PART 8 Automatic and Remote-Control Systems

CONTENTS

CHAPTER 1 Automatic and Remote-Control Systems

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SECTION 1 General

1.1 Scope

1.1.1 The Rules contained in this Chapter apply to ships equipped with remote controlled and/or automated machinery and are in addition to other relevant Rules of the Society or the International Convention for the Safety of Life at Sea in force. Consideration may be given to alternatives to the provisions of these rules, provided that they will provide at least the same safety standards.

1.1.2 Systems and equipment used in ships as in 1.1.1 may be classified in one or more of the following categories:

(1) Alarm systems
(2) Safety systems
(3) Automatic control systems
(4) Remote control systems
(5) Recording equipment

1.1.3 The extent of Control Engineering Systems used onboard, may render a ship eligible for one of the following class notations:

a) Integrated Propulsion: " IP "
b) Control from a Central Station: " CCS "
c) Unattended Machinery Operation: " UMS "

1.1.4 SECTION 2 contains the principles for the design of such system, SECTION 3 states the specific requirements (parameters) in terms of these systems for Main Machinery and SECTION 4 states the same for Auxiliary Machinery. SECTION 5 states the requirements for the various grades of automation.

1.2 Definitions

1.2.1 Alarm systems give warning when a parameter gets out of predetermined limits. They include:

(1) Machinery alarm systems
(2) Fire detection and alarm systems
(3) Bilge level alarm systems

1.2.2 Safety systems take action of the following nature, in order to protect from damage or safeguard the operation of machinery:

(1) Starting of, or change-over to, standby equipment
(2) Power (or speed) reduction
(3) Shutdown of machinery

1.2.3 Automatic control systems govern the following parameters in order to maintain steady state conditions: Pressure, temperature, rotating speed, levels, combustion parameters and electrical values.

1.2.4 Remote control systems use mechanical, hydraulic, pneumatic or electrical power to remotely control the operation of Main or Auxiliary machinery.

1.2.5 Recording equipment records intelligently faults and trends potentially leading to faults and processes logged main parameters.

1.3 Documents

1.3.1 The following documents are to be submitted in triplicate for approval where automatic control, remote control, alarm and safety systems are to be installed:

– Description of operation with explanatory diagrams.

- Line diagrams of control circuits.
- List of monitored points.
- List of control points.
- List of alarm points.
- Test schedules which should include methods of testing and test facilities provided.

1.3.2 Plans for the automatic control, remote control, alarm and safety system of the following are to be submitted:

- Air compressors
- Bilge and ballast systems.
- Cargo pumping systems for tanker.
- Cargo and ballast pumps in hazardous areas.
- Controllable pitch propeller.
- Electric generating plant.
- Evaporating and distilling systems.
- Incinerators.
- Inert gas generators.
- Lifts.
- Main propelling machinery including essential auxiliaries.
- Oil fuel transfer and storage systems. (Purifiers and oil heaters).
- Oily water separators.
- Steam raising plant. (Boilers and their ancillary equipment).
- Steering gear.
- Thermal fluid heaters.
- Transverse thrust units.
- Miscellaneous machinery (where control, alarm and safety systems are specified by other Sections of the Rules).
- Waste heat boiler.
- Valve position indicating systems, see 2.5.8.

1.3.3 Alarm systems

Details of the overall alarm system linking the main control station, subsidiary control stations, the bridge area and accommodation are to be submitted.

1.3.4 Programmable electronic systems

In addition to the documentation required by 1.3.1 the following is to be submitted:

- Details of the hardware configuration in the form of a system block diagram.
- A graphic representation of sequential function elements, e.g. flow charts, ladder diagrams, function block diagrams.
- Details of self-monitoring techniques.
- Details of the communication protocol.
- Details of the data transfer rate including anticipated data latency.
- Details of the voice or video signals which may share a local area network.
- Details of the software quality plan or the appropriate certification of the software quality procedures, as applicable.
- Factory acceptance test schedules for hardware and software verification.
- The system requirements specification.

1.3.5 Control station

Location and details of control stations are to be submitted, e.g. control panels and consoles.

1.3.6 Fire detection systems

Plans showing the system operation, the type and location of fire detector heads, manual call points and the fire detector indicator panel are to be submitted.

1.3.7 Approved system
Where it is intended to employ a standard system which has been previously approved, plans are not required to be submitted providing there have been no changes in the applicable Rule requirements. The building port, where applicable, and date of the previous approval is to be advised.

1.4 Equipment

1.4.1 Every essential remotely controlled or automated system should also be capable of being manually operated.

1.4.2 Sensors, actuators, fire detection equipment as well as essential parts of the Alarm, Safety, Automatic and Remote-Control Systems should be type - tested under the conditions prescribed in SECTION 6. Major units of above systems are to be surveyed at the manufacturer's works to the Surveyor's satisfaction.

1.4.3 For equipment requiring a controlled environment, alternative means for maintaining such an environment, outside the normal air conditioning system, is to be provided.

1.4.4 Performance parameters of the equipment used, such as accuracy, repeatability etc. are to be in accordance with an International Standard such as Publication 51 of the IEC "Recommendations for indicating electrical measuring instruments and their accessories".

SECTION 2 Design principles

2.1 Control stations

2.1.1 A system of indicating instruments, alarm displays and controls must be provided, ensuring satisfactory supervision and remote control of Main and essential Auxiliary machinery, as well as indication of faults. This may be provided at a Main control station at or near the machinery space, or, alternatively at the navigating bridge, which in this latter case will be considered as the Main control station. Subsidiary control stations may also be provided. In this case, a master alarm display at the Main control must be provided showing which of the subsidiary control stations is indicating a fault.

2.1.2 If a Main control station is provided at the machinery space then Secondary control stations for the control of propulsion machinery may be provided at the bridge or other locations. The Secondary control stations are to be kept as simple as possible, provided only with means for control and indication of speed, direction of rotation and pitch (in the case of controllable pitch propeller) of propeller, as well as with group alarms for machinery, steering gear, fire-detection and bilge-level.

2.1.3 Means of communication between Main control station, navigating bridge, accommodation of engineers, Secondary control stations and, if necessary, the machinery space, are to be provided.

2.1.4 Provision is to be made at all stations for the manual operation of an engineer's alarm which is to be audible in the engineer's accommodation.
2.1.5 Control of Main and Auxiliary machinery must be possible only from one station at a time, and indication is to be provided at all stations showing which station is in control.

2.1.6 Changeover of control between stations, may only be effected with the consent of the station taking control. This must be ensured with suitable interlocks.

2.1.7 Means are to be provided for an emergency stop of the Main propulsion machinery from the bridge. This is to be independent of the bridge remote control system.

2.2 Alarm systems

2.2.1 The alarm system must warn the duty personnel of any fault in the machinery monitored parameters, as well as in the alarm, safety and remote-control systems themselves, indicating exactly which parameter was at fault or which safety action has been undertaken or which control circuit has failed.

2.2.2 Alarms signals must be given at the Main control station, engineer's accommodation area and at the bridge (when this is not the Main control station), if the machinery spaces are unattended. The alarm signal to the engineer officer on duty must be individually selectable and indicated on the bridge. In the case of unattended machinery, the engineer's alarm required by 2.1.4 is to be activated automatically in the event that a machinery alarm has not been acknowledged in the space within a predetermined time.

2.2.3 The alarm system should function independently of automatic control and safety systems.

2.2.4 All alarms are to be both audible and visual. The audible alarm is normally one, while, visual alarms in the Main control station are to be individual for each parameter monitored, it (the parameter) being written on the particular warning light which has the form of a button.

2.2.5 Acknowledgment of the audible alarm may silence it but it is not to extinguish the visual alarm.

2.2.6 Acknowledgment of the individual visual alarm (by pressing the button in 2.2.4) changes it from flickering to constant light which goes off when the fault has been rectified.

2.2.7 If an alarm has been acknowledged and a second fault occurs before the first one has been rectified, audible and visual alarms are to operate.

2.2.8 When the Main control station is not at the navigating bridge, visual alarms at the bridge are to be kept to a minimum by grouping them into the following, distinct from each other, groups:

1) Safety alarms, except those caused by the starting of standby equipment. (Red light)
   The alarm indicating shutdown of the Main Engine is to be separate.
2) Alarms due to other machinery faults. (Yellow light)
3) Fire detection alarms (Separate panel)
4) Bilge level alarms (Blue light)

Group alarms on the bridge are to be individualized at the Main control station (see 2.2.4)

2.2.9 Acknowledgment of an alarm at a station outside the Main control station (or at the bridge) silences the audible alarm only at that station. When the individual visible alarm has been acknowledged of the Main control station, then the visual (group) alarm on the bridge goes off.

2.2.10 In the case of short transient faults, which in the meantime have been self-corrected, alarms are required to stay on until acknowledged.

2.2.11 The application of the "fail safe" principle in the design of alarm systems means that they should be designed to monitor themselves, i.e. they are to operate on the closed circuit principle.

2.2.12 Disconnection or manual overriding of any part of the alarm system should be clearly indicated.

2.2.13 Failure of the normal electricity supply to any of the alarm systems is to be indicated as a separate alarm (audibly and visually). Automatic changeover to standby electricity supply is to be provided in this case so that continuity of supply is ensured

2.2.14 When alarm systems are provided with means to adjust their set point, the arrangements are to be such that the final settings can be readily identified.

2.3 Safety systems

2.3.1 Safety systems must take action automatically in case of serious faults in order to protect from damage or safeguard the operation of machinery. More specifically their purpose is as follows:

(1) To restore normal operating conditions by starting of, or changeover to standby equipment.

(2) To adjust temporarily the operation of machinery to the existing conditions by power reduction.

(3) To protect Main engines, Boilers and Generating sets from critical conditions by shutting them down automatically (interruption of fuel or steam supply). See also 1.2.2.

2.3.2 Safety systems are to operate in the sequence indicated in 2.3.1(1), (2) and (3) in order to avoid unnecessary interruption.

2.3.3 When a safety system is activated, an audible and visual alarm is to operate indicating the safety action. The visual alarm to do this is to be located at the Main control station except of the Main engine shutdown alarm which is also to be located on the bridge. Everything governing location and acknowledgment of the safety alarms is to be as set out in 2.2.

2.3.4 Safety systems are to function as far as practicable independently of automatic control and alarm systems.

2.3.5 Each safety system circuit is to be provided with a manual reset.

2.3.6 The principle of "fail safe" is implemented by designing most of the safety systems with open circuit. Main boiler safety systems are an exception. Generally, the implementation of the "fail safe" principle is to be evaluated not only on the basis of the particular safety system's integrity but also of the complete ship safety.

2.3.7 Safety systems of different item are to be independent of each other so that failure of one of them does not interfere with the operation of the remaining.

2.3.8 Where overriding of a safety system is a possibility, this should be arranged to prevent inadvertent operation. Visual indication is to appear when a safety system is overridden.

2.3.9 The provisions of 2.2.13 about continuity of power supply, apply to safety systems equally well.

2.4 Automatic control systems

2.4.1 Automatic control systems are to keep automatically the values of certain parameters within predetermined limits (nearly at a required set value). They are to be stable and maintain steady state conditions.

2.4.2 Typical parameters to be controlled automatically are: Propeller speed, speed of generating sets and other machinery, pressures, temperatures, combustion parameters, levels, electrical values.

The specific parameters to be automatically controlled are listed in SECTION 3 and SECTION 4 for the various types of machinery.

2.4.3 Automatic control systems are to be independent of alarm and safety systems.

2.4.4 Adequate instrumentation should be provided at the Main control station, and other control stations as required, to ensure effective control and indication of proper functioning of each automatic control system. This is to be independent of the alarm system which may exist for monitoring the same parameter.

2.4.5 Automatic control systems are to be so designed that when one of them is out of action, it is possible to operate the relevant machinery by manual control. Manual local control points are to be provided with adequate instrumentation for effective operation of the machinery.

2.4.6 The principle of "fail safe" is to be implemented in the case of automatic control system by designing them so that if one of them fails, the parameters controlled by it remain constant at the values they had at the time of failure (locked). At the same time an audible and visual alarm must operate indicating which automatic control system has failed. The provisions of 2.2 about the location and acknowledgment of alarms apply in this case.

2.4.7 The automatic control systems are to be so designed that during their normal operation no overloads of any kind are induced in the machinery.

2.4.8 The provisions of 2.2.13 about continuity of power supply, apply to automatic control systems equally well.

2.5 Remote-control systems

2.5.1 Remote control systems use auxiliary power to remotely control the operation of machinery and equipment from the main control station, or the navigating bridge, or an appropriate secondary control station.

2.5.2 The auxiliary power systems (hydraulic, pneumatic, electric or combinations of them) used to remotely control the operation of machinery and equipment, are to be suitable for the intended duty and are to be designed to operate safely at full power conditions under the specified environmental conditions.

2.5.3 The principle of "fail safe" is implemented in the case of remote-control systems by designing them so that should one of them fail, the parameters controlled by it remain constant at the values they had at the time of failure (locked). At the same time an audible and visual alarm must operate indicating which automatic control system has failed. The provisions of 2.2 about the location and acknowledgment of alarms apply in this case.

2.5.4 For a system fitted on the bridge to remotely control the Main machinery, means should be provided for effective control of the propulsion machinery in both the ahead and astern directions. Additionally, the requirements of 2.5.5 and 2.5.6 are to be satisfied.

2.5.5 More specifically, the following equipment and instruments should be provided:

(1) An indicator showing which control position is in command, if more than one control stations exist.
(2) A two-way telegraph which may be combined with the remote-control actuating mechanism.
(3) An emergency shut-down control mechanism for the main propulsion machinery, independent of the bridge remote control system. See 2.1.7
(4) A propeller speed indicator.
(5) A direction of rotation indicator, for fixed pitch propellers.
(6) An indicator showing the value of pitch, for controllable pitch propellers.

(7) An indicator showing the position of clutch, if fitted, and Main engine speed (in the case of installation fitted with reversing gears).
(8) An indicator showing the position of shaft brake, if fitted.

2.5.6 If there are more than one remote control stations for the propulsion machinery, the following requirements should be observed:
(1) Remote control should be possible only from one station at a time. See 2.1.5.
(2) Transfer of control from one station to another, except for the Main control-station override, is to be effected only with acknowledgment by the receiving station.
(3) Two means of communication are to be provided between the bridge and the Main control station and the machinery space. One of them may be the bridge remote control system. The other must be independent of the main electrical supply.

2.5.7 Where machinery is arranged to start automatically or from a remote-control station, interlocks are to be provided to prevent start-up under conditions which could hazard the machinery.

2.5.8 Remote control systems of cargo, bilge, ballast fuel oil transfer and sea valves for engine services, may be installed if the requirements of 2.5.9 to 2.5.11 are observed.

2.5.9 Clear indication must be provided at the remote-control station showing the actual valve position.

2.5.10 Valves in tanks or after locations which may flooded should be capable of operating when submerged.

2.5.11 Manual means of operating the valves, should the power remote control system fail, must be provided.

2.5.12 Where transverse thrust units are remotely controlled means are to be provided at the remote-control station to stop the propulsion unit.

2.5.13 Transverse thrust units are to be provided with a pitch indicator or means of indicating direction of thrust at each station from which it is possible to control the propeller pitch.

2.5.14 An indication of the angular position of rotatable thrust units is to be provided at each station from which it is possible to control the direction of thrust.

2.6 Automatic fire detection systems

2.6.1 An automatic fire detection system guarding the machinery space, if fitted should satisfy the requirements of this subsection.

2.6.2 The system is to be made up of detectors, manual facilities for initiating the fire alarms, audible and visual alarms and a fire detection indicator panel. The latter should be located in the navigating bridge or at the fire-fighting station. The panel is to indicate the location of the fire in accordance with suitable arrangement of the detectors in fire zones, by means of visual alarms.

2.6.3 An audible alarm with a tone clearly different from that of any other alarm system is to be provided and energized by the fire detectors. The audible fire alarm must be audible on the bridge, the fire control station, the Main control station (if there is one), in all parts of the machinery space and the accommodation areas.

2.6.4 Fire detectors, fire detection panels and manual call facilities, should be type-tested and type-approved. See 1.4.2.

2.6.5 Detector heads whose operation is based on a variety of principles, must be used in order to protect against all potential types of fires. The sensitivity of fire detectors if adjustable, is to be effected by such means that the set point can be fixed and easily identified. Detector heads are to operate effectively under all environmental conditions.

2.6.6 If a detector is temporarily switched off, this must be clearly indicated on the detector itself and at the control panel. Reactivation of the detector must take place automatically after a preset time.

2.6.7 Manual facilities for initiating the fire alarm system, are to be provided at the following locations:
(1) Points near the entrances to engine and boiler rooms
(2) Navigating bridge
(3) Engine room control station
(4) Fire control station.

2.6.8 The principle of "fail safe" is to be implemented in the case of automatic fire detection systems by designing them to monitor themselves, i.e., with closed contacts.

2.6.9 The automatic fire detection system should be provided with two independent and exclusive electrical power supply circuits: one fed from the main electricity source and one from an emergency electricity source.

2.6.10 Facilities are to be provided on the fire detection panel for periodical functional testing and resetting of the various circuits of the system. Testing and retesting is to be possible without renewal of any components.

2.7 Bilge level alarms (IACS UR M27)

2.7.1 All vessels intended to operate with unattended machinery space, are to be fitted with an alarm system comprising suitable detectors which give warning when liquid in bilges has reached to a predetermined level. There are to be at least two liquid-level sensors in the machinery space but the number and location of the sensors must be such that rising of liquids will be detected at all angles of heel and trim.

2.8 Recording equipment

2.8.1 Recording equipment must possess a temporary memory of at least 24h in a hard disc. The contents of this memory will be used to plot data relevant to:

(1) Regular recordings of operational data at predetermined time intervals.
(2) Alarm points and action by the safety system related to faults.

2.8.2 Each alarm point or data must be plotted with simultaneous indication of the time and date. The beginning and end of fault must be clearly indicated.

2.8.3 In the case of combined fault alarm point/data recording and maneuver recording devices, the operating speed and storage capacity must be sufficient to ensure that any fault must be sufficient to ensure that any fault is electronically recorded within 5 s and subsequently printed within 30 s.

2.8.4 The recordings for operational data must be clearly distinguishable from the recordings of faults and associated alarm points.

SECTION 3 Control and supervision of main machinery

3.1 Alarms, remote indications and safeguards for main reciprocating I.C. engines installed in unattended machinery spaces (IACS UR M35 Rev.8)[1]

3.1.1 General

Alarms, remote indications and safeguards listed in Table 1.3.1 and Table 1.3.2 are respectively referred to cross-head and trunk-piston reciprocating internal combustion engines.

3.1.2 Alarms

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.

The detailed requirements covering communications of alarms from machinery spaces to the bridge area and accommodation for engineering personnel, are contained in 6.1.

3.1.3 Remote indications

Remote indications are required only for ships which are operated with machinery space unattended but under a continuous supervision from a position where control and monitoring devices are centralized, without the traditional watch service being done by personnel in machinery space.

3.1.4 Safeguards

(1) Automatic start of standby pumps - slow down

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

(2) Automatic reduction of power

If overriding devices of the required automatic reduction of power are provided, they are to be so arranged as to preclude their inadvertent operation, and a suitable alarm is to be activated by their operation.

(3) Automatic stop - shut down

If overriding devices of the required automatic stops are provided, they are to be so arranged as to preclude their inadvertent operation, and a suitable alarm is to be operated by their activation. When the engine is stopped automatically, restarting after restoration of normal operating conditions is to be possible only after manual reset, e.g. by-passing the control lever through the 'stop' position.

Automatic restarting is not permissible (see 6.2.2(8)).

[1] NOTE:

1. The requirements of M35 Rev.8 are to be uniformly implemented by the Society for engines:
   i. when an application for certification of an engine is dated on or after 1 January 2020; or
   ii. which are installed in new ships for which the date of contract for construction is on or after 1 January 2020.

2. The "contracted for construction" date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder.

Table 1.3.1: Cross-head diesel engines

	Gr 1			Gr 2	Gr 3
Monitored parameters for crosshead diesel engines	**Remote Indication**	**Alarm activation**	**Slow down with alarm**	**Automatic start of standby pump with alarm**	**Shut down with alarm**
1. Fuel oil system					
Fuel oil pressure after filter (engine inlet)	x	low		x	
Fuel oil viscosity before injection pumps or Fuel oil temp before injection pumps		high low			
Leakage from high pressure pipes		x			
Level of fuel oil in daily service tank (1)		low			
2. Lubricating oil system					
Lub. oil to main bearing and thrust bearing, pressure	x	low	x	x	x
Lub. oil to crosshead bearing pressure (2)	x	low	x	x	x
Lub. oil to camshaft pressure (2)		low		x	x
Lub. oil to camshaft temp (2)		high			
Lub oil inlet temp		high			
Thrust bearing pads temp or bearing outlet temp		high	x	x	x
Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: - the engine main, crank and crosshead bearing oil outlet; or - the engine main, crank and crosshead bearing) (3)		x	x		
Flow rate cylinder lubricator. Each apparatus		low	x		
Level in lubricating oil tanks (4)		low			
Common rail servo oil pressure		low			
3. Turbocharger system					
Turbocharger lub oil inlet pressure (9)		low			
Turbocharger lub oil outlet temp each bearing (10)		high			
Speed of turbocharger (11)	x	high			
4. Piston cooling system					
Piston coolant inlet pressure (5)		low	x	x	
Piston coolant outlet temp each cylinder		high	x		
Piston coolant outlet flow each cylinder (8)		low	x		
Level of piston coolant in expansion tank		low			
5. Sea water cooling system					
Sea water pressure		low		x	
6. Cylinder fresh cooling water system					
Cylinder water inlet pressure		low	x	x	
Cylinder water outlet temp (from each cylinder) or Cylinder water outlet temp (general) (6)		high	x		
Oily contamination of engine cooling water system (7)		x			
Level of cylinder cooling water in expansion tank		low			
7. Starting and control air systems					
Starting air pressure before main shut-off valve	x	low			
Control air pressure		low			
Safety air pressure		low			
8. Scavenge air system					
Scavenge air receiver pressure	x				
Scavenge air box temp (fire)		high	x		
Scavenge air receiver water level		high			

Monitored parameters for crosshead diesel engines	Gr 1			Gr 2	Gr 3
	Remote Indication	**Alarm activation**	**Slow down with alarm**	**Automatic start of standby pump with alarm**	**Shut down with alarm**
9. Exhaust gas system					
Exhaust gas temp after each cylinder	x	high	x		
Exhaust gas temp after each cylinder. Deviation from average.		high			
Exhaust gas temp before each T/C	x	high			
Exhaust gas temp after each T/C	x	high			
10. Fuel valve coolant					
Pressure of fuel valve coolant		low		x	
Temperature of fuel valve coolant		high			
Level of fuel valve coolant in expansion tank		low			
11. Engine speed/direction of rotation.	x				
Wrong way		x			
12. Engine overspeed					x
13. Control-Safety-Alarm system power supply failure		x			

Gr 1 Common sensor for indication, alarm, slow down
Gr 2 Sensor for automatic start of standby pump with alarm
Gr 3 Sensor for shut down

NOTES

1. High-level alarm is also required if no suitable overflow arrangement is provided.
2. If separate lub. oil systems are installed.
3. When required by UR M10.8 (LHR Rules Part 5, Chapter 2, SECTION 5, 5.5.8) or by SOLAS Reg. II-1/47.2 .
4. Where separate lubricating oil systems are installed (e.g. camshaft, rocker arms, etc.), individual level alarms are required for the tanks.
5. The slowdown is not required if the coolant is oil taken from the main cooling system of the engine.
6. Where one common cooling space without individual stop valves is employed for all cylinder jackets.
7. Where main engine cooling water is used in fuel and lubricating oil heat exchangers.
8. Where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted.
9. Unless provided with a self-contained lubricating oil system integrated with the turbocharger.
10. Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
11. Only required for turbochargers of Categories B and C. (see M73.5)

Table 1.3.2: Trunk-piston diesel engines

	Gr 1			Gr 2	Gr 3
Monitored parameters for trunk-piston diesel engines	**Remote Indication**	**Alarm activation**	**Slow down with alarm**	**Automatic start of standby pump with alarm**	**Shut down with alarm**
1. Fuel oil system					
Fuel oil pressure after filter (engine inlet)	x	low		x	
Fuel oil viscosity before injection pumps or Fuel oil temp before injection pumps (1)		high low			
Leakage from high pressure pipes		x			
Level of fuel oil in daily service tank (2)		low			
Common rail fuel oil pressure		low			
2. Lubricating oil system					
Lub. oil to main bearing and thrust bearing, pressure	x	low		x	x
Lub oil filer differential pressure	x	high			
Lub oil inlet temp	x	high			
Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: - the engine main, crank and crosshead bearing oil outlet; or - the engine main, crank and crosshead bearing) (3)		x			x
Flow rate cylinder lubricator. Each apparatus		low	x		
Common rail servo oil pressure		low			
3. Turbocharger system					
Turbocharger lub oil inlet pressure (5)	x	low			
Turbocharger lub oil outlet temp each bearing (8)		high			
Speed of turbocharger (9)	x	high			
4. Sea water cooling system					
Sea water pressure	x	low		x	
5. Cylinder fresh cooling water system					
Cylinder water inlet pressure or flow	x	low	x	x	
Cylinder water outlet temp (general) (6)	x	high	x		
Level of cylinder cooling water in expansion tank		low			
6. Starting and control air systems					
Starting air pressure before main shut-off valve	x	low			
Control air pressure	x	low			
7. Scavenge air system					
Scavenge air receiver temp		high			
8. Exhaust gas system					
Exhaust gas temp after each cylinder (7)	x	high	x		
Exhaust gas temp after each cylinder. Deviation from average. (7)		high			
9. Engine speed	x				
10. Engine overspeed					x
11. Control-Safety-Alarm system power supply failure		x			

Gr 1 Common sensor for indication, alarm, slow down
Gr 2 Sensor for automatic start of standby pump with alarm
Gr 3 Sensor for shut down

NOTES
1. For heavy fuel oil burning engines only.

	Gr 1			Gr 2	Gr 3
Monitored parameters for trunk-piston diesel engines	**Remote Indication**	**Alarm activation**	**Slow down with alarm**	**Automatic start of standby pump with alarm**	**Shut down with alarm**

2. High-level alarm is also required if no suitable overflow arrangement is provided.
3. When required by UR M10.8 (LHR Part 5, Chapter 2, SECTION 5, 5.5.8) 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. If necessary for the safe operation of the engine.
5. Unless provided with a self-contained lubricating oil system integrated with the turbocharger.
6. Two separate sensors are required for alarm and slow down.
7. For engine power > 500 kW/cyl.
8. Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
9. Only required for turbochargers of Categories B and C. (see M73.5)

3.2 Other means of propulsion

3.2.1 In case of means of propulsion other than Diesel Engines, the alarm, safety systems and automatic systems listed in Table 1.3.3 to Table 1.3.6 are required for unattended operation of main machinery and propulsion equipment.

3.2.2 The requirements for standby equipment to be installed are described in SECTION 5.

3.2.3 For all parameters marked with an "I" in Table 1.3.3 to Table 1.3.6 indication is required at the central control station and for this purpose effective instrumentation is to be provided.

Table 1.3.3: Steam Turbines for propulsion

Parameter	Alarm	Notes	Automat. Shutdown or Power reduction	Automat. Control	Display Required at CCS
Lubricating oil inlet pressure	L	Turbines and Reduction Gear			I
	LL		S		
Lubricating oil temperature at outlet from each bearing	H	Turbines and Reduction Gear		X	I
Lubricating oil inlet temperature	H				
Lubricating oil sump level	L				
Lubricating oil filters differential pressure	H				
Condenser condensate level	H		S or R	X	
Gland steam pressure	H			X	I
	L				
Astern turbine temperature	H				
Sea water pressure (or flow)	L				
Main condenser vacuum	L		S or R		I
Turbine vibration	H		S		
Axial movement of turbine rotor	H		S		
Overspeed	X		S		
Thrust bearing temperature	H				

Table 1.3.4: Gas Turbines for propulsion

Parameter	Alarm	Notes	Automat. Shutdown or Power Reduction	Automat. Control	Display required at CCS
Overspeed	X		S		
Lubricating oil inlet pressure	L		S		I
Lubricating oil inlet temperature	H			X	
Exhaust gas temperature	H		S	X	I
Fuel oil inlet temperature (or viscosity)	L			X	I
	H				
Flame and ignition	Failure		S		
Turbine vibration	H		S		

Table 1.3.5: Boilers (Main, auxiliary and others)

Parameter	Alarm	Notes	Automat. Shutdown or Power Reduction	Automat. Control	Indication Required at CCS
Water level	L	Two independently operating sensors for water level detection (2), (3)	S	X	I
Steam drum or superheater outlet pressure*	H				
	H			X	I
Superheated steam temperature*	L				
Desuperheated steam temperature	H			X	I
Feed water forced circulation flow*	H			X	
Fuel oil pressure	L		S		
Fuel oil temperature (or viscosity)	L	Heavy fuel oil only			I
	L			X	I
Fuel oil atomizing steam pressure*	H				
Combustion air pressure	L				
Burner flame and ignition	L		S		I
Salinity of condensate after condenser*	Failure	One monitor for each burner (4)	S		I
Uptake temperature	H				
	H	Where economizers ad/or exhaust gas air heaters are integral with the boiler			I
De-aerator water level				X	
Desuperheated steam pressure				X	
Combustion system				X	

NOTES:

1. Items marked * are not required for Boilers not supplying steam for propulsion.

2. Only one independent system of low water level detection, alarm and automatic oil fuel shut off need be fitted in the case of small forced circulation or re-circulation coiled water tube "package" type boilers.

3. Where two level sensors are provided these may be used for other functions, e.g. high level alarm, level control, trip systems, etc.

4. Combustion spaces are to be purged automatically before re-ignition takes place in the event of a flame out on all burners.

5. Burner controls are to be so arranged, that light off is only possible at the minimum firing rate compatible with flame establishment.

6. For dual evaporation boilers the primary circuit is to be fitted with two independent low water level detectors which will operate alarms and shut off the oil fuel to the burners automatically. The secondary circuit is to be fitted with one low water level detector which will operate alarms and shut off the oil fuel to the burners automatically. Additionally one high water level alarm is to be fitted on the secondary circuit which may be operated by the same detector as that provided for low water level detection.

Table 1.3.6: Controllable pitch propellers and transverse thrusters

Parameter	Alarm	Notes	Automat. Shutdown or Power Reduction	Automat. Control
Hydraulic system pressure	L			
	LL	Automatic start of standby pump, see Also Table 1.5.1		
Hydraulic oil supply tank level	L			
Hydraulic oil temperature	H	Where an oil cooler is fitted		
Power supply to the control between the remote control station and the hydraulic actuator	Failure			
Propulsion electric motor	overload			

SECTION 4 Control and supervision of auxiliary machinery

4.1 Alarms and safeguards for auxiliary reciprocating internal combustion engines driving generators in unattended machinery spaces (IACS UR M36 Rev.6)[2]

4.1.1 General

The Section 4.1, refers to trunk piston reciprocating internal combustion engines on fuel oil.

4.1.2 Alarms

All monitored parameters for which alarms are required to identify machinery faults and associated safeguards are listed in Table 1.4.1.

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 Section 6.1.

[2] NOTE:

1. The requirements of this Section are to be uniformly implemented by the Society for engines:
   (i) when an application for certification of an engine is dated on or after 1 January 2020; or
   (ii) which are installed in new ships for which the date of contract for construction is on or after 1 January 2020.
2. The "contracted for construction" date means the date on which the contract to build the vessel is signed between the prospective owner and shipbuilder.

Table 1.4.1: Auxiliary reciprocating internal combustion engines – Monitored Parameters

Monitored parameters	Alarm	Shut down
Fuel oil leakage from high pressure pipes	x	
Lubricating oil temperature	high	
Lubricating oil pressure	low	x
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)	x	x
Pressure or flow of cooling water	low	
Temperature of cooling water or cooling air	high	
Level in cooling water expansion tank, if not connected to main system	low	
Level in fuel oil daily service tank	low	
Starting air pressure	low	
Overspeed activated		x
Fuel oil viscosity before injection pumps or fuel oil temp before injection pumps (1)	low high	
Exhaust gas temperature after each cylinder (2)	high	
Common rail fuel oil pressure	low	
Common rail servo oil pressure	low	
Speed of turbocharger (4)	high	

NOTES

1. For heavy fuel oil burning engines only
2. For engine power above 500 kW/cyl.
3. When required by UR M10.8 (LHR Part 5, Chapter 2, SECTION 5, 5.5.8) or by SOLAS Reg. II-1/47.2 one oil mist detector for each engine (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 system. (For engines having a power of more than 2250 kW or a cylinder bore of more than 300 mm).
4. Only required for turbochargers of Categories B and C. (see M73.5)

4.2 Alarms and safeguards for auxiliary engines other than reciprocating internal combustion

4.2.1 The alarms, safety systems and automatic control systems listed in Table 1.4.2 to Table 1.4.7 of this section are required for unattended operation of the auxiliary machinery, when engines other than reciprocating internal combustion engines are used.

4.2.2 The requirements for standby equipment to be installed are described in SECTION 5.

4.2.3 For all parameters marked with an "I" in Table 1.4.2 to Table 1.4.7 indication is required at the central control station and for this purpose effective instrumentation is to be provided.

Table 1.4.2: Inert gas generators

Parameter	Alarm	Notes	Automat. Shutdown or Power Reduction	Automat. Control
Inert gas pressure	L			
Inert gas outlet temperature	H		S	
Combustion air pressure	L		S	
Fuel oil pressure	L			
Fuel oil temperature (or viscosity)	L	Heavy fuel oil only		
	H			
Burner flame and ignition	Failure		S	
Cooling water temperature	H			
Inert gas oxygen content	H			
Combustion system				X

Table 1.4.3: Incinerators

Parameter	Alarm	Notes	Automat. Shutdown or Power Reduction	Automat. Control
Fuel oil temperature (or viscosity)	L	Heavy fuel oil and sludge		
	H			
Fuel oil pressure	L			
Combustion air pressure	L		S	
Burner flame and ignition	Failure		S	
Furnace temperature	H		S	X
	L			
Exhaust gas temperature	H			

Table 1.4.4: Thermal fluid heater

Parameter	Alarm	Notes	Automat. Shutdown or Power Reduction	Automat. Control
Expansion tank level	L		S	
Thermal fluid flow	L		S	
Thermal fluid outlet temperature	H			X
	HH		S	
Combustion air pressure	L		S	
Fuel oil pressure	L			
Fuel oil temperature (or viscosity)	L	Heavy fuel oil only		X
	H			
Fuel oil atomizing steam or air pressure	L			
Combustion system	Failure	One monitor for each burner	S	
				X

Table 1.4.5: Cargo and ballast pumps in hazardous areas

Parameter	Alarm	Notes	Automat. Shutdown or Power Reduction	Automat. Control
Bearing temperature	H			
Pump casing temperature	H	Cargo pumps only		
Bulkhead driving shaft gland temperature	H			

Table 1.4.6: Electricity supply system

Parameter	Alarm	Notes	Automat. Shutdown or Power Reduction	Automat. Control
Bus-bar voltage	H L			X
Bus-bar frequency	L			X
Operation of load shedding	Warning			
Generator cooling air temperature	H	For closed air circuit water cooled machines		

Table 1.4.7: Miscellaneous machinery

Parameter	Alarm	Notes	Automat. Shutdown or Power Reduction	Indication Required at CCS
Stern tube lubricating oil tank level	L			
Stern tube bearing temperature	H	For oil lubricated stern gear.		
Coolant tanks level	L			
Daily service fuel oil tanks level	H L			
Daily service fuel oil tanks temperature	H	Where heating coils are fitted		
Fuel oil settling tanks temperature	H	Where heating coils are fitted		
Common fuel oil overflow tank level	H			
Sludge tanks level	H			
Feed water tanks level	L			
Purifier water seal	Failure			
Purifier oil inlet temperature	H			
Air compressor lubricating oil pressure	L		S	
Air compressor discharge air temperature	H			
Remote control hydraulic system pressure	L			I
Remote control pneumatic system pressure	L			I
Oil heater temperature	H			
Controlled environmental conditions	Abnormal			

SECTION 5 Grades of automation

5.1 General

5.1.1 When machinery is fitted with automatic or remote-control systems, the following requirements and notations apply:

Notation	Requirements						
	2.1	2.2	2.3	2.4	2.5	2.6	2.7
Integrated propulsion : IP	*	*	*	*	*	-	-
Controlled from a Central Station : CCS	*	*	-	-	*	*	*
Unattended Machinery : UMS	*	*	*	*	*	*	*

5.2 Machinery controlled from a Central control station

5.2.1 In the case of remotely controlled machinery from a Central control station, remote starting of standby machinery and automatic start following restoration of electrical power supply, after a blackout, is to be provided according to Table 1.5.1.

Table 1.5.1: Automatic changeover and remote starting of auxiliary machinery

Auxiliary machinery	Automatic changeover to standby	Remote starting	Automatic start following blackout restoration	Automatic start and stop
MAIN ENGINE (DIESEL)				
Lubricating oil pumps	X	X	X	
Cylinder cooling water pumps	X	X		
Piston cooling medium pumps	X	X		
Secondary fresh water-cooling pumps	x	X		
Seawater pumps	x	X		
Fuel injector coolant pumps	X	X		
Fuel oil booster pumps	X	X		
MAIN STEAM TURBINE				
Lubricating oil pumps	X	X	X	
Condensate pumps	X	X		
MAIN BOILERS				
Feed water pumps	X	X		
Circulating pumps	X	X		
Fuel oil service pumps	X	X		
DIESEL GENERATORS				
Fuel oil booster pumps	X	X		
Cylinder cooling water pumps	X	X		
TURBO GENERATOR				
Lubricating oil pumps	X	X	X	
MAIN SOURCE OF ELECTRICAL POWER	X	X		
MISCELLANEOUS				
Reduction Gear lub. oil pumps	X	X	X	
Hydraulic pumps for steering gear	X	X	X	
Hydraulic pumps for controllable pitch propellers	X	X	X	
Starting air compressors				X
Control air compressors				X

5.3 Bridge control of propulsion machinery for unattended machinery spaces (IACS UR M43 & M47)

5.3.1 Under all sailing conditions, including maneuvering, the speed, direction of thrust and, if applicable, pitch of the propeller shall be fully controllable from the navigating bridge.

5.3.2 In principle the remote control mentioned under 5.3.1 is to be performed by a single control device for each independent propeller, with automatic performance of all associated services including, where necessary, means of preventing overload and prolonged running in critical speed ranges of the propelling machinery.

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

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

5.3.5 The main propulsion machinery shall be provided with an emergency stopping device on the navigating bridge and independent from the bridge control system.

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

5.3.7 For steam turbines a slow-turning device should be provided which operates automatically if the turbine is stopped longer than admissible. Discontinuation of this automatic turning from the bridge must be possible. If the slow-turning device is arranged to be operated manually, automatic operation will not be required.

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

5.3.9 The number of automatic consecutive attempts which fail to produce a start shall be limited to maintain sufficient starting air pressure. An alarm shall be provided at an air pressure level, which still permits main engine starting operation.

5.3.10 It shall be possible for the propulsion machinery to be controlled from a local position even in the case of failure in any part of the automatic or remote-control systems.

5.3.11 Remote control of the propulsion machinery shall be possible only from one control location at one time; at such locations interconnected control positions are permitted.

5.3.12 The control system shall include means to prevent the propelling thrust from altering significantly when transferring control from one control to another.

5.3.13 Each control location is to be provided with means to indicate which of them is in control. Propulsion machinery orders from the navigating bridge shall be indicated in the engine control room or at the maneuvering platform, as appropriate.

5.3.14 The transfer of control between the navigating bridge and machinery spaces shall be possible only in the main machinery space or the main machinery control room.

SECTION 6 Requirements for vessels with periodically unattended machinery spaces

6.1 Alarm systems for vessels with periodically unattended machinery spaces (IACS UR M29 Rev.3)

6.1.1 Definition

The alarm system is intended to give warning of a condition in which deviation occurs outside the preset limits on selected variables. The arrangement of the alarm display should assist in identifying the particular fault condition and its location within the machinery space. Alarm systems, including those incorporating programmable electronic systems, are to satisfy the environmental requirements of Section 7.2.

6.1.2 General requirements

Where an alarm system is required by the Rules, the system is to comply with the conditions given in (1) to (10):

(1) The system is to be designed to function independently of control and safety systems so that a failure or malfunction in these systems will not prevent the alarm system from operating. Common sensors for alarms and automatic slowdown functions are acceptable as specified in Table 1.3.1 and Table 1.3.2 as Gr 1.

(2) Machinery faults are to be indicated at the control locations for machinery.

(3) The system is to be so designed that the engineering personnel on duty are made aware that a machinery fault has occurred.

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

(i) a machinery fault has occurred,
(ii) the machinery fault is being attended to,
(iii) the machinery fault has been rectified. Alternative means of communication between the bridge area, the accommodation for engineering personnel and the machinery spaces may be used for this function.

(5) Group alarms may be arranged on the bridge to indicate machinery faults. Alarms associated with faults requiring speed reduction or the automatic shutdown of propulsion machinery are to be separately identified.

(6) The alarm system should be designed with self-monitoring properties. In so far as practicable, any fault in the alarm system should cause it to fail to the alarm condition.

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

(8) Upon failure of normal power supply, the alarm system is to be powered by an independent standby power supply, e.g. a battery. Failure of either power supply to the alarm system is to be indicated as a separate alarm fault. Where an alarm system could be adversely affected by an interruption in power supply, change-over to the stand by power supply is to be achieved without a break.

(9)

(a) Alarms are to be both audible and visual. If arrangements are fitted to silence audible alarms they are not to extinguish visible alarms.

(b) The local silencing of bridge or accommodation alarms is not to stop the audible machinery space alarm.

(c) Machinery alarms should be distinguishable from other audible alarms, i.e. fire, CO_2 flooding.

(d) The alarm system is to be so arranged that acknowledgement of visual alarms is clearly noticeable.

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

6.2 Safety systems for vessels with periodically unattended machinery spaces (IACS UR M30 Rev.1)

6.2.1 Definition

The safety system is intended to operate automatically in case of faults endangering the plant so that:

(i) normal operating conditions are restored (by starting of standby units), or

(ii) the operation of the machinery is temporarily adjusted to the prevailing conditions (by reducing the output of machinery), or

(iii) machinery and boilers are protected from critical conditions by stopping the machinery and shutting off the fuel to the boilers respectively (shutdown).

6.2.2 General requirements

(1) Where a safety system is required by the Rules, the system is to comply with (2) to (8).

(2) Operation of the safety system shall cause an alarm.

(3) The safety system intended for the functions listed under 6.2.1(iii) is to be independent of all other control and alarm systems so that failure or malfunction in these systems will not prevent the safety system from operating. For the safety systems intended for functions listed under 6.2.1(i) and 6.2.1(ii), complete independence of other control and alarm systems is not required.

(4) In order to avoid undesirable interruption in the operation of machinery, the system is to intervene sequentially after the operation of alarm system by:

- Starting of standby units,
- load reduction or shutdown, such that the least drastic action is taken first.

(5) The system should be designed to 'fail safe'. The characteristics of 'fail safe' of a system is to be evaluated on the basis not only of the safety system itself and its associated machinery, but also on the inclusion of the whole machinery installation as well as the ship.

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

(7) When the system has been activated, means are to be provided to trace the cause of the safety action.

(8) When the system has stopped a unit, the unit is not to be restarted automatically before a manual reset has been carried out.

6.3 Continuity of electrical power supply for vessels with periodically unattended machinery spaces (IACS UR M31)

6.3.1 The continuity of electrical power on vessels with periodically unattended machinery spaces is to be assured in accordance with 6.3.2 and 6.3.3.

6.3.2 For vessels having the electrical power requirements normally supplied by one ship's service generator in case of loss of the generator in operation, there shall be adequate provisions for automatic starting and connecting to the main switchboard of a standby generator of sufficient capacity to permit propulsion and steering and to ensure the safety of the ship with automatic re-starting of the essential auxiliaries including, where necessary, sequential operations. This standby electric power is to be available automatically in not more than 45 seconds.

6.3.3 For vessels having the electrical power requirements normally supplied by two or more ship's service generating sets operating in parallel, arrangements are to be provided (by load shedding, for instance) to ensure that in case of loss of one of these generating sets, the remaining ones are kept in operation without overload to permit propulsion and steering and to ensure the safety of the ship.

6.4 Alarms and safeguards for emergency diesel engines (IACS UR M63)

6.4.1 Field of application

These requirements apply to diesel engines required to be immediately available in an emergency and capable of being controlled remotely or automatically operated.

6.4.2 Information to be submitted

Information demonstrating compliance with these requirements is to be submitted to the Society. The information is to include instructions to test the alarm and safety systems.

6.4.3 Alarms and safeguards

.1 Alarms and safeguards are to be fitted in accordance with Table 1.6.1.

.2 The safety and alarm systems are to be designed to "fail safe". The characteristics of the "fail safe" operation are to be evaluated on the basis not only of the system and its associated machinery, but also the complete installation, as well as the ship.

.3 Regardless of the engine output, if shutdowns additional to those specified in Table 1.6.1 are provided except for the overspeed shutdown, they are to be automatically overridden when the engine is in automatic or remote-control mode during navigation.

.4 The alarm system is to function in accordance with 6.1, with additional requirements that grouped alarms are to be arranged on the bridge.

.5 In addition to the fuel oil control from outside the space, a local means of engine shutdown is to be provided.

.6 Local indications of at least those parameters listed in Table 1.6.1 are to be provided within the same space as the diesel engines, and are to remain operational in the event of failure of the alarm and safety systems.

Table 1.6.1:

Parameter	≥ 220kW	< 220kW
Fuel oil leakage from pressure pipes	○	○
Lubricating oil temperature	◓	
Lubricating oil pressure	◒	◒
Oil mist concentration in crankcase (1)	◓	
Pressure or flow of cooling water	◒	
Temperature of cooling water (or cooling air)	◓	◓
Overspeed activated	○ + □	

Note:

1. For engines having a power of more than 2250 kW or a cylinder bore of more than 300mm.

◒ Alarm for low value

◓ Alarm for high value

○ Alarm activated

□ Shut down

SECTION 7 Programmable Electronic Systems

7.1 Special requirements for programmable electronic systems - Hardware

7.1.1 The rules of this Section apply where control, alarm and safety systems incorporate programmable electronic equipment.

7.1.2 Control, alarm and safety shut-down functions are to be arranged such that a single failure or malfunction of the electronic equipment will not affect more than one of these functions. This may be achieved by dedicated equipment for each of these functions within a single system, or by the provision of standby equipment, or by other suitable means.

7.1.3 Where standby equipment is provided, the changeover arrangements are to possess high reliability themselves.

7.1.4 The system is to be designed according to the "fail safe" principle.

7.1.5 The location of a hardware fault is to be indicated to a level compatible with the equipment's designed repair/replacement policy.

7.1.6 The system is to be arranged to operate automatically from an alternative power supply in the event of a failure of the normal power supply.

7.1.7 Failure of any power supply to the system is to initiate an audible and visual alarm.

7.1.8 Program and data held in the system are to be protected from corruption by loss of power.

7.1.9 Where any part of the program is stored in volatile memory a permanent copy of the program and the means to re-enter it are to be provided.

7.1.10 Access for alterations to program or data is to have effective security arrangements.

7.2 Type test specification (IACS UR E10 Rev.7)[3]

7.2.1 General

This Test Specification is applicable, but not confined, to electrical, electronic and programmable equipment intended for control, monitoring, alarm and protection systems for use in ships.

7.2.2 Testing

These tests are to demonstrate the ability of the equipment to function as intended under the testing conditions.

The extent of the testing (i.e. the selection and sequence of carrying out tests and number of pieces to be tested) is to be determined upon examination and evaluation of the equipment or component subject to testing giving due regard to its intended usage.

[3] NOTE:

1. The requirements of this Section are to be uniformly implemented by the Society for equipment for which the date of application for type approval certification is dated on or after 1 January 2020.
2. Equipment intended to be installed on ships contracted for construction on or after 1 January 2022 is to comply with the requirements of this Section.
3. The "contracted for construction" date means the date on which the contract to build the vessel is signed between the prospective owner and shipbuilder.
4. The "date of application for type approval" is the date of documents accepted by the Society as request for type approval certification of a new equipment type or of an equipment type that has undergone substantive modifications in respect of the one previously type approved, or for renewal of an expired type approval certificate

Equipment is to be tested in its normal position if otherwise not specified in the test specification.

Relevant tests may be as listed in the Table 1.7.1.

7.2.3 Navigational and Radio Equipment

Test conditions as specified in IEC 60945 (Marine navigational and radiocommunication equipment and systems - General requirements, Methods of testing and required test results) are to be applied for the above-mentioned equipment.

Note:

a) * These test requirements are harmonised with IEC 60092-504:2016 "Electrical Installations in Ships - Part 504: Special features - Control and Instrumentation" and IEC 60533:2015 "Electrical and electronic installations in ships – electromagnetic compatibility". Electrical and electronic equipment on board ships, required neither by classification rules nor by International Conventions, liable to cause electromagnetic disturbance shall be of type which fulfil the test requirements of test specification items 19 and 20.

b) As used in this section, and in contrast to a complete performance test, a functional test is a simplified test sufficient to verify that the equipment under test (EUT) has not suffered any deterioration caused by the individual environmental tests.

Table 1.7.1: Type-testing conditions for equipment covered by 7.2.1

<table>
<tr><th>No</th><th>TEST</th><th>PROCEDURE ACC. TO: (*)</th><th>TEST PARAMETERS</th><th>OTHER INFORMATION</th></tr>
<tr><td colspan="5">* indicates the testing procedure which is normally to be applied. However, equivalent testing procedure may be accepted by the individual Society provided that the Unified Requirements stated in the other columns are fulfilled. The latest edition of the normative reference applies.</td></tr>
<tr><td>1.</td><td>Visual inspection</td><td>-</td><td>-</td><td>- conformance to drawings, design data</td></tr>
<tr><td>2.</td><td>Performance test</td><td>Manufacturer performance test programme based upon specification and relevant Rule requirements.
When the EUT is required to comply with an international performance standard, e.g. protection relays, verification of requirements in the standard are to be part of the performance testing required in this initial test and subsequent performance tests after environmental testing where required in the UR.</td><td>- standard atmosphere conditions
- temperature: 25°C ± 10°C
- relative humidity: 60% ± 30%
- air pressure: 96 KPa ± 10KPa</td><td>- confirmation that operation is in accordance with the requirements specified for particular system or equipment;
- checking of self-monitoring features;
- checking of specified protection against an access to the memory;
- checking against effect of unerroneous use of control elements in the case of computer systems.</td></tr>
<tr><td>3.</td><td>External power supply failure</td><td>-</td><td>- 3 interruptions during 5 minutes;
- switching-off time 30 s each case</td><td rowspan="2">- The time of 5 minutes may be exceeded if the equipment under test needs a longer time for start-up, e.g. booting sequence
- For equipment which requires booting, one additional power supply interruption during booting to be performed Verification of:
- equipment behaviour upon loss and restoration of supply;
- possible corruption of programme or data held in programmable electronic systems, where applicable.</td></tr>
<tr><td>4.</td><td>Power supply variations
a) electric

b) pneumatic and hydraulic</td><td>-</td><td>AC SUPPLY
<table>
<tr><th>Combination</th><th>Voltage variation permanent %</th><th>Frequency variation permanent %</th></tr>
<tr><td>1</td><td>+6</td><td>+5</td></tr>
<tr><td>2</td><td>+6</td><td>-5</td></tr>
<tr><td>3</td><td>-10</td><td>-5</td></tr>
<tr><td>4</td><td>-10</td><td>+5</td></tr>
<tr><td></td><td>Voltage transient 1,5 s %</td><td>Frequency transient 5 s %</td></tr>
<tr><td>5</td><td>+20</td><td>+10</td></tr>
<tr><td>6</td><td>-20</td><td>-10</td></tr>
</table>
DC SUPPLY
<table>
<tr><td>Voltage tolerance continuous</td><td>± 10%</td></tr>
<tr><td>Voltage cyclic variation</td><td>5%</td></tr>
<tr><td>Voltage ripple</td><td>10%</td></tr>
</table>
Electric battery supply:
- +30% to –25% for equipment connected to charging battery or as determined by the charging/discharging characteristics, including ripple voltage from the charging device;
- +20% to –25% for equipment not connected to the battery during charging.</td></tr>
</table>

No	TEST	PROCEDURE ACC. TO: (*)	TEST PARAMETERS	OTHER INFORMATION
			Pressure: ±20% Duration: 15 minutes	
5.	Dry heat (see note 1)	IEC 60068-2-2:2007 Test Bb for non-heat dissipating equipment	Temperature: 55° ± 2°C Duration: 16 hours or Temperature: 70°C ± 2°C Duration: 16 hours	- equipment operating during conditioning and testing; - functional test (b) during the last hour at the test temperature. - for equipment specified for increased - temperature the dry heat test is to be conducted at the agreed test temperature and duration.
		IEC 60068-2-2:2007 Test Be for heat dissipating Equipment	Temperature: 55° ± 2°C Duration: 16 hours or Temperature: 70°C ± 2°C Duration: 16 hours	- equipment operating during conditioning and testing with cooling system on if provided; - functional test (b) during the last hour at the test temperature. - for equipment specified for increased temperature the dry heat test is to be conducted at the agreed test temperature and duration.
6.	Damp heat	IEC 60068-2-30:2005 test D_b	Temperature: 55°C Humidity: 95% Duration: 2 cycles 2 x (12 +12 hours)	- measurement of insulation resistance before test; - the test shall start with 25°C ± 3°C and at least 95% humidity; - equipment operating during the complete first cycle and switched off during second cycle except for functional test; - functional test during the first 2 hours of the first cycle at the test temperature and during the last 2 hours of the second cycle at the test temperature; Duration of the second cycle can be extended due to more convenient handling of the functional test. - recovery at standard atmosphere conditions; - insulation resistance measurements and performance test.
7.	Vibration	IEC 60068-2-6:2007 Test F_c	$2\ ^{+3}_{-0}$ Hz to 13.2 Hz – amplitude ±1mm 13.2 Hz to 100 Hz – acceleration ± 0.7 g. For severe vibration conditions such as, e.g. on diesel engines, air compressors, etc.: 2.0 Hz to 25 Hz – amplitude ±1.6 mm 25.0 Hz to 100 Hz – acceleration ± 4.0 g. Note: More severe conditions may exist for example on exhaust manifolds or fuel oil injection systems of diesel engines. For equipment specified for increased vibration levels the vibration test is to be conducted at the agreed vibration level, frequency range and duration. Values may be required to be in these cases 40 Hz to 2000 Hz -	- duration in case of no resonance condition 90 minutes at 30 Hz; - duration at each resonance frequency at which Q ≥ 2 is recorded - 90 minutes; - during the vibration test, functional tests are to be carried out; - tests to be carried out in three mutually perpendicular planes; - it is recommended as guidance that Q does not exceed 5. - where sweep test is to be carried out instead of the discrete frequency test and a number of resonant frequencies is detected close to each other, duration of the test is to be 120 min. Sweep over a restricted frequency range between 0.8 and 1.2 times the critical frequencies can be used where appropriate.

<table>
<tr><th>No</th><th>TEST</th><th>PROCEDURE ACC. TO: (*)</th><th>TEST PARAMETERS</th><th>OTHER INFORMATION</th></tr>
<tr><td></td><td></td><td></td><td>acceleration ± 10.0g at 600°C, duration 90 min.*</td><td>Note: Critical frequency is a frequency at which the equipment being tested may exhibit:
- malfunction and/or performance deterioration
- mechanical resonances and/or other response effects occur, e.g. chatter</td></tr>
<tr><td>8.</td><td>Inclination</td><td>IEC 60092-504:2016</td><td>Static 22.5°

Dynamic 22.5°</td><td>a) inclined to the vertical at an angle of at least 22.5°
b) inclined to at least 22.5° on the other side of the vertical and in the same plane as in (a),
c) inclined to the vertical at an angle of at least 22.5° in plane at right angles to that used in (a),
d) inclined to at least 22.5° on the other side of the vertical and in the same plane as in (c).
Note: The period of testing in each position should be sufficient to fully evaluate the behaviour of the equipment.

Using the directions defined in a) to d) above, the equipment is to be rolled to an angle of 22.5° each side of the vertical with a period of 10 seconds.
The test in each direction is to be carried out for not less than 15 minutes.
On ships for the carriage of liquified gases and chemicals, the emergency power supply is to remain operational with the ship flooded up to a
maximum final athwart ship inclination of 30°.
Note: These inclination tests are normally not required for equipment with no moving parts.</td></tr>
<tr><td>9.</td><td>Insulation resistance</td><td><table><tr><th rowspan="2">Rated supply voltage Un (V)</th><th rowspan="2">Test voltage (D.C. voltage) (V)</th><th colspan="2">Min. insulation resistance</th></tr><tr><th>before test M ohms</th><th>after test M ohms</th></tr><tr><td>Un ≤ 65</td><td>2 x Un
min. 24V</td><td>10</td><td>0,1</td></tr><tr><td>Un > 65</td><td></td><td>100</td><td>10</td></tr></table></td><td>- For high voltage equipment, reference is made to UR E11.
- insulation resistance test is to be carried out before and after: damp heat test, cold test, salt mist test and high voltage test;
- between all phases and earth; and where appropriate, between the phases.
Note: Certain components e.g. for EMC protection may be required to be disconnected for this test.</td></tr>
<tr><td>10.</td><td>High voltage</td><td><table><tr><th>Rated voltage Un (V)</th><th>Test voltage (A.C. voltage 50 or 60Hz) (V)</th></tr><tr><td>Up to 65</td><td>2 x Un + 500</td></tr><tr><td>66 to 250</td><td>1500</td></tr><tr><td>251 to 500</td><td>2000</td></tr><tr><td>501 to 690</td><td>2500</td></tr></table></td><td>- For high voltage equipment, reference is made to UR E11.
- separate circuits are to be tested against each other and all circuits connected with each other tested against earth;
- printed circuits with electronic components may be removed during the test;
- period of application of the test voltage: 1 minute</td></tr>
</table>

No	TEST	PROCEDURE ACC. TO: (*)	TEST PARAMETERS	OTHER INFORMATION
11.	Cold	IEC 60068-2-1:2007	Temperature: +5°C ± 3°C Duration: 2 hours or Temperature: –25°C ± 3°C Duration: 2 hours (see note 2)	- initial measurement of insulation resistance; - equipment not operating during conditioning and testing except for functional test; - functional test during the last hour at the test temperature; - insulation resistance measurement and the functional test after recovery
12.	Salt mist	IEC 60068-2-52:2017 Test Kb	Four spraying periods with a storage of 7 days after each.	- initial measurement of insulation resistance and initial functional test; - equipment not operating during conditioning; - functional test on the 7th day of each storage period; - insulation resistance measurement and performance test 4 to 6h after recovery. (see Note 3) - on completion of exposure, the equipment shall be examined to verify that deterioration or corrosion (if any) is superficial in nature.
13.	Electrostatic discharge	IEC 61000-4-2:2008	Contact discharge: 6kV Air discharge: 2kV, 4kV, 8kV Interval between single discharges: 1 sec. No. of pulses: 10 per polarity According to test level 3.	- to simulate electrostatic discharge as may occur when persons touch the appliance; - the test is to be confined to the points and surfaces that can normally be reached by the operator; - Performance Criterion B (See Note 4).
14.	Electromagnetic field	IEC 61000-4-3:2020	Frequency range: 80 MHz to 6 GHz Modulation**: 80% AM at 1000Hz Field strength: 10V/m Frequency sweep rate: ≤1.5 x 10-3 decades/s (or 1%/3 sec) According to test level 3.	- to simulate electromagnetic fields radiated by different transmitters; - the test is to be confined to the appliances exposed to direct radiation by transmitters at their place of installation. - Performance criterion A (See Note 5) **If for tests of equipment an input signal with a modulation frequency of 1000 Hz is necessary a modulation frequency of 400 Hz may be chosen. - If an equipment is intended to receive radio signals for the purpose of radio communication (e.g. wifi router, remote radio controller), then the immunity limits at its communication frequency do not apply, subject to the provisions in UR E22.5.2.
15.	Conducted low Frequency		AC: Frequency range: rated frequency to 200th harmonic; Test voltage (rms): 10% of supply to 15th harmonic reducing to 1% at 100th harmonic and maintain this level to the 200th harmonic, min 3 V r.m.s, max 2 W. DC: Frequency range: 50 Hz - 10 kHz; Test voltage (rms): 10% of supply	- to stimulate distortions in the power supply system generated for instance, by electronic consumers and coupled in as harmonics; - performance criterion A (see Note 5). - See figure - "Test set-up" - for keeping max. 2W, the voltage of the test signal may be lower

No	TEST	PROCEDURE ACC. TO: (*)	TEST PARAMETERS	OTHER INFORMATION
			max. 2 W	
16.	Conducted Radio Frequency	IEC 61000-4-6:2013	AC, DC, I/O ports and signal/control lines: Frequency range: 150 kHz - 80 MHz Amplitude: 3 V rms (See Note 6) Modulation ***: 80% AM at 1000 Hz Frequency sweep range: ≤ 1.5 x 10^{-3} decades/s (or 1%/3sec.) According to test level 2.	- Equipment design and the choice of materials is to stimulate electromagnetic fields coupled as high frequency into the test specimen via the connecting lines. - performance criterion A (see Note 5). *** If for tests of equipment an input signal with a modulation frequency of 1000 Hz is necessary a modulation frequency of 400 Hz may be chosen.
17.	Electrical Fast Transients / Burst	IEC 61000-4-4:2012	Single pulse rise time: 5 ns (between 10% and 90% value) Single pulse width: 50 ns (50% value) Amplitude (peak): 2kV line on power supply port/earth; 1kV on I/O data control and communication ports (coupling clamp) Pulse period: 300 ms; Burst duration: 15 ms; Duration/polarity: 5 min According to test level 3.	- arcs generated when actuating electrical contacts; - interface effect occurring on the power supply, as well as at the external wiring of the test specimen; - performance criterion B (see Note 4).
18.	Surge	IEC 61000-4-5:2017	Test applicable to AC and DC power ports Open-circuit voltage: Pulse rise time: 1.2 μs (front time) Pulse width: 50 μs (time to half value) Amplitude (peak): 1kV line/earth; 0.5kV line/line Short-circuit current: Pulse rise time: 8 μs (front time) Pulse width: 20 μs (time to half value) Repetition rate: ≥ 1 pulse/min No of pulses: 5 per polarity Application: continuous According to test level 2.	- interference generated for instance, by switching "ON" or "OFF" high power inductive consumers; - test procedure in accordance with figure 10 of the standard for equipment where power and signal lines are identical; - performance criterion B (see Note 4).
19.	Radiated Emission	CISPR 16-2-3:2018 IEC 60945:2002 for 156-165 MHz	Limits below 1000 MHz For equipment installed in the bridge and deck zone. Frequency range: / Quasi peak limits 0.15 – 0.3 MHz / 80 – 52 dBμV/m 0.3 – 30 MHz / 52 – 34 dBμV/m 30 – 1000 MHz / 54 dBμV/m except for: 156 -165 MHz / 24 dBμV/m For equipment installed in the general power distribution zone.	- procedure in accordance with the standard but distance 3 m between equipment and antenna - for the frequency band 156 MHz to 165 MHz the measurement shall be repeated with a receiver bandwidth of 9 kHz (as per IEC 60945:2002). - alternatively, the radiation limit at a distance of 3 m from the enclosure port over the frequency 156 MHz to 165 MHz shall be 30 dB micro-V/m Peak (as per IEC 60945:2002).

<table>
<tr><th>No</th><th>TEST</th><th>PROCEDURE ACC. TO: (*)</th><th>TEST PARAMETERS</th><th>OTHER INFORMATION</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><td>Frequency range:</td><td>Quasi peak limits</td></tr>
<tr><td>0.15 – 30 MHz</td><td>80 – 50 dBμV/m</td></tr>
<tr><td>30 – 100 MHz</td><td>60 – 54 dBμV/m</td></tr>
<tr><td>100 – 1000 MHz</td><td>54 dBμV/m</td></tr>
<tr><td>except for:</td><td></td></tr>
<tr><td>156 -165 MHz</td><td>24 dBμV/m</td></tr>
</table>
Limits above 1000 MHz
<table>
<tr><td>Frequency range:</td><td>Average limit</td></tr>
<tr><td>1000 - 6000 MHz</td><td>54 dBμV/m</td></tr>
</table>
</td><td>- procedure in accordance with the standard (distance 3 m between equipment and antenna)
- Equipment intended to transmit radio signals for the purpose of radio communication (e.g. wifi router, remote radio controller) may be exempted from limit, within its communication frequency range, subject to the provisions in UR E22.5.2.</td></tr>
<tr><td>20.</td><td>Conducted Emission</td><td>CISPR 16-2-1:2017</td><td>Test applicable to AC and DC power ports
For equipment installed in the bridge and deck zone.
<table>
<tr><td>Frequency range:</td><td>Limits</td></tr>
<tr><td>10 – 150 kHz</td><td>96 – 50 dBμV</td></tr>
<tr><td>150 – 350 kHz</td><td>60 – 50 dBμV</td></tr>
<tr><td>350 kHz – 30 MHz</td><td>50 dBμV</td></tr>
</table>
For equipment installed in the general power distribution zone.
<table>
<tr><td>Frequency range:</td><td>Limits</td></tr>
<tr><td>10 – 150 kHz</td><td>120 – 69 dBμV</td></tr>
<tr><td>150 – 500 kHz</td><td>79 dBμV</td></tr>
<tr><td>0.5 – 30 MHz</td><td>73 dBμV</td></tr>
</table>
</td><td></td></tr>
<tr><td>21.</td><td>Flame retardant</td><td>IEC 60092-101:2018 or

IEC 60695-11-5:2016</td><td>Flame application: 5 times 15 s each.
Interval between each application:
15s or 1 time 30s.

Test criteria based upon application.

The test is performed with the EUT or housing of the EUT applying needle-flame test method.</td><td>- the burnt out or damaged part of the specimen by not more than 60 mm long.
- no flame, no incandescence or
- in the event of a flame or incandescence being present, it shall extinguish itself within 30 s of the removal of the needle flame without full combustion of the test specimen.
- any dripping material shall extinguish itself in such a way as not to ignite a wrapping tissue. The drip height is 200 mm ± 5 mm.</td></tr>
<tr><td colspan="5">Notes:
1. Dry heat at 70 °C is to be carried out to automation, control and instrumentation equipment subject to high degree of heat, for example mounted in consoles, housings, etc. together with other heat dissipating power equipment.
2. For equipment installed in non-weather protected locations or cold locations test is to be carried out at –25°C.
3. Salt mist test is to be carried out for equipment installed in weather exposed areas.
4. Performance Criterion B: (For transient phenomena): The EUT shall continue to operate as intended after the tests. No degradation of performance or loss of function is allowed as defined in the technical specification published by the manufacturer. During the test, degradation or loss of function or performance which is self-recoverable is however allowed but no change of actual operating state or stored</td></tr>
</table>

No	TEST	PROCEDURE ACC. TO: (*)	TEST PARAMETERS	OTHER INFORMATION

data is allowed.

5. Performance Criterion A: (For continuous phenomena): The Equipment Under Test shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed as defined in relevant equipment standard and the technical specification published by the manufacturer.
6. For equipment installed on the bridge and deck zone, the test levels shall be increased to 10V rms for spot frequencies in accordance with IEC 60945 at 2, 3, 4, 6.2, 8.2, 12.6, 16.5, 18.8, 22, 25 MHz.

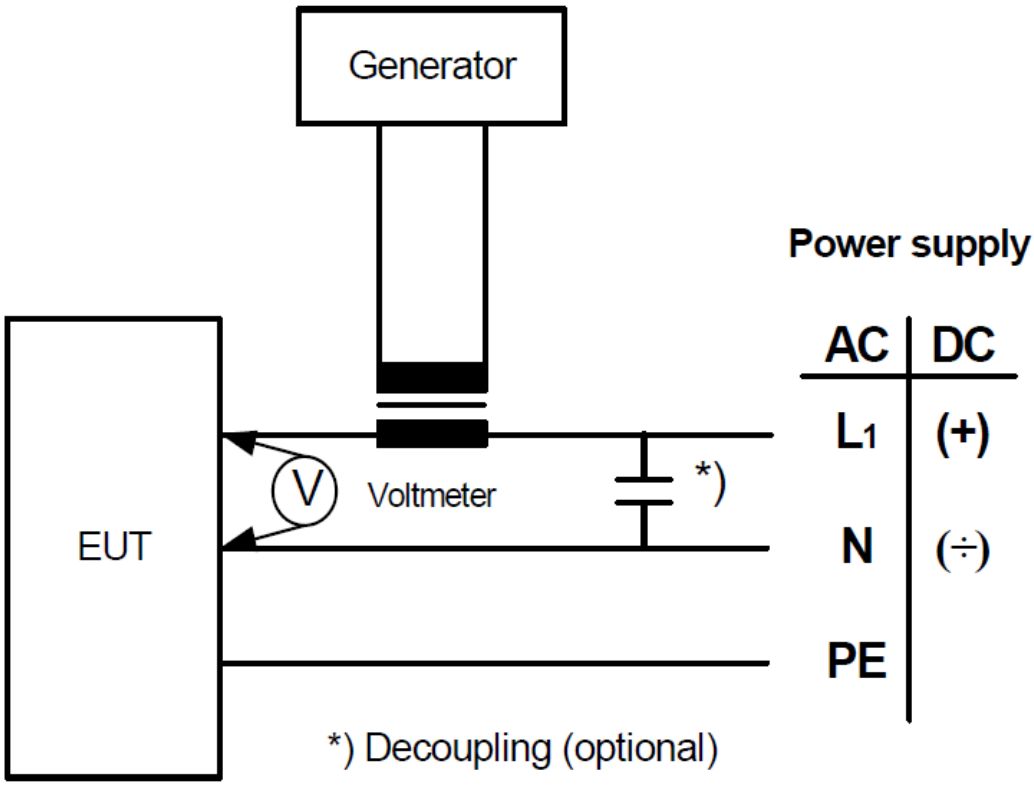

Figure - Test Set-up – Conducted Low Frequency Test

SECTION 8 Trials on board

8.1 General

8.1.1 Upon completion of the installation, complete performance tests of all systems are to be carried out during dock and sea trials to demonstrate that the system will perform successfully during standby, maneuvering and steady conditions as well as during transfer of controls.

8.2 Schedule of trials

8.2.1 The trials should be carried out according to programs scheduled by the builder and approved by the Society. For UMS notation the programs shall contain operation in the unattended mode for a period of not less than 6 hours.

8.3 Record of trials

8.3.1 A copy of the record of the trials signed by the Surveyor and the builder is to be submitted to the Society, and one is to be kept on board for reference purposes, future adjustments and testing.