil contamination in cylinder cooling water system **(6)**	F			
Pressure of LT (low temperature) freshwater cooling circuit	L			
Temperature of LT (low temperature) freshwater cooling circuit	H			
Temperature of cylinder cooling water at engine inlet	L			
Starting and control air systems				
Starting air pressure before main shut-off valve **(9), (11)**	L, RI			
Control air pressure	L, RI			

Table 9.1 Main propulsion diesel engines (medium and high speed) *(continued)*

F = Fault L = Low limit H = High limit R = Reduction RI = Remote Indication S = Shut down T = Trigger Stand-by activation	Sensor for alarms	Sensor for stand-by aggregate	Sensor for safety functions	Individual alarm at the bridge
Scavenge air system				
Scavenge air receiver temperature	H			
Exhaust gas system				
Exhaust gas temperature turbocharger inlet and outlet	H			
Exhaust gas temperature after each cylinder **(3)**	H, R, RI			
Exhaust gas temperature after each cylinder.Deviation from average **(3)**	H			
Engine speed	RI			
Engine overspeed (2)			H, S	
Control-safety-alarm system power supply failure	F			

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

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

(3) *For engines > 500 kW/cyl.*

(4) *For each engine, one oil mist detector (or engine bearing temperature monitoring system or equivalent device) having two independent outputs for initiating the alarm and shut-down would satisfy the requirement for independence between alarm and shut-down systems.*

(5) *Where all cylinders have a common cooling water chamber with no individual shut-offs, individual monitoring may be dispensed with. In this case, separate sensors for alarm and reduction are required.*

(6) *Where cooling water is used for preheating or cooling fuel, lubricating oil.*

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

(8) *Not applicable for selfcontained lubricating oil circuits.*

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

(10) *If possible due to size, otherwise a shutdown for cooling temperature cylinder outlet to be provided when reaching high limit.*

(11) *Where engine is started electronically the failure of the battery charger is to be alarmed.*

(12) *Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be agreed with **TL**. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.*

(13) *For heavy fuel oil burning engines only.*

(14) *High-level alarm is also required if no suitable overflow arrangement is provided.*

(15) *Only required for turbochargers of Categories B and C (see **TL** Machinery Rules, Chapter 4, Section 4,A.).*

C. Sensors for Propulsion Gas Turbines

Table 9.2 Propulsion gas turbines

Meaning of symbols: F = **F**ault L = **L**ow limit H = **H**igh limit R = **R**eduction S = **S**hut-down	**Individual Alarm Indication**	**Group Alarm Indication**	**Shut-down**
Fuel temperature		H	
Fuel oil supply pressure	L		
Fuel filter, differential pressure **(2)**	H		
Level in lubrication oil sump		L H	
Lubrication oil pressure	L		L S
Lubrication oil temperature inlet	H		
Lubrication oil filter, differential pressure	H		
Cooling water temperature		H	
Cooling water pressure	L		
Compressor inlet pressure or air intake filter, differential pressure	H L		H S L S
Power turbine overspeed, speed sensor	H		H S
Failure to reach idle speed **(2)**	F		
Failure to ignite	F		F S
Flame out detection	F		F S
Power turbine inlet temperature **(1)**	L		
Exhaust temperature (power turbine outlet)	H		H S
Bearing temperature	H		
Thrust bearing temperature	H		
Vibration, vibration sensor (for bearings) **(3)**	H		H S
Axial displacement of power turbine, thrust bearing value	H		H S
Power loss of monitoring system	F		
Power loss of control system	F		
Loss of cooling air supply (pressure or flow)	L		
Starting system failure	F		
Fire detection inside gas turbine enclosure	F		F S

(1) *Not less than 6 temperature sensors per turbine*

(2) *Not required for generator driving turbines*

(3) *Details in accordance with monitoring concept of the gas turbine manufacturer*

D. Sensors for Electric Propulsion Plants

Table 9.3 Indicators for electric permanent excited propulsion motors (PE), as well as synchronous motors (SY) and asynchronous motors (AS)

Descriptions F = **F**ault L = **L**ow limit H = **H**igh limit R = **R**eduction (R) = if applicable S = **S**hut-down (S) = if applicable T = **T**rigger standby activation C = Collective alarm		**Sensor for alarms**	**Sensor for stand-by aggregate**	**Sensor for safety functions**	**Alarm at the bridge**
Electric motor					
External lubrication failure	**PE SY AS**	F		F(R) (S)	C
Bearing temperature	**PE SY AS**	H		H	C
Stator winding temperature	**PE SY AS**	H		H R	C
Sliprings condition	**SY**	Inspection			-
External cooling water and/or air failure	**PE SY AS**	F		F	C
Cooling air temperature, engine inlet at closed loop cooling system	**PE SY AS**	H		H	C
Coolant leakage	**PE SY AS**	F		F	C
Speed	**PE SY AS**	H		H S	C
Voltage regulator breakdown	**SY**	F		F S	C
Earth fault monitoring at stator with transformer feeding	**PE SY AS**	L		L	C
Earth fault monitoring of exciting system with transformer feeding	**SY**	L		L	C
Transformer reactor					
Transformer winding temperature	**PE SY AS**	H		H R	C
Coolant leakage	**PE SY AS**	F		F	C
External cooling failure	**PE SY AS**	F		F	C
Converter					
Mains failure	**PE SY AS**	F		S	C
External cooling failure	**PE SY AS**	F		F R	C
Power section temperature	**PE SY AS**	H		H S	C
Cooling quality (only at direct cooling)	**PE SY AS**	L		L	C
Coolant leakage	**PE SY AS**	F		F	C
General warning	**PE SY AS**				C
Breakdown	**PE SY AS**	F		F S	C
Speed-/rotor position sensor detection failure	**PE SY AS**	F		F	C
Emergency stop (converter de-energized)	**PE SY AS**	F		F S	C

Table 9.3 Indicators for electric permanent excited propulsion motors (PE), as well as synchronous motors (SY) and asynchronous motors (AS) *(continued)*

Descriptions F = **F**ault L = **L**ow limit H = **H**igh limit R = **R**eduction (R) = if applicable S = **S**hut-down (S) = if applicable T = **T**rigger standby activation C = Collective alarm		**Sensor for alarms**	**Sensor for stand-by aggregate**	**Sensor for safety functions**	**Alarm at the bridge**
Semiconductor fuse	**PE SY AS**	F		F S	C
Chopper temperature	**PE SY AS**	H		H R	C
DC-Link, voltage	**PE SY AS**	H		H S	C
DC-Link, current	**PE SY AS**	H		H S	C
Output current	**PE SY AS**	H		H S	C
Propulsion net/ship electrical system					
Harmonic filter breakdown	**PE SY AS**	F		F	C

E. Sensors for Propulsion Shafting and Steering Gear

Table 9.4 Propulsion plant (prime mover engine excluded)

Meaning of symbols: F = **F**ault L = **L**ow limit H = **H**igh limit R = **R**eduction S = **S**hut-down T = **T**rigger standby activation	**Sensor for alarms**	**Sensor for stand-by aggregate**	**Sensor for safety functions**	**Individual alarm at the bridge**
Main gear				
Lubricating oil pressure gear input	L R	L T **(1)**	L S	
Lubricating oil temperature gear input / after cooler **(2)**	H R			
Lubricating oil temperature gear output / before cooler **(3)**	H R			
Pressure drop lubricating oil at filter	H			
Temperature radial bearings **(4)**	H			
Temperature gear integrated thrust bearing **(5) (6)**	H R			
Level in lubrication oil sump tank	L			

Table 9.4 Propulsion plant (prime mover engine excluded) *(continued)*

Meaning of symbols: F = **F**ault L = **L**ow limit H = **H**igh limit R = **R**eduction S = **S**hut-down T = **T**rigger standby activation	**Sensor for alarms**	**Sensor for stand-by aggregate**	**Sensor for safety functions**	**Individual alarm at the bridge**
Mechanical/multi disc clutch (stand-alone or gear integrated)				
Operating pressure	L R	L T		
Control of unintended slip in engaged condition			L S **(7)**	
Shaft Bearings, Stern tube				
Temperature or lub. oil temperature radial bearings **(8)**	H			
Temperature or lub. oil temperature thrust bearing **(5),(8)**	H R			
Temperature aft. stern tube bearing **(9)**	H			
Oil level sterntube storage / gravity tank	L			
Direction of rotation **(10)**	F			
Controllable Pitch Propeller Plant				
Pressure of hydraulic oil	L	L T **(1)**		L
Level of hydraulic oil of control mechanism in tank	L			
Temperature hydraulic oil	H			
Pressure drop in filter for hydraulic oil	H			
Failure / Malfunction of CP control	F			

(1) *Only when a stand-by pump is recommended*
(2) *For all gears with plain bearings and for gears with roller bearings with a transmitted power > 500 kW.*
(3) *Required only for applications, where no further temperatures are monitored within the gear*
(4) *Not needed for applications with roller bearings*
(5) *Only for the fwd. pads / direction*
(6) *For roller bearing applications may be replaced by monitoring of lub. oil temperature*
(7) *May be measured by direct methods, e.g. differential speed measurements, or indirectly, e.g. monitoring of minimal tolerable pressure. Shut down the driving engine can also be replaced by alternative protection methods, e.g. disengaging of the slippery clutch.*
(8) *Not needed for applications with roller bearings when the shaft diameter is less than 300 mm*
(9) *For oil lubrication and shaft diameters less than 400 mm the oil temperature in the next vicinity of the aft. bearing may be monitored. Not needed to be monitored for water lubricated bearings so far the shaft's diameter is less than 400 mm.*
(10) *For reversible engines only (Direct coupled or for geared plants not equipped with reverse gear stage)*

Table 9.5A Steering device

Meaning of symbols: F = **F**ault L = **L**ow limit H = **H**igh limit R = **R**eduction S = **S**hut-down T = **T**rigger standby activation	**Sensor for alarms**	**Sensor for stand-by aggregate**	**Sensor for safety functions**	**Individual alarm at the bridge**
Steering gear (1), (2)				
Loss of voltage supply for power unit	F	F T **(3)**		F
Overload and failure of one phase of electric drive	F	F T **(3)**		F
Low level hydraulic oil tank	L	F T **(3)**		L
Loss of voltage supply control unit of steering gear	F	F T **(3)**		F
Functional failure of hydraulic system (hydraulic lock)	F	F T **(3)**		F

(1) *The sensors as listed in this table are to a great extent based on **SOLAS** regulations and are therefore required also for vessels without the Class Notation **AUT**.*

(2) *For each steering device common alarm in machinery space is acceptable.*

(3) *The defective subsystem is to be stopped and the affected parts shall be isolated.*

Table 9.5B Azimuthing propulsors

Meaning of symbols: L = **L**ow I = **I**ndication H = **H**igh S = **S**hut-down HH = **H**igh **H**igh A = **A**larm	**Applicable for pods only**	**Parameter**	**Kind of information**	**Information transfer**
Propulsion motor				
Electromotor with closed air system	X	Humidity	I	Display
Closed circuit cooling	X	Temperature	H	F
		Flow	I	L
Gears				
Lubrication oil tank		Temperature	H	
		Pressure	L	
Lubrication oil tank		Min. + max. level	L H	

Table 9.5B Azimuthing propulsors *(continued)*

Meaning of symbols: L = **L**ow I = **I**ndication H = **H**igh S = **S**hut-down HH = **H**igh **H**igh A = **A**larm	**Applicable for pods only**	**Parameter**	**Kind of information**	**Information transfer**
Shafting				
Shaft bearings	X	Wear (Accelerations)	I	
		Metal particles detection	I	
		Temperature	H	Alarm, two stage
Lubrication of shafting				
Redundant lubrication oil pump		Flow	I in two stages	Display
	X	Switching over	I	Display
Lubrication oil		Temperature	H	Alarm
		Min. + Max. level	L H	L-alarm/ H-display
Shaft sealing				
Header tank		Min. + Max. level	L H	Alarm
Any leakage		Leakage	H	Alarm
Emergency sealing device	X	Operability	I	Alarm (if fault)
Shaft movement				
Locking device for propeller shaft		Engagement	I	Display
Clutch for power transmission		Engagement	I	Display
Bilge system				
Liquid in gondola	X	Bilge level	H HH	Alarm, two stage
Liquid in gondola	X	Bilge level monitoring	L HH	Alarm, S
Liquid in motor	X	Bilge level	H HH	Alarm, two stage, S
Steering device				
Control components		Failure	I	Alarm
Steering angle limitation		Failure	I	Display
Hydrauylic systems				
Permissible oil level in tanks		Level	L H	Display
Electrical systems				
Comparing of redundant parameters for measurements		Missing plausibility	I	Display
Data transmission		Signal fault	I	Display
Critical situations	X	Occurrence	I	Display
Fire alarm	X	Smoke detected	I	Display

F. Sensors for Auxiliary Diesel Engines

Table 9.6 Auxiliary diesel engines

F = Fault L = Low limit H = High limit R = Reduction S = Shut down T = Trigger Stand-by activation	Sensor for alarms	Sensor for stand-by aggregate	Sensor for safety functions	Individual alarm at the bridge
Auxiliary diesel engines				
Fuel oil leakage from high pressure pipes	F			
Lubricating oil temperature	H			
Lubricating oil pressure	L		L, S	
Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: - the engine main and crank bearing oil outlet; or - the engine main and crank bearing) **(3)**	F		S	
Pressure or flow of cooling water	L			
Temperature of cooling water or cooling air	H			
Level in cooling water expansion tank, if separate circuit	L			
Level in fuel oil daily service tank	L			
Pressure of starting air	L			
Overspeed activated			H, S	
Fuel oil viscosity before injection pumps or fuel oil temperature before injection pumps **(1)**	L H			
Exhaust gas temperature after each cylinder **(2)**	H			
Common rail fuel oil pressure	L			
Common rail servo oil pressure	L			
Speed of turbocharger **(4)**	H			

Notes:

(1) *For heavy fuel oil burning engines only.*

(2) *For engine power above 500 kW/cyl.*

(3) *When required by UR M10.8 or by SOLAS Reg. II-1/47.2. for each engine one oil mist detector (or engine bearing temperature monitoring system or equivalent device) having two independent outputs for initiating the alarm and shut-down would satisfy the requirement for independence between alarm and shut-down systems.*

(4) *Only required for turbochargers of Categories B and C. (see **TL** Machinery Rules, Chapter 4, Section 4,A.).*

G. Sensors for Fuel, Separator, Generation and Utilization of Heat

Table 9.7 Fuel oil, separator, generation and utilization of heat

Meaning of symbols: F = **F**ault L = **L**ow limit H = **H**igh limit R = **R**eduction S = **S**hut-down T = **T**rigger standby activation	**Sensor for alarms**	**Sensor for stand-by aggregate**	**Sensor for safety functions**	**Individual alarm at the bridge**
Fuel oil				
Fuel level (gas blanket) **(2)** in closed stand pipe	L			
Fault in automatic fuel oil filter	F			
Level in fuel oil service tank	L **(3)**			
Differential pressure of fuel indicator filter	H			
Fuel oil temperature in daily service oil fuel tanks and setting tanks **(6)**	H			
Separator Systems				
Temperature of separating medium	L H			
Unintentional opening of drum	F			
Water in the discharge of the separation medium	F			
Loss of water seal	F			
Sludge tank level	H			
Oil fired heaters				
Temperature at heater	H			
Circulation	L			
Temperature of flue gas	H			
Leakage	F			
Exhaust gas fired heaters				
Temperature at heater	H			
Circulation	L			
Exhaust gas temperature at heater outlet	H			
Fire in heater	F			
Leakage	F			
Auxiliary steam plant				
Condensate, feed water and steam system				
Steam pressure	L			
Level in condensate tank	L			
Salt content	H			
Oil penetration	F			

Table 9.7 Fuel oil, separator, generation and utilization of heat *(continued)*

Meaning of symbols: F = **F**ault L = **L**ow limit H = **H**igh limit R = **R**eduction S = **S**hut-down T = **T**rigger standby activation	**Sensor for alarms**	**Sensor for stand-by aggregate**	**Sensor for safety functions**	**Individual alarm at the bridge**
Oil fired boiler				
Level of water	L H			
Pressure of steam	H			
Circulation	L			
Exhaust gas boiler				
Level of water	L H			
Pressure of steam	H			
Fire in exhaust gas boiler (boiler with framed tubes)	F			
Oil fired system for auxiliary steam plants				
Fuel supply system				
Fuel oil pressure **(1)**	L			
Fuel oil temperature / viscosity	L H			
Service tank level	L			
Oil burner				
Fuel oil pressure in pressure atomizer **(5)**	L			
Atomizing medium pressure	L H			
Rotary cup speed / primary air pressure	L			
Flame disturbance **(1)**	F			
Combustion air pressure **(5)**	L			
Induced draught	L			
Evaporator plant				
Salt content of the produced distillate	H			

(1) *Reduce and registration for main steam plants*
(2) *Not applicable in the case of automatic gas-venting*
(3) *High level alarm is also required if no suitable overflow arrangement is provided.*
(4) *It may be agreed with **TL** to alarm the temperature alternatively.*
(5) *If the fan for combustion air and the pump for fuel oil will be driven by one common motor the realisation of one of the stated alarms is sufficient.*
(6) *Only if tanks are fitted with heating arrangements and the flashpoint of the oil fuel can be exceeded.*

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

Table 9.8 Fire alarm systems, electrical plants and others

Meaning of symbols: F = **F**ault L = **L**ow limit H = **H**igh limit R = **R**eduction S = **S**hut-down T = **T**rigger standby activation	**Sensor for alarms**	**Sensor for stand-by aggregate**	**Sensor for safety functions**	**Individual alarm at the bridge**
Fire alarm system				
Fire alarm **(1)**	F			F
Fault	F			
FWBLAFFS (Local Fire Fighting System)				
Prealarm	F			
Released	F			F
Fault	F			
Electrical plant				
Failure of ship's main	F			
Disconnection of non-essential consumers	F			
Generator switch activated	F			
Low frequency	L			
Over voltage	H			
Failure 24 V main charger	F			
Common fault power management	F			
Others				
Failure of remote control	F			F
Failure of alarm system/duty alarm system	F			F
Failure of safety system	F			
Activation of the safety system	F			
Override of safety system is activated	F			
Set/actual values deviation of a remote control	F			
Automatic start of a stand-by unit **(4)**	F			
Fault of a stand-by control unit	F			
Level of engine room bilge, bilge suction pipe **(3)**	H			
Oil content of bilge water after separator	H			
Switching-on time and frequency of automatic bilge pumps	H			
Level of fuel overflow tank	H			

Table 9.8 Fire alarm system, electrical plants and others *(continued)*

Meaning of symbols: F = **F**ault L = **L**ow limit H = **H**igh limit R = **R**eduction S = **S**hut-down T = **T**rigger standby activation	**Sensor for alarms**	**Sensor for stand-by aggregate**	**Sensor for safety functions**	**Individual alarm at the bridge**
Level leakage oil tank	H			
Failure of CO_2 -low pressure system	F			
Failure of compressor for starting air **(2)**	F			
System pressure of fire extinguishing system	L			
Activation of automatic fire extinguishing system	F			F
Failure of electrical speed governor	F			

(1) *Alarm to be optically and acoustically 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*

(4) *If not started due to normal condition.*

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

Table 9.9 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
Diesel engine for propulsion	Lubricating oil pumps **(1)**	X	X
	Piston coolant pumps	X	X
	HT (high temperature) fresh cooling water pumps	X	X
	LT (low temperature) fresh cooling water pumps	X	X
	Sea water cooling pumps	X **(2)**	X
	Fuel valve coolant pumps	X	X
	Fuel feeding pumps	X	X
	Fuel pressure increasing pumps	X	X
Gas turbine	Lubricating oil pumps	X	X
	Coolant pumps	X	X
	Fuel feeding pumps	X	X
	Fuel pressure increasing pumps	X	X
Auxiliary diesel engine	Fuel feeding pumps	X	X
	Cylinder water cooling pumps	X	X
Auxiliary steam plant	Feedwater pumps	X	X **(5)**
	Circulating pumps	X	X **(5)**
Oil burning system	Fuel feeding pumps	X	
Gas turbine generator	Back-up lubricating pump	X	X
Pump for gear lubricating oil		X	X
Pump for power oil of controllable pitch propeller		X	X
Pump for hydraulic oil of steering gear		X **(3)**	X
Compressor for starting air		X **(4)**	
Compressor for control air		X **(4)**	
Main fire extinguishing pump		X **(3)**	

(1) *Valid for separated circuit*
(2) *For scoop operation automatic switch-on/ switch-off of main coolant pump as a function of the rate of speed as substitution*
(3) *Starting by remote control from bridge*
(4) *Automatic switching on or off depending on pressure*
(5) *For auxiliary steam plant the starting after shut-down and return of the ship's supply is not required.*

J. Remote Control for small Naval Vessels

For small naval vessels with a length of **L ≤** 48 m and Class Notation **RC** the Tables 9.10 to 9.12 summarize the monitored parameters and define the limits for an alarm.

Table 9.10 Alarm for propulsion machinery – Main engines, gear and shafting

Monitored parameters : L = **L**ow limit H = **H**igh limit F = **F**ault	**Alarm**	**Comments**
Main engine		
Engine overspeed	H	Stop by safety system
Lubricating oil pressure at engine inlet	L	Stop by safety system
Lubricating oil temperature at engine inlet	H	
Differential pressure across lubricating oil pressure filter	H	
Fault in automatic lubricating oil filter	F	
Fuel oil pressure at engine inlet	L	
Fuel oil leakage from high pressure pipes	F	
Differential pressure across fuel oil filters	H	
Fault in automatic fuel oil filter	F	
Fuel level in closed stand pipe	L	Does not apply when automatic gas venting
Cylinder cooling water pressure or flow at engine	L	Stop by safety system
Cylinder cooling water temperature at cylinder outlet	H	
Oil contamination of engine cooling water	H	Where cooling water is used for heat exchangers with fuel or thermal oil
Sea cooling water pressure	L	
Secondary fresh cooling water pressure	L	
Secondary fresh cooling water temperature	H	
Charge air temperature at charge air cooler outlet	L H	Or “water in charge air duct” instead of flow limit
Start air pressure	L	Where engine is started electrically the failure of the battery charger is to be alarmed
Control air pressure	L	
Exhaust gas temperature	H	
Oil mist concentration in crankcase	H	Stop by safety system Approved alternative methods may be used, 2250 kW and above or cylinder diameter > 300 mm
Gear		
Lubricating oil temperature	H	500 kW and above
Lubricating oil pressure inlet	L	Stop by safety system

Table 9.10 Alarm for propulsion machinery - Main engines, gear and shafting *(continued)*

Monitored parameters : L = **L**ow limit H = **H**igh limit F = **F**ault	**Alarm**	**Comments**
Shafting		
Temperature of stern tube bearing aft	H	For shaft diameter < 400 mm sensor may be located in the vicinity of the aft bearing
Temperature of intermediate shaft bearings	H	500 kW and above
Thrust block lubricating oil temperature or thrust block temperature	H	
Controllable pitch propeller system,if applicable		
Hydraulic oil pressure	L	May be displayed on bridge jointly with "Failure of remote control system".
Hydraulic oil level in gravity tank or backing pump pressure	L	Stop by safety system
Couplings		
Control of unintended slip in engaged condition	L	Stop by safety system

Table 9.11 Alarm for auxiliary machinery, tanks and miscellaneous items

Monitored parameters : L = **L**ow limit H = **H**igh limit F = **F**ault	**Alarm**	**Comments**
Diesel generators		
Engine overspeed	H	Stop by safety system
Lubricating oil pressure at engine inlet	L	Stop by safety system > 220 kW
Lubricating oil temperature	H	
Fuel oil pressure at engine inlet	L	
Fuel oil leakage from high pressure pipes	F	
Cylinder cooling water pressure or flow at engine inlet	L	
Cylinder cooling water temperature at cylinder outlet	H	
Voltage	L H	
Frequency	L	
Tripping of non-essential consumers	F	
Failure of main source of electrical power	F	
Separator systems		
Temperature of medium for separation	L H	If local individual indication is provided, one common alarm is sufficient in the central alarm panel
Unintentional discharge of bowl/loss of water seal/water in medium to be separated or equivalent	F	

Table 9.11 Alarm for auxiliary machinery, tanks and miscellaneous items *(continued)*

Monitored parameters : L = **L**ow limit H = **H**igh limit F = **F**ault	**Alarm**	**Comments**
Steering gear		
Failure of steering gear	F	
Phase failure / overload	F	
Failure of control system	F	
Tank levels		
Fuel service tanks	L	All tanks with automatic or remote controlled filling are to be provided with additionally high level alarms
Expansion cooling tanks	L	
Sludge, leak oil and fuel oil overflow tanks	H	
Gravity oil tanks for stern tube	L	
Main engine lubticating oil sump trunks / tanks	L	
Steering gear hydraulic oil tank	L	
Fire detection system		
Fire alarm	F	
Fault	F	
Miscellaneous		
Failure of remote control system	F	Individual alarm
Failure of alarm system	F	
Failure of safety system	F	
Activation of safety system	F	
Automatic change-over of auxiliary machinery	F	
Level of machinery space bilges/drain wells	H	At least 2 sensors and detecting loops per machinery per space
Fault in fire-extinguishing system	F	
Release of automatic fire-extinguishing system	F	Indivudual alarm

Tablo 9.12 Alarm for auxiliary steam boilers

Monitored parameters : L = **L**ow limit H = **H**igh limit F = **F**ault	**Limit**	**Comments**
Steam boilers		
Tripping of safety system	F	
Steam pressure	L H	
Water level	L H	
Failure of circulating pump	F	
Salinity of condensate	H	
Oil contamination of condensate	H	

SECTION 10

SPARE PARTS

A. General Requirements

1. When specifying the amount of spare parts for automation systems, allowance is to be made for the manufacturer's recommendations.

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

ANNEX

INTEGRATED COMPUTER CONTROL (ICC)

Page

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 NAVINS (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.