RULES FOR CLASSIFICATION OF

Ships

PART 4 CHAPTER 1

NEWBUILDINGS
MACHINERY AND SYSTEMS – MAIN CLASS

Machinery Systems, General

JULY 2011

This chapter has been amended since the main revision (July 2011), most recently in August 2011.
See "Changes" on page 3.

DET NORSKE VERITAS AS

FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

The Rules lay down technical and procedural requirements related to obtaining and retaining a Class Certificate. It is used as a contractual document and includes both requirements and acceptance criteria.

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CHANGES

General

The present edition of the rules includes additions and amendments approved by the Executive Committee as of June 2011, and supersedes the January 2011 edition of the same chapter.

The rule changes come into force as described below.

Text affected by the main rule changes is highlighted in red colour in the electronic pdf version. However, where the changes involve a whole chapter, section or sub-section, only the title may be in red colour.

This chapter is valid until superseded by a revised chapter.

Amendments August 2011

- **Sec.2 Materials**

— Sub-section element A200 Use of asbestos, has been updated to be according to SOLAS Ch.II-1/3-5.2.

Main changes coming into force 1 July 2011

- **The chapter has been revised**

— The scope is to give general requirements for machinery that can be used to evaluate both conventional and novel designs.
— The July 2010 edition of Pt.4 Ch.1 have been re-instated and the January 2011 edition has been made tentative and moved to Appendix A of this chapter.
— Appendix A - Tentative rules for function based machinery, general, is intended for novel design of a component, a system or the complete arrangement of a vessel.
— Clarifications of application of the tentative rules in Appendix A have been made in Sec.1 of this chapter.
— All references made to Pt.4 Ch.1 elsewhere in the rules have been generalised and will refer to this chapters top level only.

CONTENTS

SECTION 1
GENERAL REQUIREMENTS

A. Classification

A 100 Application

101 This chapter contains overall requirements common for machinery, systems and components. Detailed requirements are given in the relevant rule chapters in Pt.4.

102 The rules in this chapter apply to machinery, systems and components for ships and barges for the assignment of main class.

103 Appendix A may be used for novel design of a component, a system or the complete arrangement of a vessel. In such cases, Appendix A will replace sections 1-5 in this chapter.

104 Upon request from the yard and with the agreement of the Society, Appendix A may be applied for conventional design.

105 Compliance with the rules is required for installations and equipment necessary for performing the main functions given in Pt.1 Ch.1 Sec.1 A200.

106 The rules give system requirements and prescribe minimum requirements for materials, design, manufacture, inspection and testing.

107 The requirements of this chapter are in compliance with relevant parts of SOLAS Ch. II-1.

108 For components to be installed onboard vessels with the additional class notation **Naval**, additional requirements given in Pt.5 Ch.14 shall be fulfilled.

B. Definitions

B 100 Terms

101 *Novel design* is defined as technology or solutions for which the application of prescriptive requirements in the rules of the Society is not suited.

102 *Failure* in the rule context is a sudden event or deterioration causing loss of function.

103 *Repairable failure* in the machinery is a failure which is possible to be repair on board and for which the following conditions are fulfilled:

— the machinery is arranged and designed to allow for repair work at sea
— spare parts or complete spare units necessary for permanent or provisional repairs are kept on board
— tools, instruction manuals and other necessary facilities to perform the repair work are found on board.

104 *Mean time to failure (MTTF)* is the mean value of service time until failure occurs. In the rule context, MTTF is considered to be equal to mean time between failures (MTBF).

105 *Mean time to repair (MTTR)* is the mean value of time from occurrence of failure to re-establishment of lost function.

106 *Reliability* is the ability of a component or a system to perform its required function without failure during a specified time interval.

107 *Availability* is the ratio of actual service time to expected service time at sea. Availability may be calculated from the following formula:

$$A = \frac{MTTF}{MTTF + MTTR}$$

108 *Redundancy* is the ability to maintain or restore a function when one failure has occurred. Redundancy can be achieved for instance by installation of more than one unit (component redundancy) or by having two or more separate systems capable of performing the same function (system redundancy).

109 *Redundancy types* are defined by the time lag accepted upon restoring a lost function, due to failure in a

component or system, designed with redundancy.

Redundancy type	*Time lag in re-establishment of function*
0	None (continuously available)
1	Up to 30 s
2	Up to 10 minutes
3	Up to 3 hours
not defined	More than 3 hours

110 *Active components* are components for mechanical transfer of energy, e.g. pumps, fans, electric motors, generators, combustion engines and turbines. Heat exchangers, boilers, transformers, switchgear or cables are not considered to be active components.

111 *Mutual independence* between components means that the function of the components and their power supply is not dependent on some common component or system.

112 *Piping* is defined to include the following components:

— pipes
— flanges with gaskets and bolts and other pipe connections
— expansion elements
— valves, including hydraulic and pneumatic actuators, and fittings
— hangers and supports
— flexible hoses
— pump housings.

113 *A piping system* is defined to include piping, as well as components in direct connection to the piping such as pumps, heat exchangers, evaporators, independent tanks etc. with the exception of main components such as steam and gas turbines, diesel engines, reduction gears and boilers.

For components which are subject to internal pressure and are not included in the piping, the design requirements in Ch.7 apply.

114 "Machinery spaces of category A" are those spaces and trunks to such spaces which contain:

1) internal combustion machinery used for main propulsion; or
2) internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW; or
3) any oil-fired boiler or oil fuel unit.

(SOLAS Ch. II-1/3.17)

115 "Machinery spaces" are all machinery spaces of category A and all other spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

(SOLAS Ch. II-1/3.16)

116 *Engine room* is the spaces containing propulsion machinery and machinery for generation of electrical power.

Guidance note:

Rooms within or adjacent to the engine room with visual contact with the machinery are considered to be part of the engine room.

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117 *Shut down*, implies that a unit is brought to a safe state. The safe state may be stop of a unit or decelerate rotating machinery to idle.

118 *Load reduction*, implies that a unit is brought to a safe state under the prevailing conditions, but the reduction is limited to a degree where the function the unit serves is not lost, only degraded.

119 *An independently driven* component is, when the function of the component and the power supply of the component is independent of the main engine.

C. Documentation

C 100 Documentation for approval

101 The control and monitoring system for the following shall be submitted for approval:

— remote control of essential machinery
— bridge control of propulsion machinery
— engineers' alarm.

For requirements to documentation types, see Ch.9.

D. Certification

D 100 Certification of control and monitoring system

101 The control and monitoring systems for:

— remote control of essential machinery
— bridge control of propulsion machinery
— local fire extinguishing system.

are to be certified according to Ch.9.

Amended August 2011, see page 3

SECTION 2
MATERIALS

A. General

A 100 Machinery parts

101 Requirements for documentation of quality and testing of materials intended for:

— propulsion and auxiliary machinery
— boilers and pressure vessels
— electrical installations
— instrumentation and automation
— fire protection, detection and extinction
— piping systems

are given in the respective chapters of Pt.4.

A 200 Use of asbestos

201 The use of asbestos is prohibited.
(SOLAS Ch. II-1/3-5.2)

SECTION 3
DESIGN PRINCIPLES

A. Arrangement

A 100 General

101 All machinery, systems and components that are to be operated or subject to inspection and maintenance on board are to be installed and arranged for easy access.

102 All components in a system are to be satisfactorily matched with regard to function, capacity and strength. Relative motions between parts of the machinery are to be allowed for without inducing detrimental stresses.

103 All machinery is to be equipped with control and instrumentation considered necessary for safe operation of the machinery.

104 All spaces, from which machinery is operated and where flammable or toxic gases or vapours may accumulate, or where a low oxygen atmosphere may occur, are to be provided with adequate ventilation under all conditions.

105 The capacity and arrangement of machinery spaces and emergency generator room ventilation is to cover demands for operating the machinery, boilers and emergency generator at full power in all weather conditions.

Ventilation inlets and outlets are to be located not less than 4.5 m above freeboard deck. Supply of air to the engine room is to be ensured even in the event of failure of one ventilation fan. As an alternative to the redundancy requirements in B300 alternative provision of air by adequate openings will be specially considered.

Guidance note:

Necessary capacity of ventilation may be calculated according to ISO Standard 8861.

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A 200 Prevention of inadvertent operations

201 The machinery shall be so arranged that inadvertent operation, caused by human error, cannot lead to the reduced safety of the ship and personnel.

202 The machinery and piping systems are to be arranged to prevent sea water, cargo or ballast from reaching dry spaces of the ship or cargo (oils or chemicals) from being discharged overboard as a consequence of inadvertent operations.

203 Systems and tanks are to be so arranged that leakage or operation of valves will not directly lead to increased risk of damage to machinery, ship or personnel due to mixing of different fluids.

204 Open or closed position of valves is to be easily visible.

205 If a valve's function in the system is not evident, there is to be adequate information on a name plate attached to the valve.

206 All connections to sea are to be marked:

SEA DIRECT.

A 300 Communication and engineers' alarm

301 Means of communication shall be provided.

(SOLAS Ch. II-1/37)

302 An engineers' alarm capable of being operated from the engine control room or at the manoeuvring platform, as appropriate, to alert personnel in the engineers' accommodation that assistance is needed in the engine room, shall be provided. (SOLAS Ch. II-1/38)

A 400 Fire protection

401 Where references have been given to SOLAS, this shall be taken as SOLAS 74 including amendments currently in force.

402 Fuel oil, lubrication oil, hydraulic oil and thermal oil are in this context regarded as "Flammable oils".

403 No tank containing flammable oil shall be situated where spillage or leakage therefrom can constitute a fire or explosion hazard, by coming into contact with heated surfaces (SOLAS Ch.II-2/Reg.4.2.2.3.3).

404 Flammable oil lines shall not be located immediately above or near units of high temperature, including boilers, steam pipelines, exhaust manifolds, silencers or other equipment required to be insulated by 406. As far as practicable, flammable oil lines shall be arranged far apart from hot surfaces, electrical installations or other sources of ignition and shall be screened or otherwise suitable protected to avoid oil spray or oil leakage onto the sources of ignition (SOLAS Ch.II-2/Reg.4.2.2.5.3).

405 For detailed arrangement of tanks and piping conveying flammable oils, see Ch.6.

406 Surfaces with temperatures above 220 C which may be impinged as a result of a flammable oil system failure shall be properly insulated (SOLAS Ch.II-2/Reg.4.2.2.6.1).

407 Precautions shall be taken to prevent any flammable oil that may escape under pressure from any pump, filter or heater from coming into contact with heated surfaces (SOLAS Ch.II-2/Reg.4.2.2.6.2).

408 The surface of insulation materials shall be impervious to oil or oil vapours (SOLAS Ch.II-2/Reg.4.4.3).

409 The floor plating of normal passageways in machinery spaces of category A shall be made of steel (SOLAS Ch.II-2/Reg.11.4.2).

410 Hydraulic power units shall be provided with adequate shielding in order to avoid potential oil leakage, or spray coming into contact with any sources of ignition.

411 When purifiers for heated fuel oil are not located in a separate room, consideration shall be given with regard to their location, ventilation conditions, containment of possible leakage and shielding from ignition sources.

For machinery spaces of category A above 500 m^3, the purifiers shall be protected by a fixed local application fire-extinguishing system.

Guidance note:

Reference is made to SOLAS Ch.II-2/Reg.10.5.6 and IMO MSC/Circ.913 for requirements regarding the fixed local application fire-extinguishing system.

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A 500 Requirements dependent upon damage stability calculations

501 For vessels where damage stability requirements apply, precautions are to be taken to prevent intercommunication through damaged pipe lines between flooded and intact compartments.

For this purpose, where any part of a pipe system is situated within the defined damaged area and the pipe line has an open end in a compartment assumed to be intact, an isolating valve situated outside the damaged area operable from the freeboard deck or from another position, accessible when the ship is in damaged condition is to be fitted. For bilge lines the remotely operated stop valves may be substituted by a non-return valve.

Guidance note:

Requirements for damage stability may be found in inter alia SOLAS, the International Convention on Load Lines, MARPOL, IMO Gas and Chemical Codes and for the additional class notations **SF** and **Well Stimulation**.

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A 600 Potentially hazardous, non-essential installations

601 Fixed refrigeration plants (including air condition plants) with a total prime mover rated effect of 100 kW and above shall comply with safety requirements in Pt.5 Ch.10.

This is also applicable for plants not covered by the class notations **Reefer, RM** or **RM CONTAINER** or **Tanker for Liquefied Gas**.

Refrigeration plants using Group 2 refrigerants (e.g. ammonia) shall comply with the safety requirements as given in Pt.5 Ch.10 irrespective of size.

602 Controlled atmosphere installations for dry cargoes not covered by the requirements of Pt.5 Ch.10 Sec.5 for the additional class notations **CA** or **CA (port.)** shall comply with all safety requirements of Pt.5 Ch.10 Sec.5.

603 Spaces containing refrigeration installations and not fitted with mechanical ventilations, shall be provided with an oxygen deficiency monitoring system. Alarm indication shall be located at the entrance to the space.

604 Ballast water treatment system installations shall comply with safety requirements in Pt.6 Ch.18.

B. Construction and Function

B 100 General

101 The machinery shall be so designed, installed and protected that risks of fire, explosions, accidental pollution, leakage and accidents thereof will be acceptably low.

102 Reliability and availability of the machinery are to be adapted according to considerations of the consequences from machinery failures and disturbances.

103 The design arrangement of machinery foundations, shaft connections, piping and ducting is to take into account the effects of thermal expansion, vibration, misalignment and hull interaction to ensure operation within safe limits.

Bolts and nuts exposed to dynamic forces and vibrations are to be properly secured.

B 200 Environmental conditions

201 All machinery, components and systems covered by the rules are to be designed to operate under the following environmental conditions if not otherwise specified in the detailed requirements for the machinery, component or system:

— ambient air temperature in the machinery space between 0°C and 55°C,
— relative humidity of air in the machinery space up to 96%,
— sea water temperature up to 32°C,
— list, rolling, trim and pitch according to Table B1.

The Society may consider deviations from the angles of inclination given in the table, taking into consideration the type, size and service conditions of the ship.

202 Where the rules have requirements for capacity or power of machinery, these are to be determined at the ambient reference conditions stated in Table B2.

Table B1 List, rolling, trim and pitch [1]

Installations, components	*Angle of inclination (degrees) [2]*			
	Athwartships		*Fore and aft*	
	Static	*Dynamic*	*Static*	*Dynamic*
Main and auxiliary machinery	±15	0 ±22.5	±5 [5]	0 ±7.5
Safety equipment, e.g. emergency power installations, emergency fire pumps and their devices, switch gear, electrical and electronic appliances [3] and remote control systems	±22.5 [4]	0 ±22.5 [4]	±10 [5]	0 ±10

1) The Society may consider deviations from these angles of inclination taking into consideration the type, size and service condition of the ship.

2) Athwartships and fore and aft inclinations may occur simultaneously.

3) Up to an angle of inclination of 45° no undesired switching operations or operational changes may occur.

4) In ships for the carriage of liquefied gases and of chemicals, the emergency power supply must also remain operable with the ship flooded to a final athwartships inclination up to a maximum of 30 degrees.

5) Where the length of the ship exceeds 100 m, the fore and aft static angle of inclination may be taken as 500/L degrees where L = length of ship, in m, as defined in Pt.3 Ch.1 Sec.1 B100.

Table B2 Ambient reference conditions for machinery

Parameter	*Value*
Total barometric pressure	1 bar
Ambient air temperature	45°C
Relative humidity of air	60%
Sea water temperature	32°C

203 The engine manufacturer is not to be expected to provide simulated ambient reference conditions at a test bed unless specified in the relevant rule chapters.

B 300 Functional capability and redundancy

301 Components and systems are to be arranged with redundancy so that a single failure of any active component or system (see 305) does not cause loss of any main function, specified in Pt.1 Ch.1 Sec.1 A200 for longer periods than specified in 313.

302 Redundancy can either be arranged as component redundancy or system redundancy as defined in Sec.1 B107.

Amended August 2011, see page 3

303 For redundancy on a component level a single failure of an active component shall not lead to a reduction of the output power for the main function served, as long as the main function is served by one system only.

304 For duplicated systems a single failure of an active component or a system shall not reduce the output power for the main function, served by the duplicate system, to less than 40% of the nominal output rated power. 301 and 302 shall be considered as general requirements. For evaluation of deviations or equivalent solutions reference should be made to the relevant rule chapters for the component or system in question.

Guidance note:

For single engine propulsion plants all active components must be duplicated to satisfy 301 and 307. Multi engine propulsion plants or propulsion plants with combinations of diesel engines, gas turbines and/or electrical motors are considered to provide redundancy on a system level. For these plants, duplication of the active components is not necessary provided that at least 40% of output rated power for the main function is remaining in case of a single failure. For propulsion plants where less than 40% of output rated power remains, after a single failure, duplication of the active components will be required. "Output rated power" is in this context the total rated propulsion power for the driven unit (e.g. one or several propellers).

All other main functions (see Pt.1 Ch.1 Sec.1 A200) are to be treated accordingly.

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305 The following active components are general exceptions to 301 and are not required as part of the designed redundancy, unless otherwise specified in the rules:

— main engine
— shafting, gear, driven unit (e.g. propeller)
— anchor windlass
— machinery for emergency power supply
— auxiliary thrusters.

306 Components and systems forming part of the designed redundancy are normally to be arranged as redundancy type 2 (see Sec.1 B108). When the interruption of the function, of a duplicated component or system, entails considerable hazard to other components or systems, or to the ship, redundancy type 1 is to be arranged. The installation can be arranged as redundancy type 3 if accepted in the relevant rule chapter.

307 Active components, arranged as part of the designed redundancy, are to be so dimensioned that in the event of a single failure sufficient capacity remains to cover demands at the maximum continuous load of the component served.

Guidance note:

Only relevant for plants where it is required to have redundancy on a component level (e.g. single engine plants, see 302).

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308 When two or more components are performing the same function, these are to be mutually independent and at least one is to be independently driven. Components arranged as part of the designed redundancy, yet only performing auxiliary functions to a main unit, can be directly powered by the main unit through separate power transmissions, on the condition that these components are not necessary for the starting of the main unit.

309 The machinery is to be so arranged and designed that all functions specified in Pt.1 Ch.1 Sec.1 A200 can be maintained simultaneously in normal service at sea.

310 Maintenance tasks normally expected to occur at short intervals, e.g. weekly, are to be carried out without loss of propulsion or steering.

311 Changeover from one normal operational mode to another normal operational mode of the machinery is to be possible without interruption in propulsion or steering.

312 Machinery or equipment having remote or automatic control, is in addition to have alternative provisions for attendance and operation.

313 The machinery is to be so arranged that it can be brought into operation from the «dead ship» condition within 30 minutes using only the facilities available on board.

«Dead ship» condition is understood to mean that the entire machinery installation, including the power supply, is out of operation and that auxiliary services such as compressed air, starting current from batteries etc., for bringing the main propulsion into operation and for the restoration of the main power supply are not available.

In order to restore operation from the «dead ship» condition, an emergency generator may be used provided that it is ensured that the emergency power supply from it is available at all times. It is assumed that means are available to start the emergency generator at all times.

314 The performance and capacity of auxiliary systems are to be adapted to the needs of the machinery installations served.

B 400 Failure effects

401 In the event of failure, components and systems are to enter the least hazardous of the possible failure states with regard to ship machinery, personnel and environment.

402 The probability that failure in a component causes damage or failure to other components, is to be acceptably low.

403 Failure of one component in a system arranged as part of the designed redundancy is not to lead to failure or damage to backup or parallel components or systems.

B 500 Component design

501 Components are to be designed with respect to the loads and ambient conditions which are expected to occur. Generally accepted safety margins are to be used.

502 Exceptional conditions are to be considered when justified by the risk of damage or the consequences of damage.

503 Where no specific requirements are given in the rules regarding dimensioning and choice of materials, generally recognised standards and engineering principles may be applied.

504 If acceptable accuracy cannot be obtained by strength calculations, special tests for the determination of the strength of the design may be required.

505 When it is of essential significance for the safety of the ship that the function of a component is maintained as long as possible in the event of fire, materials with high heat resistance are to be used.

506 Materials with low heat resistance are not to be used in components where fire may cause outflow of flammable or health hazardous fluids, flooding of any watertight compartment or destruction of watertight integrity.

Guidance note:

Materials with high heat resistance are materials having a melting point greater than 925°C. Materials with low heat resistance are all other materials. Deviations from the above requirement will be subject to special considerations.

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C. Reliability and Availability

C 100 Application

101 The requirements for reliability and availability apply to machinery for the main functions stated in Pt.1 Ch.1 Sec.1 A200 in general and to machinery for which these requirements are made applicable specifically in the rules.

C 200 Reliability and availability analysis

201 For novel and non-conventional machinery documentation in regard to reliability and availability is to be submitted upon request.

202 Generally recognised methods and formulae are to be used in the calculation of reliability, availability and related parameters.

203 The documentation is to include a failure mode and effect analysis (FMEA) of the component concerned.

204 When numerical calculations cannot be performed due to insufficient data, approval may be granted on the basis of qualitative failure analyses of the component or system.

205 Documentation of calculation methods and computer programs is to be submitted upon request.

D. Personnel Protection

D 100 General

101 Machinery, boilers and associated piping systems are to be so installed and protected as to reduce to a minimum any danger to persons onboard, due regard being paid to moving parts, hot surfaces and other hazards.

SECTION 4
CONTROL OF MACHINERY

A. Control and Monitoring

A 100 Control and monitoring

101 Main and auxiliary machinery essential for the propulsion, control and safety of the ship shall be provided with effective means for its operation and control. All control systems essential for the propulsion, control and safety of the ship shall be independent or designed such that failure of one system does not degrade the performance of another system.

(SOLAS Ch. II-1/31.1 and 31.5.1)

Guidance note:

Compliance with these rules and Ch.9 is regarded as compliance with the above mentioned requirements.

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102 It shall be possible for all machinery, essential for the safe operation of the ship, to be controlled from a local position, even in the case of failure in any part of the automatic or remote control systems.

(SOLAS Ch. II-1/49.4)

Guidance note:

Local position for electrical motors driving pumps, the local position is by the starter.

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103 At least two independent means shall be provided for communicating orders from the navigating bridge to the position in the machinery space or in the control room from which the speed and direction of thrust of the propellers are normally controlled: one of these shall be an engine-room telegraph which provides visual indication of the orders and responses both in the machinery spaces and on the navigating bridge. Appropriate means of communication shall be provided from the navigating bridge and the engine-room to any other position from which the speed or direction of thrust of the propellers may be controlled.

(SOLAS Ch. II-1/37)

A 200 Remote control of machinery, general requirements

201 The requirements in this chapter are additional to those given in Ch.9 and are applicable when remote control is installed.

202 The engine room or the engine control room, if provided, is normally the main command location but another permanently attended location may be accepted as a more suitable main command location.

It shall be possible at any time to take control of main functions locally at the machinery.

203 In general, automatic starting, operational and control systems shall include provisions for manually overriding the automatic controls. Failure of any part of such systems shall not prevent the use of the manual override.

(SOLAS Ch. II-1/31.4)

204 Indicators shall be fitted on the navigation bridge, the main machinery control room and at the manoeuvring platform, for:

— propeller speed and direction of rotation in the case of fixed pitch propellers; and
— propeller speed and pitch position in the case of controllable pitch propellers.

(SOLAS Ch. II-1/31.2.8 and 31.5.6)

205 Remote starting of the propulsion machinery shall be automatically inhibited if conditions exist which may hazard the machinery, e.g. turning gear engaged.

206 The design of the remote control system shall be such that in case of its failure an alarm will be given. Unless the Administration considers it impracticable the pre-set speed and direction of thrust of the propeller shall be maintained until local control is in operation.

(SOLAS Ch. II-1/31.2.7)

A 300 Bridge control of machinery

301 Overload shall be indicated on the bridge if automatic load limitation is not arranged for.

302 An alarm shall be initiated on the bridge and in the engine room at starting failure.

A 400 Bridge control of propulsion machinery

401 The speed, direction of thrust and, if applicable, the pitch of the propeller shall be fully controllable from the navigating bridge under all sailing conditions, including manoeuvring.

(SOLAS Ch. II-1/31.2.1)

402 The remote control shall be performed, for each independent propeller, by a control device so designed and constructed that its operation does not require particular attention to the operational details of the machinery. Where multiple propellers are designed to operate simultaneously, they may be controlled by one control device.

(SOLAS Ch. II-1/31.2.2)

Guidance note:

For ships less than 500 gross tonnage, two handle control may be accepted and some of the normally programmed operations may instead be carried out manually.

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403 The main propulsion machinery shall be provided with an emergency stopping device on the navigating bridge which shall be independent of the navigating bridge control system.

(SOLAS Ch. II-1/31.2.3)

Guidance note:

If means are provided to stop the propulsion without stopping the main engine(s) (e.g. clutch arrangement) then this will be accepted.

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404 Propulsion machinery orders from the navigation bridge shall be indicated in the main machinery control room and at the manoeuvring platform.

(SOLAS Ch. II-1/31.2.4)

405 Remote control of the propulsion machinery shall be possible only from one location at a time, at such locations interconnected control positions are permitted. At each location there shall be an indicator showing which location is in control of the propulsion machinery. 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. This system shall include means to prevent the propelling thrust from altering significantly when transferring control from one location to another.

(SOLAS Ch. II-1/31.2.5)

Guidance note:

The space where propulsion thrusters are located may in this context be regarded as the machinery space.

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406 It shall be possible to control the propulsion machinery locally, even in the case of failure in any part of the remote control system. It shall also be possible to control the auxiliary machinery, essential for the propulsion and safety of the ship, at or near the machinery concerned.

(SOLAS Ch. II-1/31.2.6)

407 An alarm shall be provided on the navigating bridge and in the machinery space to indicate low starting air pressure which shall be set at a level to permit further main engine starting operations. If the remote control system of the propulsion machinery is designed for automatic starting, the number of automatic consecutive attempts which fail to produce a start shall be limited in order to safeguard sufficient starting air pressure for starting locally.

(SOLAS Ch. II-1/31.2.9)

408 Automation systems shall be designed in a manner which ensures that threshold warning of impending or imminent slowdown or shutdown of the propulsion system is given to the officer in charge of the navigational watch in time to assess navigational circumstances in an emergency. In particular, the systems shall control, monitor, report, alert and take safety action to slow down or stop propulsion while providing the officer in charge of the navigational watch an opportunity to manually intervene, except for those cases where manual intervention will result in total failure of the engine and/or propulsion equipment within a short time, for example in the case of overspeed.

(SOLAS Ch. II-1/31.2.10)

Guidance note:

The above is regarded to be fulfilled when:

1) All parameters initiating slowdown and shutdown shall initiate an alarm at a set-point different from the

slowdown/shutdown set-point. These alarms shall be individually or in groups indicated on the navigating bridge whenever the propulsion machinery is controlled from this position.

Exempted from the requirement to give a pre-warning are the following parameters:

- overspeed on rotating machinery
- crankcase explosive condition using oil mist detection on diesel engines
- short-circuit in electrical propulsion plants.

2) An override facility to manually intervene on all slowdowns and shutdowns shall be available for all parameters except those which will result in total failure of the engine and/or propulsion equipment within a short time.

Note: examples of such parameters:

- lubricating oil pressure for rotating machinery
- overspeed for rotating machinery for fluid film bearings
- crankcase explosive condition on diesel engines
- short-circuit conditions in electrical installation
- high vibration for gas turbines.

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A 500 Supervision from a control room

501 Where the main propulsion and associated machinery, including sources of main electrical supply, are provided with various degrees of automatic or remote control and are under continuous manual supervision from a control room the arrangements and controls shall be so designed, equipped and installed that the machinery operation will be as safe and effective as if it were under direct supervision; for this purpose Regulations 46 to 50 shall apply as appropriate. Particular consideration shall be given to protect such spaces against fire and flooding.

(SOLAS Ch. II-1/31.3)

502 Ships intended to operate as described in 501 shall satisfy the requirements given in Pt.6 Ch.3 Sec.4.

A 600 Operation with periodically unattended machinery spaces

601 Ships intended to operate with periodically unattended machinery spaces shall be arranged and tested as required in Pt.6 Ch.3.

Guidance note:

Pt.6 Ch.3 is considered to meet the regulations of SOLAS Chapter II-1 Part E, Additional Requirements for Periodically Unattended Machinery Spaces.

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SECTION 5
SPARE PARTS

A. General

A 100 Machinery installations

101 Spare parts in general are not mandatory for retention of class. It is, however, assumed that an inventory of spare parts sufficient to meet the needs posed by the ship's plans of operation is maintained on board. Its content should be decided taking into consideration:

— the probability of need as a consequence of likely failures
— the likely failures and effect on the main functions
— the possibility of the ship's staff effecting the necessary repairs.

Further guidance for spare parts is given in the relevant rule chapters in Pt.4.

102 For general guidance purposes, machinery and electrical installations in vessels intended for common world wide trading are recommened to be provided with inventory of spare parts as listed in the Tables A1 to A6, including the necessary tools and instructions for replacement.

103 For important systems and components the recommendations of the manufacturer shall be taken into account.

104 Any applicable statutory requirement of the country of registration of the vessel is also to be considered.

105 The Society may require specific spare parts to be carried, if deemed necessary (mandatory requirement). The extent and amount will be decided on a case by case basis.

Guidance note:
The Society may require spare parts in cases where it is planned to do repairs on board instead of having redundancy on a component or system level. This will only be considered for "repairable failures" and normally only for redundancy type 3.

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A 200 Tables of recommended spare parts

201 Spare parts for internal combustion engines for propulsion, see Table A1.

202 Spare parts for internal combustion engines driving electric generators, see Table A2.

203 Spare parts for main steam turbines, and auxiliary steam turbines driving electric generators, see Table A3.

204 Vessels with boilers supplying steam necessary for performing the main functions covered by the main class as specified in Pt.1 Ch.1 Sec.1 A200 are recommended to be provided with spare parts in accordance with Table A4.

205 Spare parts for various machinery equipment, see Table A5.

206 Spare parts for electrical installations, see Table A6.

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Table A1 Recommended spare parts for internal combustion engines for propulsion of ships for unrestricted service [1)]

Item	*Specification*	*Number recommended*
Main bearings	Main bearings or shells for one bearing of each size and type fitted, complete with shims, bolts and nuts	1
Main thrust block	Pads for one face of tilting type thrust block, or	1 set
	Complete with metal thrust shoe of solid ring type, or	1
	Inner and outer race with rollers, where roller thrust bearings are fitted	1
Cylinder liner	Cylinder liner, complete with joint rings and gaskets	1
Cylinder cover	Cylinder cover, complete with valves, joint rings, gaskets and rocker arms with brackets. For engines without covers, the respective valves for one cylinder unit	1
	Cylinder cover bolts and nuts, for one cylinder	1/2 set
Cylinder valves-	Exhaust valves, complete with casings, seats, springs and other fittings for one cylinder	2 sets
	Air inlet valve, complete with casings, seats, springs and other fittings for one cylinder	1 set
	Starting air valve, complete with casing, seat, spring and other fittings	1
	Cylinder overpressure sentinel valve, complete	1
	Fuel valves of each size and type fitted, complete with all fittings, for one engine	1 set [2)]
Connecting rod bearings	Bottom end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder	1 set
	Top end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder	1 set
Pistons	**Crosshead type:** Piston of each type fitted, complete with piston rod, stuffing box, skirt, rings, studs and nuts	1
	Trunk piston type: Piston of each type fitted, complete with skirt, rings, studs, nuts, gudgeon pin and connecting rod	1
Piston rings	Piston rings, for one cylinder	1 set
Piston cooling	Telescopic cooling pipes and fittings or their equivalent, for one cylinder unit	1 set
Cylinder lubricators	Lubricator, complete, of the largest size, with its chain drive or gear wheels	1
Fuel injection pumps	Fuel pump complete or, when replacement at sea is practicable, a complete set of working parts for one pump (plunger, sleeve, valves, springs, etc.)	1
Fuel injection piping	High pressure fuel pipe of each size and shape fitted, complete with couplings	1
Scavenge blowers (including turbo-chargers)	Rotors, rotor shafts, bearings, nozzle rings and gear wheels or equivalent working parts if other types	1 set [3)]
Scavenging system	Suction and delivery valves for one pump of each type fitted	1 set
Reduction and/or reverse gear	Complete bearing bush, of each size fitted in the gear case assembly	1 set
	Roller or ball race, of each size fitted in the gear case assembly	1 set
Main engine driven air compressors	Piston rings of each size fitted	1 set
	Suction and delivery valves complete of each size fitted	1/2 set
Gaskets and packing	Special gaskets and packing of each size and type fitted for cylinder covers and cylinder liners for one cylinder	-

1) In case of multi-engine installations, the minimum recommended spares are only necessary for one engine.

2)

a) Engines with one or two fuel valves pr. cylinder: one set of fuel valves, complete

b) Engines with three or more fuel valves pr. cylinder: two fuel valves complete per cylinder and sufficient number of valve parts, excluding the body, to form with, those fitted in the complete valves, a full engine set.

3) The spare parts may be omitted where it has been demonstrated , at the builders test bench for one engine of the type concerned, that the engine can be manoeuvred satisfactorily with one blower out of action.
The requisite blanking and blocking arrangements for running with one blower out of action are to be available on board.

Guidance note:

The availability of other spare parts, such as gears and chains for camshaft drive, should be especially considered and decided upon by the owner.

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Table A2 Recommended spare parts for internal combustion engines driving electric generators of ships with unrestricted service [1)]		
Item	*Specification*	*Number recommended*
Main bearings	Main bearings or shells for one bearing of each size and type fitted, complete with shims, bolts and nuts	1
Cylinder valves	Exhaust valves, complete with casings, seats, springs and other fittings for one cylinder	2 sets
	Air inlet valves, complete with casings, seats, springs and other fittings for one cylinder	1 set
	Starting air valve, complete with casing, seat, springs and other fittings	1
	Cylinder overpressure sentinel valve, complete	1
	Fuel valves of each size and type fitted, complete, with all fittings, for one engine	1/2 set
Connecting rod bearings	Bottom end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder	1 set
	Top end bearings or shells of each type fitted, complete with shims, bolts and nuts, for one cylinder	1 set
	Trunk piston type: Gudgeon pin with bushing for one cylinder	1 set
Piston rings	Piston rings, for one cylinder	1 set
Piston cooling	Telescopic cooling pipes and fittings or their equivalent, for one cylinder unit	1 set
Fuel injection pumps	Fuel pump complete or, when replacement at sea is practicable, a complete set of working parts for one pump (plunger, sleeve, valve springs, etc.)	1
Fuel injection piping	High pressure fuel pipe of each size and type fitted, complete with couplings	1
Gaskets and packings	Special gaskets and packings of each and type fitted, for cylinder covers and cylinder liners for one cylinder	1 set

1) Where the number of generators of adequate capacity fitted for essential service exceed the required number, no spare are required for the auxiliary engines.

Table A3 Recommended spare parts for main steam turbines and auxiliary steam turbines driving electric generators of ships with unrestricted service [1) 2) 3)]		
Item	*Specification*	*Number recommended*
Main bearings	Bearing bushes or roller bearings of each size and type fitted, the rotor, pinion and gear wheel shafts, for one turbine	1
Turbine thrust	Pads of each size for one face of tilting type thrust, with liners, or rings for turbine adjusting block, of each size fitted with assorted liners, for one turbine	1 set
Main thrust block	**Tilting type:** Pads for one face [4)]	1 set
	Roller type: Inner and outer race with rollers	1
Turbine shaft sealing rings	Carbon sealing rings, where fitted, with springs, for each size and type of gland	1 set
Oil filters	Strainer baskets or inserts, for filters of special design, of each type and size	1 set

1) In case of multi-turbine installations, the minimum required spare parts are only necessary for on turbine of each type.

2) The list covers auxiliary turbines as far as applicable.

3) Where the number of generators of adequate capacity fitted for essential service exceed the required number, no spare are required for the auxiliary engines.

4) When the pads of one face differ from those of the other, a complete set of pads is to be provided.

Table A4 Recommended spare parts for boilers and steam-heated steam generators of ships with unrestricted service	
Specification	*Number recommended*
Safety valves: springs of each size	1
Water gauge glasses of round type with packings	3 sets
Water gauge glasses of flat type with packings	1 set
Strainers: strainer basket of each size for fuel oil system	1
Fuel oil burner: parts subjected to wear, for each burner	1 set
Pressure gauge for steam drum	1
Tube stoppers or plugs of each size for boilers, superheater and economiser	2%

Table A5 Recommended spare parts for various machinery equipment of ships with unrestricted service		
Item	*Specification*	*Number recommended*
Pumps [1] - fuel oil transfer - feed water - cooling water - bilge water - lubrication oil	**Piston pumps:** Valve with seats and springs each size fitted Piston rings each type and size for one piston	 1 set 1 set
	Centrifugal pumps: Bearings of each type and size Rotor sealings of each type and size	 1 1
	Gear type pumps: Bearings of each type and size Rotor sealings of each type and size	 1 1
Air compressors for essential service	Suction and delivery valves complete for each size fitted in one unit	1/2 set
	Piston rings for each type and size fitted for one piston	1 set
1) When a sufficiently rated standby pump is available, the spare parts may be dispensed with.		

Table A6 Recommended spare parts for electrical installations of ships with unrestricted service		
Item	*Specification*	*Number recommended*
Generators	The spare parts are generally to be supplied for each size and type of generator required according to Ch.8.	1 complete brush holder, 1 set of brushes, 1 set of any special tools required, 1 set of necessary spare parts for excitation and automatic voltage regulation equipment.
	For generators having excitation and voltage regulation equipment with semiconductors, the following is generally recommended.	1/3 of the number of main diodes for excitation, 1 complete set of all other semiconductor components, or alternatively 1 complete specimen of each assembled unit of such components, if the units are such that it is impracticable to carry out repairs on board.
Switchboards	For each repairable circuit-breaker on each pole:	1 set of contacts, subject to wear, 1 set of other parts, subject to wear, 1 set of springs, 1 coil of each type used, 1 resistance element of each type used. For 6 or less circuits-breakers of same type, 1 set of such spare parts.
	For each type of non-repairable circuit-breaker (e.g. »miniature« circuit-breakers):	5% of each size with a minimum of 2 of each size used.
	For each type of fuses:	10% of each size with a minimum of 12 of each size used, 3 fuse-bases of each size used.
Cables		1 set of any special tools and equipment for repairing mineral-insulated cables, where such cables are installed.
Motors	For each essential and important D.C. and A.C. motor with commutator or slipring:	1 complete brush holder, 1 set of brushes, 1 set of any special tools. For 6 or less motors of the same size and type, 1 set of such spare parts.
	In addition to the spares stated above for essential and important D.C. and A.C. motors are recommended for each size of steering gear motor and motor generator, if no standby electrical machine is installed:	*D.C. machinery:* 1 armature of each size fitted, complete with shaft and halt coupling, 1 field coil of each type fitted, *A.C. machinery:* 1 stator complete of each size fitted.
	For electric starting of main engines on ships having only one main propelling engine, with no other means of starting:	1 complete starting motor.

Table A6 Recommended spare parts for electrical installations of ships with unrestricted service (Continued)		
Item	*Specification*	*Number recommended*
Control gear	For each repairable control gear of motors and other consumers, intended for essential and important services:	1 set of the contacts which are subject to wear, 1 set of springs, 10% of each different resistance element, with at least 1 of each, 1 of each type coil used. When 6 or less motors or other consumers are fitted with control gear having interchangeable parts, it is normal to provide one set of spares for the control gear which is provided with the greatest number of parts.
	For each type of non-repairable control gear of motors and other consumers intended for essential and important services (e.g. some types of small motor starters):	5% of each size with a minimum of 2 of each size used.
Portable insulation-resistance measuring instrument		Ships with electrical installation of 100 kW and above are recommended to carry insulation-resistance measuring instrument, having a D.C. test voltage of not less than the installation's voltage.
Miscellaneous	For navigation lights with their pilot lamps:	1 complete set of lamps.
	Where the emergency lighting voltage is different from the main lighting voltage:	10% of the emergency lamps, with a minimum of 10.

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APPENDIX A
TENTATIVE FUNCTION BASED RULES FOR MACHINERY SYSTEMS, GENERAL

Amended August 2011, see page 3

SECTION 1
INTRODUCTION

A. Application

A 100 Application

101 Pt.4 sets requirements to systems and components supporting the below listed main functions to ensure aspects of availability and safety. The following are defined as main functions:

— Propulsion
— Steering
— Power generation
— Ballasting
— Drainage and bilge pumping

102 For other systems and components Pt.4 sets requirements in order to minimize the possibility for hazards to personnel, environment vessel and cargo.

103 Pt.4 Ch.1 sets functional requirements to the availability and capability of the main functions, and sets overall requirements common for systems and components.

104 Pt.4 requirements are applicable to systems and components permanently installed onboard. Temporary installations interfacing or supporting any main function are also to be in compliance.

105 Where references have been given to SOLAS, this shall be understood as SOLAS 74 including amendments currently in force.

A 200 Safety philosophy

201 The safety philosophy shall be based on fail to safe principles.

Upon incidents threatening the safety of the vessel or the availability of main functions, the vessel shall be brought into the least hazardous of the possible operating modes with respect to personnel, environment, vessel and cargo, in this order of priority.

202 A vessel in transit mode, shall upon incidents as referred to in 201 and whenever possible, continue on set track and with the same speed as before the incident occurred. The officer of the watch shall have the possibility to overrule this principle.

Guidance note:

Overruled by officer on watch also includes the acceptance of preset automatic safety initiatives.

For other operating modes and specified operating conditions, other fail-to-safe principles should be evaluated.

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A 300 General design criteria

301 *Environmental conditions*

The vessel shall, unless otherwise stated, be designed for North Atlantic weather and sea state conditions.

302 *Vessel performance*

The vessel shall be able to operate under the environmental conditions in 301 unless otherwise specified.

303 *Vessel life time*

The vessel shall normally be designed for a minimum operating life time of 20 years.

Planned maintenance and replacements may be utilised to achieve this.

B. Documentation

B 100 Information for assessment

101 Documentation shall be submitted to confirm that all the requirements of Pt.4 are adhered to. Specific documentation requirements are given in the continuation of this part.

102 If it is documented that the prescriptive requirements of Ch.1 and the following subchapters of Pt.4 are fulfilled, the function based requirements of Pt.4 Ch.1 are also considered fulfilled.

103 Any design that does not directly comply with the prescriptive requirements, shall be documented for

compliance with the function based requirements of Pt.4 Ch.1. The documentation shall also confirm that the safety is at least equivalent to what is achieved with a conventional design.

104 When yard proposes to use functional based requirements for the whole or parts of the design, they shall either

— Present the technical solutions as part of the building specification and hence the contract with owner.
— Have the technical solutions approved by owner before final acceptance by the society.

105 It may be required that verification as mentioned in 103 is based on an agreed scheme of analysis that is separately worked out and approved.

Guidance note:
For new technology, Recommended Practice DNV-RP-A203 can be a suitable basis for such scheme

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106 Further, when documentation is done according to 103 and 104, the Society withholds the right to request documents for information as defined in Table B1 as found necessary.

Table B1 Documentation requirements

Object	*Document type*	*Additional description*
Vessel	Z050 – Design philosophy	Description of the vessel's operating modes, system configuration and any conditions of importance for vessel safety related to the various modes The document shall identify the vessel's safe modes Description of the fail to safe principles laid down for the various operating modes / conditions identified in the operation manual
	Z160 – Operation manual	Description of the procedures for change from one operational mode to another and identification of preferred safe modes
	Z030 – System arrangement plan	Location of main systems / components supporting the vessel's main functions
	Z140 – Test procedure for quay and sea trial	Description of how main functions will be tested including acceptance criteria with focus on safe mode performance

Guidance note:
Such documentation will usually be required for:

— vessels with novel or unconventional design
— vessels with several defined modes of operation.

Typical modes to be covered:

— transit, manoeuvring, special operations, safe modes

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C. Definitions - Main Functions

C 100 Main Function - Propulsion

101 The function shall have the ability to:

— Move the vessel through the water in a controlled manner.
— Bring the moving vessel to stand still, by use of a pre-defined procedure.
— Keep the vessel with bow against the wind in weather conditions as applied for design.

102 The function is considered to be *available* when:

— It's capacity is sufficient to:
Move the vessel:

— At navigable speed.
— To the planned port, or to another safe stopping position.

Stop the vessel from any speed:

— According to the predefiend procedure.

103 Unless otherwise approved, navigable speed means a speed of 7 knots in calm waters, and ability to maintain position in Beauforts 8 with associated sea state conditions.

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Guidance note:
E.g.: ensure sufficient thrust in the longitudinal direction of the ship in order to keep the vessel with bow against the wind in weather conditions as applied for design. Beaufort 8 can be taken as 17 m/s or 33 knots of wind speed.

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C 200 Main Function - Steering

201 The function shall have the ability to:

Keep the vessel on course or change course in a controlled manner in weather conditions as applied for design.

202 The function is considered to be *available* when:

— Its capacity is sufficient to keep on or change course of the vessel to all desired headings at navigable speed.

C 300 Main Function - Power Generation

301 The function shall have the ability to:

— Supply electric power.

302 The function is considered to be available when:

— It's capacity is such that the vessel main functions and relevant statutory safety related functions are maintained in normal operating mode with redundancy arrangement as detailed in 4.8.

C 400 Main Function - Ballasting

401 The function shall have the ability to:

— Adjust and distribute ballast weight to ensure the vessel stability and keep structural loads within acceptable levels.

402 The function is considered to be available when:

— The ability in 401 is fulfilled.

C 500 Main Function - Drainage & Bilge Pumping

501 The function shall have the ability to:

— Discharge overboard water from leakages and the fire fighting systems.

502 The function is considered to be available when:

— The capacity is sufficient to keep the vessel afloat and stable in designed operating and foreseeable emergency conditions.
— The capacity is maintained throughout the duration of fire pumps running, 18 hours continuous operation as a minimum.

D. Definitions - Other

D 100 Terms - General

101 *Availability*

A function is considered available when it has the ability to perform the specified action.

102 *Active components* are components for mechanical transfer of energy, e.g. pumps, fans, electric motors, generators, combustion engines and turbines.

Guidance note:
Heat exchangers, boilers, transformers, switchgear or cables are not considered to be active components.

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103 *Function based requirements* are requirements referring to the main function, independent of the technological solution used.

104 *Hidden error* is a system or component malfunction not being detected until the system or component is activated in service.

105 *Mutual independence* between systems/components means that no single failure in one of them will affect the other ones, and the redundant systems/components will still be able to deliver a service.

106 *Prescriptive requirements* are direct requirements set to components or systems without reference to the main function served.

107 *Redundancy* is the ability to maintain or restore a function when a single failure has occurred. Redundancy can be achieved by the installation of more than one unit within a system or by having two or more separate systems performing the same function.

108 *Restoration time* is the time from a function loses its ability to perform, until it again is ready to perform.

Redundancy type	*Max restoration time*	*Comment*
R0	0 seconds	No interruption accepted
R1	45 seconds	Automatic restoration required
R2	15 minutes	Manual restoration accepted
R3	3 hours	Repair accepted
R4	More than 3 hours	Repair

109 *Single failure* is to be understood as a single event on system or component level, including it's immediate consequential effects, rendering the system or component unavailable. Common mode failure is in general not accepted except fire, flooding.

D 200 Spaces

201 *Engine room* is any space containing propulsion machinery or machinery for generation of electrical power.

Guidance note:
Rooms within or adjacent to the engine rooms with easy access between the spaces are considered to be part of the engine room.

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202 *Machinery spaces of category A* are those spaces and trunks to such spaces which contain:

— internal combustion machinery used for main propulsion; or
— internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW; or
— any oil-fired boiler or fuel oil unit.

(SOLAS Reg. II-1/3.17)

203 *Machinery spaces* are all machinery spaces of category A and all other spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery and similar spaces and trunks to such spaces.

(SOLAS Reg. II-1/3.16)

D 300 Operational modes

301 *Transit mode* is the mode in which the vessel is under voyage in open waters.

302 *Safe mode* is one defined mode (of a possible small number of defined modes) where the overall safety is prioritised. The safe mode may differ depending on the prior mode of operation.

303 *Special operations mode* is the mode in which the vessel carries out special operations for which the vessel is designed.

304 *Manoeuvring mode* is the mode in which the vessel is in narrow waters, entering port, etc. and where the manoeuvring capabilities of the vessel are critical for safe operation

D 400 Operational conditions

401 *Crash stop* is stopping the vessel from any speed or operational mode in the shortest possible stopping distance without damaging the equipment.

402 *Dead ship condition*

Dead ship condition is the condition under which the entire machinery installation is not in operation. All batteries and/or pressure vessels are considered depleted. Emergency generation is considered available.

403 *Load reduction*, upon failure, implies that a system/component is brought to a safe state under the prevailing condition, but the reduction is limited to a degree where the main function the unit serves is still available or to another agreed level.

404 *Shut down*, upon failure, implies that a system/component is brought to full stop. Rotating machinery

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brought to idle is considered shut down.

405 *Lost redundancy condition* is when a single failure has occurred and there is no redundancy left.

D 500 Control arrangement

501 *Automatic control* implies the control of a system/component by the use of a system independent of direct human interaction.

502 *Basic control* implies the minimum means for control, including indicators necessary to operate systems/ components in a safe and reliable way. Basic control shall be independent of the remote control system.

Guidance note:
Basic control may include a dedicated and separate automatic control system. Basic control includes SOLAS Ch II-1 C 31.8 "it shall be possible to control the propulsion machinery locally, even in the case of failure in any part of the remote control system"

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503 *Local control* implies the control of a system/component from a position in the immediate vicinity of the controlled unit.

504 *Main work station* is the position from where it is normal to control a main function, and is the only position from where it is possible to take remote control of a main function without acceptance from the work station presently holding the control.

505 *Remote control* implies the control of a system/component from any other position than the basic control position.

D 600 Piping

601 *Piping*: Is defined to include the following components:

— pipes
— flanges with gaskets and bolts and other pipe connections
— expansion element
— valves, including hydraulic and pneumatic actuators and fittings
— hangers and supports
— flexible hoses and
— pump housings.

602 *Piping system*: Is defined to include piping, as well as components in direct connection to the piping, such as pumps, heat exchangers, evaporators, independent tanks, etc. with the exception of main components such as steam and gas turbines, diesel engines, reduction gears and boilers.

SECTION 2
GENERAL SYSTEM REQUIREMENTS

A. Design Principles

A 100 Safety

101 All systems/components shall be so designed and installed that they will not constitute unacceptable hazards to personnel, vessel or cargo and such that the environment is not adversely affected. This also applies to installations not supporting main functions.

102 In the event of malfunction, the system/component shall enter the least hazardous of the possible failure states taking the overall safety statements in Sec.1 into consideration.

Guidance note:
This means that the safety of the system/component itself is of secondary importance compared to the safety of personnel, environment, vessel and cargo.

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A 200 Availability

201 Systems/components shall be designed and arranged so that all main functions are simultaneously available in all relevant operational modes unless specially considered and accepted.

202 Systems/components supporting a main function shall not be used or integrated with other systems/components in such a way that the availability of the main function may be impaired or lost.

203 Systems and components supporting a main function shall be arranged with redundancy so that a single failure does not lead to the unavailability of any main function or inability to start or stop the main function.

Guidance note:
Normally this redundancy is achieved by duplication

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204 Control systems supporting a main function shall be so arranged that, after a single failure, the control of the main function can be restored within 45 seconds.

205 The redundancy requirement of 203 may be waived upon adequate documentation of reliable performance. Adequate documentation of reliable performance may be based on one or more of the following:

— Extensive and relevant maritime service experience.
— Design based on approved and relevant standards/regulations and service experience.
— Risk based assessment following a predefined standard approved by the Society and associated relevant service experience or testing.

Guidance note:
The following systems and components of well proven design, compliant to the Society's requirements, are normally considered to have documented reliable performance (the list is not necessarily complete):

— Main engine
— Shafting
— Gears
— Propulsors
— Pipes.

The following installation is not required redundant:

— Machinery for emergency electrical power supply.

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206 Systems where hidden failures are likely, shall be designed and tested with attention to the potential detrimental effect of the hidden failure on the ship main functions. Occurrence of likely hidden failures is not to be considered as a single failure.

A 300 Design

301 All systems/components supporting main functions, shall:

a) be designed, built and tested in accordance to the class rules. Components and systems not covered by the rules shall comply with a recognised standard suitable for marine use accepted by class.

b) be designed and built such that maintenance tasks normally expected to be handled during voyage and occurring at short intervals, may be carried out without loss of propulsion or steering.

c) be so designed and built that main functions can be brought into operation from the «dead ship» condition within 30 minutes using only the facilities available on board.

Guidance note:
In order to restore operation from the «dead ship» condition, the emergency generator may be used. It is assumed that means are available to start the emergency generator at all times.

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B. Function

B 100 Redundancy

101 Redundant systems/components are to be mutually independent.

102 Redundant systems/components shall have the a capability sufficient to avoid loss of any main function in case of single failure.

B 200 Functional capability

201 The performance and capacity of auxiliary systems are to be adapted to the needs of the systems served.

202 Components in a system are to be:

— satisfactorily matched with regard to function, capacity and strength, taking all vessel operating conditions into consideration
— designed with respect to the loads and ambient conditions which are expected to occur. Generally accepted safety margins are to be used.

B 300 Operation

301 For vessels having more than one operating mode, the mode in force shall be clearly indicated at relevant command/work stations.

302 Changeover between two normal operating modes is to be possible without significant influence on propulsion or steering.

C. Arrangement

C 100 Installation

101 All systems and machinery are to be designed and installed taking due consideration to the conditions found in a marine environment.

102 Relative motions between parts of the machinery are to be allowed for without inducing detrimental stresses.

103 All systems and components that are to be operated or subject to inspection and maintenance on board, are to be installed and arranged accessible.

C 200 Control

201 *General*

— All systems/components are to be equipped with control and monitoring devices necessary for safe operation.
— All systems/components required to maintain availability of a main function shall have basic control facilities. This basic control shall be mutually independent of remote control system for the same main function
— Control and safety devices for systems/components supporting main functions, shall be independent or designed such that failure of one system does not degrade the performance of another system.

(Interpretation of SOLAS Ch. II-1/31.1 and 31.5.1)

Guidance note:
Compliance with Ch.1 and Ch.9 is regarded as fulfilling the above mentioned requirements.

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— An engineers' alarm shall be provided with the possibility to alert personnel in the engineers' accommodation that assistance is needed in the engine room.

(Interpretation of SOLAS Ch. II-1/38)

— At least two independent means shall be provided for communicating orders from the navigating bridge to the position in the machinery space or in the control room from where the speed and direction of thrust of the propulsors can be controlled in basic control mode. One of these shall provide visual indication of the orders and responses both in the machinery spaces and on the navigating bridge. Appropriate means of communication shall be provided from the navigating bridge and the engine-room to any other position from where the speed or direction of thrust of the propellers may be controlled.

(Interpretation of SOLAS Ch. II-1/37)

202 *Remote control - general*

a) When control is possible from several work stations, only one shall be in control at a time. It shall be clearly indicated at each work station which station is in control.

b) Remote starting of machinery shall be automatically inhibited if conditions exist which may cause hazard, e.g. turning gear engaged.

203 *Bridge control – general*

For systems/components supporting main functions:

— Necessary information and alarms shall be given on the bridge in case of overload if automatic load limitation is not arranged for.
— An alarm shall be initiated on the bridge and in the engine room in case of starting failure.

C 300 Prevention of inadvertent operations

301 The installation shall be so arranged as to minimize the possibility for inadvertent operation and human errors leading to reduced safety or damage of system/components.

302 The installation is to be arranged as to minimize the possibility for sea water, cargo or ballast from reaching dry spaces of the ship, and cargo (oils or chemicals) from being discharged overboard as a consequence of inadvertent operations.

303 The installation is to be so arranged that leakage or operation of valves will not directly lead to increased risk of damage to machinery, ship or personnel due to mixing of different fluids.

304 Open and closed positions of valves are to be easily visible.

305 If a valve's function in the system is not evident, there is to be adequate information on a name plate attached to the valve.

306 All connections to sea are to be marked: SEA DIRECT.

307 For vessels where damage stability requirements apply, precautions are to be taken to prevent intercommunication through damaged pipe lines between flooded and intact compartments. For this purpose, where any part of a pipe system is situated within the defined damaged area and the pipe line has an open end in a compartment assumed to be intact, an isolating valve situated outside the damaged area operable from the freeboard deck or from another position, accessible when the ship is in damaged condition is to be fitted. For bilge lines the remotely operated stop valves may be substituted by a non-return valve.

Guidance note:

Requirements for damage stability may be found in inter alia SOLAS, the International Convention on Load Lines, MARPOL, IMO Gas and Chemical Codes and for the optional class notations **SF** and **Well Stimulation**.

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C 400 Ventilation capacity

401 All spaces, from which machinery is operated and where flammable or toxic gases or vapours may accumulate, or where a low oxygen atmosphere may occur, are to be provided with adequate ventilation under all conditions.

402 The capacity and arrangement of machinery spaces and emergency generator room ventilation is to cover demands for operating the machinery, boilers and emergency generator at full power in all weather conditions.

Ventilation inlets and outlets are to be located not less than 4.5 m above freeboard deck. Supply of air to the engine room is to be ensured even in the event of failure of one ventilation fan.

Guidance note:
Necessary capacity of ventilation may be calculated according to ISO Standard 8861.

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C 500 Fire prevention

501 Fuel oil, lubrication oil, hydraulic oil and thermal oil are regarded as "*Flammable oils*".

D. Environmental Conditions

D 100 External conditions

101 All machinery, components and systems are generally to be designed to operate under the following environmental conditions, see also Table D1 and Table D3:

— Sea water temperature: ≤ 32°C
— Ambient air temperature: -10°C - +45°C
— Relative humidity of air: ≤ 100%

D 200 Reference conditions

201 Where the rules have requirements for capacity or power of machinery, these are to be determined at the ambient reference conditions stated in Table D1.

202 The engine manufacturer is not expected to provide simulated ambient reference conditions at a test bed unless specified in the relevant rule chapters.

Table D1 Ambient reference conditions for machinery	
Parameter	*Value*
Total barometric pressure	1 bar = 0.1 [Mpa]
Ambient air temperature	45°C
Relative humidity of air	60%
Sea water temperature	32°C

D 300 Ship conditions

301 All machinery, components and systems are generally to be designed to operate under the ship conditions as specified in Table D2 and D3.

302 The Society may consider deviations from the angles of inclination given in Table D2, taking the ship type, size and service conditions into consideration.

Table D2 List, rolling, trim and pitch [1]				
Installations, components	*Angle of inclination (degrees)* [2]			
	Athwartships		*Fore and aft*	
	Static	*Dynamic*	*Static*	*Dynamic*
Main and auxiliary machinery	±15	0 ± 22.5	±5 [5]	±7.5
Safety equipment, e.g. emergency power installations, emergency fire pumps and their devices, switch gear, electrical and electronic appliances [3] and remote control systems	±22.5 [4]	0 ± 22.5 [4]	±10 [5]	±10

1) The Society may consider deviations from these angles of inclination taking into consideration the type, size and service condition of the ship.
2) Athwartships and fore and aft inclinations may occur simultaneously.
3) Up to an angle of inclination of 45°C no undesired switching operations or operational changes may occur.
4) In ships for the carriage of liquefied gases and of chemicals, the emergency power supply must also remain operable with the ship flooded to a final athwartships inclination up to a maximum of 30°C.
5) Where the length of the ship exceeds 100 m, the fore and aft static angle of inclination may be taken as 500/L degrees where L = length of ship, in m, as defined in Pt.3 Ch.1 Sec.1 B100.

Table D3 Temperature, humidity, accelerations, vibrations		
Ambient air temperature:	The machinery space	0°C to 55°C
	Open deck / non-heated compartment	-10°C to 45°C
Relative humidity of air:	The machinery space	≤ 96%
	Open deck	≤ 100%
Sea water temperature (world wide operation)		< 32°C
Accelerations		1)
Vibrations		2)

1) All machinery and equipment installed onboard shall be designed for the accelerations that can occur on the location onboard where it is installed. Acceleration figures can be taken from specific calculations of the vessel, or from simplified formulae in Pt.3.
For simplified, conservative calculations, an acceleration of 0.6 g can be assumed in all directions

2) All machinery and equipment installed on board shall be designed to withstand the vibration level that can occur on the location where it is installed.
A free vibration level of walls and decks of 45 mm/s for frequencies 3 to 13 Hz, and 4 g for frequencies 13 to 100 Hz can be assumed in all directions. The figures can be used directly, or as input for response analyse for installed machinery.

Amended August 2011, see page 3

SECTION 3
MAIN FUNCTIONS - REQUIREMENTS

A. General requirements

A 100 Modes of operation

101 For vessels with multiple defined modes of operation (transit mode, manoeuvring mode, etc.), specific availability requirements for the main functions in each mode may be agreed.

B. Main functions

B 100 Propulsion

101 A main work station shall be arranged.

102 The propulsion system shall be so arranged that, after a single failure, it may be restored within 15 minutes without repair.

Guidance note:
The propulsion system may be arranged as a single propulsion line having systems/components arranged with redundancy, unless specifically exempted. Reference is made to Sec.2 A204.

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103 Propulsion machinery - control

a) The speed, direction of thrust and, if applicable, the pitch of the propeller shall be fully controllable from the navigating bridge under all sailing conditions, including manoeuvring.
(SOLAS Ch. II-1/31.2.1)

b) Propulsion machinery orders from the navigation bridge shall be indicated in the main machinery control room and at the manoeuvring platform.
(SOLAS Ch. II-1/31.2.4)

Guidance note:
Manoeuvring platform is to be understood as the location for basic control.

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c) The remote control shall be performed, for each independent propeller, by a control device so designed and constructed that its operation does not require particular attention to the operational details of the machinery. Where multiple propellers are designed to operate simultaneously, they may be controlled by one control device.
(SOLAS Ch. II-1/31.2.2)

Guidance note:
For ships less than 500 gross tonnage, two handle control may be accepted and some of the normally programmed operations may instead be carried out manually.

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d) The main propulsion machinery shall be provided with an emergency stopping device on the navigating bridge which shall be independent of the navigating bridge control system.
(SOLAS Ch. II-1/31.2.3)

Guidance note:
If means are provided to stop the propulsion without stopping the main engine(s) (e.g. clutch arrangement) then this will be accepted.

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e) Indicators shall be fitted on the navigation bridge and in the engine control room for:

— propeller speed and direction of rotation in the case of fixed pitch propellers; and
— propeller speed and pitch position in the case of controllable pitch propellers.

(Interpretation of SOLAS Ch. II-1/31.2.8 and 31.5.6)

f) An alarm shall be provided on the navigating bridge and in the machinery space to indicate low starting air pressure which shall be set at a level to permit further main engine starting operations. If the remote control system of the propulsion machinery is designed for automatic starting, the number of automatic consecutive

attempts which fail to produce a start shall be limited in order to safeguard sufficient starting air pressure for starting locally.
(SOLAS Ch. II-1/31.2.9)

g) Automation systems shall be designed in a manner which ensures that threshold warning of impending or imminent slowdown or shutdown of the propulsion system is given to the officer of the watch in time to assess navigational circumstances in an emergency. In particular, the systems shall control, monitor, report, alert and take safety action to slow down or stop propulsion while providing the officer of the watch an opportunity to manually intervene, except for those cases where manual intervention will result in total failure of the engine and/or propulsion equipment within a short time, for example in the case of overspeed.
(SOLAS Ch. II-1/31.2.10)

Guidance note:
The above is regarded to be fulfilled when:

1) All process parameters initiating slowdown or shutdown shall initiate an alarm before reaching the slowdown / shutdown limit. These alarms shall be individually or in groups indicated on the navigating bridge whenever the propulsion machinery is controlled from this position. Exempted from the requirement to give a pre-warning are the following parameters:

— overspeed on rotating machinery
— crankcase explosive condition using oil mist detection on diesel engines
— short-circuit in electrical propulsion plants.

2) An override facility to manually intervene on all slowdowns and shutdowns shall be available for all parameters except those which will result in total failure of the engine and/or propulsion equipment within a short time, or cause threat to personnel. For multi engine plants this requirement can usually be waived.
Examples of such parameters:

— lubricating oil pressure for rotating machinery
— overspeed for rotating machinery for fluid film bearings
— crankcase explosive condition on diesel engines
— short-circuit conditions in electrical installation
— high vibration for gas turbines.

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B 200 Steering

201 Main work station shall be the navigation bridge, unless otherwise stated. The total steering system shall be so arranged that the officer on watch may control the course of the vessel without due delay and with acceptable safety and availability.

202 The steering system shall be so arranged that, after a single failure, it may be restored within 15 minutes without repair.

The systems and components shall be arranged with redundancy unless specifically exempted. Reference is made to Sec.2 A204.

203 The main steering system shall have sufficient capacity to change direction of the vessel in a controlled and adequate manner to all desired headings at maximum ahead service speed.

Guidance note:
Compliance with IMO Interim standards for ship manoeuvrability is considered sufficient for fulfilment of the above. Maximum ahead service speed is defined in Pt.4 Ch.14 Sec.1 A208.

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B 300 Electric Power Generation

301 A main work station shall be arranged.

302 The vessel shall be provided with a minimum of two main sources of power, both independently capable of keeping the vessel in normal operation with regard to main functions and safety, without recourse to the emergency source of power.

303 The power generation system shall be so arranged that, after a single failure, it may be restored within 45 seconds.

B 400 Ballasting

401 A main work station shall be arranged.

402 The ballasting system shall be so arranged that, after a single failure, it may be restored within 15 minutes without repair.

Amended August 2011, see page 3

B 500 Drainage and bilge pumping

501 A main work station shall be arranged.

502 The drainage and bilge pumping system shall be so arranged that, after a single failure, it may be restored within 15 minutes without repair.

Guidance note:

The systems and components shall be arranged with redundancy unless specifically exempted. Reference is made to Sec.2 A204.

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SECTION 4
MISCELLANEOUS REQUIREMENTS

A. All Vessels

A 100 Materials

101 Where no specific requirements are given in the rules regarding dimensioning and choice of materials, generally recognised standards and engineering principles may be applied.

102 When it is of essential significance for the safety of the ship that the function of a component is maintained as long as possible in the event of fire, materials with high heat resistance are to be used.

103 Materials with low heat resistance are not to be used in components where fire may cause outflow of flammable or health hazardous fluids, flooding of any watertight compartment or destruction of watertight integrity.

Guidance note:
Materials with high heat resistance are materials having a melting point greater than 925°C. Materials with low heat resistance are all other materials. Deviations from the above requirement will be subject to special considerations.

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104 The use of asbestos is prohibited.

(SOLAS Ch. II-1/3-5.2)

A 200 Controlled atmosphere installations

201 Fixed refrigeration plants (including air condition plants) with a total prime mover rated effect of 100 kW and above, shall comply with safety requirements in Pt.5 Ch.10. Refrigeration plants using Group 2 refrigerants (e.g. ammonia) shall comply with the safety requirements as given in Pt.5 Ch.10 irrespective of size.

202 Controlled atmosphere installations for dry cargoes shall comply with all safety requirements of Pt.5 Ch.10 Sec.5.

203 Spaces containing refrigeration installations and not fitted with mechanical ventilations, shall be provided with an oxygen deficiency monitoring system. Alarm indication shall be located at the entrance to the space.

Amended August 2011, see page 3

SECTION 5
TESTING

A. Verification of main functions

A 100 Safety and availability

101 The test program shall demonstrate that the rules requirements are adhered to.

Guidance note:

Several systems and components such as diesel engines have specific requirements to testing and verification in underlying chapters, the motivation for a final test is to ensure that all systems perform together in a safe manner in order to demonstrate availability of main functions in all relevant operational modes.

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102 Main function availability

The test program shall demonstrate that the availability requirements of the main functions are met in the different and relevant modes of operations.

103 Test of basic control

Basic controls of main functions have to be tested

104 Main function capability

The test program shall demonstrate, and form basis for a general documentation, of the operating capability of the vessel (speed, turning radius, crash stop length etc.) in the different modes of operation, fallback operation in degraded mode, and specified failure scenarios.