BAHRIA CLASSIFICATION SOCIETY

REDUNDANT PROPULSION and STEERING SYSTEMS

PART C

Chapter 23- Redundant Propulsion and Steering Systems

2022

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SECTION 1

GENERAL REGULATIONS AND INSTRUCTIONS

A. General

1. The Rules relating to redundant propulsion and steering systems apply to ships, which are classified by **TL** and are to receive the notation RP1 x%, RP2 x% or RP3 x% affixed to the character of classification.

The Rules apply in addition to the Society's Rules for Classification of steel ships, in particular.

– Chapter 1, Hull,

– Chapter 4, Machinery, – Chapter 5, Electric.

2. The Rules for redundant propulsion and steering systems stipulate the level of redundancy for the propulsion and steering systems . It is characterised by the appropriate notation to be affixed to the character of classification.

3. The Rules are based on the single-failure concept.

B. Definitions

These Rules are subject to the following definitions:

Single-failure concept:
The basis of the single-failure concept within the context of these Rules is: With regard to a possible loss of propulsion or steering capability of the ship, only one single failure (initiating event) is acceptable at any given time. The simultaneous occurrence of unrelated failures is excluded. Exception to this rule is the common occurrence of failures, if they arise as an inevitable consequence of a single primary failure.

Propulsion system:

A system, which provides thrust to propel the ship. It consists of propulsion machines and the auxiliary systems needed to operate them, all the equipment to transmit propulsion power into thrust and all the requisite monitoring and control systems, alarm and safety systems.

Steering systems:

A system for controlling the course of the ship. It consists of the rudder, the rudderstock and the steering gear together with all the requisite monitoring and control systems, alarm and safety systems.

Azimuth propulsion system:

A combined system for steering the ship and provision of propulsion power. Podded drives, rudder propellers, rotatable waterjets and cycloid propellers are regarded as azimuth propulsion systems within the context of these Rules.

The requirements stated in these Rules are based on system configurations with a conventional shaft propulsion system for providing propulsion and with a steering system for controlling the ship's course.

In the case of azimuth propulsion systems, the requirements relating to propulsion systems and steering systems apply in an analogous manner unless other requirements specific to azimuth propulsion systems are explicitly specified.

Main propulsion power:

The total power provided by the prime movers installed to provide propulsion. Unless otherwise specified, this does not include the power provided by propulsion units, which can be switched on when required but are not intended to provide propulsion during normal operation, e.g. shaft-driven generators in power take-in mode or additional waterjet propulsion units.

Level of redundancy:

The classification of mechanical, electrical and spatial separation and also the independence of the systems required for propulsion and steering. The redundant propulsion power of the propulsion system is denoted by the additional index x%.

Example: The additional index 40% means, that following a failure of one of the redundant propulsion systems, at least 40% of the main propulsion power will still be available.

C. Documents to be Submitted

1. Compliance with the requirements set out in Section 3, in accordance with the notation applied for, must be demonstrated by block diagrams, schematic drawings, descriptions of system functions and operation, calculations and arrangement plans.

Model tests or calculations shall be used to show the speed and manoeuvring qualities that have to be attained during sea trials in order to demonstrate compliance with the requirements set out in Section 3, Part A .

2. A failure mode and effects analysis (HDEA) or an equivalent analysis must be conducted for the propulsion and steering systems, and for the auxiliary systems needed to operate them.

The analysis must demonstrate that a single failure cannot lead to any loss in propulsion and/or in steering ability in accordance with the requirements set out in Section 3, Part A.

The analysis shall further demonstrate that measures are in place for failure detection and control of possible effects and that these measures are adequate to ensure in particular that the propulsion and steering of the ship can be rapidly restored. In addition, the analysis must deal with the identification of possible failure conditions, which have a common cause. The identification of technical elements and/or operational procedures, which could undermine the redundancy concept, must also be accounted for.

For the notation RP1 x%, the HDEA only has to be performed for the redundant propulsion machines and their requisite auxiliary systems. The events of water ingress or fire in a machinery compartment, and a failure of any of the common elements of the propulsion train, in accordance with Section 2, Part B, do not have to be considered.

For the notation RP2 x%, the HDEA has to be performed for the redundant propulsion and steering systems. The events of water ingress ior fire in a machinery compartment an water ingress in a steering gear compartment do not have to be considered.

3. A programme of tests to be conducted during sea trials must be submitted for approval.

SECTION 2

NOTATION AFFIXED TO THE CHARACTER OF CLASSIFICATION

A. General

1. A distinction is made between the three levels of redundancy RP1 x%, RP2 x% and RP3 x%.

2. The RP1 notation requires redundancy for ship propulsion systems (redundant prime movers; engines with different power are acceptable), but no redundancy for steering the ship. With this classification, initiating events such as the ingress of water or fire in a machinery compartment, the ingrees of water in the steering gear compartment and also a failure of any of the common components of the propulsion train or the steering gear could lead to loss of propulsion or directional control of the ship.

3. The RP2 notation requires redundant systems for ship propulsion and for steering. Each redundant system must be mechanically and electrically separated and independent from each other. With this classification, initiating events such as water ingress or fire in a machinery compartment and water ingress in a steering gear compartment could lead to loss of propulsion or directional control of the ship.

4. The RP3 notation requires that the redundant systems for ship propulsion and steering are each mechanically and electrically separated and installed in separate compartments. The redundant systems must be independent from each other. With this classification, initiating events such as water ingress or fire in a machinery compartment and water ingress in a steering gear compartment must not lead to any loss of propulsion or directional control of the ship.

5. The additional index x% denotes what percentage of the main propulsion power of the ship is provided by the redundant propulsion system.

Examples of system configurations for each of the three notations are illustrated in Figure 2.1.

B. Classification

1. RP1 x%

This notation is assigned to ships, which have at least two propulsion machines, which are independent or can be isolated from each other. This also applies to the auxiliary systems, which are needed to operate the prime movers. No redundancy of propeller, shaft system, gearbox and steering system is required.

Possible propulsion configurations include multi-engine systems with a common shaft system, where the engine systems are mechanically and electrically separated from each other. Single-engine systems with a PTI propulsion system, where the two systems are isolated from each other from a systems engineering point of view may also meet the conditions for RP1 classification (Figs 2.1 A and B).

2. RP2 x%

This notation is assigned to ships which have at least two propulsion systems and two steering systems, each of which are independent or can be isolated from each other. This also applies to each of the auxiliary systems required to operate the propulsion and steering systems. Possible propulsion configurations include multi-shaft systems and multi-steering systems, where the redundant systems are mechanically and electrically separated from each other. Azimuth propulsion systems which have been installed in isolation, and also combinations of these

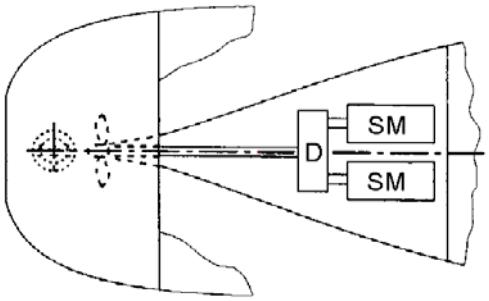
with conventional shaft propulsion systems may also meet the conditions for the RP2 classification (Figs. 2.1 C and D).

3. RP3 x%

This notation is assigned to ships which have at least two propulsion systems and steering systems, each of which are independent or can be isolated from each other, and are each installed in separate compartments. This also applies to each of the auxiliary systems required for operating the propulsion and steering systems. The separation of the compartments must be

adequate to ensure that incidents such as water ingress or fire in a machinery compartment and water ingress in a steering gear compartment does not impair the function of the redundant propulsion system or steering system concerned.

Possible propulsion configurations include multi-shaft systems and multi-steering systems, where the redundant systems are mechanically and electrically separated from each other, and are each installed in separated compartments. Azimuth propulsion systems which have been installed in isolation, and combinations of these with conventional shaft propulsion systems may also meet the conditions for RP3 classification (Figs 2.1 E and F).



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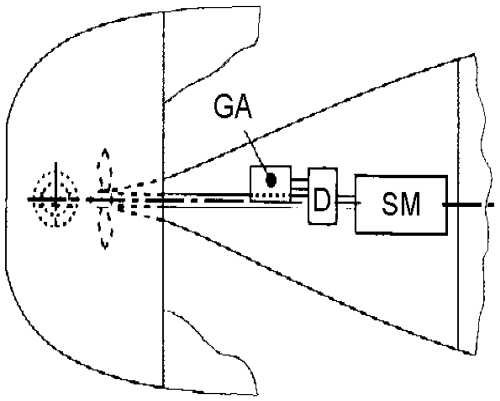
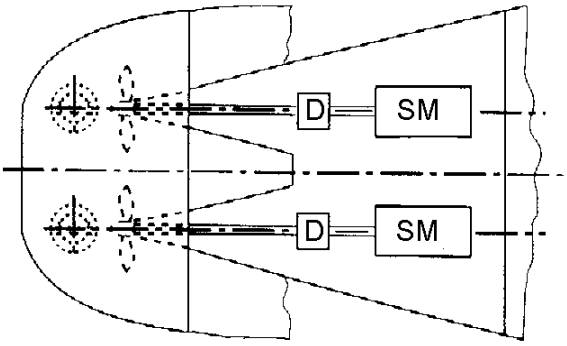


B

Examples for notation RP1 x%



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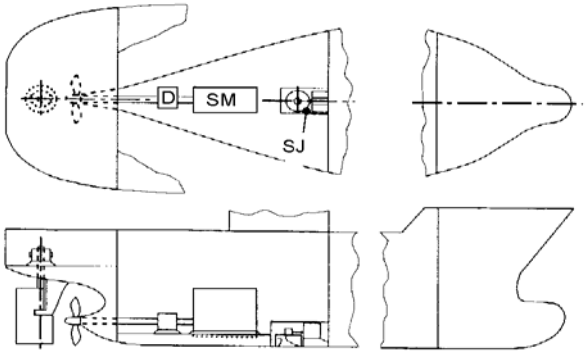

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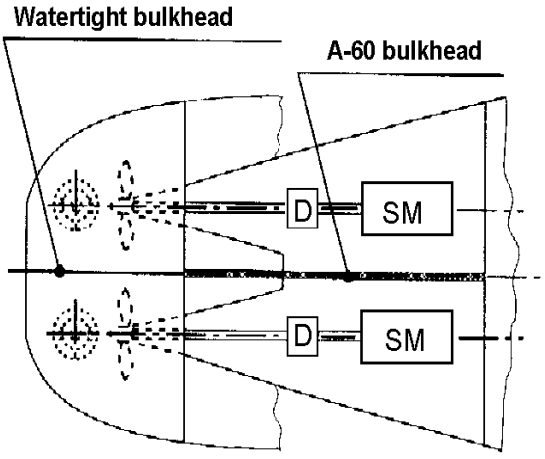
Examples for notation RP2 x%



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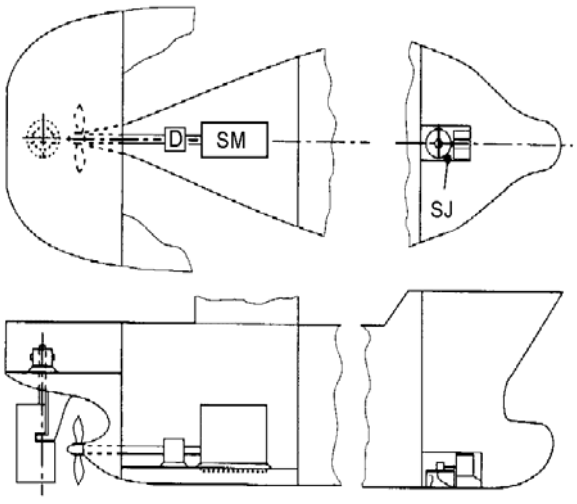

F

Examples for notation RP3 x%

Abbreviations:
SM = Propulsion machine
D = Gearbox
SJ = Waterjet unit
GA = Shaft-driven generator in Power Take-In mode

Fig. 2.1 System configurations for notations RP1 x%, RP2 x% and RP3 x% (examples)

SECTION 3 REQUIREMENTS

A. General Requirements

In accordance with the requirements set out in these Rules, it must be ensured that when a failure in a propulsion or steering system occurs:

1. The manoeuvrability of the ship can be maintained so that even under unfavourable weather conditions **(1)** the ship can be manoeuvred into a position of less resistance to the weather and can be maintained in this position;

2. A minimum speed can be maintained to keep the ship under control and ensure that it is able to make speed over the ground in waters where there is a strong current. The minimum speed under normal weather coditions **(2)** must be at least 7 knots or half the design speed (the lower value may be applied);

3. The requirements stated in paragraphs 1 and 2 can be met for a minimum period of 72 hours **(3)**;

4. The requirements stated in paragraphs 1, 2 and 3 can be met irrespective of the ship's loading condition;

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(1) *Within the context of these Rules, unfavourable weather conditions are regarded as being a wind speed of up to and including 21 m/sec. (8 on the Befaufort scale) and a significant wave height of 5,4 m with an average wave period of 8,3 secs.*

(2) *Normal weather conditions are regarded as being a wind speed of up to and including 11 m/sec. (5 on the Beauford scale) and a significant wave height of 2,8 m with an average wave period of 6,7 secs.*

(3) *For ships, which normally spend less than 72 hours cruising at sea, the period specified may be limited to the maximum time of a voyage.*

5. The redundant propulsion systems and steering systems are ready for operation at any time and can be activated on demand,

6. The redundant propulsion system is capable of taking up operation from a still standing propulsion plant.

Compliance with the above requirements must be demonstrated by calculations and/or model tests and verified in a suitable manner during sea trials.

B. Requirements for Propulsion Systems

1. Auxiliary systems

1.1 Auxiliary systems for redundant propulsion systems whose function have a direct effect on the propulsion system, for example fuel, lubrication oil, cooling water, control air and uninterrupted power supply systems, must be provided for each propulsion system independently of each other.

Where standby units are specified for these systems in accordance with Society rules, these must be provided for each of the systems in question.

1.2 Auxiliary systems for redundant propulsion systems whose failure do not have a direct effect on the propulsion system, such as fuel treatment, starting air supply systems etc. are to be designed to be separate from each other. For these systems no additional standby units have to be provided if interconnection lines are provided between the systems and if the units are designed so that the propulsion systems can be supplied with power simultaneously without restriction. In the connection lines shut-off valves are to be provided which must be kept closed during normal operation.
On ships with class notation RP3 x% a shut-off valve must be fitted on either side of the partition bulkhead between the machinery compartments.

1.3 In heavy fuel oil systems, the heating facilities for preheating the fuel oil must be designed so that if one propulsion system fails, the required preheating of the fuel oil for the redundant propulsion system can be ensured.

It is not necessary to provide a redundant heating facility if diesel oil storage tanks are provided which allow unrestricted operation for the redundant propulsion system for the period of time specified in Section 3, para. A.3.

1.4 Supply lines from fuel oil service tanks of redundant propulsion systems must be provided with an interconnection fitted between service tank and pump of each system. The interconnection is to be provided with a shut-off device, which must be kept closed during normal operation.

On ships with class notation RP3 x%, a shut-off valve must be fitted on either side of the partition bulkhead between the machinery compartments.

1.5 The seawater supply of redundant propulsion systems may be achieved via a common sea chest connection by means of a pump assigned to each propulsion system. The systems must be capable of being isolated by means of a shut-off valve in the connection line.

On ships with class notation RP3 x% the sea chests are to be installed in separate compartments in accordance with Section 3, para. D.1. The shut-off valve in the connection line must be fitted to the partition bulkhead and be capable of being operated either from both machinery compartments or from a position outside the machinery compartments.

1.6 On ships which carry the ice class notation B1 to B4, the seawater cooling systems must be designed so that if one seawater cooling system fails it is possible to operate the redundant propulsion system when the ship is operating in ice conditions.

On ships with class notation RP3 x% it must be possible to operate the redundant propulsion system when one of the seawater cooling systems fails, in accordance with the compartment separation requirements specified in Section 3.D .1.

2. Auxiliary Systems for Electric Propulsion Systems

2.1 In electric propulsion systems the main and

excitation converter systems, and where appropriate, their supply transformers, their protection and control facilities and the corresponding uninterrupted power supply systems (UPS) must be designed in such a way that the redundant propulsion power of the ship remains available when a single failure occurs. Auxiliary systems (e.g. recooling devices and auxiliary power supplies) are to be designed so that they are separate from one another.

2.2 The supplying main switchboard for a redundant electric propulsion system must have an automatically releasing bus-tie switch or breaker that divides the system into at least two sections. If one of the sections of the switchboard fails, the remaining section must supply the propulsion system and its auxiliary power supplies.

A faulty bus tie switch / breaker should not jeopardise both sides of the switchboard.

All equipment, which is of primary importmance to operation, must be distributed symmetrically over the two sections of the switchboard. The two sections of the switchboard must be capable of being controlled and monitored independently of each other. Uninterrupted power supplies necessary for this purpose have to be of redundant design. Where power management systems are required to provide a reliable power supply to the propulsion systems, these must also be of redundant design.

3. Control and Monitoring Systems

3.1 Controls

The redundant propulsion systems must be capable of being controlled by means of a simple control from the ship's bridge. A local control must also be provided for emergency operation.

Common controls, e.g. joystick controls that operate redundant propulsion systems must be designed so that a single failure does not affect an intact system, and the control remains possible without restriction by means of another method of control (individual control or emergency control).

In the case of multiple propulsion systems, a central emergency control facility must be provided, for example from the machinery control room, at which it is possible to adjust the speed and direction of rotation of the propulsion machines centrally.

3.2 Monitoring devices

The redundant propulsion machines and their auxiliary systems are to be monitored by independent alarms. Alarms and status indicators are to be provided in the machinery compartment and on the bridge.

C. Requirements for Steering Systems 1. Rudders

Every redundant steering system must consist of a main and an auxiliary steering gear, each with independent control .

The rudder position must be indicated by means of electrically independent rudder position indicators.

The ship's steering capability must be ensured even when the rudder is blocked at maximum deflection. If the steering ability is impaired to the extent that the requirements set out in Section 3.A cannot be met, it must be possible to move and lock the failed rudder into the midships position.

2. Azimuth Propulsion Units as Steering Systems

Where ship steering is exclusively performed by azimuth propulsion systems, at least two azimuth propulsion systems must be provided, each with independent controls.

The position of the individual azimuth propulsion systems must be indicated by electrically independent indicators.

If the ship's steering ability is impaired, even when the propulsion of a defective azimuth propulsion system is disconnected, to the extent that the requirements stated in Section 3.A cannot be met, it must be possible to

move and to lock the defective azimuth propulsion unit into the midships position.

D. Compartment Separation Requirements for RP3 x%

1. Bulkheads and Partitions

1.1 Redundant propulsion systems and steering systems must be separated from each other by watertight bulkheads.

1.2 Partitions between machinery compartments containing redundant propulsion systems must comply with a fire resistance, the level of which depends on the fire potential of the machinery compartments. The partitions must comply with a fire integrity standard of at least "A-O".

1.3 Partition walls of machinery compartments, which are isolated from each other by cofferdams, tanks or other spaces, must comply with a fire integrity standard of at least "A-O".

1.4 Watertight doors may be permitted in accordance with SOLAS II-1 / Reg. 18 or Reg. 15 respectively. These have to be equipped with an open / closed status indication and a remote control on the bridge.

Watertight doors must not be regarded as emergency exits for category A machinery compartments under the terms of SOLAS II-2 / 28.3.1 and II-2 / 45.3.

2. Ventilation

Machinery compartments are to be fitted with independent ventilation systems.

SECTION 4

TRIALS

A. Requirements

Tests are to be performed during sea trials in accordance with an approved sea trials programme. The tests are designed to prove that.

– The ship is able to meet the requirements set out in Section 3;

– The propulsion and steering systems have the necessary redundancy in line with the notation applied for;

– The conclusions drawn in the HDEA regarding the effects of failure conditions and measures to detect and control these failure conditions are correct and adequate.