

Excerpt from ABS Rules Developed for Steering Gear



Booklet developed on 1 January, 2026



Excerpt from ABS Rules Developed for Steering Gear

American Bureau of Shipping
Incorporated by Act of legislature
of the State of New York 1862.

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Foreword

Purpose

This booklet is an excerpt from the ABS Rules. It has been created to support equipment manufacturers in identifying the appropriate ABS Rules for their products.

Application

Equipment manufacturers seeking to have their products approved for marine and offshore applications under ABS classification or certification will find this booklet a practical reference for determining which sections of the ABS Rules are applicable to their specific equipment types.

This excerpt does not replace or supersede the complete ABS Rules. Users are responsible for consulting the full text of the applicable Rules and ensuring compliance with the most current edition, including any published corrigenda and notices.

Additional Information

For questions regarding the applicability of specific Rules to your equipment. Please contact your local ABS office.

The ABS Rules are available in their complete form at American Bureau of Shipping (ABS) Eagle.org.

Chapter 3 Propulsion and Maneuvering Machinery

Section 4 Steering Gears

1 General**1.1 Application (2024)**

This section is applicable to vessels, for which steering is effected by means of a rudder or rudders and an electric, hydraulic or electro-hydraulic steering gear.

Additional requirements for non-traditional or rudderless arrangements are given in 1.10 and in 4-3-5/5.11 for azimuthal thrusters, 4-3-8/11.9 for podded thrusters, and Section 4-3-6 and 9 for waterjets.

Steering gears intended for vessels strengthened for navigation in ice are to comply also with additional requirements in Part 6.

Additional requirements specific to passenger vessels and to vessels intended to carry oil, chemical or liquefied gases in bulk are provided in 23 and 25 hereunder.

1.2 Objective (2024)**1.2.1 Goals**

The steering gears are to be designed, constructed, operated, and maintained to:

Goal No.	Goal
PROP 4	provide means to maneuver the vessel.
PROP 5	provide redundancy and/or reliability to maintain maneuverability
POW 2	provide power to enable the equipment to perform its required function necessary for the safe operation of the vessel
FIR 1	<i>prevent the occurrence of fire and explosion. (SOLAS II-2/Reg 2.1.1)</i>
AUTO 1	perform its functions as intended and in a safe manner.
AUTO 2	indicate the system operational status and alert operators of any essential machinery/systems deviate from its defined design/operating conditions or intended performance
AUTO 3	have an alternative means to enable safe operation in the event of an emergency or failure of remote control
AUTO 4	provide the equivalent degree of safety and operability from a remote location as those provided by local controls.
SAFE 1.1	minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems
COMM 2	provided with means for internal communications.

Materials are to be suitable for the intended application in accordance with the following goals and support the Tier 1 goals as listed above.

Goal No.	Goal
MAT 1	The selected materials' physical, mechanical, and chemical properties are to meet the design requirements appropriate for the application, operating conditions, and environment.

The goals in the cross-referenced Rules/Regulations are also to be met.

1.2.2 Functional Requirements

In order to achieve the above stated goals, the design, construction, and maintenance of steering gears are to be in accordance with the following functional requirements.

Functional Requirement No.	Functional Requirements
Materials (MAT)	
MAT-FR1	The material and manufactured components for steering gears are to withstand the maximum working stresses without any plastic deformation or fatigue failure.
MAT-FR2	Hardness to be considered for wear/abrasion resistance
Propulsion (PROP)	
PROP-FR1	Steering gears, components, joints and connections are to be designed to withstand the most severe conditions related to stress, pressure, temperature, loads and vessel motions
PROP-FR2	The steering system is protected from external impacts.
PROP-FR3	The steering capability is maintained or can be regained in case of malfunction in either the steering control or steering actuating sub-systems or both together
PROP-FR4	The steering system provides adequate steering performance for ship operation
PROP-FR5	Proper ship operation is enabled by providing information about ship's maneuvering characteristics
PROP-FR6	The steering system is arranged to minimize impact of erroneous functionality and operation.
PROP-FR7	Provide mechanical, electrical and control redundancy/reliability that a single failure will not impair the steering capability of the vessel
PROP-FR8	Provide arrangements such that non-duplicated components offer equivalent degree of safety as duplicated components
PROP-FR9 (SAFE)	Provide additional safety means to stop the gear before mechanical stops are reached to protect propeller and ship stern in the event of failure which allows rudder to swing in an uncontrolled manner
PROP-FR10	It is to be designed so that the failure of seal arrangements does not affect the operation of actuator
PROP-FR11	Provide protective devices if the equipment can be subjected to a pressure more than its design pressure.
PROP-FR12	Protective device and its inlet and escape pipe are to be sized to provide sufficient relief capacity to prevent the equipment from over pressurization
Power Generation and Distribution (POW)	
POW-FR1	Provide sufficient power to move the steering mechanism with rated torque at specified speed.
POW-FR2	Provide a power source independent of the main source of power to operate steering gear when the main source of power is not available
POW-FR3	Provide sufficient power capacity to operate steering gear in all operating conditions.
POW-FR4	Electrical motors are rated for steering the vessel reliably in all operating conditions
POW-FR5	Provide protection against overload, undervoltage and short circuit conditions to prevent damage to equipment and maintain continuity of power to remaining circuits.
Automation: Control, Monitoring and Safety Systems (AUTO)	
AUTO-FR1	A single failure of piping systems or malfunctions of control systems are to be alarmed and monitored in the manned control station
AUTO-FR2	Provide autonomous steering failure alarm system to minimize the influence of other related systems
AUTO-FR3	Be able to control the equipment from a local position, even in the case of failure in any part of the automatic or remote-control systems.
AUTO-FR4	Provide means to effectively operate, control and monitor the operation
AUTO-FR5	Provide visual and audible notification upon occurrence of fault in the system preventing steering failure
Communications (COMM)	
COMM-FR1	Provide means to communicate between major control stations and the steering gear compartment
Fire Safety (FIR)	
FIR-FR1	Provide fire segregation between duplicated control systems

The functional requirements in the cross-referenced Rules/Regulations are also to be met.

1.2.3 Compliance

A vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved, refer to Part 1D, Chapter 2.

1.3 Basic Principles (2020)

When the Rule required upper rudder stock diameter is over 120 mm, excluding strengthening for navigation in ice, vessels are to be provided with power operated means of main steering, as necessary to meet the requirements of 1.9.1. Such means, as a minimum, is to be supported by duplication of power units, and by redundancy in piping, electrical power supply, and control circuitry. Steering is to be capable of being readily regained in the event of the failure of a power unit, a piping component, a power supply circuit, or a control circuit.

1.5 Definitions

For the purpose of this section the following definitions apply:

1.5.1 Steering Gear (2024)

Steering gears for ships with a single steering propulsion unit are defined under 1.5.1(a). Steering gears for ships with multiple steering propulsion units consist of a main steering gear and an auxiliary steering gear, see 1.5.1(a) and 1.5.1(b). The main steering gear and the auxiliary steering gear are to be so arranged that the failure of one of them will not render the other one inoperative. In either case, any single failure in the steering gear, control system or power supply, the ship steering is to be maintained.

1.5.1(a) Main Steering Gear. (2024)

Main steering gear is the machinery, rudder actuators, power units, ancillary equipment and the means of applying torque to the rudder stock (e.g., tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the ship under normal service conditions.(SOLAS II-1, Reg. 3).

1.5.1(b) Auxiliary Steering Gear. (2024)

Auxiliary steering gear is the equipment other than any part of the main steering gear necessary to steer the vessel in the event of failure of the main steering gear, but not including the tiller, quadrant or components serving the same purpose. (SOLAS II-1, Reg. 3).

1.5.2 Steering Gear Power Unit (2025)

Steering Gear Power Unit is:

- i. *In the case of electrohydraulic steering gears, an electric motor and its associated electrical equipment and connected pump; (SOLAS II-1, Reg. 3)*
- ii. *In the case of other hydraulic steering gears, a driving engine and connected pump; (SOLAS II-1, Reg. 3)*
- iii. *In the case of electric steering gears, an electric motor and its associated electrical equipment. (SOLAS II-1, Reg. 3)*

For the purpose of alternative steering arrangements (see 4-3-4/1.10), electric steering motors are to be considered as part of the power unit and rudder actuator.

1.5.3 Power Actuating System

Power Actuating System of hydraulic and electrohydraulic steering gears is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with the associated pipes and fittings and a rudder actuator. Where duplicated power actuating system is required by the Rules, they may share common mechanical components (i.e., tiller, quadrant and rudder stock, or components serving the same purpose).

1.5.4 Rudder Actuator

Rudder Actuator is the component which directly converts hydraulic pressure into mechanical action to move the rudder. This may be a hydraulic cylinder or a hydraulic motor.

1.5.5 Maximum Working Pressure

Maximum Working Pressure is the pressure needed to satisfy the operational conditions specified in 1.9.

1.5.6 Steering Gear Control System

Steering Gear Control System is the equipment by which orders are transmitted from the navigation bridge to the steering gear power actuating system. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables required to control the steering gear power actuating system. For the purpose of the Rules, steering wheels, steering levers, and rudder angle feedback linkages are not considered to be part of the control system

1.5.7 Maximum Ahead Service Speed (2024)

Maximum Ahead Service Speed is the greatest speed which the vessel is designed to maintain in service at sea at the deepest seagoing draft. (SOLAS II-1, Reg. 3)

1.5.8 Rule Required Upper Rudder Stock Diameter

The Rule Required Upper Rudder Stock Diameter is the rudder stock diameter in way of the tiller calculated as given in 3-2-14/7.1. This required diameter excludes strengthening for navigation in ice.

FIGURE 1
Rotary Vane Steering Gear (2024)

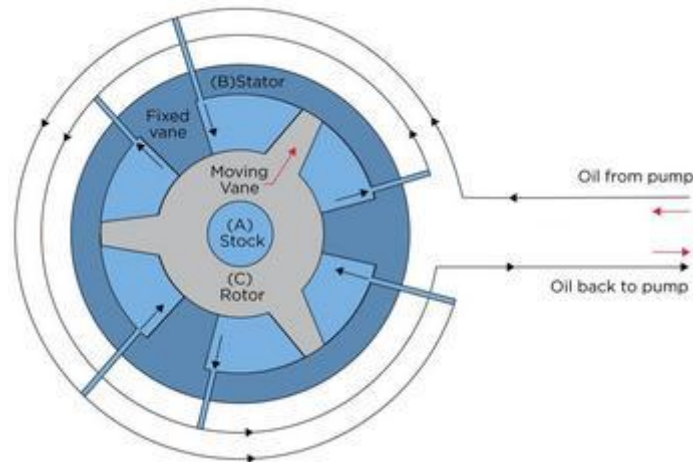


FIGURE 2
RAM Type Steering Gear (2024)

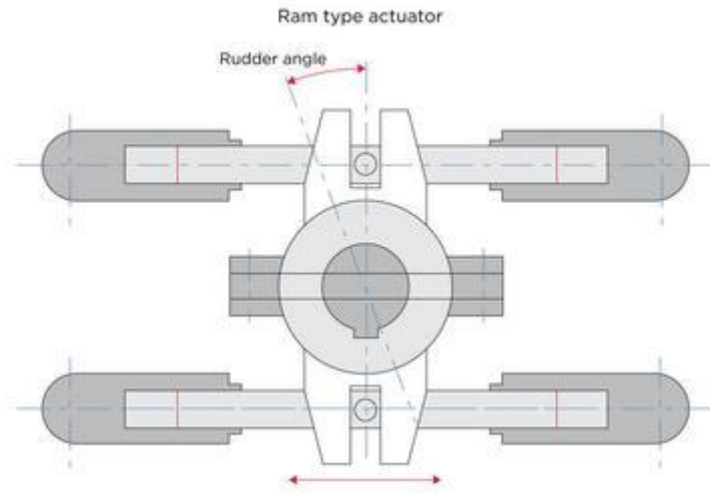
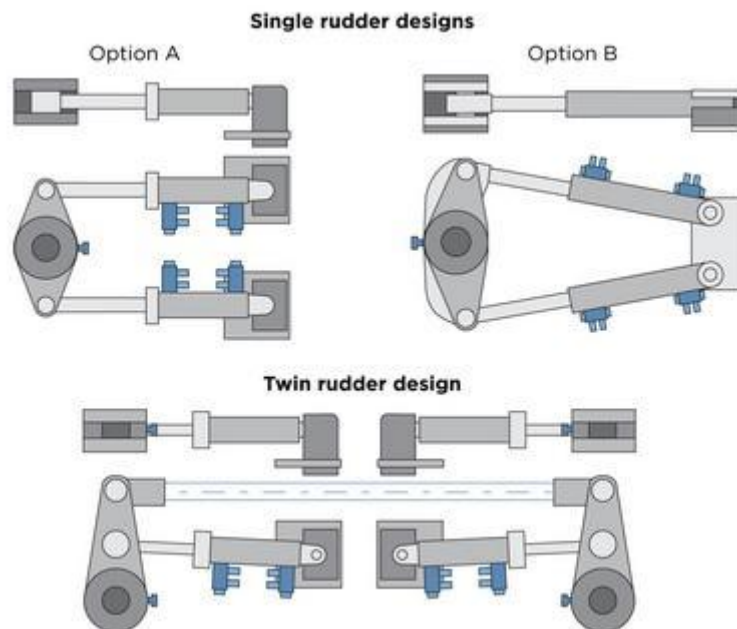


FIGURE 3
Steering Gear with Linked Cylinder Actuator (2024)



1.5.9 Rudder Stock (2024)

Rudder stock is a vertical shaft that connects the rudder to the steering gear.

1.7 Steering Gear Compartment (1 July 2022)

The steering gear is to be protected from the weather. Steering gear compartments are to be readily accessible and, as far as practicable, separated from the machinery spaces. For vessels less than 90 meters in length, the power units may be located either within or outside of the compartment containing the rudder actuators. Working access is to be provided to the steering gear machinery and controls with handrails, gratings or other non-slip surfaces for suitable working conditions in the event of hydraulic fluid leakage.

In the event of control system failure, or the need to operate the main or the auxiliary steering gear from within the steering compartment or from positions other than the navigation bridge, vessels of 500 gross tons and above are to be provided with means to indicate the position of the rudder at these positions where emergency steering is to be conducted.

Steering gear compartments in vessels of 500 gross tons and above are to be provided with visual compass readings.

1.9 Performance for Vessels with Traditional Propulsion and Steering Systems for a Vessel's Directional Control (1 July 2020)

1.9.1 Main Steering Gear Capability (2024)

The steering gear is to be capable of:

- i. Putting the rudder from 35° on one side to 35° on the other side with the vessel running ahead at the maximum ahead service speed and at the summer load waterline and, under the same conditions, from 35° on either side to 30° on the other side in not more than 28 seconds

1.9.2 Auxiliary Steering Gear Capability

- i. The auxiliary steering gear, when it is not integral with the main steering gear, is to be capable of putting the rudder from 15° on one side to 15° on the other side in not more than 60 seconds with the vessel running ahead at half speed, or seven knots, whichever is greater.
- ii. The auxiliary steering gear is to be so arranged that the failure of the main steering gear will not render it inoperative. Likewise, failure of the auxiliary steering gear is not to affect the main steering gear.
- iii. An auxiliary steering gear is not required when the main steering gear comprises two or more power units, and is so arranged that after a single failure in its piping system or in one of the power units, the defect can be isolated so that the steering capability can be maintained or regained; and provided that the main steering gear is to be capable of operating the rudder, as required by , while all the power units are in operation.

1.9.3 Tugs of an Articulated Connection (2020)

For tugs of an articulated connection, where the steering system is optimized for the integrated tug-barge (ITB) system and the required "hard over" rudder angle of 35 degrees to 35 degrees for the tug operating alone results in excessive angles of heel when tested at maximum continuous RPM, a lesser angle is acceptable with the following condition:

- i. The required hard over rudder angle of 35 degrees to 35 degrees is to be demonstrated with the tug and barge coupled.
- ii. For the tug operating alone, the hard over rudder angle is to be tested at the maximum angle and conditions defined by the designer. The owner is to be aware of this operating mode and the rudder angle operating restrictions.
- iii. The test conditions defined in condition 4-3-3/1.9.2ii) are to be considered as the limit for operation while the tug is alone and means are to be provided to avoid exceeding this limit; the following are to be considered:
 - a. A warning plate indicating the maximum rudder angle and conditions for operating the tug alone is to be fitted at the navigating position.
 - b. An audible and visual alarm is to be fitted at the navigation bridge if the maximum rudder angle is exceeded.

The above arrangements are to be considered subject to the flag Administration approval.

1.10 Performance for Vessels with Propulsion and Steering Systems other than Traditional Arrangements (see 4-3-5, 4-3-6 and 4-3-8) for a Vessel's Directional Control (1 July 2020)

1.10.1 Vessels Fitted with Multiple Steering-Propulsion Units

For a vessel fitted with multiple steering-propulsion units, such as but not limited to azimuthing propulsors (thrusters) or water jet propulsion systems, each of the steering-propulsion units is to be provided with a main steering gear and an auxiliary steering gear or with two or more identical steering actuating systems in compliance with 1.10.3(c). The main steering gear and the auxiliary steering gear are to be so arranged that the failure of one of them will not render the other inoperative.

1.10.2 Vessels Fitted with a Single Steering-Propulsion Unit

For a vessel fitted with a single steering-propulsion unit, the steering gear is to be provided with two or more steering actuating systems and is compliance with 1.10.3(c). A detailed risk assessment is to be submitted in order to demonstrate that in the case of any single failure in the steering gear, control system and power supply, the ship steering is maintained.

1.10.3 Arrangements

1.10.3(a) The main steering gear arrangements for vessel's directional control is to be:

- i. Of adequate strength and capable of steering the vessel at maximum ahead service speed.
- ii. Capable of changing direction of the vessel's steering-propulsion unit from one side to the other at declared steering gear angle limits at an average turning speed of not less than 2.3°/s with vessel running ahead at maximum ahead service speed.
- iii. Operated by power.
- iv. Reverse direction of thrust in sufficient time, and so to bring the vessel to rest within a reasonable distance from maximum ahead service speed, is to be demonstrated and recorded.

The requirements in apply.

1.10.3(b) The auxiliary steering arrangements for vessel's directional control is to be:

- i. Of adequate strength and capable of steering the vessel at navigable speed and of being brought quickly into action in an emergency.
- ii. Capable of changing direction of the vessel's directional control system from one side to the other at declared steering angle limits at an average turning speed, of not less than 0.5°/s; with the vessel running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater; and
- iii. For all vessels, operated by power where necessary to meet the requirements of and in any vessel having power of more than 2,500 kW propulsion power per steering-propulsion unit.

The requirements in apply.

1.10.3(c) For a vessel fitted with a single steering-propulsion unit where the main steering gear comprises two or more identical power units and two or more identical steering actuators, an auxiliary steering gear need not be fitted provided that the steering gear:

- i. in a passenger vessel, is capable of satisfying the requirements in while any one of the power units is out of operation;
- ii. in a cargo vessel, is capable of satisfying the requirements in in while operating with all power units; and
- iii. is arranged so that after a single failure in its piping system or in one of the power units' steering capability can be maintained or speedily regained.

1.10.3(d) For a vessel fitted with multiple steering-propulsion systems, where each main steering system comprises two or more identical steering actuating systems, an auxiliary steering gear need not be fitted, provided that each steering gear:

- i. For a passenger vessel, is capable of satisfying the requirements in while any one of the steering gear steering actuating systems is out of operation;
- ii. For a cargo vessel, is capable of satisfying the requirements in while operating with all steering gear steering actuating systems;
- iii. is arranged so that after a single failure in its piping or in one of the steering actuating systems, vessel's steering capability can be maintained or speedily regained. The above capacity requirements apply regardless whether the steering systems are arranged with common or dedicated power units.

1.10.4 Independent Source of Power (applies to steering propulsion units having certain proven steering capability due to vessel speed also in case propulsion power has failed).

Where the propulsion power exceeds 2,500 kW per thruster unit, an alternative power supply, sufficient at least to supply the steering arrangements which comply with the requirements of 1.10.3(b).ii. and also its associated control system and the steering gear response indicator, is to be provided automatically, within 45 seconds, either from the emergency source of electrical power or from an independent source of power located in the

steering gear compartment. This independent source of power is to be used only for this purpose. In every vessel of 10,000 gross tonnage and upwards, the alternative power supply is to have a capacity for at least 30 minutes of continuous operation and in any other vessel for at least 10 minutes.

1.10.5 Electric and Electrohydraulic Steering Systems

For a vessel fitted with multiple steering systems, the requirements in 11.1 are to be applied to each of the steering systems.

1.10.6 Sea Trial Results

The stopping times, vessel headings and distances recorded on trials, together with the results of trials to determine the ability of vessels having multiple propulsion/steering arrangements to navigate and maneuver with one or more of these devices inoperative, are to be available on board for the use of the Master or designated personnel.

1.11 Plans and Particulars to be Submitted (2024)

The following plans and particulars are to be submitted for review **(R)** or for information **(I)**:

- Arrangement of steering gear machinery **(R)**
- Hydraulic piping system diagram **(R)**
- Power supply system diagrams **(R)**
- Motor control system diagrams **(R)**
- Steering control system diagrams including automatic isolating system in **(R)**
- Instrumentation and alarm system diagrams **(R)**
- Drawings and details for rudder actuators **(R)**
- Drawings, details and strength calculations for torque transmitting parts and parts subjected to internal hydraulic pressure **(I)**
- Weld details and welding procedure specifications **(R)**
- Strength calculations for rudder actuators and torque transmitting parts including those subjected to internal hydraulic pressure **(I)**
- Operating Instructions **(I)**
- Data sheet including rated torque **(I)**
- Failure mode and effect analysis **(I)**

3 Materials

3.1 General

All parts of the steering gear transmitting forces to the rudder and pressure retaining components of hydraulic rudder actuators are to be of steel, brass or other approved ductile material. Materials are not to have a tensile strength in excess of 650 N/mm² (66 kgf/mm², 94,300 psi).

Gray cast iron or other material having an elongation ($L_0/d = 4$) less than 12% in 50 mm (2 in.) is not to be used for these parts.

3.3 Material Testing (2024)

Except as modified below, materials for the parts and components mentioned in 3.1 are to be tested in the presence of the Surveyor in accordance with the requirements of Part 2, Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)* or other material specifications which are to be approved in connection with a particular design. See also consolidated table in 4-3-4/Table 1.

3.3.1 Coupling Bolts and Keys

Material tests for steering gear coupling bolts and torque transmitting keys need not be witnessed by the Surveyor, but manufacturer's test certificates traceable to these components are to be presented upon request.

3.3.2 Small Parts of Rudder Actuators

Material tests for forged, welded or seamless steel parts (including the internal components) of rudder actuators that are not more than 150 mm (6 in.) in internal diameter need not be carried out in the presence of the Surveyor. Such parts are acceptable on the basis of a review of mill certificates by the Surveyor.

3.3.3 Tie Rod Nuts

Material tests for commercially supplied tie-rod nuts need not be witnessed by the Surveyor provided the nuts are in compliance with the approved steering gear drawings and are marked and identified in accordance with a recognized industry standard. Mill test reports for the tie-rod nuts are to be made available to the Surveyor upon request. For all non-standard tie-rod nuts, material testing is required to be performed in the presence of the Surveyor.

3.3.4 Piping Material

Piping materials need not be tested in the presence of the Surveyor. Pipes are acceptable based on certification by the mill, and on physical inspection and review of mill certificate by the Surveyor.

3.4 Rotary Vane (2020)

Material tests for pressure retaining and torque transmitting components such as rotor, housing and cover are to be witnessed by the Surveyor. Material tests for the vanes are acceptable based on manufacturers certified material test reports.

TABLE 1
Required Material and Nondestructive Tests of Steering Gear Components (2024)

Steering Gear Part		Material Properties	Nondestructive Tests & Inspections		Visual Inspection and Component Certificate	
			Magnetic Particle, Liquid Penetrant, or Similar Tests, Ultrasonic Tests	Dimensional Inspection, Including Surface Condition	Visual Inspection (Surveyor)	Component Certificate
Piping		W(C+M)				W
Valve and Housing		SC(C+M)	W (UT+CD)	W	X	SC
Tiller		SC(C+M)	W (UT+CD)	W	X	SC
Hydraulic Cylinders	Cylinders	SC(C+M)	W (UT+CD)	W	X	SC
	Piston Rod	SC(C+M)	W (UT+CD)	W	X	SC
	Piston	W(C+M)	W (UT+CD)			W
	Cover	W(C+M)	W (UT+CD)			W
Stopper		W(C+M)	W (UT+CD)			W
Coupling Bolts and Keys		W(C+M)				W
Tie Rods	Rods	SC(C+M)	W (UT+CD)	W	X	SC
	Nuts	W(C+M)				W
Rotary Vane	Rotor	SC(C+M)	W (UT+CD)	W	X	SC
	Vane	W(C+M)	W (UT+CD)			W
	Housing/ Stator	SC(C+M)	W (UT+CD)	W	X	SC
	Cover	W(C+M)	W (UT+CD)			W

Symbol Description:

C: chemical composition; CD: crack detection by MPI or DP; D: cylinder bore diameter (mm); GJL: gray cast iron; GJS: spheroidal graphite cast iron; GS: cast steel; M: mechanical properties; SC: Society certification; TR: test report; UT: ultrasonic testing; W: work's certificate; X: visual examination of accessible surfaces by the Surveyor.

5 System Arrangements

5.1 Power Units

The steering gear is to be composed of two or more identical power units and is to be capable of operating the rudder as required by [1.9.1.i](#) and [4-3-4/1.9.1.ii](#). The power units are to be served by at least two power circuits (see [11](#)). Power units are required to be type tested, see [19.5](#).

5.3 Rudder Actuators

Steering gears may be composed of a single rudder actuator for all vessels except the following:

- For oil carriers, fuel oil carriers, chemical carriers and gas carriers of 100,000 tonnes deadweight and above, the steering gear is to be comprised of two or more identical rudder actuators.
- For oil carriers, fuel oil carriers, chemical carriers and gas carriers of 10,000 gross tonnage and above but less than 100,000 tonnes deadweight, the steering gear may be comprised of a single, non-duplicated rudder actuator, provided it complies with .

5.5 Single Failure Criterion

The hydraulic system is to be designed so that after a single failure in the piping system or one of the power units, the defect can be isolated so that the integrity of the remaining part of the system will not be impaired and the steering capability can be maintained or speedily regained. See also [9](#).

5.7 Independent Control Systems

Two independent steering gear control systems are to be provided, each of which can be operated from the navigation bridge. These control systems are to allow rapid transfer of steering power units and of control between the units. See [13](#).

5.9 Non-duplicated Components

Essential components which are not required to be duplicated are to utilize, where appropriate, anti-friction bearings, such as ball bearings, roller bearings or sleeve bearings which are to be permanently lubricated or provided with lubrication fittings.

5.11 Power Gear Stops

The steering gear is to be fitted with arrangements, such as limit switches, for stopping the gear before the structural rudder stops (see [3-2-14/1.9](#)) or positive mechanical stops within the steering gear are reached. These arrangements are to be synchronized with the rudder stock or the position of the gear itself and may be an integral part of the rudder actuator. Arrangements to satisfy this requirement through the steering gear control system are not permitted.

5.13 Steering Gear Torques

5.13.1 Minimum Required Rated Torque

The rated torque of the steering gear is not to be less than the expected torque as defined in [3-2-14/1.7](#).

5.13.2 Maximum Allowable Torque

The transmitted torque, $T_{\max}$, of the steering gear is not to be greater than the maximum allowable torque, T_{ar} , based on the actual rudder stock diameter.

5.13.2(a) Transmitted torque. (2020)

The transmitted torque, $T_{\max}$, is to be based on the relief valve setting and to be determined in accordance with the following equations:

- For ram type actuator:

$$T_{\max} = P \cdot N \cdot A \cdot L_2 / (C \cdot \cos^2 \theta) \quad \text{kN-m (tf-m, Ltf-ft)}$$

- For rotary vane type actuator:

$$T_{\max} = P \cdot N \cdot A \cdot L_2 / C \quad \text{kN-m (tf-m, Ltf-ft)}$$

- For linked cylinder type actuator:

$$T_{\max} = P \cdot N \cdot A \cdot L_2 \cos \theta / C \quad \text{kN-m (tf-m, Ltf-ft)}$$

where

P	=	steering gear relief valve setting pressure, bar (kgf/cm ² , psi)
N	=	number of active pistons or vanes
A	=	area of piston or vane, mm ² (cm ² , in ²)
L_2	=	torque arm, equal the distance from the point of application of the force on the arm to the center of the rudder stock at zero (0) degrees of rudder angle, m (ft)
C	=	factor, 10000 (1000, 2240)
θ	=	maximum permissible rudder angle (normally 35 degrees)

5.13.2(b) Maximum allowable torque for rudder stock. (2020)

The maximum allowable torque, T_{ar} , for the actual rudder stock diameter is to be determined in accordance with the following equation:

$$T_{ar} = 2.0(D_r/N_u)^3/K_s \quad \text{kN-m (tf-m, Ltf-ft)}$$

where

K_s	=	material factor for rudder stock (see 3-2-14/1.5)
D_r	=	actual rudder stock diameter at minimum point below the tiller or the rotor, mm (mm, in)
N_u	=	factor, 42.0 (89.9, 2.39)

7 Mechanical Component Design

7.1 Mechanical Strength

All mechanical components, which transmit force to or from the rudder, are to have strength equivalent to that of the Rule required upper rudder stock (see 1.5.8).

7.3 Rudder Actuators

7.3.1 Design

Rudder actuators are to be designed in accordance with the requirements of pressure vessels in Section 4-1-1, except that the maximum allowable stress S is not to exceed the lower of the following:

$$\frac{U}{A} \text{ or } \frac{Y}{B}$$

where

U = minimum specified tensile strength of material at room temperature

Y = minimum specified yield point or yield strength

A and B are factors given below:

	Rolled or forged steel	Cast steel	Nodular cast iron
A	3.5	4	5
B	1.7	2	3

For requirements relative to vessels intended to carry oil, chemicals, or liquefied gases in bulk of 10,000 gross tonnage and over, but less than 100,000 tonnes deadweight, fitted with non-duplicated rudder actuators, see 25.5.

7.3.2 Oil Seals

Oil seals between non-moving parts forming part of the exterior pressure boundary are to be of the metal upon metal type or of an equivalent type. Oil seals between moving parts forming part of the external pressure boundary are to be fitted in duplicate so that the failure of one seal does not render the actuator inoperative. Alternative seal arrangements are acceptable provided equivalent protection against leakage can be assured.

7.5 Tillers, Quadrants and Other Mechanical Parts

7.5.1 General

All steering gear parts, such as tillers, quadrants, rams, pins, tie rods and keys, which transmit force to or from the rudder, are to be proportioned so as to have strength equivalent to that of the Rule required upper rudder stock, taking into consideration the difference in materials between the rudder stock and the component.

7.5.2 Tillers and Quadrants

7.5.2(a) Tiller or quadrant hub.

Dimensions of the hub are to be as follows (use consistent system of units):

- i. Depth of hub is not to be less than S .
- ii. Mean thickness of hub is not to be less than $S/3$.
- iii. Notwithstanding above, polar section modulus of hub is not to be less than that given below:

$$0.196S^3 \frac{K_h}{K_s}$$

where

S = Rule required upper rudder stock diameter

K_s = material factor of rudder stock (see)

K_h = material factor of hub (see)

7.5.2(b) Tiller or quadrant arm.

The section modulus of the tiller or quadrant arm anywhere along its length is not to be less than that given below (use consistent system of units):

$$\frac{0.167S^3 (L_2 - L_1)}{L_2} \cdot \frac{K_t}{K_s}$$

where

L_2 = distance from the point of application of the force on the arm to the center of the rudder stock

L_1 = distance between the section of the arm under consideration and the center of the rudder stock

K_t = material factor of tiller or quadrant arm (see 3-2-14/1.5)

Other symbols are as defined above.

7.5.2(c) Bolted hub.

Split or semi-circular tiller or quadrant hubs assembled by bolting are to have bolts on any side having total cross-sectional area not less than that given below (use consistent system of units):

$$\frac{0.196S^3}{L_3} \cdot \frac{K_b}{K_s}$$

where

L_3 = distance between the center of the bolts and the center of the rudder stock

K_b = material factor of bolt (see 3-2-14/1.5)

Other symbols are as defined above.

The thickness of the bolting flange is not to be less than the minimum required diameter of the bolt.

7.5.2(d) Tiller pin. (2020)

The total effective shear area of tiller pin is not to be less than that given below. (Use consistent system of units):

$$\frac{0.196S^3}{L_2} \cdot \frac{K_p}{K_s}$$

where

K_p = material factor of the pin (see 3-2-14/1.5).

Other symbols are defined above.

7.5.3 Tie Rod

For multiple rudder installations or similar, where tie rod (or jockey bar) is fitted between tillers to synchronize them, the buckling strength of the tie rod is not to be less than that given below (use consistent system of units):

$$\frac{0.113S^3U_R}{L_2}$$

where

U_R = ultimate tensile strength of the rudder stock

Other symbols are defined above.

7.7 Rudder Stock to Tiller/Quadrant Connection

7.7.1 Key

The effective area of the key in shear is not to be less than that given below (use a consistent system of units):

$$\frac{0.196S^3}{r} \frac{K_k}{K_s}$$

where

S = Rule required upper rudder stock diameter
 r = actual rudder stock radius at mid length of key
 K_s = material factors of rudder stock (see 3-2-14/1.5)
 K_k = material factors of key (see 3-2-14/1.5)

Bearing stresses of the tiller and rudder stock keyways are not to be more than 90% of the applicable material yield stress.

7.7.2 Keyless Coupling

Hydraulic or shrink fitted keyless coupling is to be based on preload stress calculations and fitting procedures. The calculated torsional holding capacity is to be at least 2.0 times the transmitted torque based on the steering gear relief valve setting. The coefficient of friction for the oil injection method of fit is to be taken as no greater than 0.14 and that for dry method is to be taken as no greater than 0.17. Preload stress is not to exceed 90% of

the minimum yield strength. Maximum equivalent Von-Mises Stress is not to exceed minimum yield strength considering all loads including preload stress and two times transmitted torque.

7.9 Welding

All welded joints within the pressure boundary of a rudder actuator or connecting parts transmitting mechanical loads are to be full penetration type or to be of other approved design.

9 Hydraulic System

9.1 System Design

9.1.1 General

The hydraulic system is to be fitted with two or more power units, see 5.1. It may be fitted with a single hydraulic rudder actuator unless required otherwise by 5.3.

9.1.2 Piping Arrangements

Piping is to be arranged such that:

- Single failure criteria in are met.
- Transfer between power units can be readily effected.
- Air may be bled from the system.

9.1.3 Hydraulic Locking (2023)

Hydraulic locking includes all situations where two hydraulic systems (usually identical) oppose each other in such a way that it may lead to loss of steering. It can either be caused by pressure in the two hydraulic systems working against each other or by hydraulic "by-pass" meaning that the systems puncture each other and cause pressure drop on both sides or make it impossible to build up pressure. Hydraulic locking may occur where a piping system is arranged such that malfunctions (for example, in directional valves or in the valve control) can cause power units to work in a closed circuit against each other rather than in parallel delivering fluid to the rudder actuator, thus resulting in loss of steering. Where a single failure can lead to hydraulic locking and loss of steering, an audible and visual hydraulic locking alarm, which identifies the failed system, is to be provided on the navigation bridge. See also Note 4 of TABLE 2.

Alternatively, an independent steering failure alarm for follow-up control systems complying with the following requirements may be provided in lieu of a hydraulic locking alarm.

Where an independent steering failure alarm is installed for follow-up control systems, it is to comply with the following:

9.1.3(a)

The steering failure alarm system is to actuate an audible and visible alarm in the wheelhouse when the actual position of the rudder differs by more than 5 degrees from the rudder position ordered by the follow-up control systems for more than:

- 30 seconds for ordered rudder position changes of 70 degrees;
- 6.5 seconds for ordered rudder position changes of 5 degrees; and

The time period calculated by the following formula for ordered rudder positions changes between 5 degrees and 70 degrees:

$$t = (R/2.76) + 4.64$$

where:

t = maximum time delay in seconds

R = ordered rudder change in degrees

9.1.3(b)

The steering failure alarm system is to be separated from, and independent of, each steering gear control system, except for input received from the steering wheel shaft.

9.1.3(c)

Each steering failure alarm system is to be supplied by a circuit that:

- i. Is independent of other steering gear system and steering alarm circuits.
- ii. Is fed from the emergency power source through the emergency distribution panel in the wheelhouse, if installed; and
- iii. Has no overcurrent protection except short circuit protection.

9.1.4 Isolation Valves

Isolating valves are to be fitted on the pipe connections to the rudder actuators. For vessels with non-duplicated rudder actuators, the isolating valves are to be directly mounted on the actuator.

9.1.5 Filtration

A means is to be provided to maintain the cleanliness of the hydraulic fluid.

9.1.6 System Over-pressure Protection

Relief valves are to be provided for the protection of the hydraulic system at any part which can be isolated and in which pressure can be generated from the power source or from external forces. Each relief valve is to be capable of relieving not less than 110% of the full flow of the pump(s) which can discharge through it. With this flow condition the maximum pressure rise is not to exceed 10% of the relief valve setting, taking into consideration increase in oil viscosity for extreme ambient conditions.

The relief valve setting is to be at least 1.25 times the maximum working pressure (see 1.5.5), but is not to exceed the maximum design pressure (see 9.5.1).

9.1.7 Fire Precautions

Where applicable, the requirements of 4-6-7/3.7.1 are to be met.

9.3 Hydraulic Oil Reservoir and Storage Tank

In addition to the power unit reservoir, a fixed hydraulic oil storage tank independent of the reservoir is to be provided for vessels of 500 gross tons and above. The storage tank is to have sufficient capacity to recharge at least one power actuating system, including the power unit reservoir. The tank is to be permanently connected by piping in such a manner that the system can be readily recharged from a position within the steering gear compartment. The storage tank is to be provided with an approved level indicating system.

See also 4-6-7/3.3 for arrangements of the power unit reservoir and the storage tank.

9.5 Piping Design

9.5.1 System Pressure

Hydraulic system piping is to be designed to at least 1.25 times the maximum working pressure (1.5.5), taking into account any pressure which may exist in the low-pressure side of the system.

9.5.2 Pipes and Pipe Fittings

Pipes and pipe branches are to meet the design requirements of [4-6-2/5.1](#) and [4-6-2/5.3](#). Pipe joints are to be in accordance with [4-6-2/5.5](#), and [4-6-7/3.5.1](#). Particular attention is to be paid to footnotes 1 and 2 in [4-6-7/3.5.1](#) [TABLE 1](#) where additional limitations on pipe joints are specified for steering gear hydraulic piping. See also [9.7.3](#).

9.7 Piping Components

9.7.1 Power Units

Power units are to be certified by ABS. See [5.1](#) and [19.5](#).

9.7.2 Rudder Actuators

Rudder actuators are to be design approved and are to be certified by ABS. See [5.3](#), [7.3](#) and [19.7](#).

9.7.3 Pipes and Pipe Fittings

For pipes and pipe fittings, refer to [9.5.2](#). Piping materials for hydraulic service are to be traceable to manufacturers' certificates, but need not be certified by ABS. See also [4-6-1/7](#) for certification of piping system components.

9.7.4 Other Piping Components

For valves, hoses and accumulators, refer to [4-6-7/3.5](#). For relief valve, see also [9.1.6](#).

9.7.5 Relief Valves

In addition to [9.7.4](#), discharge capacity test reports verifying the capacity required in [9.1.6](#) for all relief valves are to be submitted for review.

11 Electrical Systems

11.1 Power Supply Feeder (2020)

Each electric or electrohydraulic steering gear is to be served by at least two exclusive circuits, fed directly from the main switchboard; however, one of the circuits may be supplied through the emergency switchboard. Each of duplicated power units required by [5.1](#) is to be served by one of these circuits. The circuits supplying an electric or electrohydraulic steering gear are to have adequate rating for supplying all motors, control systems and instrumentation which are normally connected to them and operated simultaneously. The circuits are to be separated throughout their length as widely as is practicable. See also [4-8-2/7.11](#) for steering gear power supply.

For vessels fitted with alternative propulsion and steering arrangements, such as azimuthing propulsors, where the propulsion power exceeds 2,500 kW per thruster unit, see [4-3-5/5.12.3](#).

11.3 Electrical Protection (2020)

11.3.1 General

Each steering gear feeder is to be provided with short-circuit protection which is to be located at the main or the emergency switchboard, as applicable. Power unit motor overload protection is normally not to be provided, except as indicated in [4-8-2/9.17.5\(a\)](#). Other means of protection, namely, motor overload alarm and motor phase failure alarm, as applicable, are to be provided as indicated in [TABLE 2](#) item d. See also [4-8-2/9.17.5](#) for protection of steering gear feeder circuit.

11.5 Undervoltage Release

Power unit motor controllers and other automatic motor controllers are to be fitted with undervoltage release (capable of restarting automatically when power is restored after a power failure).

11.7 Motor Rating

11.7.1 Steering Gears with Intermittent Working Duty

Electric motors of, and converters associated with, electro-hydraulic steering gears with intermittent working duty are to be at least of 25% non-periodic duty rating (corresponding to S6 of IEC Publication 60034-1) as per 4-8-3/3.3.3 and 4-8-3/TABLE 4. Electric motors of electro-mechanical steering gears are, however, to be at least of 40% non-periodic duty rating (corresponding to S3 of IEC Publication 60034-1).

11.7.2 Steering Gears with Continuous Working Duty

Electric motors of, and converters associated with, steering gears with continuous working duty are to be of continuous rating (corresponding to S1 of IEC Publication 60034-1) as per 4-8-3/3.3.4 and 4-8-3/TABLE 4.

11.9 Emergency Power Supply (2020)

Where the required rudder stock diameter (see 1.5.8) is over 230 mm (9 inches), an alternative power supply, sufficient at least to supply one steering gear power unit and its associated control system and the rudder angle indicator, is to be provided automatically within 45 seconds either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power is to be used only for this purpose.

The steering gear power unit under alternative power supply is to be capable of moving the rudder as required by 4-3-4/1.9.2i).

In every vessel of 10,000 gross tonnage and upwards, the alternative power supply is to have a capacity for at least 30 minutes of continuous operation and in any other vessel for at least 10 minutes.

13 Control Systems

13.1 General

13.1.1 Redundancy (2020)

There are to be two independent control systems (see definition in 1.5.6) provided, each of which can be operated from the navigation bridge. Steering gear controls are to be located in the navigation bridge and steering gear compartment or the space containing the power unit, as applicable. These control systems are to be independent in all respects and are to provide on the navigation bridge all necessary apparatus and arrangements for the starting and stopping of steering gear motors and the rapid transfer of steering power and control between units.

Control cables and piping for the independent control systems are to be separated throughout their length as widely as is practicable.

Wires, terminals and the components for duplicated steering gear control systems installed in units, control boxes, switchboards or bridge consoles are to be separated throughout their length as widely as is practicable. Where physical separation is not practicable, separation may be achieved by means of a fire retardant plate.

13.1.2 Local Steering Gear Control

Local steering gear control is to be provided in the steering gear compartment. However, if the power unit is located in a space other than the steering compartment, the local control is to be provided in that space instead of the steering compartment. For the purpose of local control from the steering gear compartment (or the space containing the power unit), a means is to be provided in the steering compartment (or the space containing the

power unit) to disconnect any control system from the navigation bridge. Such means for disconnecting are to be operable by a single person without the need for tools. See [13.5.1](#).

13.1.3 Duplication

All electric components of the steering gear control system are to be duplicated. This does not require duplication of a steering wheel or steering lever.

13.1.4 Steering Mode Selector Switch

If a joint steering mode selector switch (uniaxial switch) is employed for both steering gear control systems, the connections for the circuits of the control systems are to be divided accordingly and separated from each other by an isolating plate or by air gap.

13.1.5 Follow-up Amplifier

In the case of double follow-up control, the amplifiers are to be designed and fed so as to be electrically and mechanically separated. In the case of non-follow-up control and follow-up control, the follow-up amplifiers are to be protected selectively.

13.1.6 Additional Control Systems

Control circuits for additional control systems, e.g. steering lever or autopilot, are to be designed for all - pole disconnection.

13.1.7 Feed-back Units and Limit Switches

The feed-back units and limit switches, if any, for the steering gear control systems are to be separated electrically and mechanically connected to the rudder stock or actuator separately.

13.1.8 Hydraulic Control Components

Hydraulic system components in the power actuating or hydraulic servo systems controlling the power systems of the steering gear, (e.g. solenoid valves, magnetic valves,) are to be considered as part of the steering gear control system and are to be duplicated and separated.

Hydraulic system components in the steering gear control system that are part of a power unit may be regarded as being duplicated and separated when there are two or more separate power units provided and the piping to each power unit can be isolated.

13.1.9 System Response Under Failure (1 July 2023)

The failures (as listed, but not limited to those items in [TABLE 2](#)) likely to cause uncontrolled movements of rudder are to be clearly identified. In the event of detection of such failure, the rudder is to stop in the current position without manual intervention or is to return to the midship/neutral position. Failure Mode and Effect Analysis methodology may be used to identify the failures. For mechanical failures such as sticking valves and failure of static components (pipes, cylinders), the system response without manual intervention is not mandatory, and the operator can follow instructions on the signboard in case of such failures, in accordance with [21.3](#). For hydraulic locking failure, refer also to [9.1.3](#) and [21.3](#).

13.3 Control Power Supply (2020)

If the control systems operable from the navigation bridge are electric, then each system is to be served by its own separate circuits supplied from a steering gear power circuit in the steering gear compartment, or directly from the switchboard bus bars supplying that steering gear power circuit at a point on the switchboard adjacent to the supply to the steering gear power circuit.

Circuits supplying power to steering gear controls are to be provided with short-circuit protection only.

13.5 Control System Override

13.5.1 Steering Gear Compartment

Means are to be provided in the steering gear compartment to disconnect the steering gear control system from the power circuit when local control is to be used. Additionally, if more than one steering station is provided, a selector switch is to disconnect completely all stations, except the one in use.

13.5.2 Autopilot

13.5.2(a)

Steering gear systems provided with an autopilot system are to have a device at the primary steering station to completely disconnect the autopilot control to permit change over to manual operation of the steering gear control system. A display is to be provided at the steering station such that the helmsman can readily and clearly recognize which mode of steering control (autopilot or manual) is in operation.

13.5.2(b) (2020)

In addition to the change over device as in 13.5.2(a), for primary steering stations, where fitted with an automatic autopilot override to change over from autopilot control to manual operation, the following are to be provided.

An audible and visual alarm is to be provided at the primary steering station in the event that:

- i. The automatic autopilot override fails to respond when the manual helm order is 5 degrees of rudder angle or greater, and
- ii. It is immediately activated upon automatic autopilot override actuation.

The alarm is to be separate and distinct from other bridge alarms, and is to continue to sound until it is acknowledged.

13.7 Hydraulic Telemotor

Where the control system consists of a hydraulic telemotor, a second independent system need not be fitted, except in oil or fuel oil carriers, chemical carriers, or gas carriers of 10,000 gross tonnage and above (see also 25).

13.9 Computer-based Systems

Steering control systems that are computer-based systems are to comply with Section 4-9-3 and are to be considered system category III.

15 Instrumentation (2024)

Instruments for monitoring the steering gear system are to be provided as indicated in TABLE 2. All alarms are to be audible and visual and are to be of the self-monitoring type so that a circuit failure will cause an alarm condition. There are to be provisions for testing alarms. Alarms are to be tested in the presence of the Surveyor.

TABLE 2
Steering Gear Instrumentation (2023)

Monitored parameters	Display / Alarm	Location
a) Rudder angle indicator ⁽¹⁾	Display	• Navigation bridge • Steering gear compartment
b) Power unit motor running	Display	• Navigation bridge • Engine room control station

Monitored parameters	Display / Alarm	Location
c) Power unit power supply failure	Alarm	• Navigation bridge • Engine room control station
d) Power unit motor overload ⁽²⁾	Alarm	• Navigation bridge • Engine room control station
e) Power unit motor phase failure ^{(2), (3)}	Alarm	• Navigation bridge • Engine room control station
f) Control power failure	Alarm	• Navigation bridge • Engine room control station
g) Hydraulic oil reservoir low level ⁽²⁾	Alarm	• Navigation bridge • Engine room control station
h) Hydraulic locking ⁽⁴⁾	Alarm	• Navigation bridge
i) Auto-pilot running ⁽⁵⁾	Display	• Navigation bridge
j) Auto-pilot failure ⁽⁵⁾	Alarm	• Navigation bridge
k) Steering mode (autopilot/manual) indication	Display	• Navigation bridge
l) Automatic autopilot ⁽⁵⁾ override failure	Alarm	• Navigation bridge
m) Automatic autopilot ⁽⁵⁾ override activated	Alarm	• Navigation bridge
n) Loop failures ⁽⁶⁾	Alarm	• Navigation bridge
o) Computer-based system failures ⁽⁷⁾	Alarm	• Navigation bridge
p) Earth fault on AC and DC circuits	Alarm	• Navigation bridge
q) Deviation between rudder order and feedback ⁽⁸⁾	Alarm	• Navigation bridge

Notes:

- 1 The rudder angle indication is to be independent of the steering gear control system, and readily visible from the control position.
- 2 The operation of this alarm is not to interrupt the circuit.
- 3 For three phase AC supply only.
- 4 The alarm is to be activated when position of the variable displacement pump control system does not correspond to the given order; or when incorrect position of 3-way full flow valve or similar in constant delivery pump system is detected. Monitoring for hydraulic locking is not required, when a steering failure alarm system is provided. See [9.1.3\(a\)](#) to [9.1.3\(c\)](#).
- 5 If provided.
- 6 Monitoring is to be provided for short circuit, broken connections and earth faults for command and feedback loops. Monitoring for loop failures is not required, when a steering failure alarm system is provided. See [9.1.3\(a\)](#) to [9.1.3\(c\)](#).
- 7 For steering control systems that are computer-based systems, monitoring is to be provided for data communication errors, computer hardware failures and software failure. See also Section [4-9-3](#). Monitoring for computer-based system failures is not required, when a steering failure alarm system is provided. See [9.1.3\(a\)](#) to [9.1.3\(c\)](#).
- 8 Deviation alarm is to be initiated if the rudder's actual position does not reach the set point within acceptable time limits for the closed loop control systems (e.g. follow-up control and autopilot). Deviation alarm can be caused by mechanical, hydraulic or electrical failures. For acceptable time delay period, please refer to [9.1.3\(a\)](#).

17 Communications

A means of communication is to be provided between the navigation bridge and the steering gear compartment including all other locations where steering can be effected. Additionally, communication is to be provided between these spaces and the main propulsion control station, in accordance with [4-8-2/11.5](#).

19 Certification

19.1 General (2024)

Steering gear components are to be inspected, tested and certified by a Surveyor at the plant of manufacture in accordance with the following requirements. Hydraulic oil pumps are to be certified, see [4-6-1/7.3.1.i](#). See also consolidated table in [TABLE 3](#).

19.3 Material Testing

For testing of steering gear component materials, see 3.3.

19.5 Prototype Tests of Power Units

Where the Rules required upper rudder stock diameter is 120 mm (4.7 in.) or greater, power units are to be tested and certified in accordance with the following requirements. For required upper rudder stock diameter less than 120 mm (4.7 in.), and where the vessel is 500 gross tons or greater, power units are to be tested and certified in accordance with 4-6-1/7.3 only. For vessels less than 500 gross tons, power units are acceptable based on manufacturer’s guarantee for suitability for the intended purpose and subject to satisfactory functional tests after installation.

A prototype of each new design power unit pump is to be shop tested for a duration of not less than 100 hours. The testing is to be carried out in accordance with an approved program and is to include the following as a minimum:

- i. The pump and stroke control (or directional control valve) is to be operated continuously from full flow and relief valve pressure in one direction through idle to full flow and relief valve pressure in the opposite direction.
- ii. Pump suction conditions are to simulate lowest anticipated suction head. The power unit is to be checked for abnormal heating, excessive vibration, or other irregularities. Following the test, the power unit pump is to be disassembled and inspected in the presence of a Surveyor.

19.7 Components Shop Tests

Each component of the steering gear piping system, including the power units, rudder actuators and piping is to be inspected by a Surveyor during fabrication and hydrostatically tested to 1.5 times the relief valve setting (or system design pressure) in the presence of a Surveyor.

TABLE 3
Certification of Steering Gears and Components (2024)

Steering Gear and Components	Certificate Type	Design Assessed	Manufacture Survey	Surveyor Attendance upon Installation	Rules Reference
Piping Assemblies	SC	x	x	x	4-3-4/9, 4-6-2/5, 4-6-7/3
Hydraulic Cylinders Assemblies (where separately supplied)	SC	x	x	x	4-3-4/9
Actuators System for Steering (where separately supplied)	SC	x	x	x	4-3-4/9
Pumps	SC	-	x	x	4-6-1/7.3.1.i
Control and Monitoring System	SC	x	x	x	4-3-4/11, /13, /15, /17
Steering Gear	SC	x	x	x	4-3-4

Symbol Description: SC: Society certificate; W: work’s certificate

21 Installation, Tests and Trials

21.1 Steering Gear Seating

Steering gears are to be bolted to a substantial foundation effectively attached to the hull structure. Suitable chocking arrangements are to be provided to the satisfaction of the Surveyor.

21.3 Operating Instructions

Operating instructions with a block diagram showing change-overprocedures for steering gear control systems and steering gear power units are to be permanently displayed on the navigation bridge and in the steering gear

compartment. Where failure alarms are provided to indicate hydraulic locking, instructions are to be permanently posted on the navigation bridge and in the steering gear compartment for the operator to shut down the failed system.

21.5 Installation Tests

After installation on board the vessel, the complete piping system, including power units, rudder actuators and piping is to be subjected to a hydrostatic test equal to 110% of the relief valve setting, including a check of the relief valve operation in the presence of the Surveyor.

21.7 Sea Trials

The steering gear is to be tried out on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of this section have been met. The trials are to be performed with the rudder fully submerged. Where full rudder submergence cannot be obtained in ballast conditions, steering gear trials are to be conducted at a displacement as close as reasonably possible to full-load displacement as required by Section 6.1.2 of ISO 19019:2005 on the conditions that either:

- i. The rudder is fully submerged (zero speed waterline) and the vessel is in an acceptable trim condition.
- ii. The rudder load and torque at the specified trial loading condition have been predicted (based on the system pressure measurement) and extrapolated to the full load condition using the following method to predict the equivalent torque and actuator pressure at the deepest seagoing draft:

$$Q_F = Q_T \alpha$$

$$\alpha = 1.25 \left(\frac{A_F}{A_T} \right) \left(\frac{V_F}{V_T} \right)^2$$

where

α = extrapolation factor

Q_F = rudder stock moment for the deepest service draft and maximum service speed condition

Q_T = rudder stock moment for the trial condition

A_F = total immersed projected area of the movable part of the rudder in the deepest seagoing condition

A_T = total immersed projected area of the movable part of the rudder in the trial condition

V_F = contractual design speed of the vessel corresponding to the maximum continuous revolutions of the main engine at the deepest seagoing draft

V_T = measured speed of the vessel (considering current) in the trial condition

Where the rudder actuator system pressure is shown to have a linear relationship to the rudder stock torque, the above equation can be taken as:

$$P_F = P_T \alpha$$

where

P_F = estimated steering actuator hydraulic pressure in the deepest seagoing draft condition

P_T = maximum measured actuator hydraulic pressure in the trial condition

Where constant volume fixed displacement pumps are utilized, the requirements can be deemed satisfied if the estimated steering actuator hydraulic pressure at the deepest draft is less than the specified maximum working pressure of the rudder actuator. Where a variable delivery pump is utilized, pump data are to be supplied and interpreted to estimate the delivered flow rate that corresponds to the deepest seagoing draft in order to calculate the steering time and allow it to be compared to the required time.

Where A_T is greater than $0.95A_F$, there is no need for extrapolation methods to be applied.

- iii. Alternatively the designer or builder may use computational fluid dynamic (CFD) studies or experimental investigations to predict the rudder stock moment at the full sea going draft condition and service speed. These calculations or experimental investigations are to be to the satisfaction of ABS.

In any case for the main steering gear trial, the speed of ship corresponding to the number of maximum continuous revolution of main engine and maximum design pitch applies.

21.7.1 Full Speed Trial (2024)

Satisfactory performance is to be demonstrated under the following conditions:

- i. Changing the rudder position from 35° on either side to 30° on the other side in not more than 28 seconds with the vessel running ahead at the maximum ahead service speed. For controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for the above maximum continuous ahead rated rpm.
- ii. Unless, or is applicable, this test is to be carried out with all power units intended for simultaneous operation for this condition under actual operating conditions.

21.7.2 Half Speed Trial (2024)

Satisfactory performance is to be demonstrated under the following conditions.

- i. Changing the rudder position from 15° on either side to 15° on the other side in not more than 60 seconds while running at one-half of the maximum ahead service speed or 7 knots whichever is the greater.
- ii. This test is to be conducted with either one of the power units used in reserve.
- iii. This test may be waived where the steering gear consists of two identical power units with each capable of meeting the requirements in

21.7.3 Steering Gears with More than Two Power Units

Where three or more power units are provided, the test procedures are subject to the basis of the specifically approved operating arrangements of the steering gear system.

21.7.4 Additional Items

The trial is also to include the operation and verification of the following:

- i. The power units, including transfer between power units.
- ii. The emergency power supply, if applicable.
- iii. The steering gear controls, including transfer of control, and local control.
- iv. The means of communication between the navigation bridge, engine room, and the steering gear compartment.
- v. The alarms and indicators required by above (test may be done at dockside).
- vi. The storage and recharging system in above (test may be done at dockside).
- vii. The isolation of one power actuating system and time for regaining steering capability (test may be done at dockside).
- viii. Where steering gear is designed to avoid hydraulic locking (above), this feature is to be demonstrated.
- ix. Where practicable, simulation of single failure in the hydraulic system, and demonstration of the means provided to isolate it and the regaining of steering capability, as in and above.
- x. The stopping of the steering gear before the rudder stop is reached, as in above.

23 Additional Requirements for Passenger Vessels

23.1 Performance

The steering gear is to be designed to be capable of operating the rudder as required by 1.9.1.i. with any one of the power units inoperative.

23.3 Sea Trials

The performance test criteria in 21.7.1.i. is to be demonstrated during sea trial with any one of the power units in reserve.

25 Additional Requirements for Oil or Fuel Oil Carriers, Chemical Carriers and Gas Carriers

25.1 Vessels of 10,000 Gross Tonnage and Upwards

25.1.1 Single Failure Criterion

The steering gear is to be so arranged that in the event of the loss of steering capability due to a single failure in any part of one of the power actuating systems (see 1.5.3), excluding the tiller, quadrant or components serving the same purpose, or seizure of the rudder actuators, steering capability is to be regained in not more than 45 seconds.

25.1.2 Power Actuating System

The steering gear is to comprise either:

- i. Two independent and separate power actuating systems, each capable of meeting the requirements of ; or
- ii. At least two identical power actuating systems which, acting simultaneously in normal operation, are to be capable of meeting the requirements of Where necessary to comply with this requirement, interconnection of hydraulic power actuating systems may be provided. Loss of hydraulic fluid from one system is to be capable of being detected and the defective system automatically isolated so that the other actuating system or systems is to remain fully operational.

The electric power and control system for the above automatic isolating system is to be of fail-safe design, see and is to have a self-monitoring feature, see . Where the automatic isolating system is a computer based system, the system is to be of Category III in accordance with .

25.1.3 Non-hydraulic Steering Gears

Steering gears other than of the hydraulic type are to achieve equivalent standards.

25.3 Alternative for Vessels 10,000 Gross Tonnage and Upwards but Less than 100,000 Tonnes Deadweight

Vessels within this size range, in lieu of meeting completely the requirements in 25.1, may, as an alternative, exclude the application of single failure criterion to rudder actuator, provided that an equivalent safety standard is achieved and that:

- i. Following the loss of steering capability due to a single failure of any part of the piping system or in any one of the power units, steering capability is to be regained within 45 seconds; and
- ii. The single rudder actuator meets the requirements of .

25.5 Non-duplicated Rudder Actuators for Vessels of 10,000 Gross Tonnage and Upwards but Less than 100,000 Tonnes Deadweight

For oil or fuel oil carriers, chemical carriers or gas carriers of 10,000 gross tonnage and upwards but of less than 100,000 tonnes deadweight, a single rudder actuator is acceptable provided the following additional requirements are complied with.

25.5.1 Analysis

Detail calculations are to be submitted for the rudder actuator to show the suitability of the design for the intended service. This is to include a stress analysis of the pressure retaining parts of the actuator to determine the stresses at the design pressure.

Where considered necessary due to the design complexity or manufacturing procedures, a fatigue analysis and fracture mechanic analysis are to be required. In connection with these analyses, all foreseen dynamic loads are to be taken into account. Experimental stress analysis may be required in addition to, or in lieu of, theoretical calculations depending on the complexity of the design.

25.5.2 Allowable Stresses

For the purpose of determining the general scantlings of parts of rudder actuators subject to internal hydraulic pressure, the allowable stresses are not to exceed:

$$\sigma_m \leq f$$

$$\sigma_\ell \leq 1.5f$$

$$\sigma_b \leq 1.5f$$

$$\sigma_\ell + \sigma_b \leq 1.5f$$

$$\sigma_m + \sigma_b \leq 1.5f$$

where

σ_m = equivalent primary general membrane stress

σ_ℓ = equivalent primary local membrane stress

σ_b = equivalent primary bending stress

σ_B = specified minimum tensile strength of material at ambient temperature

σ_Y = specified minimum yield stress or 0.2 percent proof stress of material at ambient temperature

f = the lesser of σ_B/A or σ_Y/B , where A and B are as follows:

	Steel	Cast steel	Nodular cast iron
A	4	4.6	5.8
B	2	2.3	3.5

25.5.3 Burst Test

Pressure retaining parts not requiring fatigue analysis and fracture mechanic analysis are acceptable on the basis of a certified burst test and the detailed stress analysis required by 25.5.1 need not be submitted.

The minimum bursting pressure is to be calculated as follows:

$$P_b = PA \frac{\sigma_{Ba}}{\sigma_B}$$

where

P_b	=	minimum bursting pressure
P	=	design pressure as defined in 9.5.1
A	=	from table in 25.5.2
σ_{Ba}	=	actual tensile strength
σ_B	=	tensile strength as defined in 25.5.2

25.5.4 Nondestructive Testing

The rudder actuator is to be subjected to complete nondestructive testing to detect both surface flaws and volumetric flaws. The procedure and acceptance criteria are to be in accordance with the requirements of recognized standards or as may be determined by approved fracture mechanic analysis.

25.7 Sea Trials

For vessels having two independent and separate power actuating systems as per 25.1.2.i., the performance test criteria in 21.7.1.i. are to be demonstrated during sea trial with any one of the power units in reserve. The capabilities of the steering gear to function as required in 25.1.1 and 25.3, as applicable, are also to be demonstrated.

Chapter 6 Piping Systems

Section 7 Other Piping Systems

1 General (2024)

Part 4, Chapter 6, Section 7 (referred to as Section 4-6-7) covers requirements for piping systems not covered in Sections 4-6-4, 4-6-5 and 4-6-6. It includes hydraulic oil systems, pneumatic systems, helicopter refueling systems, and flammable gas systems, liquefied petroleum gases and ammonia refrigeration for air conditioning system. The provisions of Sections 4-6-1, 4-6-2 and 4-6-3 apply to piping systems in Section 4-6-7.

3 Hydraulic Oil Systems

3.1 Application (2024)

The requirements of 4-6-7/3 apply to all shipboard hydraulic oil systems. Hydraulic oil systems fitted in self-contained equipment not associated with propulsion and maneuvering of the vessel (e.g. a crane) and completely assembled by the equipment manufacturer need not comply with this subsection. Such hydraulic oil systems, however, are to comply with the accepted industry standards.

Hydraulic oil systems essential for the propulsion and maneuvering of the vessel are subject to further requirements. Controllable pitch propeller hydraulic system and steering gear hydraulic systems are also to comply with the requirements in Sections 4-3-3 and 4-3-4, respectively.

Hydraulic oil systems associated with remote propulsion control are to also comply with 4-9-2/5.5 for, among other requirements, duplication of hydraulic pumps. The same systems associated with propulsion machinery spaces intended for centralized or unattended operation (optional ACC/ACCUI/ABCU notations) are also to meet the requirements of 4-9-9/9 for, among other requirements, flash point of hydraulic fluid.

3.2 Objective (2024)

3.2.1 Goals

The piping systems addressed in this section are to be designed, constructed, operated, and maintained to meet the following goals:

Goal No.	Goal
FIR 1	<i>prevent the occurrence of fire and explosion.</i>
SAFE 1.1	minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems.
PROP 1	provide sufficient thrust/power to move or maneuver the vessel when required.
POW 2	provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel.

Materials are to be suitable for the intended application in accordance with the following goals and support the Tier 1 goals as listed above.

Goal No.	Goal
MAT 1	The selected materials' physical, mechanical, and chemical properties are to meet the design requirements appropriate for the application, operating conditions, and environment.

The goals covered in the cross-referenced Rules are also to be met.

3.2.2 Functional Requirements

In order to achieve the above-stated goals, the design, construction, and maintenance of the hydraulic oil system are to be in accordance with the following functional requirements:

Functional Requirement No.	Functional Requirements
Safety of Personnel (SAFE)	
SAFE-FR1	Be provided with means to determine level or amount of hydraulic oil in the storage tanks.
SAFE-FR2	Piping design is to mitigate hazards due to failure of joints.
SAFE-FR3	Piping and equipment are to safely contain the fluid media it conveys and able to withstand the most severe condition of coincident design pressures, temperatures, and loadings.
SAFE-FR4	Provide protective devices if the system/equipment can be subjected to a pressure more than its design pressure.
SAFE-FR5	Piping material is to be compatible with the fluid media it conveys.
Fire Safety (FIR)	
FIR-FR1	Provide means to prevent hydraulic oil from self-igniting or being ignited by flame/spark with due regard to leakages, spillage, hot surfaces and moving parts.
Materials (MAT)	
MAT-FR1	Fracture Toughness to be considered when required by design.
MAT-FR2	Tensile Properties to be considered for designing to a given load/force (tensile or compressive or shear or bending or torsion or bearing or hoop stress or buckling) a. Yield Strength b. Ultimate Tensile Strength c. Elongation d. Reduction of Area e. Modulus of Elasticity
Power Generation and Distribution (POW)	
POW-FR1 (PROP)	Be provided with sufficient sources or capacity for the starting of essential propulsion services without recharging for the starting of the main engines.

The functional requirements covered in the cross-referenced Rules are also to be met.

3.2.3 Compliance

A vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved. Refer to Part 1D, Chapter 2.

3.3 Hydraulic Oil Storage Tanks

3.3.1 Location of Storage Tanks

Hydraulic oil tanks are not to be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces in excess of 220°C (428°F).

3.3.2 Tank Vents (1 July 2024)

Hydraulic tank vents are to meet the requirements of 4-6-4/9. Vents from hydraulic oil tanks, other than double bottom or similar structural tanks, can be terminated in machinery and other enclosed spaces provided that their outlets are so located that overflow therefrom will not impinge on electrical equipment, heated surfaces, or other sources of ignition; see 4-6-4/9.3.4(c). Tank vents of hydraulic systems utilized for the actuation of valves located in cargo oil tanks are, however, to be terminated in the weather; see 5C-2-3/3.5.3.

3.3.3 Means of Sounding

A means of sounding is to be fitted for each hydraulic oil tank; such means is to meet the requirements of 4-6-4/11. If tubular gauge glasses are fitted to hydraulic oil tanks, they are subject to conditions indicated in 4-6-4/11.5.2(b) and 4-6-4/11.5.2(c).

3.5 Hydraulic System Components

3.5.1 Pipes and Fittings

Pipes, pipe fittings and joints are to meet the general requirements of certification in 4-6-1/7.1 (except that ABS certification is not required for all classes of hydraulic piping); materials in 4-6-2/3; and design in 4-6-2/5 subject to limitations in 4-6-7/3.5.1 TABLE 1.

TABLE 1
Pipe Joint Limitations for Hydraulic Piping (2024)

Types of joint	Class I	Class II	Class III
Butt welded joint	No limitation	No limitation	No limitation
Socket welded joint ⁽¹⁾	Max. 80 mm (3 in.)	Max. 80 mm (3 in.)	No limitation
Slip-on welded sleeve joint ⁽²⁾	Max. 80 mm (3 in.)	Max. 80 mm (3 in.)	No limitation
Flanged joint ⁽³⁾	Types A, B & G only. For type B, ≤ 400°C (752°F) For type G, see 4-6-2/9.19 TABLE 7	Types A, B, C, D & G only. For types D, ≤ 250°C (482°F) For type G, see 4-6-2/9.19 TABLE 7	Types A, B, C, D & G only. For type G, see 4-6-2/9.19 TABLE 7
Taper-thread joint ⁽⁴⁾	≤ 80 mm (3 in.), or ≤ 495°C (923°F), permissible pressure/size: see 4-6-2/5.5.5(a)	As for Class I	No limitation
Straight thread O-ring joint	Straight thread O-ring type fittings can be used for pipe connection to equipment such as pumps, valves, cylinders, accumulators, gauges and hoses, without size and pressure limitations. However, such fittings are not to be used for connecting sections of pipe.		

Types of joint	Class I	Class II	Class III
Compression couplings ⁽⁵⁾	≤ 60 mm (2.4 in.) OD.	As for Class I	No size limitation.
Hoses	Subject to fire resistance test. See 4-6-2/5.7.3(c)	As for Class I	As for Class I
Molded non-metallic expansion joint	Not permitted	Not permitted	Not permitted
Molded expansion joint of composite construction	Subject to compliance with 4-6-2/5.8.1	Subject to compliance with 4-6-2/5.8.1	Subject to compliance with 4-6-2/5.8.1
Slip-on Joints	Not permitted	Not permitted	See Note 5

Pipe sizes indicated are nominal pipe size unless specified otherwise.

Notes:

- 1 See [4-6-2/5.5.2](#) for further operational limitations.
- 2 See [4-6-2/5.5.3](#) for further operational limitations.
- 3 Split flanges are not permitted in steering gear system, certified thruster systems, nor in systems which are vital to the propulsion or safety of the vessel.

Notes:

Split flanges within the thruster unit can be used in certified thruster systems subject to the following:

- The split-flanges are being used as internal components and integral part of the thruster design.
- The split flanges are designed in accordance with SAE J518 Standard and are to be used in conjunction with O-ring seals specified in SAE J120 and connecting bolts of SAE Grade 5 material or better as specified in SAE J429.
- The burst pressure of the split flanges is to be at least four (4) times the system pressure. The test report is to be submitted for review.
- The manufacturers are requested to submit their service experience to ABS for evaluation of their equipment. For example, the thruster manufacturer is to submit their service experience and declare that there have been no failures related to the internal split flanges used in their unit(s).

End of Commentary

- 4 Taper-thread joints up to 80 mm (3 in.) can be used without pressure limitation for pipe connection to equipment, such as pumps, valves, cylinders, accumulators, gauges and hoses. When such joints are used to connect sections of pipe, they are to be in accordance with limitations shown. However, hydraulic systems for the following services are to comply with the stated limitations in all respects [see [4-6-2/5.5.5\(b\)](#) and [4-6-2/5.5.5\(c\)](#)]:
 - Steering gear hydraulic systems.
 - Controllable pitch propeller hydraulic systems.
 - Hydraulic systems associated with propulsion or propulsion control.
- 5 See [4-6-2/5.9](#) for further limitations.

3.5.2 Hoses

Hoses are to comply with the requirements of [4-6-2/5.7](#) for flammable fluid service.

3.5.3 Valves

Valves are to meet the general requirements of certification in [4-6-2/7.1](#); materials in [4-6-2/3](#); and design in [4-6-2/5.11](#) and [4-6-2/5.13](#). Directional valves are to be treated as pipe fittings and are subject to pressure, temperature and fluid service restrictions specified by the manufacturers.

3.5.4 Hydraulic Accumulators

Welded hydraulic accumulators having operating pressures above 6.9 bar (7 kgf/cm², 100 psi) are to be certified in accordance with Section [4-4-1](#) as pressure vessels regardless of their diameters.

Accumulators of extruded seamless construction are to be designed, manufactured and tested in accordance with a recognized standard for this type of pressure vessel. Their acceptance will be based on their compliance with the standard as verified by either ABS or an agency recognized by a national authority (in the country of manufacture) having jurisdiction over the safety of such pressure vessels. The certificate of compliance, traceable to the cylinder's serial number, is to be presented to the Surveyor for verification in each case.

Each accumulator which may be isolated from the system is to be protected by its own relief valve or equivalent. Where a gas charging system is used, a relief valve is to be provided on the gas side of the accumulator.

3.5.5 Hydraulic Power Cylinder

3.5.5(a) General. Hydraulic cylinders subject to Classes I and II fluid pressures and temperatures as defined in 4-6-1/5 TABLE 1 are to be designed, constructed and tested in accordance with a recognized standard for fluid power cylinders. Acceptance will be based on manufacturer's certification of compliance and on verification of permanent identification on each cylinder bearing the manufacturer's name or trademark, standard of compliance and maximum allowable working pressure and temperature. (1 July 2025)

3.5.5(b) Non-compliance with a Recognized Standard. As an Alternative to 4-6-7/3.5.5(a), hydraulic cylinders subject to Classes I and II fluid pressures and temperatures and which are not constructed to a recognized standard may be accepted based on the following: (1 July 2025)

- i. Regardless of diameter, the design of the cylinder is to be shown to comply with one of the following:
 - A recognized pressure vessel code,
 - *Section of the Rules.* For instance, the cylinder is to have wall thickness not less than that given by equation 2 of ; and the cylinder ends are to meet the requirements of flat heads in , or
 - *Verification through burst tests.* Steel cylinders (other than cast steel) are to withstand not less than 4 times the maximum allowable working pressure, while cast steel, cast iron and nodular iron cylinders are to withstand not less than 5 times the maximum allowable working pressure.

Documentation in this regard is to be submitted for review.

- ii. Each individual unit is to be hydrostatic tested to 1.5 times the maximum allowable working pressure (2 times, for cast iron and nodular iron cylinders) by the manufacturer. Test certificate is to be submitted.
- iii. Each cylinder is to be affixed with a permanent nameplate or marking bearing the manufacturer's name or trademark and the maximum allowable working pressure and temperature.

3.5.5(c) Materials. The materials of hydraulic power cylinders addressed in 4-6-7/3.5.5(a) and 4-6-7/3.5.5(b) above are to comply with the following: (1 July 2025)

- i. The materials of a cylinder are to comply with the requirements of the standard or code to which the cylinder is designed and constructed. Where the design is verified through burst tests, the materials of the cylinder are to comply with or other acceptable standards.
- ii. Ordinary cast iron having an elongation of less than 12% is not to be used for cylinders expected to be subjected to shock loading.
- iii. Copies of certified mill test reports are to be made available to the Surveyor upon request.

3.5.5(d) Rudder Actuators. Rudder actuators are to comply with the material requirements of 4-3-4/3, be designed in accordance with 4-3-4/7 and to be certified by ABS in accordance with 4-3-4/19 (1 July 2025)

3.5.5(e) Cylinders for Class III piping systems. Cylinders subjected to Class III fluid pressures and temperatures can be used in accordance with the manufacturer's rating. (1 July 2025)

3.5.5(f) Exemptions. Fluid power cylinders that do not form part of the vessel's piping systems, machinery or equipment covered in Part 4 of these Rules are exempt from the requirements of 4-6-7/3.5.5. However, those fluid power cylinders which are integrated into piping systems associated with optional classification notations are to comply with the requirements of 4-6-7/3.5.5 and the applicable requirements specified in the applicable ABS Rules and Guides. (1 July 2025)

3.7 System Requirements

3.7.1 Fire Precautions

Hydraulic power units, including pumps and other pressurized components, with working pressure above 15 bar (225 psi) installed within machinery spaces are to be placed in separate room or rooms or shielded as necessary to prevent any oil or oil mist that may escape under pressure from coming into contact with surfaces with temperatures in excess of 220°C (428°F), electrical equipment, or other sources of ignition. Piping and other components are to have as few joints as practicable.

3.7.2 Relief Valves

Relief valves are to be fitted to protect the system from over-pressure. The relieving capacity is not to be less than full pump flow with a maximum pressure rise in the system of not more than 10% of the relief valve setting.

3.9 Hydraulic Starting

Hydraulic oil accumulators for starting the main propulsion engines are to have sufficient capacity without recharging for starting the main engines, as required in 4-6-5/9.5.1.

5 Pneumatic Systems

5.1 Application

The requirements of 4-6-7/5 apply to shipboard pneumatic systems for control and actuation services. The requirements for starting air system are in 4-6-5/9. Pneumatic systems fitted in self-contained equipment not associated with the propulsion and maneuvering of the vessel and completely assembled by the equipment manufacturer need not comply with this subsection. Such pneumatic systems, however, are to comply with the accepted practice of the industry.

5.2 Objectives (2024)

5.2.1 Goals

The pneumatic systems addressed in this section are to be designed, constructed, operated, and maintained to meet the following goals:

Goal No.	Goals
SAFE 1.1	minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems.
PROP 2	provide redundancy and/or reliability to maintain propulsion.
POW 2	provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel.

The goals covered in the cross-referenced Rules are also to be met.

5.2.2 Functional Requirements

In order to achieve the above-stated goals, the design, construction, and maintenance of the pneumatic systems are to be in accordance with the following functional requirements:

Functional Requirement No.	Functional Requirements
Safety of Personnel (SAFE)	
SAFE-FR1	Piping and equipment are to safely contain the fluid media being conveyed and able to withstand the most severe condition of coincident design pressures, temperatures, and loadings.
SAFE-FR2	Provide protective devices if the system/equipment can be subjected to a pressure more than its design pressure.
SAFE-FR3	Provide means to remove contaminants or accumulated water from the system and in all normal vessel conditions to prevent equipment damage.
SAFE-FR4	Provide arrangements to preclude the entry of oil or other contaminants into the safety and control air systems.

Functional Requirement No.	Functional Requirements
SAFE-FR5	Reduce risk of failure of joints and to mitigate hazards upon failure.
Power Generation and Distribution (POW)	
POW-FR1 (PROP)	Be provided with sufficient sources or capacity for the starting of essential propulsion services without recharging for the starting of the main engines.
POW-FR2 (PROP)	Starting and pneumatic control systems are to be arranged and controlled to allow automatic availability and adequate independence.
Propulsion, Maneuvering and Station Keeping (PROP)	
PROP-FR1	Provide redundancy for rotating machinery in pneumatic control system to prevent loss of propulsion in case of malfunction.

The functional requirements covered in the cross-referenced Rules are also to be met.

5.2.3 Compliance

A vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved. Refer to Part 1D, Chapter 2.

5.3 Pneumatic System Components

5.3.1 Air Reservoir

Air reservoirs having a design pressure greater than 6.9 bar (7 kgf/cm², 100 lb/in²) are to be certified by ABS (see 4-4-1/1.9, and for accumulators 4-6-7/3.5.4). Air reservoirs are to be fitted with drain connections effective under extreme conditions of trim. Where they can be isolated from the system safety valve, they are to be provided with their own safety valves or equivalent devices.

5.3.2 Pipe Fittings and Joints

Pipe fittings and joints are to meet the requirements for certification in 4-6-1/7.1; materials in 4-6-2/3; and design in 4-6-2/5.5 and 4-6-2/5.15 subject to limitations in 4-6-7/5.3.2 TABLE 2.

TABLE 2
Pipe Joint Limitations for Pneumatic Systems

Pipe joints	Class I	Class II	Class III
Butt welded joint	No limitation	No limitation	No limitation
Socket welded joint ⁽¹⁾	Max. 80 mm (3 in.)	Max. 80 mm (3 in.)	No limitation
Slip-on welded sleeve joint ⁽²⁾	Max. 80 mm (3 in.)	Max. 80 mm (3 in.)	No limitation
Flanged joint	Types A, B & G For type G, see 4-6-2/9.19 TABLE 7	Types A, B, C, D & G For type G, see 4-6-2/9.19 TABLE 7	Types A, B, C, D & G For type G, see 4-6-2/9.19 TABLE 7
Taper-thread joint	≤ 80 mm (3 in.) Permissible pressure/size, see 4-6-2/5.5.5(a)	≤ 80 mm (3 in.) Permissible pressure/size, see 4-6-2/5.5.5(a)	No limitation
Compression couplings	≤ 60 mm (2.4 in.) OD	≤ 60 mm (2.4 in.) OD	No limitation

Notes:

- 1 See 4-6-2/5.5.2 for further operational limitations.
- 2 See 4-6-2/5.5.3 for further operational limitations.

Pipe sizes indicated are nominal diameter, except where specified otherwise.

5.3.3 Pneumatic Power Cylinders

The requirements of hydraulic cylinders in 4-6-7/3.5.5 apply also to pneumatic cylinders.

5.5 Pneumatic System Requirements

5.5.1 Pneumatic Air Source (1 July 2025)

The arrangements for the supply of compressed air to essential services are to be designed that sufficient compressed air is available to meet the total demand of the essential services at all times, including during normal operation, maintenance, and in the event of a failure of the compressed air system.

Where compressed air for general pneumatic control and actuation services or other essential services is drawn from engine starting air reservoirs, the aggregate capacity of the starting air reservoirs is to be sufficient for continued operation of these services after the air necessary for the required number of engine starts (as specified in 4-6-5/9.5.1) has been used.

For propulsion remote control purposes, pneumatic air is to be available from at least two air compressors. The starting air system, where consisting of two air compressors, can be used for this purpose. The required air pressure is to be automatically maintained. Pneumatic air supplies to safety and control systems may be derived from the same source but are to be by means of separate lines.

5.5.2 Air Quality

5.5.2(a) General. Provisions are to be made to minimize the entry of oil or water into the compressed air system. Suitable separation and drainage arrangements are to be provided before the air enters the reservoirs. (2020)

5.5.2(b) Safety and Control Air Systems. For requirements regarding the quality of the air supplied to safety and control air systems, see 4-9-2/5.7. (2020)

5.5.3 Overpressure Protection

Means are to be provided to prevent over-pressure in any part of the pneumatic system. This includes water jackets or casing of air compressors and coolers which may be subjected to dangerous over-pressure due to leakage into them from air pressure parts.

7 Fixed Oxygen-Acetylene Systems

7.1 Application

The requirements of 4-6-7/7.3 apply to oxygen-acetylene installations that have two or more cylinders of oxygen and acetylene, respectively. Spare cylinders of gases need not be counted for this purpose. Requirements of 4-6-7/7.5 and 4-6-7/7.7, as applicable, are to be complied with for fixed installations regardless of the number of cylinders.

7.2 Objective (2024)

7.2.1 Goals

The fixed oxygen-acetylene systems addressed in this section are to be designed, constructed, operated, and maintained to meet the following goals:

Goal No.	Goal
SAFE 1.1	minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems.
FIR 1	prevent the occurrence of fire and explosion.

Materials are to be suitable for the intended application in accordance with the following goals and support the Tier 1 goals as listed above.

Goal No.	Goal
MAT 1	The selected materials' physical, mechanical, and chemical properties are to meet the design requirements appropriate for the application, operating conditions, and environment.

The goals covered in the cross-referenced Rules are also to be met.

7.2.2 Functional Requirements

In order to achieve the above-stated goals, the design, construction, and maintenance of the fixed oxygen-acetylene system are to be in accordance with the following functional requirements:

Functional Requirement No.	Functional Requirements
Safety of Personnel (SAFE)	
SAFE-FR1	Minimize danger to persons on board from toxicity, asphyxiation and flammability.
SAFE-FR2	Piping is to be designed, arranged, or protected to minimize chance of mechanical damage and corrosion.
SAFE-FR3	Piping and equipment are to safely contain the fluid media it conveys and able to withstand the most severe condition of coincident design pressures, temperatures, and loadings.
SAFE-FR4	Reduce risk of failure of joints and to mitigate hazards upon failure.
SAFE-FR5	Piping material is to be compatible with the fluid media it conveys.
SAFE-FR6	Provide protective devices if the system/equipment can be subjected to a pressure more than its design pressure.
SAFE-FR7	Discharge arrangement is not to endanger the safety of persons onboard, equipment/systems and environment.
Fire Safety (FIR)	
FIR-FR1	<i>Be arranged or be provided with means to prevent the ignition of flammable gases.</i>
FIR-FR2 (SAFE)	Provide arrangements to maintain the level of flammable gases or vapors below 30% of their lower explosive limits (LEL).
FIR-FR3	Electrical equipment is to be of appropriate type for the hazardous areas that they will be operating in and are arranged to minimize fire risk when located in such areas.
Materials (MAT)	
MAT-FR1	Chemical Composition to be considered for corrosion resistance, weldability, final mechanical properties.
MAT-FR2	Physical Properties typically considered when selecting materials for a given application a. Density b. Specific heat c. Electric resistivity d. Melting or boiling point e. Thermal Conductivity f. Coefficient of thermal expansion g. Coefficient of friction

The functional requirements covered in the cross-referenced Rules are also to be met.

7.2.3 Compliance

A vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved. Refer to Part 1D, Chapter 2.

7.3 Gas Storage

7.3.1 Storage of Gas Cylinders

7.3.1(a) Storage room. The gas cylinders are to be stored in rooms dedicated for this purpose only. A separate room is to be provided for each gas. The rooms are to be on or above the upper-most continuous deck and are to be constructed of steel. Access to the rooms is to be from the open deck and the door is to open outwards. The boundaries between the rooms and other enclosed spaces are to be gastight. Suitable drainage of the storage room or area is to be provided. **(2020)**

7.3.1(b) Open area. Where no storage room is provided, the gas cylinders can be placed in an open storage area. In such cases, they are to be provided with weather protection (particularly from heavy seas and heat) and effectively protected from mechanical damage. Suitable drainage of the open storage area is to be provided. **(2020)**

7.3.1(c) Piping passing through storage room or area. Piping systems containing flammable fluids are not to run through the storage room or open storage area. **(2020)**

7.3.2 Ventilation of Storage Room

Acetylene gas cylinder storage room is to be fitted with ventilation systems capable of providing at least six air changes per hour based on the gross volume of the room. The ventilation system is to be independent of ventilation systems of other spaces. The space within 3 m (10 ft) from the power ventilation exhaust, or 1 m (3 ft) from the natural ventilation exhaust is to be considered a hazardous area, see [4-8-4/27.3.3\(d\)](#). The fan is to be of the non-sparking construction, see [4-8-3/11](#). Small storage spaces provided with sufficiently large openings for natural ventilation need not be fitted with mechanical ventilation.

7.3.3 Electrical Installation in Storage Room

Electrical equipment installed within the acetylene storage room, including the ventilation fan motor, is to be of the certified safe type, see [4-8-4/27.5.4](#).

7.5 Piping System Components

7.5.1 Pipe and Fittings **(2024)**

7.5.1(a) General. All oxygen and acetylene pipes, pipe fittings, pipe joints and valves are to be in accordance with the requirements of Sections [4-6-1](#) and [4-6-2](#), except as modified below. **(2020)**

7.5.1(b) Piping materials. Materials for acetylene on the high-pressure side between the cylinders and the regulator are to be steel. Copper or copper alloys containing more than 65% copper are not to be used in acetylene piping (high or low pressure). Materials for oxygen on the high-pressure side are to be steel or copper. All pipes, both high- and low-pressure sides, are to be seamless. **(2020)**

7.5.1(c) Design pressure. Pipes, pipe fittings and valves on the oxygen high-pressure side are to be designed for not less than 207 bar (211 kgf/cm², 3000 psi). Pipes used on the low-pressure side are to be at least of standard wall thickness. **(2020)**

7.5.1(d) Pipe joints. All pipe joints outside the storage room or open storage area are to be welded. **(2020)**

7.5.1(e) Flexible hoses. Flexible hoses used to connect oxygen or acetylene gas cylinders to a fixed piping system or manifold are to comply with an acceptable standard and be suitable for the intended pressure and service. Further, the internal surface of a hose used to connect an acetylene tank is to be of a material that is resistant to acetone and dimethylformamide decomposition*. **(2020)**

Where a flexible hose is connected from an oxygen cylinder to the piping system or manifold directly (i.e. no intervening pressure regulator), the internal liner of the oxygen hose is to be of a material that has an autoignition temperature of not less than 400°C (752°F) in oxygen*.

Note:

* Criteria based on ISO 14113 Gas welding equipment - Rubber and plastic hose and hose assemblies for use with industrial gases up to a maximum design pressure of 450 bar (45 MPa).

7.5.2 Pressure Relief Devices

Pressure relief devices are to be provided in the gas piping if the maximum design pressure of the piping system can be exceeded. These devices are to be set to discharge at not more than the maximum design pressure of the piping system to a location in the weather remote from sources of vapor ignition or openings to spaces or tanks. The area within 3 m (10 ft) of the pressure relief device discharge outlet is to be regarded as a hazardous area. The pressure relief devices is to be either a relief valve or a rupture disc.

7.5.3 System Arrangements

Where two or more gas cylinders are connected to a manifold, high pressure piping between each gas cylinder and the manifold is to be fitted with a non-return valve. The piping is not to run through unventilated spaces or accommodation spaces. Outlet stations are to be fitted with shutoff valves. Outlet stations are to be provided with suitable protective devices to prevent back flow of gas and the passage of flame into the supply lines.

7.5.4 Gas Cylinders (1 July 2024)

Gas cylinders are to be designed, constructed and certified in accordance with the requirements of 4-4-1/1.11.5. Each cylinder is to be fitted with a suitable pressure relief device such as a fusible plug or a rupture disc. If each cylinder is not provided with such a pressure relief device, all valves installed between the cylinders and the pressure relief device in 4-6-7/7.5.2 are to be locked in the open position to protect the cylinders.

The area within 3 m (10 ft) of the pressure relief device discharge outlet from an acetylene gas cylinder is to be regarded as a hazardous area.

7.7 Testing

Piping on the oxygen high-pressure side is to be tested before installation to at least 207 bar (211 kgf/cm², 3000 psi) and the piping on the acetylene high-pressure side is to be tested in accordance with Section 4-6-2. The entire system is to be leak-tested with nitrogen or a suitable inert gas after installation. Care is to be taken to cleanse the piping with a suitable medium to remove oil, grease and dirt and to blow-through with oil-free nitrogen or other suitable medium before putting the system in service.

9 Helicopter Refueling Systems

9.1 Application

The requirements of 4-6-7/9 are applicable to helicopter refueling facilities for fuel with a flash point at or below 60°C (140°F) close cup test. For fuel with a flash point of above 60°C, the requirements for spill containment in 4-6-7/9.5 hereunder and the requirements for fuel oil storage and transfer systems in 4-6-4/13 are applicable.

9.2 Objectives (2024)

9.2.1 Goals

The helicopter refueling systems addressed in this section are to be designed, constructed, operated, and maintained to meet the following goals:

Goal No.	Goal
STRU 1	in the intact condition, have sufficient structural strength to withstand the environmental conditions, loading conditions, and operational loads anticipated during the design life.
SAFE 1.1	minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems.

Goal No.	Goal
FIR 1	<i>prevent the occurrence of fire and explosion.</i>
FIR 2	<i>reduce the risk to life caused by fire.</i>
OTH SG5	enable safe helicopter operations.
ENV 1	prevent and minimize oil pollution due to vessel operation and accidents.

Materials are to be suitable for the intended application in accordance with the following goals and support the Tier 1 goals as listed above.

Goal No.	Goal
MAT 1	The selected materials' physical, mechanical, and chemical properties are to meet the design requirements appropriate for the application, operating conditions, and environment.

The goals in the cross-referenced Rules are also to be met.

9.2.2 Functional Requirements

In order to achieve the above-stated goals, the design, construction, and maintenance of the helicopter refueling system are to be in accordance with the following functional requirements:

Functional Requirement No.	Functional Requirements
Safety of Personnel (SAFE)	
SAFE-FR1 (ENV)	Provide arrangements to collect and drain fuel spillage to a safe location which does not interfere with normal operation.
SAFE-FR2	Piping material is to be compatible with the fluid media it conveys.
SAFE-FR3	Provide protective devices if the system/equipment can be subjected to a pressure more than its design pressure.
SAFE-FR4	Piping is to be designed, arranged, or protected to minimize chance of mechanical damage.
SAFE-FR5	Piping is to safely contain the fluid media it conveys and able to withstand the most severe condition of coincident design pressures, temperatures, and loadings.
Structure (STRU)	
STRU-FR1	<i>Withstand the maximum working stresses to which tanks may be subjected in all service conditions.</i>
Fire Safety (FIR)	
FIR-FR1	<i>Be arranged or be provided with means to prevent the ignition of flammable gases.</i>
FIR-FR2	Be arranged to separate helicopter fuel from safe areas to prevent spread of fire and to allow escape.
FIR-FR3	Be arranged and controlled such that the machinery operation will be as safe and effective as if it were under direct supervision.
FIR-FR4	Provide remote means to stop flammable liquid supply in case of an abnormal situation.
FIR-FR5	Provided with arrangements to prevent build-up of static electricity and increased risk of fire/explosion due to electrostatic discharge.
FIR-FR6	Effective containment and extinction of fire within space of origin with due regard to fire growth potential of the protected spaces.
Other Systems (OTH)	
OTH-FR1	Provide information at appropriate locations to advise of hazards associated with helicopter refueling.
OTH-FR2	Provide remote means to stop flammable liquid supply in case of an abnormal situation.
Materials (MAT)	
MAT-FR1	Fracture Toughness to be considered when required by design

Functional Requirement No.	Functional Requirements
MAT-FR2	Physical Properties typically considered when selecting materials for a given application i. Density ii. Specific Heat iii. Elastic resistivity iv. Melting or boiling point v. Thermal Conductivity vi. Coefficient of thermal expansion vii. Coefficient of friction

The functional requirements covered in the cross-referenced Rules are also to be met.

9.2.3 Compliance

A vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved. Refer to Part 1D, Chapter 2.

9.3 Fuel Storage and Refueling Equipment Area

9.3.1 Isolation

The designated fuel storage and refueling areas are to be isolated from the following:

- Accommodation areas including vent openings;
- Embarkation stations;
- Escape routes;
- Helicopter landing area; and
- Areas containing any source of vapor ignition.

The method of isolation is to be by means of a safe and adequate distance or erected barriers capable of preventing the spread of fire.

9.3.2 Hazardous Area

The fuel storage and refueling area is to be permanently marked to identify it as a restricted area where smoking or other naked flame is not permitted. "NO SMOKING" signs are to be displayed. Open spaces within 3 m (10 ft) of the refueling equipment and within 3 m of the storage tank vent outlet are to be regarded as hazardous areas (see [4-8-4/27.3.3](#)).

9.5 Spill Containment (2024)

The fuel storage area is to be provided with arrangements whereby fuel spillage can be collected and drained to a safe location which does not interfere with the safe operation of the vessel and the normal work of crews. These arrangements are to be at least as provided below.

For drainage of a helicopter deck see [4-6-4/3.9.2](#).

The arrangement for the vessels assigned with "HELIDK(SRF)" Notation are to, at a minimum, comply with 3/1.5 of *ABS Guide for the Class Notation Helicopter Decks and Facilities*. This Guide is applicable to new and existing vessels for which the optional "HELIDK" or "HELIDK (SRF)" notation has been requested.

9.5.1 Coaming

A coaming surrounding the fuel storage tanks, associated piping and the pumping unit is to be provided. The height of this coaming is to be at least 150 mm (6 in.), so as to contain fuel spillage as well as fire extinguishing agents. Where the pumping unit or any other unit such as dispenser/coalescer unit is situated at a remote

distance from the fuel storage tank, a separate coaming of the same minimum height is to be provided around each unit.

9.5.2 Drainage

Arrangements for drainage from within the coaming area are to be as follows.

- i. Permanent piping and a suitable holding tank are to be fitted so that drainage can be either led to the holding tank (for draining oil) or discharged overboard (for draining water) through a three-way valve. No other valve is permitted in the drain piping.
- ii. The cross sectional area of the drain pipe from the fuel tank coaming is to be twice that of the fuel storage tank outlet pipe.
- iii. The area within the coaming is to be sloped towards the drain pipe.

Where the area within the fuel tank coaming is not provided with drainage arrangements, the height of the coaming is to be sufficient to contain the full volume of the fuel storage tank plus 150 mm (6 in.).

For drainage of helicopter deck, see [4-6-4/3.9.2](#).

9.7 Fuel Storage Tanks

9.7.1 Construction (2021)

Independent fixed fuel storage tanks are to be of approved metal construction and meet [4-6-4/13.5.2\(b\)](#) through [4-6-4/13.5.2\(e\)](#), as applicable. Mounting, securing arrangements, and electrical bonding arrangements are to be submitted for approval.

9.7.2 Tank Valves

Fuel storage tank outlet valves are to be provided with a means of remote closure. Such means is not to be cut off in the event of a fire in the fuel storage and the refueling area. The requirements of [4-6-4/13.5.3](#) are to be complied with.

9.7.3 Tank Vents and Sounding (2024)

The requirements of [4-6-4/9](#) and [4-6-4/11](#) are applicable. However, tank vents are to be extended at least 2.4 m (8 ft) above the weather deck. Other venting arrangements will be considered.

Commentary:

During tank filling, to prevent the free fall of liquid, the discharge line should be as short as practicable, and the outlet should be arranged to discharge against the vertical boundary of the tank.

End of Commentary

9.9 Refueling Pumps

Refueling pump is to incorporate a device that will prevent over-pressurization of the delivery hose or of the filling hose. Relief valve, where fitted, is to discharge either to the suction side of the pumps or to the storage tanks. Means are to be provided for remote stopping of the refueling pumps from a position not likely to be cut-off in the event of a fire in the fuel storage and refueling area.

9.11 Fuel Piping

Refueling pump is to be arranged to connect to only one tank at a time. Piping between the refueling pump and the tank is to be as short as practicable and protected against damage. Fuel piping is to be of steel or equivalent material and to comply with [4-6-4/13.7.1](#) and [4-6-4/13.7.2](#). The piping system and all equipment used during refueling operation are to be electrically bonded.

9.13 Fuel Storage and Refueling Systems Installed in Enclosed Spaces

9.13.1 Machinery Spaces

Helicopter refueling facilities for fuel with a flash point of 60°C or less are not to be installed in machinery spaces.

9.13.2 Arrangements of the Enclosed Space

The fuel storage and refueling compartment is to be bounded by gas-tight bulkheads and decks. Access to this compartment is to be from the open deck only which can be by means of a trunk. There is to be no access to this compartment from other compartments.

9.13.3 Machinery and Electrical Installations

The compartment containing refueling facilities is to be regarded as having the same fire and explosion hazards as a Ro-Ro cargo space, see Section 5C-10-4. Specifically, the following requirements of Section 5C-10-4 are to be met:

- : for ventilation capacity of the compartment.
- and : for acceptable certified safe equipment and alternative electrical equipment in the compartment.
- : for exhaust fan and ducting.
- and : for bilge system of the compartment.

9.13.4 Storage Tanks

9.13.4(a) Independent tanks. Independent fuel tanks can be installed in the same compartment as the refueling system. The tank, vents, means of sounding and valves are to comply with 4-6-7/9.7.

9.13.4(b) Structural tanks. Fuel tanks can be integral with the vessel's structure. Cofferdams (see Part 5C, Chapter 2) are to be fitted to separate such fuel tanks from machinery spaces, cargo spaces, accommodation, service spaces, and other spaces containing a source of ignition. The compartment containing the refueling equipment, ballast tanks, and fuel oil tanks containing fuel oil having a flash point of more than 60°C can be regarded as a cofferdam. Tank vents, means of sounding, and outlet valves are to be as in 4-6-7/9.13.4(a). Particular attention is to be directed to the height of the tank vent/overflow with respect to the design head of the tank. Overflows, where fitted, are to comply with 4-6-4/9.5.5.

9.15 Fire Extinguishing System

Fixed fire extinguishing systems are to be fitted to protect helicopter fuel storage and refueling equipment areas (or compartments) in accordance with 4-7-2/5.3.2 and 4-7-2/5.3.5.

11 Liquefied Petroleum Gases

11.1 General

LPG can be used for cooking and heating on all vessels except passenger vessels. LPG systems are to be of the vapor withdrawal type only. Cylinders designed to admit the liquid phase of the gas into any other part of the system are prohibited. All component parts of the system, except cylinders, appliances and low pressure tubing, are to be designed to withstand a pressure of 34 bar (35 kgf/cm², 500 psi) without rupture.

11.1.1 Goals (2024)

The LPG systems addressed in this section are to be designed, constructed, operated, and maintained to meet the following goals:

Goal No.	Goal
SAFE 1.1	minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems.
FIR 1	<i>prevent the occurrence of fire and explosion.</i>
FIR 3	<i>reduce the risk of damage caused by fire to the ship, its cargo and the environment.</i>

Materials are to be suitable for the intended application in accordance with the following goals and support the Tier 1 goals as listed above.

Goal No.	Goal
MAT 1	The selected materials' physical, mechanical, and chemical properties are to meet the design requirements appropriate for the application, operating conditions, and environment.

11.1.2 Functional Requirements (2024)

In order to achieve the above-stated goals, the design, construction, and maintenance of the LPG system are to be in accordance with the following functional requirements:

Functional Requirement No.	Functional Requirements
Safety of Personnel (SAFE)	
SAFE-FR1	Piping and equipment are to safely contain the fluid media it conveys and able to withstand the most severe condition of coincident design pressures, temperatures, and loadings
SAFE-FR2	Piping material is to be compatible with the fluid media it conveys
Fire Safety (FIR)	
FIR-FR1	<i>Be arranged or be provided with means to prevent the ignition of flammable gases.</i>
Materials (MAT)	
MAT-FR1	Tensile Properties to be considered for designing to a given load/force (tensile or compressive or shear or bending or torsion or bearing or hoop stress or buckling) a. Yield Strength b. Ultimate Tensile Strength c. Elongation d. Reduction of Area e. Modulus of Elasticity

11.1.3 Compliance (2024)

A vessel is considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved, refer to Part 1D, Chapter 2.

11.3 Storage Cylinders

Cylinders for the storage of LPG are to be designed and constructed in accordance with a recognized pressure vessel standard.

11.5 Installation and Testing (2020)

Where LPG are used, the installation and testing is to comply with a recognized standard. Gas bottles are to be stored on the open deck or in a well ventilated space which opens only to the open deck.

13 Refrigeration Plants other than Cargo Refrigeration Plants (1 July 2023)

Application

The provisions of 4-6-7/13 apply to non-cargo refrigeration plants, and centralized air conditioning systems using ammonia (R717) as refrigerant.

Commentary:

The use of refrigerants that may introduce fire or toxic hazards onboard vessels (such as those listed in safety groups A2L and B2L per ASHRAE Standard 34 "Designation and Safety Classification of Refrigerants") may be accepted on a case-by-case basis.

Refrigerant R717, Ammonia, is listed as refrigerant safety group B2L per ASHRAE Std 34.

Refrigerants containing Ozone Depleting Substances (ODS) are prohibited. Refrigerants with GWP >2000 are to be avoided.

For requirements aimed at reducing the potential adverse effects on the air quality in the environment by refrigerant systems on board vessels, refer to the *ABS Guide for the Environmental Protection Notations for Vessels*.

End of Commentary

13.1 Objective (1 July 2024)

13.1.1 Goals

The Refrigeration Plants covered in this section are to be designed, constructed, operated and maintained to:

Goal No.	Goal
ENV 6	prevent and minimize air pollution.
SAFE 1.1	minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems
FIR 1	<i>prevent the occurrence of fire and explosion.</i>
FIR 2	<i>detect, contain, control and suppress or swiftly extinguish a fire in the compartment of origin.</i>
EER 1	<i>provide means of escape so that persons on board can safely and swiftly escape to a protected place of refuge, muster station, or embarkation station.</i>
AUTO 2	indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance.

The goals covered in the cross-referenced Rules/Regulations are also to be met.

13.1.2 Functional Requirements

In order to achieve the above stated goals, the design, construction, installation and maintenance of the Refrigeration Plants are to be in accordance with the following functional requirements:

Functional Requirement No.	Functional Requirements
PROTECTION OF ENVIRONMENT (ENV)	
ENV-FR1	Provide means to minimize refrigerant release during maintenance.
SAFETY OF PERSONAL (SAFE)	
SAFE-FR1	Ammonia refrigerant machinery and associated equipment are to be installed in a dedicated space that prevent the spread of ammonia into adjacent spaces due to a leakage.

Functional Requirement No.	Functional Requirements
SAFE-FR2	Adequate ventilation is to be provided to prevent the accumulation of ammonia and the ventilation systems are to be arranged to prevent ventilated air from communicating with other ventilation systems for personnel safety.
SAFE-FR3	The Storage of ammonia Cylinders and associated refrigeration machinery are to be such that the probability and consequences of ammonia related hazards are limited to a minimum through arrangement and system design.
FIRE SAFETY (FIR)	
FIR-FR1	Electrical equipment and cables installed in hazardous areas are to be suitable for the environment (gas group and temperature classification) in which they operate.
FIR-FR2	Provide means for the effective containment and extinction of any fire with due regard to the fire growth potential.
FIR-FR3	Provide immediate availability and easy accessibility to fire-extinguishing appliances.
ESCAPE, EVACUATION RESCUE (EER)	
EER-FR1	Redundant means of egress from refrigerant machinery space to safe areas are to be provided in case of an emergency.
AUTOMATION (CONTROL, MONITORING AND SAFETY SYSTEMS) (AUTO)	
AUTO-FR1	Provide effective means to detect and notify the leakage of ammonia for personnel to take immediate action to maintain a safe environment within the refrigerant machinery space and the spaces where ammonia leakage is expected.

The functional requirements covered in the cross-referenced Rules/Regulations are also to be met.

13.1.3 Compliance

Refrigeration Plants are considered to comply with the goals and functional requirements within the scope of classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved. Refer to Part 1D, Chapter 2.

13.2 General

13.2.1 Stand Alone Units (1 July 2024)

Stand-alone units are not subject to the requirements of this subsection. Such units, however, are to comply with the accepted industry standards.

Commentary:

Stand-alone units refers to air-conditioning or refrigeration units that are fitted in:

- i. a permanently sealed equipment, where there are no refrigerant charging connections or potentially removable components containing ozone depleting substances (ODS)
- ii. the equipment having charging connections or potentially removable components but containing no ozone depleting substances (ODS) provided that the equipment will not be changed to contain an ODS refrigerant.

End of Commentary

13.2.2 Containerized Units

In order to be considered as a containerized unit, the refrigerant system is to be installed inside a steel gastight enclosure.

13.3 Design Considerations

13.3.1 Refrigerant Systems

Refrigerant systems are to comply with the requirements shown in *Arial italics* in Part 6, Chapter 2 and the requirements of this subsection. R-717 (ammonia) refrigerant systems are to comply with the additional requirements in Section 6-2-11, and may only be used as a primary refrigerant, requiring a secondary refrigerant or a heat transfer fluid.

13.3.2 Location of Refrigeration Machinery

Refrigeration units and associated equipment containing ammonia are to be located in a dedicated space. The space is to comply with the requirements in 6-2-11/3.

Commentary:

Refrigerant systems with less than 25 kg (55 lb) of refrigerant charge may be located inside the main/auxiliary machinery space in vessels with less than 500 GT, subject to acceptance of the flag administration. The refrigerant system should be fitted as a skid and the area above the skid should be provided with a water deluge system in compliance with 6-2-11/3.11.

End of Commentary

13.4 Containerized Units

13.4.1

The unit is to be normally unmanned and may be entered occasionally for repairs, maintenance or other purpose when the refrigerant system is not running.

13.4.2

The unit is to be provided with two access doors located at opposite ends. The access doors are to be gas-tight, self-closing and outward-swinging. The access doors are to be operable from both sides. Catches to prevent inadvertent closing when the unit is manned are considered acceptable.

13.4.3 (1 July 2024)

Containerized units with less than 25 kg (55 lb) may be accepted with one access door. Other units may be considered with one access door based on ABS technical assessment and approval.

13.4.4

The refrigerant system is to comply with a recognized design code or standard.

13.4.5

The system is to be arranged with appropriate means for isolation of sections and components to allow for system maintenance without releasing any substantial quantity of the refrigerant. Unavoidable minimal release associated with recovery is permitted provided recovery units are installed for the evacuation of the system. For refrigerant recovery, compressors/recovery units are to be capable of evacuating a system charge into an independent/separate liquid storage container(s). The recovered refrigerant storage capacity of this storage container(s) is to be at least 125% of the largest volume of refrigerant in any one segment of the refrigeration system which can be isolated. Each portion of the system that can be isolated is to have piping connections suitable for the attachment of the recovery equipment.

13.4.6

The enclosure is to be provided with an independent mechanical exhaust ventilation system designed in accordance with 6-2-11/3.5. In addition, a push button for temporary stop of the ventilation fans is to be located near the access doors.

13.4.7

An appropriate leak detection system is to be provided to continuously monitor the inside of the enclosure. In addition, two gas detectors are to be provided inside the enclosure and are to be suitable for the type of refrigerant. Further, an alarm is to be given by any detector in a manned location when the refrigerant concentration exceeds 25 ppm. If the concentration exceeds 300 ppm, detectors inside the enclosure are to stop the refrigerant system. Corrective action to repair a refrigerant leak is to be taken as soon as practicable after the activation of the alarm.

13.4.8

The area inside the enclosure is to be considered a hazardous area Zone 1. Areas within 1 m from the inlet ventilation opening, and within 3 m from the exhaust duct outlet are to be classified as hazardous area Zone 2. The exhaust ventilation fans are to be of the non-sparking type in compliance with 4-8-3/11, and the electrical equipment are to be of a certified safe type suitable for installation in the hazardous areas.

13.4.9

The unit may be installed on the open deck. If located in an enclosed space, the space is to be dedicated for the self-contained unit(s). The enclosure and the dedicated space, as applicable, are to be provided with heat and smoke detectors connected to the fixed fire detection and fire alarms systems of the vessel, in compliance with 4-7-3/11. A manual operated call point is to be fitted at each access door.

13.4.10

Reserve refrigerant may be stored inside the enclosure in portable steel storage cylinders approved by a nationally recognized agency or other similar authorized body. The maximum amount of refrigerant to be stored is not to exceed one complete charge of refrigerant or 140 kg (308 lb), whichever is less. Storage of spare refrigerant cylinders inside the dedicated space may be considered acceptable, provided the space is fitted with an independent ventilation system of at least 12 air changes per hour and gas detectors set to alarm at 25 ppm at a manned location. The ventilation system is to be capable to automatically increase to 30 air changes per hour upon detection of gas concentrations exceeding 25 ppm.

13.4.11

At least one portable fire extinguisher complying with 4-7-3/15 is to be provided at each access door of the enclosure.

High Speed Craft (HSC Rules) (Jan 2026)

Part 4 Craft Systems and Machinery

Chapter 1 General

Section 1 Classification of Machinery

Goals

The machinery covered in this section is to be designed, constructed, operated and maintained to:

Goal No.	Goal
POW 1	provide safe and reliable storage and supply of fuel/energy/power.
POW 5	enable supply/power for essential services to be restored after malfunction.
PROP 1	provide sufficient thrust/power to maneuver the craft when required.
PROP 2	provide redundancy and/or reliability to maintain propulsion.
PROP 3	<i>provide sufficient power for going astern...to secure proper control and bring the craft to rest in all normal circumstances.</i>
SAFE 1	promote the occupational health and safety of personnel onboard.
SAFE 1.1	minimize danger to person on board, the craft, and surrounding equipment/installation from hazards associated with machinery and systems.
MGMT 5.1	facilitate safe access, ease of inspection, survey, and maintenance of the craft, machinery, and electrical systems.
AUTO 2	indicate the system operational status and alert operators of any essential machinery/systems deviate from its defined design/operating conditions or intended performance.

The goals in the cross-referenced Rules/Regulations are also to be met.

Functional Requirements

In order to achieve the above stated goals, the design, construction, installation, and maintenance of machinery is to be in accordance with the following functional requirements:

Functional Requirement No.	Functional Requirements
POWER GENERATION & DISTRIBUTION (POW)	
POW-FR1 (PROP)	Means are to be provided to bring the machinery into operation from a condition where the machinery is not in operation due to the loss of the main source of electrical power and the stored energy to re-start propulsion is not available.
PROPULSION, MANEUVERING, STATION KEEPING (PROP)	
PROP-FR1 (POW)	Operate under anticipated environmental and craft conditions, such as weather and vibrations, onboard.
PROP-FR2	Propulsion machinery is to effectively operate in and efficiently switch over to astern mode without abnormal responses.
PROP-FR3	Propulsion machinery is to provide sufficient astern power to bring the craft to rest from maximum ahead service speed in order to avoid a dangerous situation.
PROP-FR4 (POW)	Provide adequate ventilation to allow machinery and personnel to work effectively and machinery for propulsion and emergency services to operate continuously.
SAFETY OF PERSONNEL (SAFE)	
SAFE-FR1	Materials that harm human health are not to be used in machinery.
SAFETY MANAGEMENT (MGMT)	
MGMT-FR1	Machinery spaces are to be arranged to allow safe access to operate and maintain the machinery.
AUTOMATION (CONTROL, MONITORING AND SAFETY SYSTEMS) (AUTO)	
AUTO-FR1 (PROP)	Visual and audible notifications are to be provided to alert the status of the machinery at manned stations.

The functional requirements in the cross-referenced Rules/Regulations are also to be met.

Compliance

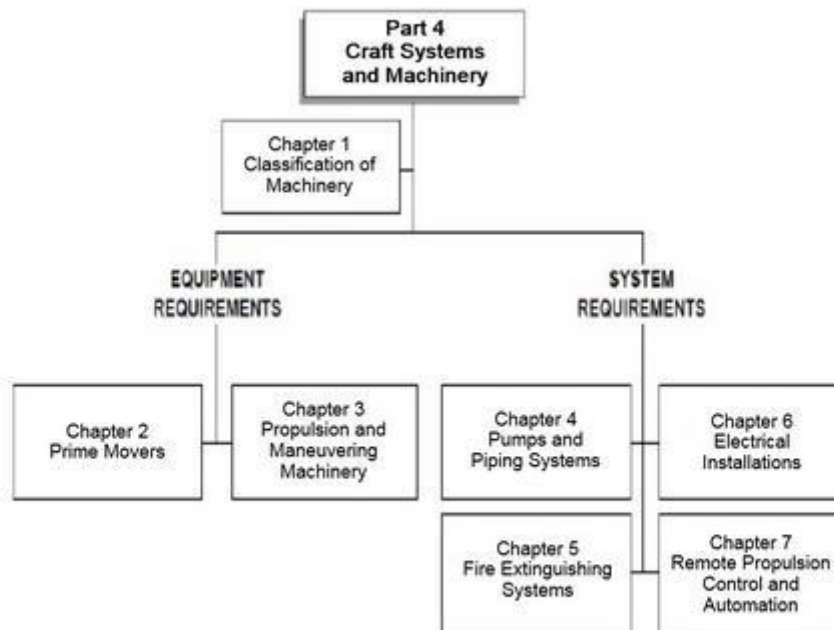
A craft is considered to comply with the goals and functional requirements within the scope of Classification when the applicable prescriptive requirements are complied with or when an alternative arrangement has been approved, refer to Part 1D, Chapter 2.

1 General

1.1 Organization of the High Speed Craft Rules (2025)

Part 4 provides classification requirements for machinery. These requirements are organized in two broad segments: that specific to equipment, and that specific to systems. 4-1-1/Figure 1 shows the overall organization of Part 4

FIGURE 1
Organization of Part 4 (2025)



3 Certification of Machinery

3.1 Basic Requirements (2025)

These Rules define the extent of evaluation to varying degrees, required for products, machinery, equipment and their components based on the level of criticality of each item. There are three basic evaluation constituents:

- Design review; type/prototype testing, as applicable;
- Survey during construction and testing at the plant of manufacture; and
- Survey during installation onboard the craft and at trials.

Where design review is required by these Rules, a letter will be issued by ABS upon satisfactory review of the plans to evidence the acceptance of the design. In addition to, or independent of, design review, ABS may require survey and testing of forgings, castings and component parts at the various manufacturers' plants as well as survey and testing of the finished product. A certificate or report will be issued upon satisfactory completion of each survey to evidence acceptance of the forging, casting, component or finished product. Design review, survey and the issuance of reports or certificates constitute the *certification* of machinery.

Based on the intended service and application, some products do not require certification because they are not directly related to the scope of classification or because normal practices for their construction within the industry are considered adequate. Such products are accepted based on the manufacturers' documentation on design and quality.

Surveys during installation onboard the craft and at trials are required for all items of machinery. This is not considered a part of the product certification process. There may also be instances where letters or certificates issued for items of machinery contain conditions which are to be verified during installation, tests or trials.

3.3 Type Approval Program

Products that can be consistently manufactured to the same design and specification may be Type Approved under the ABS Type Approval Program. The ABS Type Approval Program is a voluntary option for the demonstration of the compliance of a product with the Rules or other recognized standards. It may be applied at the request of the designer or manufacturer. The ABS Type Approval Program covers Product Type Approval (1C-1-4/11.9.3), but is also applicable for a more expeditious procedure towards Unit-Certification, as specified in 1C-1-4/11.9.2.

See the *ABS Type Approval Program* in Appendix 1C-1-A2. The *ABS Type Approval Program* and the indicated references are available for download from the ABS website at <http://www.eagle.org>.

3.5 Non-mass Produced Machinery

Non-mass produced critical machinery, such as propulsion boilers, slow speed diesel engines, turbines, steering gears and similar critical items are to be individually unit certified in accordance with the procedure described in 4-1-1/3.1. Alternatively, granting Type Approval to such machinery in the category of Recognized Quality System (RQS). The category of Product Quality Assurance (PQA) will not be available for all products, and such limitations are indicated in 4-1-1/Table 1 through 4-1-1/Table 6 of the *ABS Rules for Building and Classing Marine Vessels (Marine Vessel Rules)*. In each instance where Type Approval is granted, in addition to quality assurance and quality control assessment of the manufacturing facilities, ABS requires some degree of product-specific survey during manufacture.

3.7 Details of Certification of Some Representative Products (2025)

4-1-1/Tables 1 through 6 of the *Marine Vessel Rules* summarize certification requirements of typical machinery based on the basic requirements of the Rules for machinery. The tables also show the applicability of the Type Approval Program for each item.

The tables contain six product categories, as follows:

- Prime movers
- Propulsion, maneuvering and mooring machinery
- Electrical and control equipment
- Fire safety equipment
- Boilers, pressure vessels and fired equipment
- Piping system components

Commentary:

The approval tiers indicated in the 4-1-1/Table 1 through 6 of the *Marine Vessel Rules* are the minimum tiers of certification. Tier 5 is the highest and Tier 1 the lowest. Some equipment is customized for each project and may not be suitable for Type Approval (Tier 3) or Product Design Assessment (Tier 4) that are for mass-produced or standardized equipment. Therefore, if the equipment has Tier 5 approval (unit certification), then it is considered to meet Tier 4 and other lower tier requirements. Refer to 1C-1-A3/1 for details of each Tier of Approval.

End of Commentary

For craft assigned • AMS notation, refer to 1C-1-3/11 for classification of machinery requirements.

3.9 ABS Marking on Finished Components and Equipment (2021)

All finished components/equipment issued with unit certificates are to be permanently marked at an accessible location for identification and traceability. The identification is to include but not limited to the model number or part number, serial number and other data that are necessary to comply with other ABS Rule requirements.

At the request of the manufacturer, an ABS Marking may be applied. The marking includes the ABS mark (⌘) and a unique identification number generated by ABS.

An example of ABS marking: ⌘ 123456.

Markings are to be permanently marked (i.e. steel-die-stamped, laser etched, etc.) at an accessible location by the manufacturer on each finished component or equipment.

ABS Certificates for the components and equipment are to be provided to the responsible party (e.g. owner or shipyard) and Surveyor at installation.

5 Shipboard Automatic or Remote Control and Monitoring Systems (2025)

Automatic or remote control and monitoring systems associated with propulsion machinery and monitoring systems of propulsion-machinery space installed onboard classed craft are to comply with the requirements in Section 4-7-1 and with those in Section 4-7-2, Section 4-7-5 or Section 4-7-6, as applicable. Additionally, where requested by the Owner and provided that compliance with Section 4-7-3 or Section 4-7-4 is met, the aforementioned systems will be assigned the optional notations *ACCU* or *ABCU*, respectively. See Section 4-7-1 for general requirements.

7 Machinery Plans and Data (2025)

Machinery and systems plans required by the Rules are to be submitted electronically by the manufacturer, designer, or shipyard to ABS. Where so stated in the shipbuilding contract, the Owner may require the shipyard to provide it with copies of approved plans and related correspondence. A fee will be charged for the review of plans which are not covered by a contract of classification with the shipyard.

All plans are to be submitted and approved before proceeding with the work.

7.1 General (2025)

Details of dead craft start arrangements (see 4-1-1/19).

7.3 Automation and Remote Control Systems (2025)

Plans and data listed on 4-7-1/7

Certificates or test reports attesting to the suitability of the particular equipment in compliance with the environmental criteria set forth in Section 4-7-7 and Section 4-7-9, as applicable. For equipment that have been already certified by ABS and provided their certification remains valid, the submission of a copy of pertinent certificate will suffice (see 4-7-9/13.15).

Installation methods (electrical, pneumatic and hydraulic) (see 4-7-9/13)

7.5 Boilers, Pressure Vessels and Heat Exchangers

Arrangements and details of boilers, pressure vessels and heat exchangers required by Part 4, Chapter 4 of the *Marine Vessel Rules*

Plans and data for hydraulic and pneumatic power cylinders, as required by 4-4-6/3

7.7 Electrical Systems (2025)

One line diagrams for the electrical systems listed in 4-6-2/1.1.1 containing the information specified in 4-6-2/1.1.2 are to be submitted for review.

Short-circuit data (see 4-6-2/1.3)

Protective device coordination study (see 4-6-2/1.5)

Electric-plant load analysis (see 4-6-2/1.7)

Booklet of standard wiring practices and details (see 4-6-3/1.1)

General arrangement plan of electrical equipment showing the location of the equipment listed in 4-6-3/1.3

Location of splices and cable boxes together with information of their services (see 4-6-3/1.3)

Hazardous area plan (see 4-6-3/1.5)

List of all equipment in hazardous areas (see 4-6-3/1.5)

Details of electrical components, as required by 4-6-4/1

7.9 Fire Safety

Arrangement and details of control station for emergency closing of openings and stopping machinery

Details and location of fireman's outfits

Details of fire extinguishing appliances

Fire control plans (see 4-5-1/1.9)

Plans of the following systems:

- Fire main system
- Foam smothering system
- Fire detection systems
- Fixed gas extinguishing system
- Fixed water spraying system

Other fire extinguishing arrangements

For craft 500 GT and over, the most severe service condition for the operation of the emergency fire pump (e.g., lightest draft as shown in Trim and Stability Booklet, etc.)

For craft 500 GT and over, calculations and pump data demonstrating that the emergency fire pump system can meet the operational requirements specified in 4-5-2/5.3.3 and 4-5-2/5.3.6 with the proposed pump location and piping arrangements (e.g., adequate suction lift, discharge pressure, capacity, etc.) at the most severe service condition

7.11 Gas Turbines

Plans and particulars as required by Section 4-2-3 of the *Marine Vessel Rules*

Additionally, details of the manufacturer's proposed automatic safety devices in accordance with 4-2-2/1.7 of these Rules

7.13 Diesel Engines

Plans and particulars as required by Section 4-2-1 of the *Marine Vessel Rules*

7.15 Lift Devices (2025)

Details and material specifications of torque transmitting parts

Full details for all components that directly provide thrust and lift including all machinery items and any associated air propellers, ducts, vanes, scoop and nozzles (see 4-3-6/1.3)

Design basis stress calculations for propulsion and lift devices (propellers, impellers, shafting, gears, belt drives, couplings, keys, bearings, and control mechanism) (see 4-3-6/5.1.2)

7.17 Piping Systems (2025)

Diagrammatic plans, as applicable, of the following piping systems containing the information specified in 4-4-1/3.3:

- Propulsion machinery space arrangement including location of fuel oil tanks
- Booklet of standard details (see 4-4-1/3.5)
- Ballast system (Including any Ballast Water Treatment)
- Bilge and drainage system (gravity drains, weather deck drains, helideck drains, as applicable)
- Cargo systems
- Compressed air systems (including starting air systems and control systems)
- Cooling water systems
- Exhaust gas systems (for boilers, incinerators and engines)
- Exhaust Gas Cleaning System (as applicable, see 6-3-1/9.11 of the *Marine Vessel Rules*)
- Ventilation systems

- Crankcase ventilation
- Fire-fighting systems
- Fixed oxygen-acetylene systems
- Fuel oil systems, including storage tanks, drip trays and drains
- Helicopter refueling system, fuel storage tanks and its securing and bonding arrangements
- Hydraulic and pneumatic systems
- Lubricating oil systems
- Potable water system (including desalination plant, as applicable)
- Sanitary system
- Sea water systems
- Vent, sounding and overflow arrangements
- Tank venting and overflow systems
- All Class I and II piping systems not covered above

7.19 Propellers (2025)

For all propellers (air or water), a propeller plan giving design data and characteristics of the material (see 4-3-2/1.5)

For highly-skewed propellers and other unconventional design propeller, a propeller load and stress analysis demonstrating the adequacy of the blade strength, as required by 4-3-2/5.5 or 4-3-2/5.7 (see 4-3-2/1.5.3)

For controllable pitch propellers, plans of the propeller hub, propeller blade flange and bolts, internal mechanisms, hydraulic piping control systems, and instrumentation and alarm systems; also strength calculations for the internal mechanism (see 4-3-2/1.5.3)

Detailed stress calculations and fitting instructions for keyless propeller connections (see 4-3-2/1.5.4)

Detailed drawings of the arrangement of the Propeller Boss Cap Fin (PBCF) (see 4-3-2/1.5.5)

7.21 Reduction Gears

Arrangements, details and data as required by Section 4-3-1 of the *Marine Vessel Rules*

7.23 Shafting (2025)

Detailed plans together with material specifications of the propulsion shafting, couplings, coupling bolts, propulsion shafting arrangement, tail shaft bearings and lubrication system, if oil-lubricated (see 4-3-1/3)

Calculations for flexible couplings and demountable couplings (see 4-2-1/17 and 4-3-1/19.9)

Shaft alignment and vibration calculations, if required by 4-3-1/27

Detailed preloading and stress calculations and fitting instructions for non-fitted coupling bolts (see 4-3-1/19.3)

Thrust plate calculations

7.25 Steering Gears (2025)

General arrangements of the main and auxiliary steering gears and steering compartment (see 4-3-3/1.5.1).

Assembly of upper rudder stock, tiller, tie rod, rudder actuators, etc. (see 4-3-3/1.5.1).

Construction details of all torque-transmitting components such as tiller, tiller pin, tiller/rudder stock interference fit mechanism, tie rod, rudder actuator, etc., including bill of materials, welding procedures and nondestructive testing, as applicable (see 4-3-3/1.5.1).

Control system incorporating schematic electrical control logic diagram, instrumentation, alarm devices, etc., and including bill of materials (see 4-3-3/1.5.1).

Design calculations for torque-transmitting components such as tiller, tie rod, rudder actuator, etc. (see 4-3-3/1.5.2).

Details of electrical power supply to power units and to steering gear control, including schematic diagram of motor controllers, feeder cables and feeder cable electrical protection (see 4-3-3/1.5.1).

Rated torque of main steering gear (see 4-3-3/1.5.2).

Schematic hydraulic piping plan incorporating hydraulic logic diagram and including bill of materials, typical pipe to pipe joint details, pipe to valve joint details, pipe to equipment joint details, pressure rating of valves and pipe fittings and pressure relief valve settings (see 4-3-3/1.5.1).

7.27 Steering Vanes

Details and material specifications of torque transmitting parts

Airfoil analysis including vane freestream characteristics (lift and drag characteristics)

Control system arrangements

7.29 Thrusters (Steerable, Athwartship)

Drawings and data as per 4-3-5/1.7 of the *Marine Vessel Rules*

7.31 Waterjets (2025)

Details and material specifications of torque transmitting parts

Design basis stress calculations for the impellers, shafting, steering mechanism and reversing mechanism (see 4-3-4/3)

Calculations or test results to substantiate the suitability and strength of the pressure and suction housing (see 4-3-4/5)

7.33 Windlass or Winch (2025)

Drawings and data as per 4-5-1/1.5 of the *Marine Vessel Rules*.

9 Machinery

Rotating machinery of 100 kW (135 HP) and over is to be in accordance with the requirements of Part 4, Chapters 1 through 6, as applicable. Machinery of less than 100 kW (135 HP) designed, constructed and equipped in accordance with good commercial practice are acceptable subject to a satisfactory performance test conducted to the satisfaction of the Surveyor after installation.

11 Machinery Spaces

Machinery spaces are to be arranged so as to provide access to all machinery and controls as necessary for operation or maintenance.

13 Definitions

For the purpose of machinery installations, electrical installations, periodically unattended machinery spaces, fire protection, fire detection and fire extinction, the following terms are defined:

13.1 Machinery Spaces of Category A

Machinery spaces of Category A are those spaces and trunks to such spaces which contain: internal combustion machinery used for main propulsion; internal combustion machinery used for purposes other than main propulsion, where such machinery has an aggregate total power output of not less than 375 kW (500 HP); any oil-fired equipment such as an incinerator, waste disposal unit, etc.; or any oil fuel units.

13.3 Machinery Spaces (2025)

Machinery spaces are machinery spaces of Category A and other spaces containing propelling machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical equipment, oil

filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, similar spaces and trunks to such spaces.

13.5 Oil Fuel Unit (2025)

An oil fuel unit is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of oil fuel, heated or not, to an internal-combustion engine (including gas turbine), and includes any oil pressure pumps, filters and heaters dealing with oil at a gauge pressure of more than 0.18 MPa (1.8 bar, 26 psi).

13.7 Accommodation Spaces

Accommodation spaces are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces.

13.9 Public Spaces

Public spaces are those portions of the accommodation which are used for meeting halls, dining rooms, lounges and similar permanently enclosed spaces.

13.11 Service Spaces

Service spaces are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store-rooms, workshops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces.

13.13 Cargo Spaces (2025)

Cargo spaces are all spaces used for cargo (including cargo oil tanks and tanks for other liquid cargoes) and trunks to such spaces.

13.15 Special Category Spaces (2025)

Special category spaces are those enclosed vehicle spaces above or below the bulkhead deck intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion, into and from which such vehicles can be driven and to which passengers have access.

13.17 Sources of Ignition

Sources of ignition are considered to include a flame, arc, spark and electrical equipment, machinery and other equipment having hot surfaces with the potential of causing a non-intentional explosion or fire when exposed to an explosive or flammable atmosphere or material.

13.19 Vital Systems (2025)

Vital systems are those systems necessary for the craft's survivability and safety, including:

- i. Systems for fill, transfer and service of fuel oil.
- ii. Fire-main systems, including emergency fire pump.
- iii. Other required fire-extinguishing and detection systems.
- iv. Bilge systems, including emergency bilge suction.
- v. Ballast systems.
- vi. Steering systems and steering control systems.
- vii. Propulsion systems and their necessary auxiliaries (fuel oil, lubricating oil, cooling water, starting system, etc.) and control systems.
- viii. Systems for transfer and control of cargo.
- ix. Craft's service and emergency electrical generation systems and their auxiliaries (fuel oil, lubricating oil, cooling water, starting system, etc.) and control systems.
- x. Venting and sounding systems.
- xi. Engine room ventilation systems.

- xii. Other required ventilation systems.
- xiii. Controllable pitch propeller systems, including controls.
- xiv. Electrical power and lighting systems.
- xv. Systems used for navigation.
- xvi. Required communication and alarm systems.
- xvii. Hydraulic systems for anchor windlass/winch.
- xviii. Systems necessary due to special characteristics or special service of a craft.
- xix. Any other system identified by ABS as crucial to the survival of the craft or to the safety of the personnel aboard.

13.21 Cargo Craft

Any craft other than a passenger craft, and which is capable of maintaining the main functions of safety systems of unaffected spaces after damage in any one compartment on board. The notation **Cargo Craft** defines a craft that is certified in accordance with the IMO International Code of Safety for High-Speed Craft.

13.23 Dead Craft Condition

Dead craft condition means a condition under which:

- i. The main propulsion plant, boilers and auxiliary machinery are not in operation due to the loss of the main source of electrical power, and
- ii. In restoring propulsion, the stored energy for starting the propulsion plant, the main source of electrical power and other essential auxiliary machinery is assumed to be not available.

13.25 Blackout (1 July 2022)

Blackout situation means the loss of the main and auxiliary machinery installations, including the main power supply, are out of operation, but the services for bringing them into operation (e.g., compressed air, starting current from batteries, etc.) are available.

15 Astern Propulsion Power

15.1 General (2026)

The minimum astern power required by SOLAS II-1/28.1 to secure proper control of the craft in all normal circumstances is to be determined by the craft designer and is not to exceed the maximum permissible astern power (MPAP) for which the propulsion plant is designed. Astern trials are to be conducted in accordance with the provisions of ISO 19019:2005, section 5.4: Astern trials. Main propulsion systems with reversing gears, controllable pitch propellers or electric propulsion drive are to be designed for the maximum permissible astern power, which is not to lead to overload of the propulsion machinery.

Note: The designed maximum astern power, as referred to in SOLAS II-1/3.15, defining the maximum astern speed for the design of the main steering gear and rudder stock as per 3-2-8/3.1 and SOLAS II-1 /29.3.4, are not to be taken less than the MPAP.

The **astern** tests are to be carried out from control positions. A test plan is to be provided by the shipyard and accepted by the Surveyor. If specific operational characteristics have been defined by the manufacturer, these are to be included in the test plan. The ability of the machinery, including the blade pitch control system of controllable pitch propellers, to reverse the direction of thrust of the propeller in sufficient time, and so to bring the craft to rest within a reasonable distance from maximum ahead service speed, is to be demonstrated and recorded during trials.

17 Inclinations (2025)

Machinery installations are to be designed to allow proper operations under the conditions as shown in 4-1-1/ TABLE 1.

The equipment manufacturer is to submit:

- Test reports showing operation under maximum angles of inclination, or
- Calculations or simulation, or
- Evidence of satisfactory service experience

19 Dead Craft Start

Means are to be provided to bring the machinery into operation from a “dead craft” condition as defined in 4-1-1/13.23. See 4-6-2/3.1.3 and 4-6-3/3.27 for the required starting arrangements.

21 Machinery Equations (2025)

Equations for rotating parts of the machinery in the following sections are based upon strength considerations and their application does not relieve the manufacturer from responsibility for the presence of harmful vibrations and other consideration in the machinery at speeds within the operating range.

23 Machinery Space Ventilation (2025)

Ventilation is to be provided for machinery spaces so as to allow simultaneously for crew attendance and for engines, boilers and other machinery to operate at rated power in all weather conditions, including heavy weather. The main propulsion machinery space is to be provided with mechanical means of ventilation.

24 Machinery and Equipment Vibrations (2025)

Mechanical vibrations onboard typically originate from rotating machinery (such as propellers, motors, internal combustion engines), pulsating flows in pipes and ducts, and gears. These vibrations transmit throughout the craft via shafts, foundations, hull, deck structures, pipe supports and equipment mounts. Different modes of vibrations in propulsion shafting systems are to comply with 4-3-1/27. Electrical equipment for automation is to be tested to vibration limits in 4-7-9/Table 2.

If significant local vibration exists during sea trials, corrective actions or vibration measurements are to be taken at the discretion of the ABS Surveyor.

25 Engineers' Alarm

Engineers' alarms are required on craft of 500 gross tons and over, which are intended for international voyages. An engineers' alarm is to be operable from the main propulsion control station. It is to be audible in the engineers' accommodations. See 4-6-2/17.3.

27 Automatic Trips

A description of all automatic trips that may affect the craft's propulsion system is to be submitted for review.

29 Thrusters and Dynamic Positioning Systems (2025)

Compliance with Section 4-3-5 of the *Marine Vessel Rules* is required as a condition for Class for main propulsion thrusters and is optional for propulsion-assist thrusters and athwartship thrusters. Dynamic positioning systems, including their thrusters, are to comply with the *ABS Guide for Dynamic Positioning Systems* where an optional notation in this Guide is requested.

31 Boilers, Pressure Vessels and Turbines

When fitted, boilers and pressure vessels are to be designed and constructed in accordance with Part 4, Chapter 4 of the *Marine Vessel Rules*. Turbines are to comply with Section 4-2-3 and Section 4-2-4 of the *Marine Vessel Rules*.

33 Sea Trial

33.1 General (2025)

A final underway trial is to be made of all machinery, including the steering gear, anchor windlass, stopping and maneuvering capability, including supplementary means for maneuvering, if any. Insofar as practicable, the craft is to be ballasted or otherwise arranged to simulate fully laden condition so as to allow propulsion machinery to deliver its rated power. The entire machinery installation is to be operated in the presence of the Surveyor to demonstrate its reliability and capability to function satisfactorily under operating conditions and its freedom from harmful vibrations and other detrimental operating phenomena at speeds within the operating range. The ability

of the machinery to reverse the direction of thrust of the propeller from maximum ahead speed and to bring the craft to rest is to be demonstrated on sea trials to the satisfaction of the Surveyor.

All automatic controls, including tripping of all safety protective devices that affect the craft's propulsion system, are to be tested underway or alongside the pier to the satisfaction of the Surveyor. References are also to be made to the following for more detailed requirements:

• Steering gear trial:	4-3-3/15.3
• Anchor windlass trial:	3-7-2/1
• Remote propulsion control and automation trial:	4-7-7/5
• Shipboard trials for diesel engines:	4-2-1/19,4-2-1/21

Based on the sea trials, the following information is to be provided on board:

- Stopping time (see also 4-1-1/15),
- Craft headings and distances recorded on sea trials, and
- For crafts with multiple propellers, ability to navigate and maneuver with one or more propellers inoperative.

References may be made to IMO Resolution A.209(VII) *Recommendation on Information to be Included in the Maneuvering Booklet and IMO Resolution A.601(15) Recommendation on the Provision and the Display of Maneuvering Information on board ships.*

33.3 Residual Fuel

The viscosity of the fuel used on the sea trial is to be entered in the classification report.

35 Units

These Rules are written in three systems of units, i.e., SI units, MKS units and US customary units. Each system is to be used independently of any other system. Unless indicated otherwise, the format presentation in these Rules of the three systems of units is as follows:

SI units (MKS units, US customary units).

37 Materials Containing Asbestos

Installation of materials which contain asbestos is prohibited.

39 Ambient Temperature (2025)

For craft of unrestricted service, ambient temperature, as indicated in 4-1-1/TABLE 2, is to be considered in the selection and installation of machinery, equipment and components. For craft of restricted (see 1C-2-2/7) or special service, the ambient temperature appropriate to the specific service is to be considered.

TABLE 1
Design Angles of Inclinations (2025)

Installations, Components	Angle of Inclination, Degrees ⁽¹⁾			
	Athwartships		Fore & Aft	
	Static	Dynamic	Static	Dynamic
Main and auxiliary machinery	15	22.5	5	7.5
Safety Equipment				
emergency power installations ⁽³⁾	22.5	22.5	10	10
emergency fire pumps and their drives	22.5	22.5	10	10
Switchgear				

	Angle of Inclination, Degrees ⁽¹⁾			
	Athwartships		Fore & Aft	
Installations, Components	Static	Dynamic	Static	Dynamic
electrical and electronic appliances and remote control systems	22.5 ⁽²⁾	22.5 ⁽²⁾	10	10

Notes:

- 1 Athwartships and fore-aft inclinations occur simultaneously.
- 2 Switches and controls are to remain in their last set position (no undesired switching operations or operational changes are to occur).
- 3 In craft designed for the carriage of liquefied gases and of chemicals, the emergency power installation is to remain operable with the craft flooded to its permissible athwartships inclination up to a maximum of 30 degrees.

TABLE 2
Ambient Temperatures for Unrestricted Service (2025)

Air		
<i>Installations, Components</i>	<i>Location, Arrangement ^(1, 2)</i>	<i>Temperature Range (°C)</i>
Machinery and electrical installations	Enclosed Spaces – General	0 to +45
	Components mounted on machinery associated with high temperature	According to specific machinery and installation
	In spaces subject to higher temperature (details to be submitted)	According to the actual maximum ambient temperature
	In spaces with temperature lower than +45°C (details to be submitted)	According to the actual ambient temperature subject to minimum +40
	Open Deck ⁽³⁾	–25 to +45
Water		
<i>Coolant</i>		<i>Temperature (°C)</i>
Seawater		+32

Notes:

- 1 Electronic equipment is to be suitable for operations up to 55°C.
- 2 For environmentally controlled spaces, see 4-6-1/17.3. For automatic or remote control and monitoring systems required to meet 4-7-9/15.5 TABLE 9 or 4-9-9/15.7 TABLE 1 of the *Marine Vessel Rules*, see test 3 of 4-7-9/15.5 TABLE 9, or test 4-9-9/15.7 TABLE 1 of the *Marine Vessel Rules*.
- 3 Control, monitoring and safety devices/systems of equipment for essential services (item (m) of 4-6-1/21.3 TABLE 4 and item (s) of 4-6-1/21.3 TABLE 5 when located on the open deck are to be rated at -25°C to +45°C. However, the ambient temperature above -25°C is acceptable provided that the selected ambient temperature is specified in the contract specification or the craft operation manual.

Yacht Rules (Jan 2026)

Part 4 Vessel Systems And Machinery

Chapter 3 Propulsion and Maneuvering Machinery

Section 3 Steering Gear

1 General

1.1 Application

These requirements apply to yachts which have rule-required upper rudder stock diameter less than 230 mm (9 in.). Where the rule-required upper rudder stock diameter is 230 mm (9 in.) or above, Section 4-3-4 of the *Marine Vessel Rules* is to be applied.

1.3 Definitions

1.3.1 Main Steering Gear

Main steering gear is the machinery, rudder actuators, power units, ancillary equipment and the means of applying torque to the rudder stock (e.g., tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the yacht.

1.3.2 Auxiliary Steering Gear

Auxiliary steering gear is the equipment other than any part of the main steering gear necessary to steer the yacht in the event of failure of the main steering gear, but not including the tiller, quadrant or components serving the same purpose.

1.3.3 Steering Gear Control System

Steering gear control system is the equipment by which orders are transmitted from the navigation bridge to the steering gear power actuating system. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables required to control the steering gear power actuating system. For the purposes of these Rules, steering wheels, steering levers, and rudder angle feedback linkages are not considered to be part of the control system.

1.3.4 Power Units (2025)

A steering gear power unit is:

- i. In the case of electric steering gears, an electric motor and its associated electrical equipment,
- ii. In the case of electro-hydraulic steering gears, an electric motor and its associated electrical equipment and connected pump(s), and
- iii. In the case of other hydraulic steering gears, a driving engine and connected pump(s).

For the purpose of alternative steering arrangements, electric steering motors are to be considered as part of the power unit and rudder actuator.

1.3.5 Power Actuating System

Power actuating system is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a power unit or units together with the associated pipes and fittings and a rudder actuator. The power actuating systems may share common mechanical components (i.e., tiller, quadrant, rudder stock, or components serving the same purpose).

1.3.6 Rudder Actuator

Rudder actuator is the component which directly converts hydraulic pressure into mechanical action to move the rudder.

1.3.7 Maximum Working Pressure

Maximum working pressure is the expected pressure in the system when the steering gear is operated to comply with [4-3-3/1.9](#).

1.5 Plans and Data

Plans and data of the steering gear system to be submitted are as follows:

1.5.1 Plans

General arrangements of the main and auxiliary steering gears, and of the steering gear compartment.

Assembly of upper rudder stock, tiller, tie rod, rudder actuators, etc., as applicable.

Construction details of all torque-transmitting components of steering gear, such as tiller, tiller pin, tiller/rudder stock interference fit mechanism, tie rod, rudder actuator, etc., including bill of materials, welding procedures, nondestructive testing, as applicable.

Schematic hydraulic piping diagram, incorporating hydraulic logic diagram, and including bill of materials, typical pipe to pipe joint details, pipe to valve joint details, pipe to equipment joint details, pressure rating of valves and pipe fittings and pressure relief valve settings.

Steering gear control system incorporating schematic electrical control logic diagram, instrumentation, alarm devices, etc., and including bill of materials.

Electrical power supply to power units and to steering gear control, including schematic diagram of motor controllers, feeder cables, feeder cable electrical protection.

1.5.2 Data

Rated torque of main steering gear.

Calculations of torque-transmitting components such as tiller, tie rod, rudder actuator, etc.

1.7 Power Operation

The main steering gear is to be power-operated by one or more power units if the rule-required upper rudder stock diameter is 120 mm (4.7 in.) or greater.

Notwithstanding the above, the performance requirements stated in [4-3-3/1.9](#) and [4-3-3/1.11](#) are to be used to determine if it is necessary for the main and auxiliary steering gears to be power-operated.

1.9 Main Steering Gear

The main steering gear is to be capable of putting the rudder from 35° on one side to 35° on the other side with the yacht running ahead at maximum continuous shaft rpm and at the summer load waterline; and under the same conditions, the travel time from 35° on either side to 30° on the other side is not to be more than 28 seconds. For controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for the above maximum continuous ahead rated rpm.

1.11 Auxiliary Steering Gear

The auxiliary steering gear is to be capable of putting the rudder from 15° on one side to 15° on the other side in not more than 60 seconds with the yacht running ahead at half speed, or seven knots, whichever is greater.

The auxiliary steering gear is to be so arranged that the failure of the main steering gear will not render it inoperative. Likewise, failure of the auxiliary steering gear is not to affect the main steering gear.

An auxiliary steering gear is not required under the following conditions.

- i. When the main steering gear comprises two or more power units, and is so arranged that after a single failure in its piping system or in one of the power units, the defect can be isolated so that the steering

capability can be maintained or regained; and provided that the main steering gear is capable of operating the rudder, as required in , while any one of the power units is out of operation.

- ii. When the main steering gear is non-power-operated, such as an orbitrol system, or consists solely of mechanical components such as sheaves, blocks, wires, chains, etc.

1.13 Steering Gear Compartment Unit Location

The main and the auxiliary steering gears are to be protected from weather. The power units may be located either within or outside of the compartment containing the rudder actuators. In the event of loss of hydraulic fluid and of the need to restore the operation of the main or the auxiliary steering gear, the steering gear compartment is to be provided with handrails and gratings or other non-slip surfaces to ensure suitable working conditions.

In the event of control system failure, or the need to operate the main or the auxiliary steering gear from within the steering compartment or from positions other than the navigation bridge, yachts of 500 gross tons and above are to be provided with a means to indicate the position of the rudder at these positions where emergency steering is to be conducted.

3 Materials

3.1 General

All steering gear components transmitting a force to the rudder and pressure retaining components of the hydraulic rudder actuator are to be of steel or other approved ductile material. The use of gray cast iron or other material having an elongation less than 12% in 50 mm (2 in.) is not acceptable.

3.3 Material Testing

Except as modified below, materials for the parts and components mentioned in 4-3-3/3.1 are to be tested in the presence of the Surveyor in accordance with the requirements of Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*.

Material tests for steering gear coupling bolts and torque transmitting keys need not be witnessed by the Surveyor.

Material tests for commercially supplied tie-rod nuts need not be witnessed by the Surveyor, provided the nuts are in compliance with the approved steering gear drawings and are appropriately marked and identified in accordance with a recognized industry standard. Mill test reports for the tie-rod nuts are to be made available to the Surveyor upon request. For all non-standard tie-rod nuts, material testing is required to be performed in the presence of the Surveyor.

Material tests for forged, welded or seamless steel parts (including the internal components) and all non-ferrous parts of rudder actuators that are under 150 mm (6 in.) in internal diameter need not be carried out in the presence of the Surveyor. Such parts are to comply with the requirements of Chapter 3 of the above referenced Part 2, or such other appropriate material specifications as may be approved in connection with a particular design, and will be accepted on the basis of presentation of mill certificates to the Surveyor for verification.

5 Design

5.1 Power Gear Stops

Power-operated steering gears are to be provided with arrangements, such as limit switches, for stopping the steering gear before the structural rudder stops (see 3-2-9/1.7) or positive mechanical stops within the steering gear are reached. These arrangements are to be synchronized with the rudder stock or position of the steering gear itself rather than with the steering-gear control system.

5.3 Mechanical Components

All steering gear parts transmitting force to or from the rudder, such as tillers, quadrants, rams, pins, tie rods and keys, are to be proportioned to have strength equivalent to that of the rule-required upper rudder stock diameter.

5.4 Steering Gear Torque

5.4.1 Minimum Required Rated Torque

The rated torque of the steering gear is not to be less than the expected torque, as defined in 3-2-9/1.5.

5.4.2 Maximum Allowable Torque

The transmitted torque, T_{max} , of the steering gear is not to be greater than the maximum allowable torque, T_{ar} , based on the actual rudder stock diameter.

5.4.2(a) Transmitted Torque

The transmitted torque, T_{max} , is to be based on the relief valve setting and to be determined in accordance with the following equations:

For ram type actuator:

$$T_{max} = P \cdot N \cdot A \cdot L_2 / (C \cdot \cos^2 \theta) \text{ kN-m (tf-m, Ltf-ft)}$$

For rotary vane type actuator:

$$T_{max} = P \cdot N \cdot A \cdot L_2 / C \text{ kN-m (tf-m, Ltf-ft)}$$

For linked cylinder type actuator:

$$T_{max} = P \cdot N \cdot A \cdot L_2 \cos \theta / C \text{ kN-m (tf-m, Ltf-ft)}$$

where

P	=	steering gear relief valve setting pressure, bar (kgf/cm ² , psi)
N	=	number of active pistons or vanes
A	=	area of piston or vane, mm ² (cm ² , in ²)
L_2	=	torque arm, equal the distance from the point of application of the force on the arm to the center of the rudder stock at 0 deg of the rudder angle, m (ft)
C	=	factor, 10000 (1000, 2240)
θ	=	maximum permissible rudder angle (normally 35 degrees)

5.4.2(b) Maximum Allowable Torque for Rudder Stock

The maximum allowable torque “ T_{ar} ” for the actual rudder stock diameter is to be determined in accordance with the following equation:

$$T_{ar} = 2.0(D_r/N_u)^3 / K_s \text{ kN-m (tf-m, Ltf-ft)}$$

where

K_s	=	material factor for rudder stock (see 3-2-9/1.3)
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D_r = actual rudder stock diameter at minimum point below the tiller or the rotor, mm (in.)

N_u = factor, 42.0 (89.9, 2.39)

5.5 Tiller

Tillers are to comply with the following requirements. All terms in the formulae are to have consistent units.

5.5.1

Depth of the tiller hub is not to be less than the rule-required upper rudder stock diameter.

5.5.2

Thickness of the tiller hub is not to be less than one third of the rule-required upper rudder stock diameter.

5.5.3

Notwithstanding 4-3-3/5.5.2 above, the polar section modulus of the tiller hub is not to be less than:

$$0.196S^3 \frac{K_h}{K_s}$$

where

S = rule-required upper rudder stock diameter.

K_s = material factor of the rudder stock (see 3-2-9/1.3)

K_h = material factor of the hub (see 3-2-9/1.3)

5.5.4

The shear area of the tiller key is not to be less than:

$$\frac{0.196S^3}{r} \cdot \frac{K_h}{K_s}$$

where

r = mean radius of the rudder stock in way of the key

K_k = material factor of the key (see 3-2-9/1.3)

Other symbols are defined above.

5.5.5

Bearing stress of the tiller and rudder stock keyways are not to be more than 0.9 times the material yield stress.

5.5.6 (2016)

If the tiller is shrink-fitted to the rudder stock, preloading and stress calculations and fitting instructions are to be submitted. The calculated torsional holding capacity is to be at least two times the transmitted torque based on the steering gear relief valve setting. Preload stress is not to exceed 70% of the minimum yield strength.

5.5.7

Section modulus of the tiller arm at any point within its length is not to be less than:

$$\frac{0.167S^3 (L_2 - L_1)}{L_2} \cdot \frac{K_t}{K_s}$$

where

L_2 = distance from the point of application of the force on the tiller to the center of rudder stock

L_1 = distance between the section of the tiller arm under consideration and the center of the rudder stock

K_t = material factor of the tiller or quadrant arm (see 3-2-9/1.3)

Other symbols are defined above.

5.5.8

Split or semi-circular tiller or quadrant hubs assembled by bolting are to have bolts on each side having a total cross-sectional area not less than that given below (use a consistent system of units):

$$\frac{0.196S^3}{L_3} \cdot \frac{K_b}{K_s}$$

where

L_3 = distance between the center of the bolts and the center of the rudder stock

K_b = material factor of bolt (see 3-2-9/1.3)

Other symbols are as defined above.

This formula appears to apply to bolts working under shear: normal split configurations have bolts working under tension only. Clarification suggested

The thickness of the bolting flange is not to be less than the minimum required diameter of the bolt.

5.5.9

Where the tiller is of welded construction, weld design and weld sizes are to be proportioned such that they are commensurate with the strength of the tiller.

5.7 Pin

Shear area of the tiller pin is not to be less than:

$$\frac{0.196S^3}{L_2} \cdot \frac{K_p}{K_s}$$

where

K_p = material factor of the pin (see 3-2-9/1.3)

Other symbols are defined above.

5.9 Tie Rod (Jockey Bar)

The buckling strength of the tie rod is not to be less than:

$$\frac{0.113S^3U_R}{L_2}$$

where

U_R = ultimate tensile strength of the rudder stock

Other symbols are defined above.

5.9.1 Synchronization Only

When the tie rod is fitted for synchronization purposes only, 4-3-3/5.9 is not required to be met.

5.11 Rudder Actuators

5.11.1 General

Rudder actuators are to meet the requirements in 4-3-3/3 for materials and material tests and 2-4-2/1 for welding. They are also to meet the requirements for pressure vessels in the *Marine Vessel Rules*, specifically 4-4-1-A1/3.1 (for nodular cast iron, use $y = 0.5$), 4-4-1-A1/5 and 4-4-1-A1/7 (in association with S , as defined below) for design and 4-4-1-A1/21 for hydrostatic tests. The maximum allowable stress, S , is not to exceed the lower of the following:

$$\frac{U}{A}$$

or

$$\frac{Y}{B}$$

where

U = minimum specified tensile strength of material at room temperature

Y = minimum specified yield point or yield strength

A, B = factors as given in the following table.

Factor	Rolled or Forged Steel	Cast Steel	Nodular Cast Iron
<i>A</i>	3.5	4	5
<i>B</i>	1.7	2	3

5.11.2 Oil Seals

Oil seals between non-moving parts forming the external boundary are to be of the pressure seal type. Oil seals between moving parts forming the external pressure boundary are to be fitted in duplicate so that the failure of one seal does not render the actuator inoperative. Alternative seal arrangement may be acceptable, provided equivalent protection against leakage can be ensured.

5.13 Mechanical Steering Gear

Where mechanical steering systems are permitted, the following are applicable.

5.13.1 Steering Chains and Wire Ropes

Steering chains and wire rope are to be tested as required by Sections 2-2-1 and 2-2-2 of the *ABS Rules for Materials and Welding (Part 2)*, respectively.

5.13.2 Sheaves

Sheaves are to be of ample size and so placed as to provide a fair lead to the quadrant and avoid acute angles. Parts subjected to shock are not to be of cast iron. Guards are to be placed around the sheaves to protect against injury. For sheaves intended for use with ropes, the radius of the grooves is to be equal to that of the rope plus 0.8 mm ($\frac{1}{32}$ in.), and the sheave diameter is to be determined on the basis of wire rope flexibility. For 6 × 37 wire rope, the sheave diameter is to be not less than 18 times that of the rope. For wire ropes of lesser flexibility, the sheave diameter is to be increased accordingly. Sheave diameters for chain are to be not less than 30 times the chain diameter.

5.13.3 Buffers

Steering gears other than the hydraulic type are to be designed with suitable buffer arrangement to relieve the gear from shocks to the rudder.

7 Hydraulic System

7.1 Pipes, Valves and Fittings

Pipes, valves and fittings are to meet the requirements of 4-4-6/1, as applicable. The design pressure of piping components subject to internal hydraulic pressure is to be at least 1.25 times the maximum working pressure of the system. Arrangements for bleeding air from the hydraulic system are to be provided, where necessary.

7.3 Relief Valves

Relief valves are to be provided for the protection of the hydraulic system at any part which can be isolated and in which pressure can be generated from the power source or from external forces. Each relief valve is to be capable of relieving not less than 110% of the full flow of the pump(s) which can discharge through it. With this flow condition, the maximum pressure rise is not to exceed 10% of the relief valve setting, taking into consideration increase in oil viscosity for extreme ambient conditions.

The relief valve setting is to be at least 1.25 times the maximum working pressure (see 4-3-3/1.3.7), but is not to exceed the maximum design pressure (see 4-3-3/7.1).

7.5 Filtration

A means is to be provided to maintain cleanliness of the hydraulic fluid.

7.7 Single Failure

Where multiple power units are provided and an auxiliary steering gear is not fitted, the steering gear hydraulic system is to be designed so that after a single failure in its piping system, one of the power units, or mechanical connection to the power units, the defect can be isolated so that the integrity of the remaining part of the system will not be impaired and the steering capability can be maintained or regained. For this purpose, the piping system associated with each power unit is to be independent of that of the other units as far as practicable and connections are to be made only where necessary. Isolation valves are to be fitted, as necessary, to allow any single failure in the piping system to be isolated and the steering gear to be operated with the remaining intact part of the system. Isolation valves are to be fitted at the pipe connections to rudder actuators. Where a non-duplicated rudder actuator is employed, the isolation valves are to be mounted directly on the actuator. Piping systems are to be so arranged that transfer between power units can be readily affected.

7.9 Reservoir and Storage Tank

All open-loop hydraulic systems are to be provided with an oil reservoir of suitable capacity. In addition, for yachts of 500 gross tons and above, a fixed storage tank having sufficient capacity to recharge at least one hydraulic power system including the reservoir is to be provided. The tank is to be permanently connected by piping in such a manner that the system can be readily recharged from a position within the steering gear compartment.

9 Power Units

If the rule required upper rudder stock diameter is 120 mm (4.7 in.) or greater, power units are to be tested and certified in accordance with the following requirements. If the rule-required upper rudder stock diameter is less than 120 mm (4.7 in.), and if the yacht is 500 gross tons or greater, power units are to be tested and certified in accordance with [4-3-3/9.3](#) only. For yachts less than 500 gross tons, power units may be accepted based on manufacturer's guarantee for suitability for the intended purpose and subject to satisfactory functional tests after installation.

9.1 Prototype Test

A prototype of each new design power unit pump is to be shop-tested for a duration of not less than 100 hours. The testing is to be carried out in accordance with an approved agenda and is to include the following as a minimum.

9.1.1

The pump and stroke control (or directional control valve) is to be operated continuously from full flow and relief valve pressure in one direction through idle to full flow and relief valve pressure in the opposite direction.

9.1.2

Pump suction conditions are to simulate lowest anticipated suction head. The power unit is to be checked for abnormal heating, excessive vibration or other irregularities. Following the test, the power unit pump is to be disassembled and inspected in the presence of a Surveyor.

9.3 Production Unit Test

Each power unit pump is to meet the hydrostatic and capacity tests in accordance with [4-4-2/1](#), as applicable.

11 Steering Gear Control System

11.1 Locations of Control

11.1.1 Main Steering Gear

The main steering gear is to be provided with control from the navigation bridge and local control from within the steering gear compartment. However, if the power unit is located in a space other than the steering compartment, the local control is to be provided in that space instead of the steering compartment. For the purpose of local control from the steering gear compartment (or the space containing the power unit), a means is to be provided in the steering compartment (or the space containing the power unit) to disconnect any control system from the navigation bridge. Such means for disconnecting are to be operable by a single person without the need for tools.

11.1.2 Auxiliary Steering Gear

The auxiliary steering gear is to be operable from a space in which the operation of the auxiliary steering gear can be effectively carried out, or from within the steering compartment. However, if power operated, it is to be provided with control from the navigation bridge also.

11.1.3 Duplicate Power Units

Where duplicate (or more) power units are provided and an auxiliary steering gear is not fitted, two independent systems of control are to be provided. Each of these systems is to meet the requirements of the control system of the main steering gear (See [4-3-3/11.1.1](#)). Where the control system consists of a hydraulic telemotor, a second independent system need not be fitted.

11.1.4 Manual Means

If the steering gear is operated by manual means only, such as by means of a steering wheel through a mechanical or a non-power-operated hydraulic system, only the requirements of [4-3-3/11.7](#) and [4-3-3/11.9.1](#) are applicable.

11.3 General

11.3.1 Main and Auxiliary Steering Gears

Control systems of the main and the auxiliary steering gears are to be independent of each other in all respects. The independent control systems are to meet the following requirements.

11.3.1(a) Redundancy (2020)

Steering gear controls are to be located in the navigation bridge and steering gear compartment or the space containing the power unit, as applicable. These control systems are to be independent in all respects and are to provide on the navigation bridge all necessary apparatus and arrangements for the starting and stopping of steering gear motors and the rapid transfer of steering power and control between units.

The control cables and piping are to be separated throughout their length as widely as is practicable.

Wires, terminals and the components for duplicated steering gear control systems installed in units, control boxes, switchboards or bridge consoles are to be separated throughout their length as widely as is practicable. Where physical separation is not practicable, separation may be achieved by means of a fire retardant plate.

11.3.1(b) Duplication

All electric components of the steering gear control system are to be duplicated. This does not require duplication of a steering wheel or steering lever.

11.3.1(c) Steering Mode Selector Switch

If a joint steering mode selector switch (uniaxial switch) is employed for both steering gear control systems, the connections for the circuits of the control systems are to be divided accordingly and separated from each other by an isolating plate or by air gap.

11.3.1(d) *Follow-up Amplifier*

In the case of double follow-up control, the amplifiers are to be designed and fed so as to be electrically and mechanically separated. In the case of non-follow-up control and follow-up control, the follow-up amplifiers are to be protected selectively.

11.3.1(e) *Additional Control Systems*

Control circuits for additional control systems (e.g., steering lever or autopilot) are to be designed for all-pole disconnection.

11.3.1(f) *Feed-back Units and Limit Switches*

The feed-back units and limit switches, if any, for the steering gear control systems are to be separated electrically and mechanically connected to the rudder stock or actuator separately.

11.3.1(g) *Hydraulic Control Components*

Hydraulic system components in the power actuating or hydraulic servo systems controlling the power systems of the steering gear, (e.g., solenoid valves, magnetic valves) are to be considered as part of the steering gear control system and are to be duplicated and separated.

Hydraulic system components in the steering gear control system that are part of a power unit may be regarded as being duplicated and separated when there are two or more separate power units provided and the piping to each power unit can be isolated.

11.3.2 Duplicate Power Units

If the main steering gear consists of duplicated (or more) power units and an auxiliary steering is not fitted, the two independent means of control are to comply with the requirements of [4-3-3/11.3.1](#).

11.3.3 Single Power Units

If the main steering gear consists of a single power unit and the auxiliary steering gear is not power operated, only one control system for the main steering gear need be provided.

11.3.4 Computer-based Systems

Steering control systems that are computer-based systems are to comply with Section 4-9-3 of the *Marine Vessel Rules* and are to be considered Category III.

11.3.5 System Response Under Failure (1 July 2023)

The failures (as listed, but not limited to items in [4-3-3/11.9](#)) likely to cause uncontrolled movements of rudder are to be clearly identified. In the event of detection of such failure, the rudder is to stop in the current position without manual intervention or is to return to the midship/neutral position. Failure Mode and Effect Analysis methodology may be used to identify the failures. For mechanical failures such as sticking valves and failure of static components (pipes, cylinders), the system response without manual intervention is not mandatory, and the operator can follow instructions on the signboard in case of such failures, in accordance with [4-3-3/11.11](#). For hydraulic locking failure, refer also to [4-3-3/11.9.8](#) and [4-3-3/11.11](#).

11.5 Control System Power Supply

Electrical power for the steering gear control system is to be derived from the motor controller of the power unit that it is controlling, or from the main switchboard at a point adjacent to the supply to the power unit.

11.7 Communication

A means of communication is to be provided between the navigation bridge and all other locations where steering can be effected, such as the steering gear compartment, the space where the power units are located and the space where auxiliary steering gear is to be operated, as applicable.

11.9 Instrumentation and Alarms

The following instruments and alarms are to be provided. The audible and visual alarms are to have provisions for testing.

11.9.1 Rudder Position Indicator

The angular position of the rudder is to be indicated on the navigational bridge and all other locations where steering can be effected, such as the steering gear compartment, the space where the power units are located and the space where auxiliary steering gear is to be operated, as applicable. The rudder angle indication is to be independent of the steering gear control system.

11.9.2 Autopilot

Where autopilot is fitted, a visual and audible alarm is to be provided on the navigation bridge to indicate its failure.

Where a power unit is provided and steering is controlled from navigation bridge, the following are applicable:

11.9.3 Motor Alarm

A visual and audible alarm is to be given on the navigation bridge and the engine room control station to indicate an overload condition of the steering gear power unit motor. Where three phase electrical power is used, a visual audible alarm is to be installed which indicates failure of any one of the supply phases. The operation of these alarms is not to interrupt the circuit.

11.9.4 Motor Running Indicators

Indicators for running indication of motors are to be installed on the navigation bridge and the engine room control station.

11.9.5 Power Failure

A visual and audible alarm is to be given on the navigation bridge and engine room control station to indicate a power failure to any one of the steering gear power units.

11.9.6 Control Power Failure

A visual and audible alarm is to be given on the navigation bridge and the engine room control station to indicate an electrical power failure in any steering gear control circuit or remote control circuit.

In addition, hydraulic power operated steering gear is to be provided with the following:

11.9.7 Low Oil Level Alarm (1 July 2017)

A visual and audible alarm is to be given on the navigation bridge and engine room control station to indicate a low oil level in any power unit reservoir. The operation of this alarm is not to interrupt the power supply circuit.

11.9.8 Hydraulic Locking (2023)

Hydraulic locking includes all situations where two hydraulic systems (usually identical) oppose each other in such a way that it may lead to loss of steering. It can either be caused by pressure in the two hydraulic systems working against each other or by hydraulic "by-pass" meaning that the systems puncture each other and cause pressure drop on both sides or make it impossible to build up pressure. Hydraulic locking may occur where a piping system is arranged such that malfunctions (for example, in directional valves or in the valve control) can cause power units to work in a closed circuit against each other rather than in parallel delivering fluid to the rudder actuator, thus resulting in loss of steering. Where the arrangement is such that a single failure may cause hydraulic locking and loss of steering, an audible and visual hydraulic locking alarm which identifies the failed system or component is to be provided on the navigation bridge. The alarm is to be activated upon steering gear failure if:

- Position of the variable displacement pump control system does not correspond to the given order, or
 - Incorrect position of the 3-way full flow valve or similar in the constant delivery pump system is detected.
- Alternatively, an independent steering failure alarm for follow-up control systems complying with the following requirements may be provided in lieu of a hydraulic locking alarm.

Where an independent steering failure alarm is installed for follow-up control systems it is to comply with the following:

11.9.8(a) The steering failure alarm system is to actuate an audible and visible alarm in the wheelhouse when the actual position of the rudder differs by more than 5 degrees from the rudder position ordered by the follow-up control systems for more than: (2020)

- 30 seconds for ordered rudder position changes of 70 degrees;
- 6.5 seconds for ordered rudder position changes of 5 degrees; and

The time period calculated by the following formula for ordered rudder positions changes between 5 degrees and 70 degrees:

$$t = (R/2.76) + 4.64$$

where:

- t = maximum time delay in seconds
- R = ordered rudder change in degrees

11.9.8(b) The steering failure alarm system must be separate from, and independent of, each steering gear control system, except for input received from the steering wheel shaft. (2020)

11.9.8(c) Each steering failure alarm system is to be supplied by a circuit that: (2020)

- i. Is independent of other steering gear system and steering alarm circuits.
- ii. Is fed from the emergency power source through the emergency distribution panel in the wheelhouse, if installed; and
- iii. Has no overcurrent protection except short circuit protection

11.9.9 Autopilot Override (2020)

11.9.9(a) Steering gear systems provided with an autopilot system are to have a device at the primary steering station to completely disconnect the autopilot control to permit change over to manual operation of the steering gear control system. A display is to be provided at the steering station to ensure that the helmsman can readily and clearly recognize which mode of steering control (autopilot or manual) is in operation. (2020)

11.9.9(b) (2020)

In addition to the changeover device as in 4-3-3/11.9.9(a), for primary steering stations, where fitted with an automatic autopilot override to change over from autopilot control to manual operation, the following are to be provided.

An audible and visual alarm is to be provided at the primary steering station in the event that:

- i. The automatic autopilot override fails to respond when the manual helm order is 5 degrees of rudder angle or greater, and
- ii. It is immediately activated upon automatic autopilot override actuation.

The alarm is to be separate and distinct from other bridge alarms, and is to continue to sound until it is acknowledged.

The following instrumentation and alarms are to be provided.

11.9.10 Loop Failures

A visual and audible alarm is to be given on the navigation bridge to indicate a loop failure.

Note:

Monitoring is to be provided for short circuit, broken connections and earth faults for command and feedback loops. Monitoring for loop failures is not required, when a steering failure alarm system is provided. See 4-3-3/11.9.8(a).

11.9.11 Computer-based System Failures

For steering control systems that are computer-based systems, a visual and audible alarm is to be given on the navigation bridge to indicate a computer-based system failure.

Note:

Monitoring is to be provided for data communication errors, computer hardware failures and software failure. See also Section 4-9-3 of the *Marine Vessel Rules*. Monitoring for computer-based system failures is not required, when a steering failure alarm system is provided. See 4-3-3/11.9.8(a).

11.9.12 Earth Fault (1 July 2017)

A visual and audible alarm is to be given on the navigation bridge to indicate an earth fault on AC and DC circuits

11.9.13 Deviation (1 July 2017)

Where arrangements discussed in 4-3-3/11.9.8, 4-3-3/11.9.9, 4-3-3/11.9.10 and 4-3-3/11.9.11 can lead to reduced or erroneous system performance of the commanded change in rudder angle, a deviation alarm visible and audible at the navigating bridge is to be initiated if the rudder's actual position does not reach the set point within acceptable time limits for the closed loop control systems (e.g., follow-up control, computer based systems, and autopilot). Deviation alarm may be caused by mechanical, hydraulic or electrical failures. See 4-3-3/11.9.8, 4-3-3/11.9.9, 4-3-3/11.9.10 and 4-3-3/11.9.11 for acceptable time limits or angle deviations, as applicable.

11.11 Operating Instructions

Appropriate operating instructions with a block diagram showing the change-over procedures for steering control systems and steering gear power units are to be permanently posted at a conspicuous location on the navigation

bridge and in or near the steering gear compartment. Where system failure alarms in 4-3-3/11.9.8 are provided, appropriate instructions are to be permanently posted on the navigation bridge to shut down the failed system.

13 Electrical Power Supply

Electrical power circuits are to meet the requirements of 4-6-2/11 and 4-6-2/5.3.

15 Testing and Trials

15.1 Testing of Piping System

The following tests are to be performed in the presence of the Surveyor.

15.1.1 Shop Tests

After fabrication, each component of the steering gear piping system, including the power units, hydraulic cylinders and piping, is to be hydrostatically tested at the plant of manufacture to 1.5 times the relief valve setting.

15.1.2 Installation Tests

After installation in the yacht, the complete piping system, including power units, hydraulic cylinders and piping, is to be subjected to a hydrostatic test equal to 1.1 times the relief valve setting, including a check of the relief valve operation.

15.3 Trials

The steering gear is to be tried out on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of these Rules have been met. The trial is to include the operation of the following:

15.3.1 (2017)

The main steering gear, including demonstration of the performance requirements of 4-3-3/1.9 or with the rudder fully submerged. Where full rudder submergence cannot be obtained in ballast conditions, steering gear trials are to be conducted at a displacement as close as reasonably possible to full-load displacement as required by Section 6.1.2 of ISO 19019:2005 on the conditions that either:

- i. The rudder is fully submerged (zero speed waterline) and the yacht is in an acceptable trim condition.
- ii. The rudder load and torque at the specified trial loading condition have been predicted (based on the system pressure measurement) and extrapolated to the full load condition using the following method to predict the equivalent torque and actuator pressure at the deepest seagoing draft:

$$Q_F = Q_T \alpha$$

$$\alpha = 1.25 \left(\frac{A_F}{A_T} \right) \left(\frac{V_F}{V_T} \right)^2$$

where

α = extrapolation factor

Q_F = rudder stock moment for the deepest service draft and maximum service speed condition

Q_T = rudder stock moment for the trial condition

A_F = total immersed projected area of the movable part of the rudder in the deepest seagoing condition

A_T = total immersed projected area of the movable part of the rudder in the trial condition

- V_F = contractual design speed of the yacht corresponding to the maximum continuous revolutions of the main engine at the deepest seagoing draft
- V_T = measured speed of the yacht (considering current) in the trial condition

Where the rudder actuator system pressure is shown to have a linear relationship to the rudder stock torque, the above equation can be taken as:

$$P_F = P_T \alpha$$

where

- P_F = estimated steering actuator hydraulic pressure in the deepest seagoing draft condition
- P_T = maximum measured actuator hydraulic pressure in the trial condition

Where constant volume fixed displacement pumps are utilized, the requirements can be deemed satisfied if the estimated steering actuator hydraulic pressure at the deepest draft is less than the specified maximum working pressure of the rudder actuator. Where a variable delivery pump is utilized, pump data should be supplied and interpreted to estimate the delivered flow rate that corresponds to the deepest seagoing draft in order to calculate the steering time and allow it to be compared to the required time.

Where A_T is greater than $0.95A_F$, there is no need for extrapolation methods to be applied.

- iii. Alternatively the designer or builder may use computational fluid dynamic (CFD) studies or experimental investigations to predict the rudder stock moment at the full sea going draft condition and service speed. These calculations or experimental investigations are to be to the satisfaction of ABS.

In any case for the main steering gear trial, the speed of the yacht corresponding to the number of maximum continuous revolution of main engine and maximum design pitch applies.

15.3.2

The auxiliary steering gear, if required, including demonstration to the performance requirements of 4-3-3/1.11 and transfer between main and auxiliary steering gear.

15.3.3

The power units, including transfer between power units.

15.3.4

The emergency power supply required by 4-6-2/5.3.

15.3.5

The steering gear controls, including transfer of control and local control.

15.3.6

The means of communications, as required by 4-3-3/11.7.

15.3.7

The alarms and indicators required by 4-3-3/11.9 (test may be done at dockside).

15.3.8

The storage and recharging system contained in [4-3-3/7.9](#) (test may be done at dockside).

15.3.9

The isolating of one power actuating system and checking for regaining steering capability are required by [4-3-3/7.7](#), if applicable (test may be done at dockside).

15.3.10

Where the steering gear is designed to avoid hydraulic locking, this feature is to be demonstrated.

River Rules (Steel Vessels for Service On Rivers and Intracoastal Waterways) (July 2025)

Part 4 Vessel Systems and Machinery

Chapter 2 Propulsion and Maneuvering Machinery

Section 3 Steering Gear

1 Steering Gear Requirements for All Type of Vessels

1.1 General

All self-propelled vessels are to be provided with effective means for steering which is to be capable of putting the rudder from hard over to hard over. In general, power operated steering gears are to be designed to be capable of putting the rudder from 35 degrees on one side to 35 degrees on the other side with the vessel running ahead at the maximum continuous rated shaft RPM and at the design waterline.

Steering gears for passenger vessels which are over 100 gross tons or are intended to carry more than 150 passengers are to be designed, constructed and tested in accordance with [4-2-3/3](#). Steering gears for all other self-propelled vessels are to comply with the following.

1.3 Plans

Detailed plans and calculations of the steering arrangement are to be submitted for approval.

1.5 Power Gear Stops (2010)

Power gears are to be provided with arrangements, such as limit switches, for stopping the gear before the structural rudder stops or positive mechanical stops within the steering gear are reached. These arrangements are to be synchronized with the position of the gear itself, such as from the rudder stock, tiller, or ram rather than by the control system.

1.7 Strength Requirements

Tillers, quadrants, yokes, steering chains, rods, and cables and all parts of steering gears subject to load from the rudder are to be of materials tested in accordance with the applicable requirements of Chapter 1 of the *ABS Rules for Materials and Welding (Part 2)*. In general, steering gears are to be so proportioned as to have a strength equivalent to that of the required upper rudder stock (see [3-2-4/23.5.1](#) or [3-2-5/25.5.1](#) as applicable. Parts in tension or subject to shock (impact) are not to be of cast iron.

1.9 Steering Chains

Steering chains and wire rope are to be of special quality and tested as required by Sections [2-2-1](#) and [2-2-2](#) of the *ABS Rules for Materials and Welding (Part 2)*, respectively.

1.11 Sheaves

Sheaves are to be of ample size, and so placed as to provide a fair lead to the quadrant and avoid acute angles. Parts subjected to shock are not to be of cast iron. For sheaves intended to be used with wire ropes, the radius of the grooves is to equal that of the wire rope plus 0.8 mm ($\frac{1}{32}$ in.) and the sheave diameter is to be determined on the basis of the wire rope flexibility. For 6 × 37 wire rope, the sheave diameters are to be not less than 18 times that of the wire rope. For wire rope of lesser flexibility, the sheave diameter is to be increased accordingly. Sheave diameters for chain are to be not less than 30 times the chain diameter.

1.13 Buffers

Steering gears other than hydraulic types are to be designed with suitable buffer arrangements to relieve the gear from shock from the rudder.

1.15 Hydraulic Piping for Steering Gears

A relief valve is to be provided for the protection of the hydraulic system. Pressure piping is to meet the requirements of Part 4, Chapter 3, except that the mill tests need not be witnessed by the Surveyor. After fabrication, the piping system or each piping component is to be subjected, in the presence of the Surveyor, to a hydrostatic test equal to 1.5 times the design working pressure. After installation in the vessel, the piping is to be tested under working conditions including a check of the relief valve operation.

1.17 Electrical Parts of Steering Gears

Electrical parts of steering gears are to meet the applicable requirements of Part 4, Chapter 5.

1.19 Trials

The steering gear is to be tested to demonstrate to the Surveyor's satisfaction that the requirements of these Rules have been met. Satisfactory performance is to be demonstrated under the following conditions.

1.19.1 Towboats and Tugs

From 35 degrees on either side to 30 degrees on the other side in 20 seconds with vessel moored to a dock or the river bank and with the main propulsion engines operating at approximately the full load rack setting.

1.19.2 Passenger Vessels and Other Self-propelled Vessels

From 35 degrees on either side to 30 degrees on the other side in not more than 28 seconds with the vessel running ahead at the maximum continuous rated shaft RPM. For controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for the above maximum continuous ahead rated RPM. Where a test with the vessel running ahead at full speed is not practicable, the test for towboats and tugs in 4-2-3/1.19.1 may be used.

Consideration may be given to other means for proving the adequacy of the steering arrangements and power subject to the satisfaction of the attending Surveyor.

3 Steering Gear for Passenger Vessels Over 100 Gross Tons or Carrying More than 150 Passengers

3.1 General

All passenger vessels which are over 100 gross tons or are intended to carry more than 150 passengers are to be provided with an approved means of steering. All power-operated steering gears for such vessels are to be constructed to the satisfaction of and tested in the presence of the Surveyor as follows:

3.1.1 Design

i. *Capability.* The steering gear is to be designed to be capable of:

- Putting the rudder from 35 degrees on one side to 35 degrees on the other side with the vessel running ahead at the maximum continuous rated shaft RPM and at the design waterline, and

- Meeting the performance requirements in accordance with . In this respect, any approval is to be understood as being subject to compliance with .

3.1.2 Special Steering

Vessels having cycloidal, azimuthing or similar type propulsion systems in which the steering is effected by changing the direction of the propulsion thrust are to comply with the provisions in Section 4-3-5 of the *Marine Vessel Rules*.

3.1.3 Single Failure (1996)

The steering gear system is to be designed so that after a single failure in its piping system, one of the power units or mechanical connections to the power units the defect can be isolated so that the integrity of the remaining part of the system will not be impaired and the steering capability can be maintained or speedily regained.

3.3 Plans

Detailed plans of the steering arrangement, including machinery, controls, instrumentation, power supplies, piping systems, and pressure cylinders are to be submitted for approval. See 4-1-1/5.3.

The rated torque of the unit is to be indicated in the data submitted for review.

3.5 Steering-gear Protection

The steering gear is to be protected from the weather. Steering gear compartments are to be readily accessible. Handrails and gratings or other non-slip surfaces are to be provided in way of steering gear machinery and controls.

3.7 Power-driven Steering Gear

The steering gear is to be power-operated if the required upper stock diameter is 120 mm (4.7 in.) or greater. Refer to 3-2-5/25.5.1.

3.9 Mechanical Components

All steering gear parts transmitting force to or from the rudder, such as tillers, quadrants, rams, pins, tie rods and keys are to be proportioned as to have strength equivalent to that of the upper rudder stock required by 3-2-5/25.5.1.

3.11 Power Units

3.11.1 Definitions (2025)

For purposes of the Rules, a steering gear power unit is:

- Electric Steering Gear.* An electric motor and its associated electrical equipment.
- Electro-hydraulic Steering Gear.* An electric motor and its associated electrical equipment and connected pump or pumps.
- Other Hydraulic Steering Gear.* A driving engine and connected pump or pumps.

For the purpose of alternative steering arrangements, electric steering motors are to be considered as part of the power unit and rudder actuator.

3.11.2 Composition

The steering gear is to be comprised of two or more identical power units and is to be capable of operating the rudder as required by 4-2-3/3.33.1 while operating with one or more of the power units. Mechanical connections to the power unit are to be of substantial construction.

The steering gear is to be arranged so that a single failure in one of the power units or mechanical connections to the power units will not impair the integrity of the remaining part of the steering gear. See 4-2-3/3.1.3.

3.11.3 Testing

A prototype of each new design power unit pump is to be shop tested for a duration of not less than 100 hours. The testing is to be carried out in accordance with an approved agenda and is to include the following as a minimum:

- i. The pump and stroke control (or directional control valve) is to be operated continuously from full flow and relief valve pressure in one direction through idle to full flow and relief valve pressure in the opposite direction.
- ii. Pump suction conditions are to simulate lowest anticipated suction head. The power unit is to be checked for abnormal heating, excessive vibration, or other irregularities. Following the test, the power unit pump is to be disassembled and inspected in the presence of a Surveyor.

3.13 Mechanical Steering

Steel-wire rope, chain and other mechanical steering systems are to comply with [4-2-3/1.9](#), [4-2-3/1.11](#) and [4-2-3/1.13](#).

3.15 Material

3.15.1 General

All parts of steering gear transmitting a force to the rudder and pressure retaining components of hydraulic rudder actuators are to be of steel or other approved ductile material. The use of gray cast iron or other material having an elongation less than 12% in 50 mm (2 in.) is not acceptable.

3.15.2 Material Test Attendance (2010)

Except as modified below, materials for the parts and components mentioned in [4-2-3/3.15.1](#) are to be tested in the presence of the Surveyor in accordance with the requirements of Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*. See also [4-2-3/3.23.2](#).

Material tests for steering gear coupling bolts and torque transmitting keys need not be witnessed by the Surveyor. For upper rudder stock keys, see [3-2-5/25.1](#).

Material tests for forged, welded or seamless steel parts (including the internal components) of rudder actuators that are under 150 mm (6 in.) in internal diameter need not be carried out in the presence of the Surveyor. Such parts are to comply with the requirements of Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)* or such other appropriate material specifications as may be approved in connection with a particular design, and may be accepted on the basis of a review of mill certificates by the Surveyor.

3.17 Transfer

An effective means of rapid transfer between power units is to be provided. Such transfer arrangements are also to include the capability to initiate the transfer process manually (i.e., non-automatic) from the navigation bridge.

3.19 Power-gear Stops

Power gears are to be provided with stops in accordance with [4-2-3/1.5](#).

3.21 Rudder Actuators

3.21.1 General

Hydraulic cylinders and housings of vane-type steering gears are to meet the requirements of [4-2-3/3.15](#) for material and material tests, and also [2-4-2/1](#) of the *ABS Rules for Materials and Welding (Part 2)* for welding, see equation 2 of [4-4-1-A1/3.1](#), [4-4-1-A1/5](#), and [4-4-1-A1/7](#) of the *Marine Vessel Rules* for design, and [4-4-1-A1/21](#) of the *Marine Vessel Rules* for hydrostatic tests. For cylinders, see also [4-3-4/1.11](#) of the *Marine Vessel Rules* for plans.

3.21.2 Non-duplicated Rudder Actuators

Regardless of extent of nondestructive testing, casting quality factor is not to exceed 0.85. See the last note of [4-4-1-A1/21 TABLE 2 \(SI units\)](#) of the *Marine Vessel Rules*.

3.21.3 Oil Seals

Oil seals between non-moving parts forming part of the exterior pressure boundary are to be of the pressure seal type. Oil seals between moving parts forming the external pressure boundary are to be fitted in duplicate so that the failure of one seal does not render the actuator inoperative. Alternative seal arrangements will be considered where they are shown to be equivalent.

3.23 Piping Arrangement

3.23.1 General

Piping for hydraulic gears is to be arranged so that transfer between units can be readily effected. The arrangement is to be such that a single failure in one part of the piping will not impair the integrity of remaining parts of the system. See [4-2-3/3.1.3](#). Where necessary, arrangements for bleeding air from the hydraulic system are to be provided.

3.23.2 Requirements

Piping systems are to meet the requirements of [4-3-8/1.3](#) through [4-3-8/1.7](#). The design pressure for steering gear system piping and components subject to internal hydraulic pressure is to be at least 1.25 times the maximum working pressure to be expected in order to satisfy the operational conditions specified in [4-2-3/3.33.1](#).

3.23.3 Valves (1996)

In general, valves are to comply with the requirements of [4-3-2/11](#). Isolating valves are to be fitted on the pipe connections to the rudder actuator. For vessels with non-duplicated rudder actuators, the isolating valves are to be directly mounted on the actuator.

3.23.4 Relief Valves (1996)

Relief valves are to be provided for the protection of the hydraulic system. Each relief valve is to be capable of relieving not less than the full flow of all the pumps which can discharge through it increased by 10%. With this flow condition, the maximum pressure rise is not to exceed 10% of the relief valve setting. In this regard, consideration is to be given to the extreme expected ambient conditions in respect to oil viscosity.

The relief valve setting is to be at least 1.25 times the maximum working pressure to be expected in order to satisfy the operational conditions specified in [4-2-3/3.33.1](#) but is not to exceed the design pressure in [4-2-3/3.33.2](#).

3.23.5 Filtration

A means is to be provided to maintain cleanliness of the hydraulic fluid.

3.23.6 Storage Tank

A fixed storage tank having sufficient capacity to recharge the complete hydraulic power system including the power unit reservoirs is to be provided. The tank is to be permanently connected by piping in such a manner that the system can be readily recharged from a position within the steering gear compartment. The storage tank is to be provided with an approved level indicating system in accordance with [4-3-3/9](#).

3.23.7 Testing

The following tests are to be performed in the presence of the Surveyor.

Shop Tests (2008). After fabrication, each component of the steering gear piping system, including the power units, hydraulic cylinders and piping, is to be hydrostatically tested at the plant of manufacture to 1.5 times the relief valve setting.

Installation Test. After installation in the vessel, the complete piping system, including power units, hydraulic cylinders and piping, is to be subjected to a hydrostatic test equal to 1.1 times the relief valve setting, including a check of the relief-valve operation.

3.25 Controls

3.25.1 General (1 July 2011)

Control system is the equipment by which orders are transmitted from the navigation bridge to the power units. Control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables. For the purpose of these Rules, steering wheels or steering levers are not considered to be part of the control system.

There are to be two independent control systems provided, each of which can be operated from the navigation bridge. The independent control systems are to meet the following requirements.

3.25.1(a) Redundancy. (2020)

Steering gear controls are to be located in the navigation bridge and steering gear compartment or the space containing the power unit, as applicable. These control systems are to be independent in all respects and are to provide on the navigation bridge all necessary apparatus and arrangements for the starting and stopping of steering gear motors and the rapid transfer of steering power and control between units.

The control cables and piping are to be separated throughout their length as widely as is practicable.

Wires, terminals and the components for duplicated steering gear control systems installed in units, control boxes, switchboards or bridge consoles are to be separated throughout their length as widely as is practicable. Where physical separation is not practicable, separation may be achieved by means of a fire retardant plate. See [4-5-2/11.1](#) and [4-5-6/9.3](#).

Local Steering Gear Control. In addition to the steering gear control systems required above, local steering gear control is to be provided in the steering gear compartment. These controls if electric are to be supplied from the steering gear power circuit from a point within the steering gear compartment.

Duplication. All electric components of the steering gear control system are to be duplicated. This does not require duplication of a steering wheel or steering lever.

Steering Mode Selector Switch. If a joint steering mode selector switch (uniaxial switch) is employed for both steering gear control systems, the connections for the circuits of the control systems are to be divided accordingly and separated from each other by an isolating plate or by air gap.

Follow-up Amplifier. In the case of double follow-up control, the amplifiers are to be designed and fed so as to be electrically and mechanically separated. In the case of non-follow-up control and follow-up control, the follow-up amplifiers are to be protected selectively.

Additional Control Systems. Control circuits for additional control systems, e.g. steering lever or autopilot, are to be designed for all - pole disconnection.

Feed-back Units and Limit Switches. The feed-back units and limit switches, if any, for the steering gear control systems are to be separated electrically and mechanically connected to the rudder stock or actuator separately.

Hydraulic Control Components. Hydraulic system components in the power actuating or hydraulic servo systems controlling the power systems of the steering gear, (e.g. solenoid valves, magnetic valves,) are to be considered as part of the steering gear control system and shall be duplicated and separated.

Hydraulic system components in the steering gear control system that are part of a power unit may be regarded as being duplicated and separated when there are two or more separate power units provided and the piping to each power unit can be isolated.

3.25.2 Hydraulic Telemotor (1 July 2011)

When the control comprises a hydraulic telemotor, a second independent control system will not be required.

3.25.3 Control System Disconnect (1998)

Means are to be provided in the steering gear compartment to disconnect the steering gear control system from the power circuit when local control is to be used. Such means for disconnecting are to be operable by one person without the need for tools. Additionally, if more than one steering station is provided, a selector switch is to disconnect completely all stations, except the one in use.

3.25.4 Communications

A means of communication is to be provided in accordance with 4-5-6/9.7.

3.25.5 Computer-based Systems (1 July 2011)

Steering control systems that are computer-based systems are to comply with Section 4-9-3 of the *Marine Vessel Rules* and are to be considered Category III.

3.25.6 System Response Under Failure (2021)

The failures (as listed, but not limited to items in 4-2-3/3.27) likely to cause uncontrolled movements of rudder are to be clearly identified. In the event of detection of such failure, the rudder is to stop in the current position without manual intervention or is to return to the midship/neutral position. Failure Mode and Effect Analysis methodology may be used to identify the failures. For mechanical failures such as sticking valves and failure of static components (pipes, cylinders), the system response without manual intervention is not mandatory, and the

operator can follow instructions on the signboard in case of such failures, in accordance with 4-2-3/3.31. For hydraulic locking failure, refer also to 4-2-3/3.27.7 and 4-2-3/3.31.

3.27 Instrumentation and Alarms

The following instruments and alarms are to be provided. The audible and visual alarms required are to be of the self-monitoring type so that a circuit failure will cause an alarm condition and they are to have provisions for testing.

3.27.1 Rudder Position Indicator

The angular position of the rudder is to be indicated on the navigation bridge and in the steering gear compartment. The rudder angle indication is to be independent of the steering gear control system, and readily visible from the control position.

3.27.2 Power Failure

A visual and audible alarm is to be given on the navigation bridge and engine room control station to indicate a power failure to any one of the steering gear power units.

3.27.3 Motor Alarms (2000)

A visual and audible alarm is to be given on the navigation bridge to indicate an overload condition of the steering gear power unit motor. Where a three-phase supply is used a visual and audible alarm is to be supplied which will indicate failure of any one of the supply phases. The operation of this alarm is not to interrupt the circuit.

3.27.4 Control Power Failure

A visual and audible alarm is to be given on the navigation bridge and engine room control station to indicate an electrical power failure in any steering gear control circuit, or remote control circuit.

3.27.5 Motor Running Indicators

Indicators for running indication of motors are to be installed on the navigation bridge and in the engine room control station.

3.27.6 Low Oil-level Alarm (1 July 2017)

A visual and audible alarm is to be given on the navigation bridge and engine room control station to indicate a low oil level in any power unit reservoir. The operation of this alarm is not to interrupt the power supply circuit.

3.27.7 Hydraulic Locking (2023)

Hydraulic locking includes all situations where two hydraulic systems (usually identical) oppose each other in such a way that it may lead to loss of steering. It can either be caused by pressure in the two hydraulic systems working against each other or by hydraulic "by-pass" meaning that the systems puncture each other and cause pressure drop on both sides or make it impossible to build up pressure. Hydraulic locking may occur where a piping system is arranged such that malfunctions (for example, in directional valves or in the valve control) can cause power units to work in a closed circuit against each other rather than in parallel delivering fluid to the rudder actuator, thus resulting in loss of steering.

Where the arrangement is such that a single failure may cause hydraulic locking and loss of steering, an audible and visual hydraulic locking alarm which identifies the failed system or component is to be provided on the navigation bridge. The alarm is to be activated upon steering gear failure if:

- Position of the variable displacement pump control system does not correspond to the given order, or
- Incorrect position of 3-way full flow valve or similar in constant delivery pump system is detected.

Alternatively, for follow-up control systems, an independent steering failure alarm complying with the following requirements may be provided in lieu of a hydraulic locking alarm:

- i. The steering failure alarm system is to actuate an audible and visible alarm in the wheelhouse when the actual position of the rudder differs by more than 5 degrees from the rudder position ordered by the follow-up control systems for more than:
- 30 seconds for ordered rudder position changes of 70 degrees;
 - 6.5 seconds for ordered rudder position changes of 5 degrees; and
- The time period calculated by the following formula for ordered rudder positions changes between 5 degrees and 70 degrees:
- $$t = (R/2.76) + 4.64$$
- where:

t = maximum time delay in seconds
R = ordered rudder change in degrees

- ii. The steering failure alarm system must be separate from, and independent of, each steering gear control system, except for input received from the steering wheel shaft.
- iii. Each steering failure alarm system is to be supplied by a circuit that:
- a. is independent of other steering gear system and steering alarm circuits.
 - b. is fed from the emergency power source through the emergency distribution panel in the wheelhouse, if installed; and
 - c. has no overcurrent protection except short circuit protection.

3.27.8 Autopilot Override (1999)

Steering gear control systems capable of operation in the autopilot mode are to be provided with the means to automatically disengage the autopilot controls when an effort is made to manually steer the vessel from the main steering station at the navigation bridge. Additionally, an audible and visual alarm is to be provided at the navigation bridge in the event the override mechanism fails to respond within a preset period.

3.27.9 Loop Failures (1 July 2011)

A visual and audible alarm is to be given on the navigation bridge to indicate a loop failure.
Note:

Monitoring is to be provided for short circuit, broken connections and earth faults for command and feedback loops. Monitoring for loop failures is not required, when a steering failure alarm system is provided. See 4-2-3/3.27.7.

3.27.10 Computer-based System Failures (1 July 2011)

For steering control systems that are computer-based systems, a visual and audible alarm is to be given on the navigation bridge to indicate a computer-based system failure.
Note:

Monitoring is to be provided for data communication errors, computer hardware failures and software failure. See also Section 4-9-3 of the *Marine Vessel Rules*. Monitoring for computer-based system failures is not required, when a steering failure alarm system is provided. See 4-2-3/3.27.7(i), (ii) and (iii).

3.27.11 Earth Fault (1 July 2017)

A visual and audible alarm is to be given on the navigation bridge to indicate an earth fault on AC and DC circuits

3.27.12 Deviation (1 July 2021)

Where arrangements discussed in 4-2-3/3.27.7, 4-2-3/3.27.8, 4-2-3/3.27.9 and 4-2-3/3.27.10 can lead to reduced or erroneous system performance of the commanded change in rudder angle, a deviation alarm visible and audible at the navigating bridge shall be initiated if the rudder's actual position does not reach the set point within acceptable time limits for the closed loop control systems (e.g., follow-up control, computer based

systems, and autopilot). Deviation alarm may be caused by mechanical, hydraulic or electrical failures. For the acceptable time delay period, please see 4-2-3/3.27.7.

3.29 Electrical Components (1996)

Electrical components of the steering gear are to meet the applicable requirements of Part 4, Chapter 5. The steering gear electrical circuit is to comply with 4-5-2/11.

3.31 Operating Instructions

Appropriate operating instructions with a block diagram showing the changeover procedures for steering gear control systems and steering gear power units are to be permanently displayed on the navigation bridge and in the steering gear compartment.

3.33 Trials

The steering gear is to be tried out on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of these Rules have been met. The trial is to include the operation of the following:

3.33.1 (2017)

The steering gear, including demonstration of the performance requirements as shown below with the rudder fully submerged. Where full rudder submergence cannot be obtained in ballast conditions, steering gear trials are to be conducted at a displacement as close as reasonably possible to full-load displacement as required by Section 6.1.2 of ISO 19019:2005 on the conditions that either:

- i. The rudder is fully submerged (zero speed waterline) and the vessel is in an acceptable trim condition.
- ii. The rudder load and torque at the specified trial loading condition have been predicted (based on the system pressure measurement) and extrapolated to the full load condition using the following method to predict the equivalent torque and actuator pressure at the deepest seagoing draft:

$$QF = QT\alpha$$

$$\alpha = 1.25 (AF/AT) (VF/VT)^2$$

where

α = extrapolation factor

QF = rudder stock moment for the deepest service draft and maximum service speed condition

QT = rudder stock moment for the trial condition

AF = total immersed projected area of the movable part of the rudder in the deepest seagoing condition

AT = total immersed projected area of the movable part of the rudder in the trial condition

VF = contractual design speed of the vessel corresponding to the maximum continuous revolutions of the main engine at the deepest seagoing draft

VT = measured speed of the vessel (considering current) in the trial condition

Where the rudder actuator system pressure is shown to have a linear relationship to the rudder stock torque, the above equation can be taken as:

$$PF = PT\alpha$$

where

PF = estimated steering actuator hydraulic pressure in the deepest seagoing draft condition

PT = maximum measured actuator hydraulic pressure in the trial condition

Where constant volume fixed displacement pumps are utilized, the requirements can be deemed satisfied if the estimated steering actuator hydraulic pressure at the deepest draft is less than the specified maximum working pressure of the rudder actuator. Where a variable delivery pump is utilized, pump data should be supplied and interpreted to estimate the delivered flow rate that corresponds to the deepest seagoing draft in order to calculate the steering time and allow it to be compared to the required time.

Where AT is greater than $0.95AF$, there is no need for extrapolation methods to be applied.

- iii. Alternatively the designer or builder may use computational fluid dynamic (CFD) studies or experimental investigations to predict the rudder stock moment at the full sea going draft condition and service speed. These calculations or experimental investigations are to be to the satisfaction of ABS.

In any case for the main steering gear trial, the speed of the vessel corresponding to the number of maximum continuous revolution of main engine and maximum design pitch applies.

Satisfactory performance is to be demonstrated under the following conditions.

Full Speed Trial. From 35 degrees on either side to 30 degrees on the other side in not more than 28 seconds with the vessel running ahead at the maximum continuous rated shaft RPM. For controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for the above maximum continuous ahead rated RPM. This test is to be met with one of the power units in reserve.

Half Speed Trial. From 15 degrees on either side to 15 degrees on the other side in not more than 60 seconds while running at one-half of the maximum ahead speed or 7 knots, whichever is the greater. This test is to be conducted with one of the power units in reserve. This test may be waived where the steering gear consists of two identical power units with each capable of meeting the requirements in [4-2-3/3.33.1](#) above.

Where three or more power units are provided, the test procedures are to be specially considered on basis of the specifically approved operating arrangements of the steering gear system.

3.33.2

The power units, including transfer between power units.

3.33.3

The emergency power supply required by [4-5-6/9.3](#).

3.33.4

The steering gear controls, including transfer of control, and local control.

3.33.5

The means of communications between the navigation bridge, engine room, and the steering gear compartment.

3.33.6

The alarms and indicators required by [4-2-3/3.27](#) (test may be done at dockside).

3.33.7

The storage and recharging system contained in [4-2-3/3.23.6](#) (test may be done at dockside).

3.33.8

The isolation and automatic starting provisions of [4-2-3/3.1.3](#) (test may be done at dockside).

Light Warships, Patrol and High-Speed Naval Vessels (Jan 2026)

Part 4 Craft Systems and Machinery

Chapter 3 Propulsion and Maneuvering Machinery

Section 4 Steering Gears

Goals

The steering gears are to be designed, constructed, operated, and maintained to:

Goal No.	Goal
PROP 4	provide means to maneuver the vessel.
PROP 5	provide redundancy and/or reliability to maintain maneuverability
POW 2	provide power to enable the equipment to perform its required function necessary for the safe operation of the vessel.
FIR 1	prevent the occurrence of fire and explosion.
AUTO 1	perform its functions as intended and in a safe manner.
AUTO 2	indicate the system operational status and alert operators of any essential machinery/systems deviate from its defined design/operating conditions or intended performance.
AUTO 3	have an alternative means to enable safe operation in the event of an emergency or failure of remote control.
AUTO 4	provide the equivalent degree of safety and operability from a remote location as those provided by local controls.
SAFE 1.1	minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems.
COMM 2	provided with means for internal communications.

Materials are to be suitable for the intended application in accordance with the following goals and support the Tier 1 goals as listed above.

Goal No.	Goal
MAT 1	The physical, mechanical and chemical properties of base materials and weldments are to meet the design requirements appropriate for the application, operating conditions and environment.

The goals in the cross-referenced Rules/Regulations are also to be met.

Functional Requirements

In order to achieve the above stated goals, the design, construction, installation and maintenance of steering gears are to be in accordance with the following functional requirements:

Functional Requirement No.	Functional Requirements
MATERIALS (MAT)	
MAT-FR1	The material and manufactured components for steering gears are to withstand the maximum working stresses without any plastic deformation or fatigue failure.
MAT-FR2	Hardness to be considered for wear/abrasion resistance.
PROPULSION (PROP)	
PROP-FR1	Steering gears, components, joints and connections are to be designed to withstand the most severe conditions related to stress, pressure, temperature, loads and vessel motions.
PROP-FR2	The steering system is protected from external impacts.
PROP-FR3	The steering capability is maintained or can be regained in case of malfunction in either the steering control or steering actuating sub-systems or both together.
PROP-FR4	The steering system provides adequate steering performance for ship operation.
PROP-FR5	Proper ship operation is enabled by providing information about ship's maneuvering characteristics.
PROP-FR6	The steering system is arranged to minimize impact of erroneous functionality and operation.
PROP-FR7	Provide mechanical, electrical and control redundancy/reliability that a single failure will not impair the steering capability of the vessel

Functional Requirement No.	Functional Requirements
PROP-FR8	Provide arrangements such that non-duplicated components offer equivalent degree of safety as duplicated components.
PROP-FR9 (SAFE)	Provide additional safety means to stop the gear before mechanical stops are reached to protect propeller and ship stern in the event of failure which allows rudder to swing in an uncontrolled manner.
PROP-FR10	It is to be designed so that the failure of seal arrangements does not affect the operation of actuator.
PROP-FR11	Provide protective devices if the equipment can be subjected to a pressure more than its design pressure.
PROP-FR12	Protective device and its inlet and escape pipe are to be sized to provide sufficient relief capacity to prevent the equipment from over pressurization.
POWER GENERATION AND DISTRIBUTION (POW)	
POW-FR1	Provide sufficient power to move the steering mechanism with rated torque at specified speed.
POW-FR2	Provide a power source independent of the main source of power to operate steering gear when the main source of power is not available.
POW-FR3	Provide sufficient power capacity to operate steering gear in all operating conditions.
POW-FR4	Electrical motors are rated for steering the vessel reliably in all operating conditions.
POW-FR5	Provide protection against overload, undervoltage and short circuit conditions to prevent damage to equipment and maintain continuity of power to remaining circuits.
AUTOMATION: CONTROL, MONITORING AND SAFETY SYSTEMS (AUTO)	
AUTO-FR1	A single failure of piping systems or malfunctions of control systems are to be alarmed and monitored in the manned control station.
AUTO-FR2	Provide autonomous steering failure alarm system to minimize the influence of other related systems.
AUTO-FR3	Be able to control the equipment from a local position, even in the case of failure in any part of the automatic or remote-control systems.
AUTO-FR4	Provide means to effectively operate, control and monitor the operation.
AUTO-FR5	Provide visual and audible notification upon occurrence of fault in the system preventing steering failure.
COMMUNICATION (COMM)	
COMM-FR1	Provide means to communicate between major control stations and the steering gear compartment.
FIRE SAETY (FIR)	
FIR-FR1	Provide fire segregation between duplicated control systems.

The functional requirements in the cross-referenced Rules/Regulations are also to be met.

Compliance

A vessel is considered to comply with the goals and functional requirements within the scope of classification when the prescriptive requirements are complied with or when an alternative arrangement has been approved. Refer to Part 1D, Chapter 2.

1 General (2025)

This section is applicable to high-speed vessels for which steering is effected by means of a rudder or rudders and an electric, hydraulic or electro-hydraulic steering gear.

Additional requirements for other than traditional arrangements are given in 4-3-4/1.10 and in 4-3-5/5.11 for azimuthal thrusters and Section 4-3-6 and 4-3-4/9 for waterjets.

Steering gears intended for vessels strengthened for navigation in ice are to comply also with additional requirements in Part 6 of the *ABS Rules for Building and Classing Marine Vessels*.

1.1 Basic Principles (2020)

When the Rule required upper rudder stock diameter is over 120 mm, excluding strengthening for navigation in ice, vessels are to be provided with power operated means of main steering, as necessary to meet the requirements of 4-3-2/1.9. Such means, as a minimum, is to be supported by duplication of power units, and by redundancy in piping, electrical power supply, and control circuitry. Steering is to be capable of being readily regained in the event of the failure of a power unit, a piping component, a power supply circuit, or a control circuit.

1.3 Definitions

For the purpose of this section the following definitions apply:

1.3.1 Steering Gear

Steering Gear is the machinery, rudder actuators, steering gear power units and ancillary equipment and the means of applying torque to the rudder stock (e.g., tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the vessel under normal service conditions.

1.3.2 Steering Gear Power Unit (2025)

Steering Gear Power Unit is:

- i. In the case of electro-hydraulic steering gears, an electric motor and its associated electrical equipment and connected pump;
- ii. In the case of other hydraulic steering gears, a driving engine and connected pump;
- iii. In the case of electric steering gears, an electric motor and its associated electrical equipment.

For the purpose of alternative steering arrangements (see 4-3-4/1.10), electric steering motors are to be considered as part of the power unit and rudder actuator.

1.3.3 Power Actuating System

Power Actuating System of hydraulic and electro-hydraulic steering gears is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with the associated pipes and fittings and a rudder actuator. Where duplicated power actuating systems are required by these Rules, they may share common mechanical components (i.e., tiller, quadrant and rudder stock, or components serving the same purpose).

1.3.4 Rudder Actuator

Rudder Actuator is the component which directly converts hydraulic pressure into mechanical action to move the rudder. This may be a hydraulic cylinder or a hydraulic motor.

1.3.5 Maximum Working Pressure

Maximum Working Pressure is the pressure needed to satisfy the operational conditions specified in 4-3-4/1.7.

1.3.6 Steering Gear Control System (1 July 2011)

Steering Gear Control System is the equipment by which orders are transmitted from the navigation bridge to the steering gear power actuating system. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables required to control the steering gear power actuating system. For the purpose of these Rules, steering wheels, steering levers, and rudder angle feedback linkages are not considered to be part of the control system.

1.3.7 Maximum Ahead Service Speed

Maximum Ahead Service Speed is the greatest speed which the vessel is designed to maintain in service at sea at the deepest seagoing draft.

1.3.8 Rule Required Upper Rudder Stock Diameter (2025)

The *Rule Required Upper Rudder Stock Diameter* is the rudder stock diameter in way of the tiller, calculated as given in 3-2-8/5.1. This required diameter excludes strengthening for navigation in ice.

1.3.9 Rudder Stock (2025)

Rudder stock is a vertical shaft that connects the rudder to the steering gear.

FIGURE 1
Rotary Vane Steering Gear (2025)

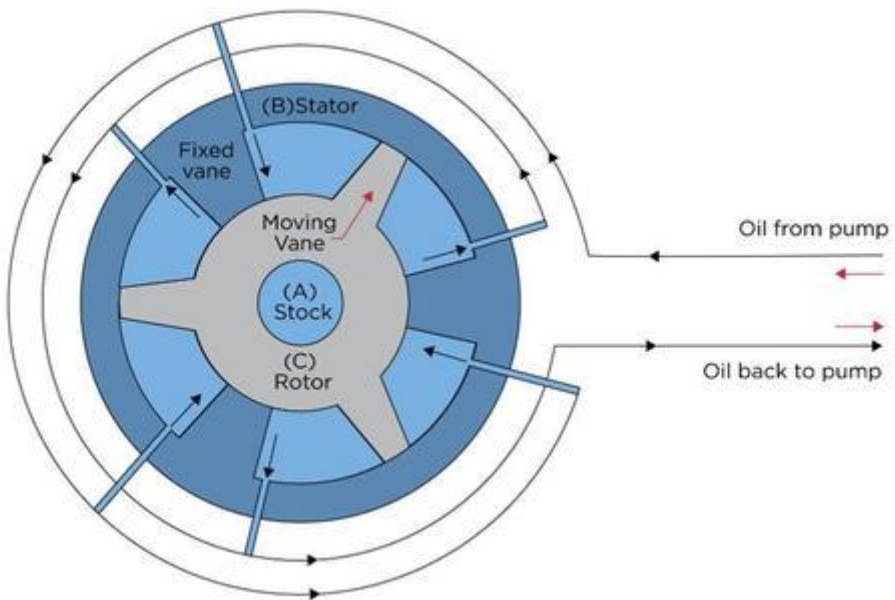


FIGURE 2
RAM Type Steering Gear (2025)

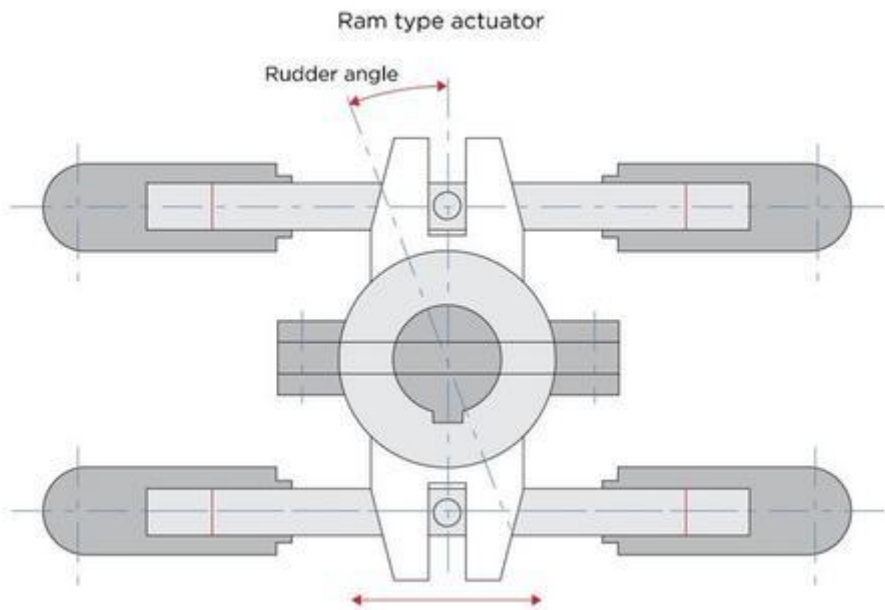
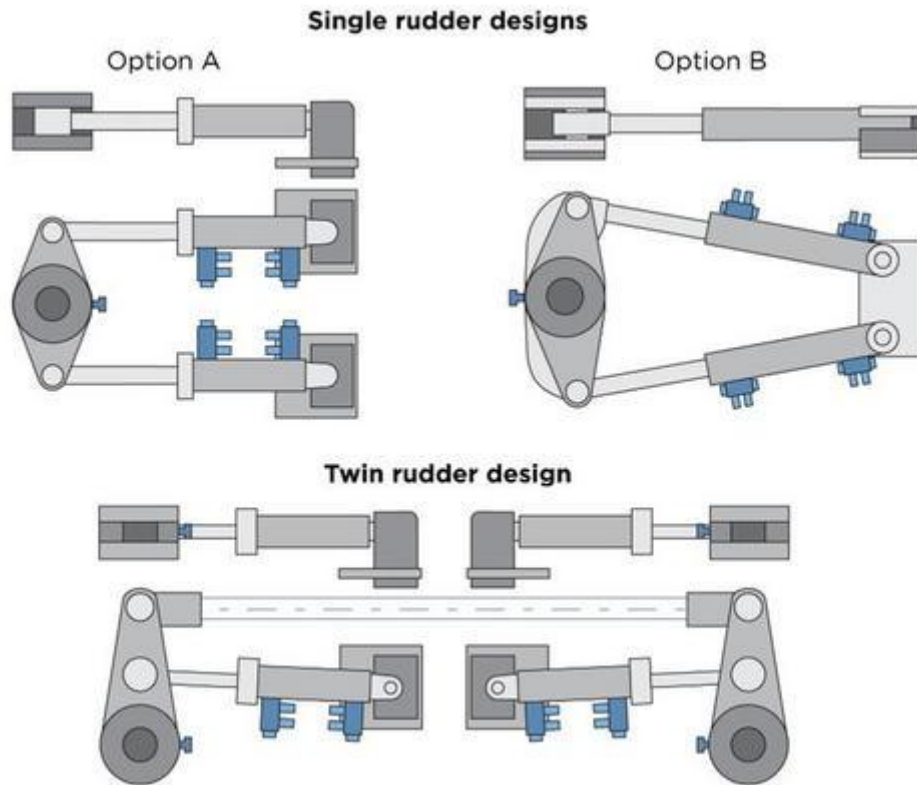


FIGURE 3
Steering Gear with Linked Cylinder Actuator (2025)



1.5 Steering Gear Compartment (2025)

The steering gear is to be protected from the weather. Steering gear compartments are to be readily accessible and, as far as practicable, separated from the machinery spaces. The power units may be located either within or outside the compartment containing the rudder actuators. Working access is to be provided to the steering gear machinery and controls with handrails, gratings or other non-slip surfaces suitable for safe working conditions in the event of hydraulic fluid leakage.

1.7 Performance for Vessels with Traditional Propulsion and Steering Systems for a Vessel's Directional Control (2025)

The steering gear is to be capable of:

- i. Putting the rudder from 35° on one side to 35° on the other side with the vessel running ahead at the maximum ahead service speed and at the summer load waterline and, under the same conditions, from 35° on either side to 30° on the other side in not more than 28 seconds; and
- ii. An auxiliary steering gear is not required under the following conditions:
 - When the main steering gear comprises two or more power units, and is so arranged that after a single failure in its piping system or in one of the power units the defect can be isolated so that the steering capability can be maintained or regained; and provided that the main steering gear is to be capable of operating the rudder as required by while all of the power units are in operation.
 - When the main steering gear is non-power operated such as an orbitrol system or consists solely of mechanical components such as sheaves, blocks, wires, chains, etc.

1.9 Performance for Vessels with Propulsion and Steering Systems other than Traditional Arrangements (see Sections 4-3-5, 4-3-6, and 4-3-10) for a Vessel's Directional Control (1 July 2020)

1.9.1 Vessels Fitted with Multiple Steering-Propulsion Units

For a vessel fitted with multiple steering-propulsion units, such as but not limited to azimuthing propulsors (thrusters) or water jet propulsion systems each of the steering-propulsion units is to be provided with a main steering gear and an auxiliary steering gear or with two or more identical steering actuating systems in

compliance with 4-3-4/1.10.3(c). The main steering gear and the auxiliary steering gear are to be so arranged that the failure of one of them will not render the other one inoperative.

1.9.2 Vessels Fitted with a Single Steering-Propulsion Unit

For a vessel fitted with a single steering-propulsion unit, the steering gear is to be provided with two or more steering actuating systems and is compliance with 4-3-4/1.10.3(c). A detailed risk assessment is to be submitted in order to demonstrate that in the case of any single failure in the steering gear, control system and power supply the ship steering is maintained.

1.9.3 Arrangements

1.9.3(a) The main steering gear arrangements for vessel's directional control is to be:

- i. Of adequate strength and capable of steering the vessel at maximum ahead service speed.
- ii. Capable of changing direction of the vessel's steering-propulsion unit from one side to the other at declared steering gear angle limits at an average turning speed of not less than 2.3°/s with vessel running ahead at maximum ahead service speed.
- iii. Operated by power.
- iv. Reverse direction of thrust in sufficient time, and so to bring the vessel to rest within a reasonable distance from maximum ahead service speed, is to be demonstrated and recorded.

The requirements in 4-3-5/1.5.6 apply .

1.9.3(b) The auxiliary steering arrangements for vessel's directional control is to be:

- i. Of adequate strength and capable of steering the vessel at navigable speed and of being brought quickly into action in an emergency.
- ii. Capable of changing direction of the vessel's directional control system from one side to the other at declared steering angle limits at an average turning speed, of not less than 0.5°/s; with the vessel running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater; and
- iii. For all vessel, operated by power where necessary to meet the requirements of 4-3-4/1.10.3(b).ii and in any vessel having power of more than 2,500 kW propulsion power per steering-propulsion unit.

The requirements in 4-3-5/1.5.6 apply.

1.9.3(c) For a vessel fitted with a single steering-propulsion unit where the main steering gear comprises two or more identical power units and two or more identical steering actuators, an auxiliary steering gear need not be fitted provided that the steering gear:

- i. in a passenger vessel is capable of satisfying the requirements in 4-3-4/1.10.3(a) while any one of the power units is out of operation;
- ii. in a cargo vessel, is capable of satisfying the requirements in in 4-3-4/1.10.3(a) while operating with all power units; and
- iii. is arranged so that after a single failure in its piping system or in one of the power units' steering capability can be maintained or speedily regained.

1.9.3(d) For a vessel fitted with multiple steering-propulsion systems, where each main steering system comprises two or more identical steering actuating systems, an auxiliary steering gear need not be fitted, provided that each steering gear:

- i. For a passenger vessel, is capable of satisfying the requirements in 4-3-4/1.10.3(a) while any one of the steering gear steering actuating systems is out of operation;
- ii. For a cargo vessel, is capable of satisfying the requirements in 4-3-4/1.10.3(a) while operating with all steering gear steering actuating systems;
- iii. is arranged so that after a single failure in its piping or in one of the steering actuating systems, vessel's steering capability can be maintained or speedily regained. The above capacity requirements apply regardless whether the steering systems are arranged with common or dedicated power units.

1.9.4 Independent Source of Power (applies to steering propulsion units having certain proven steering capability due to vessel speed also in case propulsion power has failed).

Where the propulsion power exceeds 2,500 kW per thruster unit, an alternative power supply, sufficient at least to supply the steering arrangements which comply with the requirements of 4-3-4/1.10.3(b)ii and also its associated control system and the steering gear response indicator, is to be provided automatically, within 45 seconds, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power is to be used only for this purpose. In every vessel of 10,000 gross tonnage and upwards, the alternative power supply is to have a capacity for at least 30 minutes of continuous operation and in any other vessel for at least 10 minutes.

1.9.5 Electric and Electrohydraulic Steering Systems

For a vessel fitted with multiple steering systems, the requirements in 4-3-4/11.1 are to be applied to each of the steering systems.

1.9.6 Sea Trial Results

The stopping times, vessel headings and distances recorded on trials, together with the results of trials to determine the ability of vessel having multiple propulsion/steering arrangements to navigate and maneuver with one or more of these devices inoperative, are to be available on board for the use of the Master or designated personnel.

1.11 Plans and Particulars to be Submitted (2025)

The following plans and particulars are to be submitted for review (R) or for information (I):

- Arrangement of steering gear machinery (R)
- Hydraulic piping system diagram (R)
- Electrical and power supply system diagrams (R)
- Motor control system diagrams (R)
- Steering control system diagrams (R)
- Control, instrumentation and alarm system diagrams (R)
- Drawings and details for rudder actuators (R)
- Drawings, details and strength calculations for torque transmitting parts and parts subjected to internal hydraulic pressure (I)
- Weld details and welding procedure specifications (R)
- Strength calculations for rudder actuators and torque transmitting parts including those subjected to internal hydraulic pressure (I)
- Operating Instructions (I)
- Data sheet including rated torque (I)
- Failure mode and effect analysis (I)

3 Materials

3.1 General

All parts of the steering gear transmitting forces to the rudder and pressure retaining components of hydraulic rudder actuators are to be of steel, brass or other approved ductile material.

Gray cast iron or other material having an elongation ($L_0/d = 4$) less than 12% in 50 mm (2 in.) is not to be used for these parts.

3.3 Material Testing (2025)

Except as modified below, materials for the parts and components mentioned in 4-3-4/3.1 are to be tested in the presence of the Surveyor in accordance with the requirements of Chapter 3 of the *ABS Rules for Materials and*

Welding (Part 2) or other material specifications which are to be approved in connection with a particular design. See also 4-3-4/Table 1.

3.3.1 Coupling Bolts and Keys

Material tests for steering gear coupling bolts and torque transmitting keys need not be witnessed by the Surveyor, but manufacturer's test certificates traceable to these components are to be presented upon request.

3.3.2 Small Parts of Rudder Actuators (2010)

Material tests for forged, welded or seamless steel parts (including the internal components) of rudder actuators that are under 150 mm (6 in.) in internal diameter need not be carried out in the presence of the Surveyor. Such parts are acceptable on the basis of a review of mill certificates by the Surveyor.

3.3.3 Tie Rod Nuts

Material tests for commercially supplied tie-rod nuts need not be witnessed by the Surveyor provided the nuts are in compliance with the approved steering gear drawings and are marked and identified in accordance with a recognized industry standard. Mill test reports for the tie-rod nuts are to be made available to the Surveyor upon request. For all non-standard tie-rod nuts, material testing is required to be performed in the presence of the Surveyor.

3.3.4 Piping Material

Piping materials need not be tested in the presence of the Surveyor. Pipes are acceptable based on certification by the mill, and on physical inspection and review of mill certificate by the Surveyor.

3.4 Rotary Vane (2025)

Material tests for pressure retaining and torque transmitting components such as rotor, housing and cover are to be witnessed by the Surveyor. Material tests for the vanes are acceptable based on manufacturers certified material test reports.

TABLE 1
Required Material and Nondestructive Tests of Steering Gear Components (2025)

Steering Gear Part		Material Properties	Nondestructive Tests & Inspections		Visual Inspection and Component Certificate	
			Magnetic Particle, Liquid Penetrant, or Similar Tests, Ultrasonic Tests	Dimensional Inspection, Including Surface Condition	Visual Inspection (Surveyor)	Component Certificate
Piping		W (C+M)	-	-	-	W
Valve and Housing		SC(C+M)	W (UT+CD)	W	X	SC
Tiller		SC(C+M)	W (UT+CD)	W	X	SC
Hydraulic Cylinders	Cylinders	SC(C+M)	W (UT+CD)	W	X	SC
	Piston Rod	SC(C+M)	W (UT+CD)	W	X	SC
	Piston	W (C+M)	W (UT+CD)	-	-	W
	Cover	W (C+M)	W (UT+CD)	-	-	W
Stopper		W (C+M)	W (UT+CD)	-	-	W
Coupling Bolts and Keys		W (C+M)	-	-	-	W
Tie Rods	Rods	SC(C+M)	W (UT+CD)	W	X	SC
	Nuts	W (C+M)	-	-	-	W

Steering Gear Part		Material Properties	Nondestructive Tests & Inspections		Visual Inspection and Component Certificate	
			Magnetic Particle, Liquid Penetrant, or Similar Tests, Ultrasonic Tests	Dimensional Inspection, Including Surface Condition	Visual Inspection (Surveyor)	Component Certificate
Rotary Vane	Rotor	SC(C+M)	W (UT+CD)	W	X	SC
	Vane	W (C+M)	W (UT+CD)	-	-	W
	Housing/ Stator	SC(C+M)	W (UT+CD)	W	X	SC
	Cover	W (C+M)	W (UT+CD)	-	-	W

Symbol Description:

C:	chemical composition;
CD:	crack detection by MPI or DP;
D:	cylinder bore diameter (mm);
GJL:	gray cast iron;
GJS:	spheroidal graphite cast iron;
GS:	cast steel;
M:	mechanical properties;
SC:	class certificate;
TR:	test report;
UT:	ultrasonic testing;
W:	work certificate;
X:	visual examination of accessible surfaces by the Surveyor.

5 System Arrangements

5.1 Power Units

The main steering gear is to be power operated by one or more power units if the rule required upper rudder stock diameter is 120 mm (4.7 in.) or greater. Notwithstanding the above, the performance requirements of [4-3-4/1.7](#) are to be used to determine if it is necessary for the main and auxiliary steering gears to be power operated. The steering gear is to be capable of operating the rudder as required by [4-3-4/1.7.i](#) and [4-3-4/1.7.ii](#). The power units are to be served by at least two power circuits (see [4-3-4/11](#)). Power units are required to be type tested. See [4-3-4/19.5](#).

5.3 Rudder Actuators

Steering gears may be composed of a single rudder actuator for all vessels. See [4-3-4/13.7](#).

5.5 Single Failure Criterion

The hydraulic system is to be designed so that after a single failure in the piping system or one of the power units, the defect can be isolated so that the integrity of the remaining part of the system will not be impaired and the steering capability can be maintained or regained in 45 seconds or less. See also [4-3-4/9](#).

5.7 Independent Control Systems

Two independent steering gear control systems are to be provided, each of which can be operated from the navigation bridge. These control systems are to allow rapid transfer of steering power units and of control between the units. See [4-3-4/13](#).

5.9 Non-duplicated Components

Essential components which are not required to be duplicated are to utilize, anti-friction bearings, such as ball bearings, roller bearings or sleeve bearings, which are to be permanently lubricated or provided with lubrication fittings.

5.11 Power Gear Stops (2010)

The steering gear is to be fitted with arrangements, such as limit switches, for stopping the gear before the structural rudder stops (see 3-2-8/1.7) or positive mechanical stops within the steering gear are reached. These arrangements are to be synchronized with the rudder stock or the position of the gear itself and may be an integral part of the rudder actuator. Arrangements to satisfy this requirement through the steering gear control system are not permitted.

5.13 Steering Gear Torques

5.13.1 Minimum Required Rated Torque

The rated torque of the steering gear is not to be less than the expected torque, as defined in 3-2-8/1.5.

5.13.2 Maximum Allowable Torque

The transmitted torque, T_{max} , of the steering gear is not to be greater than the maximum allowable torque, T_{ar} , based on the actual rudder stock diameter.

5.13.2(a) Transmitted Torque.

The transmitted torque, T_{max} , is to be based on the relief valve setting and to be determined in accordance with the following equations:

- For ram type actuator:

$$T_{max} = P \cdot N \cdot A \cdot L_2 / (C \cdot \cos^2 \theta) \text{ kN} - \text{m}(\text{tf} - \text{m}, \text{Ltf} - \text{ft})$$

- For rotary vane type actuator:

$$T_{max} = P \cdot N \cdot A \cdot L_2 / C \text{ kN} - \text{m}(\text{tf} - \text{m}, \text{Ltf} - \text{ft})$$

- For linked cylinder type actuator:

$$T_{max} = P \cdot N \cdot A \cdot L_2 / \cos \theta / C \text{ kN} - \text{m}(\text{tf} - \text{m}, \text{Ltf} - \text{ft})$$

where

P = steering gear relief valve setting pressure, bar (kgf/cm², psi)

N = number of active pistons or vanes

A = area of piston or vane, mm² (cm², in²)

L_2 = torque arm, equal the distance from the point of application of the force on the arm to the center of the rudder stock at zero (0) degrees of rudder angle, m (ft)

C = factor, 10000 (1000, 2240)

θ = maximum permissible rudder angle (normally 35 degrees)

5.13.2(b) Maximum Allowable Torque for Rudder Stock.

The maximum allowable torque, T_{ar} , for the actual rudder stock diameter is to be determined in accordance with the following equation:

$$T_{ar} = 2.0 (D_r / N_u)^3 / K_s \text{ kN} - \text{m} (\text{tf} - \text{m}, \text{Ltf} - \text{ft})$$

where

- K_s = material factor for rudder stock (see 3-2-8/1.3)
- D_r = actual rudder stock diameter at minimum point below the tiller or the rotor, mm (in.)
- N_u = factor, 42.0 (89.9, 2.39)

7 Mechanical Component Design

7.1 Mechanical Strength

All mechanical components which transmit force to or from the rudder are to have strength equivalent to that of the rule required upper rudder stock (see 4-3-4/1.3.8).

7.3 Rudder Actuators

7.3.1 Design

Rudder actuators are to be designed in accordance with the requirements of pressure vessels in Section 4-4-1, except that the maximum allowable stress S is not to exceed the lower of the following:

$$\frac{U}{A} \text{ or } \frac{Y}{B}$$

where

- U = minimum specified tensile strength of material at room temperature
- Y = minimum specified yield point or yield strength

A and B are factors given below:

	Rolled or forged steel	Cast steel	Nodular cast iron
A	3.5	4	5
B	1.7	2	3

7.3.2 Oil Seals

Oil seals between non-moving parts forming part of the exterior pressure boundary are to be of the metal upon metal type or of an equivalent type. Oil seals between moving parts forming part of the external pressure boundary are to be fitted in duplicate so that the failure of one seal does not render the actuator inoperative. Alternative seal arrangements are acceptable provided equivalent protection against leakage can be assured

7.5 Tillers, Quadrants and Other Mechanical Parts

7.5.1 General

All steering gear parts, such as tillers, quadrants, rams, pins, tie rods and keys, which transmit force to or from the rudder are to be proportioned so as to have strength equivalent to that of the rule required upper rudder stock, taking into consideration the difference in materials between the rudder stock and the component.

7.5.2 Tillers and Quadrants

7.5.2(a) Tiller or Quadrant Hub.

Dimensions of the hub are to be as follows (use consistent system of units):

- i. Depth of the hub is not to be less than S .
- ii. Mean thickness of the hub is not to be less than $S/3$.
- iii. Notwithstanding above, polar section modulus of the hub is not to be less than that given below:

$$0.196S^3 \frac{K_h}{K_s}$$

where

S = rule required upper rudder stock diameter

K_s = material factor of rudder stock (see 3-2-8/1.3)

K_h = material factor of hub (see 3-2-8/1.3)

7.5.2(b) Tiller or Quadrant Arm.

The section modulus of the tiller or quadrant arm anywhere along its length is not to be less than that given below (use consistent system of units):

$$\frac{0.167S^3 (L_2 - L_1)}{L_2} \cdot \frac{K_t}{K_s}$$

where

L_2 = distance from the point of application of the force on the arm to the center of the rudder stock

L_1 = distance between the section of the arm under consideration and the center of the rudder stock

K_t = material factor of tiller or quadrant arm (see 3-2-8/1.3)

Other symbols are as defined above.

7.5.2(c) Bolted Hub.

Split or semi-circular tiller or quadrant hubs assembled by bolting are to have bolts on any side having a total cross-sectional area not less than that given below (use a consistent system of units):

$$\frac{0.196S^3}{L_3} \cdot \frac{K_b}{K_s}$$

where

L_3 = distance between the center of the bolts and the center of the rudder stock

K_b = material factor of bolt (see 3-2-8/1.3)

Other symbols are as defined above.

The thickness of the bolting flange is not to be less than the minimum required diameter of the bolt.

7.5.2(d) Tiller Pin.

The total effective shear area of the tiller pin is not to be less than that given below. (Use consistent system of units):

$$\frac{0.196S^3}{L_2} \cdot \frac{K_p}{K_s}$$

where

K_p = material factor of the pin (see 3-2-8/1.3)

Other symbols are defined above.

7.5.3 Tie Rod

For multiple rudder installations or similar, where tie rod (or jockey bar) is fitted between tillers to synchronize them, the buckling strength of the tie rod is not to be less than that given below (use a consistent system of units):

$$\frac{0.113S^3U_R}{L_2}$$

where

U_R = ultimate tensile strength of the rudder stock

Other symbols are defined above.

7.7 Rudder Stock to Tiller/Quadrant Connection

7.7.1 Key

The bearing stress of the tiller and rudder stock keyways are not to be less than 0.9 times the material yield stress. The effective area of the key in shear is not to be less than that given below (use consistent system of units):

The effective area of the key in shear is not to be less than that given below (use a consistent system of units):

$$\frac{0.196S^3}{r} \frac{K_k}{K_s}$$

where

S = rule required upper rudder stock diameter

r	=	actual rudder stock radius at mid length of key
K_s	=	material factor of rudder stock (see 3-2-8/1.3)
K_k	=	material factor of rudder stock (see 3-2-8/1.3)

7.7.2 Keyless Coupling (2016)

Hydraulic or shrink fitted keyless coupling is to be based on preload stress calculations and fitting procedures. The calculated torsional holding capacity is to be at least 2.0 times the transmitted torque based on the steering gear relief valve setting. The coefficient of friction for the oil injection method of fit is to be taken as no greater than 0.14 and that for dry method is to be taken as no greater than 0.17. Preload stress is not to exceed 90% of the minimum yield strength. Maximum equivalent Von-Mises Stress is not to exceed minimum yield strength considering all loads including preload stress and two times transmitted torque.

7.9 Welding

All welded joints within the pressure boundary of a rudder actuator or connecting parts transmitting mechanical loads are to be full penetration type or to be of other approved design.

9 Hydraulic System

9.1 System Design

9.1.1 General

The hydraulic system is to be fitted with two or more power units. See 4-3-4/5.1.

9.1.2 Piping Arrangements

Piping is to be arranged such that:

- Single failure criteria in is met;
- Transfer between power units can be readily effected; and
- Air may be bled from the system.

9.1.3 Hydraulic Locking (2023)

Hydraulic locking includes all situations where two hydraulic systems (usually identical) oppose each other in such a way that it may lead to loss of steering. It can either be caused by pressure in the two hydraulic systems working against each other or by hydraulic "by-pass" meaning that the systems puncture each other and cause pressure drop on both sides or make it impossible to build up pressure. Hydraulic locking may occur where a piping system is arranged such that malfunctions (for example, in directional valves or in the valve control) can cause power units to work in closed circuit with each other rather than in parallel delivering fluid to the rudder actuator, thus resulting in loss of steering. Where a single failure leads to hydraulic locking and loss of steering, an audible and visual hydraulic locking alarm, which identifies the failed system, is to be provided on the navigation bridge. See also Note 4 of 4-3-4/15 TABLE 2.

Alternatively, an independent steering failure alarm for follow-up control systems complying with the following requirements are acceptable to be provided in lieu of a hydraulic locking alarm.

Where an independent steering failure alarm is installed for follow-up control systems, it is to comply with the following:

9.1.3(a)

The steering failure alarm system is to actuate an audible and visible alarm in the wheelhouse when the actual position of the rudder differs by more than 5 degrees from the rudder position ordered by the follow-up control systems for more than:

- 30 seconds for ordered rudder position changes of 70 degrees;
- 6.5 seconds for ordered rudder position changes of 5 degrees; and

The time period calculated by the following formula for ordered rudder positions changes between 5 degrees and 70 degrees:

$$t = (R/2.76) + 4.64$$

where

$$t = \text{maximum time delay in seconds}$$

$$R = \text{ordered rudder change in degrees}$$

9.1.3(b)

The steering failure alarm system is to be separated from, and independent of, each steering gear control system, except for input received from the steering wheel shaft.

9.1.3(c)

Each steering failure alarm system is to be supplied by a circuit that:

- Is independent of other steering gear system and steering alarm circuits.
- Is fed from the emergency power source through the emergency distribution panel in the wheelhouse, if installed; and
- Has no overcurrent protection except short circuit protection

9.1.4 Isolation Valves

Isolating valves are to be fitted on the pipe connections to the rudder actuators.

9.1.5 Filtration

A means is to be provided to maintain cleanliness of the hydraulic fluid.

9.1.6 System Overpressure Protection

Relief valves are to be provided for the protection of the hydraulic system at any part which can be isolated and in which pressure can be generated from the power source or from external forces. Each relief valve is to be capable of relieving not less than 110% of the full flow of the pump(s) which can discharge through it. With this flow condition, the maximum pressure rise is not to exceed 10% of the relief valve setting, taking into consideration increase in oil viscosity for extreme ambient conditions.

The relief valve setting is to be at least 1.25 times the maximum working pressure (see [4-3-4/1.3.5](#)), but is not to exceed the maximum design pressure (see [4-3-4/9.5.1](#)).

9.1.7 Fire Precautions

Where applicable, the requirements of [4-6-6/3.7.1](#) are to be met.

9.3 Hydraulic Oil Reservoir and Storage Tank

In addition to the power unit reservoir, a fixed hydraulic oil storage tank independent of the reservoir is to be provided for all vessels over 500 gross tons. The storage tank is to have sufficient capacity to recharge at least one power actuating system, including the power unit reservoir and an additional 25%. The tank is to be permanently connected by piping in such a manner that the system can be readily recharged from a position

within the steering gear compartment. The storage tank is to be provided with an approved level indicating system.

See also [4-6-6/3.3](#) for arrangements of the power unit reservoir and the storage tank.

9.5 Piping Design

9.5.1 System Pressure

Hydraulic system piping is to be designed to at least 1.25 times the maximum working pressure ([4-3-4/1.3.5](#)), taking into account any pressure which may exist in the low-pressure side of the system.

9.5.2 Pipes and Pipe Fittings

Pipes and pipe branches are to meet the design requirements of [4-6-2/5.1](#) and [4-6-2/5.3](#). Pipe joints are to be in accordance with [4-6-2/5.5](#) and [4-6-6/3.5.1](#). Attention is to be paid to footnotes 2 and 3 in [4-6-6/3.5.1](#) **TABLE 1** where additional limitations on pipe joints are specified for steering gear hydraulic piping. See also [4-3-4/9.7.3](#).

9.7 Piping Components

9.7.1 Power Units

Power units are to be certified by ABS. See [4-3-4/5.1](#) and [4-3-4/19.3](#). For vessels less than 500 gross tons, power units accepted based on manufacturer's guarantee for suitability for the intended purpose and satisfactory functional tests after installation.

9.7.2 Rudder Actuators

Rudder actuators are to be design approved and are to be certified by ABS. See [4-3-4/5.3](#), [4-3-4/7.3](#) and [4-3-4/19.7](#).

9.7.3 Pipes and Pipe Fittings

For pipes and pipe fittings, refer to [4-3-4/9.5.2](#). Piping materials for hydraulic service are to be traceable to manufacturers' certificates, but need not be certified by ABS. See also [4-6-1/7](#) for certification of piping system components.

9.7.4 Other Piping Components

For valves, hoses and accumulators, refer to [4-6-6/3.5](#). For relief valve, see also [4-3-4/9.1.6](#).

9.7.5 Relief Valves

In addition to [4-3-4/9.7.4](#), discharge capacity test reports verifying the capacity required in [4-3-4/9.1.6](#) for all relief valves are to be submitted for review.

11 Electrical Systems

11.1 Power Supply Feeder (2020)

Each electric or electro-hydraulic steering gear is to be served by at least two exclusive circuits, fed directly from the main switchboard. However, one of the circuits is to be supplied through the emergency switchboard. Each of duplicated power units required by [4-3-4/5.1](#) is to be served by one of these circuits. The circuits supplying an electric or electro-hydraulic steering gear are to have adequate rating for supplying all motors, control systems and instrumentation which are normally connected to them and operated simultaneously. The circuits are to be separated throughout their length as widely as is practicable. See also [4-8-2/7.15](#) for the steering gear power supply.

For vessels fitted with alternative propulsion and steering arrangements, such as azimuthing propulsors, where the propulsion power exceeds 2,500 kW per thruster unit, see 4-3-5/5.12.3.

11.3 Electrical Protection (2020)

11.3.1 General

Each steering gear feeder is to be provided with short-circuit protection which is to be located at the main or the emergency switchboard, as applicable. Power unit motor overload protection is not to be provided, except as indicated in 4-3-4/11.3.3. Other means of protection, namely, motor overload alarm and motor phase failure alarm, as applicable, are to be provided as indicated in 4-3-4/15 TABLE 2 item d. See also 4-8-2/9.19.5 for protection of the steering gear feeder circuit.

11.5 Under-voltage Release

Power unit motor controllers and other automatic motor controllers are to be fitted with under-voltage release (capable of restarting automatically when power is restored after a power failure).

11.7 Motor Rating

11.7.1 Steering Gears with Intermittent Working Duty

Electric motors of, and converters associated with, electro-hydraulic steering gears with intermittent working duty are to be at least of 25% non-periodic duty rating (corresponding to S6 of IEC Publication 60034-1), as per 4-8-3/3.3.3 and 4-8-3/15 TABLE 4. Electric motors of electro-mechanical steering gears are, however, to be at least of 40% non-periodic duty rating (corresponding to S3 of IEC Publication 60034-1).

11.7.2 Steering Gears with Continuous Working Duty

Electric motors of, and converters associated with, steering gears with continuous working duty are to be of continuous rating (corresponding to S1 of IEC Publication 60034-1), as per 4-8-3/3.3.4 and 4-8-3/15 TABLE 4.

11.9 Emergency Power Supply (2020)

Where the required rudder stock diameter (see 4-3-4/1.3.8) is over 230 mm (9 inches), an alternative power supply, sufficient at least to supply one steering gear power unit and its associated control system and the rudder angle indicator, is to be provided automatically within 45 seconds, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power is to be used only for this purpose.

The steering gear power unit under alternative power supply is to be capable of moving the rudder as required by 4-3-4/1.9i.

In every vessel, the alternative power supply is to have a capacity for at least 10 minutes of continuous operation.

13 Control Systems

13.1 General (1 July 2011)

13.1.1 Redundancy (2020)

There are to be two independent control systems (see definition in 4-3-4/1.3.6) provided, each of which can be operated from the navigation bridge. Steering gear controls are to be located in the navigation bridge and steering gear compartment or the space containing the power unit, as applicable. These control systems are to be independent in all respects and are to provide on the navigation bridge all necessary apparatus and arrangements for the starting and stopping of steering gear motors and the rapid transfer of steering power and control between units.

Control cables and piping for the independent control systems are to be separated throughout their length, as widely as is practicable.

Wires, terminals and the components for duplicated steering gear control systems installed in units, control boxes, switchboards or bridge consoles are to be separated throughout their length as widely as is practicable. Where physical separation is not practicable, separation may be achieved by means of a fire retardant plate.

13.1.2 Local Steering Gear Control

Local steering gear control is to be provided in the steering gear compartment.

13.1.3 Duplication

All electric components of the steering gear control system are to be duplicated. This does not require duplication of a steering wheel or steering lever.

13.1.4 Steering Mode Selector Switch

If a joint steering mode selector switch (uniaxial switch) is employed for both steering gear control systems, the connections for the circuits of the control systems are to be divided accordingly and separated from each other by an isolating plate or by air gap.

13.1.5 Follow-up Amplifier

In the case of double follow-up control, the amplifiers are to be designed and fed so as to be electrically and mechanically separated. In the case of non-follow-up control and follow-up control, the follow-up amplifiers are to be protected selectively.

13.1.6 Additional Control Systems

Control circuits for additional control systems (e.g., steering lever or autopilot) are to be designed for all-pole disconnection.

13.1.7 Feed-back Units and Limit Switches

The feed-back units and limit switches, if any, for the steering gear control systems are to be separated electrically and mechanically connected to the rudder stock or actuator separately.

13.1.8 Hydraulic Control Components

Hydraulic system components in the power actuating or hydraulic servo systems controlling the power systems of the steering gear (e.g., solenoid valves, magnetic valves) are to be considered as part of the steering gear control system and are to be duplicated and separated.

Hydraulic system components in the steering gear control system that are part of a power unit may be regarded as being duplicated and separated when there are two or more separate power units provided and the piping to each power unit can be isolated.

13.1.9 System Response Under Failure (2025)

The failures (as listed, but not limited to those items in [4-3-4/15 TABLE 2](#)) likely to cause uncontrolled movements of rudder are to be clearly identified. In the event of detection of such failure, the rudder is to stop in the current position without manual intervention or is to return to the midship/neutral position. Failure Mode and Effect Analysis methodology may be used to identify the failures. For mechanical failures such as sticking valves and failure of static components (pipes, cylinders), the system response without manual intervention is not

mandatory, and the operator can follow instructions on the signboard in case of such failures, in accordance with 4-3-4/21.3. For hydraulic locking failure, refer also to 4-3-4/9.1.3 and 4-3-4/21.3.

Commentary:

Refer to IACS UR E25.

End of Commentary

13.3 Control Power Supply (2020)

If the control systems operable from the navigation bridge are electric, then each system is to be served by its own separate circuits supplied from a steering gear power circuit in the steering gear compartment or directly from the switchboard bus bars supplying that steering gear power circuit at a point on the switchboard adjacent to the supply to the steering gear power circuit.

Circuits supplying power to steering gear controls are to be provided with short-circuit protection only.

13.5 Control System Override

13.5.1 Steering Gear Compartment

Means are to be provided at the emergency steering station to disconnect the steering gear control system from the power circuit when local control is to be used. Additionally, if more than one steering station is provided, a selector switch is to disconnect completely all stations, except the one in use.

13.5.2 Autopilot

13.5.2(a)

Steering gear systems provided with an autopilot system are to have a device at the primary steering station to completely disconnect the autopilot control to permit change over to manual operation of the steering gear control system. A display is to be provided at the steering station to such that the helmsman can readily and clearly recognize which mode of steering control (autopilot or manual) is in operation.

13.5.2(b) (2020)

In addition to the changeover device as in 4-3-4/13.5.2(a) for primary steering stations, where fitted with an automatic autopilot override to change over from autopilot control to manual operation, the following are to be provided.

An audible and visual alarm is to be provided at the primary steering station in the event that:

- i. The automatic autopilot override fails to respond when the manual helm order is 5 degrees of rudder angle or greater, and
- ii. It is immediately activated upon automatic autopilot override actuation.

The alarm is to be separate and distinct from other bridge alarms, and is to continue to sound until it is acknowledged.

13.7 Hydraulic Telemotor

Where the control system consists of a hydraulic telemotor, a second independent system need not be fitted.

13.9 Computer-based Systems (1 July 2011)

Steering control systems that are computer-based systems are to comply with Section 4-9-8 and are to be considered system category III.

15 Instrumentation (2025)

Instruments for monitoring the steering gear system are to be provided, as indicated in 4-3-4/15 TABLE 2. All alarms are to be audible and visual and are to be of the self-monitoring type so that a circuit failure will cause an

alarm condition. There are to be provisions for testing alarms. Alarms are to be tested in the presence of the Surveyor.

TABLE 2
Steering Gear Instrumentation (2023)

Monitored Parameters	Display/Alarm	Location
a) Rudder angle indicator (1)	Display	• Navigation bridge • Steering gear compartment
b) Power unit motor running	Display	• Navigation bridge • Engine room control station
c) Power unit power supply failure	Alarm	• Navigation bridge • Engine room control station
d) Power unit motor overload (2)	Alarm	• Navigation bridge • Engine room control station
e) Power unit motor phase failure (2) (3)	Alarm	• Navigation bridge • Engine room control station
f) Control power failure	Alarm	• Navigation bridge • Engine room control station
g) (1 July 2011) Hydraulic oil reservoir low level ⁽²⁾	Alarm	• Navigation bridge • Engine room control station
h) Hydraulic locking (4)	Alarm	• Navigation bridge
i) Auto-pilot running (5)	Display	• Navigation bridge
j) Auto-pilot failure (5)	Alarm	• Navigation bridge
k) Steering mode (autopilot/manual) indication	Display	• Navigation bridge
l) Automatic autopilot (5) override failure	Alarm	• Navigation bridge
m) Automatic autopilot (5) override activated	Alarm	• Navigation bridge
n) (1 July 2011) Loop failures (6)	Alarm	• Navigation bridge
o) (1 July 2011) Computer-based system failures (7)	Alarm	• Navigation bridge
p) (1 July 2011) Earth fault on AC and DC circuits	Alarm	• Navigation bridge
q) (1 July 2011) Deviation between rudder order and feedback ⁽⁸⁾	Alarm	• Navigation bridge

Notes:

1. The rudder angle indication is to be independent of the steering gear control system, and readily visible from the control position.
2. The operation of this alarm is not to interrupt the circuit.
3. For three phase AC supply only.
4. (1 July 2011) The alarm is to be activated when the position of the variable displacement pump control system does not correspond to the given order; or when the incorrect position of the 3-way full flow valve or similar in the constant delivery pump system is detected. Monitoring for hydraulic locking is not required, when a steering failure alarm system is provided. See , and .
5. If provided.
6. (1 July 2011) Monitoring is to be provided for short circuit, broken connections and earth faults for command and feedback loops. Monitoring for loop failures is not required, when a steering failure alarm system is provided. See , and .
7. (1 July 2011) For steering control systems that are computer-based systems, monitoring is to be provided for data communication errors, computer hardware failures and software failure. See also Section 4-9-8. Monitoring for computer-based system failures is not required, when a steering failure alarm system is provided. See , and .
8. Deviation alarm is to be initiated if the rudder's actual position does not reach the set point within acceptable time limits for the closed loop control systems (e.g. follow-up control and autopilot). Deviation alarm can be caused by mechanical, hydraulic or electrical failures. For the acceptable time delay period, please see 4-3-4/9.1.3(a).

17 Communications

A means of communication is to be provided between the navigation bridge and all other locations where steering can be effected, such as the steering gear compartment, the space where the power units are located, and the space where the auxiliary steering gear is to be operated, as applicable. Additionally, communication is to be provided between these spaces and the main propulsion control station, in accordance with 4-8-2/11.9.

19 Certification

19.1 General

Steering gear components are to be inspected, tested and certified by a Surveyor at the plant of manufacture, in accordance with the following requirements. Hydraulic oil pumps are to be certified. See 4-6-1/7.3.1.i.

19.3 Material Testing

For testing of steering gear component materials, see 4-3-4/3.3.

19.5 Prototype Tests of Power Units

For vessels with a rule-required upper rudder stock of greater than 120 mm (4.7 in.), a prototype of each new design power unit pump is to be shop tested for a duration of not less than 100 hours. The testing is to be carried out in accordance with an approved program and is to include the following as a minimum:

- i. The pump and stroke control (or directional control valve) is to be operated continuously from full flow and relief valve pressure in one direction through idle to full flow and relief valve pressure in the opposite direction.
- ii. Pump suction conditions are to simulate lowest anticipated suction head. The power unit is to be checked for abnormal heating, excessive vibration or other irregularities. Following the test, the power unit pump is to be disassembled and inspected in the presence of a Surveyor.

19.7 Components Shop Tests (2025)

Each component of the steering gear piping system, including the power units, rudder actuators and piping, is to be inspected by a Surveyor during fabrication and hydrostatically tested to 1.5 times the relief valve setting (or system design pressure) in the presence of a Surveyor.

Steering Gear and Components	Certificate Type	Design Assessed	Manufacture Survey	Surveyor Attendance upon Installation	Rules Reference
<i>Piping Assemblies</i>	SC	X	X	X	4-3-4/9, 4-6-2/5, 4-6-7/3
<i>Hydraulic Cylinders Assemblies (where separately supplied)</i>	SC	X	X	X	4-3-4/9
<i>Actuators System for Steering (where separately supplied)</i>	SC	X	X	X	4-3-4/9
<i>Pumps</i>	SC	-	X	X	4-6-1/7.3.1.i
<i>Control and Monitoring System</i>	SC	X	X	X	4-3-4/11, /13, /15, /17
<i>Steering Gear</i>	SC	X	X	X	4-3-4

Symbol Description:

SC: Society certificate

W: work's certificate

21 Installation, Tests and Trials

21.1 Steering Gear Seating (2004)

Steering gears are to be bolted to a substantial foundation effectively attached to the hull structure. Any chocking arrangements are to be in accordance with approved plans and to the satisfaction of the Surveyor.

21.3 Operating Instructions

Operating instructions with a block diagram showing change-over procedures for steering gear control systems and steering gear power units are to be permanently displayed on the navigation bridge and in the steering gear compartment. Where failure alarms are provided to indicate hydraulic locking, instructions are to be permanently posted on the navigation bridge and in the steering gear compartment for the operator to shut down the failed system.

21.5 Installation Tests

After installation on board the vessel, the complete piping system, including power units, rudder actuators and piping, is to be subjected to a hydrostatic test equal to 110% of the relief valve setting, including a check of the relief valve operation in the presence of the Surveyor.

21.7 Sea Trials (2017)

The steering gear is to be tried out on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of this section have been met. The trials are to be performed with the rudder fully submerged. Where full rudder submergence cannot be obtained in ballast conditions, steering gear trials are to be conducted at a displacement as close as reasonably possible to full-load displacement as required by Section 6.1.2 of ISO 19019:2005 on the conditions that either:

- The rudder is fully submerged (zero speed waterline) and the vessel is in an acceptable trim condition.
- The rudder load and torque at the specified trial loading condition have been predicted (based on the system pressure measurement) and extrapolated to the full load condition using the following method to predict the equivalent torque and actuator pressure at the deepest seagoing draft

$$Q_F = Q_T \alpha$$

$$\alpha = 1.25 \left(\frac{A_F}{A_T} \right) \left(\frac{V_F}{V_T} \right)^2$$

where

α	=	extrapolation factor
Q_F	=	rudder stock moment for the deepest service draft and maximum service speed condition
Q_T	=	rudder stock moment for the trial condition
A_F	=	total immersed projected area of the movable part of the rudder in the deepest seagoing condition
A_T	=	total immersed projected area of the movable part of the rudder in the trial condition
V_F	=	contractual design speed of the vessel corresponding to the maximum continuous revolutions of the main engine at the deepest seagoing draft
V_T	=	measured speed of the vessel (considering current) in the trial condition

Where the rudder actuator system pressure is shown to have a linear relationship to the rudder stock torque, the above equation can be taken as:

$$P_F = P_T \alpha$$

where

P_F	=	estimated steering actuator hydraulic pressure in the deepest seagoing draft condition
P_T	=	maximum measured actuator hydraulic pressure in the trial condition

Where constant volume fixed displacement pumps are utilized, the requirements can be deemed satisfied if the estimated steering actuator hydraulic pressure at the deepest draft is less than the specified maximum working pressure of the rudder actuator. Where a variable delivery pump is utilized, pump data are to be supplied and interpreted to estimate the delivered flow rate that corresponds to the deepest seagoing draft in order to calculate the steering time and allow it to be compared to the required time.

Where A_T is greater than 0.95 A_F , there is no need for extrapolation methods to be applied

- iii. Alternatively the designer or builder may use computational fluid dynamic (CFD) studies or experimental investigations to predict the rudder stock moment at the full sea going draft condition and service speed. These calculations or experimental investigations are to be to the satisfaction of ABS.

In any case for the main steering gear trial, the speed of the vessel corresponding to the number of maximum continuous revolution of main engine and maximum design pitch applies.

21.7.1 Full Speed Trial (2025)

Satisfactory performance is to be demonstrated under the following conditions:

- Changing the rudder position from 35° on either side to 30° on the other side in not more than 28 seconds with the vessel running ahead at the maximum ahead service speed. For controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for the above maximum continuous ahead rated rpm.
- Unless is applicable, this test is to be carried out with all power units intended for simultaneous operation for this condition under actual operating conditions.

21.7.2 Half Speed Trial (2025)

Satisfactory performance is to be demonstrated under the following conditions.

- Changing the rudder position from 15° on either side to 15° on the other side in not more than 60 seconds while running at 7 knots or one-half of the maximum ahead service speed, whichever is the lesser.
- This test is to be conducted with either one of the power units used in in reserve.

- iii. This test may be waived where the steering gear consists of two identical power units with each capable of meeting the requirements in .

21.7.3 Steering Gears with More than Two Power Units (2025)

Where three or more power units are provided, the test procedures are subject to ABS technical assessment and approval on the basis of the specifically approved operating arrangements of the steering gear system.

21.7.4 Additional Items

The trial is also to include the operation and verification of the following:

- i. The power units, including transfer between power units.
- ii. The emergency power supply, if applicable.
- iii. The steering gear controls, including transfer of control and local control.
- iv. The means of communication between the navigation bridge, engine room and the steering gear compartment.
- v. The alarms and indicators required by above (test may be done at dockside).
- vi. The storage and recharging system in above (test may be done at dockside).
- vii. The isolation of one power actuating system and time for regaining steering capability (test may be done at dockside).
- viii. Where the steering gear is designed to avoid hydraulic locking (above), this feature is to be demonstrated.
- ix. Where practicable, simulation of a single failure in the hydraulic system, and demonstration of the means provided to isolate it and the regaining of steering capability, as in and above.
- x. The stopping of the steering gear before the rudder stop is reached, as in above.