



RULES FOR BUILDING AND CLASSING

STEEL VESSELS UNDER 90 METERS (295 FEET) IN LENGTH 2017

PART 4 VESSEL SYSTEMS AND MACHINERY

**American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862**

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Rule Change Notice (2017)

The effective date of each technical change since 1993 is shown in parenthesis at the end of the subsection/paragraph titles within the text of each Part. Unless a particular date and month are shown, the years in parentheses refer to the following effective dates:

(2000) and after	1 January 2000 (and subsequent years)	(1996)	9 May 1996
(1999)	12 May 1999	(1995)	15 May 1995
(1998)	13 May 1998	(1994)	9 May 1994
(1997)	19 May 1997	(1993)	11 May 1993

Listing by Effective Dates of Changes from the 2016 Rules

Notice No. 1 (effective on 1 July 2016) to the 2016 Rules, which is incorporated in the 2017 Rules, is summarized below.

EFFECTIVE DATE 1 July 2016 – shown as (1 July 2016)
(based on the contract date for new construction between builder and Owner)

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
4-6-2/11.1	Power Supply Feeders	To align the requirements with IACS UI SC242. (Incorporates Notice No. 1)
4-6-3/3.7.5	Maintenance Schedule of Batteries	To align the requirements with the updated IACS UR E18, which clearly defines the stages for submitting the Maintenance Schedule of batteries. (Incorporates Notice No. 1)
4-6-3/3.31	High Fire Risk Areas	To align the requirements with IACS UR E15, which specifies that spaces having little or no fire risk as defined by SOLAS and MSC/Circ.1120 (i.e., spaces containing generators and major electrical units; refrigerating, stabilizing, ventilation and air conditioning machinery; and trunk to such spaces, provided they are not handling or using flammable liquids) are not considered to be high fire risk areas. (Incorporates Notice No. 1)
4-6-5/1.1.3(d)	Creepage Distances	To align the requirements with the updated IACS UR E11, which aligns with IEC 60502-1 (2009) and IEC 60502-2 (2005) with respect to testing. (Incorporates Notice No. 1)
4-6-5/1.1.3(e) (Renumbered)	Creepage Distances	To align the requirements with the updated IACS UR E11, which aligns with IEC 60502-1 (2009) and IEC 60502-2 (2005) with respect to testing. (Incorporates Notice No. 1)
4-6-5/1.1.3(f) (Deleted)	Non-standardized Parts	To align the requirements with the updated IACS UR E11, which aligns with IEC 60502-1 (2009) and IEC 60502-2 (2005) with respect to testing. (Incorporates Notice No. 1)
4-6-5/1.9.2(b)	Warning Plate	To align the requirements with the updated IACS UR E11, which aligns with IEC 60502-1 (2009) and IEC 60502-2 (2005) with respect to testing. (Incorporates Notice No. 1)
4-6-5/1.9.3(h)	Cable Test after Installation	To align the requirements with the updated IACS UR E11, which aligns with IEC 60502-1 (2009) and IEC 60502-2 (2005) with respect to testing. (Incorporates Notice No. 1)
4-6-5/1.11.2(d)	Shutters	To align the requirements with the updated IACS UR E11, which aligns with IEC 60502-1 (2009) and IEC 60502-2 (2005) with respect to testing. (Incorporates Notice No. 1)
4-6-5/1.11.2(f)	Arc Flash and Associated Installation Requirements	To align the requirements with the updated IACS UR E11, which aligns with IEC 60502-1 (2009) and IEC 60502-2 (2005) with respect to testing. (Incorporates Notice No. 1)
4-6-5/1.11.3(a)	Application	To align the requirements with the updated IACS UR E11, which aligns with IEC 60502-1 (2009) and IEC 60502-2 (2005) with respect to testing. (Incorporates Notice No. 1)

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
4-6-5/1.13.4	Accessibility	To align the requirements with the updated IACS UR E11, which aligns with IEC 60502-1 (2009) and IEC 60502-2 (2005) with respect to testing. (Incorporates Notice No. 1)

EFFECTIVE DATE 1 January 2017 – shown as (2017)
(based on the contract date for new construction between builder and Owner)

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
4-2-1/3.3	Booster Pumps	To emphasize that standby pumps are required for single engine installations, to clarify the required capacity of the specified standby pump, and to avoid the possibility of having a single engine installation with spare pump carried in lieu of a fitted standby pump.
4-2-1/9.3	Low Oil Pressure Alarms, Temperature and Level Indicators	To specify that main and auxiliary combustion engines, above 37 kW, must be fitted with an alarm device with audible and luminous signals for failure of the lubricating oil system, in line with IACS UR M2.
4-3-3/15.3.1	<No Title>	To allow rudder torque and load to be measured in the ballast condition, and to be reliably extrapolated to the full load condition where the vessel cannot be tested in this condition, in line with SOLAS Reg. II-1/29.3 and 29.4.
4-4-1/9.19.3(b)	Hose End Fittings	To remove the relaxation where flooding can be prevented by the installation of a readily accessible shutoff valve immediately upstream of the hose, and to clarify the requirement for clamps.
4-4-3/9.9.3(b)ix	<No Title>	To provide requirements for side covers, in line with IACS UR P3 Rev 4.
4-5-2/11.1.2	Design	To align the requirements with FSS Code Chapter 5, adopted by Resolution MSC.206(81) and amended by Resolution MSC.339(91).
4-5-2/11.1.3	Alarm	To align the requirements with FSS Code Chapter 5, adopted by Resolution MSC.206(81) and amended by Resolution MSC.339(91).
4-5-2/11.9.4(c)	Controls	To align the requirements with FSS Code Chapter 5, adopted by Resolution MSC.206(81) and amended by Resolution MSC.339(91).
4-5-2/15	Fireman's Outfit	To align the requirements with SOLAS II-2/Reg.10.4.
4-6-2/13.3	Navigation Light System	To remove inconsistencies and align the requirements with the <i>Steel Vessel Rules</i> .
4-6-2/17.1.2(b)	<No Title>	To align the requirements with IACS UI SC35 and MSC.311(88).
4-6-2/17.1.2(c)	<No Title>	To clarify that the power supply failure alarms of general emergency alarm system are to be provided in a normally manned control station.
4-6-4/3.21.2(c)	Variation from Rated Voltage – Transient Conditions	To clarify that voltage regulation during transient conditions need not be tested during factory testing provided that calculated values based on earlier type test records are available, in line with IACS UR E13.
4-6-4/3.21.2(d)	Short Circuit Conditions	To account for both the stationary short circuit current delivered by the generator, as well as the transient behavior of this short circuit current, in line with IACS UR E13.
4-6-4/10.5.8	Cooling Arrangements	To specify the circumstances in which the cooling liquid needs to be non-conducting and non-flammable, in line with IEC 61800-5-1.
4-6-4/10.7.2	Insulation Test (AC or DC Voltage Test)	To specify that the duration of the insulation test is 5 sec and 1 sec for the Type Test and the Routine Test, respectively, in line with IEC 61800-5-1.
4-7-1/5.33	Programmable Electronic System (PES)	To define a system based on one or more programmable electronic devices as a Programmable Electronic System, in line with ISO 17894:2005/4.8.
4-7-1/5.43 (New)	Data Communication Link	To define “data communication link”, in line with IACS UR E22/2.3.
4-7-1/5.45 (New)	System Security	To clarify system security requirements.

Vessel Systems and Machinery

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PART

4

CHAPTER 1 General

SECTION 1 Conditions of Classification of Machinery

1 General

The provisions of Part 1, Chapter 1, “Scope and Conditions of Classification,” are applicable to the classification of machinery.

3 Certification of Machinery (2003)

3.1 Basic Requirements

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

- Design review; prototype testing;
- Survey during construction and testing at the plant of manufacture; and
- Survey during installation onboard the vessel and at trials.

Where design review is required by the 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 may be accepted based on the manufacturers’ documentation on design and quality.

In general, surveys during installation onboard the vessel and at trials are required for all items of machinery. This is not considered a part of the product certification process. There may be instances, however, where letters or certificates issued for items of machinery contain conditions which must 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 generally covers Product Type Approval (1-1-4/7.7.3 of the *ABS Rules for Conditions of Classification (Part 1)*), but is also applicable for a more expeditious procedure towards Unit-Certification, as specified in 1-1-4/7.7.2 of the above-referenced Part 1.

See the *ABS Type Approval Program* in Appendix 1-1-A3 of the *ABS Rules for Conditions of Classification (Part 1)*. 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. However, consideration will be given to granting Type Approval to such machinery in the category of Recognized Quality System (RQS). The category of Product Quality Assurance (PQA) will not normally be available for all products, and such limitations will be indicated in 4-1-1/Table 1 through 4-1-1/Table 6 of the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*. In each instance where Type Approval is granted, in addition to quality assurance and quality control assessment of the manufacturing facilities, ABS will require some degree of product-specific survey during manufacture.

3.7 Details of Certification of Some Representative Products

4-1-1/Tables 1 through 6 of the *Steel Vessel Rules* provide abbreviated certification requirements of representative machinery based on the basic requirements of the Rules for machinery. The tables also provide the applicability of the Type Approval Program for each of these machinery items.

For easy reference, 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, fired equipment
- Piping system components

3.9 Equipment List (2012)

4-1-1/Table 3 of this Chapter provides an equipment listing of some representative products and certification requirements for products specific to vessels under 90 meters in length.

5 Shipboard Automatic or Remote Control and Monitoring Systems (1998)

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

7 Machinery Plans and Data

The following plans and data, as applicable for each vessel to be built under survey, are to be submitted and approved before construction is commenced, in accordance with Section 1-1-4 of the Supplement to the *ABS Rules for Conditions of Classification (Part 1)*. The sizes, dimensions, welding and other details, make and size of standard approved appliances are to be shown on the plans as clearly and fully as possible.

7.1 General

Details of dead ship start arrangements (see 4-1-1/25).

Description of all automatic trips that may affect the vessel's propulsion system

7.3 Automation and Remote Control Systems

A list of electrical, pneumatic or hydraulic equipment associated with the particular systems, including the data listed in 4-7-1/7.1.

A list of all major components installed within the particular equipment (i.e., control console, etc.) and the data as required in 4-7-1/7.1.

Certificates or test reports attesting to the suitability of the particular equipment in compliance with the environmental criteria set forth in 4-7-2/15 and 4-7-2/17, 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 4-7-2/17.3).

Plans showing the location of control and monitoring stations, controlled equipment and piping/cable runs, etc.

Arrangements and details of the control consoles and panels, including plan views and elevation details, installation details and wiring data as listed in 4-7-1/7.9.

A list of all cables connecting equipment associated with the systems (see 4-7-1/7.11).

A complete operational description of the automatic or remote control and monitoring systems (see 4-7-1/7.13).

A simplified one-line diagram (electrical and piping) of all power and automatic or remote control and monitoring systems (see 4-7-1/7.15).

A schematic diagram of all control, alarm, display and safety systems.

For computer-based systems, the following is to be included:

- Overall description and specification of the systems and equipment.
- Block diagrams for the computer hardware showing interfacing between the work stations, input/output (I/O) units, local controllers, traffic controllers, data highways, etc.
- Logic flow chart or ladder diagrams.
- Description of the alarm system indicating the ways it is acknowledged, displayed on the monitor or mimic display board, etc.
- Description of the system redundancy and back-up equipment, if any.
- Description of the data communication protocol, including anticipated data process response delays.
- Description of the system's security protocol to prevent unauthorized program changes which may compromise the integrity of the automatic or remote systems.
- Description of the system with regard to the degree of independence or redundancy provided for the control systems, alarm/display systems and safety systems.
- Description of system's task priorities.
- Where applicable, description of UPS (uninterruptible power supply) and their capacities, including system's power consumption.
- Equipment ratings and environmental parameters.

Installation methods (electrical, pneumatic and hydraulic) (see 4-7-1/7.21).

A matrix chart for each of the systems indicating the information listed in 4-7-1/7.23 upon activation of a given alarm or safety action.

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 *Steel Vessel Rules*.

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

7.7 Electrical Systems

One line diagrams for the following electrical systems containing the information specified in 4-6-2/1.1.2.

- Power supply and distribution

- Lighting including navigation lights
- Internal communication
- General emergency alarm
- Fire detection and alarm
- Steering gear control
- Intrinsically-safe equipment
- Emergency generator starting
- Inert gas control, monitoring and alarm
- Semiconductor converters for propulsion

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

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 (2010)

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 vessels 500 GRT 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 vessels 500 GRT 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 Internal Combustion Engines

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

7.13 Piping Systems

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

- Ballast system
- Bilge system
- Cargo systems
- Compressed air systems (including starting air systems and control systems)
- Cooling water systems
- Crude oil washing system
- Deck drains and scuppers
- Exhaust gas systems
- Essential fresh water service systems
- Fuel oil filling, transfer and service systems
- Hydraulic power piping systems
- Inert gas systems
- Lubricating oil systems
- Potable water system
- Sanitary system
- Essential Sea water service systems
- Steam system
- Vent, sounding and overflow piping
- Systems conveying toxic liquids, liquids with a flash point below 60°C (140°F), or flammable gases
- All Group I piping systems not covered above unless it is part of an independently manufactured unit (such as air conditioning or refrigeration) that does not form part of a vessel's piping system

A booklet of standard piping practices and details (see 4-4-1/3.5)

Plans of molded or built-up flexible expansion joints in seawater piping systems over 150 mm (6 in.), including details of the reinforcement arrangements (see 4-4-1/9.7)

Specifications for plastic pipes and components, including thermal and mechanical properties and chemical resistance (see 4-4-2/7, 4-4-2/9.11 and 4-4-2/17.7)

Drawings of non-standard valves and fittings showing details of construction, materials and basis for pressure rating (see 4-4-2/11.1.2 and 4-4-2/13.5)

Valve operating systems for all remote-controlled valves

7.15 Propellers

For all propellers, a propeller plan giving design data and characteristics of the material

For skewed propellers or propeller blades of unusual design, a detailed stress analysis, as required by 4-3-2/9.3 or 4-3-2/11.3.

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

Detailed stress calculations and fitting instructions for keyless propeller connections

7.17 Reduction Gears

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

7.19 Shafting (2008)

Detailed plans with material specifications of the propulsion shafting, couplings, coupling bolts*, propulsion shafting arrangement, tailshaft bearings and lubrication system, if oil-lubricated

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 4-3-1/21

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

* *Note:* Specific details regarding the interference fit of the coupling bolts are to be submitted. In addition, calculations and detail design basis for the sizing of the fitted bolts are to be submitted if the sizing of the bolts as per 4-3-1/19.1 of the Rules is not based on as-built line shaft diameter "D".

7.21 Steering Gears

General arrangements of the main and auxiliary steering gears and steering compartment

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

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

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

Design calculations for torque-transmitting components such as tiller, tie rod, rudder actuator, etc.

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

Rated torque of main steering gear

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

7.23 Thrusters (Steerable, Athwartship)

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

7.25 Waterjets

Details and material specifications of force transmitting parts

Design basis stress calculations for the impellers, shafting, steering mechanism and reversing mechanism (see 4-3-4/1.3)

Calculations or test results to substantiate the suitability and strength of the pressure and suction housing (see 4-3-4/1.5)

7.27 Windlass or Winch

Arrangements, details and stress calculations for the windlass or winch, drums, brakes, shaft, gears, coupling bolts, wildcat, sheaves, pulleys and foundation.

Control arrangements

Electric one-line diagram, including power ratings and cable specifications

Piping system diagram, including working pressures, welding details, material specifications and pipe specifications

9 Machinery

Rotating machinery of 100 kilowatts (135 horsepower) and over is to be in accordance with the requirements of Part 4, Chapters 1 through 6, as applicable. Machinery of less than 100 kilowatts (135 horsepower) is to be designed, constructed and equipped in accordance with good commercial practice, and will be accepted 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 Category A Machinery Spaces

Machinery spaces of Category A are those spaces and trunks to such spaces that 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); oil fired equipment such as an inert gas generator, incinerator, waste disposal unit, etc.; or any oil fuel units.

13.3 Machinery Spaces

Machinery spaces are Category A spaces and all other spaces containing propelling machinery, internal combustion engines, boilers, generators, major electrical equipment, refrigerating, stabilizing, ventilation and air conditioning machinery, similar spaces and trunks to such spaces.

13.5 Oil Fuel Unit

An oil-fuel unit is any equipment, such as pumps, filters and heaters, used for the preparation and delivery of fuel oil to oil-fired boilers (including incinerators and inert gas generators), internal combustion engines or gas turbines at a pressure of more than 1.8 bar (1.8 kgf/cm², 26 psi).

13.7 Accommodation Spaces

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

13.9 Public Spaces

Public spaces are those portions of the accommodations 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, storerooms, workshops other than those forming part of the machinery spaces, similar spaces and trunks to such spaces.

13.13 Cargo Spaces

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

13.15 Special Category Spaces

Special category spaces are those enclosed 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

Vital systems are those systems necessary for the vessel'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, lube oil, cooling water, starting system, etc.) and control systems.
- viii) Systems for transfer and control of cargo.
- ix) Ship's service and emergency electrical generation systems and their auxiliaries (fuel oil, lube 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 vessel.
- xix) Any other system identified by ABS as crucial to the survival of the vessel or to the protection of the personnel aboard.

13.21 Dead Ship Condition (2004)

Dead ship 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.

13.23 Blackout (2004)

Blackout situation means the loss of the main source of electrical power resulting in the main and auxiliary machinery to be out of operation.

15 Astern Propulsion Power (2005)

15.1 General

Sufficient power for going astern is to be provided to secure proper control of the vessel in all normal circumstances. The astern power of the main propelling machinery is to be capable of maintaining in free route astern at least 70% of the ahead rpm corresponding to the maximum continuous ahead power. For main propulsion systems with reversing gears, controllable pitch propellers or electric propulsion drive, running astern is not to lead to overload of the propulsion machinery. The ability of the machinery to reverse the direction of thrust of the propeller 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 during trials.

15.3 Steam Turbine Propulsion

Where steam turbines are used for main propulsion, they are to be capable of maintaining in free route astern at least 70% of the ahead revolutions for a period of at least 15 minutes. The astern trial is to be limited to 30 minutes or is to be in accordance with manufacturer's recommendation to avoid overheating of the turbine due to the effects of "windage" and friction.

17 Inclinations

Machinery installations are to be designed to operate under the conditions as shown in 4-1-1/Table 1.

19 Dead Ship Start (2005)

Means are to be provided to bring the machinery into operation from a "dead ship" condition as defined in 4-1-1/13.21. See 4-6-2/3.1.3 and 4-6-3/3.27 for the required starting arrangements.

21 Machinery Equations

The equations for rotating parts of the machinery in the following sections are based upon strength considerations only. Their application does not relieve the manufacturer from responsibility for the presence of dangerous vibrations in the installation at speeds within the operating range. See also 4-3-1/21.

23 Machinery Space Ventilation (2015)

Suitable ventilation is to be provided for machinery spaces so as to simultaneously allow 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.

The supply of air is to be provided through ventilators which can be used in all weather conditions. In general, ventilators necessary to continuously supply the main propulsion machinery space and the immediate supply to the emergency generator room are to have coamings of sufficient height to eliminate the need to have closing arrangements. See 3-2-14/11.3.

However, where due to the vessel size and arrangement this is not practicable, lesser heights for machinery space and emergency generator room ventilator coamings may be accepted with provision of weathertight closing appliances in accordance with 3-2-14/11.3.3 in combination with other suitable arrangements to ensure an uninterrupted and adequate supply of ventilation to these spaces.

25 Engineers' Alarm (1998)

See 4-6-2/17.3.

27 Automatic Trips

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

29 Thrusters and Dynamic Positioning Systems

Compliance with Section 4-3-5 of the *Steel 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*.

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 *Steel Vessel Rules*. Turbines are to comply with Sections 4-2-3 and 4-2-4 of the *Steel Vessel Rules*.

33 Sea Trial

33.1 General

A final underway trial is to be made of all machinery, including the steering gear, anchor windlass and ground tackle. The entire 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 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 vessel to rest is to be demonstrated on sea trials to the satisfaction of the Surveyor.

All automatic controls, including trips which may affect the vessel's propulsion system, are to be tested underway or alongside the pier to the satisfaction of the Surveyor.

See also 4-3-3/15.3, 4-2-1/19 and 4-2-1/21.

33.3 Residual Fuel

The viscosity of the fuel used on the sea trial will 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 the Rules of the three systems of units is as follows:

SI units (MKS units, US customary units).

37 Materials Containing Asbestos (2011)

Installation of materials which contain asbestos is prohibited.

39 Ambient Temperature (2008)

For vessels 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 appliances. For vessels of restricted or special service, the ambient temperature appropriate to the special nature is to be considered.

TABLE 1
Machine Installations – Inclinations

<i>Installations, Components</i>	<i>Angle of Inclination, Degrees ⁽¹⁾</i>			
	<i>Athwartships</i>		<i>Fore & Aft</i>	
	<i>Static</i>	<i>Dynamic</i>	<i>Static</i>	<i>Dynamic</i>
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				
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 Up to an angle of inclination of 45 degrees, switches and controls are to remain in their last set position.
- 3 In vessels designed for the carriage of liquefied gases and of chemicals, the emergency power installation is to remain operable with the vessel flooded to its permissible athwartships inclination up to a maximum of 30 degrees.

TABLE 2
Ambient Temperatures for Unrestricted Service (2014)

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	-25 to +45
Water		
	<i>Coolant</i>	<i>Temperature (°C)</i>
Seawater		+32

Notes:

- 1 (2014) Electronic equipment is to be suitable for operations up to 55°C.
- 2 (2014) For environmentally controlled spaces, see 4-6-1/17.3. For automatic or remote control and monitoring systems required to meet 4-7-2/Table 1 or 4-9-8/Table 1 of the *Steel Vessel Rules*, see test 3 of 4-7-2/Table 1, or test 3 of 4-9-8/Table 1 of the *Steel Vessel Rules*.

**TABLE 3
Equipment List for Steel Vessels Under 90 Meters (2012)**

This equipment list has been annotated to agree with ABS *Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length*. This list is not to be considered exhaustive: should additional equipment not listed to be fitted on board, the same will be specially considered for compliance with the Rules. In case of conflict between the content of this list and the applicable Rules and regulations, the latter are to be considered applicable.

Notes:

- 1 Please refer to the specific Rule requirement for the applicable latest revision.
- 2 ABS Surveyor may require additional certification on any equipment as considered necessary on a case-by-case basis.

<i>Symbol</i>	<i>Meaning</i>
d	DESIGN REVIEW – (Design Review Required)
m	MATERIAL TESTING – (Material Testing is to be witnessed by an ABS Surveyor)
s	MANUFACTURING SURVEYS – (Product is to be inspected during fabrication by an ABS Surveyor)
t	TYPE/PROTOTYPE – (Testing conducted on an actual sample or a prototype model is required, as applicable)
obs	ON BOARD SURVEYS – Operational, hydrostatic non-destructive testing, or other required tests are to be witnessed by an ABS surveyor after installation on board vessel
g	MANUFACTURER'S DOCUMENTATION – (Manufacturer should supply documentation to guarantee that the material or the equipment complies with an acceptable Standard, (e.g., Standard tests reports, Ex Certification, etc.)

TABLE 3A Certification Details – Prime Movers

<i>No.</i>	<i>Equipment</i>	<i>d</i>	<i>m</i>	<i>s</i>	<i>t</i>	<i>obs</i>	<i>g</i>	<i>Remarks</i>
1	Diesel Engines with Cylinder Bore > 300 mm	X	X	X	X	X		See Section 4-2-1 of SVR
2	Diesel Engines; Steam Turbines; Gas Turbines ≥ 100 kW (135 hp)	X	X	X	X	X		
3	Diesel Engines; Steam Turbines; Gas Turbines < 100 kW (135 hp)					X	X	
4	Turbochargers for Engines ≥ 100 kW (135 hp) and Bore ≥ 300 mm (11.8 in.)	X	X	X	X	X		
5	Turbochargers for Engines ≥ 100 kW (135 hp) and Bore < 300 mm (11.8 in.)	X			X	X		
6	Sea trials including tests of steering gear					X		
7	For conventional propulsion gear units above 1120 kW (1500 HP), a record of gear-tooth contact is to be made at the trials.					X		
8	The gear-tooth examination for conventional gear units 1120 kW (1500 HP) and below and all epicyclical gear units will be subject to special consideration					X	X	

TABLE 3B Certification Details – Propulsion, Maneuvering and Mooring Machinery

No.	Equipment	d	m	s	t	obs	g	Remarks
1	Propulsion Shafts, Couplings, Coupling Bolts	X	X	X		X		Typically made to custom designs. However, manufacturing facilities may be quality assurance approved, see 4-1-1/3.5
2	Cardan Shafts, Standard Couplings and Coupling Bolts	X	X	X		X		
3	Gears and Clutches ≥ 5590 kW (7500 hp)	X	X	X		X		
4	Gears and Clutches ≥ 100 kW (135 hp)	X	X	X		X		
5	Gears and Clutches < 100 kW (135 hp)					X	X	
6	Propellers, Fixed and Controllable Pitch > 1.5 m (60 in.)	X	X	X		X		Typically made to custom designs. However, manufacturing facilities may be quality assurance approved, see 4-1-1/3.5
7	Propellers, Fixed and Controllable Pitch ≤ 1.5 m (60 in.)					X	X	Applicable to planing and semi-planing vessels.
8	Propulsion Thrusters	X	X	X		X		
9	Steering Gears (Where the rule-required upper rudder stock diameter is < than 230 mm (9 in.).	X	X ⁽¹⁾	X		X		Rudder actuators that are not more than 152.4 mm (6 in.) does not need to be carried out in presence of surveyor ⁽¹⁾
10	Steering Gears Where the rule-required upper rudder stock diameter is 230 mm (9 in.) or above,	X	X	X		X		
11	Athwartship Thrusters	X	X	X		X		
12	Positioning Thruster					X	X	Thrusters in this category would be those not normally relied upon for maneuvering assistance
13	Dynamic Positioning Thrusters with DPS Notation.	X	X	X	X	X		
14	Water Jets for vessels ≤ to 24 m (79 ft)	X				X	X	
15	Water Jets for vessels over 24 m (79 ft)	X	X	X		X		
16	Steering Gear – 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.					X		

TABLE 3C Certification Details – Electrical and Control Equipment

No.	Equipment	d	m	s	t	obs	g	Remarks
1	Generators and Motors for Essential Services ≥ 100 kW (135 hp)	X		X	X	X		
2	Generators and Motors for Essential Services < 100 kW (135 hp)					X	X	
3	Propulsion Generators and Motors	X	X	X	X	X		
4	Switchboards (Propulsion, Main and Emergency)	X		X		X		Typically made to custom designs. However, manufacturing facilities may be quality assurance approved, see 4-1-1/3.5
5	Motor Controllers for Essential Services ≥ 100 kW (135 hp)	X		X		X		
6	Motor Control Centers for Essential Services ≥ 100 kW (135 hp)	X		X		X		

No.	Equipment	d	m	s	t	obs	g	Remarks
7	Battery Charging and Discharging Boards for Essential, Emergency or Transitional Source of Power	X		X		X		
8	Power Transformers and Converters and Converters of Low Voltage					X	X	
9	Power Transformers and Converters and Converters For High Voltage Systems Exceeding 1 kV	X		X		X		
10	Cables	X ⁽¹⁾			X	X		Reviewed for compliance with a recognized standard ⁽¹⁾
11	Propulsion Cables	X ⁽¹⁾			X	X		Reviewed for compliance with a recognized standard ⁽¹⁾
12	Circuit Breakers and Fuses					X	X	
13	Certified Safe Equipment				X	X	X	
14	Governors				X	X		
15	Control, Monitoring and Safety System Devices, Including Computer, Programmable Logic Controllers, etc., for ACC and ACCU Notations	X			X	X		
16	Complete Assembly or Subassembly Units for ACC and ACCU Notations	X		X	X	X		
17	Interior Communications Systems	X				X		

TABLE 3D Certification Details – Fire Safety Equipment

No.	Equipment	d	m	s	t	obs	g	Remarks
1	Fire Detection and Alarm System Components	X			X	X		
2	Fixed Fire Extinguishing System Components	X			X	X		
3	Fireman's Outfit				X	X	X	Type approved by flag
4	Fire Hoses				X	X	X	Type approved by flag
5	Portable Fire Extinguishers				X	X	X	Type approved by flag

TABLE 3E Certification Details – Boilers, Pressure Vessels and Fired Equipment

No.	Equipment	d	m	s	t	obs	g	Remarks
1	Group I Boilers and Pressure Vessels	X	X	X		X		
2	Group II Pressure Vessels	X		X		X	X	
3	Inert Gas Generators, Incinerators	X				X		

TABLE 3F Certification Details – Piping System Components

No.	Equipment	d	m	s	t	obs	g	Remarks
1	Pumps Related to Propulsion Diesel Engines (Bore > 300 mm) (11.8 in.) and Gas Turbines and Gears – Fuel, Cooling Water, Lube, Oil Services			X		X		Independently-driven pumps are to be hydrostatically tested. Capacity of the pumps is to be tested operating at design conditions. Capacity tests will not be required for individual pumps produced on a production line basis, provided the Surveyor is satisfied from periodic inspections and the manufacturer's quality assurance procedures that the pump capacities are acceptable.
2	Pumps Related to Propulsion Steam Plant and Gears - Fuel Oil, Lube Oil, Condensate, Main Circulating, Feed Water Services			X		X		Remarks in item 1 apply.
3	Hydraulic Pumps of Controllable Pitch Propellers, Anchor Windlass			X		X		The capacity test will not be required nor will the hydrostatic test need to be witnessed by the Surveyor for individual pumps assembled on a production line basis, provided the Surveyor is satisfied from periodic inspections and from the manufacturer's quality assurance procedures that the pump capacities are acceptable and that hydrostatic testing is being performed.
4	Hydraulic Pumps of Steering Gears			X		X		<ul style="list-style-type: none"> A prototype of each new design power unit pump is to be shop-tested for a duration of not less than 100 hours. Remarks in item 3 apply.
5	Pumps for Fire Main, Ballast, Bilge, CCP, Liquid Cargoes			X		X		Remarks in Item 3 apply.
6	Pumps associated with inert gas systems (i.e., fuel oil pumps for boilers/IG generators and cooling water pumps for flue gas scrubber)			X		X		Remarks in Item 3 apply.
7	Air Compressors					X	X	
8	Steel Pipes, Group I		X	X		X		
9	Steel Pipes, Group II					X	X	
10	Pipe Fittings – Flanges, Elbows, Tees, Flexible Joints, etc., and Valves; Group I	X ⁽¹⁾				X	X	Verification for compliance with recognized standard or design review by ABS ⁽¹⁾
11	Pipe Fittings - Flanges, Elbows, Tees, Flexible Joints, etc., and Valves; Group II					X	X	
12	Fabricated Piping ≥ 15 mm outside diameter for Fuel oil service, transfer and suction, starting air piping and hydraulic power piping			X				Pressure tests
13	Plastic Pipes and Pipe Joints	X ⁽²⁾	X	X	X	X		Reviewed for suitability for proposed installation ⁽²⁾ See 4-4-2/7.9.
14	Molded Expansion Joints > 150 mm (6 in.)	X			X		X	
15	Molded Expansion Joints ≤ to 150 mm (6 in.)				X		X	
16	Flexible Hoses	X ⁽²⁾			X	X	X	Reviewed for suitability for proposed installation ⁽²⁾
17	Vent Heads, Pressure Vacuum Valves	X ⁽²⁾			X	X	X	Reviewed for suitability for proposed installation ⁽²⁾

No.	Equipment	d	m	s	t	obs	g	Remarks
18	Shell Valves installed at side shell at or below the load waterline			X		X	X	Hydrotests
19	Valves						X ⁽¹⁾	Or design review by ABS ⁽¹⁾
20	Gauges, Detectors and Transmitters	X ⁽²⁾				X	X	Reviewed for suitability for proposed installation ⁽²⁾
21	Gauge Glasses					X		See 4-4-3/13.5
22	Fluid Power Cylinders and Systems, Including Valve Actuators (Other than Steering Gear Actuators)	X ⁽¹⁾					X	Verification for compliance with recognized standard or design review by ABS ⁽¹⁾
22a	Accumulators for Hydraulic Systems	X ⁽¹⁾	X	X				Verification for compliance with recognized standard or design review by ABS ⁽¹⁾
23	Strainers for Bilge System	X				X		Upon completion of the trials, the bilge strainers are to be opened, cleaned and closed up in good order.

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PART

4

CHAPTER 2 Prime Movers

SECTION 1 Internal Combustion Engines and Reduction Gears

1 General

1.1 Construction and Installation

Internal combustion engines of 100 kW [135 horsepower (hp)] and over and associated reduction gears are to be constructed in accordance with Part 4, Chapters 2 and 3 of the *Steel Vessel Rules* and installed in accordance with the following requirements to the satisfaction of the Surveyor. Engines of less than 100 kW (135 hp) and associated reduction gears are to be constructed and equipped in accordance with good commercial practice, and will be accepted subject to a satisfactory performance test conducted to the satisfaction of the Surveyor after installation.

For engines driving generators, refer to the applicable requirements of 4-6-4/3.17 and 4-6-4/3.19.

1.3 Piping Systems

In addition to requirements for the specific system in this section, piping systems are to comply with the applicable requirements in Part 4, Chapter 4.

1.5 Pressure Vessels and Heat Exchangers

Pressure vessels and heat exchangers are to be in accordance with the applicable requirements of Part 4, Chapter 4 of the *Steel Vessel Rules*.

1.7 Torsional Vibration Stresses

Refer to 4-3-1/21.

1.9 Strengthening for Navigation in Ice

For gears designed for navigation in ice, see Part 6, Chapter 1 of the *Steel Vessel Rules*.

1.11 Crankcase Ventilation

1.11.1 General

Provision is to be made for ventilation of an enclosed crankcase by means of a small breather or by means of a slight suction not exceeding 25.4 mm (1 in.) of water. Crankcases are not to be ventilated by a blast of air. Otherwise, the general arrangements and installation are to be such as to preclude the possibility of free entry of air to the crankcase.

1.11.2 Piping Arrangement

Crankcase ventilation piping is not to be directly connected with any other piping system. Crankcase ventilation pipes from each engine are normally to be led independently to the weather and fitted with corrosion-resistant flame screens. However, crankcase ventilation pipes from two or more engines may lead to a common oil mist manifold.

Where a common oil mist manifold is employed, the vent pipes from each engine are to be led independently to the manifold and fitted with a corrosion-resistant flame screen within the manifold. The arrangement is not to violate the engine manufacturer's recommendations for crankcase ventilation. The common oil mist manifold is to be accessible at all times under normal conditions and effectively vented to the weather. Where venting of the manifold to the weather is accomplished by means of a common vent pipe, the location of the manifold is to be as close as practicable to the weather such that the length of the common vent pipe is no greater than one deck height. The clear open area of the common vent pipe is not to be less than the aggregate cross-sectional area of the individual vent pipes entering the manifold, and the outlet to the weather is to be fitted with a corrosion-resistant flame screen. The manifold is also to be fitted with an appropriate draining arrangement.

1.13 Warning Notices

Suitable warning notices are to be attached in a conspicuous place on each engine and are to caution against the opening of a hot crankcase for a specified period of time after shutdown based upon the size of the engine, but not less than 10 minutes in any case. Such notice is also to warn against restarting an overheated engine until the cause of overheating has been remedied.

1.15 Bedplate

The bedplate or crankcase is to be of rigid construction, oiltight, and provided with a sufficient number of bolts to secure the same to the vessel's structure. The structural arrangements for supporting and securing the main engines are to be submitted for approval. Refer to 3-2-4/11 for structural requirements. For welded construction, see also Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*.

3 Fuel Oil Pumps and Oil Heaters

3.1 Transfer Pumps

Refer to 4-4-4/3.

3.3 Booster Pumps (2017)

3.3.1 Standby Pump, Single Engine Installation.

An independently driven standby pump is to be provided for each service pump, booster pump and other pumps serving the same purpose.

The capacity of the pumps, with any one pump out of service, is to be sufficient for continuous operation at rated power.

3.3.2 Standby Pump, Multiple Engine Installation.

For vessels fitted with two or more propulsion engines, the provision of a common standby pump (for each service pump, booster pump, etc.) capable of serving all engines sufficient for continuous operation at rated power will suffice rather than providing individual standby pumps for each engine.

3.3.3 Attached Pumps.

For multiple engine installations, engines having service, booster or similar pumps attached to and driven by the engine may, in lieu of the standby pump, be provided with a complete pump carried on board as a spare. The spare pump, upon being installed, is to allow the operation of the engine at rated power.

The spare pump need not be carried, provided that, in the event of the loss of one engine, at least forty percent of the total rated propulsion power remains.

3.5 Heaters

When fuel oil heaters are required for main engine operation, at least two heaters of approximately equal size are to be installed. The combined capacity of the heaters is to be not less than required to supply the main engine(s) at full power.

5 Fuel Oil Pressure Piping

Pipes from booster pumps to injection systems are to be at least standard seamless steel. Pipes conveying heated oil are to be at least standard seamless or electric-resistance-welded steel. ERW pipe is to be straight seam and fabricated with no filler metal (e.g., ABS Grade 2 or 3 ERW). Valves and fittings may be screwed in sizes up to and including 60 mm O.D. (2 in. N.P.S.), but screwed unions are not to be used on pressure lines in sizes 33 mm O.D. (1 in.) and over. Valves are to be so constructed as to permit packing under pressure.

7 Fuel Oil Injection System

7.1 General

Strainers are to be provided in the fuel oil injection pump suction line.

For main propulsion engines, the arrangement is to be such that the strainers may be cleaned without interrupting the fuel supply to the engine. However, where multiple engines are provided, a dedicated simplex strainer may be fitted for each engine, provided the vessel can maintain at least one-half of the design speed or seven knots, whichever is less, while operating with one engine temporarily out of service until its strainer can be cleaned.

For auxiliary engines, the arrangement is to be such that the strainers may be cleaned without undue interruption of power necessary for propulsion. Multiple auxiliary engines, each fitted with a separate strainer and arranged such that changeover to a standby unit can be accomplished without loss of propulsion capability, will be acceptable for this purpose.

Where strainers are fitted in parallel to enable cleaning without disrupting the oil supply, means are to be provided to minimize the possibility of a strainer being opened inadvertently. Strainers are to be provided with suitable means for venting when being put in operation and being depressurized before being opened. Strainers are to be so located that in the event of leakage, oil cannot be sprayed on to the exhaust manifold or surfaces with temperatures in excess of 220°C (428°F).

The injection lines are to be of seamless drawn pipe. Fittings are to be extra heavy. The material used may be either steel or nonferrous, as approved in connection with the design. Also refer to 4-4-4/3.7.

7.3 Piping Between Injection Pump and Injectors (2005)

7.3.1 Injection Piping

All external high pressure fuel delivery lines between the high-pressure fuel pumps and fuel injectors are to be protected with a jacketed piping system capable of containing fuel from a high-pressure line failure. A jacketed pipe incorporates an outer pipe into which the high-pressure fuel pipe is placed, forming a permanent assembly. Metallic hose of an approved type may be accepted as the outer pipe, where outer piping flexibility is required for the manufacturing process of the permanent assembly. The jacketed piping system is to include means for collection of leakages and arrangements are to be provided for an alarm to be given of a fuel line failure.

7.3.2 Fuel oil Return Piping

When the peak to peak pressure pulsation in the fuel oil return piping from the injectors exceeds 20 bar (20.5 kgf/cm², 285 psi), jacketing of the return pipes is also required.

7.3.3 High Pressure Common Rail System (2011)

Where a high pressure common rail system is fitted to an engine, the high pressure common rail is to be in accordance with Section 4-4-1 of the *Steel Vessels Rules* for pressure vessels, or a recognized standard as listed in 4-4-1/1.5 of the *Steel Vessels Rules*. Alternatively, the design may be verified by certified burst tests. Components are to be made of steel or cast steel. Components made of steel, other than cast steel, are to withstand not less than 4 times the maximum allowable working pressure. The cast steel common rails are to withstand not less than 5 times the maximum allowable working pressure. The use of non-ferrous materials, cast iron and nodular iron is prohibited. Materials are to comply with Chapter 3 of the *ABS Rule for Materials and Welding (Part 2)*.

The high pressure common rail system is required to be properly enclosed and provided with arrangement for leak collection and alarm in case of a failure of high pressure common rail system, see 4-2-1/7.3.1.

7.5 Piping Between Booster Pump and Injection Pumps (2005)

Spray shields are to be fitted around flanged joints, flanged bonnets and any other flanged or threaded connections in fuel oil piping systems under pressure exceeding 1.8 bar (1.84 kgf/cm², 26 psi) which are located above or near units of high temperature, including boilers, steam pipes, exhaust manifolds, silencers or other equipment required to be insulated by 4-4-4/1.1.2, and to avoid as far as practicable oil spray or oil leakage into machinery air intakes or other sources of ignition. The number of joints in such piping systems is to be kept to a minimum.

9 Lubricating Oil Systems

9.1 General

The following requirements are applicable for main and auxiliary diesel engines and for reduction gears associated with diesel propulsion. See also 4-1-1/17 and 4-4-4/9.

9.3 Low Oil Pressure Alarms, Temperature and Level Indicators (2017)

An alarm device with audible and visual signals for failure of the lubricating oil system is to be fitted for propulsion and auxiliary engines having a rated power greater than 37 kW (50 hp). Pressure and temperature indicators are to be installed in lubricating oil systems indicating that the proper circulation is being maintained.

9.5 Drain Pipes

Lubricating oil drain pipes from the sump to the drain tank are to be submerged at their outlet ends. No interconnection is to be made between the drain pipes from the crankcases of two or more engines.

9.7 Lubricating Oil Pumps (2014)

In cases where forced lubrication is used for propulsion engines, one independently driven standby pump is to be provided in addition to the necessary pumps for normal operation. Where the size and design of an engine is such that lubrication before starting is not necessary and an attached lubricating pump is normally used, an independently driven standby pump is not required if a complete duplicate of the attached pump is carried as a spare.

The spare pump need not be provided for multiple-engine installations provided that, in the event of the loss of one engine, at least forty percent of the total rated propulsion power remains.

9.9 Filters (1998)

Oil filters are to be provided. In the case of main propulsion engines which are equipped with full-flow-type filters, the arrangement is to be such that the strainers may be cleaned without interrupting the oil supply. However, where multiple engines are provided, a dedicated simplex strainer may be fitted for each engine provided the vessel can maintain at least one-half of the design speed or 7 knots, whichever is less, while operating with one engine temporarily out of service until its filter can be cleaned.

For auxiliary engines, the arrangement is to be such that the filters may be cleaned without undue interruption of power necessary for propulsion. Multiple auxiliary engines, each fitted with a separate filter and arranged such that changeover to a standby unit can be accomplished without loss of propulsion capability, will be acceptable for this purpose.

The arrangement of the valving is to be such as to avoid release of debris into the lubricating-oil system upon activation of the relieving mechanism.

Where filters are fitted in parallel to enable cleaning without disrupting the oil supply, means are to be provided to minimize the possibility of a filter under pressure being opened inadvertently. Filters are to be provided with suitable means for venting when being put in operation and being depressurized before being opened. Valves and cocks with drain pipes led to a safe location are to be used for this purpose. Filters are to be so arranged as to prevent, in the event of leakage, spraying of oil onto the exhaust manifold and surfaces with temperatures in excess of 220°C (428°F).

9.11 Lubricating-Oil Systems for Reduction Gears

Where a reduction gear is driven by a single engine and a common lubricating-oil system is used for both the engine and gear, the requirements in 4-2-1/9.1 through 4-2-1/9.9 are applicable.

Where a reduction gear is driven by more than one engine or any other case where a separate lubricating-oil system is provided for the reduction gear, the following requirements are applicable.

9.11.1 Pumps

Two lubricating-oil pumps are to be provided, at least one of which is to be independently driven. The capacity of each pump is to be sufficient for continuous operation of the main propulsion plant at its maximum rated power.

9.11.2 Coolers

One or more lubricating oil coolers with means for controlling the oil temperature is to be provided together with two separate cooling water pumps, at least one of which is to be independently driven. The coolers are to have sufficient capacity to maintain the required oil temperature while the main propulsion plant is operating continuously at its maximum rated power.

9.11.3 Indicators

Indicators are to be fitted by which the pressure and temperature of the water inlet and oil outlet may be determined. Gravity tanks are to be fitted with a low level alarm and a sight glass is to be fitted in the overflow line to the sump. Pressure systems are to be fitted with a low pressure alarm. Sump and gravity tanks are to be provided with suitable gauges for determining the level of oil within the tank.

9.11.4 Filters

A filter is to be provided in the lubricating-oil piping to each reduction gear. The requirements in 4-2-1/9.9 are applicable.

11 Cooling Water Systems

11.1 General

Means are to be provided to ascertain the temperature of the circulating water at the return from each engine and to indicate that the proper circulation is being maintained. Drain cocks are to be provided at the lowest point of all jackets. For relief valves, see 4-4-1/9.15.

11.3 Sea Suctions

At least two independent sea suction are to be provided for supplying water to the engine jackets or to the heat exchangers. The sea suction are to be located so as to minimize the possibility of blanking off the cooling water.

11.5 Strainers

Where seawater is used for direct cooling of the engines, unless other equivalent arrangements are specially approved, suitable strainers are to be fitted between the sea valves and the pump suction. The strainers are to be either of the duplex type or otherwise arranged so they can be cleaned without interrupting the cooling water supply.

11.7 Circulating Water Pumps (2014)

There are to be at least two means for supplying cooling water to main and auxiliary engines, compressors, coolers, reduction gears, etc. One of these means is to be independently driven and may consist of a connection from a suitable pump of adequate size normally used for other purposes, such as a general service pump, or in the case of fresh-water circulation, one of the vessel's fresh-water pumps. Where, due to the design of the engine, the connection of an independent pump is impracticable, the independently driven stand-by pump will not be required if a complete duplicate of the attached pump is carried as a spare. For multiple propulsion engines using identical attached pumps, only one complete pump needs to be carried as a spare.

The spare pump need not be provided for multiple-engine installations provided that, in the event of the loss of one engine, at least forty percent of the total rated propulsion power remains.

13 Starting Systems

13.1 Starting Air Systems (2013)

The design and construction of all air reservoirs are to be in accordance with the applicable requirements of Part 4, Chapter 4 of the *Steel Vessel Rules*. The piping system is to be in accordance with the applicable requirements of Part 4, Chapter 4 of these Rules. The air reservoirs are to be so installed as to make the drain connections effective under extreme conditions of trim. Compressed air systems are to be fitted with relief valves and each air reservoir which can be isolated from a relief valve is to be provided with its own safety valves or equivalent. Connections are also to be provided for cleaning the air reservoir and pipe lines.

All discharge pipes from starting air compressors are to be led directly to the starting air reservoirs, and all starting pipes from the air reservoirs to main or auxiliary engines are to be entirely separate from the compressor discharge piping system.

13.3 Starting Air Capacity (2013)

Vessels having main engines arranged for air starting are to be provided with at least two starting-air reservoirs of approximately equal size. The total capacity of the starting-air reservoirs is to be sufficient to provide, without recharging the air reservoirs, at least the number of starts stated below.

If other compressed air systems, such as control air, are supplied from starting air reservoirs, the capacity of the air reservoirs is to be sufficient for continued operation of these systems after the air necessary for the required number of consecutive starts has been used.

13.3.1 Diesel Propulsion

The minimum number of consecutive starts (total) required to be provided from the starting-air reservoirs is to be based upon the arrangement of the engines and shafting systems as indicated in the following table.

Engine Type	Single Propeller Vessels		Multiple Propeller Vessels	
	One engine coupled to shaft directly or through reduction gear	Two or more engines coupled to shaft through clutch and reduction gear	One engine coupled to each shaft directly or through reduction gear	Two or more engines coupled to each shaft through clutch and reduction gear
Reversible	12	16	16	16
Non-reversible	6	8	8	8

For arrangements of engine and shafting systems which differ from those indicated in the table, the capacity of the starting-air reservoirs will be specially considered based on an equivalent number of starts.

13.3.2 Diesel-electric Propulsion

The minimum number of consecutive starts required to be provided from the starting-air reservoirs is to be determined from the following equation:

$$S = 6 + G(G - 1)$$

where

S = total number of consecutive starts

G = number of engines necessary to maintain sufficient electrical load to permit vessel transit at full seagoing power and maneuvering. The value of G need not exceed 3.

13.5 Starting Air Compressors (2013)

For vessels having internal-combustion engines arranged for air starting, there are to be two or more air compressors, at least one of which is to be driven independently of the main propulsion unit, and the total capacity of air compressors driven independently of the main propulsion unit is to be not less than 50% of the total required.

The total capacity of the air compressors is to be sufficient to supply within one hour the quantity of the air need to satisfy 4-2-1/13.3 by charging the reservoirs from atmospheric pressure. The capacity is to be approximately equally divided between the number of compressors fitted, excluding an emergency compressor, where fitted.

The arrangement for dead ship air starting is to be such that the necessary air for the first charge can be produced onboard without external aid. See 4-1-1/19.

13.7 Protective Devices for Starting-air Mains

In order to protect starting air mains against explosions arising from improper functioning of starting valves, an isolation non-return valve or equivalent is to be installed at the starting air supply connection to each engine. Where engine bores exceed 230 mm (9¹/₁₆ in.), a bursting disc or flame arrester is to be fitted in way of the starting valve of each cylinder for direct reversing engines having a main starting manifold or at the supply inlet to the starting-air manifold for nonreversing engines.

The above requirement is applicable to engines where the air is directly injected into the cylinder. It is not intended to apply to engines utilizing air start motors.

13.9 Electrical Starting

13.9.1 Main Engine

Where the main engine is arranged for electric starting, at least two separate batteries (or separate sets of batteries) are to be fitted. The arrangement is to be such that the batteries (or sets of batteries) cannot be connected simultaneously in parallel. Each battery (or set) is to be capable of starting the main engine when in cold and ready to start conditions. The combined capacity of the batteries is to be sufficient without recharging to provide within 30 minutes the number of starts of main engines as required for air starting in 4-2-1/13.3, and if arranged also to supply starting for auxiliary engines, the number of starts required in 4-2-1/13.9.2. See also 4-2-1/13.9.3.

13.9.2 Auxiliary Engine

Electric starting arrangements for auxiliary engines are to have at least two separate batteries (or separate sets of batteries) or may be supplied by separate circuits from the main engine batteries when such are provided. Where one auxiliary engine is arranged for electric starting, one battery (or set) may be accepted in lieu of two separate batteries (or sets). The capacity of the batteries for starting the auxiliary engines is to be sufficient for at least three starts for each engine.

13.9.3 Other Requirements

The starting batteries (or set of batteries) are to be used for starting and for engine's own control and monitoring purpose only. When the starting batteries are used for engine's own control and monitoring purpose, the aggregate capacity of the batteries is to be sufficient for continued operation of such system in addition to the required number of starting capacity. Provisions are to be made to continuously maintain the stored energy at all times. See also 4-6-2/5.19 and 4-6-3/3.7.

13.11 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 4-2-1/13.3.

15 Engine Exhaust Systems

15.1 General

The exhaust pipes are to be water-jacketed or effectively insulated. Engine exhaust systems are to be so installed that the vessel's structure cannot be damaged by heat from the systems. Exhaust pipes of several engines are not to be connected together but are to be run separately to the atmosphere unless arranged to prevent the return of gases to an idle engine. Exhaust lines which are led overboard near the waterline are to be protected against the possibility of the water finding its way inboard.

15.3 Exhaust System Materials

Materials used in the exhaust system are to be resistant to saltwater corrosion, galvanically compatible to each other and resistant to exhaust products. Plate flanges will be considered where the specified material is suitable for exhaust piping pressures and temperatures.

15.5 Exhaust Gas Temperature

Propulsion engines with bores exceeding 200 mm (7.87 in.) are to be fitted with a means to display the exhaust gas temperature of each cylinder.

17 Couplings

17.1 Flexible Shaft Couplings (2014)

Details of the various components of flexible couplings for main propulsion machinery and ship's service generator sets are to be submitted for approval.

17.1.1 Design

Flexible couplings intended for use in propulsion shafting are to be of approved designs. Couplings are to be designed for the rated torque, fatigue and avoidance of overheating. Where elastomeric material is used as a torque-transmitting component, it is to withstand environmental and service conditions over the design life of the coupling, taking into consideration the full range of maximum to minimum vibratory torque. Flexible coupling design will be evaluated, based on submitted engineering analyses.

17.1.2 Torsional Displacement Limiter

Flexible couplings with elastomer or spring type flexible members, whose failure will lead to total loss of propulsion capability of the vessel, such as that used in the line shaft of a single propeller vessel, are to be provided with a torsional displacement limiter. The device is to lock the coupling or prevent excessive torsional displacement when a pre-determined torsional displacement limit is exceeded. Operation of the vessel under such circumstances may be at reduced power. Warning notices for such reduced power are to be posted at all propulsion control stations.

17.1.3 Barred Range

Conditions where the allowable vibratory torque or the allowable dissipated power may be exceeded under the normal operating range of the engine are to be identified and are to be marked as a barred range in order to avoid continuous operation within this range.

17.1.4 Diesel Generators

Flexible couplings for diesel generator sets are to be capable of absorbing short time impact torque due to electrical short-circuit conditions up to 6 (six) times the nominal torque.

17.3 Flanged Couplings and Coupling Bolts

Refer to 4-3-1/19.5 for flanged couplings.

Elongation for auxiliary machinery coupling bolts made of steel having an ultimate tensile strength over 690 N/mm² (70 kgf/mm², 100,000 psi) will be subject to special consideration. Also refer to 4-3-1/19.1 and 4-3-1/19.3.

19 Testing of Pumps Associated with Engine and Reduction Gear Operation

Pumps associated with engine and reduction gear operation (oil, water, fuel) utilized with engines having bores exceeding 300 mm (11.8 in.) are to be provided with certificates issued by the Surveyor. The following tests are to be conducted to the Surveyor's satisfaction:

19.1 Pumps Hydrostatic Tests

Independently-driven pumps are to be hydrostatically tested to 4 bar (4 kgf/cm², 57 psi), but not less than 1.5*P*, where *P* is the maximum working pressure in the part concerned.

19.3 Capacity Tests

Tests of pump capacities are to be conducted to the satisfaction of the Surveyor with the pump operating at design conditions. Capacity tests will not be required for individual pumps produced on a production line basis, provided the Surveyor is satisfied from periodic inspections and the manufacturer's quality assurance procedures that the pump capacities are acceptable.

21 Trial

Before final acceptance, the entire installation is to be operated in the presence of the Surveyor to demonstrate its ability to function satisfactorily under operating conditions and its freedom from harmful vibration at speeds within the operating range. See also 4-1-1/33.

For conventional propulsion gear units above 1120 kW (1500 HP), a record of gear-tooth contact is to be made at the trials. To facilitate the survey of extent and uniformity of gear-tooth contact, selected bands of pinion or gear teeth on each meshing are to be coated beforehand with copper or layout dye. See 7-6-2/1.1.2.

The gear-tooth examination for conventional gear units 1120 kW (1500 HP) and below and all epicyclic gear units will be subject to special consideration. The gear manufacturer's recommendations will be considered.

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PART

4

CHAPTER 3 Propulsion and Maneuvering Machinery

SECTION 1 Propulsion Shafting

1 General

The construction of the propellers and propulsion shafting for vessels is to be carried out in accordance with the following requirements and to the satisfaction of the Surveyor. For vessels distinguished in the *Record* by the words “Ice Class”, see Part 6, Chapter 1 of the *Steel Vessel Rules*.

1.1 Definitions (2014)

For the purposes of using shaft diameter formulas in this section, the following definitions apply.

1.1.1 Tail Shaft

Tail Shaft is the part of the propulsion shaft aft of the forward end of the propeller end bearing.

1.1.2 Stern Tube Shaft

Stern Tube Shaft or *Tube Shaft* is the part of the propulsion shaft passing through the stern tube from the forward end of the propeller end bearing to the in-board shaft seal.

1.1.3 Line Shaft

Line Shaft is the part of the propulsion shaft in-board of the vessel.

1.1.4 Thrust Shaft

Thrust Shaft is that part of the propulsion shaft which transmits thrust to the thrust bearing.

1.1.5 Oil Distribution Shaft

Oil Distribution Shaft is a hollow propulsion shaft where the bore and radial holes are used for distribution of hydraulic oil in controllable pitch propeller installations.

3 Plans and Data to be Submitted

Plans and specifications are to be submitted in accordance with 4-1-1/7.19, as indicated in the following:

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, are to be submitted. Calculations are to be included for flexible couplings and demountable couplings. See 4-2-1/17 and 4-3-1/19.9. See also 4-3-1/21.

5 Materials and Testing

5.1 Material (2004)

Materials for propulsion shafts, couplings and coupling bolts, keys and clutches are to be of forged steel or rolled bars, as appropriate, in accordance with Section 2-3-7 and Section 2-3-8 of the *ABS Rules for Materials and Welding (Part 2)* or other specifications as may be specially approved with a specific design. Where materials other than those specified in the Rules are proposed, full details of chemical composition, heat treatment and mechanical properties, as appropriate, are to be submitted for approval.

5.1.1 Ultimate Tensile Strength

In general, the minimum specified ultimate tensile strength of steel used for propulsion shafting is to be between 400 N/mm² (40.7 kgf/mm², 58,000 psi) and 930 N/mm² (95.0 kgf/mm², 135,000 psi).

5.1.2 Elongation (2012)

Carbon Steel with elongation ($L_o/d = 4$) of less than 16% or ($L_o/d = 5$) of less than 15% is not to be used for any shafting component, with the exception that material for non-fitted alloy steel coupling bolts manufactured to a recognized standard may have elongation ($L_o/d = 4$) of not less than 10% or ($L_o/d = 5$) of not less than 9%.

Alloy steels with elongation less than ($L_o/d = 4$) 16% or ($L_o/d = 5$) 15% may be applied subject to approval.

5.3 Material Tests

5.3.1 General (2016)

Materials for all torque-transmitting parts, including shafts, clutches, couplings, coupling bolts and keys are to be tested in the presence of the Surveyor. The materials are to meet the specifications of 2-3-7/1, 2-3-7/5, 2-3-7/7, or 2-3-8/1 of the *ABS Rules for Materials and Welding (Part 2)* or other specifications approved in connection with the design.

5.3.2 Alternative Test Requirements

Materials for shafting, couplings and coupling bolts transmitting 373 kW (500 HP) or less will be accepted based on the manufacturer's certified mill tests and hardness check witnessed by the Surveyor. Bolts manufactured to a recognized standard and used as coupling bolts will not require material testing.

5.5 Inspection

Shafting and couplings are to be surface-examined at the manufacturer. Tail shafts in the finished machine condition are to be subjected to a nondestructive examination such as magnetic particle, dye penetrant or other nondestructive methods and are to be free of linear discontinuities greater than 3.2 mm (1/8 in.), except that in the following locations, the shafts are to be free of all linear discontinuities:

5.5.1 Tapered Tail Shafts

The forward one-third length of the taper, including the forward end of any keyway and an equal length of the parallel part of the shaft immediately forward of the taper.

5.5.2 Flanged Tail Shafts

The flange fillet area.

5.7 Weldability (2008)

Steel used for tail shafts is to have carbon content in accordance with 2-3-7/1.1.2 of the *ABS Rules for Materials and Welding (Part 2)*.

7 Design and Construction (2004)

7.1 Shaft Diameters (2012)

The least diameter of propulsion shafting is to be determined by the following equation:

$$D = 100K \sqrt[3]{(H/R)[c_1/(U + c_2)]}$$

where

c_1	=	560 (41.95, 3.695)	for vessels 45.7 m (150 ft) in length and over
	=	472.5 (35.4, 3.12)	for vessels 20 m (65 ft) and over, but below 45.7 m (150 ft), where the material of the shaft is Grade 2 and the shaft is protected

- c_1 = 540 (40.3, 3.55) for vessels 20 m (65 ft) and over, but below 45.7 m (150 ft), for all other materials and unprotected Grade 2 shaft material
 = 416.4 (31.22, 2.75) for vessels below 20 m (65 ft)
- c_2 = 160 (16.3, 23180)
- D = greater of the required solid shaft diameter, in mm (in.), as required by 4-3-1/7.1, or 4-3-1/21 reflective of static and dynamic stresses, except hollow shaft in 4-3-1/7.3
- K = shaft design factor (see 4-3-1/Table 1 and 4-3-1/Table 2)
- H = power at rated speed, kW (PS, HP), [(MKS units: 1 PS = 0.735 kW), (US units: 1 HP = 0.746 kW)]
- R = rpm at rated speed
- U = minimum specified ultimate tensile strength of the material, in N/mm² (kgf/mm², psi). For calculation purposes, U is not to be taken as more than the following:
 = 415 N/mm² (42.2 kgf/mm², 60,000 psi) for carbon, and alloy steel tail shafts fitted with salt-water lubricated bearings and non-continuous shaft liners.
 = 600 N/mm² (61.2 kgf/mm², 87,000 psi) for carbon, alloy and austenitic stainless steel tail shafts fitted with oil lubricated bearings or with continuous shaft liners or equivalent.
 = 930 N/mm² (95.0 kgf/mm², 135,000 psi) for other shaft sections and for tail shafts manufactured of age-hardened martensitic stainless steels, higher-strength austenitic stainless steels such as ASTM Type XM-19, XM-21, or XM-28, or other high strength alloy materials.

Note: In general, the minimum specified ultimate tensile strength of steel used for propulsion shafting is to be between 400 N/mm² (40.7 kgf/mm², 58,000 psi) and 930 N/mm² (95.0 kgf/mm², 135,000 psi). See also 4-3-1/5.1.

TABLE 1
Shaft Design Factor K for Line Shafts, Thrust Shafts, and Oil Distribution Shafts

Propulsion Type	Design Features ⁽¹⁾							
	Integral Flange	Shrink Fit Coupling	Keyways ⁽²⁾	Radial Holes, Transverse Holes ⁽³⁾	Longitudinal Slots ⁽⁴⁾	On Both Sides of Thrust Collars	In way of Axial Bearings used as Thrust Bearings	Straight Sections
Turbine	0.95	0.95	1.045	1.045	1.14	1.045	1.045	0.95
Electric Drives								
Diesel Drives through slip couplings (electric or hydraulic)								
All Other Diesel Drives	1.0	1.0	1.1	1.1	1.2	1.1	1.1	1.0

Notes:

- Geometric features other than those listed will be specially considered
- After a length of not less than 0.2D from the end of the keyway, the shaft diameter may be reduced to the diameter calculated for straight sections.
 Fillet radii in the transverse section of the bottom of the keyway are to be not less than 0.0125D
- Diameter of bore not more than 0.3D
- Length of the slot not more than 1.4D, width of the slot not more than 0.2D, whereby D is calculated with $k = 1.0$

TABLE 2
Shaft Design Factor *K* for Tail Shafts and Stern Tube Shafts (See Note 1)

Propulsion Type	Stern Tube Configuration	Propeller Attachment Method ⁽²⁾			
		Keyed ⁽³⁾	Keyless Attachment by Shrink Fit ⁽⁴⁾	Flanged ⁽⁵⁾	Stern Tube Shafts ^(7, 8)
All	Oil-lubricated bearings	1.26	1.22	1.22	1.15
All	Water-lubricated bearings with continuous shaft liners or equivalent	1.26	1.22	1.22	1.15
All	Water-lubricated bearings with non-continuous shaft liners ⁽⁶⁾	1.29	1.25	1.25	1.18

Notes:

- 1 The tail shaft diameter may be reduced to the stern tube shaft diameter forward of the bearing supporting the propeller, and the stern tube shaft diameter reduced to the line shaft diameter inboard of the forward stern tube seal. The inboard end of tail shafts or tube shafts within the vessel, as applicable, is to be designed the same as line shafts, with shaft design factors in accordance with 4-3-1/Table 1.
- 2 Other attachments are subject to special consideration.
- 3 Fillet radii in the transverse section at the bottom of the keyway are not to be less than 0.0125*D*.
- 4 See also 4-3-1/15.
- 5 The fillet radius in the base of the flange for the tail shaft supporting the propeller is to be at least 0.125*D*. Special consideration will be given to fillets of multiple radii design. The fillet radius is to be accessible for nondestructive examination during tail shaft surveys. See 7-5-1/3 and Section 7-5-2 of the ABS Rules for Survey After Construction (Part 7). For other fillet radii, see 4-3-1/19.5.
- 6 For Great Lakes service, *K* factor corresponding to continuous liner configuration may be used.
- 7 *K* factor applies to shafting between the forward edge of the propeller-end bearing and the inboard stern tube seal.
- 8 Where keyed couplings are fitted on stern tube shaft, the shaft diameters are to be increased by 10% in way of the coupling. See Note 2 of 4-3-1/Table 1.

7.3 Hollow Shafts

For hollow shafts where the bore exceeds 40% of the outside diameter, the minimum shaft diameter is not to be less than that given by the following equation:

$$D_o = D \sqrt[3]{1/[1 - (D_i / D_o)^4]}$$

where

- D_o = required outside diameter, in mm (in.)
- D = solid shaft diameter required by 4-3-1/7, as applicable, in mm (in.)
- D_i = actual shaft bore, in mm (in.)

7.5 Alternative Criteria (2012)

As an alternative to the design equations shown in 4-3-1/7.1 and 4-3-1/7.3, shafting design may be considered for approval on the basis of axial and torsional loads to be transmitted, bending moment and resistance against fatigue. A detailed stress analysis showing a factor of safety of at least 2.0 for fatigue failure is to be submitted for approval with all supporting data.

9 Key (2004)

In general, the key material is to be of equal or higher strength than the shaft material. The effective area of the key in shear is to be not less than A , given below. The effective area is to be the gross area subtracted by materials removed by saw cuts, set screw holes, chamfer, etc., and is to exclude the portion of the key in way of spooning of the key way.

$$A = \frac{D^3}{5.1r_m} \cdot \frac{Y_S}{Y_K}$$

where

A	=	shear area of key, mm ² (in ²)
D	=	line shaft diameter, mm (in.), as determined by 4-3-1/7.1
r_m	=	shaft radius at mid-length of the key, mm (in.)
Y_S	=	specified yield strength of shaft material, N/mm ² (kgf/mm ² , psi)
Y_K	=	specified yield strength of key material, N/mm ² (kgf/mm ² , psi)

11 Tail Shaft Liners

11.1 Thickness at Bearings (2009)

11.1.1 Bronze Liner

The thickness of bronze liners to be fitted to tail shafts or tube shafts is not to be less than that given by the following equation:

$$t = T/25 + 5.1 \text{ mm} \qquad t = T/25 + 0.2 \text{ in.}$$

where

t	=	thickness of liner, in mm (in.)
T	=	required diameter of tail shaft, in mm (in.)

11.1.2 Stainless Steel Liner

The thickness of stainless steel liners to be fitted to tail shafts or tube is not to be less than one-half that required for bronze liners or 6.5 mm (0.25 inches), whichever is greater.

11.3 Thickness Between Bearings

The thickness of a continuous bronze liner between bearings is to be not less than three-fourths of the thickness, t , determined by the foregoing equation.

11.5 Continuous Fitted Liners

Continuous fitted liners are to be in one piece or, if made of two or more lengths, the joining of the separate pieces is to be done by an approved method of fusion through not less than two-thirds the thickness of the liner or by an approved rubber seal.

11.7 Fit Between Bearings

If the liner does not fit the shaft tightly between the bearing portions, the space between the shaft and liner is to be filled by pressure with an insoluble, non-corrosive compound.

11.9 Material and Fit

Fitted liners are to be of a high-grade composition, bronze or other approved alloy, free from porosity and other defects, and are to prove tight under hydrostatic test of 1.0 bar (1 kgf/cm², 15 psi). All liners are to be carefully shrunk or forced upon the shaft by pressure and they are not to be secured by pins.

11.11 Glass Reinforced Plastic Coating

Glass reinforced plastic coatings may be fitted on propulsion shafting when applied by an approved procedure to the satisfaction of the Surveyor. Such coatings are to consist of at least four plies of cross-woven glass tape impregnated with resin, or an equivalent process. Prior to coating, the shaft is to be cleaned with a suitable solvent and grit-blasted. The shaft is to be examined prior to coating and the first layer is to be applied in the presence of the Surveyor. Subsequent to coating, the finished shaft is to be subjected to a spark test or equivalent to verify freedom from porosity to the satisfaction of the Surveyor. In all cases where reinforced plastic coatings are employed, effective means are to be provided to prevent water having access to the shaft. Provisions are to be made for overlapping and adequately bonding the coating to fitted or clad liners. The end of the liner is to be stepped and tapered as required to protect the end of the wrapping.

11.13 Stainless Steel Cladding

Stainless steel cladding of shafts is to be carried out in accordance with an approved procedure. See Appendix 7-A-11, "Repair and Cladding of Shafts" of the *ABS Rules for Survey After Construction (Part 7)*.

13 Tail Shaft Bearings

13.1 Water Lubricated Bearings

13.1.1 Wood Bearings (resinous, dense hardwoods)

The length of the bearing next to and supporting the propeller is to be not less than four times the required tail shaft diameter.

13.1.2 Synthetic Bearings (rubber, reinforced resins, plastic materials)

The length of the bearing next to and supporting the propeller is to be not less than four times the required tail shaft diameter.

For a bearing design substantiated by experimental tests to the satisfaction of ABS, consideration may be given to a bearing length of less than four times, but not less than two times, the required tail shaft diameter.

13.3 Oil Lubricated Bearings

13.3.1 White Metal Lined

The length of white-metal lined, oil-lubricated propeller-end bearings fitted with an approved oil-seal gland is to be on the order of two times the required tail shaft diameter. The length of the bearing may be less, provided the nominal bearing pressure is not more than 0.80 N/mm^2 (0.0815 kgf/mm^2 , 116 psi) as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft bearing, divided by the projected area of the shaft. The minimum length, however, is not to be less than 1.5 times the actual diameter.

13.3.2 Synthetic Bearings (rubber, reinforced resins, plastic etc.)

The length of synthetic rubber, reinforced resin or plastic oil-lubricated propeller end bearings fitted with an approved oil-seal gland is to be on the order of two times the required tail shaft diameter. The length of the bearing may be less, provided the nominal bearing pressure is not more than 0.60 N/mm^2 (0.0611 kgf/mm^2 , 87 psi), as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft bearing, divided by the projected area of the shaft. The minimum length, however, is not to be less than 1.5 times the actual diameter. Where the material has demonstrated satisfactory testing and operating experience, consideration may be given to increased bearing pressure.

15 Tail Shaft Propeller End Design

Tail shafts are to be provided with an accurate taper fit in the propeller hub, particular attention being given to the fit at the large end of the taper.

15.1 Keyed (1998)

The key is to fit tightly in the keyway and be of sufficient size to transmit the full torque of the shaft, but it is not to extend into the liner counterbore on the forward side of the hub. The forward end of the keyway is to be so cut in the shaft as to give a gradual rise from the bottom of the keyway to the surface of the shaft. Ample fillets are to be provided in the corners of the keyway and, in general, stress concentrations are to be reduced as far as practicable.

15.3 Keyless (1998)

Where propellers are fitted without keys, detailed stress calculations and fitting instructions are to be submitted for review. See 4-3-2/19.

17 Flexible Couplings

See 4-2-1/17.1.

19 Solid Couplings

19.1 Fitted Bolts (2008)

The minimum diameter of fitted shaft coupling bolts is to be determined by the following equation.

$$d_b = 0.65 \sqrt{D^3 (U + c) / NBU_b} \quad \text{mm (in.)}$$

where

- d_b = diameter of bolts at joints, in mm (in.)
- D = minimum required shaft diameter designed considering the largest combined torque (static and dynamic), acting at the shaft in vicinity of the respective coupling flanges; mm (in.), see 4-3-1/21, but not less than the minimum required line shaft diameter, as per 4-3-1/7, in mm (in.)
- U = minimum specific tensile strength of shaft material, in N/mm², (kgf/mm², psi)
- c = 160 (16.3, 23180)
- N = number of bolts fitted in one coupling
- B = bolt circle diameter, in mm (in.)
- U_b = minimum specific tensile strength of bolt material, in N/mm², (kgf/mm², psi). To be not less than U . U_b is to be taken not more than 1.7 U or 1000 N/mm² (102 kgf/mm², 145,000 psi), whichever is less, for calculation purposes.

Notes: (2008)

- 1 The bolts are to be assembled with an interference fit.
- 2 The use of other materials will be subject to special consideration based on submitted engineering analyses.

19.3 Non-fitted Bolts

The diameter of pre-stressed, non-fitted coupling bolts will be considered upon the submittal of detailed preloading and stress calculations and fitting instructions. The tensile stress on the bolt due to pre-stressing and astern pull is not to exceed 90% of the minimum specified yield strength of the bolt material. In addition, the bearing stress on any member such as the shaft, bolt, threads or nut is not to exceed 90% of the minimum specified yield strength of the material for that member.

19.3.1 Power Transmitted by Prestress Only

Where bolts are under pure tension, the factor of safety against slip under the worst of the operating conditions, including mean transmitted torque plus vibratory torque due to torsional loads, is to be at least as follows:

- | | | |
|-----|---|-----|
| i) | Inaccessible couplings (external to the hull or not readily accessible) | 2.8 |
| ii) | Accessible couplings (internal to the hull) | 2.0 |

19.3.2 Power Transmitted by Combination Prestress and Shear

Where the power is transmitted by a combination of fitted bolts and pre-stressed, non-fitted bolts, the components are to meet the following criteria:

19.3.2(a) Fitted Bolts. The shear stress under the maximum torque corresponding to the worst loaded condition is to be not more than 50% of the minimum specified tensile yield strength of the bolt material.

19.3.2(b) Non-Fitted Bolts. The factor of safety against slip under the maximum torque corresponding to the worst loaded condition and the specified bolt tension is to be at least 1.6 for inaccessible couplings and 1.1 for accessible couplings.

19.3.3 Dowels Used for Transmitting Power

Dowels connecting the tail shaft flange to the controllable pitch propeller hub, utilized with non-fitted bolts to transmit power, are considered equivalent to fitted coupling bolts and are to comply with 4-3-1/19.1 and, if applicable, 4-3-1/19.3.2(a). The dowels are to be accurately fitted and effectively secured against axial movement. The coupling is to be satisfactory for astern condition.

19.5 Flanges

The thickness of coupling flanges is not to be less than the minimum required diameter of the coupling bolts or 0.2 times D (as defined in 4-3-1/7), whichever is greater. The fillet radius at the base of an integral flange is not to be less than 0.08 times the actual shaft diameter. Consideration of a recognized shaft coupling standard will be given to fillets of multiple radii design. In general, the surface finish for fillet radii is not to be rougher than 1.6 μ meters (63 μ in.) RMS. For the fillet radius for tail shaft to propeller coupling flange, see Note 4 in 4-3-1/Table 2.

19.7 Locking Arrangement (2014)

After assembly, all coupling bolts and associated nuts are to be fitted with locking arrangement.

19.9 Demountable Couplings

Couplings are to be made of steel or other approved ductile material. The strength of demountable couplings and keys is to be equivalent to that of the shaft. Couplings are to be accurately fitted to the shaft. Where necessary, provisions for resisting thrust loading are to be provided.

Hydraulic and other shrink fit couplings will be specially considered upon submittal of detailed preloading and stress calculations and fitting instructions. In general, the torsional holding capacity is to be at least 2.8 times the transmitted mean torque plus vibratory torque due to torsionals for inaccessible couplings (external to the hull or not readily accessible) and at least 2.0 times for accessible couplings (internal to the hull). The preload stress is not to exceed 70% of the minimum specified yield strength.

21 Propulsion Shaft Alignment and Vibration

21.1 General

Propulsion shafting is to be aligned with the location and spacing of the shaft bearings, being such as to give acceptable bearing reactions and shaft bending moments and also acceptable amplitudes of vibration for all conditions of vessel loading and operation.

The designer or the builder is to evaluate the propulsion shafting system, taking into consideration any forces or factors which may affect the reliability of the propulsion shafting system, including weight of the propeller and shafts, hydrodynamic forces acting on the propeller, number of propeller blades in relation to diesel engine cylinders, misalignment forces, thermal expansion, flexibility of engine and thrust bearing foundations, engine induced vibrations, gear tooth loadings, flexible couplings, effect of power take-off arrangements from the propulsion shafting system driving auxiliaries, etc., as applicable, as well as any limits for vibrations and loadings specified by the equipment manufacturers.

21.3 Vessels 61 m (200 ft) in Length and Over

21.3.1 Shaft Alignment Calculations

The requirements in 4-3-2/7.3 of the *Steel Vessel Rules* are to be complied with.

21.3.2 Torsional Vibrations

The requirements in 4-3-2/7.5.1 of the *Steel Vessel Rules* are to be complied with.

21.3.3 Axial Vibrations

The requirements in 4-3-2/7.7 of the *Steel Vessel Rules* are to be complied with.

21.3.4 Lateral (Whirling) Vibrations

The requirements in 4-3-2/7.9 of the *Steel Vessel Rules* are to be complied with.

21.3.5 Cast Resin Chocks (2009)

Resin chocks and their installation are to comply with the requirements in 4-3-2/11.1.2 of the *Steel Vessel Rules*.

21.5 Vessels Below 61 m (200 ft) in Length

21.5.1 Torsional Vibration

For vessels fitted with an unusual propulsion arrangement or without vibration dampers, a torsional vibration analysis of the propulsion system showing compliance with 4-3-2/7.5.1 of the *Steel Vessel Rules* is to be submitted. This is not required for vessels under 20 m (65 ft) in length or where the installation is essentially the same as previous designs which have been proven satisfactory.

23 Circulating Currents (2014)

Where means are provided to prevent circulating currents from passing between the propeller, shaft and the hull, a warning notice plate is to be provided in a visible place cautioning against the removal of such protection.

25 Tailshaft Condition Monitoring (TCM) (2014)

25.1 Notation

Where requested by the Owner, the class notation **TCM (Tailshaft Condition Monitoring)** may be assigned to a vessel with tailshafts specifically arranged with oil-lubricated stern tube bearings, provided the following requirements are complied with.

25.3 System Requirements

In addition to the requirements for propulsion shafting in Section 4-3-1, the following design requirements are to be complied with and relevant drawing(s) and data are to be submitted for review and approval prior to commencement of the initial surveys as specified in 4-3-1/25.7.1.

25.3.1 Temperature Monitoring and Alarm

The vessel is to be provided with a temperature monitoring and alarm system for the tailshaft stern tube aft bearing. The system is to be arranged with a high temperature alarm and two sensors. One easily interchangeable sensor may be installed in lieu of the two sensors. Where one interchangeable sensor is installed, one spare sensor is to be carried onboard the vessel.

The monitoring and alarm system is to have the following features:

- i) The main alarm system is to be provided with a power failure alarm.
- ii) An alarm that indicates an open circuit, a short circuit, or an earth fault in the temperature sensor circuit is to be provided
- iii) An alarm indicating that the sensor's temperature signal is outside the set points of the unit is to be provided.

Temperature monitoring and the alarm system are to be located in the propulsion machinery spaces. For **ACC/ACCU** machinery spaces, the temperature monitoring and alarm system is to be incorporated with the required control and monitoring system.

When a centralized control or monitoring station is installed, the alarms are to be activated in such a station.

25.3.2 Oil Seal Design

Approved type oil seals are to be used which will allow for replacement without the shaft withdrawal or removal of the propeller.

25.3.3 Bearing Wear Down Measurement

Arrangements and means are to be provided for bearing wear down measurement.

25.5 Management of the Monitored Data

The following management of the monitored data is to be implemented.

25.5.1 Lubrication Oil Sampling

Stern tube bearing lubricating oil is to be sampled monthly under service conditions, and analyzed for water content using a suitable on-board test kit. Additionally, at least every six months, oil samples are to be submitted for analysis to a recognized laboratory where testing is to be conducted for the following:

- i) Free water content in oil, if present
- ii) Bearing metals content (Pb, Fe, Cu, Al, Cr, Sn, Si, Ni)
- iii) Viscosity at 40°C

25.5.2 Stern Tube Bearings Operating Condition

Stern tube bearing temperatures are to be monitored and temperature recorded daily. The system's oil consumption is to be recorded monthly.

25.5.3 Recording and Analysis

The chief engineer is responsible for recording and maintaining a file of the shipboard performed lubricating oil sampling and analysis results, as well as stern tube bearings operating condition. Also, the results of the laboratory analysis are to be stored within the file onboard. All documentation is to be available to the Surveyor to allow for trend assessment of the measured parameters.

The shipboard record is to contain conclusions regarding the condition of the oil and whether it remains suitable for further use. Conclusions are to be supported by comparative parameters.

In case of oil replacement, a record containing the reason for replacement of the oil is to be maintained for Surveyor's review at the next Annual Survey.

25.7 Surveys

25.7.1 Initial Survey

All systems in 4-3-1/25 are to be examined and tested to the satisfaction of the attending Surveyor in accordance with the approved plans.

For initial survey of existing vessels, refer to 7-9-19/1.3 of the *ABS Rules for Survey After Construction (Part 7)*.

25.7.2 Survey After Construction

Refer to Section 7-9-19 of the *ABS Rules for Survey After Construction (Part 7)*.

PART

4

CHAPTER 3 Propulsion and Maneuvering Machinery

SECTION 2 Propellers

1 General

The construction of the propellers and propulsion shafting for vessels is to be carried out in accordance with the following requirements and to the satisfaction of the Surveyor. Upon satisfactory compliance with the requirements, a notation will be made in the *Record* indicating the type of propeller and the material of which it is made. See Part 6, Chapter 1 of the *Steel Vessel Rules* for vessels assigned an **Ice Class** notation.

1.1 Definitions (2014)

For purpose of this section, the following definitions apply.

1.1.1 Skew Angle

Skew Angle (θ) of a propeller is the angle measured from ray 'A' passing through the tip of blade at mid-chord line to ray 'B' tangent to the mid-chord line on the projected blade outline. See 4-3-2/Figure 1.

1.1.2 Highly Skewed Propeller

A *Highly Skewed Propeller* is one whose skew angle is more than 25° .

1.1.3 Propeller Rake

1.1.3(a) Rake. *Rake* is the distance at the blade tip between the generating line and the line perpendicular to the propeller axis that meets the generating line at the propeller axis. See 4-3-2/Figure 2.

1.1.3(b) Rake Angle (ϕ). *Rake Angle* of a propeller is the angle measured from the plane perpendicular to shaft centerline to the tangent to the generating line at a specified radius ($0.6 \times$ radius for the purpose of this section). See 4-3-2/Figure 2.

1.1.4 Wide Tipped Blade Propeller

A propeller blade is to be considered as a wide tipped blade if the maximum expanded blade cord length occurs at or above $0.8R$, with R being the distance measured from the centerline of the propeller hub.

3 Small Conventional Propellers

For planing and semi-planing vessels, the propellers need not to be designed and constructed in accordance with these requirements, provided they do not exceed 1.5 m (60 in.) in diameter and are part of a manufacturer's standard product line. In such instances, neither the Surveyor's attendance for the material testing and inspection nor the design review will be required.

5 Plans and Data to be Submitted

Plans and specifications are to be submitted in accordance with 4-1-1/7.15, as indicated in the following:

5.1 Fixed-Pitch Propellers

Where the propeller blades are of conventional design, a propeller plan giving the design data and characteristics of the material, as required by 4-3-2/9.1, is to be submitted. For skewed propellers or propeller blades of unusual design, a detailed stress analysis is also to be submitted as required by 4-3-2/9.3 or 4-3-2/11.3. For keyless propellers, see 4-3-2/19.3.

5.3 Controllable-Pitch Propellers

In addition to the plan and data required in 4-3-2/5.1 for the propeller blade, plans of the propeller hub, propeller blade flange and bolts, internal mechanisms, hydraulic piping control systems, and instrumentation and alarm system are to be submitted. Strength calculations are to be included for the internal mechanism. See 4-3-2/15.

7 Materials and Testing (2011)

7.1 Propeller Material

For propellers required to be of an approved design, 4-3-2/Table 1 shows the properties of materials normally used for propellers. See 2-3-14/3 and Section 2-3-15 of the *ABS Rules for Materials and Welding (Part 2)* for full details of the materials.

Where an alternative material specification is proposed, detailed chemical composition and mechanical properties are to be submitted for approval (for example, see Sections 2-3-14 and 2-3-15 of the above referenced Part 2). The f and w values of such materials to be used in the equations hereunder will be specially considered upon submittal of complete material specifications including corrosion fatigue data to 10^8 cycles.

TABLE 1
Propeller Materials (2011)

Type	Material	Tensile Strength			Yield Strength			Elongation, %	
		N/mm ²	kgf/mm ²	lb/in ²	N/mm ²	kgf/mm ²	lb/in ²	Gauge Length	
							4d	5d	
2	Manganese bronze	450	46	65,000	175	18	25,000	20	18
3	Nickel-manganese bronze	515	53	75,000	220	22.5	32,000	18	16
4	Nickel-aluminum bronze	590	60	86,000	245	25	36,000	16	15
5	Manganese-nickel-aluminum bronze	630	64	91,000	275	28	40,000	20	18
CF-3	Stainless steel	485	49	70,000	205	21	30,000	35	32

7.3 Stud Materials

The material of the studs securing detachable blades to the hub is to be of at least Grade 2 forged steel or equally satisfactory material; see 2-3-7/7 of the *ABS Rules for Materials and Welding (Part 2)* for specifications of Grade 2 forged steel.

7.5 Material Testing

Materials of propellers cast in one piece and materials of blades, hub, studs and other load-bearing parts of controllable pitch propellers are to be tested in the presence of a Surveyor. For requirements of material testing, see 2-3-7/7, 2-3-14/3, and Section 2-3-15 of the *ABS Rules for Materials and Welding (Part 2)*.

9 Blade Design

9.1 Blade Thickness

Where the propeller blades are of conventional design, the thickness of the blades is not to be less than determined by the following equations:

9.1.1 Fixed-Pitch Propellers

$$t_{0.25} = S \left[K_1 \sqrt{\frac{AH}{C_n CRN}} \pm \left(\frac{C_s}{C_n} \right) \left(\frac{BK}{4C} \right) \right] \text{ mm (in.)}$$

where

- A = $1.0 + (6.0/P_{0.70}) + 4.3P_{0.25}$
- B = $(4300wa/N) (R/100)^2 (D/20)^3$
- C = $(1 + 1.5P_{0.25})(Wf - B)$
- S = 1.0. for all propellers with $D \leq 6.1$ m (20 ft)
 = $\sqrt{(D + 24.0)/30.1}$ SI, MKS units, or
 = $\sqrt{(D + 79)/99}$ US units for solid propellers with $D > 6.1$ m (20 ft). S is not to exceed 1.025.
- $t_{0.25}$ = required thickness at the one-quarter radius, in mm (in.)
- K_1 = 337 (289, 13)
- H = power at rated speed, kW (hp, HP)
- hp = metric horsepower
- HP = US horsepower
- R = rpm at rated speed
- N = number of blades
- $P_{0.25}$ = pitch at one-quarter radius divided by propeller diameter
- $P_{0.7}$ = pitch at seven-tenths radius divided by propeller diameter, corresponding to the design ahead conditions
- W = expanded width of a cylindrical section at the 0.25 radius, in mm (in.)
- a = expanded blade area divided by the disc area
- D = propeller diameter, in m (ft)
- K = rake of propeller blade, in mm (in.) (positive for aft rake and negative for forward rake)
- C_s = a_s/WT (section area coefficient at the 0.25 or 0.35 radius). Also see below.
- C_n = $I_o/U_f WT^2$ (section modulus coefficient at the 0.25 or 0.35 radius). Also see below.
- I_o = moment of inertia of the expanded cylindrical section at 0.25 or 0.35 radius about a straight line through the center of gravity parallel to the pitch line or to the nose-tail line, in mm⁴ (in⁴)
- a_s = area of expanded cylindrical section at the 0.25 or 0.35 radius, in mm² (in²)

- U_f = maximum normal distance from the moment of inertia axis to points on the face boundary (tension side) of the section, in mm (in.)
- T = maximum thickness at the 0.25 or 0.35 radius, in mm (in.), from propeller drawing
- f, w = material constants from the following table:

Type	Representative Propeller Materials (See Part 2, Chapter 3)	SI and MKS Units		US Customary Units	
		f	w	f	w
2	Manganese bronze	2.10	8.30	68	0.30
3	Nickel-manganese bronze	2.13	8.00	69	0.29
4	Nickel-aluminum bronze	2.62	7.50	85	0.27
5	Mn-Ni-Al bronze	2.37	7.50	77	0.27
	Cast steel	2.10	8.30	68	0.30
CF-3	Austenitic stainless steel	2.10	7.75	68	0.28

Note: The f values of materials not covered will be specially considered upon submittal of complete material specifications including corrosion fatigue data to 10^8 cycles.

The values of C_s and C_n , computed as stipulated above, are to be indicated on the propeller drawing. If the C_n value exceeds 0.10, the required thickness is to be computed with $C_n = 0.10$.

For vessels below 61 m (200 ft) in length, the required thickness may be computed with the assumed values of $C_n = 0.10$ and $C_s = 0.69$.

9.1.2 Controllable-Pitch Propellers

$$t_{0.35} = K_2 \sqrt{\frac{AH}{C_n CRN}} \pm \left(\frac{C_s}{C_n} \right) \left(\frac{BK}{6.3C} \right) \text{ mm (in.)}$$

where

- A = $1.0 + (6.0/P_{0.7}) + 3P_{0.35}$ (free running)
 = $7.2 + (2.0/P_{0.7}) + 3P_{0.35}$ (bollard, APS, dynamic positioning)
- B = $(4900wa/N)(R/100)^2(D/20)^3$
- C = $(1 + 0.6P_{0.35})(Wf - B)$
- $t_{0.35}$ = required thickness at the 0.35 radius, in mm (in.)
- K_2 = 271 (232, 10.4)
- $P_{0.35}$ = pitch at 0.35 radius divided by propeller diameter, corresponding to the design ahead conditions
- W = expanded width of a cylindrical section at the 0.35 radius, in mm (in.)

$H, R, N, P_{0.7}, a, D, K, C_s, C_n, f,$ and w are as defined in 4-3-2/9.1.1.

9.1.3 Nozzle Propellers (Wide Tip Blades) (2014)

$$t_{0.35} = K_3 \sqrt{\left(\frac{AH}{C_n CRN} \right)} \pm \left(\frac{C_s}{C_n} \right) \left(\frac{BK}{5.6C} \right) \text{ mm (in.)}$$

where

- A = $1.0 + (6.0/P_{0.7}) + 2.8P_{0.35}$ (free running)
 = $7.2 + (2.0/P_{0.7}) + 2.8P_{0.35}$ (bollard, APS, dynamic positioning)
- B = $(4625wa/N)(R/100)^2(D/20)^3$

$$C = (1 + 0.6P_{0.35})(Wf - B)$$

$t_{0.35}$ = required thickness at the 0.35 radius, in mm (in.)

$$K_3 = 288 \text{ (247, 11.1)}$$

$P_{0.35}$ = pitch at 0.35 radius divided by propeller diameter, corresponding to the design ahead conditions

W = expanded width of a cylindrical section at the 0.35 radius, in mm (in.)

$H, R, N, P_{0.7}, a, D, K, C_s, C_n, f,$ and w are as defined in 4-3-2/9.1.1.

A propeller blade is to be considered as a wide tipped blade if the maximum expanded blade cord length occurs at or above $0.8R$, with R being the distance measured from the centerline of the propeller hub.

9.3 Blades of Unusual Design

Propellers of unusual design or application will be subject to special consideration upon submittal of detailed stress calculations.

9.5 Blade-root Fillets

Fillets at the root of the blades are not to be considered in the determination of blade thickness.

9.7 Built-up Blades

The required blade section is not to be reduced in order to provide clearance for nuts. The face of the flange is to bear on that of the hub in all cases, but the clearance of the spigot in its counterbore or the edge of the flange in the recess is to be kept to a minimum.

11 Skewed Propeller Blades

11.1 Definitions

11.1.1 Maximum Skew Angle

Maximum skew angle (θ) is measured from ray A passing through the tip of blade to ray B tangent to the mid-chord line of the projected blade outline. See 4-3-2/Figure 1.

11.1.2 Rake Angle

Rake angle (ϕ) for the purpose of this Subsection is the angle measured from the plane perpendicular to shaft centerline to the tangent to generating line at 0.6 radius. See 4-3-2/Figure 2.

11.3 Application

11.3.1 $\theta \leq 25^\circ$

The requirements in 4-3-2/9.1 are applicable where the maximum skew angle is 25 degrees or less.

11.3.2 $25^\circ < \theta \leq 50^\circ$

The requirements in 4-3-2/11.5 may be used for fixed pitch propellers of ABS Type 4 material having skew angle over 25 degrees but not exceeding 50 degrees. For other material/type propellers, calculations as required in 4-3-2/11.3.3 are to be submitted.

11.3.3 $\theta > 50^\circ$

Propellers with the maximum skew angle exceeding 50 degrees will be subject to special consideration upon submittal of detailed stress calculations.

The maximum stress occurring during steady or transient astern operations is not to exceed seventy percent of the minimum specified yield strength of the propeller material.

11.5 Propellers Over 25° up to 50° Skew Angle

This paragraph applies to fixed pitch propellers of ABS Type 4 material having a maximum skew angle over 25 degrees but not exceeding 50 degrees.

11.5.1 Blade Thickness at 0.25 Radius

The maximum thickness at 0.25 radius is not to be less than the thickness required in 4-3-2/9.1.1 multiplied by the factor m , as given below:

$$m = \sqrt{1 + 0.0065 (\theta - 25)}$$

11.5.2 Blade Thickness at 0.6 Radius

The maximum thickness at 0.6 radius is to be not less than that obtained from the following equation:

$$t_{0.6} = K \sqrt{(1 + C_{0.9})(1 + 2C_{0.9} / C_{0.6})[(HDI\Gamma)/(RP_{0.6}Y)]^{0.5}}$$

where

$t_{0.6}$	=	required thickness at the 0.6 radius, in mm (in.)
K	=	12.6 (6.58, 1.19)
$C_{0.9}$	=	expanded chord length at the 0.9 radius divided by propeller diameter
$C_{0.6}$	=	expanded chord length at the 0.6 radius divided by propeller diameter
Γ	=	$[1 + (\theta - 25)/\theta][\phi^2 + 0.16\phi\theta P_{0.9} + 100]$
θ	=	skew angle in degrees (see 4-3-2/11.1.1 and 4-3-2/Figure 1)
ϕ	=	rake angle in degrees (see 4-3-2/11.1.2 and 4-3-2/Figure 2), positive for rake aft
$P_{0.6}$	=	pitch at the 0.6 radius divided by propeller diameter
$P_{0.9}$	=	pitch at the 0.9 radius divided by propeller diameter
Y	=	minimum specified yield strength of ABS Type 4 propeller material, in N/mm ² (kgf/mm ² , psi)

H, D, R are as defined in 4-3-2/9.1.

11.5.3 Blade Thickness Between 0.6 and 0.9 Radius

11.5.3(a) Maximum Thickness. The maximum thickness between 0.6 and 0.9 radius is not to be less than that obtained from the following equation.

$$t_x = 3.3D + 2.5(1 - x)(t_{0.6} - 3.3D) \quad \text{mm}$$

$$t_x = 0.04D + 2.5(1 - x)(t_{0.6} - 0.04D) \quad \text{in.}$$

where

t_x	=	required maximum blade thickness at radius ratio x
$t_{0.6}$	=	blade thickness at 0.6 radius, as required by 4-3-2/11.5.2
x	=	ratio of the radius under consideration to $D/2$, $0.6 < x \leq 0.9$

11.5.3(b) Trailing Edge Thickness at 0.9 Radius. The edge thickness measured at 5% of chord length from the trailing edge is to be not less than 30% of the maximum blade thickness required by 4-3-2/11.5.3(a) above at that radius.

FIGURE 1
Maximum Skew Angle

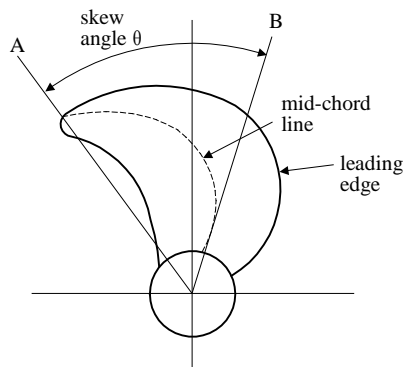
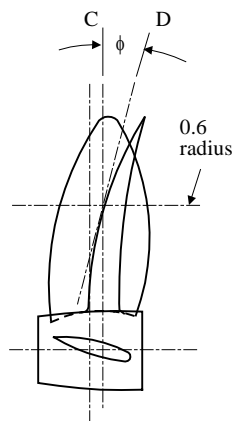


FIGURE 2
Rake Angle at the 0.6 Radius, Positive Aft



The rake angle ϕ , measured at 0.6 radius, is formed between line D , which is tangent to the generating line, and the line C , which is perpendicular to the propeller shaft centerline.

13 Studs

13.1 Stud Area

The sectional area of the studs at the bottom of the thread is to be determined by the following equation:

$$s = 0.056kWt_{0.35}^2f/rn \quad \text{mm}^2$$

$$s = 0.0018kWt_{0.35}^2f/rn \quad \text{in}^2$$

where

$$k = C/(U + C_1) \text{ material correction factor}$$

$$C = 621 \text{ (63.3, 90,000)}$$

$$C_1 = 207 \text{ (21.1, 30,000)}$$

$$U = \text{ultimate tensile strength of the stud material, N/mm}^2 \text{ (kg/mm}^2 \text{, psi)}$$

$$s = \text{area of one stud at bottom of thread, in mm}^2 \text{ (in}^2 \text{)}$$

$$n = \text{number of studs on driving side of blade}$$

$$r = \text{radius of pitch circle of the studs, in mm (in.)}$$

W, f and $t_{0.35}$ are defined under 4-3-2/9.1.

13.3 Fit of Studs and Nuts

Studs are to be fitted tightly into the hub and provided with effective means for locking. The nuts are also to have a tight-fitting thread and be secured by stop screws or other effective locking devices.

15 Blade Flange and Mechanisms

The strength of the propeller blade flange and internal mechanisms of controllable-pitch propellers subjected to the forces from propulsion torque is to be at least 1.5 times that of the blade at design pitch conditions.

17 Controllable Pitch Propeller System

17.1 Blade Pitch Control (2002)

17.1.1 Bridge Control

Where the navigation bridge is provided with direct control of propulsion machinery, it is to be fitted with means to control the pitch of the propeller.

17.1.2 Duplication of Power Unit

At least two hydraulic power pump units are to be provided for the pitch actuating system and arranged so that transfer between the pump units can be readily effected. For propulsion machinery spaces intended for unattended operation (**ACCU** notation), automatic start of the standby pump unit is to be provided. The emergency pitch actuating system [as required by 4-3-2/17.1.3iii)] may be accepted as one of the required hydraulic power pump units, provided it is no less effective.

17.1.3 Emergency Provisions

To safeguard the propulsion and maneuvering capability of the vessel in the event of any single failure in either the remote pitch control system or the pitch actuating system external to the propeller shaft and oil transfer device (also known as oil distribution box), the following are to be provided:

- i) Manual control of pitch at or near the pitch-actuating control valve (usually the directional valve or similar).
- ii) The pitch is to remain in the last ordered position until the emergency pitch actuating system is brought into operation.
- iii) An emergency pitch actuating system. This system is to be independent of the normal actuating system up to the oil transfer device, provided with its own oil reservoir and able to change the pitch from full ahead to full astern.

17.1.4 Integral Oil Systems

Where the pitch actuating hydraulic system is integral with the reduction gear lubricating oil system and/or clutch hydraulic system, the piping is to be arranged such that any failure in the pitch actuating system will not leave the other system(s) non-operational.

17.1.5 Provisions for Testing

Means are to be provided in the pitch actuating system to simulate system behavior in the event of loss of system pressure. Hydraulic pump units driven by main propulsion machinery are to be fitted with a suitable by-pass for this purpose.

17.1.6 Multiple Propellers

For vessels fitted with more than one controllable pitch propeller, each of which is independent of the other, only one emergency pitch actuating system [as required by 4-3-2/17.1.3iii)] need be fitted, provided it is arranged such that it can be used to provide emergency pitch-changing capability for all of the propellers.

17.1.7 Hydraulic Piping

Hydraulic piping is to meet the requirements of 4-4-6/1. Testing is to meet the requirements of 4-4-2/3.9.

17.3 Instrumentation and Alarms

The following instruments and alarms are to be provided.

17.3.1 Pitch Indicators

Each station capable of controlling the propeller pitch is to be fitted with a pitch indicator. In addition, a pitch indicator is to be fitted on the navigation bridge for vessels 500 gross tons and above.

17.3.2 Low Oil Pressure

Visual and audible alarms are to be provided in the engine room control station to indicate low hydraulic oil pressure.

17.3.3 High Oil Pressure

Visual and audible alarms are to be provided in the engine room control station to indicate high hydraulic oil pressure. The alarm is to be set below relief valve pressure.

17.3.4 High Temperature

Visual and audible alarms are to be provided in the engine room control station to indicate high hydraulic oil temperature.

17.5 Electrical Components

Electrical components are to meet the applicable requirements of Part 4, Chapter 6.

19 Propeller Fitting

19.1 Keyed Fitting

For shape of the keyway in the shaft and the size of the key, see 4-3-1/15.1.

19.3 Keyless Fitting (1998)

The formulas specified below apply to the ahead condition, but they will also provide adequate safety margin for the astern condition. The astern condition is to be considered if the astern torque exceeds the ahead torque. The formulas are applicable for solid propeller shafts only.

19.3.1 Design Criteria at 35°C (95°F)

The minimum required contact surface (grip) pressure, P_{\min} , at 35°C (95°F) and the corresponding minimum pull-up length, δ_{\min} , are to be determined by the following equations:

$$P_{\min} = \frac{ST}{AB} \left[-S\tau + \sqrt{\mu^2 + B \left(\frac{F_v}{T} \right)^2} \right] \quad \text{N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

$$\delta_{\min} = P_{\min} \frac{D_s}{2\tau} \left[\frac{1}{E_b} \left(\frac{K^2 + 1}{K^2 - 1} + \nu_b \right) + \frac{1}{E_s} (1 - \nu_s) \right] \quad \text{mm (in.)}$$

If the rated propeller thrust, T , is not known, it can be estimated as the thrust of a free running vessel, using the following equations, whichever yields the greater value of P_{\min} :

$$T = \frac{c_1 H}{V} \quad \text{or} \quad T = \frac{c_2 \times 10^6 H}{PR} \quad \text{N (kgf, lbf)}$$

19.3.2 Design Criteria at 0°C (32°F)

The maximum permissible contact surface (grip) pressure, P_{\max} , at 0°C (32°F), and the corresponding maximum permissible pull-up length, δ_{\max} , are to be determined from the following equations:

$$P_{\max} = \frac{\sigma_E (K^2 - 1)}{\sqrt{3K^4 + 1}} \quad \text{N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

$$\delta_{\max} = \frac{P_{\max}}{P_{\min}} \delta_{\min} \quad \text{mm (in.)}$$

19.3.3 Design Criteria at Fitting Temperature

The pull-up length, δ_t , at temperature t , where $t < 35^\circ\text{C}$ (95°F), and the corresponding contact surface (grip) pressure, P_t , are to be determined by the following equations:

$$\delta_t = \delta_{\min} + \frac{D_s}{2\tau} (\alpha_b - \alpha_s)(t_{\text{ref}} - t) \quad \text{mm (in.)}$$

$$P_t = P_{\min} \frac{\delta_t}{\delta_{\min}} \quad \text{N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

The minimum push-up load, W_t , at temperature t is to be as follows:

$$W_t = AP_t (\mu + \tau) \quad \text{N (kgf, lbf)}$$

The variables and constants used in 4-3-2/19.3.1, 4-3-2/19.3.2 and 4-3-2/19.3.3 are defined as follows:

- c = coefficient, dependent on the type of propulsion drive
 - = 1.0 for turbines, geared diesel drives, electric drives and direct diesel with a hydraulic, electromagnetic or high elasticity coupling.
 - = 1.2 for a direct diesel drive.

Higher values may be necessary for cases where extremely high pulsating torque is expected in service.

$$c_1 = \text{constant} = 1760 \text{ (132, 295)}$$

$$c_2 = \text{constant} = 57.3 \text{ (4.3, 0.38)}$$

$$t = \text{fitting temperature; } ^\circ\text{C (} ^\circ\text{F)}; t < t_{\text{ref}}$$

$$t_{\text{ref}} = 35^\circ\text{C (95}^\circ\text{F)}$$

$$A = 100\% \text{ theoretical contact surface area between propeller boss and shaft, disregarding oil grooves (i.e., } A = \pi D_s L); \text{ mm}^2 \text{ (in}^2\text{). Typically, the propeller boss forward and aft counterbore lengths (} \ell_1 \text{ and } \ell_2 \text{ in 4-3-2/Figure 3) and the forward and aft inner edge radii (} r_1 \text{ and } r_2 \text{ in 4-3-2/Figure 3), if any, are to be excluded.}$$

$$B = \mu^2 - S^2 \tau^2$$

$$D_b = \text{mean outer diameter of propeller boss, mm (in.). } D_b \text{ is to be calculated as the mean of}$$

$$D_{bm}, D_{bf} \text{ and } D_{ba} \text{ (i.e., } D_b = \frac{D_{ba} + D_{bm} + D_{bf}}{3} \text{),}$$

which are the outer diameters of boss corresponding to D_s , the forward point of contact and the aft point of contact, respectively (see 4-3-2/Figure 3).

$$D_s = \text{diameter of tail shaft at mid-point of the taper in axial direction, mm (in.), taking into account the exclusion of forward and aft counterbore length and the forward and aft edge radii (see 4-3-2/Figure 3).}$$

$$E_b = \text{modulus of elasticity for boss material, N/mm}^2 \text{ (kgf/mm}^2, \text{ psi). Material properties are given below.}$$

$$E_s = \text{modulus of elasticity of shaft material, N/mm}^2 \text{ (kgf/mm}^2, \text{ psi). Material properties are given below.}$$

$$F_v = \text{shear force at propeller/shaft interface} = \frac{2cQ}{D_s}, \text{ N (kgf, lbf)}$$

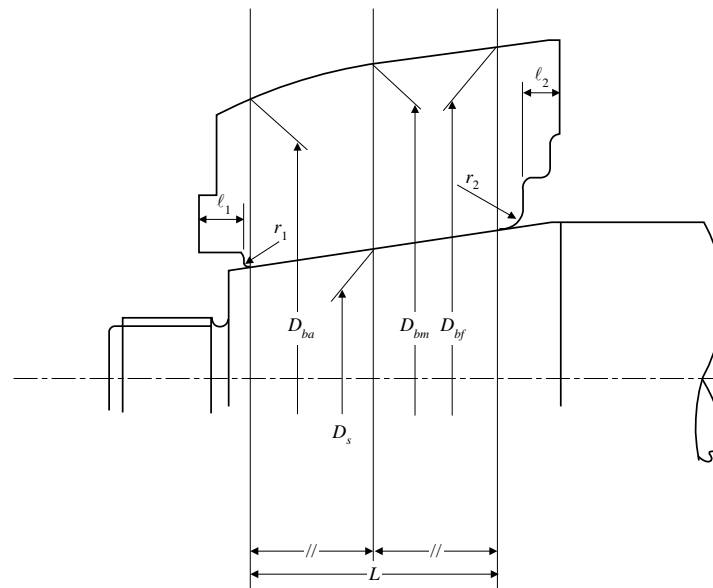
- H = rated power, kW (PS, hp)
- $K = \frac{D_b}{D_s}$
- L = contact length, mm (in.), see 4-3-2/Figure 3.
- P = mean propeller pitch, mm (in.)
- Q = rated torque corresponding to the rated power, H , and the propeller speed, R , N-mm (kgf-mm, lbf-in)
- = $9550 \times 10^3 \frac{H}{R}$ N-mm
- = $716,200 \frac{H}{R}$ kgf-mm
- = $63,025 \frac{H}{R}$ lbf-in
- R = propeller speed at rated power, rpm
- S = factor of safety against slip at 35°C (95°F). S is to be at least 2.8 under the section of rated torque (based on maximum continuous rating) plus torque due to torsional vibrations.
- T = rated propeller thrust, N (kgf, lbf)
- V = vessel speed at rated power, knots
- α_b = coefficient of linear expansion of shaft material, mm/mm-°C (in/in-°F). Material properties are given below.
- α_s = coefficient of linear expansion of shaft material, mm/mm-°C (in/in-°F). Material properties are given below.
- μ = coefficient of friction between contact surfaces. For oil injection method of fit, μ is to be taken as no greater than 0.13 for bronze/steel propeller bosses on steel shafts. For dry method of fit using cast iron on steel shafts, μ is to be taken as no greater than 0.18.
- ν_b = Poisson's ratio for boss material. Material properties are given below.
- ν_s = Poisson's ratio for shaft material. Material properties are given below.
- τ = taper of tail shaft on radius (e.g., if taper = 1/15 on diameter, τ = 1/30 on radius). τ is not to exceed 1/30.
- σ_E = maximum equivalent uniaxial stress in the boss at 0°F (32°F) based on the von Mises-Hencky criterion, N/mm² (kgf/mm², psi). For the purposes of these calculations, σ_E is to be taken as 70% of the minimum specified yield strength of the material as defined in 2-3-1/13.3. For cast iron, σ_E is to be taken as 30% of the minimum specified tensile strength.

The following material constants may be used:

Material	Modulus of Elasticity, E			Poisson's Ratio, ν	Coefficient of Expansion, α	
	N/mm ²	kgf/mm ²	psi		mm/mm°C	in./in.°F
Cast and forged steel	20.6×10^4	2.1×10^4	29.8×10^6	0.29	12.0×10^{-6}	6.67×10^{-6}
Cast iron	9.8×10^4	1.0×10^4	14.2×10^6	0.26	12.0×10^{-6}	6.67×10^{-6}
Bronzes, Types 2 & 3	10.8×10^4	1.1×10^4	15.6×10^6	0.33	17.5×10^{-6}	9.72×10^{-6}
Bronzes, Types 4 & 5	11.8×10^4	1.2×10^4	17.1×10^6	0.33	17.5×10^{-6}	9.72×10^{-6}

FIGURE 3
Keyless Propeller – Theoretical Contact Surface Area
Between Propeller Boss and Shaft (1998)

(Refer to 4-3-1/15.3 and 4-3-2/19.3)



21 Protection Against Corrosion

21.1 Propeller Aft End

The exposed steel of the shaft is to be protected from the action of the water by filling all spaces between cap, hub and shaft with a suitable material. The propeller is to be fitted with a fairwater cap, acorn nut, or other suitable after end sealing arrangement which prevents sea water from having contact with the shaft taper area. See 4-3-2/Figure 4 for a typical sealing arrangement.

21.3 Propeller Forward End

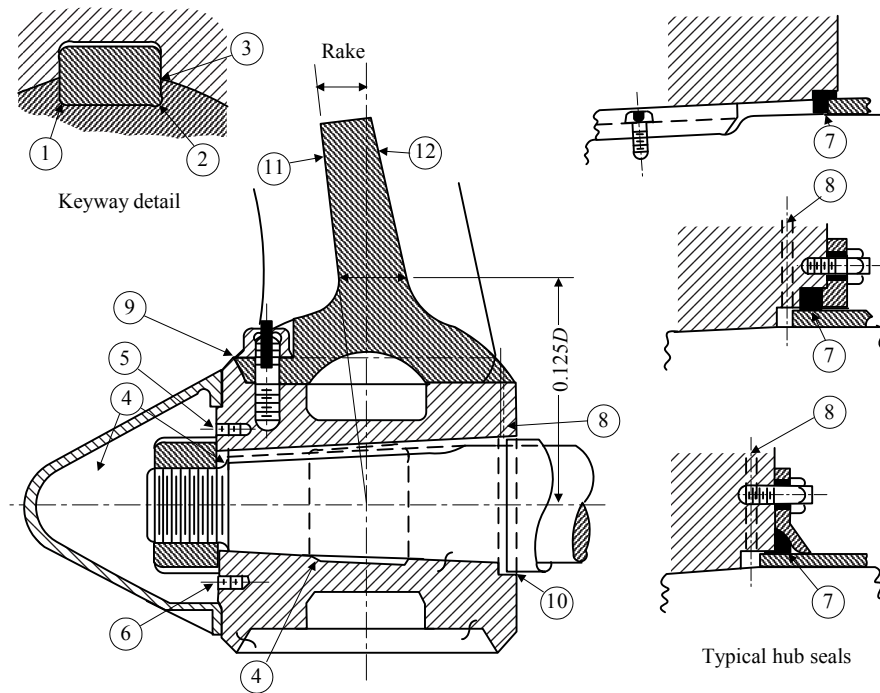
The propeller assembly is to be sealed at the forward end with a well-fitted, soft-rubber packing ring. When the rubber ring is fitted in an external gland, the hub counterbore is to be filled with suitable material, and clearances between shaft liner and hub counterbore are to be kept to a minimum. When the rubber ring is fitted internally, ample clearance is to be provided between liner and hub and the ring is to be sufficiently oversize to squeeze into the clearance space when the propeller is driven up on the shaft; and, where necessary, a filler piece is to be fitted in the propeller hub keyway to provide a flat, unbroken seating for the ring.

The recess formed at the small end of the taper by the overhanging propeller hub is to be packed with a rust preventive compound before the propeller nut is put on.

21.5 Noncorrosive, Non-pitting Alloys

The sealing arrangements above are not required where the tail shaft is fabricated of corrosion-resistant, pitting-resistant alloy unless required by the manufacturer.

**FIGURE 4
 Propeller Hub Details**



Section of typical built-up propeller

- | | | | |
|---|--|----|---|
| 1 | Liberal Fillet | 7 | Soft rubber ring |
| 2 | Chamfer corners of key | 8 | Fill and vent holes. One to be centered on keyway |
| 3 | Break sharp corners of keyway in shaft | 9 | See 4-3-2/9.7 |
| 4 | Fill with suitable sealing material | 10 | See typical hub seals |
| 5 | Locking device | 11 | Face (tension side) |
| 6 | Threaded holes for jack bolts | 12 | Back (compression side) |

PART

4

CHAPTER 3 Propulsion and Maneuvering Machinery

SECTION 3 Steering Gear

1 General

1.1 Application

These requirements apply to vessels 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, the *Steel Vessel Rules* are to be applied.

Where a rudder is not fitted and steering is achieved by change of setting of the propulsion units, such as the use of cycloidal, azimuthing or similar type propulsion systems, Section 4-3-5 in Part 4 of the *Steel 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 vessel.

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 vessel 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 (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 the 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

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).

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

1.9.1 General

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 vessel 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.

1.9.2 Tugs of an Articulated Connection (2015)

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 may be accepted 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 should 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 arrangement shall be considered subject to the flag Administration approval.

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 vessel 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.

1.11.1

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

1.11.1(a) For passenger vessel, the main steering gear is capable of operating the rudder, as required in 4-3-3/1.9, while any one of the power units is out of operation; and

1.11.1(b) For cargo vessel, the main steering gear is to be capable of operating the rudder, as required by 4-3-3/1.9, while all the power units are in operation.

1.11.2

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, vessels 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 (2010)

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 (2010)

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 3-2-11/1.7) 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 (2003)

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 3-2-11/1.5.

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:

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

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/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 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:

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

where

- K_s = material factor for rudder stock (see 3-2-11/1.3)
- 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)

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 3-2-11/1.3)
- K_h = material factor of the hub (see 3-2-11/1.3)

5.5.4

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

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

where

- r = mean radius of the rudder stock in way of the key
- K_k = material factor of the key (see 3-2-11/1.3)

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 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.

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 3-2-11/1.3)

Other symbols are defined above.

5.5.8 (2009)

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 3-2-11/1.3)

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.

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 3-2-11/1.3)

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.

5.11 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 *Steel Vessel Rules*, specifically 4-4-1A1/3.1 (for malleable cast iron, use $\gamma = 0.5$), 4-4-1A1/5 and 4-4-1A1/7 (in association with S , as defined below) for design and 4-4-1A1/21 for hydrostatic tests. The maximum allowable stress, S , is not to exceed the lower of the following:

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

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
A	3.5	4	5
B	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 ($1/32$ 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 (2010)

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 vessels 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 vessel is 500 gross tons or greater, power units are to be tested and certified in accordance with 4-3-3/9.3 only. For vessels 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 (1 July 2011)

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 (1 July 2011)

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. 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 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.

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 *Steel Vessel Rules* and are to be considered Category III.

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

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.

11.9.8 Hydraulic Lock (2006)

Where the arrangement is such that a single failure may cause hydraulic lock and loss of steering, an audible and visual hydraulic lock 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 lock 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:

- 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.

11.9.8(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

11.9.9 Autopilot Override (2003)

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.

11.9.9(b) 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.

- i) The automatic override of the autopilot is to occur when the manual helm order is 5 degrees of rudder angle or greater.
- ii) An audible and visual alarm is to be provided at the primary steering station in the event that the automatic autopilot override fails to respond when the manual helm order is 5 degrees of rudder angle or greater. The alarm is to be separate and distinct from other bridge alarms and is to continue to sound until it is acknowledged.
- iii) An audible and visual alarm that is immediately activated upon automatic autopilot override actuation is to be provided at the primary steering station. The alarm is to be 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 (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 4-3-3/11.9.8(a), (b) and (c).

11.9.11 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 *Steel 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), (b) and (c).

11.11 Operating Instructions (1999)

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 4-6-2/5.3.5.

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 (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.

15.1.2 Installation Tests

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.

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 the 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 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 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 vessel 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 4-6-2/5.3.5.

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.

PART

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CHAPTER 3 Propulsion and Maneuvering Machinery

SECTION 4 Waterjets

1 Waterjets

1.1 General

Full details are to be submitted for the force transmitting parts of waterjet units, including material specifications. For vessels over 24 m (79 ft), the units are to be manufactured under Surveys. Mill certificates are to be provided for the components of the steering section. The material tests for the impellers, shafts and couplings are to be witnessed by the Surveyor. Hydraulic cylinders are to be manufactured and inspected in accordance with the requirements of 4-4-6/3. The use of galvanically dissimilar metallic materials is to be considered in the waterjet design.

1.3 Design

Design basis stress calculations for the impellers, shafting, steering mechanism and reversing mechanism are to be submitted to substantiate the suitability and strength of component parts for the intended service. For the purpose of design review, the stress calculations are to cover the “worst case” condition for each component. The factor of safety for the above components is not to be less than 2.0 when determined by the following equation:

$$\frac{1}{FS} = \frac{S_s}{U} + \frac{S_a}{E}$$

nor less than 4.0 when determined by the following equation:

$$FS = \frac{U}{S_s}$$

where

- FS = factor of safety
- S_s = steady stress of low cycle alternating stress
- S_a = alternating stress
- U = ultimate tensile strength of material
- E = corrected fatigue strength of material (based on 10^8 cycles)

1.5 Housings

Calculations or test results to substantiate the suitability and strength of the pressure and suction housing are to be submitted for review. The condition with the inlet of the suction blocked is also to be considered. A factor of safety of not less than four based on the ultimate tensile strength of the material (or two based on the yield strength) is to be maintained at each point in the housing. Housing are to be hydrostatically tested to 1.5 times the maximum working pressure or to 3.4 bar (3.5 kgf/cm², 50 psi), whichever is greater.

1.7 Reversing Mechanisms

Astern thrust is to be provided in sufficient amounts to secure proper control of the vessel in all normal circumstances. The reversing mechanism is to provide for reversing at full power.

1.9 Impeller Bearings

Antifriction bearings are to have a B10 life of at least 80,000 hours.

PART

4

CHAPTER 3 Propulsion and Maneuvering Machinery

SECTION 5 Propulsion Redundancy (2005)

1 General

1.1 Application

The requirements in this Section apply to vessels equipped with propulsion and steering systems designed to provide enhanced reliability and availability through functional redundancy. Application of the requirements of this Section is optional. When a vessel is designed, built and surveyed in accordance with this Section, and when found satisfactory, a classification notation, as specified in 4-3-5/3, as appropriate, may be granted.

It is a prerequisite that the vessels are also to be classed to either **✕ ACCU** or **✕ ABCU** notation, in accordance with Part 4, Chapter 7.

1.3 Objective

The objective of this Section is to provide requirements which reduce the risk to personnel, the vessel, other vessels or structures, the environment and the economic consequences due to a single failure causing loss of propulsion or steering capability. This is achieved through varying degrees of redundancy based upon the vessel's Classification Notations, as described in 4-3-5/3.

The requirements in this Section are intended so that, following a single failure, the vessel is capable of either:

- i) Maintaining course and maneuverability at reduced speeds without intervention by other vessels, or
- ii) Maintaining position under adverse weather conditions, as described in 4-3-5/7.1, to avoid uncontrolled drift and navigating back to safe harbor when weather conditions are suitable.

In addition, this Section addresses aspects which would reduce the detrimental effects to the propulsion systems due to a localized fire in the machinery spaces.

1.5 Definitions

For the purpose of this Section, the following definitions are applicable:

1.5.1 Auxiliary Services System

All support systems (e.g., fuel oil system, lubricating oil system, cooling water system, compressed air and hydraulic systems, etc.) which are required to run propulsion machinery and propulsors.

1.5.2 Propulsion Machinery Space

Any space containing machinery or equipment forming part of the propulsion systems.

1.5.3 Propulsion Machine

A device (e.g., diesel engine, turbine, electrical motor, etc.) which develops mechanical energy to drive a propulsor.

1.5.4 Propulsion System

A system designed to provide thrust to a vessel, consisting of one or more propulsion machines, one or more propulsors, all necessary auxiliaries and associated control, alarm and safety systems.

1.5.5 Propulsor

A device (e.g., propeller, waterjet) which imparts force to a column of water in order to propel a vessel, together with any equipment necessary to transmit the power from the propulsion machinery to the device (e.g., shafting, gearing, etc.).

1.5.6 Steering System

A system designed to control the direction of movement of a vessel, including the rudder, steering gear, etc.

1.7 Plans and Data to be Submitted

In addition to the plans and data required by the Rules, the following are to be submitted:

- i) Results of computations showing that, upon any single failure in the propulsion and steering systems, the vessel is able to meet the capability requirements of 4-3-5/7.1, if applicable, with details of the computational methods used. Alternatively, the results of model testing are acceptable as evidence.
- ii) A Failure Mode and Effect Analysis (FMEA) or equivalent. The integrity of the propulsion systems, steering systems and auxiliary service systems is to be verified by means of a Failure Mode and Effect Analysis (FMEA) or equivalent method and is to show that a single failure will not compromise the criteria as specified in 4-3-5/7.
- iii) A Testing Plan to cover the means whereby verification of the redundancy arrangements will be accomplished.
- iv) A general arrangement detailing locations of all machinery and equipment necessary for the correct functioning of the propulsion and steering systems, including the routing of all associated power, control and communication cables. (Required for **R1-S** and **R2-S** only).
- v) Operating Manual, as required in 4-3-5/13.

3 Classification Notations

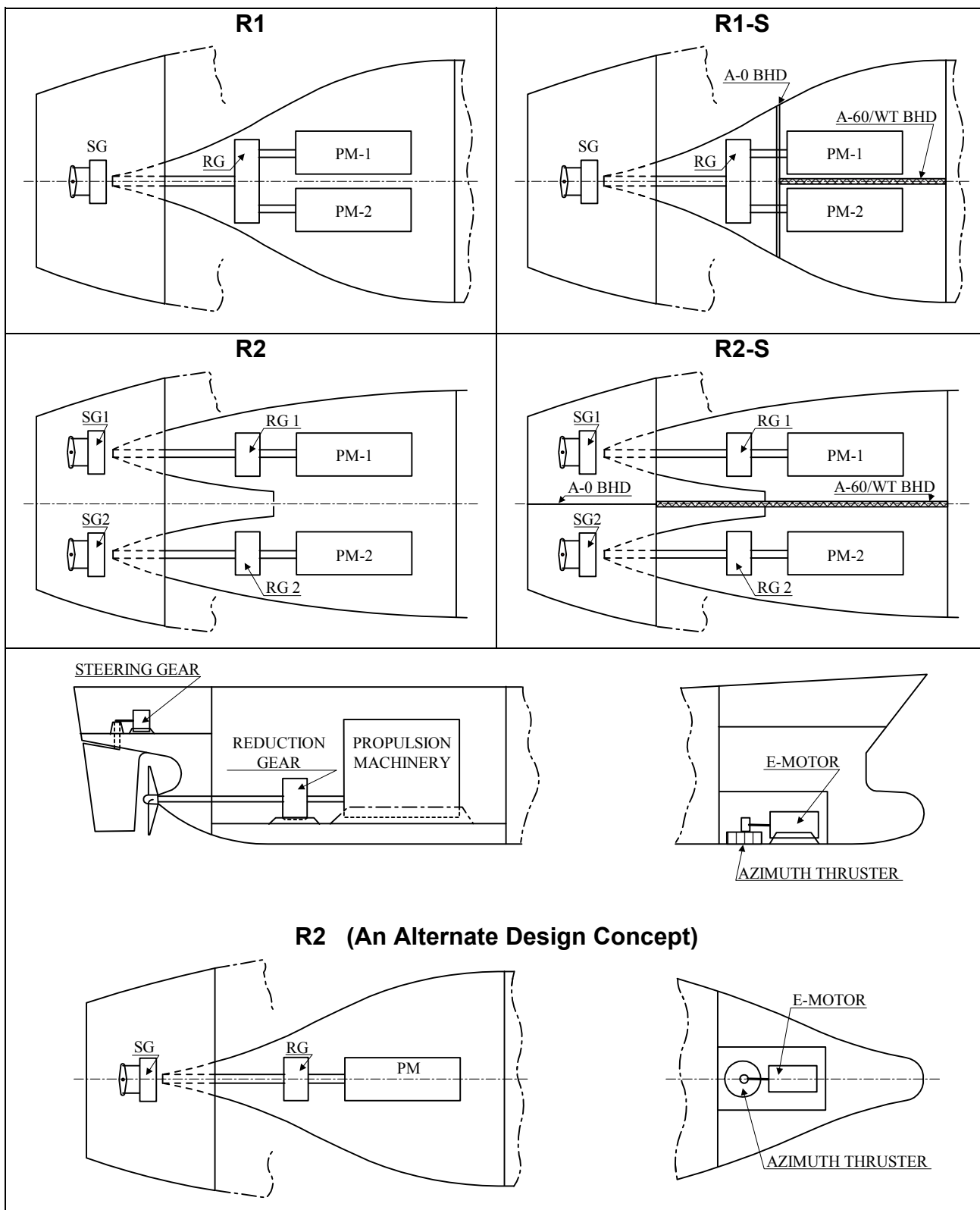
Where requested by the Owner, propulsion and steering installations which are found to comply with the requirements specified in this Section and which have been constructed and installed under survey by the Surveyor may be assigned with the following class notations, as appropriate.

- i) **R1** A vessel fitted with multiple propulsion machines but only a single propulsor and steering system will be assigned the class notation **R1**.
- ii) **R2** A vessel fitted with multiple propulsion machines and also multiple propulsors and steering systems (hence, multiple propulsion systems) will be assigned the class notation **R2**.
- iii) **R1-S** A vessel fitted with only a single propulsor but having the propulsion machines arranged in separate spaces such that a fire or flood in one space would not affect the propulsion machine(s) in the other space(s) will be assigned the class notation **R1-S**.
- iv) **R2-S** A vessel fitted with multiple propulsors (hence, multiple propulsion systems) which has the propulsion machines and propulsors, and associated steering systems arranged in separate spaces (propulsion machinery space and steering gear flat) such that a fire or flood in one space would not affect the propulsion machine(s) and propulsor(s), and associated steering systems in the other space(s) will be assigned the class notation **R2-S**.

Example arrangements for each of the above notations are shown in 4-3-5/Figure 1.

- v) **+** (Plus Symbol) The mark **+** will be affixed to the end of any of the above class notations (e.g., **R1+**, **R2-S+**) to denote that the vessel's propulsion capability is such that, upon a single failure, propulsive power can be maintained or immediately restored to the extent necessary to withstand adverse weather conditions without drifting, in accordance with 4-3-5/7.3. The lack of the mark **+** after the class notation indicates that the vessel is not intended to withstand the adverse weather conditions in 4-3-5/7.3, but can maintain course and maneuverability at a reduced speed under normal expected weather conditions, in accordance with 4-3-5/7.1.

FIGURE 1
Arrangements of Propulsion Redundancy



5 Single Failure Concept

The degree of redundancy required to meet the objectives of this Section is based upon a single failure concept. The concept accepts that failures may occur but that only one such failure is likely at any time. The final consequence of any single failure is not to compromise the propulsion and steering capability required in 4-3-5/7, unless otherwise specified.

5.1 Single Failure Criteria

5.1.1 R1 Notation

For **R1**, the single failure criterion is applied to the propulsion machines, its auxiliary service systems and its control systems. This notation does not consider failure of the propulsor or rudder, or total loss of the propulsion machinery space or steering gear flat due to fire or flood.

5.1.2 R2 Notation

For **R2**, the single failure criterion is applied to the propulsion machines, propulsors, auxiliary service systems, control systems and steering systems. This notation does not consider total loss of the propulsion machinery space or steering gear flat due to fire or flood.

5.1.3 R1-S Notation

For **R1-S**, the single failure criterion is applied as for **R1**, but a fire or flood in one of the propulsion machinery spaces is also considered.

5.1.4 R2-S Notation

For **R2-S**, the single failure criterion is applied as for **R2**, but a fire or flood in one of the propulsion machinery spaces or steering gear flats is also considered.

7 Propulsion and Steering Capability

7.1 Vessels Without + in Class Notation

Upon a single failure, the propulsion system is to be continuously maintained or restored within two (2) minutes (for alternate standby propulsion per 4-3-5/7.3 below) such that the vessel is capable of advancing at a speed of at least one-half its design speed or seven knots, whichever is less, for at least 36 hours when the vessel is fully loaded. Adequate steering capability is also to be maintained at this speed.

7.3 Vessels with + in Class Notation

In addition to 4-3-5/7.1 above, upon a single failure, the propulsion and steering system is to be continuously maintained or immediately restored within two (2) minutes, as in the case when an alternate standby type of propulsion is provided, (e.g., electric motor, diesel engine, waterjet propulsion, etc.) such that the vessel is capable of maneuvering into an orientation of least resistance to the weather, and once in that orientation, maintaining position such that the vessel will not drift for at least 36 hours. This may be achieved by using all available propulsion and steering systems including thrusters, if provided. This is to be possible in all weather conditions up to a wind speed of 17 m/s (33 knots) and significant wave height of 4.5 m (15 ft) with 7.3 seconds mean period, both of which are acting concurrently in the same direction. The severest loading condition for vessel's maneuverability is also to be considered for compliance with this weather criterion. Compliance with these capability requirements is to be verified by computational simulations, and the detailed results are to be submitted for approval. The estimated optimum capability is to be documented in the operating manual, as required in 4-3-5/13.

9 System Design

9.1 Propulsion Machinery and Propulsors

At least two independent propulsion machines are to be provided. As appropriate, a single failure in any one propulsion machine or auxiliary service system is not to result in propulsion performance inferior to that required by 4-3-5/7.1 or 4-3-5/7.3, as applicable.

9.1.1. R1 Notation

For **R1** notation, the propulsion machines and auxiliary service systems may be located in the same propulsion machinery space and the propulsion machines may drive a single propulsor.

9.1.2 R2 Notation

For **R2** notation, at least two propulsors are to be provided such that a single failure of one will not result in propulsion performance inferior to that required by 4-3-5/7.1 or 4-3-5/7.3, as applicable. The propulsion machines and auxiliary service systems may, however, be located in the same propulsion machinery space.

9.1.3 R1-S Notation

For **R1-S** notation, the propulsion machines and auxiliary service systems are to be separated in such a way that total loss of any one propulsion machinery space (due to fire or flood) will not result in propulsion performance inferior to that required by 4-3-5/7.1 or 4-3-5/7.3, as applicable. The propulsion machines may, however, drive a single propulsor, and the main propulsion gear or main power transmitting gear is to be located outside the propulsion machinery spaces separated by a bulkhead meeting the criteria per 4-3-5/9.3.

9.1.4 R2-S Notation

For **R2-S** notation, at least two propulsors are to be provided, and the propulsion systems are to be installed in separate spaces such that a single failure in one propulsor or a total loss of any one propulsion machinery space (due to fire or flood) will not result in propulsion performance inferior to that required by 4-3-5/7.1 or 4-3-5/7.3, as applicable.

9.3 System Segregation

Where failure is deemed to include loss of a complete propulsion machinery space due to fire or flooding (**R1-S** and **R2-S** notations), redundant components and systems are to be separated by watertight bulkheads with an A-60 fire classification.

Service access doors which comply with 3-2-7/7.1.1 may be provided between the segregated propulsion machinery spaces. A means of clear indication of open/closed status of the doors is to be provided in the bridge and at the centralized control station. Unless specially approved by the flag Administration, these service access doors are not to be accounted for as the means of escape from the machinery space Category A required by the requirements of Regulation II-2/13 of SOLAS 1974, as amended.

9.5 Steering Systems

An independent steering system is to be provided for each propulsor. Regardless of the type and the size of vessel, each steering system is to meet the requirements of Regulation II-1/29.16 of SOLAS 1974, as amended.

The rudder design is to be such that the vessel can turn in either direction with one propulsion machine or one steering system inoperable.

For **R2-S** notation, the steering systems are to be separated such that a fire or flood in one steering compartment will not affect the steering system(s) in the other compartment(s), and performance in accordance with 4-3-5/7.1 or 4-3-5/7.3, as applicable, is maintained.

For **R2** and **R2-S** notations, in the event of steering system failure, means are to be provided to secure rudders in the amidships position.

9.7 Auxiliary Service Systems

At least two independent auxiliary service systems, including fuel oil service tanks, are to be provided and arranged such that a single failure will not result in propulsion performance inferior to that required by 4-3-5/7.1 or 4-3-5/7.3, as applicable. However, a single failure in the vital auxiliary machinery (e.g., pumps, heaters, etc.), excluding failure of fixed piping, is not to result in reduction of the full propulsion capability. In order to meet this requirement, it will be necessary to either cross-connect the auxiliary service systems and size the components (pumps, heaters, etc.) to be capable of supplying two or more propulsion machines simultaneously, or provide duplicate components (pumps, heaters, etc.) in each auxiliary system in case one fails.

With the exception of the fuel oil service tank venting system, interconnections between auxiliary service systems will be considered, provided that the same are fitted with means (i.e., valves) to disconnect or isolate the systems from each other.

For **R1-S** and **R2-S** notations, the above-mentioned independent auxiliary service systems are to be segregated in the separate propulsion machinery spaces. With the exception of fuel oil service tank venting systems, interconnections of auxiliary service systems will be acceptable, provided that the required disconnection or isolation means are fitted at both sides of the bulkhead separating the propulsion machinery spaces. Position status of the disconnection or isolation means is to be provided at the navigation bridge and the centralized control station. Penetrations in the bulkhead separating the propulsion machinery spaces and steering gear flats (as in the case of **R2-S** notation) are not to compromise the fire and watertight integrity of the bulkhead.

9.9 Electrical Distribution Systems

Electrical power generation and distribution systems are to be arranged such that following a single failure in the systems, the electrical power supply is maintained or immediately restored to the extent that the requirements in 4-3-5/7 are met.

Where the vessel's essential equipment is fed from one main switchboard, the bus bars are to be divided into at least two sections. Where the sections are normally connected, detection of a short circuit on the bus bars is to result in automatic separation. The circuits supplying equipment essential to the operation of the propulsion and steering systems are to be divided between the sections such that a loss of one section will not result in performance inferior to that defined in 4-3-5/7. A fully redundant power management system is to be provided so that each section of the switchboard can function independently.

For **R1-S** and **R2-S** notations, the ship service power generators, their auxiliary systems, the switchboard sections and the power management systems are to be located in at least two machinery spaces separated by watertight bulkheads with an A-60 fire classification. The power distribution is to be so arranged that a fire or flooding of one machinery space is not to result in propulsion capability inferior to that defined in 4-3-5/7. Where an interconnection is provided between the separate propulsion machinery spaces, a disconnection or isolation means are to be provided at both sides of the bulkhead separating the propulsion machinery spaces. Position status of the disconnection or isolation means is to be provided at the navigation bridge and the centralized control station. Fire or flooding of one machinery space is not to result in propulsion capability inferior to that defined in 4-3-5/7. The power cables from the service generator(s) in one propulsion machinery space are not to pass through the other propulsion machinery space containing the remaining service generator(s).

Additionally, for **R1-S** and **R2-S** notations, subject to approval by the Administration, the requirements for self-contained emergency source of power may be considered satisfied without an additional emergency source of electrical power, provided that:

- i) All generating sets and other required sources of emergency source of power are designed to function at full rated power when upright and when inclined up to a maximum angle of heel in the intact and damaged condition, as determined in accordance with Part 3, Chapter 3. In no case need the equipment be designed to operate when inclined more than 22.5° about the longitudinal axis and/or when inclined 10° about the transverse axis of the vessel.
- ii) The generator set(s) installed in each machinery space is of sufficient capacity to meet the requirements of 4-6-2/3 and 4-6-2/5.
- iii) The arrangements required in each machinery space are equivalent to those required by 4-6-2/5.5.2, 4-6-2/5.9 and 4-6-2/5.15, so that a source of electrical power is available at all times for the services required by 4-6-2/5.

9.11 Control and Monitoring Systems

The control systems are to be operable both independently and in combination from the bridge or the centralized control station. The mode of operation is to be clearly indicated at each position from which the propulsion machinery may be controlled.

It is to be possible to locally control the propulsion machinery and the propulsor.

For **R1-S** and **R2-S** notations, the control and monitoring system for the propulsor (e.g., controllable pitch propeller control), including all associated cabling, is to be duplicated in each space, and fire or flooding of one space is not to adversely affect operation of the propulsor from the other space.

9.13 Communication Systems

The requirements of 4-6-2/15 are to be complied with for all installed propulsion control positions.

For **R1-S** and **R2-S** notations, the communications cables to each control position are not to be routed through the same machinery space.

11 Fire Precautions (2013)

The requirements of this section apply to Category A machinery spaces only.

For **R1** and **R2** notations, the following requirements are to be complied with in order to minimize the risk of common damage due to a localized fire in the machinery space.

- i) Each auxiliary services system is to be grouped and separated as far as practicable.
- ii) Electrical cables supplying power to redundant equipment are to exit the switchboard and be routed to the equipment, as far apart as practicable.

13 Operating Manual

An operating manual, which is consistent with the information and criteria upon which the classification is based, is to be placed aboard the vessel for the guidance of the operating personnel. The operating manual is to give clear guidance to the vessel's crew about the vessel's redundancy features and how they may be effectively and speedily put into service in the event that the vessel's normal propulsion capability is lost. The operating manual is to include the following, as a minimum:

- i) Vessel's name and ABS ID number
- ii) Simplified diagram and descriptions of the propulsion systems in normal condition
- iii) Simplified diagram and descriptions of the propulsion redundancy features
- iv) Reduced propulsion capability in terms of estimated worst sea-states which the vessel may withstand without drifting (for vessels with + in the Class Notation)
- v) Test results for the vessel's maneuverability at reduced speed (for vessels without + in the Class Notation).
- vi) Step-by-step instructions for the use of the redundancy features
- vii) Description of the communication systems
- viii) Detailed instructions for local propulsion machinery control

The operating manual is to be submitted for review by ABS solely to verify the presence of the above information, which is to be consistent with the design information and limitations considered in the vessel's classification. ABS is not responsible for the operation of the vessel.

Any modifications made to the existing propulsion systems are to be approved by ABS. The operating manual is to be updated accordingly and submitted to ABS for review.

15 Test and Trial

During the sea trial, the propulsion and steering capability are to be tested in accordance with an approved test program to verify compliance with this Section.

15.1 Fault Simulation Test

Simulation tests for the redundancy arrangements are to be carried out to verify that, upon any single failure, the propulsion and steering systems remain operational, or the back-up propulsion and steering systems may be speedily brought into service.

15.3 Communication System Test

The effectiveness of the communication systems, as required in 4-3-5/9.13 above, is to be tested to verify that local control of the propulsion systems may be carried out satisfactorily.

17 Survey After Construction

The surveys after construction are to be in accordance with the applicable requirements as contained in the *ABS Rules for Surveys After Construction (Part 7)*.

PART

4

CHAPTER 3 Propulsion and Maneuvering Machinery

SECTION 6 Contra-Rotating Propellers (2015)

1 General

1.1 Application

Contra-rotating propeller units having a rated power of 100 kW (135 hp) and over, intended for propulsion or for auxiliary services essential for propulsion, maneuvering and safety (see 4-1-1/3.1) of the vessel, are to be designed, constructed, certified and installed in accordance with the provisions of this section.

Contra-rotating propeller systems having a rated power less than 100 kW (135 hp) are not required to comply with the provisions of this Section but are to be designed, constructed and equipped in accordance with good commercial and marine practice. Acceptance of such systems will be based on the manufacturer's affidavit, verification of nameplate data and subject to a satisfactory performance test after installation conducted in the presence of the Surveyor.

1.3 Basic Principles

Contra-rotating propeller systems may be designed using either of two arrangements:

- i) One arrangement consists of a gear to effect opposing rotation between the two shafts, shafting and two propellers of opposite hand. The gear divides the power provided by the prime mover to the two propulsion shafts which rotate in opposite directions with one of the shafts rotating inside the bore of the other shaft. The outer shaft drives the forward propeller while the inner shaft drives the after propeller.
- ii) Another arrangement consists of two prime movers arranged in line such that the propulsion shaft from the forward prime mover rotates inside the hollow propulsion shaft of the after prime mover.

For either arrangement discussed, the contra-rotating aftermost propeller is designed to recover rotational energy from the slipstream shed from the forward propeller and convert to additional thrust.

1.5 Definitions

Definitions pertaining to the various components and subsystems of a contra-rotating propeller system are listed as follows:

- Gears, see 4-3-1/1.3 of the *Steel Vessel Rules*.
- Shafting, see 4-3-1/1.1
- Propellers, see 4-3-2/1.1

1.7 Plans and Particulars to be Submitted

Plans and particulars to be submitted for review are listed as follows:

- Gears, see 4-3-1/1.5 of the *Steel Vessel Rules*
- Shafting, see 4-3-1/3
- Propellers, see 4-3-2/5.

3 Materials

Material requirements and testing for the various components and subsystems are to be in accordance with the following:

- Gears, see 4-3-1/3 of the *Steel Vessel Rules*.
- Shafting, see 4-3-1/5.
- Propellers, see 4-3-2/7.

5 Design

5.1 Gears

The gear design is to be in accordance with the requirements in 4-3-1/5 of the *Steel Vessels Rules*.

5.1.1 Gears with Multiple Prime Mover Inputs/Multiple Outputs

For single helical gears with arrangements utilizing multiple prime mover inputs, and multiple outputs (e.g., the contra-rotating shafts), the following analyses for all operating modes are to be conducted:

- All bearing reactions
- Tooth modifications
- Load distributions on the gear teeth
- Contact and tooth root bending stresses

A summary of the results of these analyses for each operating mode is to be submitted for review.

5.3 Shaft Diameters

The shaft design is to be in accordance with the requirements of 4-3-1/7.

5.3.1 Alternative Criteria

As an alternative to the design equations shown in 4-3-1/7.1 and 4-3-1/7.3, shafting design may be considered for approval on the basis of axial and torsional loads to be transmitted, bending moment and resistance against fatigue. A detailed stress analysis showing a factor of safety of at least 2.0 for fatigue failure is to be submitted for approval with all supporting data.

5.5 Propeller-end Seals

Effective means are to be provided to prevent water having access to either shaft at the part between the after end of the liner and the propeller hub on the outer shaft forward propeller and between the inner shaft and outer shaft and the after propeller hub and inner shaft.

5.7 Couplings and Clutches

The requirements for the following components, if installed are:

- Demountable couplings, see 4-3-1/19.9
- Flexible couplings, see 4-2-1/17
- Clutches, see 4-3-2/5.19.6 of the *Steel Vessel Rules*
- Clutches intended for use in propulsion shafting are to be of an approved design
- Locking arrangements, see 4-3-1/19.7
- After assembly, all coupling bolts and associated nuts are to be fitted with locking arrangement

5.9 Propulsion Shaft Vibrations

Torsional vibration calculations are to be submitted in accordance with 4-3-1/21.

Additional torsional vibration calculations are to be performed for shaft arrangements where the contra-rotating shafts are coupled through a gear. The calculations are to confirm for the two modes of operation when either the forward or the after propeller is isolated from the prime mover the shafting is free from the deleterious effects of torsional vibrations.

5.11 Propellers

The propeller designer is to provide the power absorbed at rated speed for both propellers. The propellers are to be designed in accordance with the requirements of 4-3-2/9.

Arrangements are to be provided in the event of damage to either propeller or failure of one of the prime movers' auxiliary functions to be isolated from the propulsion system to permit the remaining propeller to continue to function.

5.13 Access for Inspection

Adequate access covers are to be provided to permit inspection of gear train without disassembling contra-rotating propeller unit.

5.15 Shaft Alignment

The alignment and each bearing load relative to the inner and outer shafts are dependent upon one another. An evaluation is to be submitted for the shafting system taking into consideration relative inclining angle between the inner and outer shafts, additional stresses in the shafting system resulting from the shaft alignment in relation to the location and spacing of the shaft bearings, See 4-3-1/21.

5.17 Shaft Lubrication

The lubrication system is to be designed to provide all bearings, gear meshes and other parts requiring lubrication oil with an adequate amount of oil for both lubrication and cooling purposes. This is to be maintained under all operating conditions.

5.17.1 Anti-friction Bearings

If anti-friction bearings are installed, bearing lifetime calculations are to be submitted for review. In general, the bearing design is to be based on the bearing lifetime of 65,000 hours. Loading profile of the bearing used for the calculation is to be indicated in the calculations. The bearing lifetime must exceed the 5-years time between surveys; see 7-2-1/13.1.3 of the *ABS Rules for Survey After Construction (Part 7)*.

5.17.2 Oil-lubricated Bearings

If oil-lubricated bearings are installed, load carrying capacity calculations for white metal bearings are to be submitted or bearing lifetime calculations are to be submitted for roller bearings or similar. In general, the bearing design is to be based on the bearing lifetime of 65,000 hours. Loading profile of the bearing used for the calculation is to be indicated in the calculations. The bearing lifetime must exceed the 5-years time between surveys; see 7-2-1/13.1.3 of the *ABS Rules for Survey After Construction (Part 7)*.

5.17.3 Oil-lubricating System Sampling Arrangements

An arrangement for readily obtaining accurate oil samples is to be provided. The sampling point is to be taken from the lowest point in the oil lubricating system, as far as practicable. Also, the arrangements are to be such as to permit the effective removal of contaminants from the oil lubricating system.

5.19 Propeller Fitting

The requirements for propellers fitted to the tail shaft by a keyed fitting are in 4-3-2/19.

5.19.1 Bolted to Tail Shaft

For propellers whose attachment method to the tail shaft is by a bolted connection, calculations are to be submitted for review. The strength of the bolted connection subjected to the forces from propulsion torque is to be at least 1.5 times that of the blade at design pitch conditions.

5.19.2 Keyless Fitting

For propellers whose attachment method to the tail shaft is by a keyless fitting refer to 4-3-2/19.3. In addition, for the tail shaft supporting the forward propeller, calculations are to be submitted for review to verify stresses on the shaft inner surface do not exceed 70% of the minimum specified yield strength.

7 Controls and Instrumentation

The forward and aft propellers are to be provided with arrangements to be isolated from their power source. The power source may be a single unit or multiple units.

Individual visual and audible alarms are to be provided at the engine room control station to indicate:

- i) Rpm for inner and outer shafts
- ii) Lubricating oil pressure
- iii) Lubricating oil tank low level
- iv) High temperature lubricating oil
- v) High bearing temperature for bearings inner shaft bearings and outer shaft bearings
 - a) For journal bearing arrangements, high bearing temperature for both the inner shaft bearings and outer shaft bearings, or
 - b) For anti-friction bearing (roller bearing) arrangements, high contamination level of metal particles in the lubricating oil for inner shaft roller bearings.

Control, monitoring and alarms are to be provided for local manual control and at the centralized control station. If **ACC** or **ACCU** notation is requested, remote control is to be provided on the navigation bridge as per Sections 4-7-3 and 4-7-4, as applicable.

9 Certification and Trial

Contra-rotating propeller units and associated equipment are to be inspected, tested and certified by ABS in accordance with the following requirements, as applicable:

- Diesel engines: Section 4-2-1 of the *Steel Vessel Rules*
- Gas turbines: Section 4-2-3 of the *Steel Vessel Rules*
- Electric motors: Section 4-6-4
- Gears: Section 4-3-1 of the *Steel Vessel Rules*
- Shafting: Section 4-3-1
- Propellers: Section 4-3-2

Upon completion of the installation, performance tests are to be carried out in the presence of a Surveyor in a sea trial. This is to include but not limited to running tests at intermittent or continuous rating, vessel turning tests and vessel maneuvering tests. The gear design is to be in accordance with the requirements in 4-3-1/5 of the *Steel Vessel Rules*.

CHAPTER 4 Pumps and Piping Systems

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PART

4

CHAPTER 4 Pumps and Piping Systems

SECTION 1 General

1 Construction and Installation

1.1 General Requirements

All vessels are to be provided with the necessary pumps and piping systems for safe and efficient operation in the service for which they are intended. Materials and workmanship are to be in accordance with good marine practice and to the satisfaction of the Surveyor. The arrangements and details are to comply with the following requirements which are applicable to all oceangoing vessels but which may be modified for vessels classed for limited service.

1.3 Piping Groups (2008)

To distinguish between detail requirements for the various systems, the piping on shipboard is divided into two groups.

Group I, in general, includes all piping intended for working pressures or temperatures in various services, as follows:

<i>Service</i>	<i>Pressure bar (kgf/cm², psi)</i>	<i>Temperature °C (°F)</i>
Vapor and Gas	over 10.3 (10.5, 150)	over 343 (650)
Water	over 15.5 (15.8, 225)	over 177 (350)
Lubricating Oil	over 15.5 (15.8, 225)	over 204 (400)
Fuel Oil	over 10.3 (10.5, 150)	over 66 (150)
Hydraulic Fluid	over 15.5 (15.8, 225)	over 204 (400)

Group II includes all piping intended for working pressures and temperatures below those stipulated under Group I. Group II also includes cargo-oil and tank cleaning piping in cargo area on oil carriers, and open-ended lines such as drains, overflows, engine exhausts, boiler escape pipes, and vents, regardless of the working pressures or temperatures.

3 Plans and Data to be Submitted

3.1 Plans

Before proceeding with the work, plans in accordance with 4-1-1/7 are to be submitted, showing clearly the diagrammatic details or arrangement of the equipment.

3.3 All Piping Systems

The plans are to consist of a diagrammatic drawing of each system accompanied by lists of material giving size, wall thickness, maximum working pressure and material of all pipes and the type, size, pressure rating and material of valves and fittings.

3.5 Booklet of Standard Details

A booklet of standard piping practices and details, including such items as bulkhead, deck and shell penetrations, welding details including dimensions, pipe joining details, etc., is to be submitted. Pipe welding details are to comply with Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*.

5 Material Tests and Inspection

5.1 Specifications and Purchase Orders

The appropriate material to be used for the various pipes, valves and fittings is indicated in this section. The material is to be made in accordance with the requirements of Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*, except that tests of material for valves, fittings, fluid power cylinders and Group II piping need not be witnessed by the Surveyor. Where electric resistance welding is used, the requirements of Chapter 4 of the above referenced Part 2 are also applicable. Copies in duplicate of the purchase orders for material requiring test and inspection at the mills or place of manufacture are to be forwarded to ABS for the information of the Surveyor.

5.3 Special Materials

If it is desired to use special alloys or other materials not covered by the Rules, the use of such materials will be specially considered for approval.

7 Definitions

7.1 Piping/Piping Systems

The terms *Piping* and *Piping Systems* include the pipe, fittings, system joints, method of joining and any internal or external liners, coverings and coatings required to comply with the performance criteria. For example, if the basic material needs a fire protective coating to comply with the fire endurance requirements, then the piping should be manufactured and tested with both the basic material and coating attached, and details are to be submitted to ABS for approval.

7.3 Joints

The term *Joint* refers to the method of connecting pipes by adhesive bonding, brazing, welding, bolted flanging, threading, etc.

7.5 Fittings

The term *Fittings* refers to bends, elbows, fabricated branch pieces, etc.

7.7 Positive Closing Valves

Positive Closing Valves are valves that are capable of maintaining a set position under all operating conditions.

7.9 Recognized Standard of Construction

Recognized Standards of Construction are published construction standards from organizations, such as but not limited to the American Society of Mechanical Engineers (ASME), American Society of Testing and Materials (ASTM), Department of Transportation (DOT), Japanese Industrial Standard (JIS), German Design Standard (DIN), British Standard Code of Practice (BSI), which are recognized by ABS as being acceptable standards for a specific purpose or service. Each standard is to be used independently and in a consistent manner.

7.11 Standard or Extra-Heavy Pipe

Pipe thickness referred to as *Standard* or *Extra-Heavy* are the equivalent of American National Standards Institute Schedule 40 and Schedule 80 pipe up to a maximum wall thickness of 9.5 mm (0.375 in.) and 12.5 mm (0.5 in.), respectively.

9 General Installation Details

9.1 Protection

Pipes, valves and operating rods are to be effectively secured and adequately protected from mechanical damage. These protective arrangements are to be fitted so that they may be removed to enable examination of the pipes, valves and operating rods.

9.3 Pipes Near Switchboards

The leading of pipes in the vicinity of switchboards is to be avoided as far as possible. When such leads are necessary, care is to be taken to fit no flanges or joints over or near the switchboards unless provision is made to prevent any leakage from damaging the equipment.

9.5 Expansion or Contraction Stresses (2004)

Provision is to be made to take care of expansion or contraction stresses in pipes due to temperature changes or working of the hull. Suitable provisions include, but are not limited to, piping bends, elbows, offsets, changes in direction of the pipe routing or expansion joints. Slip joints of an approved type may be used in systems and locations where possible leakage will not be hazardous

Where expansion joints are used, the following requirements apply:

- *Pipe support.* Adjoining pipes are to be suitably supported so that the expansion joints do not carry any significant pipe weight.
- *Alignment.* Expansion joints are not to be used to make up for piping misalignment errors. Misalignment of an expansion joint reduces the rated movements and can induce severe stresses into the joint material, thus causing reduced service life. Alignment is to be within tolerances specified by the expansion joint manufacturer.
- *Anchoring.* Expansion joints are to be installed as close as possible to an anchor point. Where an anchoring system is not used, control rods may be installed on the expansion joint to prevent excessive movements from occurring due to pressure thrust of the line.
- *Mechanical damage.* Where necessary, expansion joints are to be protected against mechanical damage.
- *Accessible location.* Expansion joints are to be installed in accessible locations to permit regular inspection and/or periodic servicing.
- *Mating flange.* Mating flanges are to be clean and usually of the flat faced type. When attaching beaded end flange expansion joints to raised face flanges, the use of a ring gasket is permitted. Rubber expansion joints with beaded end flange are not to be installed next to wafer type check or butterfly valves. Serious damage to the rubber flange bead can result due to lack of flange surface and/or bolt connection.

9.7 Molded Expansion Joints (2004)

Molded expansion joints may be Type Approved. See 1-1-A3/1 of the *ABS Rules for Conditions of Classification (Part 1)*.

9.7.1 Circulating Water Systems

Molded expansion fittings of reinforced rubber or other suitable materials may be used in circulating water piping systems in machinery spaces. Such fittings are to be oil-resistant. The maximum working pressure is not to be greater than 25% of the hydrostatic bursting pressure of the fitting as determined by a prototype test. Manufacturer's name and the month and year of manufacture are to be embossed or otherwise permanently marked on the outside edge of one of the flanges or other easily examined area of all flexible expansion joints intended for use in seawater piping systems over 150 mm (6 in.). Plans of the molded or built-up flexible expansion joints in seawater piping systems over 150 mm (6 in.), including details of the internal reinforcement arrangements, are to be submitted for approval.

9.7.2 Oil Systems

Where molded expansion joints of composite construction utilizing metallic material, such as steel or stainless steel or equivalent material, with rubberized coatings inside and/or outside or similar arrangements are proposed for use in oil piping systems (fuel, lubricating, or hydraulic oil), the following requirements apply:

9.7.2(a) Expansion joint ratings for temperature, pressure, movements and selection of materials are to be suitable for the intended service.

9.7.2(b) The maximum allowable working pressure of the system is not to be greater than 25% of the hydrostatic bursting pressure determined by a burst test of a prototype expansion joint. Results of the burst test are to be submitted.

9.7.2(c) The expansion joints are to pass the fire-resistant test specified in 4-4-1/9.7.3, below.

9.7.2(d) The expansion joints are to be permanently marked with the manufacturer's name and the month and year of manufacture.

9.7.3 Fire-Resistant Test

In order for a molded expansion joint of composite construction utilizing metallic material, as referenced in 4-4-1/9.7.2, to be considered fire-resistant, a prototype of the molded expansion joint is to be subjected to a fire test for at least 30 minutes at a temperature of not less than 800°C (1472°F) while water at the maximum service pressure is circulated inside. The temperature of the water at the outlets is not to be less than 80°C (176°F) during the test. The tested molded expansion joint is to be complete with end fittings and no leakage is to be recorded during or after the test. In lieu of maximum service pressure, the fire test may be conducted with the circulating water at a pressure of at least 5 bar (5.1 kgf/cm², 72.5 lb/in²), and with a subsequent pressure test to twice the design pressure.

9.9 Bulkhead, Deck or Tank Top Penetrations (2013)

9.9.1 Watertight Integrity

Where it is necessary for pipes to penetrate watertight bulkheads, decks or tank tops, the penetrations are to be made by methods which will maintain the watertight integrity. For this purpose, bolted connections are to have bolts threaded into the plating from one side; through bolts are not to be used. Welded connections are either to be welded on both sides or to have full penetration welds from one side.

9.9.2 Firetight Integrity

Where pipes penetrate bulkheads, decks or tank-tops which are required to be firetight or smoketight, the penetrations are to be made by approved methods which will maintain the same degree of firetight or smoketight integrity.

9.10 Damage Stability Consideration (2012)

Piping serving tanks and dry spaces, where installed within zones of assumed damage under damage stability conditions, is also to be considered damaged. Damage to such piping is not to lead to progressive flooding of spaces not assumed damaged. If it is not practicable to route piping outside the zone of assumed damage, then means are to be provided to prevent progressive flooding. Such means, for example, may be the provision of a remotely operated valve in the affected piping. Alternatively, intact spaces that can be so flooded are to be assumed flooded in the damage stability conditions.

In addition, where open ended piping systems are located below the bulkhead deck and penetrate watertight subdivision bulkheads, means operable from above the bulkhead deck are to be provided to prevent progressive flooding through those piping systems which remain intact following damage to the vessel.

9.11 Collision Bulkhead Penetrations (2014)

9.11.1 Allowed Penetrations

A collision bulkhead may be penetrated only as follows:

- i) Except as provided in 4-4-1/9.11.1ii), the collision bulkhead may be pierced below the bulkhead deck by not more than one pipe for dealing with fluid in the forepeak tank, provided that the pipe is fitted with a screwdown or butterfly valve capable of being operated from above the bulkhead deck; the valve chest being secured to the collision bulkhead inside the forepeak.
- ii) If the forepeak is divided to hold two kinds of liquids, the collision bulkhead may be pierced below the margin line by two pipes, each of which is fitted as required by 4-4-1/9.11.1i), provided there is no practical alternative to the fitting of such a second pipe and that, having regard to the additional subdivision provided in the forepeak, the safety of the vessel is maintained.
- iii) The valve in 4-4-1/9.11.1i) may be fitted of on the after side of the collision bulkhead provided that the valve is readily accessible under all service conditions and the space in which they are located is not a cargo space. Local operation of the valve is acceptable.

9.11.2 Penetrations Details

Piping penetrating collision bulkheads is to comply with the following requirements:

- i) Cast iron is not to be used for these valves. The use of nodular iron, also known as ductile iron or spheroidal-graphite iron, will be accepted, provided the material has an elongation not less than 12% in 50 mm (2 in.).
- ii) Tanks forward of the collision bulkhead are not to be arranged for the carriage of oil or other liquid substances that are flammable.

9.13 Sluice Valves and Cocks

No valve or cock for sluicing purposes is to be fitted on a collision bulkhead. Sluice valves or cocks may be fitted only on other watertight bulkheads, where they are accessible for examination at all times. The control rods are to be operable from the bulkhead deck and are to be provided with an indicator to show whether the valve or cock is open or closed. The control rods are also to be properly protected from injury and their weight is not to be supported by the valve or cock.

9.15 Relief Valves

All systems which may be exposed to pressures greater than that for which they are designed are to be safeguarded by suitable relief valves or the equivalent. Pressure containers such as evaporators, heaters, etc., which may be isolated from a protective device in the line are to have such devices either directly on the shell or between the shell and the isolation valve.

9.15.1 Exceptions

In pumping systems such as oil piping and fire main, where relief valves are ordinarily required at the pump, such valves need not be fitted when the system is served only by centrifugal pumps so designed that the pressure delivered cannot exceed that for which the piping is designed.

9.17 Instruments

9.17.1 Temperature

Thermometers and other temperature sensing devices registering through pressure boundaries are to be provided with instrument wells to allow for instrument removal without impairing the integrity of the pressurized system.

9.17.2 Pressure

Pressure sensing devices are to be provided with valve arrangements to allow for instrument isolation and removal without impairing the pressurized system's integrity.

9.17.3 Tanks (2006)

Pressure, temperature and level sensing devices installed on tanks at locations where they are subjected to a static head of liquid are to be fitted with valves or arranged such that they may be removed without emptying the tank.

9.19 Flexible Hoses (2006)

9.19.1 Definition

A flexible hose assembly is a short length of metallic or non-metallic hose normally with prefabricated end fittings ready for installation.

9.19.2 Scope

The requirements 4-4-1/9.19 apply to flexible hoses of metallic or non-metallic material intended for a permanent connection between a fixed piping system and items of machinery. The requirements may also be applied to temporary connected flexible hoses or hoses of portable equipment.

Flexible hose assemblies as defined in 4-4-1/9.19.1 are acceptable for use in oil fuel, lubricating, hydraulic and thermal oil systems, fresh water and sea water cooling systems, compressed air systems, bilge and ballast systems. The flexible hoses are acceptable for steam systems with pressure below 7 bar (7.1 kgf/cm², 101.5 psi) and temperature below 150°C (302°F), where they comply with 4-4-1/9.19.

Flexible hoses are not acceptable in high pressure fuel oil injection systems.

These requirements for flexible hose assemblies are not applicable to hoses intended to be used in fixed fire extinguishing systems.

9.19.3 Design and Construction

9.19.3(a) Hose Material. Flexible hoses are to be designed and constructed in accordance with recognized National or International standards acceptable to ABS. Flexible hoses constructed of rubber or plastics materials and intended for use in bilge, ballast, compressed air, oil fuel, lubricating, hydraulic and thermal oil systems are to incorporate a single or double closely woven integral wire braid or other suitable material reinforcement. Where rubber or plastics materials hoses are to be used in oil supply lines to burners, the hoses are to have external wire braid protection in addition to the integral reinforcement. Flexible hoses for use in steam systems are to be of metallic construction.

9.19.3(b) Hose End Fittings (2017). Flexible hoses are to be complete with approved end fittings in accordance with manufacturer's specification. Flanged end connections are to comply with 4-4-2/17 and threaded end connections with 4-4-2/13.1, as applicable and each type of hose/fitting combination is to be subject to prototype testing to the same standard as that required by the hose with particular reference to pressure and impulse tests.

The use of hose clamps and similar types of end attachments is not acceptable for flexible hoses in piping systems for steam, flammable media, starting air or for sea water, where failure may result in flooding. In other piping systems, the use of hose clamps may be accepted where the working pressure is less than 5 bar (5.1 kgf/cm², 72.5 psi) and provided there are **at least two stainless steel hose clamps** at each end connection. The hose clamps are to be at least 12 mm (0.5 in.) wide and are not to be dependent upon spring tension to remain fastened.

9.19.3(c) Fire Resistance. Flexible hose assemblies constructed of non-metallic materials intended for installation in piping systems for flammable media and sea water systems where failure may result in flooding are to be of a fire-resistant type*. Fire resistance is to be demonstrated by testing to ISO 15540 and ISO 15541.

* *Note:* The installation of a shutoff valve immediately upstream of a sea water hose does not satisfy the requirement for fire resistant type hose.

9.19.3(d) *Hose Application.* Flexible hose assemblies are to be selected for the intended location and application taking into consideration ambient conditions, compatibility with fluids under working pressure and temperature conditions consistent with the manufacturer's instructions and other relevant requirements of this Section.

Flexible hose assemblies intended for installation in piping systems where pressure pulses and/or high levels of vibration are expected to occur in service, are to be designed for the maximum expected impulse peak pressure and forces due to vibration. The tests required by 4-4-1/9.19.5 are to take into consideration the maximum anticipated in-service pressures, vibration frequencies and forces due to installation.

9.19.4 Installation

In general, flexible hoses are to be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery, equipment or systems.

Flexible hose assemblies are not to be installed where they may be subjected to torsion deformation (twisting) under normal operating conditions.

The number of flexible hoses, in piping systems is to be kept to minimum and is to be limited for the purpose stated in 4-4-1/9.19.2.

Where flexible hoses are intended to be used in piping systems conveying flammable fluids that are in close proximity of heated surfaces the risk of ignition due to failure of the hose assembly and subsequent release of fluids is to be mitigated as far as practicable by the use of screens or other similar protection.

Flexible hoses are to be installed in clearly visible and readily accessible locations (i.e., the hose is to be located such that inspection can be accomplished without the need to remove any bolted inspection plate or similar obstruction. A mirror or other means may be used for inspection where space is limited).

The installation of flexible hose assemblies is to be in accordance with the manufacturer's instructions and use limitations with particular attention to the following:

- Orientation
- End connection support (where necessary)
- Avoidance of hose contact that could cause rubbing and abrasion
- Minimum bend radii

9.19.5 Tests

9.19.5(a) *Test procedures.* Acceptance of flexible hose assemblies is subject to satisfactory prototype testing. Prototype test programs for flexible hose assemblies are to be submitted by the manufacturer and are to be sufficiently detailed to demonstrate performance in accordance with the specified standards.

The tests are, as applicable, to be carried out on different nominal diameters of hose type complete with end fittings for pressure, burst, impulse resistance and fire resistance in accordance with the requirements of the relevant standard. The following standards are to be used as applicable.

- ISO 6802 – Rubber and plastics hoses and hose assemblies – Hydraulic pressure impulse test without flexing.
- ISO 6803 – Rubber and plastics hoses and hose assemblies – Hydraulic pressure impulse test with flexing.
- ISO 15540 – Ships and marine technology – Fire resistance of hose assemblies – Test methods.
- ISO 15541 – Ships and marine technology – Fire resistance of hose assemblies – Requirements for test bench.
- ISO 10380 – Pipework – Corrugated metal hoses and hose assemblies.

Other standards may be accepted where agreed.

9.19.5(b) Burst test. All flexible hose assemblies are to be satisfactorily prototype burst tested to an international standard to demonstrate they are able to withstand a pressure not less than four (4) times its design pressure without indication of failure or leakage.

Note: The international standards (e.g., EN or SAE for burst testing of non-metallic hoses) require the pressure to be increased until burst without any holding period at 4 x MWP.

9.19.6 Marking

Flexible hoses are to be permanently marked by the manufacturer with the following details:

- Hose manufacturer's name or trademark.
- Date of manufacture (month/year).
- Designation type reference.
- Nominal diameter.
- Pressure rating
- Temperature rating.

Where a flexible hose assembly is made up of items from different manufacturers, the components are to be clearly identified and traceable to evidence of prototype testing.

9.21 Control of Static Electricity

Cargo tanks and cargo piping systems carrying flammable liquids and piping systems that are routed through hazardous areas are to be suitably grounded either by welding or bolting the tanks, pipes or their supports directly to the hull of the vessel or through the use of bonding straps. In general, the resistance between ground points along the length, across joints, and from pipe to ground is not to exceed 1 megohm. Where bonding straps are used, they are to be clearly visible, protected from mechanical damage and of a type not affected by corrosive product and paint. Bonding straps are required for cargo tanks and piping systems which are not permanently connected to the hull, including independent cargo tanks, cargo tanks and piping systems which are electrically separated from the hull, and pipe connections arranged for removal of spool pieces. The foregoing is not applicable to tank containers.

Components of alarms and level indicating devices located within cargo tanks are to be designed to account for conductivity.

9.23 Leakage Containment

For areas where leakage may be expected, such as oil burners, purifiers, oil drains, valves under day tanks, etc., means of containing the leakage are to be provided. Where drain pipes are fitted for collected leakages, they are to be led to a suitable oil drain tank not forming part of an overflow system.

PART

4

CHAPTER 4 Pumps and Piping Systems

SECTION 2 Pumps, Pipes, Valves and Fittings

1 Pumps

1.1 General (2011)

For self-propelled vessels 500 gross tons and above, the following pumps are to meet the test requirements of 4-4-2/1.3 and 4-4-2/1.5:

- Fire pump, including emergency fire pump
- Other fire fighting service pumps, such as, pumps for fixed water-based systems, or equivalent, local application fire-fighting systems, sprinkler systems, deck foam systems, etc.
- Bilge pump
- Ballast pump
- Hydraulic pumps for steering gears, anchor windlasses and variable pitch propellers
- Pumps associated with inert gas systems, i.e.:
 - Fuel oil pumps for boilers/inert gas generators
 - Cooling water pumps for flue gas scrubber

The tests are to be carried out at the manufacturer's plant in the presence of the Surveyor. The capacity test will not be required nor will the hydrostatic test need to be witnessed by the Surveyor for individual pumps assembled on a production line basis, provided the Surveyor is satisfied from periodic inspections and from the manufacturer's quality assurance procedures that the pump capacities are acceptable and that hydrostatic testing is being performed. See 4-1-1/3. For pumps associated with reciprocating internal combustion engines and reduction gears, see 4-2-1/19.

1.3 Hydrostatic Test

All pumps are to be hydrostatically tested to $1.5P$, but not less than 3.9 bar (4 kgf/cm², 57 psi), where P is the maximum working pressure of the part concerned. When the suction and discharge sides of the pump are tested independently, the pump suction is to be tested to 1.5 times P_s , but not less than 3.9 bar (4 kgf/cm², 57 psi), where P_s is the maximum pressure available from the system at the suction inlet. For steering gear pumps, also see 4-3-3/15.1.

1.5 Capacity Test

Pump capacities are to be checked with the pump operating at design conditions (rated speed and pressure head). For centrifugal pumps, the pump characteristic (head capacity) design curve is to be verified to the satisfaction of the Surveyor.

1.7 Relief Valve Capacity Test (2005)

For positive displacement pumps with an integrated relief valve, the valve's setting and full flow capacity corresponding to the pump maximum rating is to be verified. The operational test for relief valve capacity may be waived if previous satisfactory tests have been carried out on similar pumps.

3 Pressure Tests (2002)

3.1 General

In addition to the testing and inspection of materials, as required in Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*, the following tests on the fabricated piping are to be witnessed by the Surveyor after bending and the attachment of flanges.

Small bore pipes and tubes of less than 15 mm outside diameter may be exempted from the required hydrostatic tests.

3.3 Fuel Oil Service System

Pressure lines are to be tested before installation to 1.5 times the design pressure of the system, but not less than 3.4 bar (3.5 kgf/cm², 50 psi).

3.5 Fuel Oil Suction and Transfer Lines

Transfer systems and fuel oil suction lines are to be tested before installation to 3.4 bar (3.5 kgf/cm², 50 psi).

3.7 Starting Air Piping

Piping in starting-air systems is to be tested, preferably before installation, to 1.5 times the design pressure of the system.

3.9 Hydraulic Power Piping

After fabrication, the hydraulic power piping system or each piping component is to be tested to 1.5 times the design pressure. For steering gear piping tests, see 4-3-3/15. For controllable pitch propeller system piping, a test, including a check of relief valve operation, is to be performed after installation in the presence of the Surveyor.

3.11 All Piping

After installation, all piping is to be tested under working conditions.

Where it is not possible to carry out the required hydrostatic tests for all segments of pipes and integral fittings before installation, the remaining segments, including the closing seams, may be so tested after installation. Or, where it is intended to carry out all of the required hydrostatic tests after installation, such tests may be conducted in conjunction with those required by this paragraph. In both of these respects, testing procedures are to be submitted to the Surveyor for acceptance.

3.13 Specific Systems

3.13.1 Gas and Liquid Fuel Systems and Heating Coils in Tanks

The following piping systems are to be hydrostatically tested in the presence of the Surveyor to 1.5P, but not less than 4 bar (4.1 kgf/cm², 58 psi), after installation:

- i) Gas and liquid fuel systems
- ii) Heating coils in tanks

3.15 Hydrostatic Tests of Shell Valves

All valves intended for installation on the side shell at or below the load waterline, including those at the sea chests, are to be hydrostatically tested before installation and in the presence of the Surveyor to a pressure of at least 5 bar (5.1 kgf/cm², 72.5 psi).

3.17 Pneumatic Tests in Lieu of Hydrostatic Tests (1 July 2012)

In general, a pneumatic test in lieu of a hydrostatic test is not permitted. Where it is impracticable to carry out the required hydrostatic test, a pneumatic test may be considered. In such cases, the procedure for carrying out the pneumatic test, having regard to safety of personnel, is to be submitted to the applicable ABS Divisional Assistant Chief Surveyor's Office for special consideration.

5 Metallic Pipes

5.1 Test and Inspection of Group I Piping

Pipes intended for use in Group I piping systems are to be tested in the presence of and inspected by the Surveyor in accordance with Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)* or such other appropriate material specification as may be approved in connection with a particular design. See 4-4-6/1.5 for pipe used in hydraulic systems.

5.3 Steel Pipe

5.3.1 Seamless Pipe

Seamless-drawn steel pipe may be used for all purposes.

5.3.2 Welded Pipe

Electric-resistance-welded steel pipe may be used for temperatures up to 343°C (650°F).

Consideration will be given to the use of electric-resistance-welded (ERW) pipe for use above 343°C (650°F) where the material is shown to be suitable for the intended service (i.e. in a non-corrosive environment where the design temperature is below the lowest graphitization temperature specified for the material, etc.). Furnace butt-welded pipe up to and including 115 mm O.D. (4 in. NPS) may be used for Group II piping for temperatures up to 232°C (450°F), but is not to be used for flammable or combustible fluids.

5.5 Copper Pipe

Seamless-drawn and welded copper pipe, unless otherwise prohibited, may be used for all purposes where the temperature does not exceed 208°C (406°F) and within the limitations specified in the material specification.

5.7 Brass Pipe

Seamless-drawn brass pipe, unless otherwise prohibited, may be used where the temperature does not exceed 208°C (406°F).

5.8 Other Materials (1 February 2015)

Piping containing flammable fluids is to be constructed of steel or other materials approved by ABS. Other equivalent material with a melting point above 930°C (1706°F) and with an elongation above 12% may be accepted. Aluminum and aluminum alloys which are characterized by low melting points, below 930°C (1706°F), are considered heat sensitive materials and are not to be used to convey flammable fluids, except for such piping as arranged inside cargo tanks or heat exchangers or as otherwise permitted for engine attached filters, see 4-2-1/7.7 of the *Steel Vessel Rules*.

On oil tankers and chemical tankers aluminized pipes are prohibited in cargo tanks, cargo deck tank area, pump rooms, cofferdams, or other areas where cargo vapor may accumulate. Aluminized pipes may be permitted in ballast tanks, in inerted cargo tanks, and, provided the pipes are protected from accidental impact, in hazardous areas on open deck.

5.9 Design

5.9.1 Maximum Allowable Working Pressure and Minimum Thickness

The maximum allowable working pressure and the minimum thickness of pipes are to be determined by the following equations, with due consideration being given to the reduction in thickness at the outer radius of bent pipes:

$$W = \frac{KS(t - C)}{D - M(t - C)} \qquad t = \frac{WD}{KS + MW} + C$$

where

- W = maximum allowable working pressure, in bar, kgf/cm² (psi). See Note 1.
- t = minimum thickness of pipe, in mm (in.). See Note 5.
- K = 20 (200, 2)
- D = actual external diameter of pipe, in mm (in.)
- S = maximum allowable fiber stress, in N/mm² (kgf/mm², psi) from 4-4-2/Table 1. See Note 2.
- M = factor from 4-4-2/Table 1
- C = allowance for threading, grooving or mechanical strength
- = 1.65 mm (0.065 in.) for plain-end steel or wrought-iron pipe or tubing up to 115 mm O.D. (4 in. NPS). See Note 3.
- = 0.00 mm (0.000 in.) for plain-end steel or wrought-iron pipe or tubing up to 115 mm O.D. (4 in. NPS) used for hydraulic piping systems. See Note 3.
- = 0.00 mm (0.000 in.) for plain-end steel or wrought-iron pipe or tubing 115 mm O.D. (4 in. NPS) and larger. See Note 3.
- = 1.27 mm (0.05 in.) for all threaded pipe 17 mm O.D. ($\frac{3}{8}$ in.) and smaller
- = depth of thread, h , for all threaded pipe over 17 mm O.D. ($\frac{3}{8}$ in.). See Note 4.
- = depth of groove for grooved pipe
- = 0.00 mm (0.000 in.) for plain-end nonferrous pipe or tubing. See Note 3.

Notes:

- 1 The value of W used in the equations is to be not less than 8.6 bar (8.8 kgf/cm², 125 psi), except that for suction and other low-pressure piping of nonferrous material, the actual working pressure may be applied if a suitable addendum is provided against erosion and outside damage. However, in no case is the value of W to be less than 3.4 bar (3.5 kgf/cm², 50 psi) for use in the equations.
- 2 Values of S for other materials are not to exceed the stress permitted by ASME B31.1 Code for Pressure Piping, Power Piping.
- 3 Plain-end pipe or tubing includes those joined by any method in which the wall thickness is not reduced.
- 4 The depth of thread, h , may be determined by the equation $h = 0.8/n$ where n is the number of threads per inch, or in metric units by the equation $h = 0.8n$ where n is the number of mm per thread.
- 5 If pipe is ordered by its nominal wall thickness, the manufacturing tolerance on wall thickness is to be taken into account.

5.9.2 Pipe Bending (2005)

Pipe bending is to be in accordance with 2-3-12/25 of the *ABS Rules for Materials and Welding (Part 2)*. Alternatively, bending in accordance with a recognized standard (e.g., ASME B31.1-Section 129.1 and 129.3) or other approved specification to a radius that will result in a surface free of cracks and substantially free of buckles may be acceptable.

5.11 Working Pressure and Thickness – Alternative Consideration

Consideration will be given to the maximum allowable working pressure and the minimum thickness of piping determined from criteria of applicable recognized standards.

TABLE 1
Allowable Stress Values S for Steel Piping N/mm² (kgf/mm², psi)

Part 2, Chapter 3, Section 12/Paragraph No. and (Grade) Nominal Composition	Tensile Strength	Service Temperature—Degrees C (F)			
		−29°C (−20°F) to 334°C (650°F)	372°C (700°F)	399°C (750°F)	427°C (800°F)
		$M = 0.8$	$M = 0.8$	$M = 0.8$	$M = 0.8$
2-3-12/5.1 (Gr. 1) Elec. res. Carbon Steel	310 (31.5, 45000)	46.9 (4.78, 6800)	46.6 (4.75, 6500)		
2-3-12/5.1 (Gr. 2) Elec. res. Carbon Steel	330 (33.7, 48000)	70.3 (7.17, 10200)	68.3 (6.96, 9900)	62.8 (6.40, 9100)	53.1 (5.41, 7700)
Seamless Carbon Steel	330 (33.7, 48000)	82.8 (8.44, 12000)	80.6 (8.22, 11700)	73.7 (7.52, 10700)	62.1 (6.33, 9000)
2-3-12/5.1 (Gr. 3) Elec. res. Carbon Steel	415 (42, 60000)	88.3 (9.0, 12800)	84.1 (8.58, 12200)	75.8 (7.73, 11000)	63.4 (6.47, 9200)
Seamless Carbon Steel	415 (42, 60000)	103.5 (10.55, 15000)	99.2 (10.12, 14400)	89.6 (9.14, 13000)	74.4 (7.59, 10800)
2-3-12/5.3 (Gr. 4) Carbon Steel	330 (33.7, 48000)	82.8 (8.44, 12000)	80.7 (8.23, 11700)	73.7 (7.52, 10700)	62.1 (6.33, 9000)
2-3-12/5.3 (Gr. 5) Carbon Steel	415 (42, 60000)	103.5 (10.55, 15000)	99.2 (10.12, 14400)	89.6 (9.14, 13000)	74.4 (7.59, 10800)

Notes:

- 1 Intermediate values of S may be determined by interpolation.
- 2 For grades of piping other than those given in 4-4-2/Table 1, S values are not to exceed those permitted by ASME B31.1 Code for Pressure Piping. See 4-4-2/5.11.
- 3 Consideration is to be given to the possibility of graphite formation in carbon steel at temperatures above 425°C (800°F).

7 Plastic Pipes

7.1 General (2015)

Pipes and piping components made of thermoplastic or thermosetting plastic materials with or without reinforcement may be used in piping systems referred to in 4-4-2/Table 2 subject to compliance with the following requirements. For the purpose of these Rules, “plastic” means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as polyvinyl chloride (PVC) and fiber reinforced plastics (FRP). Plastic includes synthetic rubber and materials of similar thermo/mechanical properties.

7.3 Plans and Data to be Submitted (2007)

Rigid plastic pipes are to be in accordance with a recognized national or international standard acceptable to ABS. Specification for the plastic pipe, including thermal and mechanical properties and chemical resistance, is to be submitted for review together with the spacing of the pipe supports.

The following information for the plastic pipes, fittings and joints is to be submitted for approval.

7.3.1 General Information

- i) Pipe and fitting dimensions
- ii) Maximum internal and external working pressure
- iii) Working temperature range
- iv) Intended services and installation locations
- v) Level of fire endurance

- vi) Electrically conductive
- vii) Intended fluids
- viii) Limits on flow rates
- ix) Serviceable life
- x) Installation instructions
- xi) Details of marking

7.3.2 Drawings and Supporting Documentation

- i) Certificates and reports for relevant tests previously carried out.
- ii) Details of relevant standards.
- iii) All relevant design drawings, catalogues, data sheets, calculations and functional descriptions.
- iv) Fully detailed sectional assembly drawings showing pipe, fittings and pipe connections.

7.3.3 Materials

- i) Resin type.
- ii) Catalyst and accelerator types and concentration employed in the case of reinforced polyester resin pipes or hardeners where epoxide resins are employed.
- iii) A statement of all reinforcements employed where the reference number does not identify the mass per unit area or the tex number of a roving used in a filament winding process, these are to be detailed.
- iv) Full information regarding the type of gel-coat or thermoplastic liner employed during construction, as appropriate.
- v) Cure/post-cure conditions. The cure and post-cure temperatures and times employ for given resin/reinforcement ratio.
- vi) Winding angle and orientation.

7.5 Design

7.5.1 Internal Pressure

A pipe is to be designed for an internal pressure not less than the design pressure of the system in which it will be used. The maximum internal pressure, P_{inp} for a pipe is to be the lesser of the following:

$$P_{int} = \frac{P_{sth}}{4} \qquad P_{int} = \frac{P_{lth}}{2.5}$$

where

- P_{sth} = short-term hydrostatic test failure pressure
- P_{lth} = long-term hydrostatic test failure pressure (> 100,000 hours)

The hydrostatic tests are to be carried out under the following standard conditions:

- Atmospheric pressure = 1 bar (1 kgf/cm², 14.5 psi)
- Relative humidity = 30%
- Fluid temperature = 25°C (77°F)

The hydrostatic test failure pressure may be verified experimentally or determined by a combination of testing and calculation methods which are to be submitted to ABS for approval.

7.5.2 External Pressure

External pressure is to be considered for any installation which may be subject to vacuum conditions inside the pipe or a head of liquid on the outside of the pipe. A pipe is to be designed for an external pressure not less than the sum of the pressure imposed by the maximum potential head of liquid outside the pipe plus full vacuum, 1 bar (1 kgf/cm², 14.5 psi), inside the pipe. The maximum external pressure for a pipe is to be determined by dividing the collapse test pressure by a safety factor of 3.

The collapse test pressure may be verified experimentally or determined by a combination of testing and calculation methods which are to be submitted to ABS for approval.

7.5.3 Axial Strength

7.5.3(a) The sum of the longitudinal stresses due to pressure, weight and other dynamic and sustained loads is not to exceed the allowable stress in the longitudinal direction. Forces due to thermal expansion, contraction and external loads, where applicable, are to be considered when determining longitudinal stresses in the system.

7.5.3(b) In the case of fiber reinforced plastic pipes, the sum of the longitudinal stresses is not to exceed one-half of the nominal circumferential stress derived from the maximum internal pressure determined according to 4-4-2/7.5, unless the allowable longitudinal stress is verified experimentally or by a combination of testing and calculation methods.

7.5.4 Temperature (2007)

The maximum allowable working temperature of a pipe is to be in accordance with the manufacturer's recommendations, but in each case, it is to be at least 20°C (36°F) lower than the minimum heat distortion temperature of the pipe material determined according to ISO 75 method A or equivalent. The minimum heat distortion temperature is not to be less than 80°C (176°F). This minimum heat distortion temperature requirement is not applicable to pipes and pipe components made of thermoplastic materials, such as polyethylene (PE), polypropylene (PP), polybutylene (PB) and intended for non-essential services.

Where low temperature services are considered, special attention is to be given with respect to material properties.

7.5.5 Impact Resistance

Plastic pipes and joints are to have a minimum resistance to impact in accordance with a recognized national or international standard such as ASTM D2444 or equivalent. After the impact resistance is tested, the specimen is to be subjected to hydrostatic pressure equal to 2.5 times the design pressure for at least one hour.

7.5.6 Fire Endurance (2015)

4-4-2/Table 2 specifies fire endurance requirements for pipes based upon system and location. Pipes and their associated fittings whose functions or integrity are essential to the safety of the vessel are to meet the indicated fire endurance requirements which are described below.

i) *Level 1* will ensure the integrity of the system during a full scale hydrocarbon fire and is particularly applicable to systems where loss of integrity may cause outflow of flammable liquids and worsen the fire situation. Piping having passed the fire endurance test specified in 4-4-2/7.13 for a duration of a minimum of one hour without loss of integrity in the dry condition is considered to meet Level 1 fire endurance standard (L1).

Level 1W – Piping systems similar to Level 1 systems except these systems do not carry flammable fluid or any gas and a maximum 5% flow loss in the system after exposure is acceptable. The flow loss must be taken into account when dimensioning the system.

ii) *Level 2* intends to ensure the availability of systems essential to the safe operation of the vessel, after a fire of short duration, allowing the system to be restored after the fire has been extinguished. Piping having passed the fire endurance test specified in 4-4-2/7.13 for a duration of a minimum of 30 minutes without loss of integrity in the dry condition is considered to meet Level 2 fire endurance standard (L2).

Level 2W – Piping systems similar to Level 2 systems except a maximum 5% flow loss in the system after exposure is acceptable. The flow loss must be taken into account when dimensioning the system.

- iii) *Level 3* is considered to provide the fire endurance necessary for a water filled piping system to survive a local fire of short duration. The system's functions are capable of being restored after the fire has been extinguished. Piping having passed the fire endurance test specified in 4-4-2/7.15 for a duration of a minimum of 30 minutes without loss of integrity in the wet condition is considered to meet Level 3 fire endurance standard (L3).

Where a fire protective coating of pipes and fittings is necessary for achieving the fire endurance standards required, the following requirements apply.

- i) Pipes are generally to be delivered from the manufacturer with the protective coating applied, with on-site application limited to that necessary for installation purposes (i.e., joints). See 4-4-2/7.7.7 regarding the application of the fire protection coating on joints.
- ii) The fire protection properties of the coating are not to be diminished when exposed to salt water, oil or bilge slops. It is to be demonstrated that the coating is resistant to products likely to come in contact with the piping.
- iii) In considering fire protection coatings, such characteristics as thermal expansion, resistance against vibrations and elasticity are to be taken into account.
- iv) The fire protection coatings are to have sufficient resistance to impact to retain their integrity.
- v) (2007) Random samples of pipe are to be tested to determine the adhesion qualities of the coating to the pipe.

7.5.7 Flame Spread

7.5.7(a) *Plastic Pipes*. All pipes, except those fitted on open decks and within tanks, cofferdams, void spaces, pipe tunnels and ducts, are to have low flame spread characteristics. The test procedures in IMO Resolution A.653(16) *Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling, and Deck Finish Materials*, modified for pipes as indicated in 4-4-2/7.17, are to be used for determining the flame spread characteristics. Piping materials giving average values for all of the surface flammability criteria not exceeding the values listed in Resolution A.653(16) are considered to meet the requirements for low flame spread.

Alternatively, flame spread testing in accordance with ASTM D635 may be used in lieu of the IMO flame spread test, provided such test is acceptable to the Administration.

7.5.7(b) *Multi-core Metallic Tubes Sheathed by Plastic Materials (2016)*. The multi-core tubes in "bundles" made of stainless steel or copper tubes covered by an outer sheath of plastic material are to comply with the flammability test criteria of IEC 60332-3-22 or 60332-3-21, for Category A or A F/R, respectively. Alternatively, the tube bundles complying with at least the flammability test criteria of IEC 60332-1-2 or a test procedure equivalent thereto are acceptable provided they are installed in compliance with approved fire stop arrangements.

7.5.8 Electrical Conductivity

7.5.8(a) Piping conveying fluids with a conductivity less than 1000 pico siemens per meter are to be electrically conductive.

7.5.8(b) Regardless of the fluid being conveyed, plastic pipes are to be electrically conductive if the piping passes through a hazardous area.

7.5.8(c) Where electrically conductive pipe is required, the resistance per unit length of the pipes and fittings is not to exceed 1×10^5 Ohm/m (3×10^4 Ohm/ft). See also 4-4-2/7.7.4.

7.5.8(d) If the pipes and fittings are not homogeneously conductive, the conductive layers are to be protected against the possibility of spark damage to the pipe wall.

7.5.9 Marking (2007)

Plastic pipes and other components are to be permanently marked with identification in accordance with a recognized standard. Identification is to include pressure ratings, the design standard that the pipe or fitting is manufactured in accordance with, the material with which the pipe or fitting is made, and the date of fabrication.

7.7 Installation of Plastic Pipes

7.7.1 Supports

7.7.1(a) (2015) Selection and spacing of pipe supports in shipboard systems are to be determined as a function of allowable stresses and maximum deflection criteria. Support spacing is not to be greater than the pipe manufacturer's recommended spacing. The selection and spacing of pipe supports are to take into account pipe dimensions, length of the piping, mechanical and physical properties of the pipe material, mass of pipe and contained fluid, external pressure, operating temperature, thermal expansion effects, loads due to external forces, thrust forces, water hammer and vibrations to which the system may be subjected. Combinations of these loads are to be checked.

7.7.1(b) Each support is to evenly distribute the load of the pipe and its contents over the full width of the support. Measures are to be taken to minimize wear of the pipes where they contact the supports.

7.7.1(c) Heavy components in the piping system such as valves and expansion joints are to be independently supported.

7.7.1(d) The supports are to allow for relative movement between the pipes and the vessel's structure, having due regard for the difference in the coefficients of thermal expansion and deformations of the vessel's hull and its structure.

7.7.1(e) When calculating the thermal expansion, the system working temperature and the temperature at which assembling is performed are to be taken into account.

7.7.2 External Loads

When installing the piping, allowance is to be made for temporary point loads, where applicable. Such allowances are to include at least the force exerted by a load (person) of 980 N (100 kgf, 220 lbf) at mid-span on any pipe more than 100 mm (4 in.) nominal diameter.

Pipes are to be protected from mechanical damage where necessary.

7.7.3 Plastic Pipe Connections

7.7.3(a) The strength of fittings and joints is not to be less than that of the piping they connect.

7.7.3(b) Pipes may be joined using adhesive-bonded, welded, flanged or other joints.

7.7.3(c) Tightening of flanged or mechanically coupled joints is to be performed in accordance with manufacturer's instructions.

7.7.3(d) Adhesives, when used for joint assembly, are to be suitable for providing a permanent seal between the pipes and fittings throughout the temperature and pressure range of the intended application.

Joining techniques are to be in accordance with manufacturer's installation guidelines. Personnel performing these tasks are to be qualified to the satisfaction of ABS, and each bonding procedure is to be qualified before shipboard piping installation commences. Requirements for joint bonding procedures are in 4-4-2/7.11.

7.7.4 Electrical Conductivity

Where electrically conductive pipe is required by 4-4-2/7.5.8, installation of the pipe is to be in accordance with the following:

7.7.4(a) The resistance to earth (ground) from any point in the system is not to exceed 1 megohm. The resistance is to be checked in the presence of the Surveyor.

7.7.4(b) Pipes and fittings with conductive layers are to be protected against a possibility of spark damage caused by a different conductivity of the conductive layers.

7.7.4(c) Where used, earthing wires or bonding straps are to be accessible for inspection. The Surveyor is to verify that they are in visible locations.

7.7.5 Shell Connections

Where plastic pipes are permitted in systems connected to the shell of the vessel, the valves and the pipe connection to the shell are to be metallic. The side shell valves are to be arranged for remote control from outside the space in which the valves are located. For further details of the shell valve installation, their connections and material, refer to 4-4-2/19.

7.7.6 Bulkhead and Deck Penetrations

7.7.6(a) The integrity of watertight bulkheads and decks is to be maintained where plastic pipes pass through them.

7.7.6(b) Where plastic pipes pass through "A" or "B" class divisions, arrangements are to be made to ensure that the fire endurance is not impaired. These arrangements are to be tested in accordance with IMO Resolution. A 754 (18), Recommendation on Fire Resistance Tests for "A", "B" and "F" Class Divisions, as amended.

7.7.6(c) If the bulkhead or deck is also a fire division and destruction by fire of plastic pipes may cause inflow of liquid from a tank, a metallic shut-off valve operable from above the bulkhead deck is to be fitted at the bulkhead or deck.

7.7.7 Application of Fire Protection Coatings

Fire protection coatings are to be applied on the joints, where necessary for meeting the required fire endurance criteria in 4-4-2/7.5.6, after performing hydrostatic pressure tests of the piping system (see 4-4-2/7.19). The fire protection coatings are to be applied in accordance with the manufacturer's recommendations, using a procedure approved in each particular case.

7.9 Manufacturing of Plastic Pipes (1 July 2009)

The manufacturer is to have a quality system and be certified in accordance with 1-1-A3/5.3 and 1-1-A3/5.5 of the *ABS Rules for Conditions of Classification (Part 1)* or ISO 9001 (or equivalent). The quality system is to consist of elements necessary to ensure that pipes and components are produced with consistent and uniform mechanical and physical properties in accordance with recognized standards and including testing to demonstrate the compliance of plastic pipes, fittings and joints with 4-4-2/7.5.1 through 4-4-2/7.5.8 and 4-4-2/7.19, as applicable.

Where the manufacturer does not have a certified quality system in accordance with 1-1-A3/5.3 and 1-1-A3/5.5 of the *ABS Rules for Conditions of Classification (Part 1)* or ISO 9001 (or equivalent), the tests in with 4-4-2/7.5.1 through 4-4-2/7.5.8 and 4-4-2/7.19, as applicable, will be required using samples from each batch of pipes being supplied for use aboard the vessel and are to be carried out in the presence of the Surveyor.

Each length of pipe and each fitting is to be tested at the manufacturer's production facility to a hydrostatic pressure not less than 1.5 times the maximum allowable internal pressure of the pipe in 4-4-2/7.5.1. Alternatively, for pipes and fittings not employing hand layup techniques, the hydrostatic pressure test may be carried out in accordance with the hydrostatic testing requirements stipulated in the recognized national or international standard to which the pipe or fittings are manufactured, provided that there is an effective quality system in place.

Depending upon the intended application, ABS reserves the right to require the hydrostatic pressure testing of each pipe and/or fitting.

If the facility does not have a certified quality system in accordance with 1-1-A3/5.3 and 1-1-A3/5.5 of the *ABS Rules for Conditions of Classification (Part 1)* or ISO 9001 (or equivalent), then the production testing must be witnessed by the Surveyor.

The manufacturer is to provide documentation certifying that all piping and piping components supplied are in compliance with the requirements of Section 4-4-2.

7.11 Plastic Pipe Bonding Procedure Qualification

7.11.1 Procedure Qualification Requirements

7.11.1(a) To qualify joint bonding procedures, the tests and examinations specified herein are to be successfully completed. The procedure for making bonds is to include the following:

- i) Materials used
- ii) Tools and fixtures
- iii) Environmental requirements
- iv) Joint preparation requirements
- v) Cure temperature
- vi) Dimensional requirements and tolerances
- vii) Test acceptance criteria for the completed assembly

7.11.1(b) Any change in the bonding procedure which will affect the physical and mechanical properties of the joint will require the procedure to be requalified.

7.11.2 Procedure Qualification Testing

7.11.2(a) A test assembly is to be fabricated in accordance with the procedure to be qualified and it is to consist of at least one pipe-to-pipe joint and one pipe-to-fitting joint. When the test assembly has been cured, it is to be subjected to a hydrostatic test pressure at a safety factor of 2.5 times the design pressure of the test assembly for not less than one hour. No leakage or separation of joints is to be allowed. The test is to be conducted so that the joint is loaded in both the longitudinal and circumferential direction.

7.11.2(b) Selection of the pipes used for test assembly is to be in accordance with the following:

- i) When the largest size to be joined is 200 mm (8 in.) nominal outside diameter or smaller, the test assembly is to be the largest pipe size to be joined.
- ii) When the largest size to be joined is greater than 200 mm (8 in.) nominal outside diameter, the size of the test assembly is to be either 200 mm (8 in.) or 25% of the largest piping size to be joined, whichever is greater.

7.11.2(c) When conducting performance qualifications, each bonder and each bonding operator are to make up test assemblies, the size and number of which are to be as required above.

7.13 Tests by the Manufacturer – Fire Endurance Testing of Plastic Piping in the Dry Condition (For Level 1 and Level 2)

7.13.1 Test Method

7.13.1(a) The specimen is to be subjected to a furnace test with fast temperature increase similar to that likely to occur in a fully developed liquid hydrocarbon fire. The time/temperature is to be as follows:

at the end of 5 minutes	945°C	(1733°F)
at the end of 10 minutes	1033°C	(1891°F)
at the end of 15 minutes	1071°C	(1960°F)
at the end of 30 minutes	1098°C	(2008°F)
at the end of 60 minutes	1100°C	(2012°F)

7.13.1(b) The accuracy of the furnace control is to be as follows:

- i) During the first 10 minutes of the test, variation in the area under the curve of mean furnace temperature is to be within $\pm 15\%$ of the area under the standard curve.
- ii) During the first 30 minutes of the test, variation in the area under the curve of mean furnace temperature is to be within $\pm 10\%$ of the area under the standard curve.
- iii) For any period after the first 30 minutes of the test, variation in the area under the curve of mean furnace temperature is to be within $\pm 5\%$ of the area under the standard curve.
- iv) At any time after the first 10 minutes of the test, the difference in the mean furnace temperature from the standard curve is to be within $\pm 100^\circ\text{C}$ ($\pm 180^\circ\text{F}$).

7.13.1(c) The locations where the temperatures are measured, the number of temperature measurements and the measurement techniques are to be approved by ABS.

7.13.2 Test Specimen

7.13.2(a) The test specimen is to be prepared with the joints and fittings intended for use in the proposed application.

7.13.2(b) The number of specimens is to be sufficient to test typical joints and fittings including joints between non-metal and metal pipes and metal fittings to be used.

7.13.2(c) The ends of the specimen are to be closed. One of the ends is to allow pressurized nitrogen to be connected. The pipe ends and closures may be outside the furnace.

7.13.2(d) The general orientation of the specimen is to be horizontal and it is to be supported by one fixed support with the remaining supports allowing free movement. The free length between supports is not to be less than 8 times the pipe diameter.

7.13.2(e) Most materials will require a thermal insulation to pass this test. The test procedure is to include the insulation and its covering.

7.13.2(f) If the insulation contains or is liable to absorb moisture, the specimen is not to be tested until the insulation has reached an air dry-condition, defined as equilibrium with an ambient atmosphere of 50% relative humidity at $20 \pm 5^\circ\text{C}$ ($68 \pm 9^\circ\text{F}$). Accelerated conditioning is permissible, provided the method does not alter the properties of the component material. Special samples are to be used for moisture content determination and conditioned with the test specimen. These samples are to be so constructed as to represent the loss of water vapor from the specimen having similar thickness and exposed faces.

7.13.3 Test Condition

A nitrogen pressure inside the test specimen is to be maintained automatically at 0.7 ± 0.1 bar (0.7 ± 0.1 kgf/cm², 10 ± 1.5 psi) during the test. Means are to be provided to record the pressure inside the pipe and the nitrogen flow into and out of the specimen in order to indicate leakage.

7.13.4 Acceptance Criteria

7.13.4(a) During the test, no nitrogen leakage from the sample is to occur.

7.13.4(b) (2015) After termination of the furnace test, the test specimen together with fire protective coating, if any, is to be allowed to cool in still air to ambient temperature and then tested to the maximum allowable pressure of the pipes, as defined in 4-4-2/7.5.1 and 4-4-2/7.5.2. The pressure is to be held for a minimum of 15 minutes. Pipes without leakage qualify as Level 1 or 2 depending on the test duration. Pipes with negligible leakage (i.e., not exceeding 5% flow loss) qualify as Level 1W or Level 2W depending on the test duration. Where practicable, the hydrostatic test is to be conducted on bare pipe (i.e., coverings and insulation removed) so that any leakage will be apparent.

7.13.4(c) Alternative test methods and/or test procedures considered to be at least equivalent, including open pit testing method, may be accepted in cases where the pipes are too large for the test furnace.

7.15 Test by Manufacturer – Fire Endurance Testing of Water-Filled Plastic Piping (For Level 3)

7.15.1 Test Method

7.15.1(a) A propane multiple burner test with a fast temperature increase is to be used.

7.15.1(b) For piping up to and including 152 mm (6 in.) O.D., the fire source is to consist of two rows of five burners, as shown in 4-4-2/Figure 1. A constant heat flux averaging 113.6 kW/m^2 ($36,000 \text{ BTU/hr-ft}^2$) $\pm 10\%$ is to be maintained $12.5 \pm 1 \text{ cm}$ ($5 \pm 0.4 \text{ in.}$) above the centerline of the burner array. This flux corresponds to a pre-mix flame of propane with a fuel flow rate of 5 kg/hr (11 lb/hr) for a total heat release of 65 kW (3700 BTU/min.). The gas consumption is to be measured with an accuracy of at least $\pm 3\%$ in order to maintain a constant heat flux. Propane with a minimum purity of 95% is to be used.

7.15.1(c) For piping greater than 152 mm (6 in.) O.D., one additional row of burners is to be included for each 51 mm (2 in.) increase in pipe diameter. A constant heat flux averaging 113.6 kW/m^2 ($36,000 \text{ BTU/hr-ft}^2$) $\pm 10\%$ is still to be maintained at the $12.5 \pm 1 \text{ cm}$ ($5 \pm 0.4 \text{ in.}$) height above the centerline of the burner array. The fuel flow is to be increased as required to maintain the designated heat flux.

7.15.1(d) The burners are to be type “Sievert No. 2942” or equivalent which produces an air mixed flame. The inner diameter of the burner heads is to be 29 mm (1.14 in.). See 4-4-2/Figure 1. The burner heads are to be mounted in the same plane and supplied with gas from a manifold. If necessary, each burner is to be equipped with a valve in order to adjust the flame height.

7.15.1(e) The height of the burner stand is also to be adjustable. It is to be mounted centrally below the test pipe with the rows of burners parallel to the pipe’s axis. The distance between the burner heads and the pipe is to be maintained at $12.5 \pm 1 \text{ cm}$ ($5 \pm 0.4 \text{ in.}$) during the test. The free length of the pipe between its supports is to be $0.8 \pm 0.05 \text{ m}$ ($31.5 \pm 2 \text{ in.}$). See 4-4-2/Figure 2.

FIGURE 1
Fire Endurance Test Burner Assembly

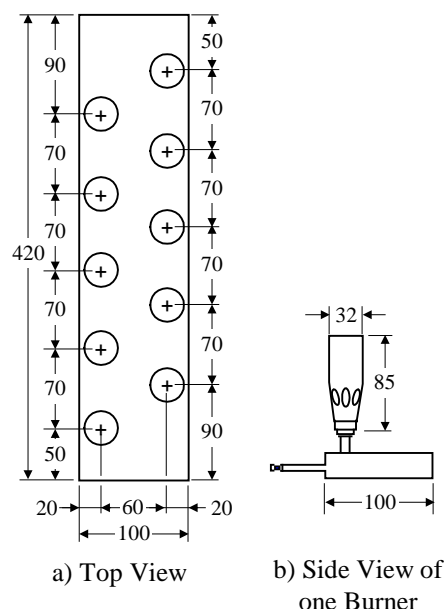
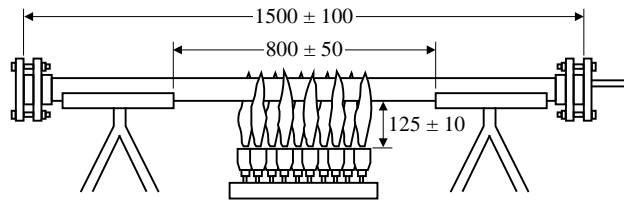


FIGURE 2
Fire Endurance Test Stand with Mounted Sample



7.15.2 Test Specimen

7.15.2(a) Each pipe is to have a length of approximately 1.5 m (5 ft).

7.15.2(b) The test pipe is to be prepared with permanent joints and fittings intended to be used. Only valves and straight joints versus elbows and bends are to be tested as the adhesive in the joint is the primary point of failure.

7.15.2(c) The number of pipe specimens is to be sufficient to test all typical joints and fittings.

7.15.2(d) The ends of each pipe specimen are to be closed. One of the ends is to allow pressurized water to be connected.

7.15.2(e) If the insulation contains or is liable to absorb moisture, the specimen is not to be tested until the insulation has reached an air dry-condition, defined as equilibrium with an ambient atmosphere of 50% relative humidity at $20 \pm 5^\circ\text{C}$ ($68 \pm 9^\circ\text{F}$). Accelerated conditioning is permissible, provided the method does not alter the properties of the component material. Special samples are to be used for moisture content determination and conditioned with the test specimen. These samples are to be so constructed as to represent the loss of water vapor from the specimen having similar thickness and exposed faces.

7.15.2(f) The pipe samples are to rest freely in a horizontal position on two V-shaped supports. The friction between pipe and supports is to be minimized. The supports may consist of two stands, as shown in 4-4-2/Figure 2.

7.15.2(g) A relief valve is to be connected to one of the end closures of each specimen.

7.15.3 Test Conditions

7.15.3(a) The test is to be carried out in a sheltered test site in order to prevent any draft influencing the test.

7.15.3(b) Each pipe specimen is to be completely filled with deaerated water to exclude air bubbles.

7.15.3(c) The water temperature is not to be less than 15°C (59°F) at the start and is to be measured continuously during the test. The water is to be stagnant and the pressure maintained at 3 ± 0.5 bar (3.1 ± 0.5 kgf/cm², 43.5 ± 7.25 psi) during the test.

7.15.4 Acceptance Criteria

7.15.4(a) During the test, no leakage from the sample(s) is to occur except that slight weeping through the pipe wall may be accepted.

7.15.4(b) After termination of the burner test, the test specimen together with fire protective coating, if any, is to be allowed to cool to ambient temperature and then tested to the maximum allowable pressure of the pipes, as defined in 4-4-2/7.5.1 and 4-4-2/7.5.2. The pressure is to be held for a minimum of 15 minutes without significant leakage [i.e., not exceeding 0.2 l/min. (0.05 gpm)]. Where practicable, the hydrostatic test is to be conducted on bare pipe (i.e., coverings and insulation removed) so that any leakage will be apparent.

7.17 Tests by Manufacturer – Flame Spread

7.17.1 Test Method

Flame spread of plastic piping is to be determined by IMO Resolution A.653(16) entitled, “Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling, and Deck Finish Materials” with the following modifications.

7.17.1(a) Tests are to be made for each pipe material and size.

7.17.1(b) The test sample is to be fabricated by cutting pipes lengthwise into individual sections and then assembling the sections into a test sample as representative as possible of a flat surface. A test sample is to consist of at least two sections. The test sample is to be at least 800 ± 5 mm (31.5 ± 0.2 in.) long. All cuts are to be made normal to the pipe wall.

7.17.1(c) The number of sections that must be assembled together to form a test sample is to be that which corresponds to the nearest integral number of sections which makes up a test sample with an equivalent linearized surface width between 155 mm (6 in.) and 180 mm (7 in.). The surface width is defined as the measured sum of the outer circumference of the assembled pipe sections that are exposed to the flux from the radiant panel.

7.17.1(d) The assembled test sample is to have no gaps between individual sections.

7.17.1(e) The assembled test sample is to be constructed in such a way that the edges of two adjacent sections coincide with the centerline of the test holder.

7.17.1(f) The individual test sections are to be attached to the backing calcium silicate board using wire (No. 18 recommended) inserted at 50 mm (2 in.) intervals through the board and tightened by twisting at the back.

7.17.1(g) The individual pipe sections are to be mounted so that the highest point of the exposed surface is in the same plane as the exposed flat surface of a normal surface.

7.17.1(h) The space between the concave unexposed surface of the test sample and the surface of the calcium silicate backing board is to be left void.

7.17.1(i) The void space between the top of the exposed test surface and the bottom edge of the sample holder frame is to be filled with a high temperature insulating wool if the width of the pipe segments extend under the side edges of the sample holding frame.

7.19 Testing By Manufacturer – General (2007)

Testing is to demonstrate the compliance of plastic pipes, fittings and joints for which approval, in accordance with Section 4-4-2, is requested. These tests are to be in compliance with the requirements of relevant standards as per 4-4-2/Table 3 and 4-4-2/Table 4.

7.21 Testing Onboard After Installation

Piping systems are to be subjected to a hydrostatic test pressure of not less than 1.5 times the design pressure to the satisfaction of the Surveyor.

For piping required to be electrically conductive, earthing is to be checked and random resistance testing is to be conducted to the satisfaction of the Surveyor.

TABLE 2
Fire Endurance Requirements Matrix for Plastic Pipes (2015)

PIPING SYSTEMS		LOCATION										
		A	B	C	D	E	F	G	H	I	J	K
CARGO (Flammable cargoes with flash point ≤60°C (140°F))												
1	Cargo lines	NA	NA	L1	NA	NA	0	NA	0 ⁽¹⁰⁾	0	NA	L1 ⁽²⁾
2	Crude oil washing lines	NA	NA	L1	NA	NA	0	NA	0 ⁽¹⁰⁾	0	NA	L1 ⁽²⁾
3	Vent lines	NA	NA	NA	NA	NA	0	NA	0 ⁽¹⁰⁾	0	NA	X
INERT GAS												
4	Water seal effluent line	NA	NA	0 ⁽¹⁾	NA	NA	0 ⁽¹⁾	0 ⁽¹⁾	0 ⁽¹⁾	0 ⁽¹⁾	NA	0
5	Scrubber effluent line	0 ⁽¹⁾	0 ⁽¹⁾	NA	NA	NA	NA	NA	NA	0 ⁽¹⁾	NA	0
6	Main line	0	0	L1	NA	NA	NA	NA	NA	0	NA	L1 ⁽⁶⁾
7	Distribution lines	NA	NA	L1	NA	NA	0	NA	NA	0	NA	L1 ⁽²⁾
FLAMMABLE LIQUIDS (flash point > 60°C (140°F))												
8	Cargo lines	X	X	L1	X	X	NA ⁽³⁾	0	0 ⁽¹⁰⁾	0	NA	L1
9	Fuel oil	X	X	L1	X	X	NA ⁽³⁾	0	0	0	L1	L1
10	Lubricating oil	X	X	L1	X	X	NA	NA	NA	0	L1	L1
11	Hydraulic oil	X	X	L1	X	X	0	0	0	0	L1	L1
SEA WATER (See Note 1)												
12	Bilge main and branches	L1 ⁽⁷⁾	L1 ⁽⁷⁾	L1	X	X	NA	0	0	0	NA	L1
13	Fire main and water spray	L1	L1	L1	X	NA	NA	NA	0	0	X	L1
14	Foam system	L1W	L1W	L1W	NA	NA	NA	NA	NA	0	L1W	L1W
15	Sprinkler system	L1W	L1W	L3	X	NA	NA	NA	0	0	L3	L3
16	Ballast	L3	L3	L3	L3	X	0 ⁽¹⁰⁾	0	0	0	L2W	L2W
17	Cooling water, essential services	L3	L3	NA	NA	NA	NA	NA	0	0	NA	L2W
18	Tank cleaning services, fixed machines	NA	NA	L3	NA	NA	0	NA	0	0	NA	L3 ⁽²⁾
19	Non-essential systems	0	0	0	0	0	NA	0	0	0	0	0
FRESH WATER												
20	Cooling water, essential services	L3	L3	NA	NA	NA	NA	0	0	0	L3	L3
21	Condensate return	L3	L3	L3	0	0	NA	NA	NA	0	0	0
22	Non-essential systems	0	0	0	0	0	NA	0	0	0	0	0
SANITARY/DRAINS/SCUPPERS												
23	Deck drains (internal)	L1W ⁽⁴⁾	L1W ⁽⁴⁾	NA	L1W ⁽⁴⁾	0	NA	0	0	0	0	0
24	Sanitary drains (internal)	0	0	NA	0	0	NA	0	0	0	0	0
25	Scuppers and discharges (overboard)	0 ^(1,8)	0 ^(1,8)	0 ^(1,8)	0 ^(1,8)	0 ^(1,8)	0	0	0	0	0 ^(1,8)	0
VENTS/SOUNDING												
26	Water tanks/dry spaces	0	0	0	0	0	0 ⁽¹⁰⁾	0	0	0	0	0
27	Oil tanks (flashpoint 60°C (140°F))	X	X	X	X	X	X ⁽³⁾	0	0 ⁽¹⁰⁾	0	X	X
MISCELLANEOUS												
28	Control air	L1 ⁽⁵⁾	L1 ⁽⁵⁾	L1 ⁽⁵⁾	L1 ⁽⁵⁾	L1 ⁽⁵⁾	NA	0	0	0	L1 ⁽⁵⁾	L1 ⁽⁵⁾
29	Service air (non-essential)	0	0	0	0	0	NA	0	0	0	0	0
30	Brine	0	0	NA	0	0	NA	NA	NA	0	0	0
31	Auxiliary low pressure steam (pressure ≤ 7 bar (7 kgf/cm ² , 100 psi))	L2W	L2W	0 ⁽⁹⁾	0 ⁽⁹⁾	0 ⁽⁹⁾	0	0	0	0	0 ⁽⁹⁾	0 ⁽⁹⁾

Locations

- A Category A machinery spaces
- B Other machinery spaces
- C Cargo pump rooms
- D Ro/Ro cargo holds
- E Other dry cargo holds
- F Cargo tanks
- G Fuel oil tanks
- H Ballast water tanks
- I Cofferdams, void spaces, pipe tunnels and ducts
- J Accommodation, service and control spaces
- K Open decks

Abbreviations

- L1 Fire endurance test in dry conditions, 60 minutes, in accordance with 4-4-2/7.13
- L2 Fire endurance test in dry conditions, 30 minutes, in accordance with 4-4-2/7.13
- L3 Fire endurance test in wet conditions, 30 minutes, in accordance with 4-4-2/7.15
- 0 No fire endurance test required
- NA Not applicable
- X Metallic materials having a melting point greater than 925°C (1700°F)

TABLE 2 (continued)
Fire Endurance Requirements Matrix for Plastic Pipes (2015)

Notes:

- 1 Where non-metallic piping is used, remotely controlled valves are to be provided at the vessel's side. These valves are to be controlled from outside the space.
- 2 Remote closing valves are to be provided at the cargo tanks.
- 3 When cargo tanks contain flammable liquids with a flash point greater than 60°C (140°F), "0" may replace "NA" or "X".
- 4 (2015) For drains serving only the space concerned, "0" may replace "L1W".
- 5 When controlling functions are not required by statutory requirements, "0" may replace "L1".
- 6 For pipe between machinery space and deck water seal, "0" may replace "L1".
- 7 For passenger vessels, "X" is to replace "L1".
- 8 Scuppers serving open decks in positions 1 and 2, as defined in Regulation 13 of the International Convention on Load Lines, 1966, are to be "X" throughout, unless fitted at the upper end with the means of closing capable of being operated from a position above the freeboard deck in order to prevent downflooding.
- 9 For essential services such as fuel oil tank heating and ship's whistle, "X" is to replace "0".
- 10 For tankers where compliance with Regulation 19.3.6 of Annex I of MARPOL 73/78 is required, "NA" is to replace "0".

TABLE 3
Standards for Plastic Pipes – Typical Requirements for All Systems (2007)

	<i>Test</i>	<i>Typical Standard</i>	<i>Notes</i>
1	Internal pressure ⁽¹⁾	4-4-2/7.5.1 ASTM D 1599, ASTM D 2992 ISO 15493 or equivalent	Top, Middle, Bottom (of each pressure range) Tests are to be carried out on pipe spools made of different pipe sizes, fittings and pipe connections.
2	External pressure ⁽¹⁾	4-4-2/7.5.2 ISO 15493 or equivalent	As above, for straight pipes only.
3	Axial strength ⁽¹⁾	4-4-2/7.5.3	As above.
4	Load deformation	ASTM D 2412 or equivalent	Top, Middle, Bottom (of each pressure range)
5	Temperature limitations ⁽¹⁾	4-4-2/7.5.4 ISO 75 Method A GRP piping system: HDT test on each type of resin acc. to ISO 75 method A. Thermoplastic piping systems: ISO 75 Method A ISO 306 Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST) VICAT test according to ISO 2507 Polyesters with an HDT below 80°C should not be used.	Each type of resin
6	Impact resistance ⁽¹⁾	4-4-2/7.5.5 ISO 9854: 1994, ISO 9653: 1991 ISO 15493 ASTM D 2444, or equivalent	Representative sample of each type of construction
7	Ageing	Manufacturer's standard ISO 9142:1990	Each type of construction
8	Fatigue	Manufacturer's standard or service experience.	Each type of construction
9	Fluid absorption	ISO 8361:1991	
10	Material compatibility ⁽²⁾	ASTM C581 Manufacturer's standard	

Notes:

- 1 Where the manufacturer does not have a certified quality system, test to be witnessed by the Surveyor. See 4-4-2/7.9.
- 2 If applicable.

TABLE 4
Standards for Plastic Pipes – Additional Requirements
Depending on Service and/or Location of Piping (2007)

	<i>Test</i>	<i>Typical Standard</i>	<i>Notes</i>
1	Fire endurance ^(1,2)	4-4-2/7.5.6	Representative samples of each type of construction and type of pipe connection.
2	Flame spread ^(1,2)	4-4-2/7.5.7	Representative samples of each type of construction.
3	Smoke generation ⁽²⁾	IMO Fire Test Procedures Code	Representative samples of each type of construction.
4	Toxicity ⁽²⁾	IMO Fire Test Procedures Code	Representative samples of each type of construction.
5	Electrical conductivity ^(1,2)	4-4-2/7.5.8 ASTM F1173-95 or ASTM D 257, NS 6126/ 11.2 or equivalent	Representative samples of each type of construction

Notes:

- 1 Where the manufacturer does not have a certified quality system, test to be witnessed by the Surveyor. See 4-4-2/7.9.
- 2 If applicable.

Note: Test items 1, 2 and 5 in 4-4-2/Table 4 are optional. However, if not carried out, the range of approved applications for the pipes will be limited accordingly (see 4-4-2/Table 2).

9 Material of Valves and Fittings

9.1 General

The physical characteristics of such material are to be in accordance with the applicable requirements of Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)* or other such appropriate material specifications as may be approved in connection with a particular design for the stresses and temperatures to which they may be exposed. Manufacturers are to make physical tests of each melt and, upon request, are to submit the results of such tests to ABS.

9.3 Forged or Cast Steel

In any system, forged or cast steel may be used in the construction of valves and fittings for all pressures and temperatures. Consideration is to be given to the possibility of graphite formation in the following steels: Carbon steel above 425°C (800°F); carbon-molybdenum steel above 468°C (875°F); chrome-molybdenum steel (with chromium under 0.60%) above 524°C (975°F).

9.5 Cast Iron

For temperatures not exceeding 232°C (450°F), cast iron of the physical characteristics specified in Section 2-3-6 of the *ABS Rules for Materials and Welding (Part 2)* may be used in the construction of valves and fittings, except in locations for which it is specifically prohibited elsewhere in the Rules.

9.7 Ductile (Nodular) Iron

Nodular-iron applications for valves will be specially considered when the material has an elongation of not less than 12% in 50 mm (2 in.) and where the temperature does not exceed 343°C (650°F). See Section 2-3-5 of the *ABS Rules for Materials and Welding (Part 2)*.

9.9 Brass and Bronze

Brass or bronze having the physical characteristics as specified in Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)* may be used in the construction of valves and fittings intended for temperatures up to 208°C (406°F). For temperatures greater than 208°C (406°F) but not in excess of 288°C (550°F), high-temperature bronze is to be used and the chemical and physical characteristics are to be submitted for approval.

Valves, fittings and flanges of nonferrous material may be attached to nonferrous pipe by an approved soldering method. For pressures up to 6.9 bar (7 kgf/cm², 100 psi) and temperatures not exceeding 93°C (200°F), ordinary solder may be used, but for higher pressures and temperatures, the method and the quality of solder to be used will be considered for each case.

9.11 Plastic

Rigid plastic compounds for valves and fittings in plastic piping systems will be considered for Group II piping systems. The design pressure and temperature together with the physical characteristics of the material verifying compliance with the requirements of 4-4-2/7 are to be submitted in all cases.

11 Valves

11.1 General

11.1.1 Standard Valves

Valves constructed and tested in accordance with a recognized standard may be used, subject to compliance with 4-4-2/11.5.

11.1.2 Non-Standard Valves

All other valves not certified by the manufacturer as being in accordance with a recognized standard may be accepted based on evidence verifying their suitability for the intended service. Acceptable evidence includes testing or analysis demonstrating adequacy including both structural and material capability aspects. Drawings of such valves showing details of construction and materials are to be submitted for review, as well as the basis for valve pressure rating, such as design calculations or appropriate burst test data.

11.3 Construction

All valves are to close with a right hand (clockwise) motion of the handwheel when facing the end of the stem and are to be either of the rising-stem type or fitted with an indicator to show whether the valve is open or closed.

All valves of Group I piping systems having nominal diameters exceeding 50 mm (2 in.) are to have bolted, pressure seal or breech lock bonnets and flanged or welding ends. Welding ends are to be the butt weld type, except that socket weld ends may be used for valves having nominal diameters of 80 mm (3 in.) or less, up to and including 39.2 bar (40.0 kgf/cm²) pressure rating class (ASME 600 Class), and for valves having nominal diameters of 65 mm (2.5 in.) or less, up to and including 98.1 bar (100 kgf/cm²) pressure rating class (ASME 1500 Class).

All cast iron valves are to have bolted bonnets or are to be of the union bonnet type. For cast iron valves of the union bonnet type, the bonnet ring is to be of steel, bronze or malleable iron.

Stems, discs or disc faces, seats and other wearing parts of valves are to be of corrosion-resistant materials suitable for the intended service.

Valves are to be designed for the maximum pressure to which they will be subjected. The design pressure is to be at least 3.4 bar (3.5 kgf/cm², 50 psi). Valves used in open systems, such as vent and drain lines, (for example, level gauge and drain cocks) may be designed for a pressure below 3.4 bar (3.5 kgf/cm², 50 psi), subject to the requirements of 4-4-2/11.1. Large fabricated ballast manifolds which connect lines exceeding 200 mm (8 in.) nominal pipe size may be used when the maximum pressure to which they will be subjected does not exceed 1.7 bar (1.75 kgf/cm², 25 psi).

All valves for Group I piping systems and valves intended for use in oil lines are to be constructed so that the stem is positively restrained from being screwed out of the body (bonnet). Plug valves, butterfly valves and valves employing resilient material will be subject to special consideration. Valve operating systems for all valves which cannot be manually operated are to be submitted for approval.

11.5 Hydrostatic Test and Identification

All valves are to be subjected by the manufacturer to a hydrostatic test at a pressure equal to that stipulated by the American National Standards Institute or other recognized standard. They are to bear the trademark of the manufacturer legibly stamped or cast on the exterior of the valve and the primary pressure rating at which the manufacturer identifies the valve as meeting the requirements of the standards.

13 Pipe Fittings

13.1 General

All fittings in Group I piping are to have flanged or welded ends in sizes over 89 mm O.D. (3 in. N.P.S.). Screwed fittings may be used in Group I piping systems, provided the temperature does not exceed 496°C (925°F) and the pressure does not exceed the maximum pressure indicated below for the pipe size.

<i>Pipe Size mm O.D. (in. N.P.S.)</i>	<i>Maximum Pressure bar (kgf/cm², psi)</i>
above 89 (3)	not permitted in Group I piping service
above 60 (2) through 89 (3)	27.6 (28.10, 400)
above 33 (1) through 60 (2)	41.4 (42.20, 600)
above 27 (0.75) through 33 (1)	82.8 (84.40, 1200)
27 (0.75) and smaller	103 (105.50, 1500)

Flared, flareless and compression fittings may be used for tube sizes not exceeding 60 mm O.D. (2 in. NPS) in Group I piping. In Group II piping, screwed fittings, flared, flareless and compression tube fittings will be accepted without size limitations. Flared fittings are to be used for flammable fluid systems, except that both flared and flareless fittings of the non-bite type may be used when the tubing system is of steel or nickel-copper or copper-nickel alloys. Only flared fittings are to be used when tubing for flammable fluid systems is of copper or copper-zinc alloys. See 4-4-6/1.7 for hydraulic systems.

13.3 Hydrostatic Test and Identification

All fittings are to be subjected by the manufacturer to a hydrostatic test at a pressure equal to that stipulated by the American National Standards Institute or other recognized standard. They are to bear the trademark of the manufacturer legibly stamped or cast on the exterior of the fitting and also the primary pressure rating at which the manufacturer guarantees the fitting to meet the requirements of the standards.

13.5 Nonstandard Fittings

Fittings which are not certified by the manufacturer as being in accordance with a recognized standard may be accepted based on evidence verifying their suitability for the intended service. Acceptable evidence includes testing or analysis demonstrating adequacy including both structural and material capability aspects. Drawings of such fittings showing details of construction, material and design calculations or test results are to be submitted for review.

13.7 Mechanical Joints (2005)

The installation of mechanical pipe joints, as covered by 4-4-2/13.1 and 4-4-2/13.5, is to be in accordance with the manufacturer's assembly instructions. Where special tools and gauges are required for installation of the joints, these are to be specified and supplied as necessary by the manufacturer. These special tools are to be kept onboard.

15 Welded Nonstandard Valves and Fittings

Non-Standard steel valves and fittings fabricated by means of fusion welding are to also comply with the requirements of Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*. However, after a manufacturer's procedure in the fabrication of equipment of this kind has been demonstrated by tests to the satisfaction of an ABS Surveyor, subsequent tests on the product need not be witnessed, but the manufacturer's guarantee that the Rules are complied with will be accepted as to other valves and fittings which conform to standards of the American National Standards Institute or other recognized standards.

17 Flanges

17.1 General

Flanges are to be designed and fabricated in accordance with a recognized standard. Slip-on flanges from flat plate may be substituted for hubbed slip-on flanges in Group II piping systems.

17.3 Group I Piping Flanges

In Group I piping, flanges may be attached to the pipes by any of the following methods appropriate for the material involved:

17.3.1 Steel Pipe

Over 60 mm O.D. (2 in. NPS) steel pipes are to be expanded into steel flanges, or they may be screwed into the flanges and seal-welded. They may in all cases be attached by fusion welding in compliance with the requirements of 2-4-2/9. Smaller pipes may be screwed without seal-welding, but oil lines are, in addition, to be expanded into the flanges in order to insure uniformly tight threads.

17.3.2 Nonferrous Pipe

In Group I, nonferrous pipes are to be brazed to composition metallic or steel flanges, and in sizes of 60 mm O.D. (2 in. NPS) and under, they may be screwed.

17.5 Group II Piping Flanges

Similar attachments are also to be used in Group II piping. However, modifications are permitted for welded flanges, as noted in 2-4-2/9.5 and 2-4-2/9.7, and screwed flanges of suitable material may be used in all sizes.

17.7 Group II Plastic Piping Flanges

Rigid plastic compounds for flanges in plastic piping systems will be considered for Group II piping systems. The design pressure and temperature together with the physical characteristics of the material are to be submitted in all cases.

19 Sea Inlets and Overboard Discharges

19.1 Installation (2006)

Piping connections bolted to the shell plating are to have the bolt heads countersunk on the outside and the bolts threaded through the plating. Where a reinforcing ring of sufficient thickness is welded to the inside of the shell, studs may be used. For compensation in way of holes in the shell plating, see 3-2-2/11.

Threaded connections outboard of the shell valves are not considered an acceptable method of connection pipe to the shell.

19.3 Valve Connections to Shell (2015)

Wafer type valves are not to be used for any connections to the vessel's shell unless specially approved. Lug type butterfly valves used as shell valves are to have a separate set of bolts on each end of the valve so that the inboard end may be disconnected with the valve closed to maintain its watertight integrity.

Where a distance piece is fitted between the shell and the shell valves, the pipe is to be as short as possible and of wall thickness not less than that specified in 4-4-2/23.3.5(a).

19.5 Materials

All shell fittings and valves required by 4-4-2/21 and 4-4-2/23 are to be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable. The use of nodular iron, also known as ductile iron or spheroidal-graphite iron, will be accepted, provided the material has an elongation of not less than 12% in 50 mm (2 in.). All pipes to which this subsection refers are to be of steel or other equivalent material, subject to special approval.

19.7 Shell Reinforcement

Overboard discharges are to have spigots extending through the shell plate and doubling plate, where fitted, but need not project beyond the outside surface of the vessel.

19.9 Common Overboard Discharge

In general, various types of systems which discharge overboard are not to be interconnected without special approval; that is, closed pumping systems, deck scuppers, gravity drains, etc. are not to have a common overboard discharge.

21 Machinery and Pumping Systems

21.1 Valves Required (2006)

Positive closing valves are to be fitted at the shell in inlet and discharge piping. The controls are to be readily accessible and are to be provided with indicators showing whether the valves are open or closed. In order to be considered readily accessible, the controls, during normal operating conditions, are to be:

- i) Located in a space normally entered without using tools,
- ii) Clear of or protected from obstructions, moving equipment and hot surfaces that prevent operation or servicing, and
- iii) Within operator's reach.

Materials readily rendered ineffective by heat are not to be used for connection to the shell where the failure of the material in the event of a fire would give rise to danger of flooding.

21.3 Sea Chests

The locations of sea chests are to be such as to minimize the probability of blanking off the suction and arranged so that the valves may be operated from the floors or gratings. Power-operated sea valves are to be arranged for manual operation in the event of a failure of the power supply.

21.3.1 Strainer Plates

Sea chests are to be fitted with strainer plates at the vessel's side. The strainers are to have a clear area of at least 1.5 times the area of the sea valves. Efficient means are to be provided for clearing the strainers.

21.3.2 Ice Strengthening

For vessels with ice strengthening, see Part 6, Chapter 1 of the *Steel Vessel Rules*.

23 Scuppers and Drains

23.1 General (2007)

23.1.1 Application

These requirements apply to gravity drain systems from watertight and non-watertight spaces located either above or below the freeboard deck.

23.1.2 Definitions

23.1.2(a) Gravity drain system. A gravity drain system is a piping system in which flow is accomplished solely by the difference between the height of the inlet end and the outlet end. For the purposes of the Rules, gravity drain systems include those which discharge both inside and outside the vessel.

23.1.2(b) Gravity discharge. A gravity discharge is an overboard drain from a watertight space such as spaces below freeboard deck or within enclosed superstructures or deckhouses. Back-flooding through a gravity discharge would affect the reserve buoyancy of the vessel.

23.1.2(c) Inboard end. The inboard end of an overboard gravity discharge pipe is that part of the pipe at which the discharge originates. The inboard end to be considered for these requirements is the lowest inboard end where water would enter the vessel if back-flooding would occur.

23.1.2(d) Scupper. A scupper is an overboard drain from a non-watertight space or deck area. Back-flooding through a scupper would not affect the reserve buoyancy of the vessel.

23.1.3 Basic Principles

Enclosed watertight spaces (spaces below freeboard deck or within enclosed superstructures or deckhouses) are to be provided with means of draining. This may be achieved by connection to the bilge system or by gravity drains. In general, a gravity drain is permitted wherever the position of the space allows liquid to be discharged by gravity through an appropriate opening in the boundary of the space. Unless specifically stated (see 4-4-2/23.5.1(b) or the following paragraph), the discharge can be directed overboard or inboard. Where directed overboard, means are to be provided to prevent entry of sea water through the opening in accordance with 4-4-2/23.3. Where directed inboard, suitable arrangements are to be provided to collect and dispose of the drainage.

Non-watertight spaces (open superstructures or deckhouses) and open decks, where liquid can accumulate, are also to be provided with means of draining. In general, a gravity drain is permitted for all non-watertight spaces. All such drains are to be directed overboard.

Gravity drains are to be capable of draining the space when the vessel is on even keel and either upright or listed 5 degrees on either side.

23.3 Protection from Sea Water Entry (2007)

23.3.1 Overboard Gravity Discharges – Normally Open (2012)

23.3.1(a) General. Discharges led through the shell, either from spaces below the freeboard deck or from within superstructures and deckhouses on the freeboard deck fitted with doors complying with the requirements of 3-2-9/5, are to be fitted with efficient and accessible means for preventing water from passing inboard.

Normally, each separate discharge is to have one automatic non-return valve with a positive means of closing it from a position above the freeboard deck, except as below. Alternatively, one automatic non-return valve and one positive closing valve controlled from above the freeboard deck may be accepted.

Where the vertical distance from the summer loadline to the inboard end of the discharge pipe exceeds $0.01L$, the discharge may have two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions. The inboard valve is to be above the tropical load waterline. If this is not practicable, then, provided a locally controlled stop valve is interposed between the two non-return valves, the inboard valve need not be fitted above the tropical load waterline.

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds $0.02L$, a single automatic non-return valve without positive means of closing may be accepted, provided it is located above the tropical load waterline (or, where assigned, timber tropical load waterline). If this is impracticable, a locally operated positive closing valve may be provided below the single non-return valve, in which case, the non-return valve need not be located above the specified tropical load waterline.

L is defined in 3-1-1/3. The means for operating the positive-action valve is to be readily accessible and provided with an indicator showing whether the valve is open or closed. See 4-4-2/Figure 3.

23.3.1(b) *Manned Machinery Space.* Where sanitary discharges and scuppers lead overboard through the shell in way of manned machinery spaces, the fitting to the shell of a locally operated positive closing valve, together with a non-return valve inboard, will be acceptable.

See 4-4-2/Figure 1 for the acceptable arrangements of scuppers, inlets and discharges.

FIGURE 3
Overboard Discharges – Valve Requirements (2012)

Discharges coming from enclosed spaces below the freeboard deck or on the freeboard deck				Discharges coming from other spaces	
General requirement where inboard end < 0.01L above SWL	Discharges through manned machinery space	Alternatives where inboard end		outboard end > 450 mm below FB deck or < 600 mm above SWL	otherwise
		> 0.01L above SWL	> 0.02L above SWL		
<p>* / control of the valves are to be in an approved position</p>					
<p>Symbols:</p> <ul style="list-style-type: none"> inboard end of pipes outboard end of pipes pipes terminating on the open deck non return valve without positive means of closing non return valve with positive means of closing controlled locally valve controlled locally remote control normal thickness substantial thickness 					

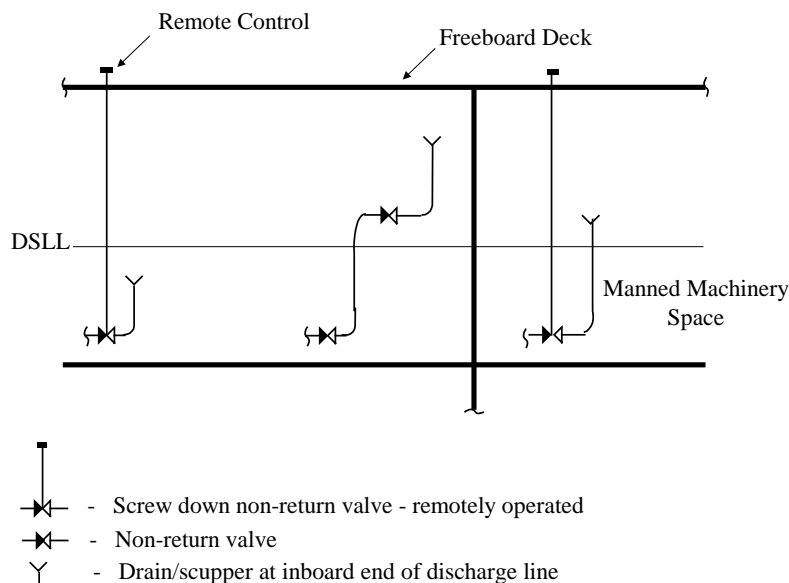
23.3.2 Overboard Gravity Discharges – Normally Closed

For overboard discharges which are closed at sea, such as gravity drains from topside ballast tanks, a single screw down valve operated from above the freeboard deck is acceptable.

23.3.3 Overboard Gravity Discharges from Spaces below the Freeboard Deck on Vessels Subject to SOLAS Requirements

For vessels subject to SOLAS requirements, instead of the requirements identified in 4-4-2/23.3.1 above, each separate gravity discharge led through the shell plating from spaces below the freeboard deck is to be provided with either one automatic non–return valve fitted with a positive means of closing it from above the freeboard deck or with two automatic non–return valves without positive means of closing, provided that the inboard valve is situated above the deepest subdivision load line (DSL) and is always accessible for examination under service conditions. Where a valve with positive means of closing is fitted, the operating position above the freeboard deck shall always be readily accessible and means shall be provided for indicating whether the valve is open or closed.

FIGURE 4
SOLAS Vessels – Overboard Discharges from Spaces below
Freeboard Deck – Valve Requirements (2007)



23.3.4 Scuppers and Discharges below the Freeboard Deck – Shell Penetration

Scuppers and discharge pipes originating at any level and penetrating the shell either more than 450 mm (17.5 in.) below the freeboard deck or less than 600 mm (23.5 in.) above the summer load waterline are to be provided with a non-return valve at the shell. This valve, unless required above, may be omitted if the length of piping up to the freeboard deck has a wall thickness at least equal to the thickness of the shell plating or extra-heavy pipe, whichever is less.

23.3.5 Required Minimum Wall Thicknesses for Pipes (2012)

For pipes in the gravity drain systems covered by 4-4-2/23.3, the wall thickness of steel piping are not be less than given below:

23.3.5(a) Piping where substantial thickness is required. For scupper and discharge pipes between hull plating and the closeable or non-return valve, where substantial thickness is required:

- i) External diameter of pipes equal to or less than 80 mm (3.15 in.): thickness not less than 7.0 mm (0.276 in.)
- ii) External diameter of pipes 180 mm (7.1 in.): thickness not less than 10.0 mm (0.394 in.)
- iii) External diameter of pipes equal to or more than 220 mm (8.7 in.): thickness not less than 12.5 mm (0.5 in.)

Intermediate sizes are to be determined by linear interpolation.

23.3.5(b) Piping where substantial thickness is not required. For scupper and discharge pipes inboard of a closeable or non-return valve, where substantial thickness is not required:

- i) External diameter of pipes equal to or less than 155 mm (6.1 in.): thickness not less than 4.5 mm (0.177 in.)
- ii) External diameter of pipes equal to or more than 230 mm (9.1 in.): thickness not less than 6.0 mm (0.236 in.)

Intermediate sizes are to be determined by linear interpolation.

23.5 Gravity Drains from Superstructures or Deckhouses

23.5.1 Enclosed Cargo Spaces (2007)

Drainage of enclosed cargo spaces situated on the bulkhead deck or the freeboard deck is to be provided with the following:

23.5.1(a) Where the summer freeboard is such that the deck edge of the space being drained is not immersed when the vessel heels five degrees, the drainage is to be by means of a sufficient number of gravity drains of suitable size discharging directly overboard, in accordance with 4-4-2/23.3.

23.5.1(b) Where the summer freeboard is such that the deck edge of the space being drained is immersed when the vessel heels five degrees, the drainage of the enclosed cargo spaces is to be led to a suitable space, or spaces, of adequate capacity, having a high water level alarm and provided with suitable arrangements for discharge overboard. In addition, the system is to be designed such that:

- i) The number, size and disposition of the drain pipes are to prevent unreasonable accumulation of free water;
- ii) The pumping arrangements are to take into account the requirements for any fixed, pressurized, water spraying, fire extinguishing system;
- iii) Water contaminated with oil or other dangerous substances is not drained to machinery spaces or other spaces where sources of ignition may be present; and
- iv) Where the enclosed cargo space is protected by a fixed gas fire extinguishing system, the drain pipes are fitted with means to prevent the escape of the smothering gas.

23.5.2 Open Superstructures and Deckhouses

Scuppers leading from superstructures or deckhouses not fitted with doors complying with the requirements of 3-2-9/5 are to be led overboard.

23.7 Vessels Receiving Subdivision Loadlines

For vessels receiving subdivision loadlines, the bulkhead deck is to apply to provisions given in 4-4-2/23.3 when it is higher than the freeboard deck.

25 Cooler Installations External to the Hull

25.1 General

The inlet and discharge connections of external cooler installations are to be in accordance with 4-4-2/19.1 through 4-4-2/19.5 and 4-4-2/21.1, except that wafer type valves will be acceptable.

25.3 Integral Keel Cooler Installations

The positive closing valves required by 4-4-2/25.1 need not be provided if the keel (skin) cooler installation is integral with the hull. To be considered integral with the hull, the installation is to be constructed such that channels are welded to the hull with the hull structure forming part of the channel, the channel material is to be at least the same thickness and quality as that required for the hull and the forward end of the cooler is to be faired to the hull with a slope of not greater than 4 to 1.

If positive closing valves are not required at the shell, all flexible hoses or joints are to be positioned above the deepest load waterline or be provided with an isolation valve.

25.5 Non-integral Keel Cooler Installations (2006)

Where non-integral keel coolers are used, if the shell penetrations are not fully welded, the penetration is to be encased in a watertight enclosure.

Non-integral keel coolers are to be suitably protected against damage from debris and grounding by recessing the unit into the hull or by the placement of protective guards.

PART

4

CHAPTER 4 Pumps and Piping Systems

SECTION 3 Bilge and Ballast Systems and Tanks

1 General Arrangement of Bilge Systems (2011)

A pumping system is to be provided in all vessels capable of pumping from and draining any compartment when the vessel is on an even keel and either upright or listed five degrees. For this purpose, wing suctions will often be necessary, except in narrow compartments at the ends of the vessel. Arrangements are to be made whereby water in the compartment will drain to the suction pipes. Efficient means are to be provided for draining water from all tank tops and other watertight flats. Peak tanks and comparatively small compartments, such as chain lockers, echo sounder spaces, and decks over peak tanks, etc., may be drained by ejectors or hand pumps. Where ejectors are used for this purpose, the overboard discharge arrangements are to comply with 4-4-2/23.

3 Bilge and Ballast Pumps (2015)

3.1 Number of Bilge Pumps

All self-propelled vessels 20 m (65 ft) in length or greater are to be provided with two power driven bilge pumps, one of which may be attached to the propulsion unit. Vessels under 20 m (65 ft) in length are to be provided with one fixed power driven pump, which may be an attached unit, and one portable hand pump.

3.3 Bilge Pump Capacity

The capacity of each pump is to be in accordance with the following:

<i>Vessel Length</i>	<i>Minimum Capacity per Pump</i>
Below 20 m (65 ft)	5.5 m ³ /hr (25 gpm) (hand pump 5 gpm, 1.13 m ³ /hr)
20 m (65 ft) or greater but below 30.5 m (100 ft)	11.36 m ³ /hr (50 gpm)
30.5 m (100 ft) or greater but below 45.7 m (150 ft)	14.33 m ³ /hr (66.6 gpm)
45.7 m (150 ft) and greater	$Q = 5.66d^2/10^3$ m ³ /hr $Q = 16.1d^2$ gpm

Q = pump capacity

d = required diameter of main bilge line suction, mm (in.). See 4-4-3/5.9.

When more than two pumps are connected to the bilge system, their arrangement and aggregate capacity are not to be less effective.

3.5 Independent Power Bilge Pumps

Sanitary, ballast and general service pumps may be accepted as independent power bilge pumps, provided they are of the required capacity and are fitted with the necessary control valves required by 4-4-3/5.1 for pumping bilges.

3.7 Number of Ballast Pumps

All self-propelled vessels 20 m (65 ft) in length or greater are to be provided with at least two power driven ballast pumps, one of which may be driven by the propulsion unit. Sanitary, bilge and general service pumps may be accepted as independent power ballast pumps.

Alternative means of deballasting, such as an educator or a suitable liquid cargo pump with an appropriate temporary connection to the ballast system, may be accepted in lieu of a second ballast pump.

3.9 Centrifugal Pumps

Where centrifugal pumps are installed, suitable means for priming are to be provided.

5 Bilge and Ballast Piping

5.1 General

The arrangement of the bilge and ballast pumping systems is to be such as to prevent the possibility of water or oil passing into the cargo and machinery spaces, or from one compartment to another, whether from the sea, water ballast or oil tanks. The bilge and ballast mains are to have separate control valves at the pumps.

5.3 Installation

Bilge or ballast pipes, where permitted to pass through compartments intended for the carriage of oil, are to be of either steel or wrought iron.

Where bilge pipes in way of deep tanks are not led through a watertight or oil-tight tunnel, the bilge lines are to be of steel and extra heavy. Similarly, where ballast pipes in way of deep tanks other than ballast tanks are not led through a watertight or oil-tight tunnel, the ballast lines are to be of steel and extra heavy. For both bilge and ballast piping, the number of joints is to be kept to a minimum and to be arc welded or extra heavy flanged. The piping within a deep tank is to be installed to take care of expansion. A non-return valve is to be fitted at the open end of bilge pipes.

5.5 Manifolds, Cocks and Valves

5.5.1 General

All manifolds, cocks and valves in connection with the bilge pumping arrangement are to be in positions which are accessible at all times under ordinary circumstances. All valves in the machinery space controlling the bilge suction from the various compartments are to be of the stop-check type. If valves are fitted at the open ends of pipes, they are to be of the non-return type.

5.5.2 Common-main-type Bilge Systems (2005)

A common-main bilge system normally consists of one or more main lines installed along the length of the vessel fitted with branch bilge suction connections to various compartments. Where only one fore-and-aft bilge main is installed, the bilge main is to be located inboard of 20% of the molded beam of the vessel, measured inboard from the side of the ship perpendicular to the centerline at the level of the summer load line. If there is at least one bilge main on each side of the vessel, then those bilge mains may be installed within 20% of the molded beam, measured inboard from the side of the ship perpendicular to the centerline at the level of the summer load line, provided they are fitted with branch lines and control valves arranged such that it is possible to effectively pump out each compartment using the main(s) on either side of the vessel.

For all common-main-type bilge systems, the control valves required in the branches from the bilge main are to be accessible at all times and are to be of the stop-check type with an approved type of remote operator. Remote operators may be located in a manned machinery space, or from an accessible position above the freeboard deck or from underdeck walkways. Remote operators may be of the hydraulic, pneumatic, electric or reach-rod type.

5.5.3 Controls for Ballast Tank Valves

Ballast tank valves are to be arranged so they will remain closed at all times, except when ballasting. For this purpose, manual screw thread operated valves, positive holding arrangements for butterfly type valves or other equivalent arrangements may be used. Where installed, remote controlled valves are to be arranged so they will close and remain closed upon loss of control power, or will remain in their last position and are provided with a readily accessible manual means of operation in case of loss of power to the valve control system. Remote control of bilge and ballast valves is to be clearly marked at the control station and means are to be provided to indicate whether the valve is open or closed.

5.7 Strainers (2005)

Bilge lines in machinery spaces other than emergency suction are to be fitted with strainers easily accessible from the floor plates and are to have straight tail pipes to the bilges. The ends of bilge lines in other compartments are to be fitted with suitable strainers having an open area of not less than three times the area of the suction pipe.

5.9 Size of Bilge Suctions

The least internal diameter of bilge suction pipes is to be that of the nearest commercial size within 6 mm (0.25 in.) of the diameter determined by the following equations:

5.9.1 Main Line

For the diameter of main bilge line suction and direct bilge suction to the pumps:

$$d = 25 + 1.68\sqrt{L(B+D)} \quad \text{mm} \qquad d = 1 + \sqrt{L(B+D)/2500} \quad \text{in.}$$

5.9.2 Branch Lines

For the equivalent diameter of the combined branch suction to a compartment:

$$d = 25 + 2.16\sqrt{c(B+D)} \quad \text{mm} \qquad d = 1 + \sqrt{c(B+D)/1500} \quad \text{in.}$$

where

- d = internal diameter of pipe, in mm (in)
- L = length of vessel, as defined in 3-1-1/3, in m (ft)
- B = breadth of vessel, as defined in 3-1-1/5, in m (ft)
- c = length of compartment, in m (ft)
- D = molded depth to bulkhead or freeboard deck, in m (ft), except that for the main line in a vessel having an enclosed cargo space on the bulkhead or freeboard deck which is internally drained in accordance with 4-4-2/23.5.1(b) and which extends for the full length of the vessel, D is to be measured to the next deck above the bulkhead or freeboard deck. Where the enclosed cargo spaces cover a lesser length, D is to be taken as a molded depth to the bulkhead or freeboard deck plus $\ell h/L$, where ℓ and h are aggregate length and height, respectively, of the enclosed cargo spaces.

5.9.3 Main Line Reduction

Where engine room bilge pumps are fitted primarily for drainage within the engine room, L may be reduced by the combined length of the cargo tanks or cargo holds. In such cases, the cross sectional area of the bilge main is not to be less than twice the required cross sectional area of the engine room branch lines.

5.9.4 Alternate Size Requirements

For vessels below 30.5 m (100 ft) in length, the bilge pipe sizes may be in accordance with the following in lieu of 4-4-3/5.9.1.

<i>Vessel Length</i>	<i>Minimum Pipe Size (I.D.)</i>
Below 20 m (65 ft)	25 mm (1 in.)
20 m (65 ft) or greater but below 30.5 m (100 ft)	38 mm (1.5 in.)

5.9.5 Size Limits

For vessels of 30.5 m (100 ft) in length or greater, no main suction piping is to be less than 63 mm (2.5 in.) internal diameter. No branch piping need be more than 100 mm (4 in.) I.D., nor is it to be less than 50 mm (2 in.) I.D., except that for drainage of small pockets or spaces 38 mm (1.5 in.) I.D. pipe may be used.

5.9.6 Bilge Common-main (2005)

The diameter of each common-main bilge line may be determined by the equation for bilge branches given in 4-4-3/5.9.2 using the combined compartment length upstream of the point where the diameter is being determined. In case of double hull construction with full depth wing tanks served by a ballast system, where the beam of the vessel is not representative of the breadth of the compartment, *B* may be appropriately modified to the breadth of the compartment. However, no common-main bilge pipe needs to be more than the diameter for the bilge main given in 4-4-3/5.9.1.

5.11 Gravity Drains

Gravity drains that penetrate the main machinery space watertight bulkheads below the freeboard deck and terminate within the main machinery space are to be fitted with a valve operable from above the freeboard deck or with quick-acting, self-closing valves. The valve should preferably be located in the main machinery space. When gravity drains from other spaces are terminated in cargo holds, the cargo hold bilge well is to be fitted with a high level alarm. Gravity drains which terminate in spaces which are protected by fixed gas extinguishing systems are to be fitted with means to prevent the escape of extinguishing medium.

5.13 Ballast Water Treatment Systems (1 July 2012)

Where a ballast water treatment system is to be installed, it is to comply with the requirements in Sections 4 and 5 of the *ABS Guide for Ballast Water Treatment* and the same is to be verified by ABS.

5.15 Oil Pollution Prevention Measures (2014)

5.15.1 General

Means are to be provided to process oil contaminated water from machinery space bilges prior to discharging it overboard for every vessel of 400 gross tonnage and above. In general, the discharge criteria of MARPOL ANNEX 1, Regulation 15 are to be complied with.

5.15.2 Oily Water Filtering or Separating Equipment

Oily water filtering equipment capable of processing oily mixtures to produce an effluent with oil content not exceeding 15 parts per millions (PPM) and complying with IMO Resolution MEPC.107(49) is to be provided to allow oily water from the bilges to be processed prior to discharging overboard. For vessels of 10,000 tons gross tonnage and above, the equipment is to be fitted with an alarm and an arrangement to automatically stop the discharge when 15 PPM cannot be maintained.

5.15.3 Sludge Tank

A tank or tanks of adequate capacity is to be provided to receive oily residues such as those resulting from the oily water filtering or separating equipment and from the purification of fuel and lubricating oils. The minimum sludge tank capacity V_1 is to be calculated by the following formula:

$$V_1 = K_1 CD \quad \text{m}^3 \text{ (ft}^3\text{)}$$

where

- K_1 = 0.015 for vessels where heavy fuel oil is purified for main engine use or
 = 0.005 for vessels using diesel oil or heavy fuel oil which does not require purification before use
- C = daily fuel oil consumption, $\text{m}^3 \text{ (ft}^3\text{)}$
- D = maximum period of voyage between ports where sludge can be discharged ashore (days). In the absence of precise data, a figure of 30 days is to be used.

The sludge tank is to be so designed as to facilitate cleaning. Where heavy fuel oil residue is expected to be received by the sludge tank, heating arrangements are to be provided to facilitate the discharge of the sludge tank.

5.15.4 Sludge Piping System

5.15.4(a) Sludge Pump. The sludge tank is to be provided with a designated pump of a suitable type, capacity and discharge head for the discharge of the tank content to shore reception facilities.

5.15.4(b) Standard Discharge Connection. To enable the discharge of sludge to shore reception facilities, the sludge piping is to be provided with a standard discharge connection, in accordance with 4-4-3/Table 1.

TABLE 1
Dimensions and Details of Standard Discharge Connection Flange (2014)

	<i>Dimension</i>
Outside diameter	215 mm
Inner diameter	According to pipe outside diameter
Bolt circle diameter	183 mm
Slots in flange	6 holes 22 mm in diameter equidistantly placed on a bolt circle of the above diameter, slotted to the flange periphery. The slot width to be 22 mm
Flange thickness	20 mm
Bolts and nuts:	6 sets, each of 20 mm in diameter and of suitable length
The flange is designed to accept pipes up to a maximum internal diameter of 125 mm and is to be of steel or other equivalent material having a flat face. This flange, together with a gasket of oil-proof material, is to be suitable for a service pressure of 6 kg/cm ²	

5.15.4(c) Sludge Piping. There is to be no interconnection between the sludge tank discharge piping and bilge piping other than the possible common piping, with appropriate valves, leading to the standard discharge connection. Piping to and from sludge tanks is to have no direct connection overboard other than the standard discharge connection referred to in 4-4-3/5.15.4(b).

7 Direct and Emergency Bilge Suctions for Main Machinery Spaces (2011)

7.1 Direct Bilge Suction

For vessels 20 m (65 ft) in length and greater, one of the independently driven bilge pumps (see 4-4-3/3.1) is to be fitted with a suction led directly from the main machinery space bilge to the suction valve chest of the pump and arranged so that it can be operated independently of the bilge system. The size of this line is to be such that the pump will deliver its full capacity. The direct bilge suction is to be controlled by a stop-check valve.

If watertight bulkheads separate the main machinery space into compartments, a direct suction is to be fitted to each compartment unless the pumps available for bilge service are distributed throughout these compartments. At least one pump in each such compartment is to be fitted with a direct suction for its compartment.

7.3 Emergency Bilge Suctions (2016)

In addition to the direct bilge suction in 4-4-3/7.1, an emergency bilge suction is to be fitted for the main machinery spaces on all oceangoing vessels 55 m (180 ft) in length and over. The emergency bilge suction is to be led straight to the largest independently driven pump in the main machinery space, other than the required bilge pumps. Where this pump is not suitable, the second largest suitable pump in the main machinery space may be used for this service, provided that the selected pump is not one of the required bilge pumps and its capacity is not less than that of the required bilge pump.

The area of the emergency bilge suction pipe is to be equal to the full suction inlet of the pump selected. The emergency bilge line is to be provided with a suction stop-check valve, which is to be so located as to enable rapid operation, and a suitable overboard discharge line. For the emergency bilge inlet, the distance between the open end of the suction inlet and the tank top is to be adequate to allow a full flow of water. The hand wheel of emergency bilge suction valve is to be position not less than 460 mm (18 in.) above the floor plates.

9 Vent Pipes

9.1 General (2011)

Except for comparatively small compartments that are not fitted with a fixed means of drainage, vent pipes are to be fitted to all tanks, cofferdams, voids, tunnels and compartments which are not fitted with other ventilation arrangements. In all vessels, the structural arrangement in double-bottom and other tanks is to be such as to permit the free passage of air and gases from all parts of the tanks to the vent pipes. Each tank is to be fitted with at least one vent pipe which is to be located at the highest part of the tank. Vent pipes are to be arranged to provide adequate drainage under normal conditions. No shutoff valve or closing device that can prevent the venting from a tank is to be installed in vent piping.

9.3 Height and Wall Thickness (2010)

9.3.1 Vents Exposed to Weather

Vent pipes on decks exposed to the weather are to have the following heights:

- i) 760 mm (30 in.) for those on the freeboard deck; and
- ii) 450 mm (17.5 in.) for those on the superstructure deck.

The height is to be measured from the deck to the point where water may have access below. Where these heights may interfere with the working of the vessel, a lower height may be accepted, provided that ABS is satisfied that the closing arrangements and other circumstances justify a lower height.

The wall thicknesses of vent pipes where exposed to the weather are to be not less than that specified below. For vent pipes located on the fore deck, as defined in 3-2-14/11.7.1, the strength and wall thickness requirements are to also comply with 3-2-14/11.7.2 and 3-2-14/11.7.3:

Nominal Size, d	Min. Wall Thickness
$d \leq 65$ mm (2.5 in.)	6.0 mm (0.24 in.)
65 mm (2.5 in.) $< d < 150$ mm (6 in.)	by interpolation ⁽¹⁾
$d \geq 150$ mm (6 in.)	8.5 mm (0.33 in.)

Note:

$$1 \quad 6 + 0.029(d - 65) \text{ mm or } 0.24 + 0.026(d - 2.5) \text{ in.}$$

9.3.2 Vents not Exposed to Weather

Vent pipes not exposed to the weather need not comply with the height and wall thickness required by 4-4-3/9.3.1.

9.5 Size

Vent pipes are to have a minimum internal diameter not less than 38 mm (1.5 in.) and not less than the internal diameter of the fill line. Where tanks are to be filled by pump pressure, the aggregate area of the vents in the tank is to be at least 125% of the effective area of the filling line, except that when overflows are fitted, the area of the overflow is to be at least 125% of the effective area of the filling line and the vents need not exceed the above minimum size. For vessels with length, L , (as defined in 3-1-1/3.1) between 80 meters (263 feet) and 90 meters (295 feet), the minimum diameter of vent pipes on the fore deck is not to be less than 65 mm [see 3-2-14/11.7.3(b)].

Notwithstanding the above, the pump capacity and pressure head are to be considered in the sizing of vents and overflows. When high capacity and/or high head pumps are used, calculations demonstrating the adequacy of the vent and overflows are to be submitted.

9.7 Location (1 July 1998)

Vents for compartments required for subdivision (such as double bottom or wing spaces) are to be led above the freeboard or bulkhead deck. In addition, vents for ballast tanks, fuel oil tanks, cargo tanks, thermal oil tanks and those cofferdams adjacent to cargo oil tanks are to be led to the weather. Vents for other tanks may terminate within the machinery space, provided that the open ends are situated to prevent the possibility of overflowing on electric equipment, engines or heated surfaces.

For vessels of 500 gross tons and above, vent pipes for fuel oil service tanks, fuel oil settling tanks and lubricating oil tanks which directly serve the engines are to be located and arranged and/or suitably protected from mechanical damage in order to minimize the possibility of being broken and allowing the ingress of seawater splashes or rainwater into the above mentioned tanks.

9.9 Vent Outlets

All vent and overflow pipes on the open deck are to terminate by way of return bends.

9.9.1 Fuel Oil Tank Vents (2007)

Vent outlets from fuel oil tanks are to be fitted with corrosion-resistant flame screens having a clear area through the mesh of not less than the required area of the vent pipe. Either a single screen of corrosion-resistant wire of at least 12 by 12 meshes per lineal cm (30 by 30 mesh per lineal inch), or two screens of at least 8 by 8 meshes per lineal cm (20 by 20 mesh per lineal inch) spaced not less than 13 mm (0.5 inch) nor more than 38 mm (1.5 inch) apart are acceptable.

Note: Mash count is defined as a number of openings in a lineal cm (inch) counted from the center of any wire to the center of a parallel wire.

9.9.2 Vent Closure (2010)

All vents terminating in the weather are to be fitted with return bends (gooseneck), or equivalent, and the vent outlet is to be provided with an automatic means of closure type i.e., close automatically upon submergence (e.g., ball float or equivalent), complying with 4-4-3/9.9.3.

9.9.3 Vent Outlet Closing Devices (2008)

9.9.3(a) *General.* Where vent outlets required by 4-4-3/9.9.2 are to be fitted with automatic closing devices, they are to comply with the following:

9.9.3(b) *Design.*

- i) Vent outlet automatic closing devices are to be so designed that they will withstand both ambient and working conditions, and be suitable for use at inclinations up to and including $\pm 40^\circ$.
- ii) Vent outlet automatic closing devices are to be constructed to allow inspection of the closure and the inside of the casing as well as changing the seals.
- iii) Efficient ball or float seating arrangements are to be provided for the closures. Bars, cage or other devices are to be provided to prevent the ball or float from contacting the inner chamber in its normal state and made in such a way that the ball or float is not damaged when subjected to water impact due to a tank being overfilled.
- iv) Vent outlet automatic closing devices are to be self-draining.
- v) The clear area through a vent outlet closing device in the open position is to be at least equal to the area of the inlet.
- vi) An automatic closing device is to:
 - Prevent the free entry of water into the tanks,
 - Allow the passage of air or liquid to prevent excessive pressure or vacuum developing in the tank.
- vii) In the case of vent outlet closing devices of the float type, suitable guides are to be provided to ensure unobstructed operation under all working conditions of heel and trim. [see 4-4-3/9.9.3(b)i]
- viii) The maximum allowable tolerances for wall thickness of floats should not exceed $\pm 10\%$ of thickness.
- ix) (2017) The inner and outer chambers of an automatic air pipe head is to be of a minimum thickness of 6 mm (0.24 inch). Where side covers are provided and their function is integral to providing functions of the closing device as outlined in 4-4-3/9.9.3(b)vi, they are to have a minimum wall thickness of 6 mm (0.24 inch). If the air pipe head can meet the tightness test in 4-4-3/9.9.3(d)i without the side covers attached, then the side covers are not considered to be integral to the closing device, in which case a wall less than 6 mm (0.24 inch) may be acceptable for side covers.

9.9.3(c) *Materials.*

- i) Casings of vent outlet closing devices are to be of approved metallic materials adequately protected against corrosion.
- ii) For galvanized steel air pipe heads, the zinc coating is to be applied by the hot method and the thickness is to be 70 to 100 micrometers (2.756 to 3.937 mil).
- iii) For areas of the head susceptible to erosion (e.g., those parts directly subjected to ballast water impact when the tank is being pressed up, for example the inner chamber area above the air pipe, plus an overlap of 10° or more to either side) an additional harder coating should be applied. This is to be an aluminum bearing epoxy, or other equivalent coating, applied over the zinc.
- iv) Closures and seats made of non-metallic materials are to be compatible with the media intended to be carried in the tank and to seawater, and suitable for operating at ambient temperatures between -25°C and 85°C (-13°F and 185°F).

9.9.3(d) *Type Testing.*

- i) *Testing of Vent Outlet Automatic Closing Devices.* Each type and size of vent outlet automatic closing device is to be surveyed and type tested at the manufacturer's works or other acceptable location.

The minimum test requirements for a vent outlet automatic closing device are to include the determination of the flow characteristics of the vent outlet closing device, the measurement of the pressure drop versus the rate of volume flow using water and with any intended flame or insect screens in place and also tightness tests during immersion/emerging in water, whereby the automatic closing device is to be subjected to a series of tightness tests involving not less than two (2) immersion cycles under each of the following conditions:

- The automatic closing device is to be submerged slightly below the water surface at a velocity of approximately 4 m/min (13.12 ft/min) and then returned to the original position immediately. The quantity of leakage is to be recorded.
- The automatic closing device is to be submerged to a point slightly below the surface of the water. The submerging velocity is to be approximately 8 m/min and the air pipe vent head is to remain submerged for not less than 5 minutes. The quantity of leakage is to be recorded.
- (2014) Each of the above tightness tests are to be carried out in the normal position as well as at an inclination of 40 degrees under the strictest conditions for the device. In cases where such strictest conditions are not clear, tests shall be carried out at an inclination of 40 degrees with the device opening facing in three different directions: upward, downward, sideways (left or right). See 4-4-3/Figures 1 to 4.

The maximum allowable leakage per cycle is not to exceed 2 ml/mm (1.312×10^{-2} gal/inch) of nominal diameter of inlet pipe during any individual test.

- ii) *Discharge/Reverse Flow Test (2014).* The air pipe head shall allow the passage of air to prevent excessive vacuum developing in the tank. A reverse flow test shall be performed. A vacuum pump or another suitable device shall be connected to the opening of the air pipe leading to the tank. The flow velocity shall be applied gradually at a constant rate until the float gets sucked and blocks the flow. The velocity at the point of blocking shall be recorded. 80% of the value recorded will be stated in the certificate. Each type and size of vent outlet automatic closing device is to be surveyed and type tested at the manufacturer's works or other acceptable location.
- iii) *Testing of Non-Metallic Floats.* Impact and compression loading tests are to be carried out on the floats before and after pre-conditioning as follows:

Test Temperature °C (°F):	-25°C (-13°F)	20°C (68°F)	85°C (185°F)
<i>Test Conditions</i>			
Dry	Yes	Yes	Yes
After immersing in water	Yes	Yes	Yes
After immersing in fuel oil	NA	Yes	NA

Immersing in water and fuel oil is to be for at least 48 hours.

- a) *Impact Test.* The test may be conducted on a pendulum type testing machine. The floats are to be subjected to 5 impacts of 2.5 N-m (1.844 lbf-ft) each and are not to suffer permanent deformation, cracking or surface deterioration at this impact loading.

Subsequently the floats are to be subjected to 5 impacts of 25 N-m (18.44 lbf-ft) each. At this impact energy level some localized surface damage at the impact point may occur. No permanent deformation or cracking of the floats is to appear.

- b) *Compression Loading Test.* Compression tests are to be conducted with the floats mounted on a supporting ring of a diameter and bearing area corresponding to those of the float seating with which it is intended that float shall be used. For ball type float, loads are to be applied through a concave cap of the same internal radius as the test float and bearing on an area of the same diameter as the seating. For a disc type float, loads are to be applied through a disc of equal diameter as the float.

A load of 3430 N (350 kgf, 770 lbf) is to be applied over one minute and maintained for 60 minutes. The deflection is to be measured at intervals of 10 minutes after attachment of the full load.

The record of deflection against time is to show no continuing increase in deflection and, after release of the load, there is to be no permanent deflection.

- iv) *Testing of Metallic Floats.* The above described impact tests are to be carried out at room temperature and in the dry condition.

FIGURE 1
Example of Normal Position (2014)

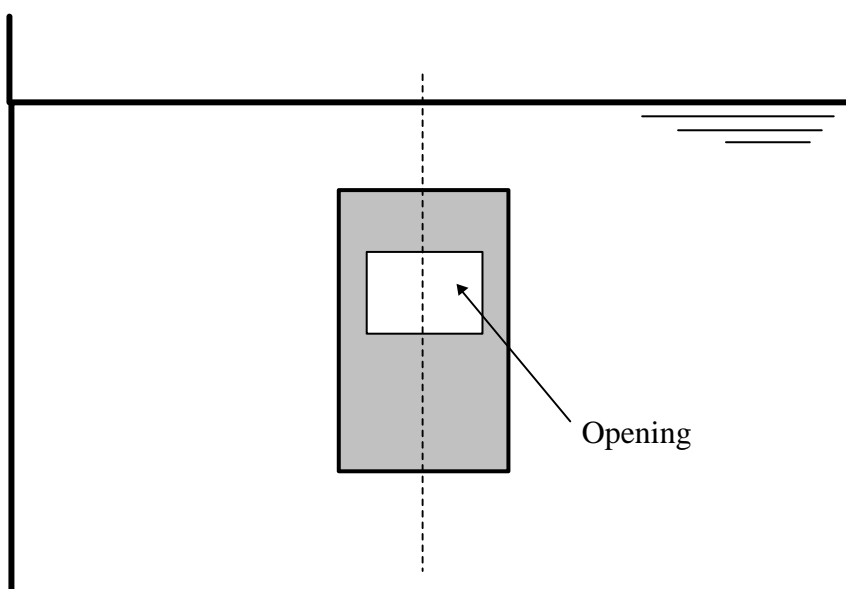


FIGURE 2
Example of Inclination 40 Degrees Opening Facing Upward (2014)

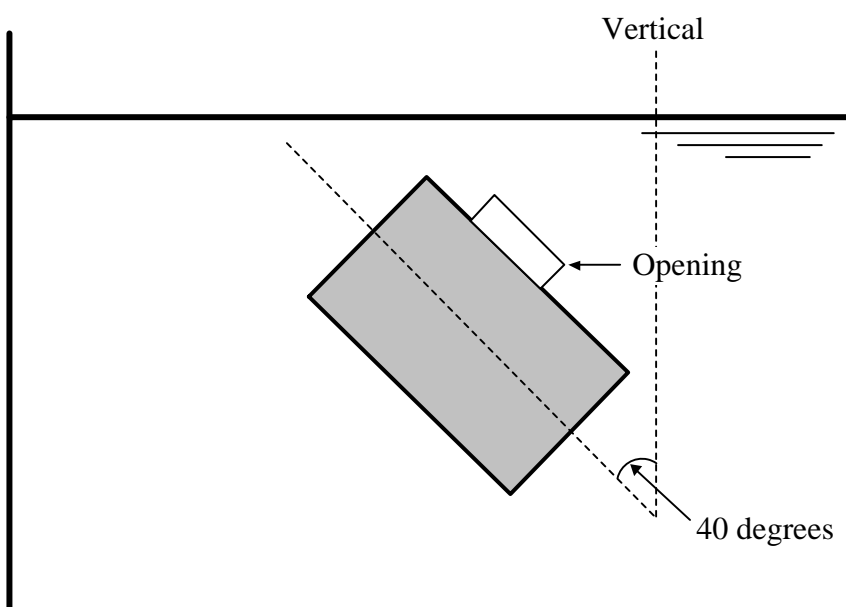


FIGURE 3
Example of Inclination 40 Degrees Opening Facing Downward (2014)

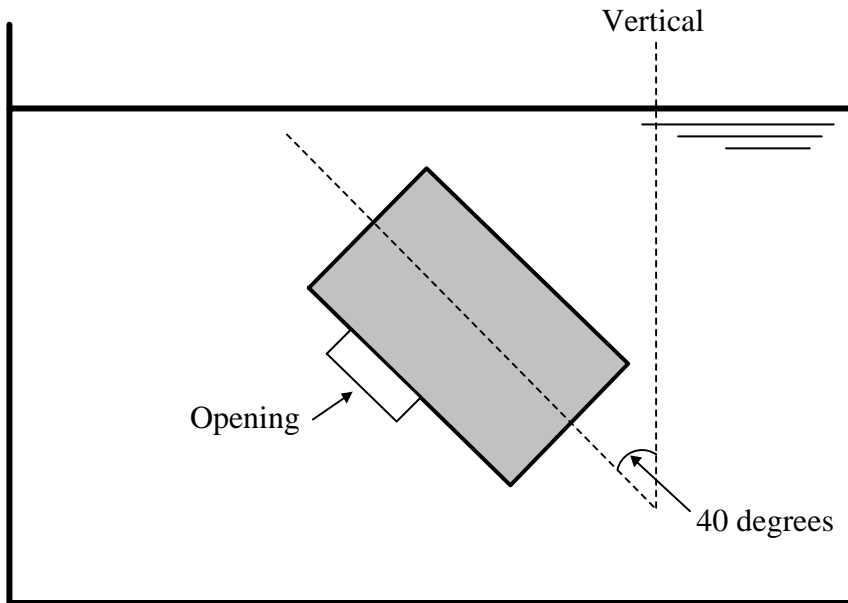
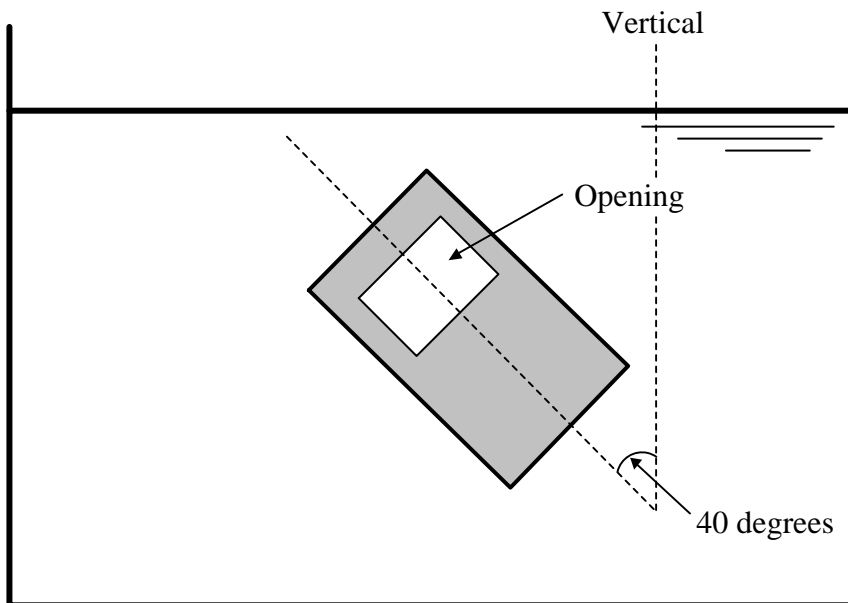


FIGURE 4
Example of Inclination 40 Degrees Opening Facing Sideways (2014)



11 Overflow Pipes (1998)

11.1 General Requirements

Overflow pipes discharging through the vessel's side are to be located as far above the deepest load line as practicable and are to be provided with nonreturn valves located on the vessel's side. Where the overflow does not extend above the freeboard deck, there is to be provided, in addition, an efficient and accessible means for preventing water from passing inboard. Such means may consist of another nonreturn valve located in an accessible position above the deepest load line.

Where it is impracticable to locate the inner valve in an accessible position, one nonreturn valve with positive means for closing from an accessible position above the freeboard or bulkhead deck will be acceptable, provided there are suitable arrangements to insure the valve not being closed by unauthorized persons and provided a notice is posted in a conspicuous place at the operating station to the effect that the valve is never to be closed, except as may be required in an emergency.

11.3 Overflows from Combustible and Flammable Liquid Tanks (2010)

Overflow pipes from combustible and flammable liquid tanks are to be led to an overflow tank or to a storage tank with sufficient excess capacity (normally 10 minutes at transfer pump capacity) to accommodate the overflow. An alarm device is to be provided to give warning when the liquid reaches a predetermined level in the overflow tank. If a sight flow glass is also provided in the overflow pipe, then such sight glasses are to be fitted only in vertical sections of overflow pipes and be in readily visible positions.

11.5 Overflow Common Header

Where overflows from the tanks in more than one watertight subdivision are connected to a common header below the freeboard or bulkhead deck, the arrangement is to be such as to prevent fore-and-aft flooding of one watertight bulkhead subdivision from another in the event of damage.

13 Sounding

13.1 General

All tanks are to be fitted with a suitable means of determining the level of the liquid therein. Such means may be sounding pipes, gauge glasses or other approved level indicating systems or devices.

All compartments, including cofferdams and pipe tunnels, which are not readily accessible are to be fitted with sounding pipes if the compartment is adjacent to the sea or has pipes carrying liquids passing through it.

13.3 Sounding Pipes

Sounding pipes are not to be less than 38 mm (1.5 in.) inside diameter. They are to be led as straight as possible from the lowest part of the tank or compartment to the bulkhead deck or to a position which is always accessible. If sounding pipes terminate below the freeboard deck, they are to be provided with means for closing in the following manner:

13.3.1 Oil Tanks

Quick-acting, self-closing gate valves are required.

13.3.2 Other Tanks

A screw cap secured to the pipe with a chain or a gate valve is required.

Provision is to be made to prevent damaging the vessel's plating by the striking of the sounding rod. In general, sounding pipes are not to pass through bilge wells, but if this is not practicable, the pipe is to be at least extra-heavy in the bilge well. Sounding pipes for combustible or flammable fluids are not to terminate in accommodation spaces.

13.3.3 Ignition of Spillage

13.3.3(a) Fuel Oil Tanks. Sounding pipes for fuel oil tanks are not to terminate in any space where the risk of ignition of spillage may exist. In particular, they are not to terminate in machinery spaces or in close proximity to internal combustion engines, generators, electric equipment or surfaces with temperatures in excess of 220°C (428°F) in other spaces. Where it is impracticable to do otherwise, sounding pipes from fuel oil tanks may terminate in machinery spaces, provided the following are met:

- i) The sounding pipes terminate in locations remote from ignition hazards or effective precautions such as shielding are taken to prevent fuel oil spillage from coming into contact with a source of ignition; and
- ii) The terminations of sounding pipes are fitted with quick-acting, self-closing gate valves and with a small diameter self-closing test cock or equivalent located below the gate valve, provided for the purpose of ascertaining that fuel oil is not present in the sounding pipe before the gate valve is opened. Provisions are to be made so as to prevent spillage of fuel oil through the test cock from creating an ignition hazard; and
- iii) (2005) An approved level gauge is provided. However, short sounding pipes may be used for oil tanks other than double bottom tanks without the additional closed level gauge, provided an overflow system is fitted, see 4-4-3/11. The oil level gauge may also be omitted for vessels less than 500 gross tons.

13.3.3(b) Lubricating Oil Tanks (2005). Sounding pipes from lubricating oil tanks may terminate in machinery spaces provided that the following are met:

- i) The sounding pipes are to terminate in locations remote from the ignition hazards, or effective precautions, such as shielding, are taken to prevent oil spillage from coming into contact with a source of ignition.
- ii) The termination of sounding pipes is fitted with a quick-acting self-closing gate valve. Alternatively, for lubricating oil tanks that cannot be filled by a pump, the sounding pipes may be fitted with an appropriate means of closure such as a shut-off valve or a screw cap attached by chain to the pipe.

13.5 Gauge Glasses (2006)

Tanks may be fitted with gauge glasses, provided the gauge glasses are fitted with a valve at each end and adequately protected from mechanical damage.

Gauge glasses for tanks containing flammable or combustible liquids are to be of the flat glass type having approved self-closing valves at each end. For hydraulic oil tanks located in spaces other than category A machinery spaces, cylindrical gauge glasses with approved self-closing valves at each end will be acceptable, provided such spaces do not contain internal combustion engines, generators, major electrical equipment or piping having a surface temperature in excess of 220°C (428°F).

Gauge glasses for tanks integral with the shell which are located below the deepest load waterline are to be of the flat glass type and have approved self-closing valves at each end.

Isolation valves are to be fitted to allow for gauges removal without emptying the tank, see 4-4-1/9.17.3.

13.7 Level Indicating Systems and Devices (2005)

Where a level indicating device or system is provided for determining the level in a tank containing flammable or combustible liquid, failure of the device/system is not to result in the release of the contents of the tank through the device. Level switches, which penetrate below the tank top, may be used, provided they are contained in a steel enclosure or other enclosures not being capable of being destroyed by fire. If an overflow is not fitted, means are also to be provided to prevent overfilling of the tank in the event of malfunction of the indicating device/system.

PART

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CHAPTER 4 Pumps and Piping Systems

SECTION 4 Fuel Oil and Lubricating Oil Systems and Tanks

1 Fuel Oil Piping Systems

1.1 General Arrangement

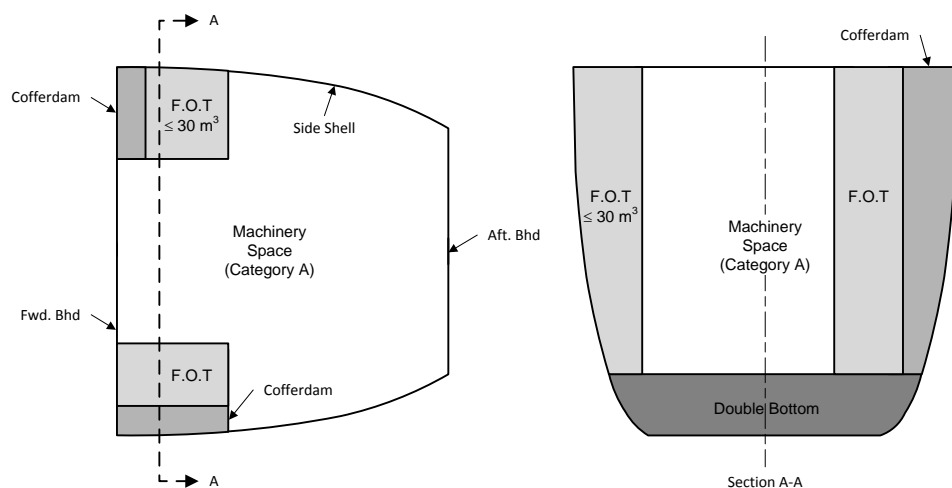
1.1.1 Tanks (2011)

1.1.1(a) *Structural Tanks* As far as practicable, fuel oil tanks are to be part of the vessel's structure and located outside of Category A machinery spaces. Where fuel oil tanks, other than double bottom tanks, are necessarily located adjacent to or within a Category A machinery space, the arrangements are to reduce the area of the tank boundary common with the machinery space of category A to a minimum, and to comply with the following:

- i) Fuel tanks having boundaries common with machinery spaces of category A are not to contain fuel oils having a flash point of 60°C (140°F) or less.
- ii) At least one of their vertical sides is to be contiguous to the machinery space boundaries. The arrangements in 4-4-4/Figure 1 are acceptable for structural tanks provided the requirements of 4-4-4/11 are complied with. (The side shell is not being included in contiguous boundary of the category A machinery space.)
- iii) The bottom of the fuel oil tank is not to be so exposed that it will be in direct contact with flame should there be a fire in a Category A machinery space. The fuel tank is to extend to the double bottom. Alternatively, the bottom of the fuel oil tank is to be fitted with a cofferdam. The cofferdam is to be fitted with suitable drainage arrangements to prevent accumulation of oil in the event of oil leakage from the tank.

FIGURE 1

Acceptable Fuel Oil Tanks Arrangements Inside Category A Machinery Spaces (2013)



1.1.1(b) Free Standing Tanks In general, the use of free standing fuel oil tanks is to be avoided. Where permitted, they are to be placed in an oil tight spill tray of ample size with adequate means of drainage in accordance with 4-4-1/9.23.

1.1.2 Spillage (2011)

No fuel oil tank is to be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces or electrical equipment. Precautions are to be taken to prevent any oil that may escape under pressure during inspection or maintenance of any pump, filter or heater from coming into contact with a source of ignition as defined in 4-1-1/13.17.

To prevent the ignition of fuel oil, all hot surfaces likely to reach a temperature above 220°C (428°F) during service are to be insulated with non-combustible, and preferably non-oil-absorbent materials. Such insulation materials, if not impervious to oil, are to be encased in oil-tight steel sheathing or equivalent. The insulation assembly is to be well-installed and supported having regard to its possible deterioration due to vibration.

1.1.3 Service and Settling Tanks (2004)

Vessels of 500 gross tonnage and above with the keel laid or in similar stage of construction on or after 1 July 1998 are to meet the following requirements of *i*), *ii*), and *iii*):

- i*) The vent pipes for fuel oil service and settling tanks which directly serve the engines are to be located and arranged and/or suitably protected from mechanical damage in order to minimize the possibility of being broken and allowing the ingress of seawater splashes or rainwater into the above mentioned tanks. At least two fuel oil service tanks are to be provided and the capacity with one service tank unavailable is to be sufficient for at least eight hours operation of the propulsion plant at maximum continuous rating and the generator plant (excluding emergency generator) at the normal sea load.
- ii*) Where the propulsion plant and auxiliary machinery are supplied by different service tanks or where more than one type of fuel is used onboard the vessel, the number and capacity of the fuel oil service tanks is to be sufficient such that the propulsion plant, including all auxiliary machinery vital for propulsion, and the generator plant have both a main fuel oil supply and a back-up fuel oil supply. The capacity of the tanks with one service tank unavailable is to be sufficient to provide the machinery it serves with enough fuel oil for at least eight hours operation, as required above.
- iii*) Alternatives equivalent to the above arrangements will be considered.

A service tank is a fuel tank which contains only fuel of a quality ready for use, that is, fuel of a grade and quality that meets the specification required by the equipment manufacturer. A service tank is to be declared as such and is not to be used for any other purpose.

1.3 Piping, Valves and Fittings

Fuel oil pipes, valves and fittings are to be of steel or other approved materials.

1.5 Oil Heating Arrangements

1.5.1 Oil Heaters

Where heaters are provided in fuel oil systems, they are to be fitted with a temperature control and either a high temperature alarm or a low flow alarm, except where the maximum temperature of the heating medium does not exceed 220°C (428°F).

Where electric heaters are fitted, they are to be arranged to de-energize automatically when the oil level falls to a predetermined height to ensure that the heating elements are permanently submerged during operation. In addition, a safety temperature switch with a manual reset independent from the automatic control sensor is to be provided to cut off the electric power supply in order to avoid a surface temperature of 220°C (428°F) or above.

1.5.2 Tanks

Unless specially approved otherwise, fuel oil in storage tanks is not to be heated to temperatures within 10°C (18°F) below flash point of the fuel oil.

Where heating arrangements are provided for settling and service tanks, the control and alarm requirements of 4-4-4/1.5.1 are applicable.

1.7 Multiple Internal Combustion Engine Installations (*1 July 2002*)

In multi-engine propulsion installations on vessels 500 gross tons and above, which are supplied from the same fuel source, means of isolating the fuel supply and spill (return) piping to individual engines is to be provided. The means of isolation is not to affect the operation of the other engines and is to be operable from a position not rendered inaccessible by a fire on any of the engines.

Similarly, for multi-engine auxiliary diesel installations on vessels 500 gross tons and above, the same requirements are applicable.

1.9 Overflows from Combustible and Flammable Liquid Tanks (*2010*)

For overflow pipes from combustible and flammable liquid tanks, see 4-4-3/11.3.

3 Fuel Oil Transfer and Filling

3.1 General

Where fuel oil transfer arrangements are furnished, two transfer pumps are to be provided and one of them is to be independent of the main engine. The fuel oil pumping arrangements are to be distinct from the other pumping systems as far as practicable, and the means provided for preventing dangerous interconnection in service are to be thoroughly effective.

3.3 Pipes in Oil Tanks

Oil pipes and other pipes, where passing through oil tanks, are to be of wrought iron or steel, except that other materials may be considered where it is demonstrated that the material is suitable for the intended service. All packing is to be of a composition not affected by oil.

3.5 Control Valves or Cocks

Valves or cocks controlling the various suctions are to be located close to the bulkhead where the suctions enter the machinery spaces and, wherever practicable, directly over the gutterway in way of deep and settling tanks. Pumps, strainers, etc., requiring occasional examination are to have drip pans.

3.7 Valves on Oil Tanks (*2016*)

Where pipe lines emanate from fuel oil tanks at such a level that they will be subjected to a static head of oil from the tank, they are to be fitted with positive closing valves. The valves are to be secured at the tank. A short length of Extra Strong pipe connecting the valve to the tank is also acceptable. Where the fuel oil piping passes through adjacent tanks, the valve required above may be located where the pipe run exits the adjacent tank(s), provided the piping in the adjacent tanks is extra-heavy and has all welded connections. However, if the adjacent tank is a fuel oil tank, the pipe run within the fuel oil tank is to be at least standard thickness.

If the valves are installed on the outside of the tank, they are not to be of cast iron. The use of nodular iron, also known as ductile iron or spheroidal-graphite iron, may be used, provided the material has an elongation not less than 12% in 50 mm (2 in.). Arrangements are to be provided for closing them at the valve and for tanks having a capacity of 500 liters (132 US gal.) or greater, from a readily accessible and safe location outside of the compartment in which the valve is located.

If the positive closing valve required above is situated in a shaft tunnel or pipe tunnel or similar space, arrangements for closing may be effected by means of an additional valve on the pipe or pipes outside of the tunnel or similar space. If such an additional valve is fitted in the machinery space, it is to be operated from a position outside of this space.

If the valves are located inside of the tank, they may be of cast iron and arranged for remote control only, but additional valves for local control are to be located in the machinery space.

Where independent filling lines are fitted, they are to enter at or near the top of the tank, but if this is impracticable, they are to be fitted with non-return valves at the tank.

The valves required above may be remotely operated by reach rods or by electric, hydraulic or pneumatic means. The source of power to operate these valves is to be located outside of the space in which the valves are located. The positioning of the valve by either local or remote means is not to interfere with the ability of the other means to close the valve. This remote means of closure is to override all other means of valve control. The use of an electric, hydraulic or pneumatic system is not acceptable to directly keep the valve in the open position.

Materials readily rendered ineffective by heat are not to be used in the construction of the valves or the closure mechanism, unless adequately protected to ensure effective closure facility in the event of fire. If electric cables are utilized, they are to be fire-resistant, meeting the requirements of IEC 60331. See 4-6-4/13.1.3. Hydraulic systems are to be in accordance with 4-4-6/1 for both Class I and II piping systems. For a pneumatic system, the air supply may be from a source from within the space, provided a separate receiver complying with the following is located outside of the space:

- i) Sufficient capacity to close all connected valves twice.
- ii) Fitted with low air pressure alarm.
- iii) Air supply line is fitted with a non-return valve adjacent to the receiver.

3.9 Remote Shutdown of Pumps

Machinery driving fuel oil transfer pumps, oil fuel unit pumps and other similar fuel pumps are to be fitted with remote shutdowns complying with 4-5-1/5.3.

3.11 Oil Drain Tanks

Drain tanks, where fitted, for waste oil, fuel oil overflows, drains, all oil drip pans, fuel injection piping, etc., are to have air and sounding pipes. Non-return valves are to be fitted in drain lines entering the drain tanks, except where backflow would not present a hazard. Suitable means are to be provided for pumping out these drain tanks.

Oil tanks not forming a part of the vessel's structure, where permitted by 4-4-4/1.1.1, are to have suitable drip pans with adequate means of drainage, in accordance with 4-4-1/9.23.

5 Fuel Oil Service and Injection Systems

Fuel oil service and injection systems for internal-combustion engines are to be in accordance with 4-2-1/3, 4-2-1/5 and 4-2-1/7.

7 Low Flash Point Fuels

7.1 General

Fuel oils with a flash point of 60°C (140°F) closed-cup or below may be accepted for the following:

7.1.1

Vessels classed for restrictive service within areas having a climate ensuring that ambient temperatures of spaces where such fuel oil is stored will not rise within 10°C (18°F) below its flash point may use fuel oil with flash point of 60°C (140°F) or below, but not less than 43°C (110°F).

7.1.2

For emergency generators, fuel oil with a flash point of not less than 43°C (110°F) may be used. See 4-6-2/5.5.2.

7.3 Fuel Heating

For oil heating arrangements, see 4-4-4/1.5.

7.5 Fuel Oil Tank Vents

Vent pipes are to extend at least 2.4 m (8 ft) above the weather deck or other effective arrangements which have been approved are to be provided.

9 Lubricating Oil Systems

9.1 General (1998)

The lubricating systems are to be so arranged that they will function satisfactorily under the conditions specified in 4-1-1/17. The lubricating-oil piping is to be entirely separated from other piping systems. In addition, the requirements of 4-4-4/1.1.2, 4-4-4/1.3 and 4-4-4/1.5 are applicable.

The requirements in 4-4-4/3.7 are also applicable for lubricating-oil tanks. However, arrangements for remotely closing the valve from a position outside of the compartment need not be provided if inadvertent valve closure could result in damage to the running machinery due to lack of lubricating oil. Where the machinery is arranged for automatic shutdown upon loss of lubricating oil, the valve required by 4-4-4/3.7 is to be provided with means to close it from a readily accessible and safe location outside of the compartment in which the valve is located.

9.3 Sight Flow Glasses

Sight flow glasses may be used in lubricating systems, provided they are fire-resistant.

9.5 Internal Combustion Engines

For internal combustion engines, see also 4-2-1/9.

9.7 Reduction Gears

For reduction gears, see also 4-2-1/9.11.

9.9 Electrical Machinery

For electrical machinery, see also 4-6-3/3.3, 4-6-3/3.5 and 4-6-4/3.15.

9.11 Hose Reels

Where hose reels are used for filling the engine or reduction gear sumps with oil, a self-closing valve is to be provided at the end of the filling hose to prevent spillage. Suitable arrangements are to be provided to properly drain and store the hose and reel when not in use. Hoses are to be approved for oil service and in accordance with the requirements for burst pressure, fire resistance, reinforcement and end fittings in 4-4-1/9.19.

11 Additional Measures for Oil Pollution Prevention (1 July 2003)

11.1 General (1 August 2007)

11.1.1 Application

The provisions of 4-4-4/11 provide the arrangement of fuel oil tanks for compliance with MARPOL 73/78, as amended. They are to be applied in addition to the requirements of 4-4-4/1 and 4-4-4/3 and are applicable to all types of vessels classed with ABS.

11.1.2 Submission of Plans

Plans showing compliance with the applicable requirements in 4-4-4/11.3 are to be submitted for review.

11.3 Tank Protection Requirements (1 August 2007)

11.3.1 General (2014)

The requirements in this section apply to vessels having an aggregate fuel oil capacity of 600 m³ (21,190 ft³) and above. However, the requirements need not be applied to individual fuel oil tanks with a capacity not greater than 30 m³ (1060 ft³), provided that the aggregate capacity of such excluded tanks is not greater than 600 m³ (21,190 ft³). Further, individual fuel oil tanks are not to have capacity greater than 2,500 m³ (88,290 ft³).

Fuel oil tanks of any volume are not to be used for ballast water.

Fuel oil tank means a tank in which fuel oil is carried, but excludes those tanks which would not contain fuel oil in normal operation, such as overflow tanks. Fuel oil capacity means the volume of a tank in cubic meters (cubic feet) at 98% tank filling.

Fuel oil means any oil used as fuel oil connection with the propulsion and auxiliary machinery of the ship in which such oil is carried.

11.3.2 Protective Location of Tanks

The protective locations for the tanks specified in 4-4-4/11.3.1 above are to be as follows:

11.3.2(a) Deterministic Approach (2009). All applicable tanks are to be located away from the vessel's bottom or side shell plating for a distance as specified in *i)*, *ii)* or *iii)*. Small suction wells may extend below fuel oil tanks bottoms, if they are as small as possible and the distance between the vessel's bottom plate and the suction well bottom is not reduced by more than half of the distance required by *i)*.

- i)* For vessels having an aggregate oil fuel capacity of 600 m³ (21,190 ft³) and above, all tanks are to be arranged above vessel's molded line of bottom shell plating at least of the distance *h* as specified below:

$$h = B/20 \text{ m or}$$

$$h = 2.0 \text{ m (6.6 ft), whichever is smaller}$$

where *B* is the breadth of the vessel, as defined in 3-1-1/5, in m (ft).

h is in no case to be less than 0.76 m (2.5 ft).

- ii)* For vessels having an aggregate oil fuel capacity greater than or equal to 600 m³ (21190 ft³) but less than 5000 m³ (176570 ft³), tanks are to be arranged inboard of the molded line of side plating not less than the distance *w* as specified below:

$$w = 0.4 + 2.4C/20000 \text{ m}$$

$$w = 1.31 + 7.87C/706290 \text{ ft}$$

where

C = vessel's total volume of oil fuel in m³ (ft³) at 98% tank filling;

w = at least 1.0 m (3.3 ft)

for individual tanks smaller than 500 m³ (17,657 ft³) *w* is to be at least 0.76 m (2.5 ft)

- iii)* For vessels having an aggregate oil fuel capacity of 5000 m³ (176570 ft³) and above, tanks are to be arranged inboard of the molded line of side plating not less than the distance *w* as specified below:

$$w = 0.5 + C/20000 \text{ m}$$

$$w = 1.64 + C/706290 \text{ ft or}$$

$$w = 2.0 \text{ m}$$

$$w = 6.6 \text{ ft, whichever is smaller}$$

where *C* is the vessel's total volume of oil fuel in m³ (ft³) at 98% tank filling.

The minimum value of *w*=1.0 m (3.3 ft).

11.3.2(b) *Probabilistic Approach (2009)*. As an alternative to the deterministic approach of 4-4-4/11.3.2(a), arrangements complying with the accidental oil fuel outflow performance standard of Regulation 12A, Annex I, MARPOL 73/78, as amended, would be acceptable.

11.5 Class Notation – POT (2009)

In addition to the requirements for fuel oil tank protection as specified in 4-4-4/11.3.1 utilizing the deterministic approach of 4-4-4/11.3.2(a), where lubricating oil tanks are also arranged in the same manner as required by the deterministic approach [4-4-4/11.3.2(a)] for fuel oil tanks, vessels are to be eligible for the optional Class notation, **POT** – Protection of Fuel and Lubricating Oil Tanks. Further, the following exemptions are applicable to lubrication oil tanks:

- i) In application of equation in 4-4-4/11.3.2(a)ii) or iii), total volume of lubricating oil tanks need not be accounted for C (vessel's total volume of oil fuel in m^3 (ft^3) at 98% tank filling).
- ii) Tanks used as main engine lubricating oil drain tanks need not be located in a protected location away from the vessel's side or bottom plates.

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CHAPTER 4 Pumps and Piping Systems

SECTION 5 Internal Combustion Engine Systems

1 Fuel Oil System

Fuel oil systems for internal combustion engines are to comply with 4-2-1/3.

3 Lubricating Oil System

Lubricating oil systems for internal combustion engines are to comply with 4-2-1/9.

5 Cooling Water System

Cooling water systems for internal combustion engines are to comply with 4-2-1/11.

7 Exhaust Piping

Exhaust piping for internal combustion engines is to comply with 4-2-1/15.

9 Starting-air Systems

Starting-air systems for internal combustion engines are to comply with 4-2-1/13.

PART

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CHAPTER 4 Pumps and Piping Systems

SECTION 6 Hydraulic and Pneumatic Systems

1 Hydraulic Systems

1.1 General

The arrangements for Group I hydraulic piping systems are to be in accordance with the requirements of this section, except that hydraulic systems which form part of a unit which is independently manufactured and assembled and which does not form part of the vessel's piping system are not covered by this section.

Plans clearly showing the arrangements and details are to be submitted for review.

Hydraulic pumps, actuators, motors and accessories are to be suitable for the intended duty, compatible with the working fluid and are to be designed to operate safely at full power conditions. In general, the hydraulic fluid is to be non-flammable or have a flash point above 157°C (315°F).

The requirements for fuel oil tanks contained in 4-4-4/1.1.2 and 4-4-4/1.3 are applicable to tanks containing hydraulic fluid. See also 4-3-3/7 and 4-3-2/17.

1.3 Valves

1.3.1 General

In general, valves are to comply with the requirements of 4-4-2/9 and 4-4-2/11.

1.3.2 Relief Values

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 full pump flow with a maximum pressure rise of not more than 10% of the relief valve setting.

1.5 Piping

Piping is to meet the requirements of 4-4-1/5 and 4-4-2/5, except that mill tests need not be witnessed by the Surveyor. In such cases, mill certificates are to be provided which verify the chemical and mechanical properties for the pipe.

1.7 Pipe Fittings

Fittings and flanges are to meet the requirements of 4-4-2/9, 4-4-2/13 and 4-4-2/17, except as follows:

1.7.1 Split Flanges (2004)

Split flanges are not to be used in steering gear systems, certified thruster systems, nor in systems which are vital to the propulsion or safety of the vessel. Split flanges may be considered for use in other systems. Where split flanges are permitted, they are not to be used to join sections of piping, but may be used for connections to machinery, provided the materials and construction are suitable for the system design pressure.

1.7.2 Straight-Thread "O"-Ring Connection

Straight-thread "O"-ring type connections may be used for connections to equipment such as pumps, valves, cylinders, accumulators, gauges and hoses. Such connections are not to be used for joining sections of pipe.

1.7.3 Tapered Threaded Connection

Tapered threaded connections up to and including 89 mm O.D. (3 in. NPS) may be used without limitation for connections to equipment such as pumps, valves, cylinders, accumulators, gauges and hoses. Tapered threaded connections are not to be used in steering gear systems, controllable pitch propeller systems, and other systems associated with propulsion or propulsion control, except where permitted by 4-4-2/13.1. Such connections are not to be used for joining sections of pipe, except where permitted by 4-4-2/13.1.

1.9 Accumulators and Fluid Power Cylinders

Accumulators are to meet the requirements of Part 4, Chapter 4 of the *Steel Vessel Rules*. Each accumulator which may be isolated is to be protected by suitable relief valves. Where a gas charging system is used, a relief valve is to be provided on the gas side of the accumulator.

Fluid Power Cylinders are to meet the requirements of 4-4-6/3.

1.11 Design Pressure

The pressure used for determining the strength and design of piping and components is not to be less than the relief valve setting.

1.13 Segregation of High Pressure Hydraulic Units

Hydraulic units with working pressures above 15.5 bar (15.8 kgf/cm², 225 psi) installed within a machinery space 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. For the purpose of this requirement, a hydraulic unit includes the power pack and all components of the hydraulic piping system.

3 Fluid Power Cylinders (1 July 2009)

3.1 General

Fluid power cylinders subject to pressures or temperatures greater than those indicated below are to be designed, constructed and tested in accordance with a recognized standard for fluid power cylinders.

- *Hydraulic fluid – flammable*: 7 bar (7.1 kgf/cm², 101.5 psi) or 60°C (140°F)
- *Hydraulic fluid – non-flammable*: 16 bar (16.3 kgf/cm², 232 psi) or 200°C (392°F)
- *Air*: 16 bar (16.3 kgf/cm², 232 psi) or 200°C (392°F)

Acceptance will be based on the 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.

3.3 Non-compliance with a Recognized Standard

Cylinders subject to pressures or temperatures higher than those indicated above which are not constructed to a recognized standard may be accepted based on the following:

- 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 4-4-1 of the *Steel Vessel Rules*. For instance, the cylinder is to have a wall thickness not less than that given by equation 2 of 4-4-1A1/3.1, and the cylinder ends are to meet the requirements of flat heads in 4-4-1A1/5.7, 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 hydrostatically tested to 1.5 times the maximum allowable working pressure (2 times, for cast iron and nodular iron cylinders) by the manufacturer. A 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 Materials

- i) The materials of the cylinders are to comply with the requirements of the standard or code to which they are designed and constructed. Where the design is verified through burst tests, the materials of the cylinder are to comply with 4-4-1/3 of the *Steel Vessel Rules* 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.

3.7 Rudder Actuators

Rudder actuators are to be in accordance with the requirements of 4-3-3/5.11.

3.9 Cylinders below Pressures or Temperatures Indicated in 4-4-6/3.1

Cylinders subject to pressures and temperatures at or below those indicated in 4-4-6/3.1 may be used in accordance with the manufacturer's rating and verification of suitability for the intended service.

3.11 Exemptions (2013)

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 4-4-6/3. However, those fluid power cylinders which are integrated into piping systems associated with optional classification notations are to comply with the requirements of 4-4-6/3 and the applicable requirements specified in the pertinent ABS Rules and Guides.

5 Pneumatic Systems (2005)

5.1 Application

Requirements of 4-4-6/5 apply to shipboard pneumatic systems for control and actuation services. Requirements for starting air systems are in 4-2-1/13. Pneumatic systems fitted in self-contained equipment not associated with 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

5.3 Pneumatic System Components

5.3.1 Air Reservoirs

The design and construction of all air receivers are to be in accordance with the applicable requirements of Part 4, Chapter 4 of the *Steel Vessel Rules*.

5.3.2 Pipe Fittings and Joints

The piping system and its components are to be in accordance with the applicable requirements of Part 4, Chapter 4 of these Rules.

5.5 Pneumatic System Requirements

5.5.1 Pneumatic Air Source

Compressed air for general pneumatic control and actuation services may be drawn from engine starting air reservoirs. In which case, 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 4-2-1/13.3.1) 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, may 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 (2010)

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.

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 4-7-2/11.1.4.

5.5.3 Overpressure Protection

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

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CHAPTER 4 Pumps and Piping Systems

SECTION 7 Cargo Systems

Note: Vessels classed as **Oil Carrier** in accordance with Part 5C, Chapter 2 of the ABS *Rules for Building and Classing Steel Vessels* are to meet the additional requirements in 4-4-7/1 through 4-4-7/5 of these Rules.

1 Cargo Pumps

1.1 Construction

Cargo pumps are to be so designed as to minimize the danger of sparking.

1.3 Installation

Care is to be taken to prevent leaks at the stuffing box. Where the shafts pass through gastight bulkheads, flexible couplings are to be provided in shafts between the pumps and prime movers, and stuffing boxes which can be lubricated from outside of the pump room are to be fitted at the bulkheads. The seal parts of the glands are to be of non-sparking construction. If a bellows piece is incorporated in the design, it is to be pressure-tested before being fitted.

Cargo pumps, ballast pumps and stripping pumps installed in cargo pump rooms and driven by shafts passing through pump room bulkheads are to be fitted with temperature sensing devices for bulkhead shaft glands, bearings and pump casings. High temperature alarms (audible and visual) are to be provided at the cargo control room or the pump control station.

1.5 Relief Valve and Bypass

A relief valve of suitable type is to be installed in the discharge of each pump, except as noted in 4-4-1/9.15, and piped back into the suction. A bypass is to be provided around the pump for use when loading through the suction piping.

1.7 Pressure Gauges

One pressure gauge for each pump is to be located at the pump discharge, and where the pumps are operated by engines or motors external to the pump room, additional gauges are to be provided which are visible from the operating station.

1.9 Integrated Cargo and Ballast Systems (2004)

For integrated cargo and ballast systems, see 4-6-6/1.21.

3 Cargo Piping Systems

3.1 General (1998)

Cargo piping systems are to be independent of all other piping systems and are not to pass through fuel oil tanks nor spaces containing machinery where sources of vapor ignition are normally present. Provisions are to be made for expansion of the cargo piping system.

For vessels of 5000 tons deadweight and above, cargo piping, including vent and sounding piping for cargo tanks, is not to pass through ballast tanks, except for short runs of welded steel extra heavy pipe or equivalent construction.

For vessels less than 5000 tons deadweight, cargo piping passing through ballast tanks is to be steel of extra heavy or equivalent construction. In the portion of the cargo piping located within the ballast tank, only expansion bends (not glands) are to be installed to allow for expansion and contraction stresses. All joints within the ballast tanks are to be welded or have extra heavy flanges. The number of flanged joints is to be kept to a minimum.

Where requested by the Owner, vessels in which all cargo piping and valve control piping is located above the double bottom will be distinguished in the *Record* by the notation **CPP** (Cargo Piping Protected). The **CPP** notation is not a condition of classification.

Cargo loading pipes are to be led as low as practicable in the cargo tank. Also see 4-4-1/9.21 and 4-4-2/3.5.

3.3 Cargo Tank Ballasting

3.3.1 Suction

Where it is necessary to provide a sea suction to the cargo oil pumps for severe weather ballasting, tank cleaning or other purposes, means of isolating the pumps from the sea chest is to be provided. The means of isolation is to be either a blank flange or a removable spool piece. A shut-off valve is to be fitted on each side of the blank flange or spool piece. As an alternative, the means of isolation may be two valves located inboard of the sea chest, one of which is to be capable of being locked in the closed position. Means are to be provided for detecting leakage past these valves.

3.3.2 Discharge

The discharge system is to be so designed as to enable ballast water which is carried in cargo tanks to be processed and discharged in accordance with Regulation 15 of Annex I to the International Convention for the Prevention of Pollution from Ships (MARPOL) 1973/1978, as amended.

3.5 Bow or Stern Loading and Unloading (1998)

Where bow or stern loading or unloading connections are provided, cargo lines forward or aft of the cargo area are to be led outside accommodation spaces, service spaces, machinery spaces and control stations. Pipe joints outside the cargo area are to be welded, except for connections to the manifold or loading/unloading equipment.

The cargo loading/unloading lines are to be clearly identified and provided with means to segregate them from the cargo main line when not in use. The segregation is to be achieved by either two valves located in the cargo area which can be locked in the closed position and fitted with means to detect leakage past the valves, or by one valve together with another closing device providing an equivalent standard of segregation, such as a removable spool piece or spectacle flange.

The loading/unloading connection is to be fitted with a shut-off valve and a blank flange. The blank flange may be omitted if an equivalent means of closing is incorporated in the connection to the hose coupling.

Arrangements are to be provided for cargo lines outside of the cargo area for easy draining to a slop tank or cargo tank and for cleaning and inerting. Spill containment is to be provided under the loading and unloading manifolds. The space within 3 m (10 ft) of the manifold and oil spill containment boundary is to be considered as a restricted area with regard to electrical equipment or other sources of vapor ignition.

3.7 Operating-rod Stuffing Boxes

Stuffing boxes are to be fitted where operating rods from cargo valves pass through gastight structural parts.

5 Other Piping Systems on Oil Carriers

5.1 Pump-room and Cofferdam Bilge Systems (2009)

Provision is to be made for removing drainage from the pump-room bilges and adjacent cofferdams. A separate bilge pump, eductor or a bilge suction from a cargo pump or cargo stripping pump may be provided for this purpose. The pump is not to be located in, nor is the piping to pass through, spaces containing machinery where sources of vapor ignition are normally present. Where a bilge suction is provided from a cargo or stripping pump, a stop-check valve is to be fitted in the bilge suction branch. An additional stop valve is to be fitted when the bilge suction branch is arranged so that it may be subjected to a head of oil from the filling line. Pump-room bilge suction and discharge valves and bilge-pump controls are to be operable from in the pump room, unless Flag Administrations have a specific requirement for remote operation, either from an accessible position outside the pump-room or from the pump-room casing above the freeboard deck. High levels of liquid in the pump room bilges is to activate an audible and visible alarm in the cargo control room and on the navigation bridge.

5.3 Machinery Space Bilge System

Where bilge slops from other than the cargo pump room are discharged into a cargo slop tank, the discharge piping is to be arranged as follows.

- i) Enters the cargo slop tank from the weather deck through the tank top.
- ii) The tank penetration is located as close to a vertical tank boundary as practicable.
- iii) Within the tank, the line is as short as practicable and is arranged to discharge against the vertical boundary.
- iv) A stop-check valve is provided in the discharge line and is located within the engine room as close to the engine room bulkhead as possible.
- v) A loop seal is to be located in the cargo pump room or other suitable location outside of the engine room. The height of the loop seal is to provide a static head pressure greater than the pressure setting of the cargo slop tank P/V valve or a minimum of 762 mm (30 inches), whichever is greater. A means is to be provided to prevent the loop seal from freezing.
- vi) A non-return valve is to be located in the discharge line on deck as close to the tank penetration as practicable.

5.5 Ballast Piping (2004)

For vessels of 5000 gross tons and above, ballast piping, including vent and sounding piping for ballast tanks, is not to pass through cargo tanks, except for short runs of welded steel extra heavy pipe or equivalent construction.

For vessels less than 5000 tons deadweight, ballast piping passing through cargo tanks is to be steel of extra heavy or equivalent construction. All joints within the cargo tanks are to be welded or have extra heavy flanges. The number of flanged joints is to be kept to a minimum. In the portion of the ballast piping located within the cargo tank, only expansion bends (not glands) are to be installed to allow for expansion and contraction stresses.

Ballast piping permitted to pass through cargo or connected to ballast tanks adjacent to cargo tanks is not to pass through spaces where sources of vapor ignition are normally present. Connections to the fire main for ballasting or deballasting with eductors are to be fitted with a non-return valve.

Arrangements may be provided in the cargo pump room or on deck, in the case of vessels without a cargo pump room, for a temporary connection between cargo and ballast piping by means of a portable spool piece, and are to have a non-return valve to prevent cargo from entering the ballast system and shut-off valves with blind flanges on both the ballast and cargo piping connections. Temporary connections are to be reported to the Surveyor.

For integrated cargo and ballast systems, see 4-6-6/1.21.

5.7 Piping Through Cargo Tanks

Where the arrangement of the vessel is such as to necessitate the passing through the cargo tanks of piping other than that necessary for the handling or heating of the cargo or for fire protection, the piping systems will be subject to special consideration.

5.9 Cargo Heating Systems

5.9.1 General

The medium used to directly heat the cargo oil is to be contained solely within the cargo area unless the return line of the heating system is led to an inspection tank. The inspection tank is to be of a closed type, dedicated to the cargo heating system and vented to the weather. A corrosion-resistant flame screen is to be fitted at the vent outlet. The inspection tank may be located within the main machinery space, in which case, the vent is to terminate outside of the cargo deck area and is not to be located within 3 m (10 ft) of ventilation intakes or sources of ignition. Cargo heating piping within cargo tanks is to be all welded or brazed, except that the use of a limited number of flanged joints to facilitate installation and repair will be specially considered.

5.9.2 Thermal Oil Installations

Where thermal oil heating systems are used, they are to comply with the requirements in 5C-1-7/9 of the *Steel Vessel Rules*.

5.11 Slop Tanks in Combination Carriers

Slop tanks in vessels alternately carrying oil or dry bulk cargoes are to have an approved independent venting system. A completely separate pumping system is to be provided for the slop tanks or, alternatively, all suction and filling connections for the slop tanks are to be provided with spectacle blank flanges. Suitable warning notices are to be posted when carrying dry cargo with flammable liquids or vapors in the slop tanks.

5.13 Duct Keels in Double Bottoms

Duct keels or pipe tunnels are not to pass into machinery spaces. Provision is to be made for at least two exits to the open deck arranged at a maximum distance from each other. One of these exits fitted with a watertight closure may lead to the cargo pump room. Provision is to be made in the duct for adequate mechanical ventilation.

5.15 Cargo Venting Systems

Cargo tank venting systems for oil carriers are to be in accordance with Regulation II-2/4.5.3 of SOLAS 1974, as amended and the following.

5.15.1 P-V Valve Setting

The pressure setting of pressure-vacuum relief valves is not to exceed 0.18 bar (0.18 kgf/cm², 2.6 psi) above atmospheric for vessels of 90 m (295 ft) in length and 0.12 bar (0.12 kgf/cm², 1.7 psi) for vessels of 61 m (200 ft) in length or less. For intermediate lengths, intermediate pressures will apply. The vacuum setting is to be at a pressure equal or less than 0.07 bar (0.07 kgf/cm², 1 psi) below atmospheric.

Positive pressures up to and including 0.70 bar (0.70 kgf/cm², 10 psi) gauge will be allowed in specially designed integral tanks. See 5C-2-1/1.15 of the *Steel Vessel Rules*.

Calculations are to be submitted showing that cargo tanks will not be subjected to a pressure in excess of the P-V valve setting.

5.15.2 Liquid Level Control

Provision is to be made to guard against liquid rising in the venting system to a height that would exceed the design head of the cargo tanks. This may be accomplished by using high level alarms or overflow control systems or other equivalent means together with gauging devices and tank filling procedures. In this regard, as applicable, a vent/overflow control system analysis for the protection of the cargo tanks is to be submitted for review. This system analysis is to clearly indicate the anticipated worst load/unload condition criteria.

5.15.3 Flame Screens

Vent outlets from cofferdams and from ballast tanks adjacent to cargo oil tanks are to be fitted with corrosion-resistant flame screens having a clear area through the mesh of not less than the area of the pipe.

5.15.4 Isolation

For vessels fitted with inert gas systems, arrangements are to be provided to protect cargo tanks against the effect of overpressure or vacuum caused by thermal variations when the cargo tanks are isolated from inert gas systems.

5.17 Inert-gas System

When tank vessels are equipped with a system whereby inert gas is continuously maintained in the tanks, such a system is to be in accordance with Section 3-4-1 and the following.

5.17.1 General

The inert gas may be treated flue gas from boiler(s) or from a separate inert gas generator. In all cases, automatic combustion control suitable for operation under all service conditions is to be fitted. Any proposal to use other sources of inert gas will be specially considered.

5.17.2 Pressure

The systems are to be so designed that the maximum pressure which can be exerted on the tank(s) does not exceed 0.24 bar (0.24 kgf/cm², 3.5 psi).

5.17.3 Blower Isolating Valves

Shut-off valves are to be fitted on both suction and discharge connections for each blower.

5.17.4 Demister

Demisters or equivalent devices are to be provided to minimize carry-over of water from the scrubber and the deck water seal.

5.17.5 Gas Regulating Valve

The gas regulating valve is to be arranged to close automatically when any of the following additional conditions apply.

- Loss of water pressure to deck seal(s)
- Loss of control power

5.17.6 Blowers

When two blowers are provided, the total required capacity of the inert gas system is preferably to be divided equally between the two blowers and in no case is one blower to have a capacity less than $\frac{1}{3}$ of the total capacity required.

5.17.7 Scrubber Cooling Pump

A minimum of two pumps are to be provided for inert gas scrubber cooling, one of which is to be dedicated for only this service. Pumps, other than the required dedicated pump, may be used for other services such as bilge, ballast or general service.

5.17.8 Oil-Fired Inert Gas Generators

5.17.8(a) Fire protection. The compartment in which any oil-fired inert gas generator is situated is to meet the requirements of 4-5-1/9, 4-5-2/9 and 4-5-2/19.

5.17.8(b) Venting. Arrangements are to be made to vent the inert gas from oil-fired inert gas generators to the atmosphere when the inert gas produced is off-specification, e.g., during starting-up or in the event of equipment failure.

5.17.8(c) Fuel Oil Shutdown. Automatic shutdown of the fuel oil supply to inert gas generators is to be arranged on predetermined limits being reached in respect of low water pressure or low water flow rate to the cooling and scrubbing arrangement and in respect of high gas temperature.

5.17.9 Pump Certification

The fuel oil pumps serving the boiler or inert gas generator and the cooling water pumps serving the flue gas scrubber are to be certified in accordance with 4-4-2/1.

5.19 Cargo Vapor Emission Control Systems

Cargo vapor emission control systems, where provided, are to be in accordance with 5C-1-7/21 of the *Steel Vessel Rules*.

5.21 Crude Oil Washing

When tank vessels are equipped with a system whereby crude oil is utilized for the washing of tanks, the valves, piping and other fittings are to be in accordance with 4-4-7/3.1 for cargo piping.

7 Cargo Oil Systems on Vessels Other Than Bulk Oil Carrier Type

7.1 Cargo-tank Valves in Dry-cargo Vessels

The control arrangement for valves at the sides of cargo-oil tanks, fitted in dry-cargo vessels, is to be in accordance with 4-4-4/3.7.

7.3 Edible-oil Cargoes

The arrangement for carriage of edible oils will be subject to special consideration.

7.5 Venting System for High Flash Point Cargoes

Where a vessel is intended only for the carrying of combustible liquids having a flash point above 60°C (140°F), closed cup test, a venting system consisting of individual return-bend vents fitted with flame screens may be fitted in lieu of that described in 4-4-7/5.15.

9 Cargo-Handling Systems for Dry Bulk Self-Unloading Vessels

Dry bulk cargo vessels are to meet the following additional requirements when fitted with self-unloading cargo-handling equipment.

9.1 Fail-Safe Arrangements and Safety Devices

Fail-safe arrangements and safety devices are to be provided on the self-unloading equipment. A system is considered fail-safe if a component failure or loss of power will result in a controlled securing of the equipment or control of movement so as not to endanger personnel.

9.3 Hydraulic Piping Installations

The passage of self-unloading system hydraulic pipes through cargo holds is to be limited to only that which is necessary for operational purposes. Pipes installed within cargo holds are to be protected from mechanical damage.

System connection to other hydraulic systems is subject to special consideration. Failure in any one part of the self-unloading hydraulic system is not to cause the failure of other parts of the self-unloading system or of other ship's systems.

9.5 Electrical, Control, Alarm and Monitoring Equipment Installation

For requirements regarding electrical equipment, controls, alarms, monitors and hazardous areas (as applicable), see 4-6-3/9 and 4-6-6/3.

PART

4

CHAPTER 4 Pumps and Piping Systems

SECTION 8 Other Piping Systems and Tanks

1 Fixed Oxygen-Acetylene Installations (2003)

1.1 Application (2005)

Provisions of 4-4-8/1.3 apply to fixed 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. Provisions of 4-4-8/1.5 and 4-4-8/1.7, as applicable, are to be complied with for fixed installations regardless of the number of cylinders.

1.3 Gas Storage

1.3.1 Storage of Gas Cylinders

1.3.1(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 is to be provided.

1.3.1(b) Open area. Where no storage room is provided, the gas cylinders may 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.

1.3.1(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

1.3.2 Ventilation of Storage Room

Gas cylinder storage rooms are 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 of each gas cylinder storage room is to be independent of ventilation systems of all 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. The fan is to be of a non-sparking construction. See 4-6-3/11.7. Small storage spaces provided with sufficiently large openings for natural ventilation need not be fitted with mechanical ventilation.

1.3.3 Electrical Installation in Storage Room (2016)

Electrical equipment installed within the storage room, including the ventilation fan motor, is to be of a certified safe type. Electrical equipment installed within the storage room may be any of the types indicated in 4-6-3/11.1.1 and is to be IEC Publication 60079-20-1 group IIC class T2.

1.5 Piping System Components

1.5.1 Pipe and Fittings

1.5.1(a) General (2011). In general, all oxygen and acetylene pipes, pipe fittings, pipe joints and valves are to be in accordance with the provisions of Section 4-4-2 for Group I piping systems, except as modified below. Further, only high pressure oxygen and acetylene piping is to be certified as Group I piping, see 4-4-1/5.1 for the materials testing.

1.5.1(b) *Piping materials (2010)*. 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.

1.5.1(c) *Design pressure (2006)*. 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.

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

1.5.1(e) *Flexible hoses (2009)*. 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*.

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 14113:1997 Gas welding equipment – rubber and plastic hoses assembled for compressed or liquefied gases up to a maximum design pressure of 450 bar.

1.5.2 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 may be either a relief valve or a rupture disc.

1.5.3 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 shut-off 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.

1.5.4 Gas Cylinders

Gas cylinders are to be designed, constructed and certified in accordance with the provisions of 4-4-1/1.11.4 of the *Steel Vessel Rules*. Each cylinder is to be fitted with a suitable pressure relief device such as a fusible plug or a rupture disc.

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

1.7 Testing (2006)

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 4-4-2.

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 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. The system is to be operationally tested in the presence of the Surveyor under working conditions after installation.

3 Fuel Storage and Refueling Systems for Helicopter Facilities

3.1 Fuels with Flash Point Above 60°C (140°F)

When fixed helicopter fuel storage and pumping systems are provided and the flash point of the fuel is above 60°C (140°F), closed cup test, the installation is to comply with 4-4-4/1, 4-4-4/3 and 4-4-8/3.3.5.

3.3 Fuels with Flash Point at or Below 60°C (140°F) – Installations on an Open Deck

3.3.1 General

The designated fuel storage and refueling areas are to be suitably isolated from areas which contain a source of vapor ignition, escape routes and embarkation stations, and are not to be located on landing areas. The storage and refueling areas are to be permanently marked as an area where smoking and open flames are not permitted.

3.3.2 Tanks

Fixed fuel storage tanks are to be of metal construction. Mounting, securing arrangements and electrical bonding of the storage tank and refueling system are to be approved.

3.3.3 Vents and Sounding

Fuel storage tank venting and sounding arrangements are to comply with 4-4-3/9.5, 4-4-3/9.7, 4-4-4/7.5 and 4-4-3/13.

3.3.4 Tank Valves

Fuel storage tank outlet valves are to be provided with a means of remote closure. Means are also to be provided for remote shutdown of the refueling pumps.

3.3.5 Spill Containment (2015)

To contain spillage and retain fire extinguishing agents, a coaming of at least 150 mm (6 in.) in height is to be provided. The coaming is to surround the fuel storage area, which consists of the fuel tank, associated piping and any pumping unit adjacent to the storage tank. Where the pumping unit or any other unit such as dispenser/coalescer unit is remote from the tank, a separate coaming is to be provided around each unit.

Drainage is to be provided for the area enclosed by the coaming, complying with the following:

- i) The area within the coaming is to be sloped toward the drain line.
- ii) Drainage from the area within the coaming is to be led through a valve designed for selective output (e.g., 3-way valve) either to a holding tank complying with 4-4-8/3.3.2 and 4-4-8/3.3.3 above or directly overboard. No other valves may be fitted in the drain line.
- iii) The cross sectional area of the drain line from the fuel tank coaming is to be at least twice that of the fuel storage tank outlet connection.

Fuel tank coamings not provided with drainage arrangements in accordance with the above are to be sized to contain the full volume of the fuel storage tank plus 150 mm (6 in.) of foam.

3.3.6 Electrical Equipment (2016)

All electrical equipment installed within 3 meters (10 ft) of either the tank vent outlet or the pumping/refueling equipment is to be of a certified safe type. Electrical equipment installed may be any of the types indicated in 4-6-3/11.1.1 and is to be IEC Publication 60079-20-1 group IIA class T3.

3.5 Fuels with Flash Points at or Below 60°C (140°F) – Installation within Enclosed Spaces

3.5.1 Independent Tanks

Fuel storage tanks and their venting and sounding arrangements are to comply with 4-4-8/3.3.2 and 4-4-8/3.3.3. The valving arrangements on the tanks are to comply with 4-4-4/3.7.

3.5.2 Integral Tanks

The venting and sounding arrangements for integral tanks are to comply with 4-4-8/3.3.3. Overflow and valving arrangements are to comply with 4-4-3/11 and 4-4-4/3.7, respectively. Cofferdams meeting the requirements of 5C-2-1/5.3 of the *Steel Vessel Rules* are to be provided to separate fuel tanks from the spaces mentioned therein.

3.5.3 Access Arrangements

The access to the fuel storage and refueling compartment is to be from the open deck by means of a trunk, if necessary. The compartment is to be bounded by gas tight bulkheads/decks and there is to be no direct access from any other compartment to the fuel storage and refueling compartment or access trunk.

3.5.4 Electrical Equipment (2016)

Electrical equipment installed in the refueling pump room and the space in which an independent helicopter fuel tank storage is located is to be of a certified safe type. All electrical equipment installed within three (3) meters (10 ft) of the tank vent outlet is to be of a certified safe type. Electrical equipment installed may be any of the types indicated in 4-6-3/11.1.1 and is to be IEC Publication 60079-20-1 group IIA class T3.

3.5.5 Pumps

Fuel pumps for helicopter refueling are to comply with 4-4-7/1 and are to be provided with remote shut-down.

3.5.6 Piping

Helicopter refueling piping systems are to comply with 4-4-7/3.1.

3.5.7 Bilge/Drainage System

Provision is to be made for drainage of the refueling pump room and cofferdams. A separate bilge pump, ejector or a bilge suction from a refueling pump may be provided for this purpose. The arrangements are to be in accordance with 4-4-7/5.1.

3.5.8 Ventilation

Systems for the refueling pump room and the space in which an independent helicopter fuel tank is located are to comply with 4-6-6/1.13.1.

5 Liquefied Petroleum Gases

5.1 General

Liquefied petroleum gas may be used for cooking and heating on all vessels except passenger vessels. Liquefied petroleum gas 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, shall be designed to withstand a pressure of 34 bar (35 kgf/cm², 500 psi) without rupture.

5.3 Storage Cylinders

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

5.5 Installation and Testing

Where liquefied petroleum gases are used, the installation and testing is to comply with a recognized standard.

7 Chemical and Gas Carriers

Where vessels are intended to carry hazardous cargoes such as chemicals or liquefied gases, Part 5C, Chapters 8 and 9 of the *Steel Vessel Rules* are applicable.

9 Offshore Support Vessels

Where it is intended to carry limited amounts of hazardous and noxious liquid substances in bulk on offshore support vessels, the arrangement is to comply with Section 5-2-3 of the *ABS Rules for Building and Classing Offshore Support Vessels (OSV Rules)*.

11 Ammonia System

11.1 Compartmentation

Ammonia handling machinery is to be installed in a dedicated compartment with at least two access doors. The doors are to be of the self-closing, gastight type with no hold-back arrangements.

11.3 Safety Measures

The following safety measures are to be provided for compartments containing ammonia handling machinery, including process vessels.

- i) An independent mechanical negative ventilation system capable of providing at least 30 air changes per hour based on the gross volume of the space
- ii) A sprinkler system with control outside of the compartment
- iii) A fixed ammonia detector system with alarm inside and outside of the compartment
- iv) Water screen devices operable from outside of the compartment, for all access doors.
- v) An independent bilge system located within these compartments

11.5 Ammonia Piping

Ammonia piping is not to pass through accommodation spaces.

13 Liquid Mud Cargo Tanks (2006)

Liquid mud cargo tanks are to be provided with vent pipes complying with 4-4-3/9. In order to prevent overpressure or underpressure in the event of overflow into the vent pipe or clogging of the flame screen in the case of oil based mud, vents for liquid mud tanks are to also be provided with a suitable burst disc(s) rated below the mud tank design pressure. Spare burst discs are to be carried on board so that damage burst disc can be replaced. Suitable means of gauging the mud tanks such as a tank ullage method or level indicating devices may be fitted in lieu of sounding pipe per 4-4-3/13.3.

CHAPTER 5 Fire Extinguishing Systems

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PART

4

CHAPTER 5 Fire Extinguishing Systems

SECTION 1 All Vessels

1 General

1.1 Classification Requirements

The following are the minimum classification requirements for all self-propelled oceangoing vessels under 90 meters (295 feet) in length. For vessels classed with restricted service, the requirements may be modified and the proposed fire extinguishing arrangements are to be submitted for consideration.

1.3 Governmental Authority

Attention is directed to the appropriate governmental authority. In each case, there may be additional requirements depending on the gross tonnage, length, type and intended service of the vessel, as well as other particulars and details. Consideration will be given to fire extinguishing systems which comply with the published requirements of the governmental authority of the country in which the vessel is to be registered.

1.5 Automated Propulsion Machinery Spaces

Where automatic controls for propulsion machinery spaces are installed and it is intended that the propulsion machinery spaces are either not continuously manned at sea or only one person is required on watch, the requirements of Part 4, Chapter 7 are to be met.

1.7 Plans and Specifications

The plans together with supporting data and particulars listed in 4-1-1/7 are to be submitted for review.

1.9 Fire Control Plans

1.9.1 Required Information

Fire control plans are to be general arrangement plans showing for each deck the provision, location, controls and particulars, as applicable, of fixed fire detection, alarm and extinguishing systems, portable fire fighting appliances and equipment, controls for shutdowns of the ventilation system, fuel oil pumps and valves, along with details of the means provided for the closing of openings, and locations of accesses to critical spaces (such as fire control stations, Category A machinery spaces, etc.). For vessels where structural fire protection is required by the Rules, locations and type of fire retarding bulkheads are to be specified on the plan.

1.9.2 Plan Location

The fire control plans are to be conspicuously posted in the vessel for the guidance of the crew.

1.11 Additional Fixed Fire Fighting Systems (2009)

Where a fixed fire extinguishing system not required by Sections 4-5-2 and 4-5-3 is installed, such system is to meet the applicable requirements of 4-5-2/11 and is to be submitted for approval.

3 Fire Pumps, Fire Main, Hydrants and Hoses

3.1 Materials

Materials readily rendered ineffective by heat are not to be used for fire mains unless adequately protected. In order to be considered not “readily rendered ineffective by heat”, a component is to be certified as having passed an applicable, recognized fire test, or the material is to have a melting temperature higher than the test temperature specified in an applicable fire test.

3.3 Fire Pumps

3.3.1 Number of Pumps

All vessels are to have at least two fire pumps. Refer to 4-5-2/5 for vessels of 500 gross tons or over, or 4-5-3/1 for vessels under 500 gross tons.

3.3.2 Type of Pumps

Sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil. If the pumps are subject to occasional duty for the transfer or pumping of fuel oil, changeover arrangements that prevent operation for fire fighting when configured for fuel transfer are to be fitted.

3.3.3 Pressure

Power-driven fire pumps are to have sufficient pressure to produce 12 m (40 ft) jet throw through any two adjacent hydrants located in accordance with 4-5-1/3.7.1. Also refer to 4-5-2/5.1 or 4-5-3/1.

3.3.4 Relief Valves

In conjunction with all fire pumps, relief valves are to be provided if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves are to be so placed and adjusted as to prevent excessive pressure in any part of the fire main system. In general, the relief valve is to be set to relieve at no greater than 1.7 bar (1.75 kgf/cm², 25 psi) in excess of the pump pressure necessary to maintain the requirements of 4-5-1/3.3.3.

3.5 Fire Main

3.5.1 Size

Refer to 4-5-2/3 for vessels of 500 gross tons and over. For vessels under 500 gross tons, the diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from the pump(s). Refer to 4-5-3/1 and 4-5-3/Table 1.

3.5.2 Cocks or Valve

A valve is to be fitted to serve each fire hose so that any fire hose may be removed while the fire pumps are at work.

3.5.3 Cold Weather Protection

Fire main systems are to be provided with drains, circulation loops or other means for cold weather protection.

3.7 Hydrants

3.7.1 Number and Position of Hydrants

The number and position of the hydrants are to be such that at least two jets of water not emanating from the same hydrant, one of which is to be from a single length of hose, may reach any part of the vessel normally accessible to the passengers or crew while the vessel is being navigated. In addition, the arrangements are to be such that at least two jets of water can reach any part of any cargo space when empty.

3.7.2 Materials

Materials readily rendered ineffective by heat are not to be used for fire protection systems unless adequately protected. See 4-5-1/3.1.

3.7.3 Installation

The pipes and hydrants are to be so placed that the fire hoses may be easily coupled to them. In vessels where deck cargo may be carried, the positions of the hydrants are to be such that they are always readily accessible and the pipes are to be arranged to avoid risk of damage by such cargo.

3.9 Hoses (2009)

3.9.1 General

Fire hoses are to be of a type certified by a competent independent testing laboratory as being constructed of nonperishable material to a recognized standard. The hoses are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used.

Fire hoses are to have a length of at least 10 m (33 ft), but not more than:

- 15 m (50 ft) in machinery spaces;
- 20 m (66 ft) in other spaces and open decks; and
- 25 m (82 ft) for open deck on vessels with a maximum breadth in excess of 30 m (98 ft)

Each hose is to have a nozzle and the necessary couplings. Fire hoses, together with any necessary fittings and tools, are to be kept ready for use in conspicuous positions near the hydrants.

3.9.2 Diameter

For vessels less than 500 gross tons, hoses are not to have a diameter greater than 38 mm (1.5 in.). Hoses for vessels under 20 m (65 ft) in length may be of a good commercial grade having a diameter of not less than 16 mm ($\frac{5}{8}$ in.), and are to be have a minimum test pressure of 10.3 bar (10.5 kgf/cm², 150 psi) and a minimum burst pressure of 31.0 bar (31.6 kgf/cm², 450 psi).

3.9.3 Number of Fire Hoses

In vessels of 1,000 gross tonnage and upwards, the number of fire hoses to be provided is to be at least one for each 30 m (100 ft) length of the vessel and one spare, but in no case less than five in all. This number does not include any hoses required in any engine or boiler room.

In vessels of less than 1,000 gross tonnage, the number of fire hoses to be provided is to be at least one for each 30 m (100 ft) length of the vessel and one spare. However, the number of hoses is to be in no case less than three.

Unless one hose and nozzle is provided for each hydrant in the vessel, there are to be complete interchangeability of hose couplings and nozzles.

3.11 Nozzles

3.11.1 Size

Standard nozzle sizes are to be 12 mm (0.5 in.), 16 mm (0.625 in.) and 19 mm (0.75 in.), or as near thereto as possible. Larger diameter nozzles may be permitted subject to compliance with 4-5-1/3.3.3. For accommodation and service spaces, a nozzle size greater than 12 mm (0.5 in.) need not be used. For machinery spaces and exterior locations, the nozzle size is to be such as to obtain the maximum discharge possible from two jets at the pressure mentioned in 4-5-1/3.3.3 from the smallest pump; however, a nozzle size greater than 19 mm (0.75 in.) need not be used.

3.11.2 Type

All nozzles are to be of an approved dual-purpose type (i.e., spray and jet type) incorporating a shut-off. Fire hose nozzles of plastic type material such as polycarbonate may be accepted subject to review of their capacity and serviceability as marine use fire hose nozzles.

5 Means for Closing of Openings, Stopping of Machinery and Oil Containment

5.1 Ventilation Fans and Openings

Means are to be provided for stopping ventilation fans serving machinery and cargo spaces, and for closing all doorways, ventilators and other openings to such spaces. These means are to be capable of being operated from outside such spaces in case of fire. See 4-6-2/19.1.1.

5.3 Other Auxiliaries (2009)

Machinery driving forced- and induced-draft fans, oil-fuel transfer pumps, oil-fuel unit pumps and other similar fuel pumps, fired equipment such as an incinerator, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers) are to be fitted with remote shutdowns situated outside of the spaces concerned so that they may be stopped in the event of a fire arising in the space. This need not apply to oily water separators. See 4-6-2/19.1.2.

In addition to the remote shutdowns required above, a means to shut down the equipment is to be provided within the space itself.

5.5 Oil Tank Suction Pipes (1998)

Except for small independent tanks having a capacity of less than 500 liters (132 gal.), every oil-suction pipe from a storage, settling, daily service tank or lube oil tank situated above the double bottom is to be fitted with a valve capable of being closed in the event of a fire from outside of the space where such tanks are located. In the special case of deep tanks situated in any shaft or pipe tunnel, control may be effected by means of an additional valve on the pipe line outside of the tunnel. See 4-4-4/3.7.

Where inadvertent valve closure could result in damage to the running machinery due to lack of lubricating oil, a valve is to be fitted on the lubricating oil tank, but remote control of the valve from outside of the space is not required. See 4-4-4/1.1.

7 Helicopter Facilities (2005)

7.1 Application

For each helicopter deck on board a vessel designated for helicopter operations, fire fighting system and equipment complying with 4-5-1/7.3.2 and 4-5-1/7.3.3 as applicable, are to be provided.

Helicopter deck (helideck) is a purpose-built helicopter landing area, on a vessel including all structure, fire fighting appliances and other equipment necessary for the safe operation of helicopters, but not those areas for occasional or emergency helicopter operations (e.g., circle H marked on hatch covers for drop-off/pickup of pilot). Helicopter facility is a helideck including any refueling and hangar facility.

7.3 Provisions for Helicopter Deck

7.3.1 Hoses and Nozzles

At least two combination solid stream and water spray nozzles and hoses sufficient in length to reach any part of the helicopter deck are to be provided.

7.3.2 Portable Extinguishers

The helicopter deck is to be protected by at least two dry powder extinguishers of a total capacity of not less than 45 kg (100 lb).

7.3.3 Back-up System

A back-up fire fighting system is to be provided consisting of CO₂ extinguishers of a total capacity of not less than 18 kg (40 lb) or equivalent, one of these extinguishers being equipped so as to enable it to reach the engine area of any helicopter using the helicopter deck. The back-up system is to be located so that the equipment would not be vulnerable to the same damage as the dry powder extinguisher required by 4-5-1/7.3.2.

7.3.4 Fixed Foam System

A suitable fixed foam fire extinguishing system, consisting of monitors or hose streams or both, is to be installed to protect the helicopter landing area in all weather conditions in which helicopters can operate. The system is to be capable of delivering foam solution at a discharge rate in accordance with the following table for at least five minutes. The operation of the foam system is not to interfere with the simultaneous operation of the fire main.

Category	Helicopter Overall Length, L_H	Discharge Rate	
		Liters/min.	gpm
H1	$L_H < 15 \text{ m (49 ft)}$	250	66
H2	$15 \text{ m (49 ft)} \leq L_H < 24 \text{ m (79 ft)}$	500	132
H3	$24 \text{ m (79 ft)} \leq L_H < 35 \text{ m (115 ft)}$	800	211

The foam agent is to meet the performance standards for Level B foam in the International Civil Aviation Organization's Airport Services Manual (Part 1 Chapter 8, Paragraph 8.1.5, Table 8-1) and be suitable for use with sea water.

7.3.5 Fireman's Outfits

In addition to the fireman's outfits required in 4-5-2/15, two additional sets of fireman's outfits are to be provided and stored near the helicopter deck.

7.3.6 Other Equipment

The following equipment is to be provided near the helicopter deck and is to be stored in a manner that provides for immediate use and protection from the elements:

- Adjustable wrench
- Fire resistant blanket
- Bolt cutters with arm length of 60 cm (24 in.) or more
- Grab hook or salving hook
- Heavy duty hack saw, complete with six spare blades
- Ladder
- Lifeline of 5 mm ($3/16$ in.) diameter \times 15 m (50 ft) length
- Side cutting pliers
- Set of assorted screw drivers
- Harness knife complete with sheath

7.5 Provisions for Enclosed Helicopter Facilities

Hangars, refueling and maintenance facilities are to be treated as machinery space of category A with regard to structural fire protection, fixed fire-extinguishing system and fire detection system requirements. See 4-5-2/11 and 4-5-2/21.

7.7 Operation Manual

Each helicopter facility is to have an operation manual, including a description and a checklist of safety precautions, procedures and equipment requirements. This manual may be part of the vessel's emergency response procedures.

9 Portable Extinguishers

Portable extinguishers are to be provided in the quantities and locations indicated in 4-5-1/Table 1 and 4-5-1/Table 2.

11 Paint and Flammable Liquid Lockers (2001)

Paint and flammable liquid lockers or any similar service spaces used for the storage of flammable liquids (such as solvents, adhesives, lubricants etc.) are to be protected by a fire extinguishing arrangement enabling the crew to extinguish a fire without entering the space. Unless required or permitted otherwise by the flag Administration, one of the following systems is to be provided:

11.1 Lockers of 4 m² (43 ft²) or More Floor Area and Lockers with Access to Accommodation Spaces

Paint lockers and flammable liquid lockers of floor area 4 m² (43 ft²) or more and also such lockers of any floor area with access to accommodation spaces are to be provided with one of the fixed fire extinguishing systems specified below:

- i) CO₂ system, designed for 40 % of the gross volume of the space.
- ii) Dry powder system, designed for at least 0.5 kg/m³ (0.03 lb/ft³).
- iii) Water spraying system, designed for 5 liters/m²/minute (0.12 gpm/ft²). The water spraying system may be connected to the vessel's fire main system, in which case, the fire pump capacity is to be sufficient for simultaneous operation of the fire main system, as required in 4-5-2/5.1, and the water spray system. Precautions are to be taken to prevent the nozzles from being clogged by impurities in the water or corrosion of piping, nozzles, valves and pump.
- iv) Systems or arrangements other than those referenced above may be also considered, provided they are not less effective.

11.3 Lockers of Less Than 4 m² (43 ft²) Floor Area Having no Access to Accommodation Spaces

For paint lockers and flammable liquid lockers of floor area less than 4 m² (43 ft²) having no access to accommodation spaces, portable fire extinguisher(s) sized in accordance with 4-5-1/11.1i) and which can be discharged through a port in the boundary of the lockers may be accepted. The required portable fire extinguishers are to be stowed adjacent to the port. Alternatively, a port or hose connection may be provided for this purpose to facilitate the use of water from the fire main.

TABLE 1
Classification of Portable and Semi-portable Extinguishers (1 July 2009)

Fire extinguishers are designated by type as follows: A, for fires in combustible materials such as wood; B, for fires in flammable liquids and greases; C, for fires in electrical equipment.

Fire extinguishers are designated by size where I is the smallest. Sizes I and II are hand portable extinguishers and sizes III and V are semi-portable extinguishers.

Classification		Water liters (US gallons)	Foam liters (US gallons)	Carbon Dioxide kg (lb)	Dry Chemical kg (lb)
Type	Size				
A	II	9 (2.5)	9 (2.5)	—	5 (11) ⁽¹⁾
B	II	—	9 (2.5)	5 (11)	5 (11)
B	III	—	45 (12)	15.8 (35)	9 (20)
B	V	—	152 (40)	45 (100) ⁽²⁾	22.5 (50) ⁽²⁾
C	I	—	—	1.8 (4)	0.9 (2)
C	II	—	—	5 (11)	5 (11)

Notes:

- 1 Must be specifically approved as Type A, B, C extinguisher
- 2 For outside use, double the amount to be carried.

TABLE 2
Portable and Semi-portable Extinguishers (1 July 2009)

Space	Classification	Quantity and Location ⁽⁵⁾
Safety Areas		
Communicating corridors	A-II	1 in each main corridor not more than 46 m (150 ft) apart. (May be located in stairways.)
Pilothouse (1 July 2009)	C-II	2 in vicinity of exit. See Notes 4 and 6.
Radio room	C-II	1 in vicinity of exit. See Note 4.
Accommodations		
Sleeping Accommodations	A-II	1 in each sleeping accommodation space. (Where occupied by more than four persons.)
Service Spaces		
Galleys	B-II or C-II	1 for each 230 m ² (2500 ft ²) or fraction thereof for hazards involved.
Storerooms	A-II	1 for each 230m ² (2500 ft ²) or fraction thereof located in vicinity of exits, either inside or outside of spaces. See Note 4.
Workshops	A-II	1 outside the space in vicinity of exit. See Note 4.
Machinery Spaces		
Internal combustion or gas turbine-engines	B-II and B-III	1 for each 746 kW (1000 hp), but not less than 2 nor more than 6. See Note 1. 1 required. See Note 3.
Electric motors or generators of the open type	C-II	1 for each motor or generator unit. See Note 2.

Notes:

- 1 When installation is on weather deck or open to atmosphere at all times, one B-II for every three engines is allowable.
- 2 Small electrical appliances, such as fans, etc., are not to be counted or used as basis for determining number of extinguishers required.
- 3 Not required on vessels of less than 500 gross tons.
- 4 Vicinity is intended to mean within 1 m (3 ft).
- 5 For vessels of 1000 gross tons and above, at least five extinguishers are to be provided for accommodation spaces, service spaces, spaces where the vessel's radio, main navigation equipment or emergency source of power is located, and locations where the fire recording or fire control equipment is located.
- 6 (1 July 2009) For cargo ships less than 500 gross tons, "C-I" portable extinguishers may be used.

PART

4

CHAPTER 5 Fire Extinguishing Systems

SECTION 2 Requirements for Vessels 500 Gross Tons and Over

1 Fire Safety Measures

The applicable requirements of Section 3-4-1 are to be complied with.

3 Size of Fire Main

The diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from two fire pumps operating simultaneously, except that the diameter need only be sufficient for the discharge of 140 m³/hr (616 gpm).

5 Main and Emergency Fire Pumps

5.1 Main Fire Pumps

5.1.1 Number of Pumps

For vessels of 1000 gross tons and above, the pumps are to be independently power-driven. For vessels less than 1000 gross tons, only one of the pumps need be independently power-driven and one of the pumps may be attached to the propulsion unit.

5.1.2 Total Pump Capacity

The fire pumps required by 4-5-2/5.1.1 are to be capable of delivering for firefighting purposes a quantity of water, at the appropriate pressure prescribed, not less than four-thirds of the quantity required under 4-4-3/3.3 to be dealt with by each of the independent bilge pumps when employed on bilge pumping, using in all cases L = length of vessel, as defined in 3-1-1/3, except that the total required capacity of the fire pumps need not exceed 180 m³/hr (792 gpm).

5.1.3 Individual Pump Capacity

Each of the fire pumps required by 4-5-2/5.1.1 is to have a capacity of not less than 40% of the total required capacity, but not less than 25 m³/hr (110 gpm), and in any event is to be capable of delivering at least the two required jets of water. These pumps are to be capable of supplying the water under the required conditions. Where more pumps than required are installed, their capacity will be subject to special consideration.

5.1.4 Pressure

For vessels 1000 gross tons and over with the two power-driven pumps simultaneously delivering through the nozzles specified in 4-5-1/3.11 the quantity of water specified in 4-5-1/3.5.1 through any adjacent hydrants, a pressure of 2.5 bar (2.6 kgf/cm², 37 psi) is to be maintained at all hydrants.

For vessels less than 1000 gross tons, the power-driven fire pumps are to have sufficient pressure to produce 12 m (40 ft) jet throw through any two adjacent hydrants located in accordance with 4-5-1/3.5.1.

5.1.5 Arrangement

Unless an emergency fire pump complying with 4-5-2/5.3 is provided, the two main fire pumps, including their power source, fuel supply, electric cables, and lighting and ventilation for the spaces in which they are located, are to be in separate compartments so that a fire in any one compartment will not render both main pumps inoperable. Only one common boundary is allowed between the compartments, in which case, the single common boundary is to be at least to A-0 standard.

No direct access is allowed between the compartments except that where this is impracticable, an access meeting the requirements in 4-5-2/5.1.6 may be considered.

5.1.6 Alternative Arrangement

Where it is impracticable to do otherwise, a direct access between the compartments containing the main fire pumps may be considered, provided:

- i) A watertight door capable of being operated locally from both sides of the bulkhead, and from a safe and accessible location outside of these spaces is provided. The means for the latter operation is expected to be available in the event of fire in these spaces; or
- ii) An air lock consisting of two gastight steel doors. The doors are to be self-closing without any hold back arrangements.
- iii) In addition to the arrangements specified in 4-5-2/5.1.6i) or 4-5-2/5.1.6ii) above, a second protected means of access is to be provided to the space containing the fire pumps.

5.1.7 Isolation

Isolating valves and other arrangements, as necessary, are to be provided so that if a fire pump and its associated piping within its compartment are rendered inoperable, the fire main can be pressurized with a fire pump located in another compartment.

5.3 Emergency Fire Pumps

5.3.1 When Required

If a fire in any one compartment could put all main pumps out of action (see 4-5-2/5.1.2), an independently power-driven and self-priming emergency fire pump complying with this paragraph is to be provided.

5.3.2 Arrangement

An emergency fire pump system, including power source, fuel supply, electric cables, and lighting, as well as lighting and ventilation for the emergency fire pump space, is to be in a separate compartment than the main fire pumps so that a fire in any one compartment will not render both the main and the emergency fire pumps inoperable.

No direct access is permitted between the main machinery space and the spaces containing the emergency fire pump and its source of power. Where this is impracticable, access between the space containing the emergency fire pump and the main machinery space, in accordance with 4-5-2/5.1.6, may be considered

The space containing the emergency fire pump is not to be contiguous to the boundaries of machinery spaces of Category A or the spaces containing the main fire pumps. Where this is impracticable, the common bulkhead between the two spaces is to be constructed to A-60 standard. The insulation is to extend at least 450 mm (18 in.) outside of the area of the joint bulkheads and decks.

5.3.3 Capacity

The emergency fire pump is to be capable of supplying at least two jets of water required by 4-5-1/3.5.1, using the available hydrants, hoses and nozzles, and is to have a capacity of at least 40% of the total capacity of the fire pumps required by 4-5-2/5.1.2 or 25 m³/hr (110 gpm), whichever is greater.

When the pump is delivering the quantity of water, as above, the pressure at the hydrant is to be not less than the pressure given in 4-5-2/5.1.4.

In addition, the emergency fire pump is also to be capable of simultaneously supplying the amount of water needed for any fixed extinguishing system protecting the space containing the main pumps.

5.3.4 Starting

Internal combustion engines larger than 15 kW (20 hp) are to be provided with power starting systems having a capacity sufficient for at least six starts within 30 minutes, including at least two within the first ten minutes. For engines of 15 kW (20 hp) and smaller, manual means of starting is sufficient.

Any internal combustion engine driving an emergency fire pump is to be capable of readily being started in its cold condition down to a temperature of 0°C (32°F). If this is impracticable or if lower temperatures are likely to be encountered, consideration is to be given to the provision and maintenance of heating arrangements.

5.3.5 Fuel Supply

Any service fuel tank is to contain sufficient fuel to enable the pump to run on full load for at least three hours and sufficient reserves of fuel are to be available outside of the main machinery space to enable the pump to be run on full load for an additional 15 hours.

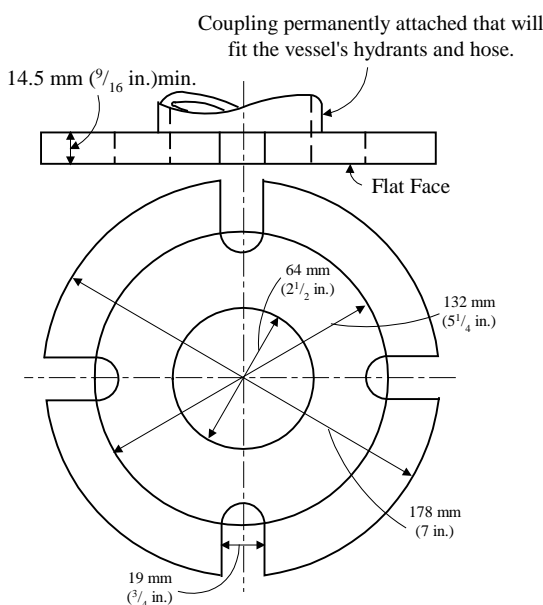
5.3.6 Suction

The total suction head and the net positive suction head of the pump is to be such that the requirements of 4-5-2/5.3.3 and 4-5-2/5.1.4 will be satisfied under all conditions of list, trim, roll and pitch likely to be encountered in service. The sea valve is to be operable from a position near the pump or locked in the open position (provided possible flooding can be detected).

7 International Shore Connection

At least one international shore connection, as shown in 4-5-2/Figure 1, is to be provided and kept aboard the vessel with gasket, bolts and eight washers. Facilities are to be available enabling such a connection to be used on either side of the vessel.

FIGURE 1
International Shore Connection



Bolts: 4, each of 16 mm ($\frac{5}{8}$ in.) diameter, 50 mm (2 in.) in length
 Flange Surface: Flat face
 Material: Any suited for 10 bar (10.5 kgf/cm², 150 psi)
 Gasket: Any suited for 10 bar (10.5 kgf/cm², 150 psi) service

9 Machinery Spaces

Category A machinery spaces are to be protected by a fixed fire extinguishing system complying with 4-5-2/11.

9.1 Fixed Local Application Firefighting Systems (1 July 2015)

For cargo vessels of 2000 gross tonnage and above, the machinery spaces of category A above 500 m³ (17,657 ft³) in volume, in addition to the fixed fire extinguishing system required in 4-5-2/11, are to be protected by an approved type of fixed water-based or equivalent local application firefighting system complying with the provisions of the IMO Guidelines for the Approval of Fixed Water-based Local Application Firefighting System for Use in Category A Machinery Spaces, MSC/Circ. 1387. In the case of periodically unattended machinery spaces, the fire fighting system is to have both automatic and manual release capabilities. In case of continuously manned machinery spaces, the fire fighting system is only required to have a manual release capability. The fixed local fire fighting systems are to protect areas such as the following without the necessity of engine shutdown, personnel evacuation or sealing the spaces:

- i) The fire hazard portion of internal combustion machinery;
- ii) Purifiers for heated fuel oil, see 4-5-2/9.3;
- iii) The fire hazard portions of incinerators; and
- iv) Boiler front.

Activation of any local application system shall give a visual and distinct audible alarm in the protected space and at continuously manned stations. The alarm is to indicate the specific system activated. The system alarm requirements described within this paragraph are in addition to, and not a substitute for, the detection and fire alarm system required elsewhere in Section 4-5-2 and Section 4-5-3. A bridge alarm is to be provided with a visual notification when the system has been deactivated or placed in manual mode.

9.3 Segregation of Purifiers for Heated Fuel Oil (1 July 2002)

Fuel oil purifiers for heated oil are to be placed in separate room or rooms enclosed by steel bulkheads extending from deck to deck and provided with self-closing doors. In addition, the room is to be provided with the following:

- i) Independent mechanical ventilation or ventilation arrangement that can be isolated from the machinery space ventilation, of the suction type.
- ii) Fire detection system.
- iii) Fixed fire extinguishing system capable of activation from outside of the room. The extinguishing system is to be dedicated to the room, but may be a part of the fixed fire extinguishing system for the machinery space.

However, for the protection of purifiers on cargo vessels of 2000 gross tonnage and above located within a machinery space of category A above 500 m³ (17,657 ft³) in volume, the above referenced fixed, dedicated system is to be a fixed, water-based or equivalent, local application fire extinguishing system complying with the provisions of 4-5-2/9.1. The system is to be capable of activation from outside of the purifier room. In addition, protection is to be provided by the fixed fire extinguishing system covering the Category A machinery space in which the purifier room is located. See 4-5-2/11.

- iv) Means of closing ventilation openings and stopping the ventilation fans, purifiers, purifier-feed pumps, etc., from a position close to where the fire extinguishing system is activated.

If it is impracticable to locate the fuel oil purifiers in a separate room, special consideration will be given with regard to location, containment of possible leakage, shielding and ventilation. In such cases, a local, fixed water-based fire extinguishing system complying with the provisions of 4-5-2/9.1 is to be provided. Where, due to the limited size of the category A machinery space, a local fixed water-based fire-extinguishing system is not provided, then an alternative type of local, dedicated, fixed fire extinguishing system is to be provided for the protection of the purifiers. In either case, the local fire extinguishing system is to activate automatically or manually from the centralized control station or other suitable location. If automatic release is provided, additional manual release is also to be arranged.

9.5 Spaces Containing Equipment with Oil Filled Capacitors (2014)

Spaces containing equipment with flammable oil filled capacitors are to be provided with any one of the following fixed fire extinguishing systems:

- i) A gas system complying with the provisions of 4-5-2/11.3; or
- ii) Other approved fire extinguishing system suitable for the equipment voltage hazard.

11 Fixed Fire Extinguishing Systems

11.1 Gas Smothering

11.1.1 Storage (2013)

Where the gas smothering medium is stored outside of the protected space, the storeroom is to be situated in a safe and readily accessible position and is to be effectively ventilated by a ventilation system independent of all other spaces.

Spaces for storage of cylinders or tanks for extinguishing gas are not to be used for other purposes. These spaces are not to be located forward of the forward collision bulkhead, when fitted. Access to these spaces is to be possible from the open deck. Spaces situated below the deck are to be located no more than one deck below the open deck.

Spaces where entrance from the open deck is not provided or which are located below deck are to be fitted with mechanical ventilation. The exhaust duct (suction) is to be lead to the bottom of the space. Such spaces are to be ventilated with at least six air changes per hour.

Fire-extinguishing media protecting the cargo holds (see 4-5-2/27) may be stored in a room located forward of the cargo holds, but aft of the collision bulkhead, provided that both the local manual release mechanism and remote control(s) for the release of the media are fitted, and the latter is of robust construction or so protected as to remain operable in case of fire in the protected spaces. The remote controls are to be placed in the accommodation area in order to facilitate their ready accessibility by the crew. The capability to release different quantities of fire-extinguishing media into different cargo holds so protected is to be included in the remote release arrangement.

11.1.2 Design (2017)

Containers and associated pressure components are to be designed based upon an ambient temperature of 55°C (131°F).

For CO₂ fire extinguishing systems, the wall thickness of steel piping is to be suitable for the pressure and not less than the thickness identified in 4-5-2/Table 1. Column A is for piping from storage containers to distribution station, and column B is for piping from distribution station to nozzles. For other fixed gas fire extinguishing systems, calculations showing compliance with 4-4-2/5.11 are to be submitted for approval.

Where the fire-extinguishing medium is used as the power source for the pre-discharge alarm, the piping to the alarm is to comply with Column B of 4-5-2/Table 1.

The relief valve of a CO₂ fire extinguishing system is to discharge outside of the CO₂ container storage compartment. **In addition, in piping sections where valve arrangements introduce sections of closed piping, such sections are to be fitted with a pressure relief valve and the outlet of the valve is to be led to open deck.**

Gray cast iron piping components are not to be used for fixed gas fire extinguishing systems. **All discharge piping, fittings and nozzles in the protected spaces are to be constructed of materials having a melting temperature which exceeds 925°C (1697°F). The piping and associated equipment are to be adequately supported.**

Threaded joints in CO₂ systems are to be allowed only inside protected spaces and in CO₂ cylinder rooms.

TABLE 1
Minimum Steel Pipe Wall Thickness for CO₂ Medium Distribution Piping (2013)

Nominal size, mm	OD mm	A mm	B mm	Nominal size, in.	OD in.	A in.	B in.
15	21.3	2.8	2.6	1/2	0.840	0.110	0.102
20	26.9	2.8	2.6	3/4	1.050	0.110	0.102
25	33.7	4.0	3.2	1	1.315	0.157	0.126
32	42.4	4.0	3.2	1 1/4	1.660	0.157	0.126
40	48.3	4.0	3.2	1 1/2	1.9	0.157	0.126
50	60.3	4.5	3.6	2	2.375	0.177	0.142
65	76.1	5.0	3.6	2 1/2	2.875	0.197	0.142
80	88.9	5.5	4.0	3	3.5	0.220	0.157
90	101.6	6.3	4.0	3 1/2	4.0	0.248	0.157
100	114.3	7.1	4.5	4	4.5	0.28	0.177
125	139.7	8.0	5.0	5	5.563	0.315	0.197
150	168.3	8.8	5.6	6	6.625	0.346	0.22

Notes:

- 1 The above minimum thicknesses are derived from those thicknesses available in ISO 4200 Series 1 (OD), JIS (N.P.S.), or ASTM (N.P.S.). Diameter and thickness according to other recognized standards will be accepted.
- 2 For threaded pipes, where approved, the thickness is to be measured to the bottom of the thread.
- 3 The internal surface of pipes outside of the engine room is to be galvanized.
- 4 For larger diameters the minimum wall thickness will be subject to special consideration by ABS.
- 5 In general, the minimum thickness is the nominal wall thickness and no allowance need be made for negative tolerance or reduction in thickness due to bending.

11.1.3 Alarm

(2017) Means are to be provided for automatically giving audible and visual warning of the release of fire extinguishing gas into any space to which personnel normally have access. **The audible alarms are to be located so as to be audible throughout the protected space with all machinery operating, and the alarms are to be distinguished from other audible alarms by adjustment of sound pressure or sound patterns.** The alarm is to operate for at least a 20 second period before the gas is released. Alarms may be pneumatically (by the extinguishing medium or by air) or electrically operated.

11.1.3(a) *Electric.* If electrically operated, the alarms are to be supplied with power from the main and an emergency source of electrical power.

11.1.3(b) *Pneumatic.* If pneumatically operated by air, the air supply is to be dry and clean and the supply reservoir is to be automatically kept charged at all times and is to be fitted with a low pressure alarm. The air supply may be taken from the starting air receivers. Any stop valve fitted in the air supply line is to be locked or sealed in the open position. Any electrical components associated with the pneumatic system are to be powered from the main and an emergency source of electrical power.

11.1.3(c) *Uninterruptible Power Supply (2013).* For fire extinguishing systems that protect the machinery space containing the main source of power, instead of the power supply arrangements required above for electrically operated alarms and electrical components associated with pneumatic alarms, an uninterruptible power supply which is supplied with power from the emergency switchboard is to be provided.

11.1.4 Controls

Except as otherwise permitted herein, two independent manual control arrangements are to be provided, one of them being positioned at the storage location and the other in a readily accessible position outside the protected space.

11.3 Carbon Dioxide Systems (2013)

In addition to the applicable requirements of 4-7-3/3.3 of the *Steel Vessel Rules*, fixed carbon dioxide fire extinguishing systems are to be in accordance with Chapter II-2, Regulations 10.4.2 and 10.4.3 of the International Convention for the Safety of Life at Sea (SOLAS) 1974 and Amendments in force, and Chapter 1.4 and Chapter 5 of the International Code for Fire Safety Systems. Fixed, low pressure carbon-dioxide systems are to be in accordance with 4-7-3/3.5 of the *Steel Vessel Rules*.

11.5 Foam (1998)

11.5.1 Fixed High Expansion Foam Systems (1 July 2009)

In addition to the applicable requirements of the Rules, fixed, high expansion foam systems are to be in accordance with Chapter 6.2.1 and Chapter 6.2.2 of the International Code for Fire Safety Systems.

Fixed foam fire-extinguishing systems using inside air are to be designed, constructed and tested in accordance with the requirements identified in MSC.1/Circ. 1271, *Guidelines for the Approval of High-Expansion Foam Systems Using Inside Air for the Protection of Machinery Spaces and Cargo Pump-Rooms*.

Foam concentrates are to be of an approved type.*

*Note: Reference is made to the International Maritime Organization MSC/Circular 670 "Guidelines for the Performance and Testing Criteria, and Surveys of High-Expansion Foam Concentrates for Fixed Fire-Extinguishing Systems."

11.5.2 Fixed Low Expansion Foam Systems

Low expansion foam systems may be fitted in addition to the required fixed fire extinguishing system. In addition to the applicable requirements of the Rules, fixed low expansion foam systems are to be in accordance with Chapter 6.2.1 and Chapter 6.2.3 of the International Code for Fire Safety Systems. Foam concentrates are to be of an approved type.**

**Note: Reference is made to the International Maritime Organization MSC/Circular 582 "Guidelines for the Performance and Testing Criteria, and Surveys of Low-Expansion Foam Concentrates for Fixed Fire-Extinguishing Systems."

11.7 Fixed Water Spraying Systems

In addition to the requirements of the Rules, fixed water spraying systems are to be in accordance with Chapter 7 of the International Code for Fire Safety Systems.

11.9 Clean Agent Fire Extinguishing Systems (2013)

Fixed gas fire-extinguishing systems equivalent to those specified in 4-5-2/11.1 through 4-5-2/11.7 are to be submitted for approval, based on the guidelines specified in the IMO MSC/Circ. 848 as amended by MSC/Circ. 1267 and this subsection.

Fire extinguishing systems using Halon 1211, 1301, and 2402 and perfluorocarbons are prohibited. The use of a fire-extinguishing medium, which either by itself or under expected conditions of use gives off toxic gases, liquids and other substances in such quantities as to endanger persons, is not permitted.

11.9.1 Fire Suppression Agent

The agent is to be recognized as a fire extinguishing medium by NFPA Standard 2001 or other recognized national standard. The minimum extinguishing concentration for net volume total flooding of the protected space at the lowest expected operating temperature, but not greater than 0°C (32°F), is to be determined by an acceptable cup burner test. The minimum design concentration is to be at least 30% above the minimum extinguishing concentration and is to be verified by full-scale test (see 4-5-2/11.9.2).

The fire extinguishing agent is to be acceptable for use in occupied spaces by U.S. EPA or other recognized national organization. The concentrations for cardiac sensitization NOAEL (No Observed Adverse Effect Level), LOAEL (Lowest Observed Adverse Effect Level) and ALC (Approximate Lethal Concentration) are to be submitted.

11.9.2 Fire Tests

The system is to pass the fire tests in the Appendix of the IMO MSC/Circ. 848 as amended by MSC.1/Circ. 1267. The testing is to include the system components.

The system is to pass an additional fire test (number 1 in the Appendix of MSC/Circ. 848) with the agent storage cylinder at the lowest expected operating temperature, but not greater than 0°C (32°F).

11.9.3 System Components

The system is to be suitable for use in a marine environment. Major components (valves, nozzles, etc.) are to be made of brass or stainless steel, piping is to be corrosion resistant (stainless steel or galvanized) and the material is to have a melting point of not less than 927°C (1700°F).

The system and its components are to be designed, manufactured and installed in accordance with recognized national standards.

Containers and associated pressure components are to be designed based upon an ambient temperature of 55°C (131°F).

Minimum wall thickness for distribution piping is to be in accordance with 4-5-2/Table 1 (Columns A or B, as applicable).

11.9.4 System Installation

11.9.4(a) Storage. As far as practicable, the fire suppression agent is to be stored outside the protected space in a dedicated storeroom. The storeroom is to be in accordance with 4-5-2/11.1.1, except that when mechanical ventilation is provided, the location of the exhaust duct (suction) is dependent on the density of the agent relative to air.

When allowed by the flag Administration, the fire suppression agent may be stored inside the protected space. In addition to the related instructions from the flag Administration, the installation is to be in accordance with paragraph 11 of IMO MSC/Circ. 848 as amended by MSC.1/Circ. 1267.

In the case of new installation in existing units, the storage of the fire suppression agent within a low fire risk space with a net volume at least two (2) times greater than the net volume of the protected space may be specially considered, based on the type of agent and the possible hazards for the personnel within the space.

11.9.4(b) Alarm. An audible and visual predischage alarm in accordance with 4-5-2/11.1.3 and paragraph 6 of IMO MSC/Circ. 848 as amended by MSC.1/Circ. 1267 is to be provided.

11.9.4(c) Controls (2017). Except as otherwise permitted herein two independent manual control arrangements are to be provided, one of them being positioned at the storage location and the other in a readily accessible position outside of the protected space.

Automatic actuation is not permitted when the protected space is normally **manned or interferes with the safety navigation of the vessel**. If the protected space is **normally unmanned and may be entered occasionally for brief periods such as** for repairs, maintenance **or other purpose**, automatic actuation may be allowed in addition to manual actuation, provided that the following conditions are met

- i) The egress from the protected space is horizontal. **Exit doors from the spaces are to be outward-swinging self-closing doors (i.e., opening in the direction of escape routes) which can be opened from the inside, including when the doors are locked from the outside.**
- ii) Notices that the space is protected by an automatic activation system are prominently posted at the entrance to the space.

- iii) A switch is provided near the entrance to disable the automatic release feature of the system. The switch is to have an indicator of its status such as red pilot light to indicate when the switch is activated (automatic release feature disabled). A sign is to be posted near the switch indicating that the automatic release feature is to be disabled when the space is occupied and that the automatic actuation is to be enabled when leaving the space. The sign is to also indicate that the manual release of the system remains enabled and the space is to be vacated immediately when the release alarm sounds.
- iv) When the automatic release feature is disabled, all other controls, alarms, etc., are to remain activated.
- v) An indicator at the control console is provided to indicate when the automatic release feature has been disabled.
- vi) The medium release warning alarm is to operate for the length of time needed to evacuate the space, but in no case less than 30 seconds for space exceeding 6000 ft³ (170 m³) and 20 seconds for spaces 6000 ft³ (170 m³) or less before the medium is released.
- vii) The automatic release of a clean agent fire extinguishing system is to be approved by the vessel's flag Administration.

11.9.4(d) *Nozzles.* The nozzle type, maximum nozzle spacing, maximum height and minimum nozzle pressure are to be within the limits to provide fire extinction as tested and verified in the appropriate fire test (see 4-5-2/11.9.2).

13 Additional Requirements for Vessels of 500 Gross Tons and Over Engaged in International Voyages

Vessels of 500 gross tons and over, engaged in international voyages, are to comply with the additional requirements in 4-5-2/15 through 4-5-2/37. These requirements need not be applied for vessels in domestic service which do not engage in international voyages.

15 Fireman's Outfit (2017)

At least two complete fireman's outfits are to be carried on board the vessel. See 4-5-2/33.7 for vessels intended to carry oil in bulk.

Each outfit is to consist of an approved breathing apparatus, lifeline, a safety lamp, an axe, non-conduction boots and gloves, a rigid helmet and protective clothing.

Two (2) spare charges are to be provided for each required breathing apparatus. All air cylinders for breathing apparatus are to be interchangeable. Vessels that are equipped with suitably located means for fully recharging the air cylinders free from any contamination need carry only one spare charge for each required apparatus.

A minimum of two two-way portable radiotelephone apparatus for each fire party for fire-fighter's communication are to be carried on board. Those two-way portable radiotelephone apparatus are to be of an explosion-proof type or intrinsically safe.

The fireman's outfits and equipment are to be stored so as to be easily accessible and ready for use and are to be stored in widely separate positions.

16 Emergency Escape Breathing Devices (EEBDs) (2005)

16.1 Accommodation Spaces

All ships are to carry at least two emergency escape breathing devices and one spare device within accommodation spaces.

16.3 Machinery Spaces

On all vessels, within the machinery spaces, emergency escape breathing devices are to be situated ready for use at easily visible places, which can be reached quickly and easily at any time in the event of fire. The location of emergency escape breathing devices is to take into account the layout of the machinery space and the number of persons normally working in the spaces. (See the Guidelines for the performance, location, use and care of emergency escape breathing devices, MSC/Circ. 849 and 1081). The number and locations of EEBDs are to be indicated in the fire control plan required in 4-5-1/1.9.

A summary of the MSC/Circ. 1081 requirements are shown in 4-5-2/Table 1. This applies to machinery spaces where crew are normally employed or may be present on a routine basis.

TABLE 2
Minimum Number of Required EEBDs (2005)

A. In machinery spaces for category A containing internal combustion machinery used for main propulsion ⁽¹⁾:
<ul style="list-style-type: none"> a) One (1) EEBD in the engine control room, if located within the machinery space b) One (1) EEBD in workshop areas. If there is, however, a direct access to an escape way from the workshop, an EEBD is not required; and c) One (1) EEBD on each deck or platform level near the escape ladder constituting the second means of escape from the machinery space (the other means being an enclosed escape trunk or watertight door at the lower level of the space).
B. In machinery spaces of category A other than those containing internal combustion machinery used for main propulsion,
One (1) EEBD should, as a minimum, be provided on each deck or platform level near the escape ladder constituting the second means of escape from the space (the other means being an enclosed escape trunk or watertight door at the lower level of the space).
C. In other machinery spaces
The number and location of EEBDs are to be determined by the Flag Administration.

Note:

- 1 Alternatively, a different number or location may be determined by the Flag Administration taking into consideration the layout and dimensions or the normal manning of the space.

17 Portable Fire Extinguishers (2007)

Spare charges are to be provided for 100% of the first ten (10) extinguishers and 50% of the remaining fire extinguishers capable of being recharged on board. Not more than sixty (60) total spare charges are required. Instructions for recharging are to be carried on board.

For fire extinguishers which cannot be recharged on board, additional portable fire extinguishers of the same quantity, type, capacity and number, as determined above, are to be provided in lieu of spare charges.

19 Portable Foam Applicator Units (1 July 2009)

Each Category A machinery space is to be provided with at least one portable foam applicator unit.

19.1 Specification

A portable foam applicator unit is to consist of a foam nozzle/branch pipe, either of a self-inducing type or in combination with a separate inductor, capable of being connected to the fire main by a fire hose, together with a portable tank containing at least 20 l (5.3 US gal.) of foam concentrate and at least one spare tank of foam concentrate of the same capacity.

19.3 System Performance

- i) The nozzle/branch pipe and inductor is to be capable of producing effective foam suitable for extinguishing an oil fire, at a foam solution flow rate of at least 200 l/min (52.8 gpm) at the nominal pressure in the fire main.
- ii) The foam concentrate shall be approved by ABS based on guidelines in the Guidelines for the Performance and Testing Criteria and Surveys of Low-expansion Foam Concentrates for Fixed Fire-extinguishing Systems (MSC/Circ.582/Corr.1).
- iii) The values of the foam expansion and drainage time of the foam produced by the portable foam applicator unit is not to differ more than $\pm 10\%$ of that determined in 4-5-2/19.3ii).
- iv) The portable foam applicator unit is to be designed to withstand clogging, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered on ships.

21 Fire Detection and Fire Alarm Systems (2012)

Any required fixed fire detection and fire alarm system is to meet the requirements in Chapter 9 of the International Code for Fire Safety Systems.

In addition to the above, the requirement of SOLAS II-2/7.7 “*manually operated call points complying with the Fire Safety Systems Code shall be installed throughout the accommodation spaces, service spaces and control stations*”, does not require the fitting of a manually operated call point in an individual space within the accommodation spaces, service spaces and control stations. However, a manually operated call point are to be located at each exit (inside or outside) to the open deck from the corridor such that no part of the corridor is more than 20 m (66 ft) from a manually operated call point. Service spaces and control stations which have only one access, leading directly to the open deck, are to have a manually operated call point not more than 20 m (66 ft) (measured along the access route using the deck, stairs and/or corridors) from the exit. A manually operated call point is not required to be installed for spaces having little or no fire risk, such as voids and carbon dioxide rooms, nor at each exit from the navigation bridge, in cases where the control panel is located in the navigation bridge.

23 Sample Extraction Smoke Detection Systems

Any required fixed sample extraction smoke detection system is to meet the requirements in Chapter 10 of the International Code for Fire Safety Systems.

25 Accommodation and Service Spaces

25.1 Fixed Systems

A fire detection and alarm system (methods IC or IIIC) or an automatic sprinkler, fire detection and fire alarm system (method IIC) is to be installed in accommodation and service spaces, in accordance with Regulation II-2/7.5.5 and Regulation II-2/10.6.2 of the International Convention for the Safety of Life at Sea (SOLAS) 1974 and Amendments in force.

25.3 Portable Fire Extinguishers

Portable fire extinguishers are to be provided, as required by 4-5-1/9. However, for vessels of 1000 gross tons and above, the total number of extinguishers for accommodation spaces, service spaces, spaces in which the vessel's radio or main navigation equipment or emergency source of power is located, and locations where the fire recording or fire control equipment is located is not to be less than five.

27 Fixed Fire Extinguishing Arrangements in way of Cargo Spaces

27.1 Cargo Vessels of 2000 Gross Tons and Over

Except for cargo spaces covered by 4-5-2/29 and 4-5-2/31, cargo spaces of cargo vessels of 2000 gross tons and above are to be provided with approved fixed fire extinguishing systems.

27.3 Exceptions

A fixed system need not be fitted in the case of cargo holds fitted with steel hatch covers, and where all ventilators and other openings leading to the holds can be effectively closed, and the vessel is constructed and intended solely for carrying ore, coal, grain, unseasoned timber or noncombustible cargoes.

27.5 Controls

As an alternative to providing the controls required by 4-5-2/11.1.4, a single manual means may be provided at the storage location.

29 Ro-Ro Cargo Spaces

29.1 Fire Detection

An approved automatic fire detection and fire alarm system complying with 4-5-2/21 and the following is to be provided. Manual call points are to be provided to activate the fire alarm from the navigation bridge and the passageways having entrances to the ro-ro spaces. The fire alarm indicator/control panel is to be located on the bridge or at the fire control station, if provided. When the indicator/control panel is located at the fire control station, an additional alarm is to be provided on the navigation bridge.

29.3 Fire Extinguishing Arrangements

Ro-ro cargo spaces capable of being sealed are to be fitted with an approved fixed gas fire extinguishing system. If a carbon dioxide system is fitted, the quantity of gas available is to be at least sufficient to give a minimum volume of free gas equal to 45% of the gross volume of the largest such cargo space which is capable of being sealed, and the arrangements are to be such as to ensure that at least two thirds of the gas required for the relevant spaces is introduced within 10 minutes.

In lieu of the above, a fixed high expansion foam system or water spray system may be fitted subject to special consideration. Ro-ro spaces not capable of being sealed are to be fitted with a fixed pressure water-spraying system. The water-spraying system, drainage and pumping arrangements will be subject to special consideration.

As an alternative to providing the controls required by 4-5-2/11.1.4, a single manual means may be provided at the storage location.

29.5 Portable Fire Extinguishers

At least one approved portable extinguisher is to be located at each cargo space access.

29.7 Ro-Ro Spaces Carrying Motor Vehicles with Fuel in Their Tanks

29.7.1

Each ro-ro cargo space intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion is to meet the requirements of 4-6-6/5.5.

29.7.2

Gravity drainage systems are not to be led to machinery spaces or other spaces where sources of ignition are present.

29.7.3

In addition, each space is to be provided with at least three water fog applicators and one portable foam applicator unit complying with the provisions of 4-5-2/19, provided that at least two such units are available on the vessel for use in such ro-ro cargo spaces.

29.7.4

Portable fire extinguishers suitable for fighting oil fires are to be provided at each vehicle deck level in all spaces where vehicles are carried. Extinguishers are to be located not more than 20 m (65 ft) apart on both sides of the vessel. Portable extinguishers required under 4-5-2/29.5 may be credited in meeting this requirement.

31 Cargo Spaces Carrying Vehicles with Fuel in Their Tanks (Other Than Ro-Ro Spaces) (1 July 2007)

Cargo spaces, other than ro-ro spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion are to comply with 4-5-2/29 with the following exceptions:

- i) A sample extraction smoke detection system complying with the provisions of 4-5-2/23 may be permitted in lieu of 4-5-2/29.1, and
- ii) The provisions of 4-5-2/29.7.3 and 4-5-2/29.3.4 may be omitted

33 Additional Requirements for Vessels Intended to Carry Oil in Bulk

33.1 Fixed Fire Extinguishing Systems

33.1.1 Cargo Pump Rooms

Cargo pump rooms are to be provided with an approved fixed fire extinguishing system controlled from the deck. See also 4-6-6/1.13.1(b).

33.1.2 Pump Room Alarms

Audible alarms to warn of the release of fire extinguishing medium into pump rooms, as required by 4-5-2/11.1.3, may be of the pneumatic type or electric type. Air, and not CO₂, is to be used in the testing of pneumatic alarms. When electrically operated alarms are used, the arrangements are to be such that the electric actuating mechanism is located outside of the pump room.

33.1.3 System Arrangement

When a tank smothering system is fitted, arrangements are to be provided to prevent tank gases from entering dry spaces. When mixed cargo is to be carried, the smothering lines for the cargo oil tanks are to be fitted with stop-check valves in order to prevent contamination of cargo from one tank to another.

33.1.4 Cargo Tank Protection

For tankers of 30.5 m (100 ft) in length and above, a deck foam system is to be installed for the protection of all cargo tanks. For tankers less than 30.5 m (100 ft) in length, two B-V extinguishers (see 4-5-1/Table 1) are to be provided for the protection of the cargo tanks.

33.3 Fire Main Isolation Valves

Isolation valves are to be fitted in the fire main at the poop front in a protected position and on the tank deck at intervals of not more than 40 m (131 ft).

33.5 Gas Detectors

Two portable gas detectors are to be provided.

33.7 Fireman's Outfits

Two outfits, in addition to those required by 4-5-2/15, are to be provided.

35 Chemical and Gas Carriers

A fixed fire extinguishing system suitable for use with the intended cargo is to be provided in accordance with Part 5C, Chapters 8 and 9 of the *Steel Vessel Rules*, as appropriate. Other special product carriers will be subject to special considerations.

37 Release of Smoke from Machinery Space (2011)

Suitable arrangements are to be made to permit the release of smoke, in the event of fire, from the machinery space of Category A. The normal ventilation may be acceptable for this purpose. The means of control is to be provided for permitting the release of smoke and such control is to be located outside the space concerned so that they will not be rendered inaccessible in the event of fire in the space they serve. See also 4-6-3/5.17.1.

PART

4

CHAPTER 5 Fire Extinguishing Systems

SECTION 3 Requirements for Vessels Under 500 Gross Tons

1 Fire Pumps

1.1 Number of Pumps

All vessels are to have at least two fire pumps. Only one of the pumps need be independently power-driven, and one of the pumps may be attached to the propulsion unit. For vessels less than 20 m (65 ft) in length, one power-driven pump, which may be an attached unit, and one hand operated fire pump may be provided.

1.3 Capacity

The capacity of each power-driven fire pump is to be in accordance with the 4-5-3/Table 1. Hand pumps, where permitted, are to have a minimum capacity of 1.1 m³/hr (5 gpm).

3 Fixed Fire Extinguishing Systems (2003)

3.1 Fixed Systems

For all vessels, fixed fire extinguishing systems are to be fitted in the machinery spaces when propulsion and auxiliary engines with a total aggregate power of 750 kW (1000 bhp) or greater are installed (see 4-1-1/13.1) and in any machinery space in which an oil fuel unit for heated fuel oil is installed, regardless of the total aggregate power.

3.3 Portable Extinguishers

Machinery spaces are to be provided with portable fire extinguishers, in accordance with the applicable requirements in 4-5-1/Table 2.

5 Carbon Dioxide Systems

Where a fixed carbon dioxide fire extinguishing system is installed, the system is to comply with the requirements of 4-5-2/11.1 and 4-5-2/11.3, except that storage arrangements may be in accordance with the following.

5.1 Storage

Generally, the cylinders are to be located outside of the protected space in a room which is situated in a safe and readily accessible location. The access doors to the storage space are to open outwards. The storage room is to be gastight and effectively ventilated. The ventilation system is to be independent of the protected space. Any entrance to the storage room is to be independent of the protected space, except that where this is impracticable due to space limitations, the following requirements may be considered:

- i) The door between the storage location and the protected space is to be self-closing with no hold-back arrangements.
- ii) The space where cylinders are stored is to be adequately ventilated by a system which is independent of the protected space.

- iii) Means are to be provided to prevent unauthorized release of gas, such as containment behind a break glass.
- iv) There is to be provision to vent the bottles to the atmosphere in order to prevent a hazard to personnel occupying the storage area.
- v) An additional entrance to the storage location, independent of the protected space, is provided.

7 Axe

One fire axe is to be provided on each vessel 20 m (65 ft) in length and over.

9 Vessels Intended to Carry Oil in Bulk

9.1 Cargo Pump Rooms

Cargo pump rooms are to be provided with an approved fixed fire extinguishing system controlled from the deck.

9.3 Cargo Tank Protection

For tankers of 30.5 m (100 ft) in length and above, a deck foam system is to be installed for the protection of all cargo tanks. For tankers less than 30.5 m (100 ft) in length, two B-V extinguishers (see 4-5-1/Table 1) are to be provided for the protection of the cargo tanks.

TABLE 1
Fire Pump Minimum Capacity for Vessels Less Than 500 Gross Tons

<i>Vessel Length</i>	<i>Minimum Capacity</i>
Less than 20 m (65 ft)	5.50 m ³ /hr (25 gpm)
20 m (65 ft) or greater but less than 30.5 m (100 ft)	11.0 m ³ /hr (50 gpm)
30.5 m (100 ft) or greater but less than 61 m (200 ft)	14.3 m ³ /hr (66.6 gpm)
61 m (200 ft) or greater	Capacity to be in accordance with 4-5-2/5.1

CHAPTER 6 Electrical Installations

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PART

4

CHAPTER 6 Electrical Installations

SECTION 1 General

1 Applications

Electrical apparatus and wiring systems are to be constructed and installed to the satisfaction of the Surveyor, in accordance with the following requirements which are applicable to all ocean-going vessels, but which may be modified for vessels classed for limited service. The following detailed rules are minimum requirements for classification purposes. Consideration will be given, however, to arrangements or details which can be shown to comply with other recognized standards, provided they are not less effective.

For vessels having an aggregate generator capacity not exceeding 75 kW, the requirements contained in 4-6-5/7 are to be complied with. Electrical installations in machinery spaces with gasoline engines will be specially considered.

3 Definitions

The following definitions apply for the purpose of this Section.

3.1 Cascade Protection (2014)

The application of protective devices in which the device nearest to the source of power has short-circuit ratings equal to or in excess of the maximum prospective short-circuit current, while devices in succeeding steps further from the source have lower short-circuit ratings.

3.3 Earth (2014)

A large conducting body, such as the metal hull of the ship, used as an arbitrary zero of potential.

3.5 Earthed Distribution System

A system in which one pole of a single phase system or the neutral point of a three phase system is earthed, but the earthing connection does not normally carry current.

3.7 Essential Services (2004)

Essential services are those considered necessary for:

- Continuous operation to maintain propulsion and steering (primary essential services);
- Non-continuous operation to maintain propulsion and steering and a minimum level of safety for the vessel's navigation and systems, including safety for dangerous cargoes to be carried (secondary essential services); and
- Emergency services as described in 4-6-2/5.3 (each service is either primary essential or secondary essential depending upon its nature).

Examples of primary essential services and secondary essential services are as listed in 4-6-1/Table 4 and 4-6-1/Table 5, respectively.

3.9 Explosion-proof (Flameproof) Equipment

Explosion-proof equipment is equipment:

3.9.1

Having an enclosure capable of:

- i) Withstanding an explosion within it of a specified flammable gas or vapor, and
- ii) Preventing the ignition of the specified flammable gas or vapor in the atmosphere surrounding the enclosure by sparks, flashes or explosions of the gas or vapor within, and

3.9.2 (2016)

Operates at such an external temperature that a surrounding flammable atmosphere will not be ignited. Where explosion-proof equipment is required by these Rules, equipment certified as being flameproof, as defined in IEC Publication 60079 series or other recognized standard may be accepted.

3.11 Hazardous Area (Hazardous Location)

An area where flammable or explosive vapor, gas, or dust may normally be expected to accumulate.

3.13 High Voltage (2014)

High Voltage in these Rules refers to voltages above 1000 V up to and including 15 kV AC.

3.15 Hull-return System

A system in which insulated conductors are provided for connection to one pole or phase of the supply, the hull of the vessel or other permanently earthed structure being used for effecting connections to the other pole or phase.

3.17 Increased Safety

Type of protection applied to electrical apparatus that does not produce arcs or sparks in normal service, in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arc and sparks. See IEC Publication 60079-7.

3.19 Inhomogeneous Field (2014)

An electric field which does not have a constant voltage gradient between electrodes.

3.21 Intrinsically-safe

A circuit or part of a circuit is intrinsically safe when any spark or any thermal effect produced in the test conditions prescribed in a recognized standard (such as IEC Publication 60079-11) is incapable of causing ignition of the prescribed explosive gas atmosphere.

3.21.1 Category "ia" (2016)

Apparatus which is incapable of causing ignition in normal operation, or with a single fault, or with any combination of two faults applied, with the following safety factors:

In normal operation:	1.5
With one fault:	1.5
With two faults:	1.0

Above safety factors are applied to the current, voltage, or their combination, as specified in 5.2 of IEC Publication 60079-11.

3.23 Low Voltage (2016)

Low Voltage in these Rules refers to voltages up to and including 1000 V AC and 1500 V DC.

3.25 Minimum Comfortable Condition of Habitability (2014)

A condition in which at least services such as cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water are adequately provided.

3.27 Nominal Voltage (2014)

Nominal Voltage (U_n) – The nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240 V, 480/277 V, 600 V). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

U_o (as relates to cable voltage rating) – The rated power frequency voltage between conductor and earth or metallic screen for which the cable is designed.

3.29 Non-periodic Duty Rating

A rating at which the machine is operated continuously or intermittently with varying load and speed within the permissible operating range. The load and speed variations include the overloads applied frequently, which may greatly exceed the full load rating of the machine.

3.31 Non-sparking Fan

A fan consisting of a combination of impeller and housing which are unlikely to produce sparks by static electricity or by entry of foreign objects in both normal and abnormal conditions.

3.33 Overvoltage Category (2014)

Overvoltage Category (of a circuit or within an electrical system) – Conventional number based on limiting the values of prospective transient overvoltages occurring in a circuit and depending on the means employed to influence the overvoltages.

3.35 Overvoltage Withstand Test (2014)

Overvoltage Withstand Test (layer test) – Test intended to verify the power-frequency withstand strength along the winding under test and between its phase (strength between turns and between layers in the windings).

3.37 Periodic Duty Rating

A rating at which the machine is operated repeatedly on a cycle of sequential loading with starting, electric braking, no-load running, rest and de-energized periods, where applicable. The time for the duration of operating cycle (duty cycle) is to be 10 minutes and the ratio (i.e., cyclic duration factor) between the period of loading (including starting and electric braking) and the duty cycle is to be one of the values of 15%, 25%, 40% or 60%.

3.39 Pollution Degree (2014)

Pollution Degree (of environmental conditions) – A conventional number based on the amount of conductive or hygroscopic dust, ionized gas or salt, and on the relative humidity and its frequency of occurrence resulting in hygroscopic absorption or condensation of moisture leading to reduction in dielectric strength and/or surface resistivity of the insulating materials of devices and components.

3.41 Portable Apparatus

Portable apparatus is any apparatus served by a flexible cord.

3.43 Pressurized Equipment

Equipment having an enclosure in which positive pressure is maintained to prevent against the ingress of external atmosphere and complying with the requirements in 4-6-3/11.3.3.

3.45 Semi-enclosed Space

A space limited by decks and/or bulkheads in such a manner that the natural conditions of ventilation in the space are notably different from those obtained on open deck.

3.47 Separate Circuit

A circuit which is independently protected by a circuit protection device at the final sub-circuit and is dedicated to a single load.

3.49 Short Circuit

A short circuit is an abnormal connection through a negligible impedance, whether made accidentally or intentionally, between two points of different potential in a circuit.

3.51 Short-time Rating

A rating at which the machine is operated for a limited period, which is less than that required to reach the steady temperature condition, followed by a rest and de-energized period of sufficient duration to re-establish the machine temperature within 2°C (3.6°F) of the coolant.

4 Electrical Power Critical Notations (2014)

The following Class notations are dependent upon the supply of electrical power and the services are to be maintained with one generator held in reserve: Fire Fighting (**FFV**) notations as per 5-4-1/3 of the *OSV Rules* and Refrigeration notations as per 6-2-1/7.1 of the *Steel Vessel Rules*.

5 Plans and Data to Be Submitted

See 4-6-2/1, 4-6-3/1, 4-6-4/1 and 4-6-5/3.3.

7 Standard Distribution System (2014)

The following are recognized as standard systems of distribution. Distribution systems differing from these will be specially considered.

- Two-wire direct current
- Three-wire direct current
- Two-wire single-phase alternating
- Three-wire three-phase alternating current*
- Four-wire three-phase alternating current with solidly earthed neutral but not with hull return

* *Note:* Three-wire single-phase AC may be used in conjunction with this system for lighting.

9 Voltage and Frequency Variations (2008)

Electrical appliances supplied from the main or emergency systems, are to be so designed and manufactured that they are capable of being operated satisfactorily under the normally occurring variations in voltage and frequency. Unless otherwise stated in national or international standards, the variations from the rated value may be taken from the 4-6-1/Table 1. Any special system, such as electronic circuits, which cannot operate satisfactorily within the limit shown in 4-6-1/Table 1, is not to be supplied directly from the system but by alternative means, such as through a stabilized supply.

For generators, see 4-6-4/3.17.1, 4-6-4/3.19.1, and 4-6-4/3.21.2.

11 Materials

All electrical equipment is to be constructed of durable and flame-retardant materials. Materials are to be resistant to corrosion, moisture, high and low temperatures, and are to have other qualities necessary to prevent deterioration in the ambient conditions that the equipment may be expected to encounter.

13 Insulation Material

For the purposes of these requirements, insulating material is designated as follows.

13.1 Class A Insulation

Materials or combinations of materials such as cotton, silk and paper when suitably impregnated or coated or when immersed in a dielectric liquid such as oil. Other materials or combinations of materials may be included in this class if by experience or accepted tests they can be shown to be capable of operation at 105°C (221°F).

13.3 Class B Insulation

Materials or combinations of materials such as mica, glass fiber, etc., with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if by experience or accepted tests they can be shown to be capable of operation at 130°C (266°F).

13.5 Class E Insulation

Materials or combinations of materials which by experience or accepted tests can be shown to be capable of operation at 120°C (248°F) (materials possessing a degree of thermal stability allowing them to be operated at a temperature 15°C (27°F) higher than Class A materials).

13.7 Class F Insulation

Materials or combinations of materials such as mica, glass fiber, etc., with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if by experience or accepted tests they can be shown to be capable of operation at 155°C (311°F).

13.9 Class H Insulation

Materials or combinations of materials such as silicone elastomer, mica, glass fiber, etc., with suitable bonding substances such as appropriate silicone resins. Other materials or combinations of materials may be included in this class if by experience or accepted tests they can be shown to be capable of operation at 180°C (356°F).

13.11 Insulation for Temperature Above 180°C (356°F)

Materials or combination of materials which by experience or accepted tests can be shown to be capable of satisfactory operation at temperature over 180°C (356°F) will also be considered. Supporting background experience or report of tests conducted in accordance with a recognized standard ascertaining their suitability for the intended application and temperature operation are to be submitted for review.

15 Degree of Protection for Enclosure (2014)

The designation to indicate the degree of protection consists of the characteristic letters IP followed by two numerals (the “characteristic numerals”) indicating conformity with conditions stated in 4-6-1/Table 2 and 4-6-1/Table 3. The test and inspection for determining the degree of protection may be carried out in accordance with IEC Publication 60529 by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. The type of enclosure required for protection of equipment is to be suitable for the intended location. See 4-6-3/3.1.1 for selection of a protective enclosure for electrical equipment based on location condition. Equipment in compliance with recognized national standards will also be considered. For high voltage equipment see 4-6-5/Table 1.

17 Temperature Ratings

17.1 General (2014)

For equipment associated with control and monitoring systems described in Part 4, Chapter 7, refer to 4-7-2/15.9.2.

For purposes of rating of equipment a maximum ambient air temperature of 45°C (113°F) is to be assumed.

Where ambient temperatures in excess of 45°C (113°F) are expected the rating of equipment is to be based on the actual maximum ambient air temperature.

The use of lower ambient temperatures may be considered provided the total rated temperature of the equipment is not exceeded and where the lower values can be demonstrated. The use of a value for ambient temperature less than 40°C (104°F) is only permitted in spaces that are environmentally controlled.

17.3 Reduced Ambient Temperature (2005)

17.3.1 Environmentally Controlled Spaces

Where electrical equipment is installed within environmentally-controlled spaces, the ambient temperature for which the equipment is to be rated may be reduced from 45°C and maintained at a value not less than 35°C, provided:

- i) The equipment is not to be used for emergency services.
- ii) Temperature control is achieved by at least two independent cooling systems so arranged that in the event of loss of one cooling system for any reason, the remaining system(s) is capable of satisfactorily maintaining the design temperature. The cooling equipment is to be rated for a 45°C ambient temperature.
- iii) The equipment is to be able to initially start to work safely at a 45°C ambient temperature until such a time that the lesser ambient temperature may be achieved.
- iv) Audible and visual alarms are provided, at a continually-manned control station, to indicate any malfunction of the cooling systems.

17.3.2 Rating of Cables

In accepting a lesser ambient temperature than 45°C, it is to be ensured that electrical cables for their entire length are adequately rated for the maximum ambient temperature to which they are exposed along their length.

17.3.3 Ambient Temperature Control Equipment

The equipment used for cooling and maintaining the lesser ambient temperature is to be classified as a secondary essential service, in accordance with 4-6-1/3.7, and the capability of cooling is to be witnessed by the Surveyor at sea trial.

19 Clearances and Creepage Distances

The distances between live parts of different potential and between live parts and the case or other earthed metal, whether across surfaces or in air, are to be adequate for working voltage having regard to the nature of the insulating material and the conditions of service. See 4-6-4/7.11.6 and 4-6-5/1.1.4 for additional requirements for switchboard and high voltage systems.

21 Service Trial

21.1 Electrical Installation for Ship Services

All auxiliary apparatus is to be tried under working conditions. Each generator is to be run for a time sufficient to show satisfactory operation, and parallel operation with all possible combinations is to be demonstrated. Each auxiliary motor necessary to the operation of the vessel is to be run for a time sufficient to show satisfactory performance at such load as can readily be obtained. All main switches and circuit breakers are to be operated, but not necessarily at full load. The operation of the lighting system, heaters, etc., is to be satisfactorily demonstrated. The entire installation is to operate to the satisfaction of the Surveyor, and the drop in voltage on any part of the installation is not to exceed 6%. See 4-6-3/5.1.3.

21.3 Communication Facilities

Satisfactory operation of the interior communications system required by 4-6-2/15 is to be demonstrated to the Surveyor during sea trials. Particular attention is to be given to demonstrating that the voice communication systems required by 4-6-2/15 provide the capability of carrying on a conversation while the vessel is being navigated.

TABLE 1
Voltage and Frequency Variations [See 4-6-1/9] (2008)

<i>Voltage and Frequency Variations for AC Distribution Systems</i>		
<i>Quantity in Operation</i>	<i>Permanent Variation</i>	<i>Transient Variation (Recovery Time)</i>
Frequency	±5%	±10% (5 s)
Voltage	+6%, -10%	±20% (1.5 s)

<i>Voltage Variations for DC Distribution Systems (such as systems supplied by DC generators or rectifiers)</i>	
<i>Parameters</i>	<i>Variations</i>
Voltage tolerance (continuous)	±10%
Voltage cyclic variation deviation	5%
Voltage ripple (AC rms over steady DC voltage)	10%

<i>Voltage Variations for Battery Systems</i>	
<i>Type of System</i>	<i>Variations</i>
Components connected to the battery during charging (see Note)	+30%, -25%
Components not connected to the battery during charging	+20%, -25%

Note: Different voltage variations as determined by the charging/discharging characteristics, including the ripple voltage from the charging device, may be considered.

TABLE 2
Degree of Protection of Electrical Equipment (First IP Numeral)

<i>First IP Numeral</i>	<i>Short Description</i>	<i>Definition</i>
0	Non-protected	No special protection
1	Protected against solid objects greater than 50 mm (2 in.)	A large surface of the body, such as a hand (but no protection against deliberate access). Solid object exceeding 50 mm (2 in.) in diameter.
2	Protected against solid objects greater than 12 mm (0.5 in.)	Fingers or similar objects not exceeding 80 mm (3.15 in.) in length. Solid objects exceeding 12 mm (0.5 in.) in diameter.
3	Protected against solid objects greater than 2.5 mm (0.1 in.)	Tools, wires, etc. of diameter or thickness greater than 2.5 mm (0.1 in.). Solid objects exceeding 2.5 mm (0.1 in.) in diameter
4	Protected against solid objects greater than 1 mm (0.04 in.)	Wires or strips of thickness greater than 1 mm (0.04 in.). Solid objects exceeding 1 mm (0.04 in.) in diameter.
5	Dust protected	Ingress of dust is not totally prevented, but dust does not enter in sufficient quantity to interfere with satisfactory operation of the equipment
6	Dust-tight	No ingress of dust

[Designation]

The degree of protection is designated as shown in the following examples:

When it is required to indicate the degree of protection by only one characteristic numeral which shows either degree of protection against foreign bodies and electrical shock or against liquid, the omitted numeral is to be replaced by the letter X.

Examples:

- 1 IP56 The first characteristic numeral of "5"
The second characteristic numeral of "6".
- 2 IPX5 Degree of protection against only liquid.
- 3 IP2X Degree of protection against only foreign bodies and electrical shock.

TABLE 3
Degree of Protection of Electrical Equipment (Second IP Numeral) (2016)

<i>Second IP Numeral</i>	<i>Short Description</i>	<i>Definition</i>
0	Non-protected	No special protection.
1	Protected against dripping water	Dripping water (vertically falling drops) is to have no harmful effect.
2	Protected against dripping water when tilted up to 15°.	Vertically dripping water is to have no harmful effect when the enclosure is tilted at any angle up to 15° from its normal position.
3	Protected against spraying water	Water falling as spray at an angle up to 60° from the vertical is to have no harmful effect.
4	Protected against splashing water	Water splashed against the enclosure from any direction is to have no harmful effect.
5	Protected against water jets	Water projected by a nozzle against the enclosure from any direction is to have no harmful effect.
6	Protected against heavy seas	Water from heavy seas or water projected in powerful jets is not to enter the enclosure in harmful quantities.
7	Protected against the effects of immersion	Ingress of water in a harmful quantity is not to be possible when the enclosure is immersed in water under defined conditions of pressure and time.
8	Protected against submersion	The equipment is suitable for continuous submersion in water under conditions which are to be specified by the manufacturer. <i>Note:</i> Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter, but only in such a manner that it produces no harmful effects.
9 (2016)	Protected against high pressure and temperature water jets	Water projected at high pressure and high temperature against the enclosure from any direction shall not have harmful effects

See Designation and examples in 4-6-1/Table 2.

TABLE 4
Primary Essential Services (2010)

(a)	Steering gears
(b)	Pumps for controllable pitch propellers
(c)	(2010) Scavenging air blower, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines, turbines and shafting necessary for propulsion.
(d)	Ventilation necessary to maintain propulsion
(e)	Forced draft fans, feed water pumps, water circulating pumps, vacuum pumps and condensate pumps for steam plants on steam turbine ships, and also for auxiliary boilers on vessels where steam is used for equipment supplying primary essential services
(f)	Oil burning installations for steam plants on steam turbine vessels and for auxiliary boilers where steam is used for equipment supplying primary essential services
(g)	(2010) Low duty gas compressor and other boil-off gas treatment facilities supporting boil-off gas usage as fuel to main propulsion or electric power generation machinery.
(h)	Azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps, etc.
(i)	Electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps
(j)	Electric generators and associated power sources supplying primary essential equipment
(k)	Hydraulic pumps supplying primary essential equipment
(l)	Viscosity control equipment for heavy fuel oil
(m)	Control, monitoring and safety devices/systems of equipment for primary essential services.

TABLE 5
Secondary Essential Services (2010)

(a)	Windlass
(b)	Fuel oil transfer pumps and fuel oil treatment equipment
(c)	Lubrication oil transfer pumps and lubrication oil treatment equipment
(d)	Pre-heaters for heavy fuel oil
(e)	Starting air and control air compressors
(f)	Bilge, ballast and heeling pumps
(g)	Fire pumps and other fire extinguishing medium pumps
(h)	Ventilating fans for engine and boiler rooms
(i)	Services considered necessary to maintain dangerous spaces in a safe condition (inert gas system of an oil carrier, ventilation for Ro-Ro cargo spaces, etc.)
(j)	(2010) Re-liquefaction plant on liquefied gas carriers
(k)	Navigation lights, aids and signals
(l)	Internal communication equipment required by 4-6-2/15
(m)	Fire detection and alarm system
(n)	Lighting system
(o)	Electrical equipment for watertight and fire-tight closing appliances
(p)	Electric generators and associated power sources supplying secondary essential equipment
(q)	Hydraulic pumps supplying secondary essential equipment
(r)	Control, monitoring and safety systems for cargo containment systems
(s)	Control, monitoring and safety devices/systems of equipment for secondary essential services.
(t)	(2005) Ambient temperature control equipment required by 4-6-1/17.3
(u)	(2010) Watertight Doors (see Sections 3-2-7, 3-2-12 and 3-2-13)

PART

4

CHAPTER 6 Electrical Installations

SECTION 2 Shipboard Systems

1 Plans and Data to be Submitted

1.1 Wiring

1.1.1 Systems

One line diagrams for the following electrical systems are to be submitted for review.

- Power Supply and Distribution
- Lighting including Navigation Light
- Internal Communication
- General Emergency Alarm
- Fire Detection and Alarm
- Steering Gear Control
- Intrinsically-safe Equipment
- Emergency Generator Starting
- Inert Gas Control, Monitoring, and Alarm

1.1.2 Data for Wiring Systems

The one line diagrams are to show the circuit designation, type and size of cables, cable grouping and banking, trip setting and rating of the circuit protection devices, the location of electrical equipment accompanied by list of components, complete feeder list, rated load current for each branch circuit. The one line diagram for power supply and distribution systems is to indicate the following component details.

Note: For vessels having a length of 61 m (200 ft) and over, a voltage drop calculation for the longest run of each cable size is to be included.

- Generator: kW rating, voltage, rated current, frequency, number of phases, power factor
- Batteries: type, voltage, capacity, conductor protection (when required)
- Motors: kW rating, remote stops (when required)
- Transformers: kVA rating, rated voltage and current on primary and secondary side, connection method

The one line diagram for power supply and distribution systems is also to include a list of sequential start of motors and equipment having emergency tripping or preferential tripping features.

1.3 Short-circuit Data (2016)

In order to establish that the protective devices on the main and emergency switchboards have sufficient short-circuit breaking and making capacities, data are to be submitted giving the maximum calculated short-circuit current in symmetrical rms and asymmetrical peak values available at the main bus bars together with the maximum allowable breaking and making capacities of the protective device. Similar calculations are to be made at other points in the distribution system, where necessary, to determine the adequacy of the interrupting capacities of the protective devices.

Reference may be made to IEC Publication 61363-1 Electrical Installations of Ships and Mobile and Fixed Offshore Units – Part 1: Procedures for Calculating Short-Circuit Currents in Three-Phase A.C.

1.5 Protective Device Coordination

A protective device coordination study is to be submitted for review. This protective device coordination study is to consist of an organized time-current study of all of the protective devices in series from the utilization equipment to the source for all circuit protection devices having different setting or time-current characteristics for long-time delay tripping, short-time delay tripping and instantaneous tripping, where applicable. Where an over-current relay is provided in series and adjacent to the circuit protection device, the operating and time-current characteristics of the relay are to be considered for coordination. See 4-6-2/9.1.5.

1.7 Load Analysis (2012)

An electric-plant load analysis is to be submitted for review. The electric-plant load analysis is to cover all operating conditions of the vessel, such as normal sea going, cargo handling (loading/unloading), harbor in/out and emergency operations.

The analyses are to include:

- The simultaneous operation of loads on the emergency switchboard as per 4-6-2/5.3. Where the emergency generator capacity is less than the sum of all of the nameplate rated loads, which can be simultaneously connected to the emergency switchboard, then the analysis is to be supported by a justification for each reduced or non-simultaneous load used.
- High voltage ship service transformers or converters, where applicable per 4-6-2/7.1.6
- Identifying the loads to be tripped to ensure continuity of supply per 4-6-2/3.3.2iv), 4-6-2/3.1.6(a), 4-6-2/9.3.3.

3 Ship Service Main Source of Power

3.1 Power Supply by Generators

3.1.1 Number of Generators

All oceangoing and Great Lakes vessels using electricity for ship's service power or light are to be provided with at least two electric generators for the ship service electrical demand.

3.1.2 Capacity of Generators (2014)

The capacity of the generating sets is to be such that in the event of any one generating set being stopped, it will still be possible without recourse to the emergency source of power to supply those services necessary to provide normal operational conditions of propulsion and safety, preservation of the cargo and minimum comfortable conditions of habitability, which are to include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water and the electric power critical notations listed in 4-6-1/4. See also 4-6-2/3.1.6.

In addition, the generating sets are to be such that with any one generator or its primary source of power out of operation, the remaining generating sets are capable of providing the electrical services necessary to start the main propulsion plant in conjunction with other machinery, as appropriate, from a dead ship condition, as defined in 4-1-1/13.21, within thirty minutes of the blackout. See also 4-6-2/3.1.3.

3.1.3 Starting from Dead Ship Condition (2009)

In restoring the propulsion from a dead ship condition (see 4-1-1/13.21), no stored energy is to be assumed available for starting the propulsion plant, the main source of electrical power and other essential auxiliaries. It is assumed that means are available to start the emergency generator at all times.

The emergency source of electrical power may be used to restore the propulsion, provided its capacity either alone or combined with that of any other available source of electrical power is sufficient to provide at the same time those services required to be supplied by 4-6-2/5.3.2 to 4-6-2/5.3.3.

The emergency source of electrical power and other means needed to restore the propulsion are to have a capacity such that the necessary propulsion starting energy is available within 30 minutes of blackout, as defined in 4-1-1/13.23. Emergency generator-stored starting energy is not to be directly used for starting the propulsion plant, the main source of electrical power and/or other essential auxiliaries (emergency generator excluded).

See also 4-6-2/3.1.6 and 4-6-4/7.15.2, below.

3.1.4 Power Supplied by Propulsion Generator

For vessels propelled by electric power and having two or more constant voltage propulsion generators, the ship's service electric power may be derived from this source and additional ship's service generators need not be fitted, provided that with one propulsion generator out of service, a speed of seven knots or one-half of the design speed, whichever is the lesser, can be maintained. See 4-6-5/3.17.4 and 4-6-5/3.17.5.

3.1.5 Fuel Capacity for Generator Prime Mover

Where the fuel for any ship's service generator prime mover differs from the fuel for the main propulsion plant, adequate fuel capacity for that ship's service generator prime mover with adequate margins is to be provided for the longest anticipated run of the vessel between fueling ports.

3.1.6 System Arrangement (2004)

3.1.6(a) General. For vessels of 500 GT and above where the main source of electrical power is necessary for propulsion and steering and the safety of the vessel, the system is to be so arranged that the electrical supply to equipment necessary for these services is maintained or is capable of being restored in the case of loss of any one of the generators in service in accordance with the provision in 4-6-2/3.1.6(b) or 4-6-2/3.1.6(c).

Load shedding of nonessential services and, where necessary, secondary essential services (see 4-6-1/3.7) or other arrangements as may be necessary are to be provided to protect the generators against the sustained overload. For main bus bar subdivision, see 4-6-4/7.15.2.

3.1.6(b) Single Generator Operation. Where the electrical power is normally supplied by a single generator, provision is to be made upon loss of power for automatic starting and connecting to the main switchboard of a stand-by generator(s) of sufficient capacity with automatic restarting of the essential auxiliaries in sequential operation, if necessary to permit propulsion and steering and to ensure the safety of the vessel. Starting and connection to the main switchboard of the stand-by generator is to be preferably within 30 seconds after loss of the electrical power supply, but in no case in more than 45 seconds.

3.1.6(c) Multiple Generator Operation. Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, the system is to be so arranged that in the event of the loss of any one of the generators in service, the electrical supply to equipment necessary for propulsion and steering and to ensure the safety of the vessel will be maintained by the remaining generator(s) in service.

3.3 Generator Driven by Propulsion Unit (2004)

3.3.1 Constant Speed Drive

A generator driven by a main propulsion unit (shaft generator) capable of operating continuously at a constant speed (e.g., a system where the vessel speed and direction are controlled only by propeller pitch) may be considered to be one of the generators required by 4-6-2/3.1.1, provided that the arrangements stated in *i*) to *iii*) below are complied with:

- i)* The generator and the generating systems are capable of maintaining the voltage and frequency variation within the limits specified in 4-6-4/3.21.2 and 4-6-1/Table 1 under all weather conditions during sailing or maneuvering and also while the vessel is stopped.
- ii)* The rated capacity of the generator and the generating systems is safeguarded during all operations given under *i)* and is such that the services required by 4-6-2/3.1.2 can be maintained upon loss of any generator in service.
- iii)* An arrangement is made for starting a standby generator and connecting it to the switchboard, in accordance with 4-6-2/3.1.6.

3.3.2 Variable Speed Drive

Shaft generator installations not capable of operating continuously at a constant speed may be used for normal operational and habitable conditions of the vessel, provided that the arrangements stated in *i)* to *v)* below are complied with. This type of generator will not be counted as one of the generators required by 4-6-2/3.1.2.

- i)* In addition to this type of generator, generators of sufficient and adequate rating are provided, which constitute the main source of electrical power required by 4-6-2/3.1.2.
- ii)* When the frequency variations at the main bus bar exceed the following limits due to the speed variation of the propulsion machinery which drives the generator, arrangements are made to comply with 4-6-2/3.1.6.

Permanent frequency variation: $\pm 5.5\%$

Transient frequency variation: $\pm 11\%$ (5 sec)

- iii)* The generators and the generating systems are capable of maintaining the voltage and frequency variation within the limits specified in 4-6-4/3.21.2 and 4-6-1/Table 1.
- iv)* Where load-shedding arrangements are provided, they are fitted in accordance with 4-6-2/9.3.3.
- v)* Where the propulsion machinery is capable of being operated from the navigation bridge, means are provided or procedures are in place to ensure that power supply to essential services is maintained during maneuvering conditions in order to avoid a blackout situation.

3.5 Sizing of AC Generator

In selecting the capacity of an alternating-current generating plant, particular attention is to be given to the starting current of motors forming part of the system. Under the normal seagoing condition of the vessel with one generator held in reserve as a standby, the remaining generator sets, operating in parallel and initially carrying the minimum load necessary for operating the vessel, are to have sufficient capacity with respect to the largest idle motor on the vessel so that the motor can be started and the voltage drop occasioned by its starting current will not cause any already running motor to stall or control equipment to drop out.

5 Emergency Source of Power

5.1 General

A self-contained emergency source of electrical power is to be provided.

5.1.1 Location

The emergency source of electrical power, its associated transforming equipment, if any, transitional source of emergency power, the emergency switchboard, the emergency lighting switchboard and the fuel oil tank for the emergency generator prime mover are to be located above the uppermost continuous deck outside of the machinery casing, and are to be readily accessible from the open deck. They are not to be located forward of the collision bulkhead.

5.1.2 Separation

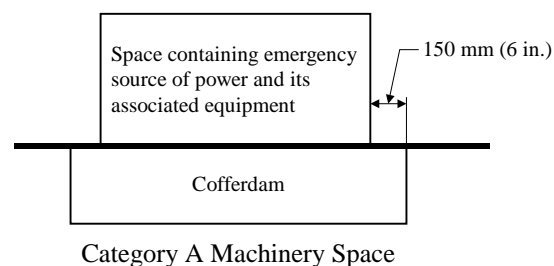
5.1.2(a) *Machinery Space of Category A.* The location of the emergency source of electrical power, its associated transforming equipment, if any, and the emergency switchboard, and the transitional source of emergency power (if required) is to be such that a fire or other casualty in the space containing the main source of electrical power, its associated transforming equipment, if any, and the main switchboard, or in any machinery space of category A will not interfere with the supply, control and distribution of emergency electrical power. As far as practicable, the space containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard, including trunks to such spaces, are not to be contiguous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard.

5.1.2(b) *Machinery Space Other Than Category A.* Spaces containing emergency sources of power are to be separated from machinery spaces (as defined in 4-1-1/13.3), other than Category A machinery spaces, by a boundary insulated to a level of not less than A-15 for bulkheads and decks and A-0 for the overhead from any such space (including trunks to such spaces). Where the emergency source of power is a generator, the above is not intended to preclude the location of the emergency generator in the same space as its prime mover, regardless of size.

5.1.2(c) *Alternative Arrangement (2008).* The following alternative arrangements may be considered in lieu of 4-6-2/5.1.2(a):

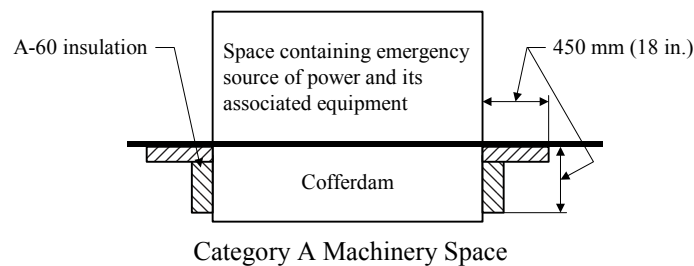
- i) Separation by a cofferdam having dimensions as required for ready access and extending at least 150 mm (6 in.) beyond the boundaries of the space containing the self-contained emergency source of power and its associated equipment as stated in 4-6-2/5.1.2(a). See 4-6-2/Figure 1 below. Except for cables feeding services located in the machinery space, emergency electric cables are not to be installed in such cofferdams unless the cofferdam is insulated to A-60.

FIGURE 1
Cofferdam with Extension Beyond the Boundaries of the Space Containing the Emergency Source (2008)



- ii) Separation by a cofferdam having dimensions as required for ready access between category A machinery space and the space containing the self-contained emergency source of power and its associated equipment as stated in 4-6-2/5.1.2(a) without extension beyond the boundaries. Any contiguous lines between these spaces at the corner of the cofferdam are to be insulated to A-60 for a length of 450 mm (18 in.) at the category A machinery space side. See 4-6-2/Figure 2 below.

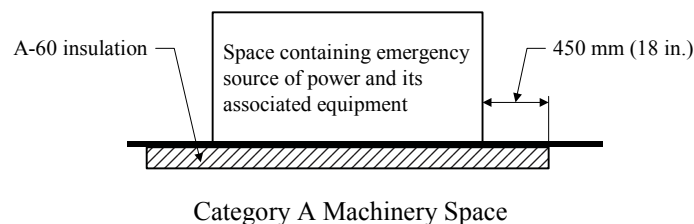
FIGURE 2
Cofferdam without Extension Beyond the Boundaries of the Space Containing the Emergency Source (2008)



- iii) The contiguous boundaries insulated to A-60 with the insulation extending at least 450 mm (18 in.) beyond the boundary of the space containing the self-contained emergency source of power and its associated equipment as stated in 4-6-2/5.1.2(a). See 4-6-2/Figure 3 below.

The arrangements indicated in 4-6-2/Figure 3 below can be considered only when it can be shown that the arrangements are in compliance with the requirements of the flag Administration.

FIGURE 3
Boundary Insulated to A-60 with the Insulation Extending Beyond the Boundaries of the Space Containing the Emergency Source (2008)



5.3 Emergency Services

5.3.1 General (2012)

- i) The electrical power available from the emergency source is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. Where the sum of the loads on the emergency generator switchboard exceeds the power available, an analysis demonstrating that the power required to operate the services simultaneously is to be produced. The analysis is to be submitted for review in support of the sizing of the emergency generator.
- ii) The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the services listed in 4-6-2/5.3.2 through 4-6-2/5.3.8 for the period specified.

5.3.2 Lighting Systems and Navigation Light

5.3.2(a) Emergency Lighting for 3 hours:

- i) At muster and embarkation stations for the survival craft
- ii) At the survival craft, their launching appliances and the area of water into which they are to be launched.

5.3.2(b) *Emergency Lighting for 18 hours:*

- i) In all service and accommodation alleyways, stairways and exits, personnel elevators and shafts;
- ii) In the machinery spaces and main generating stations, including their control positions;
- iii) In all control stations, machinery control rooms, and at each main and emergency switchboard;
- iv) At all stowage positions for firemen's outfits;
- v) At the steering gear; and
- vi) At the fire pump referred to in 4-6-2/5.3.4, at the sprinkler pump, if any, at the emergency bilge pump, if any, and at the starting positions of their motors.
- vii) (*1 July 2002*) In all cargo pump-rooms of tankers 500 GT and over which have their keel laid or are in a similar stage of construction on or after 1 July 2002.

5.3.2(c) *For period of 18 hours:*

- i) Navigation lights and other lights required by the International Regulation for Preventing Collisions at Sea in force.

5.3.3 Communication System, Navigation Aid, and Alarm Systems

For a period of 18 hours:

5.3.3(a) VHF radio installation required by Regulation IV/7.1.1 and IV/7.1.2 of SOLAS 1974, as amended; and if applicable:

- i) The MF radio installation required by Regulation IV/9.1.1, IV/9.1.2, IV/10.1.2 and IV/10.1.3 of SOLAS 1974 as amended
- ii) The ship earth station required by Regulation IV/10.1.1 of SOLAS 1974 as amended
- iii) The MF/HF radio station required by Regulation IV/10.2.1, IV/10.2.2 and IV/11.1 of SOLAS 1974 as amended.

5.3.3(b) All internal communication equipment as required in an emergency

5.3.3(c) Shipborne navigational equipment (i.e., radar, gyro compass, etc.), as required by Regulation V/12 of SOLAS 1974 as amended except that where such provision is unreasonable or impracticable for vessels less than 5,000 GT, this may be waived if evidence of approval by the Administration is submitted.

5.3.3(d) Required fire detection and fire alarm systems

5.3.3(e) Intermittent operation of the daylight signaling lamp, the ship's whistle, manually operated call points and other internal signals that are required in an emergency, unless such services have an independent supply for the period of 18 hours from an accumulator battery suitably located for use in an emergency.

5.3.4 Emergency Fire Pump

For period of 18 hours, one of the fire pumps required by 4-5-2/5.3 if dependent upon the emergency generator for its source of power.

5.3.5 Steering Gear

Steering gear to comply with 4-6-2/11.5 if powered from emergency source for a period of 10 minutes continuous operation on vessels of less than 10,000 GT.

5.3.6 Emergency Control and Monitoring Systems

Emergency control monitoring systems, as required by 4-7-4/11.

5.3.7 Vessels on Short Duration Voyages

In a vessel engaged regularly in voyages of short duration where an adequate standard of safety is attained, a lesser period than the 18 hour period specified in 4-6-2/5.3.2(b), 4-6-2/5.3.2(c), 4-6-2/5.3.3, and 4-6-2/5.3.4, but not less than 12 hours may be accepted.

5.3.8 Other Emergency Services (2005)

For a period of 30 minutes for the following:

- i) Free-fall lifeboat secondary launching appliance, if the secondary launching appliance is not dependent on gravity, stored mechanical power or other manual means, and
- ii) Power-operated watertight door, as required by 3-2-7/7.1.1.

5.5 Power Supply

5.5.1 General

The emergency source of electrical power may be either a generator or an accumulator battery, in accordance with 4-6-2/5.5.2 or 4-6-2/5.5.3, below:

5.5.2 Generator (2014)

Where the emergency source of electrical power is a generator, it is to be:

5.5.2(a) Driven by a prime mover with an independent supply of fuel having a flashpoint (closed cup test) of not less than 43°C (110°F), and

5.5.2(b)

- i) Started automatically upon failure of the main source of electrical power supply and connected automatically to the emergency switchboard – then, those services referred to in 4-6-2/5.7 are to be connected automatically to the emergency generator as quickly as is safe and practicable, subject to a maximum of 45 seconds, or
- ii) Provided with a transitional source of emergency electrical power, as specified in 4-6-2/5.7, unless an emergency generator is provided capable both of supplying the services referred to in 4-6-2/5.7 of being automatically started and supplying the required load as quickly as is safe and practicable, subject to a maximum of 45 seconds, and

5.5.2(c) An adequate fuel capacity for the emergency generator prime mover is to be provided.

Where it is intended to use fuel with a flash point of less than 60°C (140°F) then details of the precautions used to address the associated hazardous area issues are to be submitted to ABS for review (see also 4-4-4/7).

5.5.3 Accumulator Battery

Where the emergency source of electrical power is an accumulator battery, it is to be capable of:

5.5.3(a) Carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage;

5.5.3(b) Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and

5.5.3(c) Immediately supplying at least those services specified in 4-6-2/5.7.

5.5.4 Emergency Generator for Non-emergency Services (2004)

Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used, exceptionally, and for short periods, to supply non-emergency circuits during the blackout situation (see 4-1-1/13.23) dead ship condition (see 4-1-1/13.21), and routine use for testing (see 4-6-2/5.11). The generator is to be safeguarded against overload by automatically shedding such non-emergency services so that supply to the required emergency loads is always available. See also 4-6-2/5.9.5.

For use of the emergency generator in port, see 4-6-2/5.16.

5.7 Transitional Source of Power

The transitional source of emergency electrical power, where required by 4-6-2/5.5.2(b)ii), is to consist of an accumulator battery which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and be of sufficient capacity and be so arranged as to supply automatically in the event of failure of either the main or the emergency source of electrical power for half an hour at least the following services if they depend upon an electrical source for their operation:

- i) The lighting required by 4-6-2/5.3.2. For this transitional phase, the required emergency electric lighting, in respect of the machinery space and accommodation and service spaces, may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps; and
- ii) All services required by 4-6-2/5.3.3(b), 4-6-2/5.3.3(d) and 4-6-2/5.3.3(e), unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

5.9 Emergency Switchboard

5.9.1 General

The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

5.9.2 Emergency Switchboard for Generator

Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

5.9.3 Accumulator Battery

No accumulator battery fitted in accordance with 4-6-2/5.5.3 or 4-6-2/5.7 is to be installed in the same space as the emergency switchboard. An indicator is to be mounted on the main switchboard or in the machinery control room to indicate when these batteries are being discharged.

5.9.4 Interconnector Feeder Between Emergency and Main Switchboards (2014)

The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be protected at the main switchboard against overload and short circuit. The interconnector feeder is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard against short circuit. In addition, the circuit protection device at the emergency switchboard on the interconnector feeder is to trip to prevent overloading of the emergency generator.

In designs where the main switchboard voltage is different from that of the emergency switchboard the power to the emergency switchboard is to be supplied from the main ship service switchboard.

As far as practicable, the circuit coordination is to be arranged such that the outgoing circuits from the main ship service switchboard will coordinate with the transformer circuit breakers to prevent the supply to the emergency switchboard from being unavailable due to a fault on one of the other outgoing circuits from the main ship service switchboard.

Note: For the purpose of this Rule, the main ship service switchboard is a switchboard which is connected to the secondary of the step-down transformer producing the required voltage.

5.9.5 Disconnection of Non-emergency Circuits

For ready availability of the emergency source of electrical power, arrangements are to be made, where necessary, to disconnect automatically non-emergency circuits from the emergency switchboard so that electrical power is to be available automatically to the emergency circuits.

5.11 Arrangements for Periodic Testing

Provision is to be made to enable the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements.

5.13 Vessels Intended to Carry Passengers

See 5C-7-5/13.5 of the *Steel Vessel Rules*.

5.15 Starting Arrangements for Emergency Generator Sets

5.15.1 Cold Conditions

Emergency generating sets are to be capable of being readily started in their cold condition at a temperature of 0°C (32°F). If this is impracticable or if lower temperatures are likely to be encountered, heating arrangements are to be provided for ready starting of the generating sets.

5.15.2 Number of Starts

Each emergency generator that is arranged to be automatically started is to be equipped with approved starting devices with a stored energy capability of at least three consecutive starts. Unless a second independent means of starting is provided, the source of stored energy is to be protected to preclude critical depletion by the automatic starting system, i.e., the automatic starting system is only allowable for consumption of the stored energy source to a level that would still provide the capability for starting the emergency generator upon intervention by personnel. In addition, a second source of energy is to be provided for an additional three starts within 30 minutes unless manual starting can be demonstrated to the Surveyor to be effective.

5.15.3 Charging of Stored Energy

The stored energy is to be maintained at all times, as follows:

5.15.3(a) Electrical and hydraulic starting systems are to be maintained from the emergency switchboard;

5.15.3(b) Compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard;

5.15.3(c) All of these starting, charging and energy storing devices are to be located in the emergency generator space. These devices are not to be used for any purpose other than the operation of the emergency generating set. This does not preclude the supply to the air receiver of the emergency generating set from the main or auxiliary compressed air system through the non-return valve fitted in the emergency generator space.

5.15.4 Manual Starting

Where automatic starting is not required, as per 4-6-2/5.5.2(b)ii), manual (hand) starting is permissible, such as manual cranking, inertia starters, manually charged hydraulic accumulators or power charge cartridges, where they can be demonstrated to the Surveyor as being effective.

When manual (hand) starting is not practicable, the requirements of 4-6-2/5.15.2 and 4-6-2/5.15.3 are to be complied with, except that starting may be manually initiated.

5.16 Use of Emergency Generator in Port (for Vessel 500 GT and Over) (2002)

Unless instructed otherwise by the flag Administration, the emergency generator may be used during lay time in port for supplying power to the vessel, provided the following requirements are complied with.

5.16.1 Arrangements for the Prime Mover

5.16.1(a) Fuel oil tank. The fuel oil tank for the prime mover is to be appropriately sized and provided with a level alarm, which is to be set to alarm at a level where there is still sufficient fuel oil capacity for the emergency services for the period of time required by 4-6-2/5.3.

5.16.1(b) Rating. The prime mover is to be rated for continuous service.

5.16.1(c) *Filters.* The prime mover is to be fitted with fuel oil and lubricating oil filters, in accordance with 4-2-1/7.1 and 4-2-1/9.9, respectively.

5.16.1(d) *Monitoring.* The prime mover is to be fitted with alarms, displays and automatic shutdown arrangements, as required in 4-7-4/Table 7, except that for fuel oil tank low-level alarm, 4-6-2/5.16.1(a) above is to apply instead. The displays and alarms are to be provided in the centralized control station. Monitoring at the engineers' quarters is to be provided as required in 4-7-4/31.

5.16.1(e) *Fire detection.* The emergency generator room is to be fitted with fire detectors. Where the emergency generator is located in a space separated from the emergency switchboard, fire detectors are to be located in each space. The fire detection and alarm system is to be in compliance with 4-5-2/21 and may be a part of another system.

5.16.2 System Arrangements

5.16.2(a) *Independence.* The power supply circuits, including control and monitoring circuits, for the use of the emergency generator in port are to be so arranged and protected that any electrical fault, except for the emergency generator and the emergency switchboard, will not affect the operation of the main and emergency services.

5.16.2(b) *Changeover arrangement.* Means are to be provided to readily change over to emergency operation.

5.16.2(c) *Overload prevention.* The generator is to be safeguarded against overload by automatically shedding such other loads so that the supply to the required emergency loads is always available.

5.16.3 Operational Instruction

Operational instructions, such as that on fuel oil tank level, harbor/seagoing mode changeover arrangements, etc., are to be provided onboard. Before the vessel is underway, all valves, switches, etc. are to be in the positions for their intended mode of operation of the emergency generator and the emergency switchboard. Such instructions are to be distinctly posted at the emergency generator room. Planned maintenance is to be carried out only while in port.

5.17 Alarms and Safeguards for Emergency Diesel Engines (2006)

5.17.1 Information to be Submitted

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

5.17.2 Alarms and Safeguards

5.17.2(a) Alarms and safeguards are to be fitted in accordance with 4-6-2/Table 1.

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

5.17.2(c) Regardless of the engine output, if shutdowns additional to those specified in 4-6-2/Table 1 are provided, except for the overspeed shutdown, they are to be automatically overridden when the engine is in automatic or remote control mode during navigation.

5.17.2(d) The alarm system is to function in accordance with 4-7-2/5.1 through 4-7-2/5.13, with additional requirements that grouped alarms are to be arranged on the bridge.

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

5.17.2(f) Local indications of at least those parameters listed in 4-6-2/Table 1 are to be provided within the same space as the diesel engines and are to remain operational in the event of failure of the alarm and safety systems.

TABLE 1
Alarms and Safeguards for Emergency Diesel Engines
[See 4-6-2/5.17] (2009)

<i>Systems</i>	<i>Monitored Parameters</i>		<i>A</i>	<i>Auto Shut Down</i>	<i>Notes</i> [A = Alarm; x = apply]
Fuel oil	A1	Leakage from pressure pipes	x		
Lubricating oil	B1	Temperature – high	x		For engines having a power of 220 kW or more.
	B2	Lubricating oil pressure – low	x		
	B3	(2009) Oil mist in crankcase, mist concentration – high; or Bearing temperature – high; or Alternative arrangements	x		(2009) For engines having a power of 2250 kW (3000 hp) and above or having a cylinder bore of more than 300 mm (11.8 in.). See 4-2-1/7.2 of the <i>Steel Vessel Rules</i> .
Cooling medium	C1	Pressure or flow – low	x		For engines having a power of 220 kW or more.
	C2	Temperature – high	x		
Engine	D1	Overspeed activated	x	x	For engines having a power of 220 kW or more.

5.19 Vessels Less than 500 GT Having Electrical Plants of 75 kW and Above

5.19.1 General

This requirement is intended for vessels less than 500 GT having electrical plants of an aggregate capacity of 75 kW and above. The emergency source of electrical power is to be self-contained and readily available. 4-6-2/5.1.1, 4-6-2/5.1.2, 4-6-2/5.5 through 4-6-2/5.13 and 4-6-2/5.21 are also applicable. Where the source of electrical power is a battery, see 4-6-3/3.7 for the installation. For emergency lighting, a relay-controlled, battery-operated lantern is acceptable.

5.19.2 Capacity

The emergency source of electrical power is to be capable of supplying simultaneously at least the following services for the period as specified herein:

5.19.2(a) Emergency lighting for two hours:

- i) At muster and embarkation stations for survival craft
- ii) At survival craft, their launching appliances and the area of water into which they are launched

5.19.2(b) Emergency lighting for six hours:

- i) In all service and accommodation alleyways, stairways and exits, personnel elevators and shafts;
- ii) In the machinery spaces and main generating stations, including their control positions;
- iii) In all control stations, machinery control rooms, and at each main and emergency switchboard;
- iv) At all stowage positions for firemen's outfits;
- v) At the steering gear; and

5.19.2(c) Navigation lights and other lights required by the International Regulation for Preventing Collisions at Sea in force.

5.19.2(d) Radio installations for calling distress signals and rescue for six hours

5.19.2(e) Internal communication equipment, as required in an emergency for six hours.

5.21 Requirements by the Governmental Authority

Attention is directed to the requirements of the governmental authority of the country whose flag the vessel flies for the emergency services and the accumulator batteries required in various types of vessels.

7 Distribution System

7.1 Ship Service Distribution System

7.1.1 General

Current-carrying parts with potential to earth are to be protected against accidental contact.

For recognized standard distribution systems, see 4-6-1/7. Separate feeders are to be provided for essential and emergency services.

7.1.2 Method of Distribution

The output of the ship's service generators may be supplied to the current consumers by way of either branch system, meshed network system or ring main system. The cables of a ring-main or other looped circuit (e.g., interconnecting section boards in a continuous circuit) are to be formed of conductors having sufficient current-carrying and short-circuit capacity for any possible load and supply configuration.

7.1.3 Through-feed Arrangements

The size of feeder conductors is to be uniform for the total length, but may be reduced beyond any intermediate section board and distribution board, provided that the reduced size section of the feeder is protected by an overload device.

7.1.4 Motor Control Center (2006)

Feeder cables from the main switchboard or any section board to the motor control centers are to have a continuous current-carrying capacity not less than 100% of the sum of the nameplate ratings of all of the motors supplied. Feeder cables of lesser current capacity are permitted, where the design is such that connected consumers are not operated simultaneously, under any operating mode.

7.1.5 Motor Branch Circuit

A separate circuit is to be provided for each fixed motor having a full-load current rating of 6 amperes or more, and the conductors are to have a carrying capacity of not less than 100% of the motor full-load current rating. No branch circuit is to have conductors less than 1.5 mm² wire. Circuit-disconnecting devices are to be provided for each motor branch circuit and to be in accordance with 4-6-3/3.13.2 and 4-6-4/7.17.2.

7.1.6 Power Supply Through Transformers and Converters

7.1.6(a) Continuity of Supply (2014). Where transformers and/or converters form a part of the vessel's electrical system supplying essential services and services necessary for minimum comfortable conditions of habitability, the number and capacity of the transformers and/or converters are to be such that with any one transformer or converter or any one single phase of a transformer out of service, the remaining transformers and/or converters or remaining phases of the transformer are capable of supplying power to these loads under normal seagoing conditions.

See 4-6-5/1.3.6 for the additional requirements applicable for high voltage transformers.

7.1.6(b) Arrangements (2002). Each required transformer is to be located as a separate unit with separate enclosure or equivalent, and is to be served by separate circuits on the primary and secondary sides. Each of the secondary circuits is to be provided with a multipole isolating switch. This multipole isolating switch is not to be installed on the transformer casing or its vicinity (in so far as practicable), to preclude its damage by fire or other incident at the transformer. A circuit breaker provided in the secondary circuit, in accordance with 4-6-2/9.15.1, will be acceptable in lieu of a multipole isolating switch.

7.1.6(c) *Transformers and Converters for Battery Charger (2004)*. Where batteries connected to a single battery charger are the sole means of supplying DC power to equipment for essential services, as defined in 4-6-1/3.7, failure of the single battery charger under normal operating conditions should not result in total loss of these services once the batteries are depleted. In order to ensure continuity of the power supply to such equipment, one of the following arrangements is to be provided:

- i) Duplicate battery chargers; or
- ii) A single battery charger and a transformer/rectifier (or switching converter) which is independent of the battery charger, provided with a change-over switch; or
- iii) Duplicate transformer/rectifier (or switching converter) units within a single battery charger, provided with a change-over switch.

The above requirements are not applicable for the following:

- The equipment for the essential services which contains a single transformer/rectifier with a single AC power supply feeder to such equipment.
- The services which are not used continuously, such as battery chargers for engine starting batteries, etc.

7.1.7 Ventilation System

Ventilation fans for cargo space are to have feeders separate from those for accommodations. See also 4-6-2/19.1.1, 4-6-3/3.7.3, 4-6-6/1.13.1, 4-6-6/1.17.1, 4-6-6/5.3 and 4-6-6/7.3.1.

7.1.8 Heating Appliances

Each heater is to be connected to a separate final subcircuit. However, a group of up to 10 heaters whose total current does not exceed 16 A may be connected to a single final subcircuit.

7.1.9 Circuits for Bunker or Cargo Space

All lighting and power circuits terminating in a bunker or cargo space are to be provided with a multiple pole switch outside of the space for disconnecting such circuits.

7.3 Hull Return System

7.3.1 General

7.3.1(a) *All Vessels*. The hull return system is not to be used for any purpose in a tanker, or for power, heating or lighting in other type of vessels, except that the following systems may be used for all types of vessels.

- i) Impressed current cathodic protective systems;
- ii) Limited and locally earthed systems, provided that any possible resulting current does not flow directly through any hazardous areas; or
- iii) Insulation level monitoring devices, provided the circulation current does not exceed 30 mA under all possible conditions.

Current-carrying parts with potential to earth are to be protected against accidental contact.

7.3.1(b) *Tankers*. In addition to the above, also see 4-6-6/1.3.

7.3.2 Final Subcircuits and Earth Wires

Where the hull return system is used, all final subcircuits (i.e., all circuits fitted after the last protective device) are to consist of two insulated wires, the hull return being achieved by connecting to the hull one of the bus bars of the distribution board from which they originate. The earth wires are to be in accessible locations to permit their ready examination and to enable their disconnection for testing of insulation.

7.5 Earthed Distribution Systems

System earthing is to be effected by means independent of any earthing arrangements of the non-current-carrying parts. Means of disconnection is to be provided in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance. In distribution systems with neutral earthed or for generators intended to be run with neutrals interconnected, the machines are to be designed to avoid circulating currents exceeding the prescribed value. Transformer neutral is not to be earthed unless all corresponding generator neutrals are disconnected from the system (e.g. during shore supply). See 4-6-3/7.5.2 and 4-6-6/1.3 for tankers.

7.7 External or Shore Power Supply Connection

7.7.1 General

Where arrangements are made for the supply of electricity from a source on shore or other external source, a termination point is to be provided on the vessel for the reception of the flexible cable from the external source. Fixed cables of adequate rating are to be provided between the termination point and the main or emergency switchboard. Means for disconnecting the external or shore power supply are to be provided at the receiving switchboard. See 4-6-2/9.11 for the protection of external or shore power supply circuit.

7.7.2 Earthing Terminal

An earth terminal is to be provided for connecting the hull to an external earth.

7.7.3 Indicators

The external supply connection or shore connection is to be provided with a pilot lamp and a voltmeter (and frequency meter for AC) at main or emergency switchboard to show energized status of the cable.

7.7.4 Polarity or Phase Sequence

Means are to be provided for checking the polarity (for DC) or the phase sequence (for three-phase AC) of the incoming supply in relation to the vessel's system.

7.7.5 Information Plate

An information plate is to be provided at or near the connection box giving full information on the system of supply and the nominal voltage (and frequency if AC) of the vessel's system and the recommended procedure for carrying out the connection.

7.7.6 Securing of Trailing Cable

Provision is to be made for securing the trailing cable to a framework to absorb stress on the electrical terminals by catenary tension of the cable.

7.9 Harmonics (2014)

The total harmonic distortion (THD) in the voltage waveform in the distribution systems is not to exceed 8% and any single order harmonics not to exceed 5%. Other higher values may be accepted provided the distribution equipment and consumers are designed to operate at the higher limits. Where higher values of harmonic distortion are expected, any other possible effects, such as additional heat losses in machines, network resonances, errors in control and monitoring systems are to be considered.

9 Circuit Protection System

9.1 System Design

9.1.1 General (1998)

Electrical installations are to be protected against accidental overload and short circuit, except

- i) As permitted by 4-6-2/11.3,
- ii) Where it is impracticable to do so, such as engine starting battery circuit, and
- iii) Where by design, the installation is incapable of developing overload, in which case it may be protected against short circuit only.

The protection is to be by automatic protective devices for:

- i) Continued supply to remaining essential circuits in the event of a fault, and
- ii) Minimizing the possibility of damage to the system and fire.

Three-phase, three-wire alternating current circuits are to be protected by a triple-pole circuit breaker with three overload trips or by a triple-pole switch with a fuse in each phase. All branch circuits are to be protected at distribution boards only, and any reduction in conductor sizes is to be protected. Dual-voltage systems having an earthed neutral are not to have fuses in the neutral conductor, but a circuit breaker which simultaneously opens all conductors may be installed, when desired. In no case is the dual-voltage system to extend beyond the last distribution board.

9.1.2 Protection Against Short-circuit

9.1.2(a) Protective Devices. Protection against short-circuit is to be provided for each non-earthed conductor by means of circuit breakers or fuses.

9.1.2(b) Rated Short-circuit Breaking Capacity. The rated short-circuit breaking capacity of every protective device is not to be less than the maximum available fault current at that point. For alternating current (AC), the rated short-circuit breaking capacity is not to be less than the root mean square (rms) value of the AC component of the prospective short-circuit current at the point of application. The circuit breaker is to be able to break any current having an AC component not exceeding its rated breaking capacity, whatever the inherent direct current (DC) component may be at the beginning of the interruption.

9.1.2(c) Rated Short-circuit Making Capacity. The rated short-circuit making capacity of every switching device is to be adequate for maximum peak value of the prospective short-circuit current at the point of installation. The circuit breaker is to be able to make the current corresponding to its making capacity without opening within a time corresponding to the maximum time delay required.

9.1.3 Protection Against Overload

9.1.3(a) Circuit Breakers. Circuit breakers or other mechanical switching devices for overload protection are to have a tripping characteristic (overload-trip time) adequate for the overload capacity of all elements in the system to be protected and for any discrimination requirements.

9.1.3(b) Fuses. A fuse of greater than 320 amperes is not to be used for overload protection.

9.1.3(c) Rating (2005). Fuse ratings and rating (or settings, if adjustable) of time-delay trip elements of circuit breakers are not to exceed the rated current capacity of the conductor to be protected as listed in 4-6-4/Table 10, except as otherwise permitted for generator motor, and transformer circuit protection in 4-6-2/9.3, 4-6-2/9.13 and 4-6-2/9.15. If the standard ratings or settings of overload devices do not correspond to the rating or the setting allowed for conductors, the next higher standard rating or setting may be used, provided that it does not exceed 150% of the allowable current carrying capacity of the conductor, where permitted by the Standard to which the feeder cables have been constructed. Except as otherwise permitted for motor and transformer branch-circuit protection, adjustable-trip circuit breakers of the time-delay or instantaneous type are to be set to operate at not more than 150% of the rated capacity of the conductor to be protected.

9.1.3(d) Indication. The rating or setting of the overload protective device for each circuit is to be permanently indicated at the location of the protective device.

9.1.4 Back-up Protection (2011)

9.1.4(a) Back-up Fuse Arrangements. Circuit breakers having breaking and/or making capacities less than the prospective short-circuit current at the point of application will be permitted, provided that such circuit breakers are backed-up by fuses which have sufficient short-circuit capacity for that application. The fuse is to be specifically designed for back-up combinations with the circuit breaker, and the maximum fault rating for the combination is to be provided.

9.1.4(b) *Cascade Protection.* Cascade protection may be permitted, subject to special consideration. Such special consideration is not intended for new construction vessels, however may be granted when modifications are performed to existing vessels. The cascade protection is to be arranged such that the combination of circuit protective devices has sufficient short-circuit breaking capacity at the point of application [see 4-6-2/9.1.2(b)]. All circuit protective devices are to comply with the requirements for making capacity [see 4-6-2/9.1.2(c)]. Cascade protection is not to be used for circuits of primary essential services. Where cascade protection is used for circuits of secondary essential services, such services are to be duplicated, provided with means of automatic transfer and the automatic transfer is to alarm at a manned location. Cascade protection may be used for circuits of non-essential services.

9.1.5 Coordinated Tripping

Coordinated tripping is to be provided between generator, bus tie, bus feeder and feeder protective devices. See also 4-6-2/9.3.2 and 4-6-2/9.7.1. Except for cascade system (backup protection) in 4-6-2/9.1.4, the coordinated tripping is also to be provided between feeder and branch-circuit protective devices for essential services. Continuity of service to essential circuits under short-circuit conditions is to be achieved by discrimination of the protective devices, as follows:

9.1.5(a) The tripping characteristics of protective devices in series is to be coordinated.

9.1.5(b) Only the protective device nearest to the fault is to open the circuit, except for the cascade system (back-up protection), as specified in 4-6-2/9.1.4(a).

9.1.5(c) The protective devices are to be capable of carrying, without opening, a current not less than the short-circuit current at the point of application for a time corresponding to the opening of the breaker, increased by the time delay required for discrimination.

9.3 Protection for Generators

9.3.1 General

Generators of less than 25 kW not arranged for parallel operation may be protected by fuses. Any generators arranged for parallel operation and all generators of 25 kW and over are to be protected by a trip-free circuit breaker whose trip settings are not to exceed the thermal withstand capacity of the generator. The long-time over-current protection is not to exceed 15% above either the full-load rating of continuous rated machines or the overload rating of special-rated machines. The shutting down of the prime mover is to cause the tripping of the ship service generator circuit breaker.

9.3.2 Trip Setting for Coordination (2008)

The instantaneous and short-time overcurrent trips of the generators are to be set at the lowest values of current and time which will coordinate with the trip settings of feeder circuit breakers. See also 4-6-2/9.1.5, 4-6-2/9.5.1, and 4-6-2/9.5.2(a).

9.3.3 Load-shedding Arrangements (2004)

9.3.3(a) *Provision for Load Shedding Arrangements.* In order to safeguard continuity of the electrical power supply, automatic load-shedding arrangements or other equivalent arrangements are to be provided:

- i) Where only one generating set is normally used to supply power for propulsion and steering of the vessel, and a possibility exists that due to the switching on of additional loads, whether manually or automatically initiated, the total load exceeds the rated generator capacity of the running generator, or
- ii) Where electrical power is normally supplied by more than one generator set simultaneously in parallel operation for propulsion and steering of the vessel, upon the failure of one of the parallel running generators, the total connected load exceeds the total capacity of the remaining generator(s).

9.3.3(b) *Services not Allowed for Shedding.* Automatic load-shedding arrangements or other equivalent arrangements are not to automatically disconnect the following services. See 4-6-1/3.7 for the definition of essential services.

- i) Primary essential services that, when disconnected, will cause immediate disruption to propulsion and maneuvering of the vessel,
- ii) Emergency services as listed in 4-6-2/5.3, and
- iii) Secondary essential services that, when disconnected, will:
 - cause immediate disruption of systems required for safety and navigation of the vessel, such as:
 - Lighting systems,
 - Navigation lights, aids and signals,
 - Internal communication systems required by 4-6-2/15, etc.
 - prevent services necessary for safety from being immediately reconnected when the power supply is restored to its normal operating conditions, such as:
 - Fire pumps, and other fire extinguishing medium pumps,
 - Bilge pumps,
 - Ventilation fans for engine and boiler rooms

9.3.4 Emergency Generator

The emergency generator is also to comply with 4-6-2/9.1, 4-6-3/9.3, 4-6-2/9.5 and 4-6-2/9.7, where applicable. See also 4-6-2/5.9.

9.5 Protection for Alternating-current (AC) Generators

9.5.1 Short-time Delay Trip (2008)

Short-time delay trips are to be provided with circuit breakers for AC generators. See also 4-6-2/9.3.2. The current setting of the short time delay trip is to be less than the steady state short-circuit current of the generator.

For generators with a capacity of less than 200 kW having prime movers such as diesel engines or gas turbines which operate independently of the electrical system, consideration may be given to omission of short-time delay trips if instantaneous trips and long time overcurrent protection (see 4-6-2/9.3.1) are provided. When the short time delay trips are omitted, the thermal withstand capacity of the generator is to be greater than the steady state short-circuit current of the generator, until activation of the tripping system.

9.5.2 Parallel Operation

Where AC generators are arranged for parallel operation with other AC generators, the following protective devices are to be provided.

9.5.2(a) *Instantaneous Trip (2016).* Instantaneous trips are to be installed and set in excess of the maximum short-circuit contribution of the individual generator where three or more generators are arranged for parallel operation. Alternative suitable protection, such as generator differential protection, which will trip the generator circuit breaker in the event of a fault in the generator or in the supply cable between the generator and its circuit breaker, would also be acceptable. See also 4-6-2/9.3.2.

9.5.2(b) *Reverse Power Protection (2006).* A time-delayed reverse active power protection or other devices which provide adequate protection is to be provided. The setting of protective devices is to be in the range of 2% to 6% of the rated power for turbines and in the range of 8% to 15% of the rated power for diesel engines. A setting of less than 8% of the rated power of diesel engines may be allowed with a suitable time delay recommended by the diesel engine manufacturer. A fall of 50% in the applied voltage is not to render the reverse power protection inoperative, although it may alter the setting to open the breaker within the above range.

9.5.2(c) *Undervoltage Protection.* Means are to be provided to prevent the generator circuit breaker from closing if the generator is not generating and to open the same when the generator voltage collapses.

In the case of an undervoltage release provided for this purpose, the operation is to be instantaneous when preventing closure of the breaker, but is to be delayed for discrimination purposes when tripping a breaker.

9.7 Protection for Direct Current (DC) Generators

9.7.1 Instantaneous Trip

DC generator circuit breakers are to be provided with an instantaneous trip set below the generator maximum short-circuit current and are to coordinate with the trip settings of feeder circuit breakers supplied by the generator.

9.7.2 Parallel Operation

9.7.2(a) *Reverse Current Protection.* DC generators arranged for parallel operation with other DC generators or with an accumulator battery are to be provided with instantaneous or short-time delayed reverse current protection. The setting of the protection devices is to be within the power range specified by 4-6-2/9.5.2(a). When an equalizer connection is provided, the reverse current device is to be connected on the pole opposite to the equalizer connection where the series compound winding for the generator is connected. Reverse current protection is to be adequate to deal effectively with reverse current conditions emanating from the distribution system (e.g., electric driven cargo winches).

9.7.2(b) *Generator Ammeter Shunts.* Generator ammeter shunts are to be so located that the ammeters indicate total generator current.

9.7.2(c) *Undervoltage Protection.* Requirements for AC generator in 4-6-2/9.5.2(c) are also applicable to DC generator.

9.9 Protection for Accumulator Batteries

Accumulator (storage) batteries, other than engine starting batteries, are to be protected against overload and short circuits by devices placed as near as practicable to the batteries, but outside of the battery rooms, lockers or boxes, except that the emergency batteries supplying essential services are to have short circuit protection only. Fuses may be used for the protection of emergency lighting storage batteries instead of circuit breakers up to and including 320 amperes rating. The charging equipment, except converters, for all batteries with a voltage of more than 20% of the line voltage is to be provided with reverse current protection.

9.11 Protection for External or Shore Power Supply

9.11.1 General

Where arrangements are made for the supply of electricity from a source on shore or other external source, permanently fixed cables from the external supply or shore connection box to the main or emergency switchboard are to be protected by fuses or circuit breakers located at the connection box.

9.11.2 Interlocking Arrangement

Where the generator is not arranged for parallel operation with the external or shore power supply, an interlocking arrangement is to be provided for the circuit breakers or disconnecting devices between the generator and the external or shore power supply in order to safeguard from connecting unlike power sources to the same bus.

9.13 Protection for Motor Branch Circuits

9.13.1 General

Trip elements of circuit breaker for starting and for short-circuit protection are to be in accordance with 4-6-2/9.13.2 or 4-6-2/9.13.3, except that circuit breakers having only instantaneous trips may be provided as part of the motor control center. Where circuit breakers having only instantaneous trips are provided, the motor running protective device is to open all conductors, and the motor controller is to be capable of opening the circuit without damage to itself resulting from a current up to the setting of the circuit breaker. Circuit-disconnecting devices are to be provided for each motor branch circuit and to be in accordance with 4-6-3/3.13.2 and 4-6-4/7.17.2.

9.13.2 Direct-current Motor Branch Circuits

The maximum fuse rating or the setting of the time-delay trip element is to be 150% of the full-load rating of the motor served. If that rating or setting is not available, the next higher available rating or setting may be used.

9.13.3 Alternating-current Motor Branch Circuits

The maximum fuse rating or setting of the trip element is to be the value stated below. If that rating or setting is not available, the next higher available rating or setting may be used.

<i>Type of Motor</i>	<i>Rating or Setting in % Motor Full-load Current</i>
Squirrel-cage and Synchronous Full-voltage, Reactor or Resistor-starting	250
Autotransformer Starting	200
Wound Rotor	150

When fuses are used to protect polyphase motor circuits, it is to be arranged to protect against single-phasing.

The setting of magnetic instantaneous trips for short-circuit protection only is to exceed the transient current inrush of the motor, and to be the standard value nearest to, but not less than, 10 times full-load motor current.

9.13.4 Motor Running Protection (2005)

Running protection is to be provided for all motors having a power rating exceeding 0.5 kW, except that such protection is not to be provided for steering gear motors (see 4-6-2/11.3). The running protection is to be set between 100% and 125% of the motor rated current.

For athwartship thrusters having only instantaneous trips, a motor overload alarm in the wheelhouse is acceptable in lieu of the motor running protection.

9.13.5 Undervoltage Protection and Undervoltage Release (2011)

Undervoltage protection is to be provided for motors having power rating exceeding 0.5 kW (0.7 hp) to prevent undesired restarting upon restoration of the normal voltage, after a stoppage due to a low voltage condition or voltage failure condition.

Undervoltage release is to be provided for the following motors unless the automatic restart upon restoration of the normal voltage will cause hazardous conditions:

- i) Primary essential services (see 4-6-1/Table 4).
- ii) Only those secondary essential services (see 4-6-1/Table 5) necessary for safety, such as:
 - Fire pumps and other fire extinguishing medium pumps.
 - Ventilating fans for engine and boiler rooms where they may prevent the normal operation of the propulsion machinery (See Note 1 below)

Special attention is to be paid to the starting currents due to a group of motors with undervoltage release controllers being restarted automatically upon restoration of the normal voltage. Means such as sequential starting is to be provided to limit excessive starting current, where necessary.

Note 1: Undervoltage protection is to be provided for ventilation fans for engine and boiler room, which are supplied by an emergency source of power for the purpose of removing smoke from the space after a fire has been extinguished.

9.15 Protection for Transformer Circuits

9.15.1 Setting of Overcurrent Device

Each power and lighting transformer feeder is to be protected by an overcurrent device rated or set at a value not more than 125% of rated primary current. When a transformer is provided with an overcurrent device in the secondary circuit rated or set at not more than 125% of rated secondary current, the feeder overcurrent device may be rated or set at a value less than 250% of the rated primary current.

9.15.2 Parallel Operation (2006)

When the transformers are arranged for parallel operation, means are to be provided to disconnect the transformer from the secondary circuit. Where power can be fed into secondary windings, short-circuit protection (i.e., short-time delay trips) is to be provided in the secondary connections. In addition, when the disconnecting device in primary side of the transformer is opened due to any reason (e.g., the short-circuit protection, overload protection, or manual operation for opening), the disconnecting device in the secondary side of the transformer is to be arranged to open the circuit automatically.

9.17 Protection for Meters, Pilot Lamps and Control Circuits

Indicating and measuring devices are to be protected by means of fuses or current limiting devices. For devices such as voltage regulators where interruption of the circuit may have serious consequences, fuses are not to be used. If fuses are not used, means are to be provided to prevent fire in the unprotected part of installation. Fuses are to be placed as near as possible to the tapping from the supply.

9.19 Protection of Harmonic Filter Circuits (2014)

Harmonic filters circuits shall be protected against overload and short-circuit. An alarm is to be initiated in a continuously manned location in the event of an activation of overload or short-circuit protection.

In cases where multiple harmonic filter circuits are used in series or in parallel, current imbalance between the different filter circuits is to be continuously monitored. The total rms current into each phase of a passive harmonic filter circuit is also to be monitored. Detection of a current imbalance shall be alarmed in a continuously manned location. If the current imbalance exceeds the ratings of the individual filter circuit components, the appropriate circuits shall automatically trip and be prevented from interacting with other parts of the electrical network.

Harmonic filters that contain capacitors are to have means of monitoring and of providing advance warning of capacitor(s) deterioration. Harmonic filters containing oil filled capacitors are to be provided with suitable means of monitoring oil temperature or capacitor internal pressure. Refer to 4-5-2/9.5 for additional requirements. Detection of capacitor(s) deterioration shall be alarmed locally at the equipment and in a continuously manned location. Power to the harmonic filter circuit containing the deteriorated capacitor(s) shall be automatically disconnected and the capacitor discharged safely upon detection of deterioration.

In cases where provisions for automatic/manual switching and/or disconnection of harmonic filter circuits are provided, there are to be provisions to prevent transient voltages in the system and to automatically discharge the capacitors in the harmonic filter circuits before they can be put back on-line.

Capacitors used in harmonic filters/capacitor banks are to be prevented from producing a leading system power factor which could potentially lead to generator(s) becoming self-excited. In cases where a leading power factor condition approaches the point of the generator(s) becoming self-excited, the appropriate capacitive circuits shall be automatically disconnected and prevented from interacting with the rest of the electrical network.

11 System for Steering Gear

11.1 Power Supply Feeder (1 July 2016)

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 may be supplied through the emergency switchboard.

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 of the *Steel Vessel Rules*.

An auxiliary electric or electro-hydraulic steering gear associated with a main electric or electro-hydraulic steering gear may be connected to one of the circuits supplying this main steering gear. The circuits supplying an electric or electro-hydraulic steering gear are to have adequate rating for supplying all motors, control system 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.

11.3 Protection for Steering Gear Circuit

11.3.1 Short Circuit Protection

Each steering gear feeder is to be provided with short-circuit protection which is to be located at the main or emergency switchboard. Long term overcurrent protection is not to be provided for steering gear motors.

11.3.1(a) Direct Current (DC) Motors. For DC motors, the feeder circuit breaker is to be set to trip instantaneously at not less than 300% and not more than 375% of the rated full-load current of the steering-gear motor, except that the feeder circuit breaker on the emergency switchboard may be set to trip at not less than 200%.

11.3.1(b) Alternating Current (AC) Motors. For AC motors, the protection against excess current, including starting current, if provided, is to be for not less than twice the full load current of the motor or circuit so protected, and is to be arranged to permit the passage of the appropriate starting currents.

11.3.1(c) Fuses as Motor-feeder Protection. The use of fuses instead of circuit breakers for steering gear motor feeder short-circuit protection is not permitted.

11.3.1(d) Control System Power Supply Circuit. The power supply circuit for steering gear control system is to be provided with short circuit protection only. See also 4-3-3/11.5.

11.3.2 Undervoltage Release

Power unit motor controllers and other automatic motor controllers are to be fitted with undervoltage release.

11.5 Emergency Power Supply

Where the rudder stock is required by 3-2-11/7.1 to be over 230 mm (9 in.) diameter using $K_s = 1.0$ in way of the tiller, excluding strengthening for navigation in ice, an alternative power supply, sufficient at least to supply the steering gear power unit and also its associated control system and 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. The steering gear power unit under alternative power supply is to be capable of moving the rudder from 15 degrees on one side to 15 degrees on the other side in not more than 60 seconds with the vessel at the summer draft while running at one half the maximum speed ahead or 7 knots, whichever is the greater. The alternative power supply is to have a capacity for at least 10 minutes of continuous operation. See 4-6-2/5.3.5.

11.7 Controls, Instrumentation, and Alarms

See 4-3-3/11.

13 Lighting and Navigation Light Systems

13.1 Lighting System

13.1.1 Main Lighting System

A main electric lighting system is to provide illumination throughout those parts of the vessel normally accessible to and used by passengers or crew. It is to be supplied from the main source of electrical power.

13.1.2 System Arrangement

13.1.2(a) Main Lighting System. The arrangement of the main electric lighting system is to be such that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard will not render the emergency electric lighting system required by 4-6-2/5.3.2 of this Section or 5C-7-5/13.5.3 of the *Steel Vessel Rules* inoperative.

13.1.2(b) Emergency Lighting System. The arrangement of the emergency electric lighting system is to be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated transforming equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render the main electric lighting system required by 4-6-2/13.1.1 inoperative.

13.1.3 Lighting Circuits

13.1.3(a) Machinery Space and Accommodation Spaces (2006). In spaces such as:

- Public spaces;
- Category A machinery spaces;
- Galleys;
- Corridors;
- Stairways leading to boat-decks, including stairtowers and escape trunks;

there is to be more than one final sub-circuit for lighting, one of which may be supplied from the emergency switchboard in such a way that failure of any one circuit does not leave these spaces in darkness.

13.1.3(b) Cargo Spaces. Fixed lighting circuits in cargo spaces are to be controlled by multipole-linked switches situated outside of the cargo spaces. Means are to be provided on the multipole linked switches to indicate the live status of circuits.

13.1.4 Protection for Lighting Circuits

Lighting circuits are to be protected against overload and short-circuit. Overload protective devices are to be rated or set at not more than 30 amperes. The connected load is not to exceed the lesser of the rated current carrying capacity of the conductor or 80% of the overload protective device rating or setting. The control switches are to be rated for the load controlled.

13.3 Navigation Light System (2017)

13.3.1 Feeder

Navigation lights (mast head, side and stern lights) are to be fed by their own exclusive distribution board located on the bridge. The distribution board is to be supplied from the main as well as from the emergency source of power (see 4-6-2/5.3.2). A means to transfer the power source is to be fitted on the bridge.

13.3.2 Branch Circuit

Each navigation light is to have its own branch circuit, and each branch circuit is to be fitted with a protective device.

13.3.3 Duplicate Lamp

Each navigation light is to be fitted with duplicate lamps.

13.3.4 Control and Indication Panel

A control and indication panel for the navigation lights is to be provided on the navigation bridge. The panel is to be fitted with the following functions:

- i) A means to disconnect each navigation light.
- ii) An indicator for each navigation light.
- iii) Automatic visual and audible warning in the event of failure of a navigation light. If a visual signal device is connected in series with the navigation light, the failure of this device is not to cause the extinction of the navigation light. The audible device is to be connected to a separate power supply so that the audible alarm may still be activated in the event of power or circuit failure to the navigation lights.

15 Interior Communication Systems

15.1 Navigation Bridge

15.1.1 General

At least two independent means are to be provided for communicating orders from the navigation bridge to the position in the machinery space or in the control room from which the speed and direction of thrust of the propellers are normally controlled. Appropriate means of communication are to be provided to any other positions from which the main propulsion machinery may be controlled. See 4-6-2/5.3.3(b) for power supply.

15.1.2 Engine Order Telegraph

One of the communicating means between the navigation bridge and the main propulsion control position is to be an engine room telegraph which provides visual indication of the orders and responses both in the machinery space and on the navigation bridge. Final sub-circuit for power supply to this system is to be independent of other electrical systems and control, monitoring and alarm systems. See 4-6-2/5.3.3(b) for power supply. Communication network and power supply circuit for this may be combined with the engine order telegraph system specified in 4-6-2/15.3. For vessels less than 500 GT, an engine order telegraph need not be provided if the propulsion plant is controlled entirely from the navigation bridge with no means of normal engine control from the engine room.

15.3 Main Propulsion Control Stations

A common talking means of voice communication and calling or engine order telegraph repeater is to be provided between the main propulsion control station and local control positions for main propulsion engines and controllable pitch propellers. Voice communication systems are to provide the capability of carrying on a conversation while the vessel is being navigated. Final sub-circuit for power supply to these is to be independent of other electrical systems and the control, monitoring and alarm systems. Communication network and power supply circuit for the voice communication system may be combined with the system required in 4-6-2/15.5.

15.5 Voice Communications

15.5.1 Propulsion and Steering Control Stations

A common talking means of voice communication and calling is to be provided between the navigation bridge, main propulsion control station and the steering gear compartment so that the simultaneous talking among these spaces is possible at all times and the calling to these spaces is always possible even if the line is busy.

15.5.2 Elevator

Where an elevator is installed, a telephone is to be permanently installed in all cars and connected to a continuously manned area. The telephone may be sound powered, battery operated or electrically powered from the emergency source of power.

15.5.3 Independence of Power Supply Circuit

Final sub-circuit for power supply to these voice communication systems is to be independent of other electrical systems and control, monitoring and alarm systems. See 4-6-2/5.3.3(b) for power supply.

15.7 Emergency and Interior-communication Switchboard

Emergency and interior-communication switchboards, when fitted, are to comply with the applicable parts of 4-6-4/7, and attention is directed to the requirements of the governmental authority whose flag the vessel flies.

15.9 Public Address System (1 July 1998)

Vessels with the keel laid or in similar stage of construction on or after 1 July 1998 are to meet the following requirements. Where a public address system is provided to supplement the general emergency alarm required by 4-6-2/17.1.1, the public address system is to comply with subparagraphs 4-6-2/15.9.1 through 4-6-2/15.9.3, as follows:

15.9.1

The system is to be a loud speaker installation enabling the broadcast of messages to all spaces where crew members or passengers, or both, are normally present, and to muster stations. The system is to provide for the broadcast of messages from the navigation bridge and other places onboard, as may be required by ABS, with an override function so that all emergency messages may be broadcast if any loudspeaker in the spaces concerned has been turned off, its volume has been turned down or the public address system is in use for other purposes.

The system is to be installed with acoustic marginal conditions and is not to require any action from the addressee. The system is to be protected against unauthorized use.

15.9.2

With the vessel underway in normal conditions, the minimum sound pressure levels for broadcasting emergency announcements in interior spaces are to be 75 dB (A) and at least 20 dB (A) above the corresponding speech interference level.

15.9.3

The system is to be connected to the emergency source of power.

For passenger vessels, see 5C-7-5/13.15 of the *Steel Vessel Rules*.

15.9.4 (2013)

Where a single system serves for both public address and general emergency alarm functions, the system is to be arranged so that a single failure is not to cause the loss of both systems and is to minimize the effect of a single failure. The major system components, such as power supply unit, amplifier, alarm tone generator, etc., are to be duplicated. Power supply is to comply with 4-6-2/17.1.2(b) and 4-6-2/17.1.2(c).

For cargo vessels, the coverage provided by the arrangement of the system loops and speakers is to be such that after a single failure, the announcements and alarms are still audible in all spaces. Duplication of system loops and speakers in each room or space is not required provided the announcements and alarms are still audible in all spaces.

For passenger vessels, a single system serving for both public address and general emergency alarm functions would still be required to have at least two loops sufficiently separated throughout their length with two separate and independent amplifiers. See 5C-7-5/13.15ii) of the *Steel Vessel Rules*.

17 Manually Operated Alarms

17.1 General Emergency Alarm System (1 July 1998)

17.1.1 General

Each vessel over 100 GT is to be fitted with a general emergency alarm system, complying with the requirements of 4-6-2/17.1.2, to summon crew to muster stations and initiate the actions included in the muster list. The system is to be supplemented by either a public address system, in accordance with 4-6-2/15.9, or other suitable means of communication. Any entertainment sound system is to be automatically turned off when the general emergency alarm is activated. For passenger vessels, see also 5C-7-5/13.13 and 5C-7-5/13.15 of the *Steel Vessel Rules*.

17.1.2 System Requirements (2009)

17.1.2(a) The general emergency alarm system is to be capable of sounding the general emergency alarm signal consisting of seven or more short blasts followed by one long blast on the ship's whistle or siren and additionally on an electrically operated bell or klaxon or other equivalent warning system, which is to be powered from the vessel's main supply and the emergency source of electrical power required by 4-6-2/5.

17.1.2(b) (2017) There are to be not less than two sources of power supply for the electrical equipment used in the operation of the General Emergency Alarm System, one of which is to be from the emergency switchboard and the other from the main switchboard. The supply is to be provided by separate feeders reserved solely for that purpose. Such feeders are to run to an automatic change-over switch situated in, **without passing through any other distributing switchboard**, or adjacent to, the main general emergency alarm control panel.

17.1.2(c) (2017) An alarm is to be provided **in a normally manned control station** to indicate when there is a loss of power in any one of the feeders required by 4-6-2/17.1.2(b).

17.1.2(d) As an alternative to two feeders as described in 4-6-2/17.1.2(b), a battery may be considered as one of the required sources, provided the battery has the capacity of at least 30 minutes of continuous operation for alarming and 18 hours in standby. A low voltage alarm for the battery and the battery charger output is to be provided. The battery charger is to be supplied from the emergency switchboard.

17.1.2(e) The system is to be capable of operation from the navigation bridge and, except for ship's whistle, also from other strategic points. The system is to be audible throughout all of the accommodation and normal crew working spaces. The alarm is to continue to function after it has been triggered until it is manually turned off or is temporarily interrupted by a message on the public address system.

17.1.2(f) (2014) The minimum sound pressure levels for the emergency alarm tone in interior spaces are to be 80 dB and at least 10 dB (A) above ambient noise levels existing during normal equipment operation with the vessel underway in moderate weather.

17.1.2(g) The sound pressure levels at the sleeping position in cabins and in cabin bathrooms are to be at least 75 dB (A) and at least 10 dB (A) above ambient noise levels. (Refer to Code on Alarms and Indicators adopted by IMO Resolution A.830 (19).)

17.3 Engineers' Alarm (2007)

On vessels of 500 gross tons and over, intended for international voyages, an engineers' alarm operable from the centralized propulsion machinery control station in the engine room or at the propulsion machinery local control position, as appropriate, is to be provided. It is to be audible in each engineer's cabin, and its sound pressure level is to comply with 4-6-2/17.1.2. See 4-6-2/5.3.3(e) for power supply.

17.5 Refrigerated Space Alarm

Fan and diffuser rooms serving subfreezing compartments are to be provided with a device capable of activating an audible and visual alarm in a manned control center and operable from within the latter space for the protection of personnel. See 4-6-2/5.3.3(e) for power supply.

17.7 Elevator

A device which will activate an audible and visual alarm in a manned control center is to be provided in all cars. Such alarm system is to be independent of power and control systems of the elevator. See 4-6-2/5.3.3(e) for power supply.

19 Fire Protection and Fire Detection Systems

19.1 Emergency Stop

19.1.1 Ventilation System (2013)

19.1.1(a) General. All electrical ventilation systems are to be provided with means for stopping the motors in case of fire or other emergency. These requirements do not apply to closed re-circulating systems within a single space. See also 4-6-6/1.13.1(b), 4-6-6/5.3.6 and 4-5-1/5.1.

19.1.1(b) Propulsion Machinery Space Ventilation. Machinery-space ventilation is to be provided with means for stopping the ventilation fans. The means for stopping the power ventilation serving machinery spaces is to be entirely separate from the means for stopping the ventilation of spaces in 4-6-2/19.1.1(c) and 4-6-2/19.1.1(d).

In the case of vessels for which SOLAS is applicable, the means of stopping the ventilation fans is to be grouped so as to be operable from two positions, one of which is to be located outside the space.

19.1.1(c) Machinery Spaces other than Propulsion Machinery Spaces. Power ventilation systems serving these spaces are to be fitted with means for stopping the ventilation fan motors in the event of fire. The means for stopping the power ventilation serving these spaces is to be entirely separate from the means for stopping the ventilation of spaces in 4-6-2/19.1.1(b) and 4-6-2/19.1.1(d). See 4-5-1/5.1.

19.1.1(d) Accommodation Spaces, Service Spaces, Control Stations and Other Spaces. A control station for all other power ventilation systems is to be located in a centralized fire-fighting location or navigation bridge, or in an accessible position leading to, but outside of, the space ventilated.

19.1.2 Other Auxiliaries (2009)

See 4-5-1/5.3 for emergency tripping and emergency stop for other auxiliaries, such as forced and induced draft fans, fuel oil units, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers).

19.3 Fire Detection and Alarm System

See 4-5-2/21, 4-5-2/27, 4-5-2/29.1 and 4-7-4/29.5.

PART

4

CHAPTER 6 Electrical Installations

SECTION 3 Shipboard Installation

1 Plans and Data to be Submitted

1.1 **Booklet of Standard Details (2014)**

A booklet of the standard wiring practices and details, including such items as cable supports, earthing details, bulkhead and deck penetrations, cable joints and sealing, cable splicing, watertight and explosion-proof connections to equipment, earthing and bonding connections, etc., as applicable, is to be submitted. Where cable penetration methods for A- or B-class decks or bulkheads are shown, evidence of approval by an Administration signatory to 1974 SOLAS as amended is also to be submitted.

For high voltage systems see installation requirements given in 4-6-5/1.9.3.

For high voltage cables the minimum cable bending radii and securing arrangements, taking the relevant recommendations of the cable manufacturer into consideration, are to be included. Cable tray segregation (HV to HV and HV to LV arrangements) are also to be included.

1.3 **Arrangement of Electrical Equipment**

A general arrangement plan showing the location of at least the following electrical equipment is to be submitted for review.

- Generator, Essential Motor and Transformer
- Battery
- Switchboard, Battery Charger and Motor Controller
- Emergency Lighting Fixture
- General Emergency Alarm Device and Alarm Actuator
- Detector, Manual Call Point and Alarm Panel for Fire Detection and Alarm System
- Certified-safe Type Equipment

Where cable splices or cable junction boxes are provided, locations of the splices and cable junction boxes together with the information of their services are also to be submitted for review.

1.5 **Electrical Equipment in Hazardous Areas**

A plan showing hazardous areas is to be submitted for review together with the following:

- A list/booklet of intended electrical equipment in the indicated hazardous areas, including a description of the equipment, applicable degree of protection and ratings. See 4-6-3/11.3.
- For intrinsically-safe systems, also wiring plans, installation instructions with any restrictions imposed by the certification agency.
- Detail of installation for echo sounder, speed log and impressed current cathodic protection system where located in these areas.

When the selection of the equipment has been finalized, a list/booklet identifying all equipment in the hazardous areas, their method of protection (flameproof, intrinsically safe, etc.), rating (flammable gas group and temperature class), manufacturer's name, model number and evidence of certification is to be submitted for review. A copy of this list/booklet is to be maintained onboard for future reference. See 4-6-3/11.1.4.

1.7 Maintenance Schedule of Batteries (2008)

Maintenance Schedule of batteries for essential and emergency services. See 4-6-3/3.7.5.

3 Equipment Installation and Arrangement

3.1 General Consideration

3.1.1 Equipment Location (2006)

3.1.1(a) General. Electrical equipment is to be so placed or protected as to minimize the probability of mechanical injury or damage from the accumulation of dust, oil vapors, steam or dripping liquids. Equipment liable to generate arc is to be ventilated or placed in a compartment ventilated to avoid accumulation of flammable gases, acid fumes and oil vapors. See 4-6-3/Table 1 for the required degree of protection for various locations.

3.1.1(b) Equipment in Areas Affected by Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System in Machinery Spaces (2014). Electrical and electronic equipment within areas affected by Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing Systems are to be suitable for use in the affected area. See 4-6-3/Figure 1. Where enclosures have a degree of protection lower than IP44, evidence of suitability for use in these areas is to be submitted to ABS taking into account:

- i) The actual Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing system being used and its installation arrangements, and
- ii) The equipment design and layout (e.g., position of inlet ventilation openings, filters, baffles, etc.) to prevent or restrict the ingress of water mist/spray into the equipment. The cooling airflow for the equipment is to be maintained.

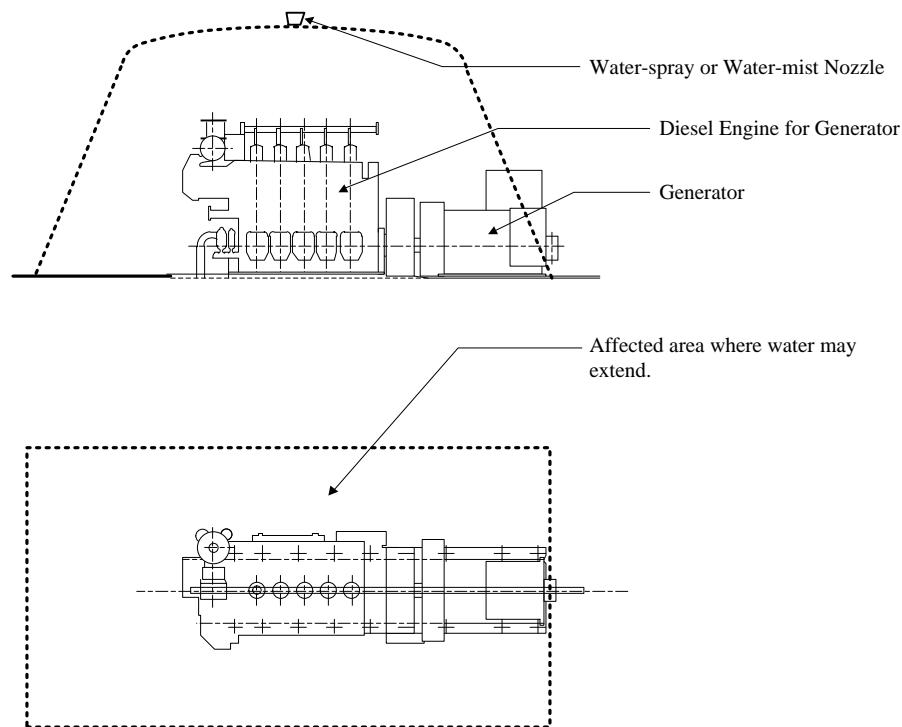
Note:

Additional precautions may be required to be taken with respect to:

- a. Tracking as the result of water entering the equipment
- b. Potential damage as the result of residual salts from sea water systems
- c. High voltage installations
- d. Personnel protection against electric shock

Equipment may require maintenance after being subjected to water mist/spray.

FIGURE 1
Example of Area Affected by Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System in Machinery Spaces (2014)



3.1.2 Protection from Bilge Water

All generators, motors and electric couplings are to be so arranged that they cannot be damaged by bilge water; and, if necessary, a watertight coaming is to be provided to form a well around the base of such equipment with provision for removing water from the well.

3.1.3 Accessibility

The design and arrangement of electrical apparatus is to provide accessibility to parts requiring inspection or adjustment. Armature and field coils, rotors and revolving fields are to be removable and where air ducts are used, there are to be means of access.

3.3 Generators

All generators are to be located with their shafts in a fore-and-aft direction on the vessel and are to operate satisfactorily in accordance with the inclination requirements of 4-1-1/17. Where it is not practicable to mount the generators with the armature shafts in the fore-and-aft direction, their lubrication will require special consideration. Provision is to be made to prevent oil or oil vapor from passing into the machine windings.

3.5 Ship Service Motors

3.5.1 General

Motors for use in the machinery space above the floor plate or spaces where subject to mechanical injury or dripping of oil or water are to have an enclosure of at least IP22 protection, in accordance with 4-6-3/Table 1. However, where they are protected by drip covers, they may have an enclosure of a lower protection grade than IP22. The motors having a protection enclosure of IP22 or lower are to be installed at a location high enough to avoid bilge water. Motors below the level of the floor plates are to have an enclosure of at least IP44 protection. Where motors intended for service at sea are not mounted with the rotor shafts in the fore-and-aft direction, the type of bearing and lubrication will require special consideration.

3.5.2 Pump Motors

Motors for operating plunger and close-coupled pumps are to have the driving end entirely enclosed or designed to prevent leakage from entering the motor.

3.5.3 Motors on Weather Decks

Motors for use on weather decks are to have an enclosure of at least IP56 protection or are to be enclosed in watertight housings.

3.5.4 Motors Below Decks

Motors below decks are to be installed at a location as dry as practicable and away from steam, water and oil piping.

3.7 Accumulator Batteries

3.7.1 General

The following requirements are applicable to permanently installed power, control and monitoring storage batteries of acid or alkaline types. Batteries are to be so arranged that the trays are accessible and provided with not less than 254 mm (10 in.) headroom. Where a relief valve is provided for discharging excessive gas due to overcharge, arrangements are to be made for releasing the gas to the weather deck away from any source of ignition.

3.7.2 Battery Installation and Arrangements

3.7.2(a) Large Batteries (2016). Large storage batteries, those connected to a charging device with an output of more than 2 kW, are to be installed in a room assigned to the battery only, but may be installed in a deck locker if such a room is not available. No electrical equipment is to be installed in the battery rooms unless essential for the operational purposes and certified safe for battery room atmosphere. Electrical equipment installed in battery rooms may be any of the types indicated in 4-6-3/11.1.1 and is to be IEC Publication 60079-20-1 group IIC class T1.

3.7.2(b) Moderate-size Batteries. Batteries of moderate size, those connected to a charging device with a power output of 0.2 kW up to and including 2 kW, may be installed in the battery room or may be installed in battery lockers or deck boxes in the emergency generator room, machinery space or other suitable location. Cranking batteries are to be located as closely as possible to the engine or engines served.

3.7.2(c) Small Batteries. Small batteries are to be installed in a battery box and may be located as desired, except they are not to be located in sleeping quarters unless hermetically sealed.

3.7.2(d) Low-hydrogen-emission Battery Installations. A low-hydrogen-emission battery installation with a battery charger having a charging rate of a large or moderate battery size installation may be treated as a moderate or small battery installation, respectively, if the following are met:

- i) Calculations under the worst case charging conditions are submitted that demonstrate that the low-hydrogen-emission battery installation does not emit more hydrogen under similar charging conditions than a bank of standard lead acid batteries supplied by a 2 kW charger for a moderate battery installation or 0.2 kW charger for a small battery installation, and
- ii) A warning notice is placed to notify maintenance personnel that additional batteries are not to be installed, and batteries are only to be replaced by other batteries of the same or lower hydrogen emission rate.

3.7.2(e) Battery Trays. Trays for batteries are to be chocked with wood strips or equivalent to prevent movement, and each tray is to be fitted with nonabsorbent insulating supports on the bottom and with similar spacer blocks at the sides or with equivalent provision to secure air-circulation space all around each tray.

3.7.2(f) Identification of Battery Types. Lead-acid batteries and alkaline batteries, when placed in the same battery compartment, are to be effectively identified as to type and segregated.

3.7.3 Ventilation

3.7.3(a) Battery Rooms. Battery rooms are to be ventilated to avoid accumulation of flammable gas. Natural ventilation may be employed if ducts are run directly from the top of the battery room to the open air above.

If natural ventilation is impractical, mechanical exhaust ventilation is to be provided with fan intake at the top of the room. Fans are to be of non-sparking construction in accordance with 4-6-3/11.7 and capable of completely changing the air in the battery room in not more than two minutes. Alternatively, a lesser ventilation rate may be considered, provided that satisfactory calculations are submitted substantiating that adequate ventilation is available to maintain the flammable gases within the battery room to a level below the lower explosive limit (L.E.L.) at the maximum battery charging current. Where the ventilation rate is based on low hydrogen emission type batteries, a warning notice to this effect is to be provided in a visible place in the battery room. Openings for air inlet are to be provided near the floor.

3.7.3(b) Battery Lockers. Battery lockers are to be ventilated, if practicable, similarly to battery rooms by a duct led from the top of the locker to the open air or to an exhaust ventilation duct. Louvers or equivalent are to be provided near the bottom for entrance of air.

3.7.3(c) Deck Boxes. Deck boxes are to be provided with a duct from the top of the box, terminating in a goose neck, mushroom head or equivalent to prevent entrance of water. Holes for air inlet are to be provided on at least two opposite sides of the box. The entire deck boxes, including openings for ventilation, is to be weathertight to prevent entrance of spray or rain.

3.7.3(d) Small Battery Boxes. Boxes for small batteries require no ventilation other than openings near the top to permit escape of gas.

3.7.4 Protection from Corrosion

The interiors of battery rooms, including the structural parts and shelves therein, as well as ventilation inlets and outlets are to be painted with corrosion-resistant paint. Shelves in battery rooms or lockers for acid batteries are to have a watertight lining of sheet lead not less than 1.6 mm ($1/16$ in.) on all sides. For alkaline batteries, the shelves are to be similarly lined with steel not less than 0.8 mm ($1/32$ in.) thick. Alternatively, a battery room may be fitted with a watertight lead pan, steel for alkaline batteries, over the entire deck, carried up not less than 152 mm (6 in.) on all sides. Deck boxes are to be lined in accordance with the above alternative method. Boxes for small batteries are to be lined to a depth of 76 mm (3 in.), consistent with the methods described above.

3.7.5 Maintenance of Batteries (2008)

3.7.5(a) Maintenance Schedule of Batteries (1 July 2016). Where batteries are fitted for use for essential and emergency services, a maintenance schedule of such batteries is to be provided and maintained.

The schedule is to include all batteries used for essential and emergency services, including system batteries installed in battery rooms, battery lockers and deck boxes as well as batteries installed within vendor supplied equipment. Examples of batteries included with equipment are:

- Computer equipment and programmable logic controllers (PLC) used in computer based systems and programmable electronic systems, when used for essential or emergency services.
- Navigation equipment, such as the equipment required by SOLAS, Chapter V, Regulation 19.

The schedule is to be submitted for review, during their plan approval or the new building survey, and is to include at least the following information regarding the batteries.

- Type and manufacturer's type designation.
- Voltage and ampere-hour rating.
- Location.
- Equipment and/or system(s) served.
- Maintenance/replacement cycle dates.

- Date(s) of last maintenance and/or replacement.
- For replacement batteries in storage, the date of manufacture and shelf life (See Note below)

Note: Shelf life is the duration of storage under specified conditions at the end of which a battery retains the ability to give a specified performance.

3.7.5(b) *Procedure of maintenance.* Procedures are to be put in place to show that, where batteries are replaced, they are to be of an equivalent performance type. Details of the schedule, procedures, and the maintenance records are to be included in the ship's safety management system and integrated into the ship's operational maintenance routine, as appropriate, which are to be verified by the Surveyor.

3.7.6 Replacement of Batteries (2008)

Where a vented type battery (See Note 1) replaces a valve-regulated, sealed type battery (See Note 2), the requirements in 4-6-3/3.7.2 and 4-6-3/3.7.3 are to be complied with on the basis of the charging capacity.

Notes:

- 1 A vented battery is one in which the cells have a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely from the cells to atmosphere.
- 2 A valve-regulated battery is one in which cells are closed but have an arrangement (valve) which allows the escape of gas if the internal pressure exceeds a predetermined value.

3.9 Switchboard (2015)

Switchboards are to be so arranged as to give easy access as may be needed to apparatus and equipment, without danger to personnel. Switchboards are to be located in a dry place so as to provide a clear working space of at least 900 mm (35 in.) at the front of the switchboard and a clearance of at least 600 mm (24 in.) at the rear which may be reduced to 457 mm (18 in.) in way of stiffeners or frames, except that for switchboards which are enclosed at the rear and are fully serviceable from the front, clearance at the rear will not be required unless necessary for cooling. Switchboards are to be secured to a solid foundation. They are to be self-supported or be braced to the bulkhead or the deck above. In case the last method is used, means of bracing is to be flexible to allow deflection of the deck without buckling the assembly structure.

3.11 Distribution Boards

3.11.1 Location and Protection (2004)

Distribution boards are to be located in accessible positions and not in such space as bunks, storerooms, cargo holds or compartments allotted alternately to passengers or cargo. Distribution boards may be located behind panels/linings within accommodation spaces, including stairway enclosures, without the need to categorize the space to a fire integrity standard, provided no provision is made for storage. Distribution boards are to have approved noncombustible, non-hygroscopic enclosures. Metal enclosures and all exposed metal parts in nonmetallic enclosures are to be earthed to the vessel's structure. All cases are to be of adequate mechanical strength.

3.11.2 Switchboard-type Distribution Boards

Distribution boards of the switchboard type, unless installed in machinery spaces or in compartments assigned exclusively to electric equipment and accessible only to authorized personnel, are to be completely enclosed or protected against accidental contact and unauthorized operation.

3.11.3 Safety-type Panels (1998)

If the method of operation demands the handling of switches by persons unfamiliar with electrical equipment, the distribution board is to be of the safety type. This type of distribution board is to be used for controlling branch lighting circuits. Dead front type panels are to be used where voltage to earth is in excess of 50 volts DC or 50 volts AC rms between conductors.

3.11.4 Lighting Distribution Boards (2013)

To prevent the simultaneous loss of main and emergency lighting distribution boards due to localized fire or other casualty, these distribution boards are to be installed as widely apart as practicable in the machinery spaces.

For spaces other than the machinery space (e.g. accommodation space, ro-ro cargo spaces, etc.), these lighting distribution boards are to be installed at locations which are separated by a boundary wall. For the navigation bridge, the main and emergency lighting distribution boards are not to be installed in the same compartment of the navigation console or panel.

Cables emanating from the main or emergency lighting switchboard to the main or emergency lighting distribution board respectively are also to be installed as widely apart as practicable. See also 4-6-2/13.1.2.

3.13 Motor Controllers and Control Centers

3.13.1 Location and Installation

Motor control centers are to be located in a dry place. Clear working space is to be provided around motor control centers to enable doors to be fully opened and equipment removed for maintenance and replacement. Motor control centers are to be secured to a solid foundation, be self-supported or be braced to the bulkhead.

3.13.2 Disconnecting Arrangements

3.13.2(a) Device. Means are to be provided for disconnecting the motor and controller from all supply conductors, except that a manually operated switch or circuit breaker may serve as both controller and disconnecting means (see 4-6-4/7.17.2).

3.13.2(b) Location (1998). The disconnecting device may be in the same enclosure with the controller or may be in a separate enclosure, and is to be externally operated. Except for remotely controlled fire extinguishing purpose motors, the branch-circuit switch or circuit breaker on the power-distribution board or switchboard may serve as the disconnect device if in the same compartment with the controller.

3.13.2(c) Locking Means (1998). If the disconnecting device is not within sight of both motor and controller, or if it is more than 15.25 m (50 ft) from either, it is to be arranged for locking in the open position. For remotely controlled fire extinguishing purpose motors, the locking means are to be provided at the feeder circuit breaker for such motors.

3.13.2(d) Identification Plate. The disconnect switch, if not adjacent to the controller, is to be provided with an identification plate.

3.13.2(e) Open and Close Indications. The disconnect device is to indicate by a position of the handle, or otherwise, whether it is open or closed.

3.13.3 Indicating-light Circuits

Where indicating-light circuits are employed, their potential is to be limited to 150 volts if the opening of the foregoing disconnecting devices does not de-energize the indicating circuit.

3.15 Resistors for Control Apparatus

The resistor is to be protected against corrosion either by rust-proofing or embedding in a protective material. Resistors are to be located in well-ventilated compartments and are to be mounted with ample clearances, about 305 mm (12 in.), to prevent excessive heating of adjacent vessel's structure or dangerous overheating of unprotected combustible material. The arrangement of the electrical equipment and wiring located within these spaces is to be such as to prevent their exposure to ambient temperatures in excess of that for which they have been designed.

3.17 Lighting Fixtures

Lighting fixtures are to be so arranged as to prevent temperature rises which could damage the cables and wiring, and to prevent surrounding material from becoming excessively hot.

3.19 Heating Equipment

Electric radiators, if used, are to be fixed in position and be so constructed as to reduce fire risks to a minimum. Electric radiators of the exposed-element type are not to be used.

3.21 Magnetic Compasses

Precautions are to be taken in connection with apparatus and wiring in the vicinity of the magnetic compass to prevent disturbance of the needle from external magnetic fields.

3.23 Portable Equipment and Outlets

Portable equipment are not to be used in cargo oil pump rooms or other hazardous areas nor are portable lights to be used for berth lights in passenger accommodations or crew's quarters.

3.25 Receptacles and Plugs of Different Ratings (2015)

Receptacles and plugs of different electrical ratings are not to be interchangeable. In cases where it is necessary to use 230 volt portable equipment, the receptacles for their attachment are to be of a type which will not permit attaching 115 volt equipment.

3.27 Installation Requirements for Recovery from Dead Ship Condition (2005)

Means are to be provided to ensure that machinery can be brought into operation from the dead ship condition without external aid. See 4-1-1/19.

Where the emergency source of power is an emergency generator which complies with 4-6-2/5.15 and 4-6-2/3.1.3, this emergency generator may be used for restoring operation of the main propulsion plant, boilers and auxiliary machinery.

Where there is no emergency generator installed, the arrangements for bringing main and auxiliary machinery into operation are to be such that the initial charge of starting air or initial electrical power and any power supplies for engine operation can be developed onboard ship without external aid. If for this purpose an emergency air compressor or an electric generator is required, these units are to be powered by a hand-starting oil engine or a hand-operated compressor.

The arrangements for bringing the main and auxiliary machinery into operation are to have a capacity such that the starting energy and any power supplies for propulsion engine operation are available within 30 minutes of a blackout condition.

3.29 Services Required to be Operable Under a Fire Condition (2008)

For the purpose of 4-6-3/5.17.2, services required to be operable under a fire condition include, but not limited thereto, are the following:

- i) Fire and general alarm system
- ii) Fire extinguishing system including fire extinguishing medium release alarms
- iii) Emergency Fire Pump
- iv) Fire detection system
- v) Control and power systems for all power operated fire doors and their status indicating systems
- vi) Control and power systems for all power operated watertight doors and their status indicating systems
- vii) Emergency lighting
- viii) Public address system
- ix) Remote emergency stop/shutdown arrangement for systems which may support the propagation of fire and/or explosion
- x) For passenger vessels, see 5C-7-5/13.7.2(b) of the *Steel Vessel Rules*.

3.31 High Fire Risk Areas (1 July 2016)

For the purpose of 4-6-3/5.17, the examples of the high fire risk areas are the following:

- i) Machinery spaces as defined by 4-1-1/13.1 and 4-1-1/13.3, except spaces having little or no fire risk such as machinery spaces which do not contain machinery having a pressure lubrication system and where storage of combustibles is prohibited (e.g., ventilation and air-conditioning rooms, windlass room, steering gear room, stabilizer equipment room, electrical propulsion motor room, rooms containing section switchboards and purely electrical equipment other than oil-filled electrical transformers (above 10 kVA), shaft alleys and pipe tunnels, and spaces for pumps and refrigeration machinery not handling or using flammable liquids).
- ii) Spaces containing fuel treatment equipment and other highly flammable substances
- iii) Galley and pantries containing cooking appliances
- iv) Laundry containing drying equipment
- v) For passenger vessels, see 5C-7-5/13.7.2(c) of the *Steel Vessel Rules*.

5 Cable Installation

5.1 General Considerations

5.1.1 Continuity of Cabling

Electric cables are to be installed in continuous lengths between terminations at equipment or in cable junction boxes. See 4-6-3/5.33. However, approved splices will be permitted at interfaces of new construction modules, when necessary to extend existing circuits for a vessel undergoing repair or alteration, and in certain cases to provide for cables of exceptional length (See 4-6-3/5.29).

5.1.2 Choice of Cables

The rated operating temperature of the insulating material is to be at least 10°C (18°F) higher than the maximum ambient temperature likely to exist or to be produced in the space where the cable is installed.

5.1.3 Cable Voltage Drop for New Installation

The cross-sectional area of conductors are to be so determined that the drop in voltage from the main or emergency switchboard bus-bars to any and every point of the installation when the conductors are carrying the maximum current under normal steady conditions of service will not exceed 6% of the nominal voltage. For supplies from batteries with a voltage not exceeding 55 V, this figure may be increased to 10%.

The above values are applicable under normal steady conditions. Under special conditions of short duration, such as motor starting, higher voltage drops may be accepted, provided the installation is capable of withstanding the effects of these higher voltage drops.

5.1.4 Restricted Location of Cabling (2015)

Cables and wiring are to be installed and supported in such a manner as to avoid chafing or other damage. Cables are to be located with a view to avoiding, as far as practicable, spaces where excessive heat and gases may be encountered, also spaces where they may be exposed to damage, such as exposed sides of deckhouses. Cables are not to be installed in the bilge or tanktop area unless protected from bilge water. Cables are not to be installed in water tanks, oil tanks, cargo tanks, ballast tanks or any liquid tanks except to supply equipment and instrumentations specifically designed for such locations and whose functions require it to be installed in the tank. See also 4-6-6/1.9.3 for cables used for echo sounder, speed log and impressed current cathodic protection system in hazardous area.

5.1.5 Means of Drainage from Cable Enclosures

Where cables are installed in a cable draw box and horizontal pipes or the equivalent used for cable protection, means of drainage are to be provided.

5.1.6 High Voltage Cables

Cables serving systems above 1 kV are not to be bunched with cables serving systems of 1 kV and below.

5.1.7 Paint on Cables (2006)

Where paint or any other coating is systematically and intentionally applied on the electric cables, it is to be established that the mechanical and fire performance properties of the cable are not adversely affected.

In this regard:

- i) Fire retardant property is to be confirmed to be in compliance with 4-6-4/13.1.2.
- ii) It is to be confirmed that the paint and the solvent used will not cause damages to the cable sheath, e.g., cracking.

Overspray on cables or painted exterior cables are not subject to the requirements of this section.

5.1.8 Cable Installation above High Voltage Switchgear and Control-gear (2006)

Where a pressure relief flap is provided for high voltage switchgear and high voltage control-gear, the cables are not to be installed near and above this equipment in order to prevent the damage of cables from the flare/flame released from the relief flap upon occurrence of short circuit in this equipment.

5.1.9 Ultra Violet (UV) Light Protection for Wiring Insulation within Fluorescent Light Fixtures (2014)

Where the supply cable's outer sheathing or covering is removed once the cable enters a fluorescent light fixture to facilitate routing and/or connection, the insulation on the individual conductors is to be protected against the possible detrimental effects of UV light exposure by one of the following:

- i) The insulation is to be manufactured with additives that protect the insulation from UV light damage and a test report is to be submitted to ABS.
- ii) Adequate shielding arrangements are to be provided inside the fixture for the entire length of the exposed insulation within the fixture.
- iii) UV protective sleeves are to be installed on the full length of the exposed conductors inside the fixture during the installation.

5.1.10 Protection of Cables in Tanks (2015)

Where cables are installed in liquid tanks, the following arrangements are to be complied with:

- i) Cables are to be installed in steel pipes with at least extra-heavy wall thickness with all joints welded and with corrosion-resistant coating.
- ii) Cable gland with gastight packing is to be provided for the cable at both ends of the cable conduit pipe
- iii) Cable inside of the vertical cable conduit pipe is to be suitably supported (e.g., by sand-filling or by strapping to a support-wire). Alternatively, the cable inside of the vertical conduit pipe may be accepted without provided support if the mechanical strength of the cable is sufficient to prevent cable damage due to the cable weight within the conduit pipe under continuous mechanical load. Supporting documentation is to be submitted to verify the mechanical strength of the cable with respect to the cable weight inside of the conduit.

5.3 Insulation Resistance for New Installation

Each power and each light circuit is to have an insulation resistance between conductors and between each conductor and earth of not less than the following values.

Up to 5 amperes load	2 meg ohms
10 amperes load	1 meg ohm
25 amperes load	400,000 ohms
50 amperes load	250,000 ohms
100 amperes load	100,000 ohms
200 amperes load	50,000 ohms
Over 200 amperes load	25,000 ohms

If the above values are not obtained, any or all appliances connected to the circuit may be disconnected for this test.

5.5 Protection for Electric-magnetic Induction

5.5.1 Multiple Conductor Cables

All phase conductors of alternating-current cables are to be contained within the same sheath in order to avoid overheating due to induction by use of multiple conductor cables.

5.5.2 Single Conductor Cables (1999)

AC installations are to be carried out, as far as possible, in twin or multi-conductor cables. However, when it is necessary to use single conductor cables in circuits rated in excess of 20 A, the following arrangements are to be complied with:

5.5.2(a) Cables are supported on non-fragile insulators;

5.5.2(b) There are to be no magnetic materials between cables of a group; and

5.5.2(c) (1999) Where single conductor cables are run in bunches, each group of cables is to comprise 360 electrical degrees. To this end, in three-phase circuits, single conductor cable runs of 30 m (100 ft) or longer and having a cross-sectional area of 185 mm² (365,005 circ. mils) or more are to be transposed throughout the length at intervals not exceeding 15 m (50 ft) in order to equalize to some degree the impedance of the three phase circuits. Alternatively, such cables may be installed in trefoil formation.

See 4-6-4/13.1.5 for armor.

5.5.3 Non-shielded Signal Cables

Except for fiber optic cables, non-shielded signal cables for automation and control systems essential for the safe operation of the vessel which may be affected by electromagnetic interference are not to be run in the same bunch with power or lighting cables.

5.7 Joints and Sealing

Cables not having a moisture-resistant insulation are to be sealed against the admission of moisture by methods such as taping in combination with insulating compound or sealing devices. Cables are to be installed in such a manner that stresses on the cable are not transmitted to the conductors. Terminations and joints in all conductors are to be so made as to retain the original electrical, flame retarding and, where necessary, fire resisting properties of the cable. Terminal boxes are to be secured in place and the moisture-resistant jacket is to extend through the cable clamp. Enclosures for outlets, switches and similar fittings are to be flame and moisture-resistant and of adequate mechanical strength and rigidity to protect the contents and to prevent distortion under all likely conditions of service. See also 4-6-3/5.17.1 and 4-6-3/5.29.

5.9 Support, Fixing and Bending

5.9.1 Support and Fixing (1999)

5.9.1(a) Where cables are fixed by means of clips, saddles or straps, they are to have a surface area so large and shaped such that the cables remain tight without their coverings being damaged. Metal clips may be screwed directly to deck or bulkhead, except on watertight bulkheads.

5.9.1(b) The distances between supports are to be suitably chosen according to the type of cable and the probability of vibration, and are not to exceed 400 mm (16 in.); for a horizontal cable run where the cables are laid on cable supports in the form of tray plates, separate support brackets or hanger ladders, the spacing between the fixing points may be up to 900 mm (36 in.), provided that there are supports with maximum spacing, as specified above. This exemption does not apply to cable runs along weather decks when the cable run is arranged so that the cables can be subjected to forces by water washing over the deck.

Note: When designing a cable support system for single-core cables, consideration is also to be given to the effects of electrodynamic forces developing on the occurrence of a short-circuit.

The above-given distances between cable supports are not necessarily adequate for these cables. Further, other recognized standards for cable support and fixing will be considered.

5.9.1(c) The supports and the corresponding accessories are to be robust and are to be of corrosion-resistant material or suitably treated before erection to resist corrosion.

5.9.1(d) Cable clips or straps made from an approved material other than metal (such as polyamide, PVC) may be used.

5.9.1(e) When cables are fixed by means of clips or straps, referred to in Item 4-6-3/5.9.1(d) above, and these cables are not laid on top of horizontal cable trays or cable supports, suitable metal cable clips or saddles are to be added at regular distances not exceeding 2 m (6.5 ft) in order to prevent the release of cables during a fire. This also applies to the fixing of non-metallic conduits or pipes.

Note: Item 4-6-3/5.9.1(e) does not necessarily apply in the case of cable runs with only one or a few cables with small diameters for the connection of a lighting fitting, alarm transducer, etc.

5.9.1(f) (2004) Non-metallic clips, saddles or straps are to be flame retardant in accordance with IEC Publication 60092-101.

5.9.2 Bending Radius

For bending radius requirements, see 4-6-3/Table 2.

5.9.3 Plastic Cable Trays and Protective Casings (2004)

5.9.3(a) *Installations (2008)*. Cable trays and protective casings made of plastic materials are to be supplemented by metallic fixing and straps such that, in the event of a fire, they and the cables affixed are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route. See 4-6-3/5.9.1(e). Cable trays and protective casings made of plastic materials are to be flame retardant (see Appendix 4-8-4A1 of the *Steel Vessel Rules*). Where plastic cable trays and protective casings are used on open deck, they are additionally to be protected against UV light by such as anti-UV coating or equivalent.

Note: “Plastic” means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and fiber reinforced plastics (FRP). “Protective casing” means a closed cover in the form of a pipe or other closed ducts of non-circular shape.

5.9.3(b) *Safe Working Load (2008)*. The load on the cable trays and protective casings is to be within the Safe Working Load (SWL). The support spacing is to be not greater than the manufacturer’s recommendation nor in excess of the spacing at the SWL test (see Appendix 4-8-4A1 of the *Steel Vessel Rules*). In general, the spacing is not to exceed 2 meters.

Note: The selection and spacing of cable tray and protective casing supports are to take into account:

- Dimensions of the cable trays and the protective casings;
- Mechanical and physical properties of their material;
- Mass of the cable trays/protective casings;
- Loads due to weight of cables, external forces, thrust forces and vibrations;
- Maximum accelerations to which the system may be subjected;
- Combination of loads.

5.9.3(c) *Cable occupation ratio in protective casing.* The sum of the total cross-sectional area of all cables on the basis of their external diameter is not to exceed 40% of the internal cross-sectional area of the protective casing. This does not apply to a single cable in a protective casing.

5.9.3(d) *Hazardous areas (2008).* Cable trays and protective casings passing through hazardous areas are to be electrically conductive (see Appendix 4-8-4A1 of the *Steel Vessel Rules*).

5.9.3(e) *Type Testing (2008).* Cable trays and protective casings made of plastic materials are to be type tested in accordance with Appendix 4-8-4A1 of the *Steel Vessel Rules*. Alternate test procedures for impact resistance test, safe working load test, flame retardant test, smoke and toxicity tests and/or resistivity test from an international or national standard may be considered instead of the test specified in Appendix 4-8-4A1 of the *Steel Vessel Rules*. The type test reports are to be submitted for review.

5.11 Cable Run in Bunches

5.11.1 Reduction of Current Rating

Where cables which may be expected to operate simultaneously are laid close together in a cable bunch in such a way that there is an absence of free air circulation around them, the following reduction factor is to be applied to the current rating obtained from 4-6-4/Table 10:

<i>Number of Cables in One Bunch</i>	<i>Reduction Factor</i>
one to six	1.0
seven to twelve	0.85

Bunches of more than twelve cables will be subject to special consideration based on the type and service of the various cables in the bunch.

5.11.2 Clearance and Segregation

A clearance is to be maintained between any two cable bunches of at least the diameter of the largest cable in either bunch. Otherwise, for the purpose of determining the number of cables in the bunch, the total number of cables on both sides of the clearance will be used.

5.11.3 Cable of Lower Conductor Temperature

The current rating of each cable in a bunch is to be determined based on the lowest conductor temperature rating of any cable in the bunch.

5.13 Deck and Bulkhead Penetrations (1 July 2013)

5.13.1 General

Where cables pass through watertight, firetight, or smoke-tight bulkheads or decks, the penetrations are to be made through the use of approved stuffing tubes, transit devices or pourable materials installed in accordance with manufacturer's installation procedures to maintain the watertight integrity or fire-rating of the bulkheads or decks. These devices or pourable materials are not to damage the cable physically or through chemical action or through heat build-up, and are to be examined and tested as specified in 3-7-1/Table 1 and 4-6-3/5.13.4.

Where cable conduit pipe or equivalent is carried through decks or bulkheads, arrangements are to be made to maintain the integrity of the water or gas tightness of the structure.

5.13.2 Non-watertight Penetrations

When cables pass through non-watertight bulkheads where the bearing surface is less than 6.4 mm (0.25 in.), the holes are to be fitted with bushings having rounded edges and a bearing surface for the cable of at least 6.4 mm (0.25 in.) in length. Where cables pass through deck beams or similar structural parts, all burrs are to be removed in way of the holes and care is to be taken to eliminate sharp edges.

5.13.3 Collision Bulkhead

Cables are not to pass through a collision bulkhead.

5.13.4 Watertight and Fire-rated Deck and Bulkhead Cable Penetrations

During installation of deck and bulkhead watertight and fire-rated cable penetrations, the attending Surveyor is to confirm that the installer is familiar with and has access to the manufacturer's installation procedures for stuffing tubes, transit devices or pourable materials.

After installation, all watertight and fire-rated cable penetrations are to be visually examined. Watertight cable penetrations are to be tested as required by 3-7-1/Table 1.

5.15 Mechanical Protection

5.15.1 Metallic Armor

Electric cables installed in locations liable to damage during normal operation of the vessel are to be provided with braided, metallic armor and be otherwise suitably protected from mechanical injury, as appropriate for the location. See also 4-6-3/11.1.3 for cables in hazardous areas.

5.15.2 Conduit Pipe or Structural Shapes

Where cables are installed in locations in way of cargo ports, hatches, tank tops, open decks subject to seas, and where passing through decks, they are to be protected by substantial metal shields, structural shapes, pipe or other equivalent means. All such coverings are to be of sufficient strength to provide effective protection to the cables. When expansion bends are fitted, they are to be accessible for maintenance. Where cables are installed in metal piping or in a metal conduit system, such piping and systems are to be earthed and are to be mechanically and electrically continuous across all joints.

5.17 Emergency and Essential Feeders

5.17.1 Location (2013)

As far as practicable, cables and wiring for emergency and essential services, including those listed in 4-6-3/3.29, are not to pass through high fire risk areas (see 4-6-3/3.31). For Emergency Fire Pumps, see requirements in 4-6-3/5.17.3.

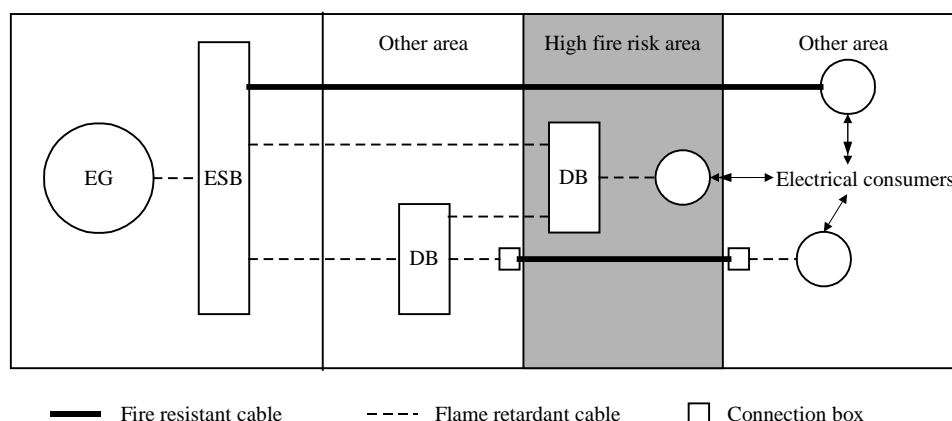
These cables and wiring are also to be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

5.17.2 Services Necessary Under a Fire Condition (2013)

Where cables for services required to be operable under a fire condition (see 4-6-3/3.29) including their power supplies pass through high fire risk areas (see 4-6-3/3.31) other than those which they serve, they are to be so arranged that a fire in any of these areas does not affect the operation of the service in any other area. For Emergency Fire Pumps, see requirements in 4-6-3/5.17.3. This may be achieved by any of the following measures:

5.17.2(a) Fire resistant cables in accordance with 4-6-4/13.1.3 are installed and run continuous to keep the fire integrity within the high fire risk area. See 4-6-3/Figure 2.

FIGURE 2
Cables within High Fire Risk Areas (2008)



5.17.2(b) At least two loops/radial distributions run as widely apart as is practicable and so arranged that in the event of damage by fire at least one of the loops/radial distributions remains operational.

Systems that are self-monitoring, fail safe or duplicated with cable runs separated as widely as practicable, may be exempted from the requirements in 4-6-3/5.17.2(a) and 4-6-3/5.17.2(b).

5.17.3 Electrical Cables for the Emergency Fire Pump (2013)

The electrical cables to the emergency fire pump are not to pass through the machinery spaces containing the main fire pumps and their sources of power and prime movers. They are to be of a fire resistant type, in accordance with 4-6-4/13.1.3, where they pass through other high fire risk areas.

5.17.4 Requirements by the Governmental Authority

Attention is directed to the requirements of the governmental authority of the country whose flag the vessel flies for the installation of emergency circuits required in various types of vessels.

5.19 Mineral Insulated Cables

At all points where mineral-insulated metal-sheathed cable terminates, an approved seal is to be provided immediately after stripping to prevent entrance of moisture into the mineral insulation. In addition, the conductors extending beyond the sheath are to be insulated with an approved insulating material. When mineral-insulated cable is connected to boxes or equipment, the fittings are to be approved for the conditions of service. The connections are to be in accordance with the manufacturer's installation recommendation.

5.21 Fiber Optic Cables

The installation of fiber optic cables is to be in accordance with the manufacturer's recommendations to prevent sharp bends where the fiber optic cables enter the equipment enclosure. Consideration is to be given to the use of angled stuffing tubes. The cables are to be installed so as to avoid abrading, crushing, twisting, kinking or pulling around sharp edges.

5.23 Battery Room

Where cables enter battery rooms, the holes are to be bushed, as required for watertight bulkheads in 4-6-3/5.13. All connections within battery rooms are to be resistant to the electrolyte. Cables are to be sealed to resist the entrance of electrolyte by spray or creepage. The size of the connecting cable is to be based on current-carrying capacities given in 4-6-4/Table 10 and the starting rate of charge or maximum discharge rate, whichever is the greater, is to be taken into consideration in determining the cable size.

5.25 Paneling and Dome Fixtures

Cables may be installed behind paneling, provided all connections are accessible and the location of concealed connection boxes is indicated. Where a cable strip molding is used for cable installation on the incombustible paneling, it is to be of incombustible material. Dome fixtures are to be installed so that they are vented or they are to be fitted with fire-resistant material in such a manner as to protect the insulated wiring leading to the lamps and any exposed woodwork from excessive temperature.

5.27 Sheathing and Structural Insulation

Cables may be installed behind sheathing, but they are not to be installed behind nor imbedded in structural insulation. They are to pass through such insulation at right angles and are to be protected by a continuous pipe with a stuffing tube at one end. For deck penetrations, this stuffing tube is to be at the upper end of the pipe and for bulkhead penetrations, it is to be on the uninsulated side of the bulkhead. For refrigerated-space insulation, the pipe is to be of phenolic or similar heat-insulating material joined to the bulkhead stuffing tube, or a section of such material is to be inserted between the bulkhead stuffing tube and the metallic pipe.

5.29 Splicing of Electrical Cables

5.29.1 Basis of Approval

Replacement insulation is to be fire-resistant and is to be equivalent in electrical and thermal properties to the original insulation. The replacement jacket is to be at least equivalent to the original impervious sheath and is to assure a watertight splice. Splices are to be made using an approved splice kit which contains the following:

- Connector of correct size and number
- Replacement insulation
- Replacement jacket
- Instructions for use

In addition, prior to approval of a splicing kit, it will be required that completed splices be tested for fire resistance, watertightness, dielectric strength, etc. to the satisfaction of the Surveyor. This requirement may be modified for splice kits which have had such tests conducted and reported on by an independent agency acceptable to ABS.

5.29.2 Installation

All splices are to be made after the cable is in place and are to be accessible for inspection. The conductor splice is to be made using a pressure type butt connector by use of a one-cycle compression tool. See 4-6-3/11.1.3 for splices in hazardous area.

5.29.3 Protection

Splices may be located in protected enclosures or in open wireways. Armored cables having splices will not be required to have the armor replaced, provided that the remaining armor has been earthed in compliance with 4-6-3/7.9 or provided that the armor is made electrically continuous. Splices are to be so located such that stresses (as from the weight of the cable) are not carried by the splice.

5.31 Splicing of Fiber Optic Cables

Splicing of fiber optic cables is to be made by means of approved mechanical or fusion methods.

5.33 Cable Junction Box

Except for propulsion cables, junction boxes may be used in the installation of electric cables aboard the vessel, provided the plans required by 4-6-3/1.3 for junction boxes are submitted and the following requirements are complied with.

5.33.1

The design and construction of the junction boxes are to comply with 4-6-4/11.7 as well as 4-6-3/5.33.2, below.

5.33.2

The junction boxes are to be suitable for the environment in which they are installed (i.e., explosion-proof in hazardous areas, watertight or weathertight on deck, etc.).

5.33.3 (1998)

Separate junction boxes are to be used for feeders and circuits of each of the following rated voltage levels:

5.33.3(a) Rated voltage levels not exceeding those specified in 4-6-3/7.1i).

5.33.3(b) Rated voltage levels exceeding those in 4-6-3/5.33.3(a) up to and including 1 kV. A physical barrier is to be used within the junction box to separate distribution systems of different rated voltages, such as 480 V, 600 V and 750 V.

5.33.3(c) Rated voltage levels exceeding 1 kV. Separate junction boxes are to be used for each of the rated voltage levels exceeding 1 kV.

Each junction box and the compartment in the junction box separated by a physical barrier are to be appropriately identified as regards the rated voltage of the feeders and circuits that it contains. A physical barrier may be used in lieu of two separate junction boxes for circuits having rated voltage levels corresponding to those in either 4-6-3/5.33.3(a) or 4-6-3/5.33.3(b).

5.33.4

The junction boxes for emergency feeders and circuits are to be separate from those used for normal ship service feeders and circuits.

5.33.5 (1998)

Cables are to be supported, as necessary, within junction boxes so as not to put stress (as from the weight of the cable) on the cable contact mountings. The connections are to be provided with locking type connections.

In addition to the above, the applicable requirements in 4-6-3/5 and 4-6-4/13 regarding cable installation and application details are to be complied with.

7 Earthing

7.1 General

Exposed metal parts of electrical machines or equipment which are not intended to be live but which are liable under fault conditions to become live are to be earthed unless the machines or equipment are:

- i) (1998) supplied at a voltage not exceeding 50 volts DC or 50 volts AC rms between conductors; auto-transformers are not to be used for the purpose of achieving this voltage; or
- ii) Supplied at a voltage not exceeding 250 V AC rms by safety isolating transformers supplying only one consuming device; or
- iii) Constructed in accordance with the principle of double insulation.

7.3 Permanent Equipment

The metal frames or cases of all permanently installed generators, motors, controllers, instruments and similar equipment are to be permanently earthed through a metallic contact with the vessel's structure. Alternatively, they are to be connected to the hull by a separate conductor, in accordance with 4-6-3/7.5. Where outlets, switches and similar fittings are of non-metallic construction, all exposed metal parts are to be earthed.

7.5 Connections

7.5.1 General

All earthing conductors are to be of copper or other corrosion-resistant material and are to be protected against damage. The nominal cross-sectional area of every copper earthing conductor is to be not less than that required by 4-6-3/Table 3.

7.5.2 Earthed Distribution System

Earthing conductors in an earthed distribution system are to comply with 4-6-3/7.5.1, except that the earthing conductor in line C4 of 4-6-3/Table 3 is to be $A/2$.

7.5.3 Connection to Hull Structure

All connections of an earth-continuity conductor or earthing lead to the vessel's structure are to be made in an accessible position and be secured by a screw of brass or other corrosion-resistant material having a cross-sectional area equivalent to the earth-continuity conductor or earthing lead, but not less than 4 mm (0.16 in.) in diameter. The earth connection screw is to be used for this purpose only. See 4-4-1/9.21 for control of static electricity.

7.7 Portable Cords (1998)

Receptacle outlets operating at 50 volts DC or 50 volts AC rms or more are to have an earthing pole.

7.9 Cable Metallic Covering

All metal sheaths, armor of cable and mineral-insulated, metal-sheathed cable are to be electrically continuous and are to be earthed to the metal hull at each end of the run, except that final sub-circuits may be earthed at the supply end only. All metallic coverings of power and lighting cables passing through hazardous areas or connected to equipment in such an area are to be earthed at least at each end. See also 4-7-2/15.9.3.

7.11 Lightning Earth Conductors

Each wooden mast or topmast is to be fitted with lightning earth conductors. They need not be fitted to steel masts.

9 Installation in Cargo Hold for Dry Bulk Cargoes

9.1 Equipment

The installation of electrical equipment in cargo holds for dry bulk cargoes is to be limited to only that which is absolutely necessary. Where electrical equipment must be installed in such spaces, it is to be protected from mechanical damage. All electrical equipment in cargo holds or spaces through which cargo passes is to have an IP55 enclosure, as defined in 4-6-1/15.

9.3 Self-Unloading Controls and Alarms

9.3.1 General

Where vessels are equipped with self-unloading systems, controls are to be provided for the safe operation of the self-unloading system. These controls are to be clearly marked to show their functions. Energizing the power unit at a location other than the cargo control station is not to set the gear in motion.

9.3.2 Monitors

As appropriate, monitoring is to indicate the system operational status (operating or not operating), availability of power, overload alarm, air pressure, hydraulic pressure, electrical power or current, motor running and motor overload and brake mechanism engagement.

9.3.3 Emergency Shutdowns

Remote emergency shutdowns of power units for self-unloading equipment are to be provided outside of the power unit space so that they may be stopped in the event of fire or other emergency. Where remote controls are provided for cargo gear operation, means for the local emergency shutdowns are to be provided.

11 Equipment and Installation in Hazardous Areas

11.1 General Considerations

11.1.1 General (2015)

Electrical equipment and wiring are not to be installed in hazardous areas unless essential for operational purposes. Generally electrical equipment certified for use in hazardous areas in accordance with the IEC 60079 series is considered suitable for use in temperatures from -20°C to 40°C (-4°F to 104°F). Account is to be taken of the temperature at the point of installation when selecting electrical equipment for installation in hazardous areas.

11.1.1(a) Electrical Equipment Types (2016). Only electrical equipment of the following types, complying with IEC Publication 60079 series or other recognized standards, is to be considered for installation in hazardous areas.

- Intrinsically safe type (Ex i)
- Flameproof (explosion-proof) type (Ex d)
- Increased safety type (Ex e)
- Pressurized or purged type (Ex p)

Consideration is to be given to the flammability group and the temperature class of the equipment for suitability for the intended hazardous area, see IEC Publication 60079-20.

11.1.1(b) Fans. Fans used for the ventilation of the hazardous areas are to be of non-sparking construction in accordance with 4-6-3/11.7.

11.1.2 Lighting Circuits (2002)

All switches and protective devices for lighting fixtures in hazardous areas are to interrupt all poles or phases and are to be located in a non-hazardous area. However, a switch may be located in a hazardous area if the switch is of a certified safe type for the hazardous location in which it is to be installed. On solidly grounded distribution systems, the switches need not open the grounded conductor. The switches and protective devices for lighting fixtures are to be suitably labeled for identification purposes.

11.1.3 Cables Installation (2006)

Cables in hazardous areas are to be armored or mineral-insulated metal-sheathed, except for cables of intrinsically safe circuits subject to the requirements of 4-6-3/5.15. Where cables pass through hazardous area boundaries, they are to be run through gastight fittings. No splices are allowed in hazardous areas, except in intrinsically-safe circuits.

11.1.4 Permanent Warning Plates

Permanent warning plates are to be installed in the vicinity of hazardous areas in which electrical equipment is installed, such as the pump room, to advise personnel carrying out maintenance, repair or surveys of the availability of the booklet/list of equipment in hazardous areas referenced in 4-6-3/1.5, if required for their use.

11.3 Certified-safe Type and Pressurized Equipment and Systems

11.3.1 Installation Approval

Electrical equipment in hazardous areas is to be of a type suitable for such locations. Where permitted by the Rules, electrical equipment of a certified safe type, such as explosion-proof type and intrinsically-safe electrical instruments, circuitry and devices, will be approved for installation, provided such equipment has been type-tested and certified by a competent independent testing laboratory as explosion-proof or intrinsically-safe and provided that there is no departure in the production equipment from the design so tested and approved.

11.3.2 Intrinsically-safe System (2005)

11.3.2(a) Installation of Cables and Wiring. Installations with intrinsically safe circuits are to be erected in such a way that their intrinsic safety is not adversely affected by external electric or magnetic fields under normal operating condition and any fault conditions, such as a single-phase short circuit or earth fault in non-intrinsically safe circuits, etc.

11.3.2(b) Separation and Mechanical Protection. The installation of the cables is to be arranged as follows:

- i) Cables in both hazardous and non-hazardous areas are to meet one of the following requirements:
 - Intrinsically safe circuit cables are to be installed a minimum of 50 mm (2 in.) from all non-intrinsically safe circuit cables, or
 - Intrinsically safe circuit cables are to be so placed as to protect against the risk of mechanical damage by use of a mechanical barrier, or
 - Intrinsically safe or non-intrinsically safe circuit cables are to be armored, metal sheathed or screened.
- ii) Conductors of intrinsically safe circuits and non-intrinsically safe circuits are not to be carried in the same cable.
- iii) Cables of intrinsically safe circuits and non-intrinsically safe circuits are not to be in the same bundle, duct or conduit pipe.
- iv) Each unused core in a multi-core cable is to be adequately insulated from earth and from each other at both ends by the use of suitable terminations.

11.3.2(c) Sub-compartment. When intrinsically safe components are located by necessity within enclosures that contain non-intrinsically safe systems, such as control consoles and motor starters, such components are to be effectively isolated in a sub-compartment by earthed metallic or nonmetallic insulating barriers having a cover or panel secured by bolts, locks, Allen-screws, or other approved methods. The intrinsic safety in the sub-compartment is not to be adversely affected by external electric or magnetic fields under normal operating condition and any fault conditions in non-intrinsically safe circuits.

11.3.2(d) Termination Arrangements. Where it is impracticable to arrange the terminals of intrinsically safe circuit in the sub-compartment, they are to be separated from those for non-intrinsically safe circuits by either of the following methods. Other National or International recognized Standards will also be accepted.

- i) When separation is accomplished by distance, then the clearance between terminals is to be at least 50 mm, or
- ii) When separation is accomplished by use of an insulating partition or earthed metal partition, the partitions are to extend to within 1.5 mm of the walls of the enclosure, or alternatively provide a minimum measurement of 50 mm between the terminals when taken in any direction around the partition.

11.3.2(e) *Identification Plate.* The terminals and sub-compartment for intrinsically safe circuit and components are to have a nameplate indicating that the equipment within is intrinsically safe and that unauthorized modification or repairs are prohibited.

11.3.2(f) *Replacement.* Unless specifically approved, replacement equipment for intrinsically-safe circuits is to be identical to the original equipment.

11.3.3 Pressurized Equipment

Pressurized equipment is to consist of separately ventilated enclosures supplied with positive-pressure ventilation from a closed-loop system or from a source outside the hazardous areas, and provision is to be made such that the equipment cannot be energized until the enclosure has been purged with a minimum of ten air changes and required pressure is obtained. Ventilating pipes are to have a minimum wall thickness of 3 mm (0.12 in. or 11 gage). In the case of loss of pressurization, power is to be automatically removed from the equipment, unless this would result in a condition more hazardous than that created by failure to de-energize the equipment. In this case, in lieu of removal of power, an audible and visual alarm is to be provided at a normally manned control station.

Pressurized equipment in compliance with IEC Pub. 60079-2, NFPA 496 or other recognized standard will also be acceptable.

11.5 Paint Stores

11.5.1 General (2016)

Electrical equipment in paint stores and in ventilation ducts serving such spaces as permitted in 4-6-3/11.1.1 is to comply with the requirements for group IIB class T3 in IEC Publication 60079-20-1.

The following type of equipment will be acceptable for such spaces.

- i) Intrinsically-safe defined by 4-6-1/3.21
- ii) Explosion-proof defined by 4-6-1/3.9
- iii) Pressurized defined by 4-6-1/3.43
- iv) Increased safety defined by 4-6-1/3.17
- v) Other equipment with special protection recognized as safe for use in explosive gas atmospheres by a national or other appropriate authority.

11.5.2 Open Area Near Ventilation Openings

In the areas on open deck within 1 m (3.3 ft) of the ventilation inlet or within 1 m (3.3 ft) (if natural) or 3 m (10 ft) (if mechanical) of the exhaust outlet, electrical equipment and cables, where permitted by 4-6-3/11.1.1, are to be in accordance with 4-6-3/11.1.2, 4-6-3/11.1.3 and 4-6-3/11.3.1.

11.5.3 Enclosed Access Spaces

The enclosed spaces giving access to the paint store may be considered as nonhazardous, provided that:

- i) The door to the paint store is gastight with self-closing devices without holding back arrangements,
- ii) The paint store is provided with an acceptable, independent, natural ventilation system ventilated from a safe area, and
- iii) Warning notices are fitted adjacent to the paint store entrance stating that the store contains flammable liquids.

11.7 Non-sparking Fans

11.7.1 Design Criteria

11.7.1(a) Air Gap. The air gap between the impeller and the casing is to be not less than 10% of the shaft diameter in way of the impeller bearing, but not less than 2 mm (0.08 in.). It need not be more than 13 mm (0.5 in.).

11.7.1(b) Protection Screen. Protection screens of not more than 13 mm (0.5 in.) square mesh are to be fitted in the inlet and outlet of ventilation openings on the open deck to prevent the entrance of an object into the fan casing.

11.7.2 Materials

11.7.2(a) Impeller and its Housing. Except as indicated in 4-6-3/11.7.2(c) below, the impeller and the housing in way of the impeller are to be made of alloys which are recognized as being spark proof by appropriate test.

11.7.2(b) Electrostatic Charges. Electrostatic charges both in the rotating body and the casing are to be prevented by the use of antistatic materials. Furthermore, the installation on board of the ventilation units is to be such as to ensure the safe bonding to the hull of the units themselves.

11.7.2(c) Acceptable Combination of Materials. Tests referred to in 4-6-3/11.7.2(a) above are not required for fans having the following combinations:

- i) Impellers and/or housings of nonmetallic material, due regard being paid to the elimination of static electricity;
- ii) Impellers and housings of non-ferrous materials;
- iii) Impellers of aluminum alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller;
- iv) Any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm (0.5 in.) Tip design clearance.

11.7.2(d) Unacceptable Combination of Materials. The following impellers and housings are considered as sparking-producing and are not permitted:

- i) Impellers of an aluminum alloy or magnesium alloy and a ferrous housing, regardless of tip clearance;
- ii) Housing made of an aluminum alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance;
- iii) Any combination of ferrous impeller and housing with less than 13 mm (0.5 in.) design tip clearance.

11.7.3 Type Test (2007)

Type tests on the finished product are to be carried out using an acceptable national or international standard. Such type test reports are to be made available when requested by the Surveyor.

TABLE 1
Minimum Degree of Protection [See 4-6-3/3.1.1] (2014)
(For high voltage equipment, see 4-6-5/Table 1)

Example of Location	Condition of Location	Switchboards, Distribution Boards, Motor Control Centers & Controllers (See 4-6-3/3.9 to 4-6-3/3.13)						
		Generators (See 4-6-3/3.3)						
		Motors (See 4-6-3/3.5)						
		Transformers, Converters						
		Lighting Fixtures (See 4-6-3/3.17)					Heating Appliances (See 4-6-3/3.19)	
		Accessories ⁽³⁾						
Dry accommodation space	Danger of touching live parts only	IP20	-	IP20	IP20	IP20	IP20	IP20
Dry control rooms ⁽⁴⁾ (1999)		IP20	-	IP20	IP20	IP20	IP20	IP20
Control rooms (1999)	Danger of dripping liquid and/or moderate mechanical damage	IP22	-	IP22	IP22	IP22	IP22	IP22
Machinery spaces above floor plates ⁽⁵⁾		IP22	IP22	IP22	IP22	IP22	IP22	IP44
Steering gear rooms		IP22	IP22	IP22	IP22	IP22	IP22	IP44
Refrigerating machinery rooms		IP22	-	IP22	IP22	IP22	IP22	IP44
Emergency machinery rooms		IP22	IP22	IP22	IP22	IP22	IP22	IP44
General store rooms		IP22	-	IP22	IP22	IP22	IP22	IP22
Pantries		IP22	-	IP22	IP22	IP22	IP22	IP44
Provision rooms		IP22	-	IP22	IP22	IP22	IP22	IP22
Bathrooms and Showers	Increased danger of liquid and/or mechanical damage	-	-	-	-	IP34	IP44	IP55
Machinery spaces below floor plates		-	-	IP44	-	IP34	IP44	IP55 ⁽²⁾
Closed fuel oil or lubricating oil separator rooms		IP44	-	IP44	-	IP34	IP44	IP55 ⁽²⁾
Ballast pump rooms	Increased danger of liquid and mechanical damage	IP44	-	IP44	IP44	IP34	IP44	IP55
Refrigerated rooms		-	-	IP44	-	IP34	IP44	IP55
Galleys and Laundries		IP44	-	IP44	IP44	IP34	IP44	IP44 ⁽⁶⁾
Shaft or pipe tunnels in double bottom	Danger of liquid spray presence of cargo dust, serious mechanical damage, and/or aggressive fumes	IP55	-	IP55	IP55	IP55	IP55	IP56
Holds for general cargo		-	-	-	-	IP55	-	IP55
Open decks	Exposure to heavy seas	IP56	-	IP56	-	IP55	IP56	IP56
Bilge wells	Exposure to submersion	-	-	-	-	IPX8	-	IPX8

Notes

- Empty spaces shown with “-“ indicate installation of electrical equipment is not recommended.
- Socket outlets are not to be installed in machinery spaces below the floor plates, enclosed fuel and lubricating oil separator rooms or spaces requiring certified safe equipment.
- “Accessories” include switches, detectors, junction boxes, etc. Accessories which are acceptable for use in hazardous areas are limited by the condition of the areas. Specific requirements are given in the Rules. See 4-6-3/3.23.
- (1999) For the purpose of this Table, the wheelhouse may be categorized as a “dry control room” and consequently, the installation of IP20 equipment would suffice therein, provided that: (a) the equipment is located as to preclude being exposed to steam or dripping/spraying liquids emanating from pipe flanges, valves, ventilation ducts and outlets, etc., installed in its vicinity, and (b) the equipment is placed to preclude the possibility of being exposed to sea or rain.
- (2006) See 4-6-3/3.1.1(b) where the equipment is located within areas protected by local fixed pressure water-spraying or water-mist fire extinguishing system and its adjacent areas.
- (2014) Socket outlets in galleys and laundries are to maintain their protection against splashed water when not in use.

TABLE 2
Minimum Bending Radii of Cables [See 4-6-3/5.9.2] (1999)

Cable Construction		Overall Diameter, <i>D</i>	Minimum Internal Bending Radius
Insulation	Outer Covering		
Thermoplastic or thermosetting with circular copper conductor	Unarmored or unbraided	$D \leq 25 \text{ mm (1 in.)}$	$4 D$
		$D > 25 \text{ mm}$	$6 D$
	Metal braid screened or armored	Any	$6 D$
	Metal wire or metal-tape armored or metal-sheathed	Any	$6 D$
	Composite polyester/metal laminate tape screened units or collective tape screening	Any	$8 D$
Thermoplastic or thermosetting with shaped copper conductor	Any	Any	$8 D$
Mineral	Hard metal-sheathed	Any	$6 D$

TABLE 3
Size of Earth-continuity Conductors and Earthing Connections [See 4-6-3/7.5] (2003)

Type of Earthing Connection		Cross-sectional Area, <i>A</i> , of Associated Current Carrying Conductor	Minimum Cross-sectional Area of Copper Earthing Connection
Earth-continuity conductor in flexible cable or flexible cord	A1	$A \leq 16 \text{ mm}^2$	A
	A2	$16 \text{ mm}^2 < A \leq 32 \text{ mm}^2$	16 mm^2
	A3	$A > 32 \text{ mm}^2$	$A/2$
Earth-continuity conductor incorporated in fixed cable	For cables having an insulated earth-continuity conductor		
	B1a	$A \leq 1.5 \text{ mm}^2$	1.5 mm^2
	B1b	$1.5 \text{ mm}^2 < A \leq 16 \text{ mm}^2$	A
	B1c	$16 \text{ mm}^2 < A \leq 32 \text{ mm}^2$	16 mm^2
	B1d	$A > 32 \text{ mm}^2$	$A/2$
	For cables with bare earth wire in direct contact with the lead sheath		
	B2a	$A \leq 2.5 \text{ mm}^2$	1 mm^2
B2b	$2.5 \text{ mm}^2 < A \leq 6 \text{ mm}^2$	1.5 mm^2	
Separate fixed earthing conductor	C1a	$A \leq 3 \text{ mm}^2$	Stranded earthing connection: 1.5 mm^2 for $A \leq 1.5 \text{ mm}^2$ A for $A > 1.5 \text{ mm}^2$
	C1b		Unstranded earthing connection: 3 mm^2
	C2	$3 \text{ mm}^2 < A \leq 6 \text{ mm}^2$	3 mm^2
	C3	$6 \text{ mm}^2 < A \leq 125 \text{ mm}^2$	$A/2$
	C4	$A > 125 \text{ mm}^2$	64 mm^2 (see Note 1)

Notes:

- (2003) For earthed distribution systems, the size of earthing conductor is not to be less than $A/2$.
- Conversion Table for mm^2 to circular mils:

mm^2	circ. mils	mm^2	circ. mils	mm^2	circ. mils	mm^2	circ. mils
1	1,973	2.5	4,933	6	11,841	70	138,147
1.5	2,960	4	7,894	16	31,576	120	236,823

PART

4

CHAPTER 6 Electrical Installations

SECTION 4 Machinery and Equipment

1 Plans and Data to Be Submitted (2010)

1.1 Rotating Machines of 100 kW and Over

For rotating machines of 100 kW and over intended for essential services (primary and secondary) or for services indicated in 4-6-4/Table 11, drawings showing the following particulars are to be submitted: assembly, seating arrangements, terminal arrangements, shafts, coupling, coupling bolts, stator and rotor details together with data for complete rating, class of insulation, designed ambient temperature, temperature rise, degree of protection for enclosures, weights and speeds for rotating parts. Plans to be submitted for generator prime movers are given in 4-2-3/1.5, 4-2-4/1.5 and 4-2-1/1.9 of the *Steel Vessel Rules*.

1.3 Switchboards, Distribution Boards, Controllers, etc.

For switchboards, distribution boards, battery charger units, uninterruptible power system (UPS) units, motor control centers, and motor controllers intended for essential services (primary and secondary) or for services indicated in 4-6-4/Table 11, drawings showing arrangements and details, front view, and installation arrangements are to be submitted for review together with data for protective device rating and setting, type of internal wiring, and size and rated current carrying capacity (together with short-circuit current data) of bus bars and internal wiring for power circuit. In addition, a schematic or logic diagram with a written description giving the sequence of events and system operating procedures for electrical power supply management on switchboards and sequential or automatic change-over of the motors are also to be submitted for review.

3 Rotating Machines

3.1 General

3.1.1 Applications (2010)

All rotating electrical machines of 100 kW and over intended for essential services (see 4-6-1/3.7) or for services indicated in 4-6-4/Table 11 are to be designed, constructed and tested in accordance with the requirements of 4-6-4/3.

All other rotating electrical machines are to be designed, constructed, and tested in accordance with established industrial practices and manufacturer's specifications. Manufacturer's tests for rotating electric machines less than 100 kW for essential services or for services indicated in 4-6-4/Table 11 are to include at least the tests described in 4-6-4/3.3.1(b), regardless of the standard of construction. The test certificates are to be made available when requested by the Surveyor. Acceptance of machines will be based on satisfactory performance test after installation.

3.1.2 Certification on Basis of an Approved Quality Assurance Program

See 4-1-1/3.

3.1.3 References

- 3.1.3(a) *Inclination.* For the requirements covering inclination for design condition, see 4-1-1/17.
- 3.1.3(b) *Insulation Material.* For the requirements covering insulation material, see 4-6-1/13.
- 3.1.3(c) *Capacity of Generators.* For requirements covering main generator capacity, see 4-6-2/3.1.2 and 4-6-2/3.5. For requirements covering emergency generator capacity, see 4-6-2/5.3.1.
- 3.1.3(d) *Power Supply by Generators.* For requirements covering power supply by main or emergency generator, see 4-6-2/3.1.2 and 4-6-2/5.5.2, respectively.
- 3.1.3(e) *Protection for Generator Circuits.* For requirements covering protection for generator, see 4-6-2/9.3, 4-6-2/9.5 and 4-6-2/9.7.
- 3.1.3(f) *Protection for Motor Circuits.* For requirements covering protection for motor branch circuit, see 4-6-2/9.13.
- 3.1.3(g) *Installation.* For requirements covering installation, see 4-6-3/3.3 for generators and 4-6-3/3.5 for motors.
- 3.1.3(h) *Protection Enclosures and its Selection.* For requirements covering degree of the protection and the selection of equipment, see 4-6-1/15 and 4-6-3/3.1, respectively.

3.3 Testing and Inspection

3.3.1 Applications (2010)

3.3.1(a) *Machines of 100 kW and Over.* All rotating machines of 100 kW and over intended for essential services (see 4-6-1/3.7) or for services indicated in 4-6-4/Table 11 are to be tested in accordance with 4-6-4/Table 1 in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer.

3.3.1(b) *Machines Below 100 kW.* All rotating machines of less than 100 kW intended for essential services or for services indicated in 4-6-4/Table 11 are to be tested in accordance with 4-6-4/Table 1 (item 2 through item 10 and item 12). The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

3.3.1(c) *Other Machines.* For machines not intended for essential services or for services indicated in 4-6-4/Table 11, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

3.3.2 Special Testing Arrangements

In cases where all of the required tests are not carried out at the plant of the manufacturer, the Surveyor is to be notified and arrangements are to be made so that the remaining tests will be witnessed.

3.5 Insulation Resistance Measurement

The resistance is to be measured before the commencement of the testing and after completion of the testing for all circuits. Circuits or groups of circuits of different voltages above earth are to be tested separately. This test is to be made with at least 500 volts DC and the insulation resistance in megohms of the circuits while at their operating temperatures is to be normally at least equal to:

$$\frac{\text{Rated Voltage of the Machine}}{(\text{Rating in kVA}/100) + 1000}$$

The minimum insulation resistance of the fields of machines separately excited with voltage less than the rated voltage of the machine is to be on the order of one-half to one megohm.

3.7 Overload and Overcurrent Capability

3.7.1 AC Generators (2003)

AC generators are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 30 seconds. The test may be performed in conjunction with the short circuit testing, provided the electrical input energy to the machine is not less than that required for the above overload capability.

3.7.2 AC Motors

3.7.2(a) Overcurrent Capacity (2003). Three phase motors, except for commutator motors, having rated outputs not exceeding 315 kW and rated voltages not exceeding 1 kV are to be capable of withstanding a current equal to 1.5 times the rated current for not less than two minutes. For three-phase and single phase motors having rated outputs above 315 kW, the overcurrent capacity is to be in accordance with the manufacturer's specification. The test may be performed at a reduced speed.

3.7.2(b) Overload Capacity. Three-phase induction motors are to be capable of withstanding for 15 seconds, without stalling or abrupt change in speed, an excess torque of 60% of their rated torque, the voltage and frequency being maintained at their rated values.

3.7.2(c) Overload Capacity for Synchronous Motors. Three phase synchronous motors are to be capable of withstanding an excess torque, as specified below, for 15 seconds without falling out of synchronism, the excitation being maintained at the value corresponding to the rated load.

Synchronous (wound rotor) induction motors:	35% excess torque
Synchronous (cylindrical rotor) motors:	35% excess torque
Synchronous (salient pole) motors:	50% excess torque

When automatic excitation is used, the limit of torque values is to be the same as with the excitation equipment operating under normal conditions.

3.9 Dielectric Strength of Insulation

3.9.1 Application

The dielectric test voltage is to be successively applied between each electric circuit and all other electric circuits and metal parts earthed, and for direct-current (DC) rotating machines between brush rings of opposite polarity. Interconnected polyphase windings are to be considered as one circuit. All windings except that under test are to be connected to earth.

3.9.2 Standard Voltage Test (2003)

The insulation of all rotating machines is to be tested with the parts completely assembled and not with the individual parts. The dielectric strength of the insulation is to be tested by the continuous application for 60 seconds of an alternating voltage having a frequency of 25 to 60 Hz and voltage in 4-6-4/Table 2. The requirements in 4-6-4/Table 2 apply to those machines other than high voltage systems covered by 4-6-5/1.11.1(e).

3.9.3 Direct Current Test

A standard voltage test using a direct current source equal to 1.7 times the required alternating-current voltage will be acceptable.

3.11 Temperature Ratings

3.11.1 Temperature Rises

3.11.1(a) Continuous Rating Machines. After the machine has been run continuously under a rated load until steady temperature condition has been reached, the temperature rises are not to exceed those given in 4-6-4/Table 3.

3.11.1(b) Short-time Rating Machines. After the machine has been run at a rated load during the rated time followed by a rest and a de-energized period of sufficient duration to re-establish the machine temperatures within 2°C (3.6°F) of the coolant, the temperature rises are not to exceed those given in 4-6-4/Table 3. At the beginning of the temperature measurement, the temperature of the machine is to be within 5°C (8°F) of the temperature of the coolant.

3.11.1(c) Periodic Duty Rating Machines. The machine has been run at a rated load for the designed load cycle to be applied and continued until obtaining the practically identical temperature cycle. At the middle of the period causing the greatest heating in the last cycle of the operation, the temperature rises are not to exceed those given in 4-6-4/Table 3.

3.11.1(d) Non-periodic Duty Rating Machines. After the machine has been run continuously or intermittently under the designed variations of the load and speed within the permissible operating range until reaching the steady temperature condition, the temperature rises are not to exceed those given in 4-6-4/Table 3.

3.11.1(e) Insulation Material Above 180°C (356°F). Temperature rises for insulation materials above 180°C (356°F) will be considered in accordance with 4-6-1/13.11.

3.11.2 Ambient Temperature (2007)

These final temperatures are based on an ambient temperature of 50°C (122°F), for machines located within boiler and engine rooms in accordance with 4-6-1/17. Where provision is made for ensuring the ambient temperature of the space is being maintained at 40°C (104°F) or less, as by air cooling or by locating the machine outside of the boiler and engine rooms, the temperature rises of the windings may be 5°C (9°F) higher. The ambient temperature is to be taken in at least two places within 1.83 m (6 ft) of the machine under test and by thermometers having their bulbs immersed in oil contained in an open cup.

3.13 Construction and Assemblies

3.13.1 Enclosure, Frame and Pedestals

Magnet frames and pedestals may be separate but are to be secured to a common foundation.

3.13.2 Shafts and Couplings (2006)

3.13.2(a) Rotors of non-integrated auxiliary machinery. The design of the following specified rotating shafts and components, when not integral with the propulsion shafting, are to comply with the following:

- Rotor shaft: 4-2-4/5.3.1* and 4-2-4/5.3.2*
- Hollow shaft: 4-3-1/7.3
- Key: 4-3-1/9 and 4-2-4/5.3.2*
- Coupling flanges and bolts: 4-2-1/17 and 4-3-1/19

* Note: Rules for Building and Classing Steel Vessels

3.13.2(b) Rotors of integrated auxiliary machinery (2012). Shaft motors and shaft generators, which are an integral part of the line shafting, shall be evaluated for maximum combined load (steady and dynamic torque and bending) acting within operating range of installation. Accordingly, the shaft diameter design criteria per 4-2-4/5.3.1 and 4-2-4/5.3.2 of the *Steel Vessel Rules* is to be evaluated for maximum torsional moment acting within the operating speeds, instead of torsional moment T at rated speed.

The shaft diameter of the motors and generators, that are an integral part of the line shafting, may also be designed per 4-3-1/7 and are to be evaluated based on engineering analyses.

3.13.3 Circulating Currents

Means are to be provided to prevent circulating currents from passing between the journals and the bearings, where the design and arrangement of the machine is such that damaging current may be expected. Where such protection is required, a warning plate is to be provided in a visible place cautioning against the removal of such protection.

3.13.4 Rotating Exciters

Rotating exciters are to conform to all applicable requirements for generators.

3.13.5 Insulation of Windings

Armature and field coils are to be treated to resist oil and water.

3.13.6 Protection Against Cooling Water

Where water cooling is used, the cooler is to be so arranged as to avoid entry of water into the machine, whether through leakage or from condensation in the heat exchanger.

3.13.7 Moisture Condensation Prevention (2014)

All generators, and each motor rated 50 kW and over, are to be provided with a means to prevent moisture condensation in the machine when idle.

Where steam-heating coils are installed for this purpose, there are to be no pipe joints inside of the casings. See item 7 in 4-6-4/Table 7 for space heater pilot lamp for alternating-current generators.

3.13.8 Terminal Arrangements

Terminals are to be provided at an accessible position and protected against mechanical damage and accidental contact for earthing, short-circuit or touching. Terminal leads are to be secured to the frame and the designation of each terminal lead are to be clearly marked. The ends of terminal leads are to be fitted with connectors. Cable glands or similar are to be provided where cable penetrations may compromise the protection property of terminal enclosures.

3.13.9 Nameplates

Nameplates of corrosion-resistant material are to be provided in an accessible position of the machine and are to indicate at least the information as listed in 4-6-4/Table 4a.

3.15 Lubrication

Rotating machines are to have continuous lubrication at all running speeds and all normal working bearing temperatures, with the vessel's inclinations specified in 4-1-1/17. Unless otherwise approved, where forced lubrication is employed, the machines are to be provided with means to shut down their prime movers automatically upon failure of the lubricating system. Each self-lubricating sleeve bearing is to be fitted with an inspection lid and means for visual indication of oil level or an oil gauge.

3.17 Turbines for Generators

Gas-turbine prime movers driving generators are to meet the applicable requirements in Section 4-2-3 of the *Steel Vessel Rules* and, in addition, are to comply with the following requirements.

3.17.1 Operating Governor (2004)

An effective operating governor is to be fitted on prime movers driving main or emergency electric generators and is to be capable of automatically maintaining the speed within the following limits. Special consideration will be given when an installation requires different characteristics.

3.17.1(a) Transient Frequency Variations. The transient frequency variations in the electrical network, when running at the indicated loads below, are to be within $\pm 10\%$ of the rated frequency when:

- i) Running at full load (equal to rated output) of the generator and the maximum electrical step load is suddenly thrown off,

In the case when a step load equivalent to the rated output of a generator is thrown off, a transient frequency variation in excess of 10% of the rated frequency may be acceptable, provided the overspeed protective device, fitted in addition to the governor, as required by 4-6-4/3.17.2, is not activated.

- ii) Running at no load and 50% of the full load of the generator is suddenly thrown on followed by the remaining 50% load after an interval sufficient to restore the frequency to steady state.

In all instances, the frequency is to return to within $\pm 1\%$ of the final steady state condition in no more than five seconds.

3.17.1(b) Frequency Variations in Steady State. The permanent frequency variation is to be within $\pm 5\%$ of the rated frequency at any load between no load and full load.

3.17.1(c) Emergency Generator Prime Movers. For gas turbines driving emergency generators, the requirements of 4-6-4/3.17.1(a) and 4-6-4/3.17.1(b) are to be met. However, for the purpose of 4-6-4/3.17.1(a)ii), where the sum of all loads that can be automatically connected is larger than 50% of the full load of the emergency generator, the sum of these loads is to be used as the first applied load.

3.17.2 Overspeed Governor

In addition to the normal operating governor, an overspeed governor is to be fitted which will trip the turbine throttle when the rated speed is exceeded by more than 15%. Provision is to be made for hand tripping. See 4-6-4/3.15 for pressure-lubricated machines.

3.17.3 Power Output of Gas Turbines

To satisfy the requirements of 4-6-2/3.1, the required power output of gas turbine prime movers for ship's service generator sets is to be based on the maximum expected inlet air temperature.

3.19 Diesel Engines for Generators

Diesel-engine prime movers are to meet the applicable requirements in Part 4, Chapter 2 and, in addition, are to comply with the following requirements.

3.19.1 Operating Governor (2004)

An effective operating governor is to be fitted on prime movers driving main or emergency electric generators and is to be capable of automatically maintaining the speed within the following limits. Special consideration will be given when an installation requires different characteristics.

3.19.1(a) Transient Frequency Variations (2007). The transient frequency variations in the electrical network, when running at the indicated loads below, are to be within $\pm 10\%$ of the rated frequency with a recovery time within $\pm 1\%$ of the final steady state condition in not more than 5 seconds when:

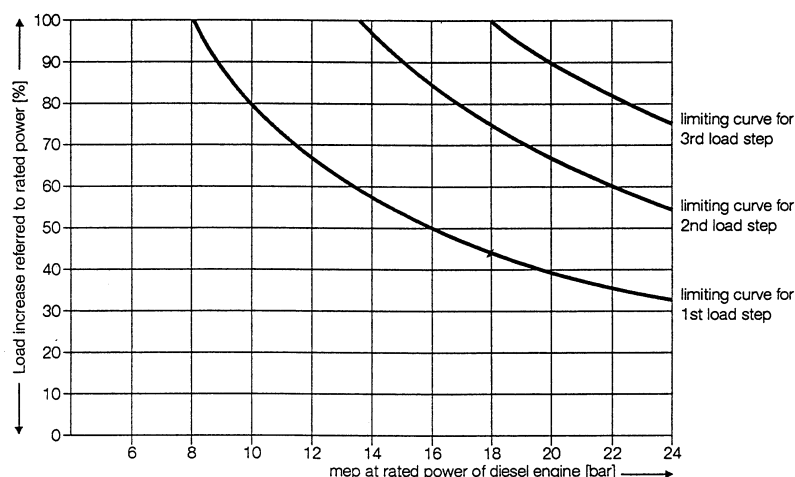
- i) Running at full load (equal to rated output) of the generator and the maximum electrical step load is suddenly thrown off,

In the case when a step load equivalent to the rated output of a generator is thrown off, a transient frequency variation in excess of 10% of the rated frequency may be acceptable, provided the overspeed protective device, fitted in addition to the governor, as required by 4-6-4/3.19.2, is not activated.

- ii) Running at no load and 50% of the full load of the generator is suddenly thrown on followed by the remaining 50% load after an interval sufficient to restore the frequency to steady state.

3.19.1(b) Power Management System. Where the electrical power system is fitted with a power management system and sequential starting arrangements, the application of loads in multiple steps of less than 50% of rated load in 4-6-4/3.19.1(a)ii) above may be permitted, provided it is in accordance with 4-6-4/Figure 1. The details of the power management system and sequential starting arrangements are to be submitted and its satisfactory operation is to be demonstrated to the Surveyor.

FIGURE 1
Limiting Curves for Loading 4-stroke Diesel Engines
Step by Step from No-load to Rated Power as Function
of the Brake Mean Effective Pressure (1998)



3.19.1(c) *Frequency Variations in Steady State.* The permanent frequency variation is to be within $\pm 5\%$ of the rated frequency at all loads between no load and full load.

3.19.1(d) *Emergency Generator Prime Movers (2007).* For prime movers driving emergency generators, the requirements of 4-6-4/3.19.1(a)i) and 4-6-4/3.19.1(c) above are to be met even when:

- i) Their total consumer load is applied suddenly, or
- ii) Their total consumer load is applied in steps, subject to:
 - The total load is supplied within 45 seconds since power failure on the main switchboard
 - The maximum step load is declared and demonstrated
 - The power distribution system is designed such that the declared maximum step loading is not exceeded
 - The compliance of time delays and loading sequence with the above is to be demonstrated at ship's trials.

3.19.2 Overspeed Governor

In addition to the normal operating governor, each auxiliary diesel engine having a maximum continuous output of 220 kW and over is to be fitted with a separate overspeed device so adjusted that the speed cannot exceed the maximum rated speed by more than 15%. Provision is to be made for hand tripping. See 4-6-4/3.15 for pressure-lubricated machines.

3.21 Alternating-current (AC) Generators

3.21.1 Control and Excitation of Generators

Excitation current for generators is to be provided by attached rotating exciters or by static exciters deriving their source of power from the machine being excited.

3.21.2 Voltage Regulation (2007)

3.21.2(a) *Voltage Regulators.* A separate regulator is to be supplied for each AC generator. When it is intended that two or more generators will be operated in parallel, reactive-droop compensating means are to be provided to divide the reactive power properly between the generators.

3.21.2(b) *Variation from Rated Voltage – Steady Conditions.* Each AC generator for ship's service driven by its prime mover having governor characteristics complying with 4-6-4/3.17.1 or 4-6-4/3.19.1 is to be provided with an excitation system capable of maintaining the voltage under steady conditions within plus or minus 2.5% of the rated voltage for all loads between zero and rated load at rated power factor. These limits may be increased to plus or minus 3.5% for emergency sets.

3.21.2(c) *Variation from Rated Voltage – Transient Conditions (2017).* Momentary voltage variations are to be within the range of minus 15% to plus 20% of the rated voltage, and the voltage is to be restored to within plus or minus 3% of the rated voltage in not more than 1.5 seconds when:

- A load equal to the starting current of the largest motor or a group of motors, but in any case, at least 60% of the rated current of the generator, and power factor of 0.4 lagging or less, is suddenly thrown on with the generator running at no load; and
- A load equal to the above is suddenly thrown off.

Subject to ABS approval, such voltage regulation during transient conditions may be calculated values based on the previous type test records, and need not to be tested during factory testing of a generator.

Consideration can be given to performing the test required by 4-6-4/Table 1, Item 4 according to precise information concerning the maximum values of the sudden loads instead of the values indicated above, provided precise information is available. The precise information concerning the maximum values of the sudden loads is to be based on the power management system arrangements and starting arrangements provided for the electrical system.

3.21.2(d) *Short Circuit Conditions (2017).* Under steady-state short-circuit conditions, the generator together with its excitation system is to be capable of maintaining a steady-state short-circuit current of not less than three times its rated full load current for a period of two seconds or of such magnitude and duration as required to properly actuate the associated electrical protective devices. In order to provide sufficient information for determining the discrimination settings in the distribution system where the generator is going to be used, the generator manufacturer is to provide documentation showing the transient behavior of the short circuit current upon a sudden short-circuit occurring when excited, and running at nominal speed. The influence of the automatic voltage regulator is to be taken into account, and the setting parameters for the voltage regulator are to be noted together with the decrement curve. Such a decrement curve is to be available when the setting of the distribution system's short-circuit protection is calculated. The decrement curve need not be based on physical testing. The manufacturer's simulation model for the generator and the voltage regulator may be used where this has been validated through the previous type test on the same model.

3.21.3 Parallel Operation

For AC generating sets operating in parallel, the following requirements are to be complied with. See also 4-6-2/9.5.2 for protection of AC generators in parallel operation.

3.21.3(a) *Reactive Load Sharing.* The reactive loads of the individual generating sets are not to differ from their proportionate share of the combined reactive load by more than 10% of the rated reactive output of the largest generator, or 25% of the rated reactive output of the smallest generator, whichever is the less.

3.21.3(b) *Load Sharing.* For any load between 20% and 100% of the sum of the rated output (aggregate output) of all generators, the load on any generator is not to differ more than 15% of the rated output in kilowatt of the largest generator or 25% of the rated output in kilowatt of the individual generator in question, whichever is the less, from its proportionate share of the combined load for any steady state condition. The starting point for the determination of the foregoing load-distribution requirements is to be at 75% of the aggregate output with each generator carrying its proportionate share.

3.21.3(c) *Facilities for Load Adjustment.* Facilities are to be provided to adjust the governor sufficiently fine to permit an adjustment of load not exceeding 5% of the aggregate output at normal frequency.

3.23 Direct-current (DC) Generators

3.23.1 Control and Excitation of Generators

3.23.1(a) *Field Regulations.* Means are to be provided at the switchboard to enable the voltage of each generator to be adjusted separately. This equipment is to be capable of adjusting the voltage of the DC generator to within 0.5% of the rated voltage at all loads between no-load and full-load.

3.23.1(b) *Polarity of Series Windings.* The series windings of each generator for a two wire DC system are to be connected to the negative terminal of each machine.

3.23.1(c) *Equalizer Connections.* See 4-6-4/7.15.3.

3.23.2 Voltage Regulation

3.23.2(a) *Shunt or Stabilized Shunt-wound Generator.* When the voltage has been set at full-load to its rated value, the removal of the load is not to cause a permanent increase of the voltage greater than 15% of the rated voltage. When the voltage has been set either at full-load or at no-load, the voltage obtained at any value of the load is not to exceed the no-load voltage.

3.23.2(b) *Compound-wound Generator.* Compound-wound generators are to be so designed in relation to the governing characteristics of the prime mover that with the generator at full-load operating temperature and starting at 20% load with voltage within 1% of rated voltage, it gives at full-load a voltage within 1.5% of rated voltage. The average of ascending and descending voltage regulation curves between 20% load and full-load is not to vary more than 3% from rated voltage.

3.23.2(c) *Automatic Voltage Regulators.* Ship's service generators which are of a shunt type are to be provided with automatic voltage regulators. However, if the load fluctuation does not interfere with the operation of essential auxiliaries, shunt-wound generators without voltage regulators or stabilized shunt-wound machines may be used. An automatic voltage regulator will not be required for the ship's service generators of an approximately flat-compounded type. Automatic voltage regulators are to be provided for all service generators driven by variable speed engines used also for propulsion purposes, whether these generators are of the shunt, stabilized shunt or compound-wound type.

3.23.3 Parallel Operation

For DC generating sets operating in parallel, the following requirements are to be complied with. See also 4-6-2/9.7.2 for protection of DC generators in parallel operation.

3.23.3(a) *Stability.* The generating sets are to be stable in operation at all loads from no-load to full-load.

3.23.3(b) *Load Sharing.* For any load between 20% and 100% of the sum of the rated output (aggregate output) of all generators, the load on any generator is not to differ more than 12% from the rated output in kilowatts of the largest generator or 25% from the rated output in kilowatts of the individual generator in question, whichever is the less, from its proportionate share of the combined load for any steady state condition. The starting point for the determination of the foregoing load-distribution requirements is to be at 75% of the aggregate output with each generator carrying its proportionate share.

3.23.3(c) *Tripping of Circuit Breaker.* DC generators which operate in parallel are to be provided with a switch which will trip the generator circuit breaker upon functioning of the overspeed device.

5 Accumulator Batteries

5.1 General

5.1.1 Application

All accumulator batteries for engine starting, essential or emergency services are to be constructed and installed in accordance with the following requirements. Accumulator batteries for services other than the above are to be constructed and equipped in accordance with good commercial practice. All accumulator batteries will be accepted subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

5.1.2 Sealed Type Batteries

Where arrangements are made for releasing gas through a relief valve following an overcharge condition, calculations demonstrating compliance with the criteria in 4-6-3/3.7.3 under the expected rate of hydrogen generation are to be submitted together with the details of installation and mechanical ventilation arrangements.

5.1.3 References

5.1.3(a) Emergency Services. For requirements covering emergency services and transitional source of power, see 4-6-2/5.5.3 and 4-6-2/5.7, respectively.

5.1.3(b) Protection of Batteries. For requirements covering protection of batteries, see 4-6-2/5.9.

5.1.3(c) Battery Installation. For requirements covering battery installation, ventilation of the battery location and protection from corrosion, see 4-6-3/3.7.

5.1.3(d) Cable Installation. For requirements covering cable installation in the battery room, see 4-6-3/5.23.

5.3 Construction and Assembly

5.3.1 Cells and Filling Plugs

The cells are to be so constructed as to prevent spilling of electrolyte due to an inclination of 40 deg. from normal. The filling plugs are to be so constructed as to prevent spilling of electrolyte due to the vessel's movements such as rolling and pitching.

5.3.2 Crates and Trays

The cells are to be grouped in crates or trays of rigid construction equipped with handles to facilitate handling. For protection from corrosion, see 4-6-3/3.7.4. The mass of crates or trays are not to exceed 100 kg (220.5 lb).

5.3.3 Nameplate

Nameplates of corrosion-resistant material are to be provided in an accessible position of each crate or tray and are to indicate at least the information as listed in 4-6-4/Table 4b.

5.5 Engine-starting Battery

Battery systems for engine-starting purposes may be of the one-wire type and the earth lead is to be carried to the engine frame. See also 4-2-1/13.9 and 4-6-2/5.15 for main engine starting and the starting arrangement of the emergency generator, respectively.

7 Switchboards, Distribution Boards, Controllers, etc.

7.1 General

7.1.1 Applications (2010)

Switchboards are to provide adequate control of the generation and distribution of electric power. The following equipment are to be constructed and tested in accordance with the following requirements to the satisfaction of the Surveyor.

7.1.1(a) Switchboards. Switchboards for essential services or for services indicated in 4-6-4/Table 11.

7.1.1(b) Motor Controllers. Motor Controllers of 100 kW and over intended for essential services or for services indicated in 4-6-4/Table 11.

7.1.1(c) Motor Control Centers. Motor control centers with aggregate loads of 100 kW or more intended for essential services or for services indicated in 4-6-4/Table 11.

7.1.1(d) Battery Charger Units and Uninterruptible Power System (UPS) Units. Battery charger units of 25 kW and over and uninterruptible power system (UPS) units of 50 kVA intended for essential services, services indicated in 4-6-4/Table 11, emergency source of power or transitional source of power.

7.1.1(e) *Distribution Boards*. Distribution boards associated with the charging or discharging of the battery system or uninterruptible power system (UPS) in 4-6-4/7.1.1(d).

Switchboard, distribution board, battery charger units, uninterruptible power system (UPS) units, motor control centers and motor controllers not covered by the above paragraph are to be constructed and equipped in accordance with good commercial practice, and will be accepted subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

7.1.2 References

7.1.2(a) *Inclination*. For requirements covering inclination for design condition, see 4-1-1/17.

7.1.2(b) *Emergency Switchboard*. For requirements covering emergency switchboard, see 4-6-3/5.9.

7.1.2(c) *Circuit Breakers*. For requirements covering generator circuit breakers, see 4-6-4/11.1.

7.1.2(d) *Feeder Protection*. For requirements covering feeder protection, see 4-6-2/9.3 to 4-6-2/9.17, 4-6-2/11.3, 4-6-2/13.1.4 and 4-6-2/13.3.3

7.1.2(e) *Hull Return and Earthed Distribution System*. For requirements covering hull return system and earthed distribution system, see 4-6-2/7.3 and 4-6-2/7.5, respectively

7.1.2(f) *Earthing*. For requirements covering earthing connections, see 4-6-3/7.

7.1.2(g) *Installation*. For requirements covering installation, see 4-6-3/3.9 for switchboard, 4-6-3/3.11 for distribution boards and 4-6-3/3.13 for motor controllers and control centers.

7.1.2(h) *Protection Enclosures and its Selection*. For requirements covering degree of the protection and the selection of equipment, see 4-6-1/15 and 4-6-3/3.1, respectively.

7.3 Testing and Inspection

7.3.1 Applications

7.3.1(a) *Switchboards (2010)*. All switchboards intended for essential services or for services indicated in 4-6-4/Table 11, are to be tested in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer. For other switchboards, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

7.3.1(b) *Motor Controllers (2010)*. All motor controllers of 100 kW and over intended for essential services or for services indicated in 4-6-4/Table 11 are to be tested in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer. For other motor controllers, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

7.3.1(c) *Motor Control Centers (2010)*. All motor control centers with aggregate loads of 100 kW and over intended for essential services or for services indicated in 4-6-4/Table 11 are to be tested in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer. For other motor control centers, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

7.3.1(d) *Battery Charger Units, Uninterruptible Power System (UPS) Units, and Distribution Boards (2010)*. Battery charger units of 25 kW and over, uninterruptible power system (UPS) units of 50 kW and over, and distribution boards [associated with the charging or discharging of the battery system or uninterruptible power system (UPS)] are used for essential services (see 4-6-1/3.7), services indicated in 4-6-4/Table 11, emergency source of power (see 4-6-2/5), and transitional source of power (see 4-6-2/5.7) are to be tested in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer. For all other battery charger units, uninterruptible power system (UPS) units, and distribution boards, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

7.3.1(e) *Test Items*. Tests are to be carried out in accordance with the requirements in 4-6-4/Table 5.

7.3.2 Special Testing Arrangements

In cases where all of the required tests are not carried out at the plant of the manufacturer, the Surveyor is to be notified and arrangements are to be made so that the remaining tests may be witnessed.

7.5 Insulation Resistance Measurement

The insulation resistance between current-carrying parts (connected together for the purpose of this test) and earth and between current-carrying parts of opposite polarity is to be measured at a DC voltage of not less than 500 volts before and after the dielectric strength tests. The insulation resistance measurement after the dielectric strength tests is to be carried out before components which have been disconnected for the dielectric tests are reconnected, and the insulation resistance is not to be less than 1 megohm.

7.7 Dielectric Strength of Insulation

The dielectric strength of the insulation is to be tested for 60 seconds by an alternating voltage applied in accordance with 4-6-4/Table 5 between:

- i) All live parts and the interconnected, exposed conductive parts, and
- ii) Each phase and all other phases connected for this test to the interconnected exposed conductive parts of the unit.

The test voltage at the moment of application is not to exceed 50% of the values given in 4-6-4/Table 5. It is to be increased steadily within a few seconds to the required test voltage and maintained for 60 seconds. Test voltage is to have a sinusoidal waveform and a frequency between 45 Hz and 60 Hz.

7.7.1 Production-line Apparatus

Standard apparatus produced in large quantities for which the standard test voltage is 2500 volts or less may be tested for one second with a test voltage 20% higher than the one-minute test voltage.

7.7.2 Devices with Low Insulation Strength

Certain devices such as potential transformers having inherently lower insulation strength are to be disconnected during the test.

7.9 Construction and Assembly

7.9.1 Enclosures and Assemblies

Enclosures and assemblies are to be constructed of steel or other suitable, incombustible, moisture-resistant materials and reinforced as necessary to withstand the mechanical, electrical (magnetic) and thermal stresses likely to be encountered in service, and are to be protected against corrosion. No wood is to be used, except for hardwood for nonconducting hand rails. Insulating materials are to be flame retardant and moisture resistant. The supporting framework is to be of rigid construction.

7.9.2 Dead Front

The dead-front type is to be used. Live-front type is not acceptable, regardless of the voltage ratings.

7.9.3 Mechanical Strength

All levers, handles, hand wheels, interlocks and their connecting links, shafts and bearings for the operation of switches and contactors are to be of such proportions that they will not be broken or distorted by manual operation.

7.9.4 Mechanical Protection (2004)

The sides and the rear and, where necessary, the front of switchboards are to be suitably guarded. Exposed live parts having voltages to earth exceeding a voltage of 55 volts DC or 55 volts AC rms between conductors are not to be installed on the front of such switchboards. Unless the switchboard is installed on an electrically insulated floor, non-conducting mats or gratings are to be provided at the front and rear of the switchboard. Where the floor on which the switchboard is installed is of electrically insulated construction, the insulation level of the floor to the earth is to be at least 50 MΩ. A notice plate is to be posted at the entrance to the switchboard room or on the switchboard front panel to state that the floor in the room is of electrically insulated construction. Drip covers are to be provided over switchboards when subject to damage by leaks or falling objects.

7.11 Bus Bars, Wiring and Contacts

7.11.1 Design

Copper bar is to be used for main and generator bus in the switchboard. Other materials and combination of materials will be specially considered. Generator bus bars are to be designed on the basis of maximum generator rating. All other bus bars and bus-bar connections are to be designed for at least 75% of the combined full-load rated currents of all apparatus that they supply, except that when they supply one unit or any group of units in continuous operation, they are to be designed for full load.

7.11.2 Operating Temperature of Bus Bars

Bus bars are to be proportioned to avoid temperature which will affect the normal operation of electrical devices mounted on the board.

7.11.3 Short Circuit Rating

Circuit breakers and bus bars are to be mounted, braced and located so as to withstand the thermal effects and mechanical forces resulting from the maximum prospective short circuit current. Switchboard instruments, controls, etc. are to be located with respect to circuit breakers so as to minimize the thermal effects due to short circuit currents.

7.11.4 Internal Wiring

Instrument and control wiring is to be of the stranded type and is to have heat-resisting and flame-retarding insulation. Wiring from hinged panels is to be of the extra-flexible type.

7.11.5 Arrangement

7.11.5(a) Accessibility. The arrangement of bus bars and wiring on the back is to be such that all lugs are readily accessible.

7.11.5(b) Locking of Connections (2004). All nuts and connections are to be fitted with locking devices to prevent loosening due to vibration. Bolted bus bar connections are to be suitably treated (e.g., silver plating) to avoid deterioration of electrical conductivity over time.

7.11.5(c) Soldered Connections. Soldered connections are not to be used for connecting or terminating any wire or cable of nominal cross-sectional area of greater than 2.5 mm² (4,933 circ. mils). Soldered connections, where used, are to have a solder contact length at least 1.5 times the diameter of the conductor.

7.11.6 Clearances and Creepage Distances

7.11.6(a) General. Bare main bus bars, but not including the conductors between the main bus bars and the supply side of outgoing units, are to have minimum clearances (in air) and creepage distances (across surfaces) in accordance with 4-6-4/Table 6.

7.11.6(b) Alternative (2014). Alternatively, reduced creepage and clearance distances may be used provided:

- i) The equipment is not installed in 'Machinery Spaces of Category A' or in areas affected by a Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System.
- ii) The minimum clearance distance shall not be less than 8 mm
- iii) The minimum creepage distance shall not be less than 16 mm.
- iv) The equipment complies with IEC 61439-1.
- v) In applying IEC 61439-1, the equipment is considered to be:
 - Of overvoltage Category III,
 - Installed in an environment of pollution degree 3,
 - Having insulating material of type IIIa, and
 - Installed in inhomogeneous field conditions

- vi) The temperature dependent criteria in IEC 61439-1 are derated to meet the ambient temperatures found on marine installations. Refer to 4-1-1/Table 2.
- vii) The equipment is subject to an impulse voltage test with test voltage values shown in the Table below. Where intermediate values of rated operational voltage are used, the next higher rated impulse withstand test voltage is to be used. The impulse voltage test reports are to be submitted to ABS for review.

<i>Rated Operational Voltage</i> V	<i>Rated Impulse Withstand Test Voltage</i> kV
50	0.8
100	1.5
150	2.5
300	4
600	6
1000	8

7.11.7 Terminals (2009)

Terminals or terminal rows for systems of different voltages are to be clearly separated from each other. The rated voltage is to be clearly indicated at least once for each group of terminals which have been separated from the terminals with other voltage ratings. Terminals with different voltage ratings, each not exceeding 50 V DC or 50 V AC may be grouped together. Each terminal is to have a nameplate indicating the circuit designation.

7.13 Control and Protective Devices

7.13.1 Circuit-disconnecting Devices

7.13.1(a) Systems Exceeding 50 Volts (2016). Distribution boards, chargers or controllers for distribution to motors, appliances, and lighting or other branch circuits are to be fitted with multipole circuit breakers or a multipole switch-fuse combination in each unearthed conductor.

7.13.1(b) System of 50 Volts and Less (2016). For distribution boards, chargers or controllers where voltage to earth or between poles does not exceed 50 volts DC or 50 volts AC rms, the fuses may be provided without switches.

7.13.1(c) Disconnect Device. The rating of the disconnecting device is to be coordinated with the voltage and current requirements of the load. The disconnect device is to indicate by position of the handle, or otherwise, whether it is open or closed.

7.13.2 Arrangement of Equipment

7.13.2(a) Air Circuit Breakers. Air circuit breaker contacts are to be kept at least 305 mm (12 in.) from the vessel's structure unless insulation barriers are installed.

7.13.2(b) Voltage Regulators. Voltage regulator elements are to be provided with enclosing cases to protect them from damage.

7.13.2(c) Equipment Operated in High Temperature. Where rheostats or other devices that may operate at high temperatures are mounted on the switchboard, they are to be naturally ventilated and so located or isolated by barriers as to prevent excessive temperature of adjacent devices. When this cannot be accomplished, the rheostat or other device is to be mounted separately from the switchboard.

7.13.2(d) Accessibility to Fuses. All fuses, except for instrument and control circuits, are to be mounted on or be accessible from the front of the switchboard.

7.13.2(e) Protective Device for Instrumentation. All wiring on the boards for instrumentation is to be protected by fuses or current limiting devices. See 4-6-2/9.17.

7.13.2(f) Wearing Parts. All wearing parts are to be accessible for inspection and readily renewable.

7.13.3 Markings

Identification plates are to be provided for each piece of apparatus to indicate clearly its service. Identification plates for feeders and branch circuits are to include the circuit designation and the rating of the fuse or circuit-breaker trip setting required by the circuit.

7.15 Switchboards

In addition to 4-6-4/7.1 to 4-6-4/7.13, as applicable, the switchboards for essential or emergency services are to comply with the following requirements.

7.15.1 Handrails

Insulated handrail or insulated handles are to be provided on the front of the switchboard. Similarly, where access to the rear is required, insulated handrail or insulated handles are also to be fitted on the rear of the switchboard.

7.15.2 Main Bus Bar Subdivision (2014)

Vessels with the keel laid or in similar stage of construction on or after 1 July 1998 are to meet the following requirements. Where the main source of electrical power is necessary for propulsion of the vessel, the main bus bar is to be subdivided into at least two sections which are to be normally connected by circuit breaker or other approved means. As far as practicable, the connection of generating sets and any other duplicated equipment is to be equally divided between the sections.

If the arrangement is such that the main switchboard is divided into separate sections which are interconnected by cable, the cable is to be protected at each end against faults.

7.15.3 Equalizer Circuit for Direct-current (DC) Generators

7.15.3(a) Equalizer Main Circuit. The current rating of the equalizer main circuit for direct-current (DC) generators is not to be less than half of the rated full-load current of the generator.

7.15.3(b) Equalizer Bus Bars. The current rating of the equalizer bus bars is not to be less than half of the rated full-load current of the largest generator in the group.

7.15.4 Equipment and Instrumentation (2005)

Equipment and instrumentation are to be provided in accordance with 4-6-4/Table 7. They are to be suitable for starting, stopping, synchronizing and paralleling each generator set from the main switchboard. They may be mounted on the centralized control console, if the main switchboard is located in the centralized control station.

7.17 Motor Controllers and Control Centers

In addition to 4-6-4/7.1 to 4-6-4/7.13, as applicable, the motor controllers and control centers for essential or emergency services are to comply with the following requirements.

7.17.1 Enclosures and Assemblies

The following materials are acceptable for the enclosures:

- Cast metal, other than die-cast metal, at least 3 mm ($1/8$ in.) thick at every point.
- Nonmetallic materials which have ample strength, are noncombustible and non-absorptive (e.g., laminated phenolic material).
- Sheet metal of adequate strength.

Motor control centers are to be constructed so that they are secured to a solid foundation, be self-supported, or be braced to the bulkhead.

7.17.2 Disconnect Switches and Circuit Breakers (1999)

Means are to be provided for the disconnection of the full load from all live poles of supply of every motor rated at 0.5 kW or above and its controlgear. Where the controlgear is mounted on or adjacent to a main or auxiliary distribution switchboard, a disconnecting switch in the switchboard may be used for this purpose. Otherwise, a disconnecting switch within the controlgear enclosure or a separate enclosed disconnecting switch is to be provided. Disconnect switches and circuit breakers are to be operated without opening the enclosures in which they are installed.

7.17.3 Auto-starters

Alternating-current (AC) motor manual auto-starters with self-contained auto-transformers are to be provided with switches of the quick-make-and-break type, and the starter is to be arranged so that it will be impossible to throw to the running position without having first thrown to the starting position. Switches are to be preferably of the contactor or air-break-type.

7.19 Battery Systems and Uninterruptible Power Systems (UPS) (2008)

In addition to 4-6-4/7.1 to 4-6-4/7.13, as applicable, equipment for essential, emergency, and transitional sources of power services are to comply with the following requirements. Such equipment would include the battery charger unit, uninterruptible power system (UPS) unit, and the distribution boards associated with the charging or discharging of the battery system or uninterruptible power system (UPS).

7.19.1 Definitions (2008)

Uninterruptible Power System (UPS) – A combination of converters, switches and energy storage means, for example batteries, constituting a power system for maintaining continuity of load power in case of input power failure.

Off-line UPS unit – A UPS unit where under normal operation the output load is powered from the bypass line (raw mains) and only transferred to the inverter if the bypass supply fails or goes outside preset limits. This transition will invariably result in a brief (typically 2 to 10 ms) break in the load supply.

Line interactive UPS unit – An off-line UPS unit where the bypass line switch to stored energy power when the input power goes outside the preset voltage and frequency limits.

On-line UPS unit – A UPS unit where under normal operation the output load is powered from the inverter, and will therefore continue to operate without break in the event of the supply input failing or going outside preset limits.

DC UPS unit – A UPS unit where the output is in DC (direct current).

7.19.2 Battery Charging Rate (2008)

Except when a different charging rate is necessary and is specified for a particular application, the charging facilities are to be such that the completely discharged battery can be recharged to 80% capacity in not more than 10 hours. See also 4-6-4/7.19.6(c)

7.19.3 Discharge Protection (2008)

An acceptable means, such as reverse current protection, is to be provided for preventing a failed component in the battery charger unit or uninterruptible power system (UPS) unit from discharging the battery.

7.19.4 Design and Construction (2008)

7.19.4(a) Construction. Battery charger units and uninterruptible power system (UPS) units are to be constructed in accordance with the IEC 62040 Series, or an acceptable and relevant national or international standard.

7.19.4(b) Operation. The operation of the UPS is not to depend upon external services.

7.19.4(c) Type. The type of UPS unit employed, whether off-line, line interactive or on-line, is to be appropriate to the power supply requirements of the connected load equipment.

7.19.4(d) *Continuity of Supply.* An external bypass is to be provided to account for a failure within the uninterruptible power system (UPS). For battery charger units and DC UPS units, see 4-6-2/7.1.6(c).

7.19.4(e) *Monitoring and Alarming.* The battery charger unit or uninterruptible power system (UPS) unit is to be monitored and audible and visual alarm is to be given in a normally attended location for the following.

- Power supply failure (voltage and frequency) to the connected load
- Earth fault,
- Operation of battery protective device,
- When the battery is being discharged, and
- When the bypass is in operation for on-line UPS units. When changeover occurs, for battery charger units and DC UPS units required to comply with 4-6-2/7.1.6(c).

7.19.5 Location (2008)

7.19.5(a) *Location.* The UPS unit is to be suitably located for use in an emergency. The UPS unit is to be located as near as practical to the equipment being supplied, provided the arrangements comply with all other Rules, such as 4-6-3/3.7, 4-6-3/3.9, 4-6-3/3.11, and 4-6-3/3.13 for location of electrical equipment.

7.19.5(b) *Ventilation.* UPS units utilizing valve regulated sealed batteries may be located in compartments with normal electrical equipment, provided the ventilation arrangements are in accordance with the requirements of 4-6-3/3.7. Since valve regulated sealed batteries are considered low-hydrogen-emission batteries, calculations are to be submitted in accordance with 4-6-3/3.7.2(d) to establish the gas emission performance of the valve regulated batteries compared to the standard lead acid batteries. Arrangements are to be provided to allow any possible gas emission to be led to the weather, unless the gas emission performance of the valve regulated batteries does not exceed that of standard lead acid batteries connected to a charging device of 0.2 kW.

7.19.5(c) *Battery Installation.* For battery installation arrangements, see 4-6-3/3.7.

7.19.6 Performance (2008)

7.19.6(a) *Duration.* The output power is to be maintained for the duration required for the connected equipment as stated in 4-6-2/5.3 for emergency services and 4-6-2/5.7 of transitional source of power, as applicable.

7.19.6(b) *Battery Capacity.* No additional circuits are to be connected to the battery charger unit or UPS unit without verification that the batteries have adequate capacity. The battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in 4-6-4/7.19.6(a).

7.19.6(c) *Recharging.* On restoration of the input power, the rating of the charging facilities are to be sufficient to recharge the batteries while maintaining the output supply to the load equipment. See also 4-6-4/7.19.2.

7.19.7 Testing and Survey (2008)

7.19.7(a) *Surveys.* Equipment units are to be surveyed during manufacturing and testing in accordance with 4-6-4/7.3.1.

7.19.7(b) *Testing.* Appropriate testing is to be carried out to demonstrate that the battery charger units and uninterruptible power system (UPS) units are suitable for the intended environment. This is expected to include as a minimum the following tests:

- Functionality, including operation of alarms;
- Temperature rise;
- Ventilation rate;
- Battery capacity

7.19.7(c) *Test upon power input failure.* Where the supply is to be maintained without a break following a power input failure, this is to be verified after installation by practical test.

9 Transformers

9.1 General

9.1.1 Applications (2004)

All transformers which serve for essential or emergency electrical supply are to be constructed, tested and installed in accordance with the following requirements. Transformers other than the above services, auto-transformers for starting motors or isolation transformers are to be constructed and equipped in accordance with good commercial practice. All transformers are to be of the dry and air cooled type. The use of liquid immersed type transformers will be subject to special consideration. Transformers other than for essential or emergency services will be accepted subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

9.1.2 References

9.1.2(a) Power Supply Arrangement. For requirements covering arrangement of power supply through transformers to ship's service systems, see 4-6-2/7.1.6.

9.1.2(b) Protection. For requirements covering protection of transformers, see 4-6-2/9.15.

9.1.2(c) Protection Enclosures and its Selection. For requirements covering selection of the protection enclosures for location conditions, see 4-6-3/3.1.1.

9.1.3 Forced Cooling Arrangement (Air or Liquid)

Where forced cooling medium is used to preclude the transformer from exceeding temperatures outside of its rated range, monitoring and alarm means are to be provided and arranged so that an alarm activates when pre-set temperature conditions are exceeded. Manual or automatic arrangements are to be made to reduce the transformer load to a level corresponding to the cooling available.

9.3 Temperature Rise (2014)

The maximum temperature rise of the transformer insulated windings, based on an ambient temperature of 45°C (113°F), is not to exceed the values listed in 4-6-4/Table 8.

9.5 Construction and Assembly

9.5.1 Windings

All transformer windings are to be treated to resist moisture, sea atmosphere and oil vapors.

9.5.2 Terminals

Terminals are to be provided in an accessible position. The circuit designation is to be clearly marked on each terminal connection. The terminals are to be so spaced or shielded that they cannot be accidentally earthed, short-circuited or touched.

9.5.3 Nameplate

Nameplates of corrosion-resistant material are to be provided in an accessible position of the transformer and are to indicate at least the information as listed in 4-6-4/Table 4c.

9.5.4 Prevention of the Accumulation of Moisture (2002)

Transformers of 10 kVA/phase and over are to be provided with effective means to prevent accumulation of moisture and condensation within the transformer enclosure where the transformer is disconnected from the switchboard during standby (cold standby). Where it is arranged that the transformer is retained in an energized condition throughout a period of standby (hot standby), the exciting current to the primary winding may be considered as a means to meet the above purpose. In case of hot standby, a warning plate is to be posted at or near the disconnecting device for the primary side feeder to the transformer.

9.7 Testing (1999)

For single-phase transformers rated 1 kVA and above or three-phase transformers rated 5 kVA and above intended for essential or emergency services, the following tests are to be carried out by the transformer's manufacturer in accordance with a recognized standard whose certificate of test is to be submitted for review upon request.

- i) Measurement of winding resistance, voltage ratio, impedance voltage, short circuit impedance, insulation resistance, load loss, no load loss and excitation current, phase relation and polarity.
- ii) Dielectric strength.
- iii) Temperature rise (required for one transformer of each size and type). See 4-6-4/9.3.

10 Semiconductor Converters for Adjustable Speed Motor Drives (2014)

10.1 Application

All semiconductor converters that are used to control motor drives having a rated power of 100 kW (135 hp) and over intended for essential services (see definition in 4-6-1/3.7) or for services indicated in 4-6-4/Table 11 are to be designed, constructed and tested in accordance with the requirements of 4-6-4/10.

Manufacturer's tests for semiconductor converters that are used to control motor drives having a rated power less than 100 kW (135 hp) for essential services (see definition in 4-6-1/3.7) or for services indicated in 4-6-4/Table 11 are to include at least the tests described in 4-6-4/10.7. All other semiconductor converters used to control motor drives are to be designed, constructed and tested in accordance with established industrial practices and manufacturer's specifications.

The required tests may be carried out at the manufacturer facility whose certificates of tests will be acceptable and are to be submitted upon request to ABS. All semiconductor converters will only be accepted subject to a satisfactory performance test conducted to the satisfaction of the attending Surveyor after installation.

10.3 Standards of Compliance

The design of semiconductor converters for adjustable speed motor drives, unless otherwise contradicted by ABS Rules, shall be in compliance with the requirements of IEC Publication 61800-5-1:2007 (titled 'Adjustable speed electrical power drive systems : Safety Requirements – Electrical, thermal and energy') and 60146-1-1:2009 (titled 'Semiconductor converters – General requirements and line commutated converters – Specification of basic requirements'). For convenience, the following requirements are listed.

10.5 Design, Construction and Assembly Requirements

10.5.1 Rating

Semiconductor converters are to be rated for continuous load conditions and if required by the application, are to have specified overload capabilities.

The operation of the semiconductor converter equipment, including any associated transformers, reactors, capacitors and filter circuits, shall not cause harmonic distortion and voltage and frequency variations in excess of the values mentioned in 4-6-2/7.9 and 4-6-1/Table 1, respectively.

The semiconductor converter circuits shall be able to withstand voltage and current transients that the system may be subject to for certain applications.

The semiconductor converters are to be suitable for environmental conditions found in marine installations such as those mentioned in 4-1-1/Table 1 and 4-1-1/Table 2.

10.5.2 Enclosures

Enclosures and assemblies are to be constructed of steel or other suitable incombustible, moisture-resistant materials and reinforced as necessary to withstand the mechanical, electro-magnetic and thermal stresses which may be encountered under both normal and fault conditions.

Enclosures are to be of the closed type. The degree of protection of the enclosure is to be in accordance with 4-6-3/Table 1. For HV converters, the enclosure is to satisfy the requirements in 4-6-5/Table 1.

All wearing parts are to be accessible for inspection and be readily replaceable.

10.5.3 Nameplate Data

A nameplate made of corrosion resistant material is to be provided on the semiconductor assembly and is to indicate at least the following:

- i)* Manufacturer's name and identification reference/equipment serial number
- ii)* Number of input and output phases
- iii)* Rated input voltage and current
- iv)* Rated output voltage and current
- v)* Rated input and output frequency, if any
- vi)* Range of output frequency
- vii)* Maximum permissible prospective symmetrical rms short-circuit current of the power source
- viii)* Cooling methods
- ix)* Degree of protection

10.5.4 Warning Labels

Appropriate warning labels informing the user of the dangers with working with the different parts of the converter assembly is to be placed at all appropriate places of the assembly.

10.5.5 Hand Rails

Insulated handrails or insulated handles are to be provided for each front panel of the assembly. Where access to the rear is also required, insulated handrails or insulated handles are to be fitted to the rear of the assembly as well.

10.5.6 Accessibility

All components of the semiconductor converter assembly are to be mounted in such a manner that they can be removed from the assembly for repair or replacement without having to dismantle the complete unit.

10.5.7 Capacitor Discharge

Capacitors within a semiconductor converter assembly shall be discharged to a voltage less than 60 V, or to a residual charge less than 50 μC , within 5 seconds after the removal of power. If this requirement cannot be met, appropriate warning labels shall be placed on the assembly.

10.5.8 Cooling Arrangements (2017)

Design of cooling systems is to be based on an ambient air temperature of 45°C (113°F) indicated in 4-1-1/39 and 4-1-1/Table 2.

Semiconductor converter assemblies are to be installed away from sources of radiant energy in locations where the circulation of air is not restricted to and from the assembly and where the temperature of the inlet air to air-cooled converters will not exceed that for which the converter has been designed.

Where arrangements for forced cooling have been provided, the equipment is, unless otherwise specifically required, to be designed such that power cannot be applied to, or retained on, the semiconductor circuits, unless effective cooling is maintained. Other effective means of protection against equipment over-temperature such as reduction in the driven load may also be acceptable.

Semiconductor assemblies with forced cooling are to be provided with a means of monitoring the temperature of the cooling medium. Over-temperature of the cooling medium is to be alarmed locally and at a continuously manned location and the equipment shutdown when temperature exceeds the manufacturer specified value.

Semi-conductor assemblies with liquid cooling are to be provided with a means to detect leakage. In case of leakage, an audible and visible alarm is to be initiated locally and remotely at a continuously manned location. Means to contain any leakage are to be provided so that the liquid does not cause a failure of the semi-conductor assembly or any other electrical equipment located near the converter. **Where the cooling liquid is required to be non-conducting, the conductivity** of the cooling liquid is to be monitored and an alarm given both locally and remotely in a continuously manned location if the **conductivity** exceeds the manufacturer specified value.

In case of failure of the cooling system, an alarm is to be given both locally and remotely at a continuously manned location and the output current is to be reduced automatically.

Cooling liquids **which are in contact with live unearthed parts of the assembly** are to be non-conductive and non-flammable.

10.5.9 Emergency Stop

When required, semiconductor converter assemblies shall be provided with an emergency stop function. The emergency stop circuit is to be hard-wired and independent of any control system signal.

10.5.10 Electrical Protection (2016)

10.5.10(a) Overvoltage Protection. Means are to be provided to prevent excessive overvoltage in a supply system to which semiconductor converters are connected and to prevent the application of voltages in excess of the rating of semiconductor devices.

10.5.10(b) Overcurrent Protection. Arrangements are to be made so that the permissible current of semiconductor converters or semiconductor devices associated with the semiconductor converter cannot be exceeded during operation.

10.5.10(c) Short Circuit Protection. Semiconductor converters and the associated semiconductor devices are to be protected against short circuit.

10.5.10(d) Filter Circuits. Filter circuits are to be protected against overvoltage, overcurrent and short circuit.

10.5.10(e) Alarms. Visual and audible alarms are to be provided at the control station in the event of operation of the protection system.

10.5.11 Clearance and Creepage Distances

Clearance and creepage distances used in standard production (COTS) semiconductor converter assemblies are to be in accordance with IEC 61800-5-1 and suitable for overvoltage category III, pollution degree 3 and insulating material group IIIa. The relevant values are reproduced in the Table below for convenience.

<i>System Voltage (V)</i>	<i>Minimum Clearance Distance (mm)</i>
≤50	0.8
100	0.8
150	1.5
300	3.0
600	5.5
1000	8.0
3600	25
7200	60
12000	90
15000	120

Note: Interpolation is permitted.

<i>Working Voltage (rms) (V)</i>	<i>Minimum Creepage Distance (mm)</i>
50	1.9
100	2.2
125	2.4
160	2.5
200	3.2
250	4.0
320	5.0
400	6.3
500	8.0
630	10.0
800	12.5
1000	16
1250	20
1600	25
2000	32
2500	40
3200	50
4000	63
5000	80
6300	100
8000	125
10000	160

Note: Interpolation is permitted.

10.5.12 Protection and Monitoring Requirements

Semiconductor assemblies, as a minimum, shall have alarm functions for the following parameters:

- i)* Overcurrent
- ii)* Overload
- iii)* Overvoltage
- iv)* Ground fault
- v)* Loss of cooling
- vi)* Increase in resistivity of cooling medium (for liquid cooled converters)
- vii)* Over-temperature
- viii)* Loss of communication to process control
- ix)* Loss of motor speed feedback

If harmonic filters are used in conjunction with semiconductor converter assemblies, refer to 4-6-2/9.19 for additional protection requirements.

For vessels with electric propulsion, refer to 4-7-2/Table 6B.

10.5.13 Load-sharing

When semiconductor converters have multiple parallel/series circuits, load sharing between the multiple circuits is to be distributed uniformly, as far as practicable.

10.5.14 EMC Emission Requirements

If requested by the customer, EM immunity and EM emissions testing of the semiconductor assembly shall be done as an optional test in accordance with IEC 61800-3 (titled 'Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods').

Note: Radiated and conducted emissions/immunity does not depend on the equipment alone but also on the interaction between the semiconductor converter assembly and the rest of the power system. There shall be communication between the manufacturer and the customer as to what installation guidelines may need to be followed to satisfy the different EM emission/immunity requirements, such as cable routing, types of interconnect cables used, cable shielding, etc.

10.5.15 Harmonic Filter Requirements

If harmonic filter circuits are used in association with semiconductor converter assemblies to reduce the harmonics and transients in the system, they are to comply with the requirements in 4-6-2/9.19.

10.5.16 Performance

The converter control system shall be able to control the motor by speed ramp, torque or power, as per customer specification.

Upon loss of the reference signal, the converter shall either decelerate the driven motor to minimum speed/torque/power or down to standstill as per customer specification for the required application.

When, during normal operation, the motor is decelerated to standstill, it shall be possible to de-energize the motor by blocking the control signals to the power semiconductors, while leaving the converter input circuit energized.

When automatic restart is specified, the converter shall be capable of catching an already spinning motor.

10.7 Inspection and Testing

(2016) Semiconductor assemblies for motor drives shall undergo Type tests, Routine tests and Optional tests, if any specifically required by the Owner, at manufacturer's production facility as per the Table below. The Type tests, Routine tests and Optional tests shall be conducted in the presence of and witnessed by an ABS Surveyor. Type tests shall be carried out one prototype of a converter or the first of a batch of identical converters. Routine tests shall be carried on each assembly. A summary of the required type tests and routine tests are given in the Table below:

No.	Tests (see 4-6-4/10.7)	Type Test	Routine Test	ABS Reference	IEC Test Reference
1	Visual inspection	x	x	4-6-4/10.7.1	61800-5-1/5.2.1
2	Insulation test (AC or DC voltage test)	x	x	4-6-4/10.7.2	61800-5-1/5.2.3.2
3	Insulation resistance test	x	x	4-6-4/10.7.4	60146-1-1/7.2.3.1
4	Impulse voltage test	x		4-6-4/10.7.3	61800-5-1/5.2.3.1
5	Cooling system test	x	x	4-6-4/10.7.5	61800-5-1/5.2.4.5
6	Breakdown of components test	x		4-6-4/10.7.6	61800-5-1/5.2.3.6.4
7	Light load and functional test	x	x	4-6-4/10.7.7	60146-1-1/7.3.1
8	Rated current test	x		4-6-4/10.7.8	60146-1-1/7.3.2
9	Temperature rise test	x		4-6-4/10.7.9	61800-5-1/5.2.3.8
10	Capacitor discharge test	x		4-6-4/10.7.10	61800-5-1/5.2.3.7

10.7.1 Visual Inspection

Semiconductor assemblies are subject to visual inspection for the following aspects:

- i) Verify enclosure integrity, alignment of different cabinets in the assembly as per system drawings.
- ii) Verify if nameplate is present as per 4-6-4/10.5.3.

- iii) Check if adequate and visible warning and safety labels are present.
- iv) General hardware and electrical point-to-point wire check.
- v) Verify correct routing and connections of fiber optic cables and ethernet cables.
- vi) Verify correct connection of grounding wires on the assembly.
- vii) Point-to-point inspection of cooling system, if applicable. For drive assemblies with liquid cooling, verification of proper installation of piping and hoses, correct orientation of flow restrictors and related coolant liquid monitoring instrumentation.
- viii) Door interlocks, if any

10.7.2 Insulation Test (AC or DC Voltage Test) (2017)

Semiconductor assemblies shall be subject to insulation tests to ensure adequate dielectric strength of insulation of its components and to verify that clearance distances have not been compromised during manufacturing operations. The insulation test is to be performed with the appropriate AC or DC voltage (equal to the peak value of the specified AC rms voltage) mentioned in Table 21/ Table 22/ Table 23 of IEC 61800-5-1(2007). The AC test voltage is to be voltage of sinusoidal wave form and a frequency of 50 Hz/60 Hz. **The duration of the test is to be at least 5 sec for the Type Test and 1 sec for the Routine Test.** All main power, control power and logic circuits have to be subject to the Insulation test.

10.7.3 Impulse Voltage Test

Semiconductor assemblies shall be subject to an Impulse voltage test to simulate the impact of impulse transient over voltages generated in the mains supply or those caused by switching of equipment. The impulse voltage test is to be done as per 5.2.3.1 of IEC 61800-5-1(2007). For purposes of selection of test voltages, the semiconductor assembly shall be treated as belonging to overvoltage category III.

Impulse voltage tests shall be done as a routine test on assemblies that do not satisfy the clearance and creepage distance requirements of 4-6-4/10.5.11.

10.7.4 Insulation Resistance Test

One minute after the insulation test, insulation resistance shall be measured by applying a direct voltage of at least 500 V.

10.7.5 Cooling System Test

Semiconductor assemblies shall be subject to cooling system tests that test for failure of the cooling system and the associated response of the semiconductor assembly to these cooling system failures as per 5.2.4.5 of IEC 61800-5-1 (2007).

In addition, for liquid cooled semiconductor assemblies, the cooling piping system shall be subject to a coolant leak pressure test. The cooling system piping shall be hydrostatically tested to 1.5 times the design pressure for a period of 30 minutes. The pressure relief mechanism shall also be checked for proper calibration and operation. The cooling system shall be verified as having no leakage by monitoring the pressure and by visual inspection.

The instrumentation critical to the operation of the cooling system such as valve positions, programming of level switch sensors, flow sensors, pressure sensors, temperature sensors, pressure relief valve operation, coolant conductivity sensor, etc., shall be checked to ensure correct calibration and functionality.

10.7.6 Breakdown of Components Test

Components which have been identified by circuit analysis could result in a thermal or electric shock hazard are to be subject to a breakdown test as per 5.2.3.6.4 of IEC 61800-5-1.

10.7.7 Light Load and Functional Test

Semiconductor assemblies shall be subject to a light load and functional test to ensure that all parts of the electrical circuit and the cooling system work properly together and that the assembly meets the required proof of performance as per customer requirements. The main things to be checked include, but are not limited to:

- i) Verify that the control equipment, auxiliaries, protection equipment and main circuit are operating properly together.
- ii) Check power supplies to different power and control circuits of the assembly and associated communication control interfaces.
- iii) Check pre-charge circuit settings.
- iv) Verify the various software parameters.
- v) Check for voltage/current sharing in the semiconductor devices used in the arms of the converter.
- vi) Testing of the converter for scenarios like, but not limited to, emergency trip of the assembly, input fault protection, loss of cooling, local and remote control operation, etc.
- vii) Testing of the converter for any specific customer defined scenario like output power ramp-down on loss of input power, ability of the converter to catch a spinning motor after recovering from a trip or from automatic restart, etc.

10.7.8 Rated Current Test

The test is carried out to verify that the equipment will operate satisfactorily at rated current. The DC terminals shall be short-circuited directly or with a reactor and an alternating voltage of sufficient value, to cause at least the rated continuous direct current to flow, shall be connected to the AC terminals of the converter and operation of the assembly shall be checked.

10.7.9 Temperature Rise Test

The test is carried out to verify that parts and accessible surfaces of the semiconductor assembly do not exceed temperature limits specified below and the manufacturer's temperature limits of safety-relevant parts. The temperature rise test is to be conducted at worst-case conditions of rated power and rated output current.

<i>Materials and Components</i>	<i>Thermometer Method (°C)</i>	<i>Resistance Method (°C)</i>
Rubber/Thermoplastic-insulated conductors	55	-
User terminals	Note 1	-
Copper bus bars and connecting straps	120	-
Winding Insulation		
Class A	95	105
Class E	100	115
Class B	105	125
Class F	115	135
Class H	135	155
Class N	175	195
Phenolic composition	145	-
Bare resistor material	395	-
Capacitor	Note 2	-
Power switching semiconductors	Note 2	-
Printed wiring boards (PWB's)	Note 2	-
Liquid cooling medium	Note 2	-

Notes:

- 1 Maximum terminal temperature shall not exceed 15°C more than the insulation temperature rating of the conductor or cable specified by the manufacturer.
- 2 Maximum temperature shall be as specified by the manufacturer.

10.7.10 Capacitor Discharge Test

Verification of the capacitor discharge time as required in 4-6-4/10.7.7 is required to be done by a test and/or by calculation.

10.9 Integration Requirements

10.9.1 Integration

In cases where the semiconductor converters are integrated into larger assemblies that have other components (i.e., transformers, reactors, motors, etc.), the individual tests of the other components shall be done in accordance with relevant portions of the ABS Rules.

Installation requirements such as earthing of equipment, selection of cable and acceptable cable lengths, etc., should be as per manufacturer installation guidelines.

10.9.2 Reactors and Transformers for Semiconductor Converters

10.9.2(a) Voltage Regulation. Means to regulate transformer output voltage are to be provided to take care of increase in converter forward resistance and, in addition, to obtain the necessary performance characteristics of the converter unit in which the transformer is used.

10.9.2(b) High Temperature Alarm. Interphase reactors and transformers used with the semiconductor converters for main and auxiliary propulsion systems are to be provided with a high temperature alarm at the switchboard or the propulsion control station. The setting value of the alarm is to be determined by their specific insulation class and is not to exceed the temperature corresponding to the limit listed in 4-6-4/9.3.

10.9.3 Critical Speeds

The semiconductor converter supplier, the driven equipment supplier and the Owner should come to an agreement on the calculations of the resulting critical lateral speeds of the whole mechanical string with special attention being paid to the following:

- i) Take into account the influence of the stiffness of the bearing arrangement and the foundation.
- ii) Avoid any continuous running with insufficient damping close to lateral critical speeds ($\pm 20\%$).

11 Other Electric and Electronics Devices

11.1 Circuit Breakers

11.1.1 General

Circuit breakers are to be constructed and tested to comply with IEC Publication 60947-2 or other recognized standard. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. Circuit breakers of the thermal type are to be calibrated for an ambient-air temperature, as provided in 4-6-1/17.

Note: Where thermal-type breakers are mounted within enclosures, it is pointed out that the temperature within the enclosure may exceed the designated ambient-air temperature.

11.1.2 Mechanical Property

Arc-rupturing and main contacts of all open frame circuit breakers are to be self-cleaning.

11.1.3 Isolation

The electrical system is to be arranged so that portions may be isolated to remove circuit breakers while maintaining services necessary for propulsion and safety of the vessel, or circuit breakers are to be mounted or arranged in such a manner that the breaker may be removed from the front without disconnecting the copper or cable connections or without de-energizing the supply to the breaker.

11.3 Fuses

Fuses are to be constructed and tested to comply with IEC Publication 60269 or other recognized standard. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. All components of the fuse are to be resistant to heat, mechanical stresses and corrosive influences which may occur in normal use.

11.5 Semiconductor Converters

11.5.1 General

The requirements in this subsection are applicable to static converters for essential and emergency services using semiconductor rectifying elements such as diodes, reverse blocking triodes thyristors, etc. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. All semiconductor converters will be accepted subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

11.5.2 Cooling Arrangements

Semiconductor converters are preferably to be of a dry and air-cooled type. Where semiconductor converters are of a liquid-immersed type, a liquid over-temperature alarm and gas over-pressure protection devices are to be provided. If provision is made for breathing, a dehydrator is to be provided. Where arrangement for the forced cooling is provided, the circuit is to be designed so that power cannot be applied to, or retained on, converter stacks unless effective cooling is maintained.

11.5.3 Accessibility

Semiconductor converter stacks or semiconductor components are to be mounted in such a manner so that they can be removed from equipment without dismantling the complete unit.

11.5.4 Nameplate

A nameplate or identification is to be provided on the semiconductor converter and is to indicate at least the information as listed in 4-6-4/Table 4d.

11.7 Cable Junction Boxes

11.7.1 General

The design and construction of the junction boxes are to be in compliance with 4-6-4/11.7.2 or other recognized standard. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

11.7.2 Design and Construction

Live parts are to be mounted on durable flame-retardant moisture-resistant material, of permanently high dielectric strength and high resistance. The live parts are to be so arranged by suitable spacing or shielding with flame-retardant insulating material that short-circuit cannot readily occur between conductors of different polarity or between conductors and earthed metal. Junction boxes are to be made of flame-retardant material and are to be clearly identified, defining their function and voltage.

13 Cables and Wires

13.1 Cable Construction

13.1.1 General (2016)

Electric cables are to have conductors, insulation and moisture-resistant jackets, in accordance with IEC Publication 60092-350, 60092-352, 60092-353, 60092-354, 60092-360, 60092-370, 60092-376, or IEEE Std. 45. Other recognized marine standards will also be considered. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. Network cables are to comply with a recognized industry standard. Conductors are to be of copper and stranded in all sizes. Conductors are not to be less than the following in cross sectional size:

- 1.0 mm² (1,973.5 circ. mils) for power and lighting,
- 0.5 mm² (986.8 circ. mils) for control cables,
- 0.5 mm² (986.8 circ. mils) for essential or emergency signaling and communications cables, except for those assembled by the equipment manufacturer, and
- 0.35 mm² (690.8 circ. mils) for telephone cables for nonessential communication services, except for those assembled by the equipment manufacturer.

See 4-6-4/Table 10 for current carrying capacity for insulated copper wires and cables.

For electric cables in hazardous areas, the electric cable construction and the cable glands are to achieve the appropriate seal, such that gas cannot migrate through the cable.

Note: See clause 3.16 and clause 4.6 of IEC 60092-350 concerning the provision of an extruded impervious inner sheath that will prevent the migration of gas through the cable.

13.1.2 Flame Retardant Property

13.1.2(a) Standards. All electric cables are to be at least of a flame retardant type complying with the following:

- (2016) Depending on the intended installation, cables constructed to IEC Publication 60092 standards are to comply with the flammability criteria of IEC Publication 60332-3-22 or 60332-3-21, Category A or A F/R, or
- Cables constructed to IEEE Std. 45 are to comply with the flammability criteria of that standard, or
- (2016) Cables constructed to another recognized marine standard, where specially approved, are to comply with the flammability criteria of IEC Publication 60332-3-22 or 60332-3-21, Category A or A F/R (depending on the intended installation) or other acceptable standards.

Consideration will be given to the special types of cables, such as radio frequency cable, which do not comply with the above requirements.

13.1.2(b) Alternative Arrangement (2005). Flame-retardant marine cables, including network cables, which have not passed the above-mentioned bunched cable flammability criteria may be considered, provided that the cable is treated with approved flame-retardant material or the installation is provided with approved fire stop arrangements. Special consideration may be given to the flame retardancy of special types of cables, such as radio frequency cables. When specifically approved, bus duct may be used in lieu of cable.

13.1.3 Fire Resistant Property (2016)

Where electrical cables are required to be fire resistant, they are to comply with the requirements of IEC Standard 60331-1 for cables greater than 20 mm overall in diameter, otherwise they are to comply with the IEC Standard 60331-2 for cable diameters 20 mm or less. For special cables, requirements in the following standards may be used:

- IEC Standard 60331-23: Procedures and requirements – Electric data cables
- IEC Standard 60331-25: Procedures and requirements – Optical fiber cables

Cables complying with alternative national standards suitable for use in a marine environment may be considered. Fire resistant type cables are to be easily distinguishable. See also 4-6-3/3.2.9 and 4-6-3/5.17.

13.1.4 Insulation Material

All electrical cables for power, lighting, communication, control and electronic circuits are to have insulation suitable for a conductor temperature of not less than 60°C (140°F). See 4-6-4/Table 9 for types of cable insulation.

13.1.5 Armor for Single-conductor Cables

The armor is to be nonmagnetic for single-conductor alternating-current cables.

13.1.6 Fiber Optic Cables

Fiber optic cables are to be constructed and tested to a recognized fiber optic cable construction standard acceptable to ABS. The requirements of flame retardancy for the electrical cables are applicable to the fiber optic cables. The construction of the fiber optic cable which may pass through or enter a hazardous area is to be such that escape of gases to a safe area is not possible through the cable.

13.3 Portable and Flexing Electric Cables

Unless otherwise required in the Rules, cables for portable equipment and cables subject to flexing service need not be armored.

13.5 Mineral-insulated Metal-sheathed Cable

Mineral-insulated cable provided with approved fittings for terminating and connecting to boxes, outlets and other equipment may be used for any service up to 600 volts and may be used for feeders and branch circuits in both exposed and concealed work in dry or wet locations. The moisture-resisting jacket (sheath) of mineral-insulated metal-sheathed cable exposed to corrosive conditions is to be made of or protected by materials suitable for those conditions.

TABLE 1
Factory Test Schedule for Generators and Motors ≥ 100 kW (135 hp)
[See 4-6-4/3.3.1(a)] (2003)

Tests		AC generators		AC motors		DC machines	
		Type test ⁽¹⁾	Routine test ⁽²⁾	Type test ⁽¹⁾	Routine test ⁽²⁾	Type test ⁽¹⁾	Routine test ⁽²⁾
1	Visual inspection.	x	x	x	x	x	x
2	Insulation resistance measurement.	x	x	x	x	x	x
3	Winding resistance measurement.	x	x	x	x	x	x
4	Verification of voltage regulation system.	x	x ⁽³⁾				
5	Rated load test and temperature rise measurement.	x		x		x	
6	Overload/over-current test.	x	x ⁽⁴⁾	x	x ⁽⁴⁾	x	x ⁽⁴⁾
7	Verification of steady short circuit condition. ⁽⁵⁾	x					
8	Over-speed test.	x	x	x ⁽⁶⁾	x ⁽⁶⁾	x ⁽⁶⁾	x ⁽⁶⁾
9	Dielectric strength test.	x	x	x	x	x	x
10	Running balance test. ⁽⁷⁾	x	x	x	x	x	x
11	Verification of degree of protection.	x		x		x	
12	Bearing check after test.	x	x	x	x	x	x
13	Air gap measurement.	x	x			x	x
14	Commutation check.					x	

Notes:

- 1 Type tests apply to prototype machines or to at least the first of a batch of machines.
- 2 Machines to be routine tested are to have reference to the machine of the same type that has passed a type test. Reports of routine tested machines are to contain manufacturers' serial numbers of the type tested machines and the test results.
- 3 Only functional test of voltage regulator system.
- 4 Applicable only to generators and motors ≥ 100 kW (135 hp) for essential services.
- 5 Verification at steady short circuit condition applies to synchronous generators only.
- 6 Where so specified and agreed upon between purchaser and manufacturer. Not required for squirrel cage motors.
- 7 Static balance (machine rated 500 rpm or less) or dynamic balance (over 500 rpm) will be accepted in lieu of the specified test on machines to be close-coupled to engines and supplied without shaft and/or bearings, or with incomplete set of bearings.

TABLE 2
Dielectric Strength Test for Rotating Machines [See 4-6-4/3.9]

Item	Machine or Part	Test Voltage (AC rms)
1	Insulated windings of rotated machines having rated output less than 1 kVA, and of rated voltage less than 100 V with the exception of those in items 4 to 8.	500 V + twice the rated voltage.
2	Insulated windings of rotating machines having rated output less than 10,000 kVA with the exception of those in items 1 and 4 to 8 (See Note 2).	1,000 V + twice the rated voltage with minimum of 1,500 V (See Note 1).
3	(1999) Insulated windings of rotating machines having rated output 10,000 kVA or more, and of rated voltage (see Note 1) up to 24,000 V with the exception of those in items 4 to 8 (see Note 2).	1,000 V + twice the rated voltage.
4	Separately-excited field windings of DC machines.	1,000 V + twice the maximum rated circuit voltage with minimum of 1,500 V (See Note 1).
5	Field windings of synchronous generators and synchronous motors.	
	a) Field windings of synchronous generators	Ten times the rated excitation voltage with a minimum of 1,500 V and a maximum of 3,500 V.
	b) When the machine is intended to be started with the field winding short-circuited or connected across a resistance of value less than ten times the resistance of winding.	Ten times the rated excitation voltage with a minimum of 1,500 V and a maximum of 3,500 V.
	c) When the machine will be started either with: – the field winding connected across resistance of more than ten times the field winding resistance, or – the field windings on open circuit or without a field dividing switch.	1,000 V + twice the maximum value of the voltage with a minimum of 1,500 V – between the terminals of the field winding, or – between the terminals of any section for a sectionalized field winding, which will be occurred under the specified starting conditions (see Note 3).
6	Secondary (usually rotor) windings of induction motors or synchronous induction motors if not permanently short-circuited (e.g., if intended for rheostatic starting)	
	a) For non-reversing motors or motors reversible from standstill only.	1,000 V + twice the open-circuit standstill voltage as measured between slip-rings or secondary terminals with rated voltage applied to the primary windings.
	b) For motors to be reversed or braked by reversing the primary supply while the motor is running.	1,000 V + four times the open-circuit standstill secondary voltage as defined in item 6.a. above.
7	Exciters (except as listed below) <i>Exception 1</i> —Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field winding during starting <i>Exception 2</i> —Separately excited field windings of exciters (see Item 4 above).	As for windings to which they are connected. 1,000 V + twice the rated exciter voltage with a minimum of 1,500 V.
8	Assembled group of machines and apparatus.	A repetition of the tests in items 1 to 7 above is to be avoided if possible. But, if a test on an assembled group of several pieces of new apparatus, each one is made, the test voltage to be applied to such assembled group is to be 80% of the lowest test voltage appropriate for any part of the group (see Note 4).

Notes:

- 1 For two-phase windings having one terminal in common, the rated voltage for the purpose of calculating the test voltage is to be taken as 1.4 times the voltage of each separate phase.
- 2 High-voltage tests on machines having graded insulation is to be subject to special consideration.
- 3 The voltage, which is occurred between the terminals of field windings or sections thereof under the specified starting conditions, may be measured at any convenient reduced supply voltage. The voltage so measured is to be increased in the ratio of the specified starting supply voltage to the test supply voltage.
- 4 For windings of one or more machines connected together electrically, the voltage to be considered is the maximum voltage that occurs in relation to earth.

TABLE 3
Limits of Temperature Rise for Air-Cooled Rotating Machines
[See 4-6-4/3.11.1] (2015)

Ambient Temperature = 45°C

Item No.	Part of Machine	Temperature Measuring Method	Limit of Temperature Rise, °C for Class of Insulation				
			A	E	B	F	H
1	a) AC windings of machines having rated output of 5,000 kW (or kVA) or more	Resistance	55	—	75	95	120
		Embedded temp. detector	60	—	80	100	125
	b) AC windings of machines having rated output above 200 kW (or kVA) but less than 5,000 kW (or kVA)	Resistance	55	70	75	100	120
		Embedded temp. detector.	60	—	85	105	125
	c) AC windings of machines having rated outputs of 200 kW (or kVA) or less ⁽¹⁾	Resistance	55	70	75	100	120
		Thermometer	45	60	65	80	100
2	Windings of armatures having commutators	Resistance	55	70	75	100	120
		Thermometer	45	60	65	80	100
3	Field windings of AC and DC machines having DC excitation, other than those in item 4	Resistance	55	70	75	100	120
		Thermometer	45	60	65	80	100
4	a) Field winding of synchronous machines with cylindrical rotors having DC excitation winding embedded in slots, except synchronous induction motors	Resistance	—	—	85	105	130
		Thermometer	45	60	65	80	100
	b) Stationary field windings of AC machines having more than one layer	Resistance	55	70	75	100	120
		Embedded temp. detector.	—	—	85	105	130
		Thermometer	55	70	75	95	120
	c) Low resistance field winding of AC and DC machines and compensating windings of DC machines having more than one layer	Resistance	55	70	75	95	120
		Thermometer	60	75	85	105	130
	d) Single-layer windings of AC and DC machines with exposed bare or varnished metal surfaces and single layer compensating windings of DC machines ⁽²⁾	Resistance	60	75	85	105	130
		Thermometer	60	75	85	105	130
	5	Permanently short-circuited windings					
6	Magnetic cores and all structural components, whether or not in direct contact with insulation (excluding bearings)	The temperature rise of any parts is not to be detrimental to the insulating of that part or to any other part adjacent to it.					
7	Commutators, slip-rings and their brushes and brushing	The temperature rise of any parts is not to be detrimental to the insulating of that part or to any other part adjacent to it. Additionally, the temperature is not to exceed that at which the combination of brush grade and commutator/slip-ring materials can handle the current over the entire operating range.					

Notes

- 1 With application of the superposition test method to windings of machines rated 200 kW (or kVA) or less with insulation classes A, E, B or F, the limits of temperature rise given for the resistance method may be increased by 5°C.
- 2 Also includes multiple layer windings provided that the under layers are each in contact with the circulating coolant.

**TABLE 4
 Nameplates**

a. Rotating Machines [See 4-6-4/3.13.9]

The manufacturer's name
 The manufacturer's serial number (or identification mark)
 The year of manufacture
 Type of Machine (Generator or motor, etc.)
 Degree of protection enclosures (by IP code)
 Class of rating or duty type
 The rated output
 The rated voltage
 The rated current and type of current (AC or DC)
 The rated speed (r.p.m.) or speed range
 The class of insulation or permissible temperature rise
 The ambient temperature

Number of phase (for AC machines)
 The rated frequency (for AC machines)
 Power factor (for AC machines)
 Type of winding (for DC machines)

Exciter voltage (for synchronous machines or DC machines with separate excitation)
 Exciter current at rating (for synchronous machines or DC machines with separate excitation)
 Open-circuit voltage between slip-rings and the slip-ring current for rated conditions (for wounded-rotor induction machines)

b. Accumulator Battery [See 4-6-4/5.3.3]

The manufacturer's name
 The type designation
 The rated voltage
 The ampere-hour rating at a specific rate of discharge
 The specific gravity of the electrolyte
 (in the case of a lead-acid battery, the specific gravity when the battery is fully charged).

c. Transformer [See 4-6-4/9.5.3]

The manufacturer's name
 The manufacturer's serial number (or identification mark)
 The year of manufacture
 The number of phases
 The rated power
 The rated frequency
 The rated voltage in primary and secondary sides
 The rated current in primary and secondary sides
 The class of insulation or permissible temperature rise
 The ambient temperature

d. Semiconductor Converter [See 4-6-4/11.5.4]

The manufacturer's name
 The identification number of the equipment

TABLE 5
Factory Testing Schedule for Switchboards, Chargers, Motor Control Centers and
Controllers [See 4-6-4/7.3.1] (2016)

- 1 Insulation resistance measurements in accordance with 4-6-4/7.5.
- 2 Dielectric strength test in accordance with 4-6-4/7.7 and the table below.
- 3 (1998) Protective device tripping test, such as overcurrent tripping, emergency tripping, preferential tripping, etc.
- 4 Inspection of the assembly including inspection of wiring and, if necessary, electrical operation test.

Standard Test Voltage for Dielectric Strength Test

<i>Rated Insulation Voltage</i>	<i>Dielectric Test Voltage AC rms</i>
Up to and including 12 V	250 V
over 12 V to 60 V inclusive	500 V
over 60 V to 300 V inclusive	2000 V
over 300 V to 690 V inclusive	2500 V
over 690 V to 800 V inclusive	3000 V
over 800 V to 1000 V inclusive	3500 V
over 1000 V to 1500 V inclusive*	3500 V

*Note: *For Direct-current (DC) only*

TABLE 6
Clearance and Creepage Distance for Switchboards, Distribution Boards, Chargers,
Motor Control Centers and Controllers ⁽¹⁾ [See 4-6-4/7.11.6]

<i>Rated insulation voltage (V)</i>	<i>Minimum clearances mm (in.)</i>	<i>Minimum creepage distances mm (in.)</i>
Up to 250	15 (19/32)	20 (25/32)
From 251 to 660	20 (25/32)	30 (13/16)
Above 660 ⁽²⁾	25 (1)	35 (13/8)

Notes:

- 1 The values in this table apply to clearances and creepage distances between live parts as well as between live parts and exposed conductive parts, including earthing.
- 2 For 1 kV to 15 kV systems, see 4-6-5/1.1.4.

TABLE 7
Equipment and Instrumentation for Switchboard [See 4-6-4/7.15.4]

<i>Instrumentation and Equipment</i>		<i>Alternating-current (AC) Switchboard</i>	<i>Direct-current (DC) Switchboard</i>
1.	Pilot Lamp	A pilot lamp for each generator connected between generator and circuit breaker. ⁽³⁾	A pilot lamp for each generator connected between generator and circuit breaker.
2.	Generator Disconnect	A generator switch or disconnecting links in series with the generator circuit breaker which is to disconnect completely all leads of the generator and the circuit breaker from the buses, except the earth lead. ⁽¹⁾	A generator switch, or disconnecting links, in series with the circuit breaker which will open positive, negative, neutral and equalizer leads, except that for 3-wire generators, equalizer poles may be provided on the circuit breaker. For 3-wire generators, the circuit breakers are to protect against a short circuit on the equalizer buses. ⁽¹⁾
3.	Field Rheostat	A field rheostat for each generator and each exciter. ⁽²⁾	A field rheostat for each generator. ⁽²⁾
4.	Insulation Monitor and Alarm	A means for continuously monitoring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values. ⁽³⁾	A means for continuously monitoring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values. For 3-wire generators, see 4-6-5/5.3. ⁽³⁾
5.	Ammeter	An ammeter for each generator with a selector switch to read the current of each phase. ⁽³⁾	An ammeter for each 2-wire generator. For each 3-wire generator, an ammeter for each positive and negative lead and a center-zero ammeter in the earth connection at the generator switchboard. Ammeters are to be so located in the circuit as to indicate total generator current.
6.	Voltmeter	A voltmeter for each generator, with a selector switch to each phase of the generator and to one phase of the bus. ⁽³⁾	A voltmeter for each generator with voltmeter switch for connecting the voltmeter to indicate generator voltage and bus voltage. For each 3-wire generator, a voltmeter with voltmeter switch for connecting the voltmeter to indicate generator voltage, positive to negative, positive to neutral, and neutral to negative. Where permanent provisions for shore connections are fitted, one voltmeter switch to provide also for reading shore-connection voltage, positive to negative.
7.	Space Heater Pilot Lamp	Where electric heaters are provided for generators, a heater pilot lamp is to be fitted for each generator.	Where electric heaters are provided for generators, a heater pilot lamp is to be fitted for each generator.
8.	Synchroscope or Lamps	A synchroscope or synchronizing lamps with selector switch for paralleling in any combination. ⁽³⁾	Not applicable.
9.	Prime mover Speed Control	Control for prime mover speed for paralleling. ⁽³⁾	Not applicable.
10.	Wattmeter	Where generators are arranged for parallel operation, an indicating wattmeter is to be fitted for each generator. ⁽³⁾	Not applicable.
11.	Frequency Meter	A frequency meter with selector switch to connect to any generator. ⁽³⁾	Not applicable.
12.	Field Switch	A double-pole field switch with discharge clips and resistor for each generator. ⁽²⁾	Not applicable.
13.	Voltage Regulator	A voltage regulator. ⁽³⁾	Not applicable.
14.	Stator Winding Temperature Indicator	For alternating current propulsion generator above 500 kW, a stator winding temperature indicator is to be fitted for each generator control panel. ^(3,4)	For direct current propulsion generator above 500 kW, an interpole winding temperature indicator is to be fitted for each generator control panel. ^(3,4)

Notes:

- 1 The switch or links may be omitted when draw-out or plug-in mounted generator breakers are furnished.
- 2 For generators with variable voltage exciters or rotary amplifier exciters, each controlled by voltage-regulator unit acting on the exciter field, the field switch, the discharge resistor and generator field rheostat may be omitted.
- 3 (2005) Where vessels have centralized control systems in accordance with Part 4, Chapter 7 and the generators can be paralleled from the centralized control station, and the switchboard is located in the centralized control station, this equipment may be mounted on the control console. See 4-6-4/7.15.4.
- 4 For high voltage systems, see also 4-6-5/1.11.1(c).

TABLE 8
Temperature Rise for Transformers ^(1, 2) (2014)

<i>Insulation Class</i>	<i>Average Winding-Temperature Rise Limits at Rated Current, °C (°F)</i>
A (105)	55 (99)
E (120)	70 (126)
B (130)	75 (135)
F (155)	95 (171)
H (180)	120 (216)
200	130 (234)
220	145 (261)

Notes:

- 1 Metallic parts in contact with or adjacent to insulation are not to attain a temperature in excess of that allowed for the hottest-spot copper temperature adjacent to that insulation.
- 2 (2014) Temperature rises are based on an ambient temperature of 45°C (113°F). See 4-6-4/9.3.

TABLE 9
Types of Cable Insulation [See 4-6-4/13.1.4] (2013)

<i>Insulation Type Designation</i>	<i>Insulation Materials</i>	<i>Maximum Conductor Temperature</i>
V75, PVC	Polyvinyl Chloride – Heat resisting	75°C (167°F) *
R85, XLPE	Cross-linked Polyethylene	85°C (185°F) *
E85, EPR	Ethylene Propylene Rubber	85°C (185°F) *
R90, XLPE	Cross-linked Polyethylene	90°C (194°F) *
E90, EPR	Ethylene Propylene Rubber	90°C (194°F) *
M95	Mineral (MI)	95°C (203°F) *
S95	Silicone Rubber	95°C (203°F) *

* A maximum conductor temperature of 250°C (482°F) is permissible for special applications and standard end fittings may be used, provided the temperature does not exceed 85°C (185°F) at the end of fittings. However, when the temperature at the end of the fittings is higher than 85°C (185°F), special consideration will be given to an appropriate end fitting.

TABLE 10
Maximum Current Carrying Capacity for Insulated Copper Wires and Cables (2014)

Conductor Size		Maximum Current in Amperes (see 4-6-4/13.1.1) 45°C (113°F) Ambient; 750 V and Less, AC or DC; see Notes											
mm ²	10 ³ circ mils	1-core				2-core				3- or 4-core			
		V75	R85 XLPE E85 EPR	R90 XLPE E90 EPR	M95 S95	V75	R85 XLPE E85 EPR	R90 XLPE E90 EPR	M95 S95	V75	R85 XLPE E85 EPR	R90 XLPE E90 EPR	M95 S95
1.0		13	16		20	11	14		17	9	11		14
1.25		15	18		23	13	15		20	11	13		16
1.5		17	21	23	26	14	18	20	22	12	15	16	18
	4.11	21	25		32	18	21		27	15	18		22
2.5		24	28	30	32	20	24	26	27	17	20	21	22
	6.53	28	34		38	24	29		32	20	24		27
4		32	38	40	43	27	32	34	37	22	27	28	30
	10.4	38	45		51	32	38		43	27	32		36
6		41	49	52	55	35	42	44	47	29	34	36	39
	16.5	51	60		68	43	51		58	36	42		48
10		57	67	72	76	48	57	61	65	40	47	50	53
	20.8	59	70		78	50	60		66	41	49		55
	26.3	68	81		91	58	69		77	48	57		64
16		76	91	96	102	65	77	82	87	53	64	67	71
	33.1	79	93		105	67	79		89	55	65		74
	41.7	91	108		121	77	92		103	64	76		85
25		101	120	127	135	86	102	108	115	71	84	89	95
	52.6	105	124		140	89	105		119	74	87		98
	66.4	121	144		162	103	122		138	85	101		113
35		125	148	157	166	106	126	133	141	88	104	110	116
	83.7	140	166		187	119	141		159	98	116		131
50		156	184	196	208	133	156	167	177	109	129	137	146
	106	163	193		217	139	164		184	114	135		152
	133	188	222		250	160	189		213	132	155		175
70		192	228	242	256	163	194	206	218	134	160	169	179
	168	217	257		289	184	218		246	152	180		202
95		232	276	293	310	197	235	249	264	162	193	205	217
	212	251	297		335	213	252		285	176	208		235
120		269	319	339	359	229	271	288	305	188	223	237	251
	250	278	330		371	236	281		315	195	231		260
150		309	367	389	412	263	312	331	350	216	257	272	288
	300	312	370		416	265	315		354	218	259		291
	350	343	407		458	292	346		389	240	285		321
185		353	418	444	470	300	355	377	400	247	293	311	329
	400	373	442		498	317	376		423	261	309		349
	450	402	476		536	342	405		456	281	333		375
240		415	492	522	553	353	418	444	470	291	344	365	387
	500	429	509		572	365	433		486	300	356		400
	550	455	540		607	387	459		516	319	378		425
300		477	565	601	636	405	480	511	541	334	396	421	445
	600	481	570		641	409	485		545	337	399		449
	650	506	599		674	430	509		573	354	419		472
	700	529	628		706	450	534		600	370	440		494
	750	553	655		737	470	557		626	387	459		516

TABLE 10 (continued)
Maximum Current Carrying Capacity for Insulated Copper Wires and Cables (2014)

Conductor Size		Maximum Current in Amperes (see 4-6-4/13.1.1) 45°C (113°F) Ambient; 750 V and Less, AC or DC; see Notes											
mm ²	10 ³ circ mils	1-core				2-core				3- or 4-core			
		V75	R85 XLPE E85 EPR	R90 XLPE E90 EPR	M95 S95	V75	R85 XLPE E85 EPR	R90 XLPE E90 EPR	M95 S95	V75	R85 XLPE E85 EPR	R90 XLPE E90 EPR	M95 S95
400		571	677	690	761	485	575	587	647	400	474	483	533
	800	576	682		767	490	580		652	403	477		540
	850	598	709		797	508	603		677	419	496		558
	900	620	734		826	527	624		702	434	514		578
	950	641	760		854	545	646		726	449	532		598
500		656	778	780	875	558	661	663	744	459	545	546	613
	1000	662	784		882	563	666		750	463	549		617
600		736	872		981	626	741		834	515	610		687
625		755	894		1006	642	760		855	529	626		704

Notes:

- The values given above have been calculated for an ambient of 45°C (113°F), and assume that a conductor temperature equal to the maximum rated temperature of the insulation is reached and maintained continuously in the case of a group of four cables bunched together and laid in free air.
- The current rating values given in 4-6-4/Table 10 (and those derived therefrom) may be considered applicable, without correction factors, for cables double-banked on cable trays, in cable conduits or cable pipes, except as noted in Note 3.
- For bunched cables, see 4-6-3/5.11.1.
- These current ratings are applicable for both armored and unarmored cables.
- If ambient temperature differs from 45°C (113°F), the values in 4-6-4/Table 10 are to be multiplied by the following factors.

Maximum Conductor Temperature	Ambient Correction Factor					
	40°C (104°F)	50°C (122°F)	55°C (131°F)	60°C (140°F)	65°C (149°F)	70°C (158°F)
75°C (167°F)	1.08	0.91	0.82	0.71	0.58	—
85°C (185°F)	1.06	0.94	0.87	0.79	0.71	0.61
90°C (194°F)	1.05	0.94	0.88	0.82	0.74	0.67
95°C (203°F)	1.05	0.95	0.89	0.84	0.77	0.71

- Where the number of conductors in a cable exceeds four, as in control cables, the maximum current carrying capacity of each conductor is to be reduced as in the following table:

No. of Conductors	% of 3-4/C TYPE Values in 4-6-4/Table 10
5-6	80
7-24	70
25-42	60
43 and above	50

- When a mineral-insulated cable is installed in such a location that its copper sheath is liable to be touched when in service, the current rating is to be multiplied by the correction factor 0.80 in order that the sheath temperature does not exceed 70°C (158°F).
- Cables being accepted based on approved alternate standard may have current carrying capacity of that standard, provided the cables are in full compliance with that standard.

TABLE 11
Additional Services Requiring Electrical Equipment to be Designed, Constructed and Tested to the Requirements in Section 4-6-4
[See 4-6-4/1, 4-6-4/3.1.1, 4-6-4/3.3.1, 4-6-4/7.1.1 and 4-6-4/7.3.1] (2010)

(a)	Equipment necessary for specific class notations (Such as refrigerated cargo notations, dynamic positioning systems, etc.). See Note.
(b)	Cargo Pump Motors (oil carriers, gas carriers, chemical carriers, liquefied gas carriers, etc.)
(c)	Motors for hydraulic power unit for hydraulically driven cargo pump motors
(d)	High duty gas compressors on liquefied gas carriers

Note: See 6-2-1/7 of the *Steel Vessel Rules* for refrigerated cargo notations and the *ABS Guide for Dynamic Positioning Systems* for dynamic positioning notations.

PART

4

CHAPTER 6 Electrical Installations

SECTION 5 Specialized Installations

1 High Voltage Systems

1.1 General

1.1.1 Application (2003)

The following requirements in this Subsection are applicable to AC systems with nominal voltage (phase to phase) exceeding 1 kV. Unless stated otherwise, high voltage equipment and systems are to comply with the other parts in Part 4, Chapter 6 for low voltage equipment and systems, as well.

1.1.2 Standard Voltages (2003)

The nominal standard voltage is not to exceed 15 kV. A higher voltage may be considered for special application.

1.1.3 Air Clearance and Creepage Distance (1 July 2016)

1.1.3(a) *Air Clearance.* Phase-to-phase air clearances and phase-to-earth air clearances between non-insulated parts are to be not less than the minimum as specified below:

<i>Nominal Voltage in kV</i>	<i>Minimum Air Clearance in mm (in.)</i>
3–3.3	55 (2.2)
6–6.6	90 (3.6)
10–11	120 (4.8)
15	160 (6.3)

Where intermediate values of nominal voltages are accepted, the next higher air clearance is to be observed.

1.1.3(b) *Reduction.* Alternatively, reduced clearance distances may be used provided:

- i) The equipment is not installed in ‘Machinery Spaces of Category A’ or in areas affected by a Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System.
- ii) The equipment is subject to an impulse voltage test with test voltage values shown in Table below. Where intermediate values of rated operational voltage are used, the next higher rated impulse withstand test voltage is to be used. The impulse voltage test reports are to be submitted to ABS for review.

<i>Rated Voltage kV</i>	<i>Rated Impulse Withstand Voltage kV (peak value)</i>
3.6	40
7.2	60
12	75
15	95

1.1.3(c) *Insulating Material.* Any insulating material that is used to cover live parts of equipment used to comply with clearance distance requirements is to be suitable for the application. The equipment manufacturer is to submit documentation which demonstrates the suitability of such insulation material.

1.1.3(d) *Creepage Distances (1 July 2016).* Creepage distances between live parts and between live parts and earthed metal parts are to be in accordance with IEC 60092-503 for the nominal voltage of the system, the nature of the insulation material, and the transient overvoltage developed by switch and fault conditions.

- i) The minimum creepage distances for main switchboards and generators are given in the Table below:

Nominal Voltage V	Minimum Creepage Distance for Proof Tracking Index mm (in.)			
	300 V	375 V	500 V	>600 V
1000-1100	26 (1.02) ⁽¹⁾	24 (0.94) ⁽¹⁾	22 (0.87) ⁽¹⁾	20 (0.79) ⁽¹⁾
< 3300	63 (2.48)	59 (2.32)	53 (2.09)	48 (1.89)
< 6600	113 (4.45)	108 (4.25)	99 (3.9)	90 (3.54)
≤ 11000 ⁽²⁾	183 (7.20)	175 (6.89)	162 (6.38)	150 (5.91)

Notes:

- 1 A distance of 35 mm is required for busbars and other bare conductors in main switchboards.
- 2 Creepage distances for equipment with nominal voltage above 11 kV shall be subject to consideration.

- ii) The minimum creepage distances for equipment other than main switchboards and generators are given in the Table below:

Nominal Voltage V	Minimum Creepage Distance for Proof Tracking Index mm (in.)			
	300 V	375 V	500 V	>600 V
1000-1100	18 (0.71)	17 (0.67)	15 (0.59)	14 (0.55)
< 3300	42 (1.65)	41 (1.61)	38 (1.50)	26 (1.02)
< 6600	83 (3.27)	80 (3.15)	75 (2.95)	70 (2.76)
≤ 11000*	146 (5.75)	140 (5.51)	130 (5.11)	120 (4.72)

* Note: Creepage distances for equipment with nominal voltage above 11 kV shall be subject to consideration.

1.3 System Design

1.3.1 Selective Coordination

Selective coordination is to be in accordance with 4-6-2/9.1.5, regardless of the system neutral earthing arrangement.

1.3.2 Earthed Neutral Systems

1.3.2(a) *Neutral earthing (2003).* The current in the earth fault condition is to be not in excess of full load current of the largest generator on the switchboard or relevant switchboard section and in no case less than three times the minimum current required for operation of any device in the earth fault condition.

At least one source neutral to ground connection is to be available whenever the system is in the energized mode.

1.3.2(b) *Equipment (2003)*. Electrical equipment in directly earthed neutral or other neutral earthed systems is to be able to withstand the current due to a single phase fault against earth for a period necessary to trip the protection device.

1.3.3 Neutral Disconnection

Each generator neutral is to be provided with means for disconnection.

1.3.4 Hull Connection of Earthing Impedance (2003)

All earthing impedances are to be connected to the hull. The connection to the hull is to be so arranged that any circulating currents in the earth connections will not interfere with radio, radar, communication and control equipment circuits. In systems with neutral earthed, connection of the neutral to the hull is to be provided for each generator switchboard section.

1.3.5 Earth Fault Detection (2003)

An earth fault is to be indicated by visual and audible means. In low impedance or direct earthed systems, provision is to be made to disconnect automatically the faulty circuits. In high impedance earthed systems where outgoing feeders will not be isolated in case of an earth fault, the insulation of the equipment is to be designed for the phase to phase voltage.

1.3.6 Number and Capacity of Transformers (2014)

Requirements for the number and capacity of transformers are given in 4-6-2/7.1.6(a).

For transformers with a high voltage winding over 1000 V, the following would not be accepted as complying with the above requirement:

- i) The provision of a spare single phase transformer to substitute a failed transformer.
- ii) The operation of two single phase transformers in an open delta (V-V) connection.

1.5 Circuit Breakers and Switches – Auxiliary Circuit Power Supply Systems (2004)

1.5.1 Source and Capacity of Power Supply

Where electrical energy or mechanical energy is required for the operation of circuit breakers and switches, a means of storing such energy is to be provided with a capacity at least sufficient for two on/off operation cycles of all of the components. However, the tripping due to overload or short-circuit, and under-voltage is to be independent of any stored electrical energy sources. This does not preclude the use of stored energy for shunt tripping, provided alarms are activated upon loss of continuity in the release circuits and power supply failures. The stored energy may be supplied from within the circuit in which the circuit breakers or switches are located.

1.5.2 Number of External Sources of Stored Energy

Where the stored energy is supplied from a source external to the circuit, such supply is to be from at least two sources so arranged that a failure or loss of one source will not cause the loss of more than one set of generators and/or essential services. Where it will be necessary to have the source of supply available for dead ship startup, the source of supply is to be provided from the emergency source of electrical power

1.7 Circuit Protection

1.7.1 Protection of Generator (2003)

Protection against phase-to-phase fault in the cables connecting the generators to the switchboard and against inter-winding faults within the generator is to be provided. This is to trip the generator circuit breaker and automatically de-excite the generator. In distribution systems with a low impedance earthed neutral, phase to earth faults are to be likewise treated.

1.7.2 Protection of Power Transformers (2014)

Power transformers are to be provided with overload and short circuit protection. Each high-voltage transformer intended to supply power to the low-voltage ship service switchboard is to be protected in accordance with 4-6-2/9.15. In addition, the following means for protecting the transformers or the electric distribution system are to be provided:

1.7.2(a) Coordinated Trips of Protective Devices (2002). Discriminative tripping is to be provided for the following. See 4-6-2/9.1.5.

- i) Between the primary side protective device of the transformer and the feeder protective devices on the low-voltage ship service switchboard, or
- ii) Between the secondary side protective device of the transformer, if fitted, and the feeder protective devices on the low-voltage ship service switchboard.

1.7.2(b) Load Shedding Arrangement (2002). Where the power is supplied through a single set of three-phase transformers to a low-voltage ship service switchboard, automatic load shedding arrangements are to be provided when the total load connected to the low voltage ship service switchboard exceeds the rated capacity of the transformer. See 4-6-2/1.7 and 4-6-2/9.3.3.

1.7.2(c) Protection from Electrical Disturbance (2002). Means or arrangements are to be provided for protecting the transformers from voltage transients generated within the system due to circuit conditions, such as high-frequency current interruption and current suppression (chopping) as the result of switching, vacuum cartridge circuit breaker operation or thyristor-switching.

An analysis or data for the estimated voltage transients is to be submitted to show that the insulation of the transformer is capable of withstanding the estimated voltage transients. See 4-6-5/1.11.3(b).

1.7.2(d) Protection from Earth Faults (2002). Where a Y-neutral of three-phase transformer windings is earthed, means for detecting an earth fault are to be provided. The detection of the earth fault is to activate an alarm at the manned control station or to automatically disconnect the transformer from the high-voltage power distribution network.

1.7.2(e) Transformers Arranged in Parallel (2014). Refer to 4-6-2/9.15.2 for requirements.

1.7.3 Voltage Transformers for Control and Instrumentation (2003)

Voltage transformers are to be provided with overload and short circuit protection on the secondary side.

1.7.4 Fuses (2003)

Fuses are not to be used for overload protection.

1.7.5 Over Voltage Protection (2003)

Lower voltage systems supplied through transformers from high voltage systems are to be protected against overvoltages. This may be achieved by:

- i) Direct earthing of the lower voltage system,
- ii) Appropriate neutral voltage limiters, or
- iii) Earthed screen between primary and secondary winding of transformers

1.9 Equipment Installation and Arrangement

1.9.1 Degree of Protection

The degree of equipment protection is to be in accordance with 4-6-3/Table 1.

1.9.2 Protective Arrangements

1.9.2(a) Interlocking Arrangements. Where high-voltage equipment is not contained in an enclosure but a room forms the enclosure of the equipment, the access doors are to be so interlocked that they cannot be opened until the supply is isolated and the equipment earthed down.

1.9.2(b) *Warning Plate (1 July 2016)*. At the entrance of such spaces, a suitable marking is to be placed which indicates danger of high-voltage and the maximum voltage inside the space. For high-voltage electrical equipment installed outside these spaces, a similar marking is to be provided. An adequate, unobstructed working space is to be left in the vicinity of high voltage equipment for preventing potential severe injuries to personnel performing maintenance activities. In addition, the clearance between the switchboard and the ceiling/deckhead above is to meet the requirements of the Internal Arc Classification according to IEC 62271-200.

1.9.2(c) *Exposure of HV Equipment to Damaging Environments (2014)*. Consideration should be given to designing the arrangement of the installation to avoid exposure of high voltage equipment to contaminants, such as oil or dust, as might be found in machinery spaces or close to ventilation air inlets to the space, or to water spray from water-mist systems and local fire hose connections.

1.9.3 Cables

1.9.3(a) *Runs of Cables (2003)*. In accommodation spaces, high voltage cables are to be run in enclosed cable transit systems.

1.9.3(b) *Segregation (2003)*. High voltage cables of different voltage ratings are not to be installed in the same cable bunch, duct, pipe or box. Where high voltage cables of different voltage ratings are installed on the same cable tray, the air clearance between cables is not to be less than the minimum air clearance for the higher voltage side in 4-6-5/1.1.3(a). However, high voltage cables are not to be installed on the same cable tray for the cables operating at the nominal system voltage of 1 kV or less.

Higher voltage equipment is not to be combined with lower voltage equipment in the same enclosure, unless segregation or other suitable measures are taken to ensure safe access to lower voltage equipment

1.9.3(c) *Installation Arrangements (2003)*. High voltage cables are to be installed on cable trays or equivalent when they are provided with a continuous metallic sheath or armor which is effectively bonded to earth. Otherwise, they are to be installed for their entire length in metallic casings effectively bonded to earth.

1.9.3(d) *Termination and Splices (2014)*. Terminations in all conductors of high voltage cables are to be, as far as practicable, effectively covered with suitable insulating material. In terminal boxes, if conductors are not insulated, phases are to be separated from earth and from each other by substantial barriers of suitable insulating materials. High voltage cables of the radial field type (i.e., having a conductive layer to control the electric field within the insulation) are to have terminations which provide electric stress control.

Terminations are to be of a type compatible with the insulation and jacket material of the cable and are to be provided with means to ground all metallic shielding components (i.e., tapes, wires, etc.).

Splices and joints are not permitted in propulsion cables. For purposes of this Rule, propulsion cables are those cables whose service is related only to propulsion.

1.9.3(e) *Cable Rating (2014)*. The rated phase to earth voltage (U_o) of high voltage cables shall not be less than shown in the Table below:

Nominal System Voltage (U_n) (kV)	Highest System Voltage (U_m) (kV)	Rated Phase to Earth Voltage (U_o) (kV)	
		Systems with Automatic Disconnection Upon Detection of an Earth Fault	Systems without Automatic Disconnection Upon Detection of an Earth Fault
3.0	3.6	1.8	3.6
3.3	3.6	1.8	3.6
6.0	7.2	3.6	6.0
6.6	7.2	3.6	6.6
10.0	12.0	6.0	10.0
11.0	12.0	6.0	11.0
15.0	17.5	8.7	15.0

1.9.3(f) *Cable Current Carrying Capacities (2014)*. The maximum current carrying capacity of high voltage cables is to be in accordance with the Table below:

Conductor Size (mm ²)	Maximum Current in Amperes 45°C Ambient; 1000 V and More			
	1-Core		3-Core	
	85°C	90°C	85°C	90°C
16	80	85	55	60
25	105	115	75	80
35	130	140	90	95
50	165	175	115	120
70	205	215	140	150
95	245	260	170	185
120	285	305	200	210
150	330	350	230	245
185	375	400	260	280
240	440	470	310	325
300	505	540	355	375
400	605	645	425	450
500	700	740	490	520

1.9.3(g) *Marking*. High voltage cables are to be readily identifiable by suitable marking.

1.9.3(h) *Cable Test after Installation (1 July 2016)*. A voltage withstand test is to be carried out on each completed cable and its accessories before a new high voltage installation, including additions to an existing installation, is put into service.

An insulation resistance test is to be carried out prior to the voltage withstand test being conducted.

For cables with rated voltage (U_o/U) above 1.8/3 kV ($U_m = 3.6$ kV) an AC voltage withstand test may be carried out upon advice from high voltage cable manufacturer. One of the following test methods to be used:

- i) An AC test voltage for 5 min with the phase-to-phase voltage of the system applied between the conductor and the metallic screen/sheath.
- ii) An AC voltage test for 24 h with the normal operating voltage of the system.
- iii) A DC test voltage equal to $4U_o$ may be applied for 15 minutes.

For cables with rated voltage (U_o/U) up to 1.8/3 kV ($U_m = 3.6$ kV), a DC voltage equal to $4U_o$ shall be applied for 15 minutes.

After completion of the test, the conductors are to be connected to earth for a sufficient period in order to remove any trapped electric charge.

The insulation resistance test is then repeated.

The above tests are for newly installed cables. If due to repairs or modifications, cables which have been in use are to be tested, lower voltages and shorter durations should be considered.

1.9.4 High Voltage Shore Connection (2014)

Where arrangements are made for the supply of electricity at high voltage from onshore, and designed to allow the shipboard generators to be shut down while in port, the requirements given in the *ABS Guide for High Voltage Shore Connection*.

1.11 Machinery and Equipment

1.11.1 Rotating Machines (2014)

1.11.1(a) *Protection (2014)*. Refer to 4-6-5/Table 1 for ingress protection (IP) requirements.

1.11.1(b) *Windings (2003)*. Generator stator windings are to have all phase ends brought out for the installation of the differential protection.

1.11.1(c) *Temperature Detectors*. Rotating machines are to be provided with temperature detectors in their stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit. If embedded temperature detectors are used, means are to be provided to protect the circuit against over-voltage.

1.11.1(d) *Space Heater*. Effective means are to be provided to prevent the accumulation of moisture and condensation within the machines when they are idle.

1.11.1(e) *Tests (2014)*. Each design of HV generator and motor is to be assessed by testing in accordance with the “type tests” schedule indicated in 4-6-4/Table 1. Each subsequent production unit of and accepted design is to be tested in accordance with the “routine tests” schedule also indicated in 4-6-4/Table 1.

- i) *Inter-turn Insulation Test*. In addition to the tests normally required for rotating machinery, a high frequency, high voltage test, in accordance with IEC Publication 60034-15, is to be carried out on the individual coils in order to demonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.
- ii) Immediately after the high voltage test the insulation resistance is to be measured using a direct current insulation test meter between:
 - a) All current carrying parts connected together and earth
 - b) All current carrying parts of different polarity or phase where both the ends of each polarity or phase are individually accessible.

The minimum values of test voltage and corresponding insulation resistance are given in the table below. The insulation resistance is to be measured close to the operating temperature. If this is not possible then an approved method of calculation is to be used.

Rated Voltage U_n (V)	Minimum Test Voltage (V)	Minimum Insulation Resistance (M Ω)
$1000 < U_n \leq 7200$	1000	$U_n/1000 + 1$
$7200 < U_n \leq 15000$	5000	$U_n/1000 + 1$

1.11.2 Switchgear and Control-gear Assemblies (2014)

Switchgear and control gear assemblies are to be constructed according to the IEC Publication 62271-200 and the following additional requirements:

1.11.2(a) *Mechanical Construction and Configuration (2016)*.

- i) Switchgear is to be of metal-enclosed type in accordance with IEC Publication 62271-200 or of the insulation-enclosed type in accordance with IEC Publication 62271-201.
- ii) Refer to 4-6-4/7.15.2 for requirements for the division of main bus bars.

1.11.2(b) *Clearance and Creepage Distances*. For clearance and creepage distances, see 4-6-5/1.1.3.

1.11.2(c) *Locking Facilities*. Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities in both service and disconnected positions. For maintenance purposes, key locking of withdrawable circuit breakers, switches and fixed disconnectors is to be possible. Withdrawable circuit breakers, when in the service position, are to have no relative motion between fixed and moving parts.

1.11.2(d) *Shutters (1 July 2016)*. The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawn position, the live contacts of the bus bars are automatically covered. Shutters are to be clearly marked for incoming and outgoing circuits. This may be achieved with the use of colors or labels.

1.11.2(e) *Earthing and Short-circuiting Facilities (2003)*. For maintenance purposes, an adequate number of earthing and short circuiting facilities are to be provided to enable equipment and cables to be earthed or short-circuited to earth before being worked upon.

1.11.2(f) *Arc Flash and Associated Installation Requirements (1 July 2016)*

- i) Internal Arc Classification (IAC). Switchgear and control gear assemblies are to be Internal Arc Classified (IAC). Where switchgear and control gear are accessible by authorized personnel only accessibility Type A is sufficient (IEC 62271-200; Annex AA; AA 2.2). Accessibility Type B is required if accessible by non-authorized personnel. Installation and location of the switchgear and control gear is to correspond with its internal arc classification and classified sides (F, L and R).
- ii) Calculations, in accordance with the applicable parts of Standard IEEE 1584 or other recognized standard, are to be made to establish:
 - The maximum current that can flow in the case of an arc fault
 - The maximum time and current that could flow if arc protection techniques are adopted
 - The distance, from the location of the arc flash, at which the arc flash energy would be 1.2 calories per cm² if the enclosure is open
- iii) In addition to the marking required by the equipment design standard, arc flash data consistent with the Design Operating Philosophy and the required PPE is also to be indicated at each location where work on the HV equipment could be conducted.

1.11.2(g) *Tests (2014)*. A power frequency voltage test is to be carried out on high voltage switchgear and control-gear assemblies with test voltages shown in the Table below. The test procedure is to be in accordance with IEC Publication 62271-200 Section 7/ *Routine Test*.

Rated Voltage (kV)	Rated Power Frequency Withstand Voltage (kV)
3.6	10
7.2	20
12	28
15	38

Where intermediate values of switchgear rated voltages are used, the next higher power frequency withstand test voltage is to be used.

1.11.3 Transformers (2002)

1.11.3(a) *Application (1 July 2016)*. Provisions of 4-6-5/1.11.3 are applicable to power transformers for essential services. See also 4-6-4/9. Items 4-6-5/1.11.3(c) and 4-6-5/1.11.3(d) are applicable to transformers of the dry type only. These requirements are not applicable to transformers intended for the following services:

- Instrument transformers.
- Transformers for static converters.
- Starting transformers.

Dry type transformers are to comply with the applicable Parts of the IEC Publication 60076-11. Liquid filled transformers are to comply with the applicable Parts of the IEC 60076 Series. Oil immersed transformers are to be provided with the following alarms and protections:

- Liquid level (Low) – alarm
- Liquid temperature (High) – alarm
- Liquid level (Low) – trip or load reduction
- Liquid temperature (High) – trip or load reduction
- Gas pressure relay (High) – trip

1.11.3(b) Plans (2002). In addition to the details required in 4-6-4/9, the applicable standard of construction and the rated withstanding voltage of the insulation are also to be submitted for review.

1.11.3(c) Enclosure (2003). Transformers are to have a degree of protection in accordance with 4-6-1/Table 2, but not less than IP23. However, when installed in spaces accessible to unqualified personnel, the degree of protection is to be increased to IP44. For transformers not contained in enclosures, see 4-6-5/1.9.1.

1.11.3(d) Space heater. Effective means to prevent accumulation of moisture and condensation within the transformers (when de-energized) is to be provided.

1.11.3(e) Testing (2002). Three-phase transformers or three-phase bank transformers of 100 kVA and above are to be tested in the presence of the Surveyor. The test items are to be in accordance with the standard applicable to the transformer. The tests are also to be carried out in the presence of the Surveyor for each individual transformer. Transformers of less than 100 kVA will be accepted subject to a satisfactory performance test conducted to the satisfaction of the Surveyor after installation.

Specific requirements are applicable for the following tests:

- i)* In the dielectric strength test, the short duration power frequency withstand voltage to be applied is to follow the standard applicable to the transformer but not less than the estimated voltage transient generated within the system. If the short duration power frequency withstand voltage is not specified in the applicable standard, IEC 60076-3 is to be referred to. For the voltage transient, see 4-6-5/1.7.2(c).
- ii)* The induced over-voltage withstand test (layer test) is also to be carried out in accordance with the standard applicable to the transformers in the presence of the Surveyor. This test is intended to verify the power-frequency withstand strength along the winding under test and between its phase (strength between turns and between layers in the windings). If the induced over-voltage withstand test is not specified in the applicable standard, IEC 60076-3 is to be referred to.

1.11.3(f) Nameplate (2002). In addition to the requirements in 4-6-4/Table 4c, the following information is also to be indicated on the nameplate:

- Applicable standard
- Short duration power frequency withstand voltage for verification of insulation level of each winding

1.11.4 Cables (2003)

1.11.4(a) Standards. Cables are to be constructed to IEC Publication 60092-353, 60092-354 or other equivalent recognized standard. See also 4-6-4/13.1.

1.13 Design Operating Philosophy (2014)

1.13.1 Objective

While this section covers the specific ABS requirements for High Voltage (HV) systems, it is recognized that system design and equipment construction are only parts of an overall approach that are required to allow HV systems to be operated safely. Other aspects that contribute towards HV safety include maintenance procedures, vessel and equipment operating procedures, permit to work procedures, company safety policy, personal protective equipment (PPE) and training, most of which are beyond the role of Classification. However, in order to assist ABS in its review of the design and construction of the vessel and its equipment it is necessary for ABS to be assured that the design is part of a larger overall approach or plan.

The High Voltage Design Principles document is to outline the concepts that are the basis of the design. It should identify risks and document the strategies that are used to mitigate each of the risks (e.g., remote switching, arc flash energy reduction equipment).

1.13.2 HV System Failures

The design should take into account each reasonably foreseeable failure type and address what actions will be expected of the crew for each failure. Due to the limited availability of specialist tools, equipment and spare parts on board and recognizing the additional dangers associated with space limitations, the remoteness of specialized medical help and facilities in the event of emergencies, it is desirable that, as far as practicable, the crew is not exposed to dangers that could be avoided. For these reasons it is preferable that the vessel's HV electrical system be designed such that the crew can safely isolate any damaged distribution equipment and switch to alternative supplies without the need to open the HV equipment.

1.13.3 Activities

For all HV switchboards and distribution boards, each type of operation or activity is to be identified and the means of undertaking the operation or activity safely is to be established. The operations and activities to be considered are to include the following:

- i) Taking readings
- ii) Normal operational switching
- iii) Isolation and making safe
- iv) Maintenance
- v) Fault finding
- vi) Inspection
- vii) Class Surveys

Where switchgear design calls for circuit breakers to be inspected prior to being put back into service following operation on overcurrent, this should also be covered.

1.13.4 Accessibility (1 July 2016)

An adequate, unobstructed working space of at least 2 m (6 ft) is to be left in the vicinity of high voltage equipment for preventing potential severe injuries to personal performing maintenance activities. Where the clear space around a location where activity is taking place is less than 2 m (6 ft), then the activities are to be covered in sufficient detail to take into account the work involved and the possible need to have clear and safe access for emergency medical evacuation. Where recommended by the switchgear manufacturer, the working space may be reduced to a minimum of 1.5 m (5 ft) due to special considerations such as the use of arc resistant switchgear.

Activities that do not require operation at the switchboard (e.g., telephones or manual call points) should not require the operator to be within 2 m (6 ft) of the switchboard.

1.13.5 Modifications

No modifications are to be made to HV switchgear without the plans being approved and the drawings being made available to the ABS Surveyor in advance of the work taking place. Testing of approved modifications is to be conducted in the presence of the ABS Surveyor. Temporary repairs are to be in full compliance with the requirements of these Rules.

1.13.6 HV Systems with Enhanced Operating Redundancy

Where the HV electrical system is designed with sufficient redundancy to allow switching and isolation along the principles in 4-6-5/1.13.2 and still meet the requirements of 4-6-2/3.1.2 with one generator in reserve, then the activity associated with that failure is not required to be included.

1.15 Preliminary Operations Manual (2014)

1.15.1 Objective

The preliminary operations manual contains the shipyard's description of operations affecting the vessel's HV equipment. The description 'preliminary' is used to capture the fact that it may not be the final document used by the vessel's Owner.

The manual is to be complete and sufficiently detailed to capture each piece of HV equipment and how the activities associated with that equipment can be achieved consistently with the Design Operating Philosophy. This manual is to be made available to the Owner by the shipyard.

The Owner will need the information contained in the preliminary operations manual to understand how the shipyard designed the HV equipment to be operated safely. It is likely that the Owner will modify some aspects of the manual to bring it in line with their own company policies, organizational responsibilities and legal duties.

The preliminary operations manual is to include for each piece of HV equipment:

- i) Details of the tasks (operations and activities) associated with that piece of equipment
- ii) Details of the 'Authorization' needed to perform each of the tasks
- iii) Details of the tools required to perform each of the tasks
- iv) Details of PPE and safety equipment (locks, barriers, tags, rescue hooks, etc.)
- v) Identify the tasks for which a 'permit to work' system is to be used.

1.15.2 Details of Authorization

For each operation or task involving HV switchgear and for access to the HV switchgear rooms, the appropriate authorizations are to be determined before delivery.

1.15.3 Training Requirements for Authorization

Part of the basis of establishing any level of authorization is training. It is not expected that the shipyard will stipulate what training qualifications are required. However, a description of the subjects that would need to be covered in the training for each level of authorization should be included.

The Owner can be guided by the above information in making decisions regarding the crew training requirements.

1.15.4 Test, Maintenance Tools and PPE

Where tasks require the use of PPE, the required protection clothing rating should be identifiable in the preliminary operations manual and on a label on the HV equipment where that task will take place. The level of protection offered by the PPE is to be readily identified on the PPE itself in the same terms or units as used on the labels.

Some PPE for general use is not suitable for High Voltage or arc flash hazards, mostly through inappropriate fire performance; such PPE is to be excluded from high voltage switchgear rooms. Information alerting the crew of the need to be able to recognize and use the right PPE is to be included in the manual.

1.15.5 Inspection and Maintenance of Test Equipment Tools and PPE

Where PPE or test equipment is provided by the shipyard the means for its proper use, inspection, calibration and maintenance is to be made available. The instructions or directions regarding where they are kept are to be contained in the Preliminary Operations Manual.

Where the PPE is not provided by the shipyard a description or specification regarding the required tools and PPE should be provided in the Preliminary Operations Manual.

3 Electric Propulsion System

3.1 General (2007)

3.1.1 Application (2014)

The following requirements in this subsection are applicable to electric propulsion systems. Electric propulsion systems complying with other recognized standards will also be considered, provided it can be shown, through either satisfactory service experience or a systematic analysis based on sound engineering principles, to meet the overall safety standards of these Rules. Unless stated otherwise, electric propulsion equipment and systems are to comply with the applicable requirements in other parts of Part 4, Chapter 6, as well.

3.1.2 Plans and Data to be Submitted

In addition to the plans and data to be submitted in accordance with 4-6-2/1, 4-6-3/1 and 4-6-4/1, the following plans and data are to be submitted for review.

- One-line diagrams of the propulsion control system for power supply, circuit protection, alarm, monitoring, safety and emergency shutdown systems, including list of alarm and monitoring points.
- Plans showing the location of the propulsion controls and its monitoring stations.
- Arrangements and details of the propulsion control console or panel, including schematic diagram of the system therein.
- Arrangements and details of electric coupling.
- Arrangements and details of the semiconductor converters enclosure for the propulsion system, including data for the semiconductor converter and cooling system with its interlocking arrangement.

3.3 System Design (2007)

3.3.1 General (2016)

For the purposes of the electric propulsion system requirements, an electric propulsion system is one in which the main propulsion of the vessel is provided by at least one electric motor. A vessel may have more than one electrical propulsion system.

An integrated electric propulsion system is a system where a common set of generators supply power to the vessel service loads as well as the propulsion loads.

In the case of an integrated electrical propulsion system, the electrical drive train is considered to consist of the equipment connected to the electrical network such as a drive (frequency converter) and the propulsion motor(s).

All electrical equipment that is part of the electric propulsion drive train is to be built with redundancy such that a single failure will not completely disable the propulsion of the vessel. Where electric motors are to provide the sole means of propulsion for a vessel, a single propulsion motor with dual windings does not meet this requirement.

3.3.2 Generating Capacity

For vessels with an integrated electric propulsion system, under normal sea-going conditions, when one generator is out of service, the remaining generator capacity is to be sufficient to carry all of the vessel services (essential services, normal services and for minimum comfortable conditions of habitability) and an effective level of propulsion.

3.3.3 Power Management System (2014)

For vessels with an integrated electric propulsion system, a power management system is to be provided. The power management system is to control load sharing between generators, prevent blackouts, maintain power to the essential service loads and maintain power to the propulsion loads.

The system is to account for the following operating scenarios.

- All generators in operation, then the loss of one generator
- When at least one generator is not in operation and there is an increase in the propulsion loads or a loss of one of the generators, that would result in the need to start a generator that was not in operation.
- Upon failure of the power management system, there is to be no change in the available electrical power. Failure of the power management system is to be alarmed at a manned control station.

Further, the system is to prevent overloading the generators, by reducing the propulsion load or load shedding of non-essential loads. In general, the system is to limit power to the propulsion loads to maintain power to the vessel's essential service loads. However, the system is to shed non-essential loads to maintain power to the propulsion loads.

An audible and visible alarm is to be installed at each propulsion control location and is to be activated when the system is limiting the propulsion power in order to maintain power to the other essential service loads.

When at least one generator is not in operation, consideration should be given to keeping one generator in standby mode, so that it can be brought on line within 45 seconds, upon failure of one of the running generators.

Operation with only one generator on line should only be considered, when another generator can be brought on line within 45 seconds of failure of the running generator.

3.3.4 Regenerative Power (2014)

For systems where regenerative power may be developed, the regenerative power is not to cause overspeeding of the prime mover or variations in the system voltage and frequency which exceeds the limits of 4-6-1/9. See also 4-6-5/3.17.4(a) and 4-6-5/3.17.4(e).

3.3.5 Harmonics (2014)

A harmonic distortion calculation is to be submitted for review for all vessels with electric propulsion. The calculation is to indicate that the harmonic distortion levels at all locations throughout the power distribution system (main generation switchboard, downstream power distribution switchboards, etc.) are within the limits of 4-6-2/7.9. The harmonic distortion levels at dedicated propulsion buses are also to be within the limits of 4-6-2/7.9, otherwise documentation from the manufacturer is to be submitted indicating that the equipment is designed for operation at a higher level of distortion.

Where higher values of harmonic distortion are expected, any other possible effects, such as additional heat losses in machines, network resonances, errors in control and monitoring systems are to be considered.

Means of monitoring voltage harmonic distortion shall be provided, including alarms at the main generation switchboard and at continuously manned stations when to notify of an increase in total or individual harmonic distortion levels above the maximum allowable levels.

Harmonic filters, if used, are to comply with requirements mentioned in 4-6-2/9.19.

3.5 Propulsion Power Supply Systems (2014)

3.5.1 Propulsion Generators

3.5.1(a) Power Supply. The power for the propulsion equipment may be derived from a single generator. If a ship service generator is also used for propulsion purposes other than for boosting the propulsion power, such generator and power supply circuits to propulsion systems are also to comply with the applicable requirements in this subsection. See also 4-6-2/3.1.4.

3.5.1(b) Single System. If a propulsion system contains only one generator and one motor and cannot be connected to another propulsion system, more than one exciter set is to be provided for each machine. However, this is not necessary for self-excited generators or for multi-propeller propulsion vessels where any additional exciter set may be common for the vessel.

3.5.1(c) Multiple Systems. Systems having two or more propulsion generators, two or more semiconductor converters or two or more motors on one propeller shaft are to be so arranged that any unit may be taken out of service and disconnected electrically without preventing the operation of the remaining units.

3.5.1(d) Excitation Systems. Arrangements for electric propulsion generators are to be such that propulsion can be maintained in case of failure of an excitation system or failure of a power supply for an excitation system. Propulsion may be at reduced power under such conditions where two or more propulsion generators are installed, provided such reduced power is sufficient to provide for a speed of not less than 7 knots or $1/2$ of design speed, whichever is the lesser.

3.5.1(e) Features for Other Services. If the propulsion generator is used for other purposes than for propulsion, such as dredging, cargo oil pumps and other special services, overload protection in the auxiliary circuit and means for making voltage adjustments are to be provided at the control board. When propulsion alternating-current generators are used for other services for operation in port, the port excitation control is to be provided with a device that is to operate just below normal idling speed of the generator to remove excitation automatically.

3.5.2 Propulsion Excitation

3.5.2(a) Excitation Circuits. Every exciter set is to be supplied by a separate feeder. Excitation circuits are not to be fitted with overload circuit-interrupting devices, except those intended to function in connection with the protection for the propulsion generator. In such cases, the field circuit breaker is to be provided with a discharge resistor, unless a permanent discharge resistor is provided.

3.5.2(b) Field Circuits. Field circuits are to be provided with means for suppressing voltage rise when a field switch is opened. Where fuses are used for excitation circuit protection, it is essential that they do not interrupt the field discharge resistor circuit upon rupturing.

3.5.2(c) Ship's Service Generator Connection. Where the excitation supply is obtained from the ship's service generators, the connection is to be made to the generator side of the generator circuit breaker with the excitation supply passing through the overload current device of the breaker.

3.7 Circuit Protection (2016)

3.7.1 Setting

Overcurrent protective devices, if any, in the main circuits are to be set sufficiently high so as not to operate on overcurrents caused by maneuvering or normal operation in heavy seas or in floating broken ice.

3.7.2 Direct-current (DC) Propulsion Circuits

3.7.2(a) Circuit Protection. Direct-current propulsion circuits are not to have fuses. Each circuit is to be protected by overload relays to open the field circuits or by remote-controlled main-circuit interrupting devices. Provision is to be made for closing circuit breakers promptly after opening.

3.7.2(b) Protection for Reversal of the Rotation. Where separately driven DC generators are connected electrically in series, means shall be provided to prevent reversal of the rotation of a generator upon failure of the driving power of its prime mover.

3.7.3 Excitation Circuits

An overload protection is not to be provided for opening of the excitation circuit.

3.7.4 Reduction of Magnetic Fluxes

Means are to be provided for selective tripping or rapid reduction of the magnetic fluxes of the generators and motors so that overcurrents do not reach values which may endanger the plant.

3.7.5 Direct-current (DC) Propulsion Motors Supplied by Semiconductor Converters (2008)

The protection features of the semiconductor converters are to be arranged to avoid a damaging flashover in the DC propulsion motor. A possible cause of a damaging flashover would be removal of the field current. The protection features of the semiconductor converters are to take into account the increase in armature current created by the removal of the field current, due to accidental loss of the field, or activation of a protection feature intended to protect the field.

To verify compliance with the above, the maximum time-current characteristics that can be commutated by the motor as well as the time-current characteristics of the protective features of the semiconductor converters are to be submitted for review. To avoid a damaging flashover, the maximum time-current characteristics of the motor is to be provided by the motor manufacturer and is to be used by the semiconductor converter manufacturer to determine the appropriate set points for the protection features of the semiconductor converters.

3.9 Protection for Earth Leakage

3.9.1 Main Propulsion Circuits

Means for earth leakage detection are to be provided for the main propulsion circuit and be arranged to operate an alarm upon the occurrence of an earth fault. When the fault current flowing is liable to cause damage, arrangements for opening the main propulsion circuit are also to be provided.

3.9.2 Excitation Circuits

Means are to be provided for earth leakage detection in excitation circuits of propulsion machines but may be omitted in circuits of brushless excitation systems and of machines rated up to 500 kW.

3.9.3 Alternating current (AC) Systems

Alternating current propulsion circuits are to be provided with an earthing detector alarm or indicator. If the neutral is earthed for this purpose, it is to be through an arrangement which will limit the current at full-rated voltage so that it will not exceed approximately 20 amperes upon a fault to earth in the propulsion system. An unbalance relay is to be provided which is to open the generator and motor-field circuits upon the occurrence of an appreciable unbalanced fault.

3.9.4 Direct-current (DC) Systems

The earthing detector may consist of a voltmeter or lights. Provision is to be made for protection against severe overloads, excessive currents and electrical faults likely to result in damage to the plant. Protective equipment is to be capable of being so set as not to operate on the overloads or overcurrents experienced in a heavy seaway or when maneuvering.

3.11 Electric Propulsion Control

3.11.1 General

Failure of a control signal is not to cause an excessive increase in propeller speed. The reference value transmitters in the control stations and the control equipment are to be so designed that any defect in the desired value transmitters or in the cables between the control station and the propulsion system will not cause a substantial increase in the propeller speed.

3.11.2 Automatic and Remote Control Systems

Where two or more control stations are provided outside of the engine room, or where automatic control of the propulsion machinery is provided, Sections 4-7-1 through 4-7-5, as applicable, are to be complied with. See 4-7-1/3 for propulsion class symbols.

3.11.3 Testing and Inspection

Controls for electric propulsion equipment are to be inspected when finished and dielectric strength tests and insulation resistance measurements made on the various circuits in the presence of the Surveyor, preferably at the plant of manufacture. The satisfactory tripping and operation of all relays, contactors and the various safety devices are also to be demonstrated.

3.11.4 Initiation of Control

The control of the propulsion system can be activated only when the delegated control lever is in zero position and the system is ready for operation.

3.11.5 Emergency Stop

Each control station shall have an emergency stop device which is independent of the control lever.

3.11.6 Prime Mover Control

Where required by the system of control, means are to be provided at the control assembly for controlling the prime mover speed and for mechanically tripping the throttle valve.

3.11.7 Control Power Failure

If failure of the power supply occurs in systems with power-aided control (e.g., with electric, pneumatic or hydraulic aid), it is to be possible to restore control in a short time.

3.11.8 Protection

Arrangements are to be made so that opening of the control system assemblies or compartments will not cause inadvertent or automatic loss of propulsion. Where oil gauges are mounted on the main-control assembly, provision is to be made so that the oil will not come in contact with the energized parts in case of leakage.

3.11.9 Interlocks

All levers for operating contactors, line switches, field switches and similar devices are to be interlocked to prevent their improper operation. Interlocks are to be provided with the field lever to prevent the opening of any main circuit without first reducing the field excitation to zero, except that when the generators simultaneously supply power to an auxiliary load apart from the propulsion, the field excitation need only be reduced to a low value.

3.13 Instrumentation at the Control Station

3.13.1 Indication, Display and Alarms

The necessary instruments to indicate existing conditions at all times are to be provided and mounted on the control panel convenient to the operating levers and switches. Instruments and other devices mounted on the switchboard are to be labeled and the instruments provided with a distinguishing mark to indicate full-load conditions. Metallic cases of all permanently installed instruments are to be permanently earthed. The following instruments, where applicable, are to be provided.

3.13.1(a) For AC Systems. Ammeter, voltmeter, indicating wattmeter and field ammeter (*) for each propulsion generator and for each synchronous motor. See also 4-7-4/Table 6.

3.13.1(b) For DC Systems. An ammeter for each main circuit and one or more voltmeters with selector switches for reading voltage on each propulsion generator and motor. See also 4-7-4/Table 6.

3.13.1(c) For Electric Slip Couplings. An ammeter for the coupling excitation circuit.

* Field ammeter is not required for brushless generators

3.13.2 Indication of Propulsion System Status

The control stations of the propulsion systems are to have at least the following indications for each propeller.

3.13.2(a) "Ready for Operation". Power circuits and necessary auxiliaries are in operation.

3.13.2(b) "Faulty". Propeller is not controllable.

3.13.2(c) "Power Limitation". In case of disturbance, for example, in the ventilators for propulsion motors, in the converters, cooling water supply or load limitation of the generators.

3.15 Equipment Installation and Arrangement (2014)

3.15.1 General

The arrangement of bus bars and wiring on the back of propulsion-control assemblies is to be such that all parts, including the connections, are accessible. All nuts and connections are to be fitted with locking devices to prevent loosening due to vibration. Clearance and creepage distance are to be provided between parts of opposite polarity and between live parts and earth to prevent arcing. See 4-6-1/19, 4-6-4/7.11.6 and 4-6-5/1.11.2(b).

3.15.2 Accessibility and Facilities for Repairs

3.15.2(a) Accessibility. For purposes of inspection and repair, provision is to be made for access to the stator and rotor coils, and for the withdrawal and replacement of field coils. Adequate access is to be provided to permit resurfacing of commutators and slip-rings, as well as the renewal and bedding of brushes.

3.15.2(b) Facility for Supporting. Facilities shall be provided for supporting the shaft to permit inspection and withdrawal of bearings.

3.15.2(c) Slip-couplings. Slip-couplings are to be designed to permit removal as a unit without axial displacement of the driving and driven shaft, and without removing the poles.

3.15.3 Propulsion Cables

Propulsion cables are not to have splices or joints, except terminal joints, and all cable terminals are to be sealed against the admission of moisture or air. Similar precautions are to be taken during installation by sealing all cable ends until the terminals are permanently attached. Cable supports are to be designed to withstand short-circuited conditions. They are to be spaced less than 915 mm (36 in.) apart and are to be arranged to prevent chafing of the cable. See 4-6-3/5.9.1.

3.17 Machinery and Equipment (2014)

3.17.1 Material Tests

The following materials intended for main propulsion installation are to be tested in accordance with the *ABS Rules for Materials and Welding (Part 2)*: thrust shafts, line shafts, propeller shafts, shafting for propulsion generators and motors, coupling bolts, and in the case of direct-connected turbine-driven propulsion generators, fan shrouds, centering and retaining rings. Major castings or built-up parts such as frames, spiders and end shields are to be surface inspected and the welding is to be in accordance with the *ABS Rules for Materials and Welding (Part 2)*.

3.17.2 Temperature Rating

When generators, motors or slip-couplings for electric propulsion are fitted with an integral fan and will be operated at speeds below the rated speed with full-load torque, full-load current or full-load excitation temperature rise limits according to 4-6-4/Table 3 are not to be exceeded.

3.17.3 Protection Against Moisture Condensation

4-6-4/3.13.7 is applicable for rotating machines and converters, regardless of the weight of the machines.

3.17.4 Prime Movers

3.17.4(a) Capability. The prime mover rated output is to have adequate overloading and build-up capacity for supplying the power which is necessary during transitional changes in operating conditions of the electrical equipment. When maneuvering from full propeller speed ahead to full propeller speed astern with the vessel making full way ahead, the prime mover is to be capable of absorbing a proportion of the regenerated power without tripping due to overspeed.

3.17.4(b) Speed Control. Prime movers of any type are to be provided with a governor capable of maintaining the preset steady speed within a range not exceeding 5% of the rated full-load speed for load changes from full-load to no-load.

3.17.4(c) *Manual Controls.* Where the speed control of the propeller requires speed variation of the prime mover, the governor is to be provided with means for local manual control, as well as for remote control. For turbines driving AC propulsion generators, where required by the system of control, the governor is to be provided with means for local hand control, as well as remote adjustment from the control station.

3.17.4(d) *Parallel Operation.* In case of parallel operation of generators, the governing system is to permit stable operation to be maintained over the entire operational speed range of the prime movers.

3.17.4(e) *Protection for Regenerated Power.* Braking resistors or ballast consumers are to be provided to absorb excess amounts of regenerated energy and to reduce the speed of rotation of the propulsion motor. These braking resistors or ballast consumers are to be located external to the mechanical and electric rotating machines. Alternatively, the amount of regenerated power may be limited by the action of the control system.

3.17.5 Rotating Machines for Propulsion

The following requirements are applicable to propulsion generators and propulsion motors.

3.17.5(a) *Ventilation and Protection.* Electric rotating machines for propulsion are to be enclosed ventilated or be provided with substantial wire or mesh screen to prevent personnel injury or entrance of foreign matter. Dampers are to be provided in ventilating air ducts, except when re-circulating systems are used.

3.17.5(b) *Fire-extinguishing Systems.* Electric rotating machines for propulsion which are enclosed or in which the air gap is not directly exposed are to be fitted with fire-extinguishing systems suitable for fires in electrical equipment. This will not be required where it can be established that the machinery and insulation is self-extinguishing.

3.17.5(c) *Air Coolers (2004).* Air cooling systems for propulsion generators are to be in accordance with 4-2-1/11.3 and 4-2-1/11.7. Water-air heat exchangers of rotating propulsion machines for single systems (single generator and single motor), as specified in 4-6-5/3.5.1(b), are to have double wall tubes and be fitted with a leak detector feature to monitor for any water leakage. A visual and audible alarm is to be provided at a normally manned location to indicate such water leakage.

3.17.5(d) *Temperature Sensors (1997).* Stator windings of AC machines and interpole windings of DC machines rated above 500 kW are to be provided with temperature sensors. See 4-7-4/Table 6.

3.17.5(e) *Generator Excitation (2014).* Excitation current for propulsion generators may be derived from attached rotating exciters, static exciters, excitation motor-generator sets or special purpose generating units. Power for these exciters may be derived from the machine being excited or from any ship service, emergency or special purpose generating units.

3.17.5(f) *Propulsion Motors (2014).* Propulsion motors are to be designed to be capable of withstanding the mechanical and thermal effects of a short-circuit at its terminals.

3.17.6 Direct-current (DC) Propulsion Motors

3.17.6(a) *Rotors.* The rotors of DC propulsion motors are to be capable of withstanding overspeeding up to the limit reached in accordance with the characteristics of the overspeed protection device at its normal operational setting.

3.17.6(b) *Overspeed Protection.* An overspeed protection device is to be provided to prevent excessive overspeeding of the propulsion motors due to light loads, loss of propeller, etc.

3.17.7 Electric Couplings

3.17.7(a) *General.* Couplings are to be enclosed ventilated or be provided with wire or mesh screen to prevent personnel injury or the entrance of foreign material. All windings are to be specially treated to resist moisture, oil and salt air.

3.17.7(b) *Accessibility for Repairs.* The coupling is to be designed to permit removal as a unit without moving the engine. See also 4-6-5/3.15.2.

3.17.7(c) *Temperature Rating.* The limits of temperature rise are to be the same as for alternating-current generators given in 4-6-4/Table 3, except that when a squirrel-cage element is used, the temperature of this element may reach such values as are not injurious. Depending upon the cooling arrangements, the maximum temperature rise may occur at other than full-load rating so that heat runs will require special consideration. For this purpose, when an integral fan is fitted, the coupling temperatures are not to exceed the limits in 4-6-4/Table 3 when operated continuously at 70% of full-load rpm, full excitation and rated torque. Temperature rises for insulation materials above 180°C (356°F) will be considered in accordance with 4-6-1/13.11.

3.17.7(d) *Excitation.* Excitation is to be provided as required for propulsion generators. See 4-6-4/3.21.1, 4-6-4/3.23.1 and 4-6-5/3.17.5(e).

3.17.7(e) *Control Equipment.* Electric-coupling control equipment is to be combined with the prime mover speed and reversing control and is to include a two-pole disconnect switch, short-circuit protection only, ammeter for reading coupling current, discharge resistor and interlocking to prevent energizing the coupling when the prime mover control levers are in an inappropriate position.

3.17.7(f) *Nameplates.* Nameplates of corrosion-resistant material are to be provided in an accessible position of the electric coupling and are to contain the following typical details:

- Manufacturer's name, serial number and frame designation
- Rated output and type of rating
- Ambient temperature range
- Rated voltage, speed and temperature rise
- Rated exciter voltage and current

3.17.8 Semiconductor Converters for Propulsion (2014)

Semiconductor converters are to comply with the requirements in 4-6-4/10.

3.17.9 Reactors and Transformers for Semiconductor Converters

3.17.9(a) *General.* Interphase reactors and transformers used with semiconductor converters are to conform with the requirements of 4-6-4/9.1.1, 4-6-4/9.1.2(c), 4-6-4/9.3, 4-6-4/9.5.1 and 4-6-4/9.5.2, and the following.

3.17.9(b) *Voltage Regulation.* Means to regulate transformer output voltage are to be provided to take care of increase in converter forward resistance and, in addition, to obtain the necessary performance characteristics of the converter unit in which the transformer is used.

3.17.9(c) *High Temperature Alarm.* Interphase reactors and transformers used with the semiconductor converters for main and auxiliary propulsion systems are to be provided with high temperature alarm at the switchboard or the propulsion control station. The setting value of the alarm is to be determined by their specific insulation class and is not to exceed the temperature corresponding to the limit listed in 4-6-4/Table 8.

3.17.10 Switches

3.17.10(a) *General Design.* All switches are to be arranged for manual operation and so designed that they will not open under ordinary shock or vibration. Contactors, however, may be operated pneumatically, by solenoids or other means in addition to the manual method which is to be provided, unless otherwise approved.

3.17.10(b) *Generator and Motor Switches.* Switches for generators and motors are preferably to be of the air-break type, but for alternating-current systems, where they are to be designed to open full-load current at full voltage, oil-break switches using nonflammable liquid may be used if provided with leak-proof, non-spilling tanks.

3.17.10(c) *Field Switches.* Where necessary, field switches are to be arranged for discharge resistors unless discharge resistors are permanently connected across the field. For alternating-current systems, means are to be provided for de-energizing the excitation circuits by the unbalance relay and ground relay.

3.17.11 Propulsion Cables

3.17.11(a) Conductors. The conductors of cables external to the components of the propulsion plant, other than cables and interconnecting wiring for computers, data loggers or other automation equipment requiring currents of very small value, are to consist of not less than seven strands and have a cross-sectional area of not less than 1.5 mm² (2,960 circ. mils).

3.17.11(b) Insulation Materials. Ethylene-propylene rubber, cross-linked polyethylene or silicone rubber insulated cables are to be used for propulsion power cables, except that polyvinyl chloride insulated cables may be used where the normal ambient temperature will not exceed 50°C (122°F).

3.17.11(c) Braided Metallic Armor and Impervious Metallic Sheaths (1998). Propulsion cables need not have braided metallic armor nor impervious metallic sheaths. Where metallic sheaths are provided, they are not to be used with single alternating current cables.

3.17.11(d) Inner Wiring. The insulation of internal wiring in main control gear, including switchboard wiring, shall be of flame-retardant quality.

3.17.11(e) Testing. All propulsion cables, other than internal wiring in control gears and switchboards, are to be subjected to dielectric and insulation tests in the presence of the Surveyor.

3.19 Dock and Sea Trials (2014)

Complete tests of the entire electric propulsion system are to be carried out during sea-trials including the following:

- i)* Duration runs with the ship at full propulsion load.
- ii)* Maneuvering tests which should include a reversal of the vessel from full speed ahead to full speed astern during which important measurements such as system currents, voltages, speed, etc. shall be recorded.
- iii)* Tests to check for operation of all protective devices, safety functions, alarms, indicators, control modes and stability tests for control.

All tests necessary to demonstrate that major components of the electric propulsion plant and the system as a whole are satisfactory for duty are to be performed. Immediately prior to trials, the insulation resistance is to be measured and recorded.

5 Three-wire Dual-voltage DC System

5.1 Three-wire DC Ship's Generators

Separate circuit-breaker poles are to be provided for the positive, negative, neutral and also for the equalizer leads, unless protection is provided by the main poles. When equalizer poles are provided for the three-wire generators, the overload trips are to be of the algebraic type. No overload trip is to be provided for the neutral pole, but it is to operate simultaneously with the main poles. A neutral overcurrent relay and alarm system is to be provided and set to function at a current value equal to the neutral rating.

5.3 Neutral Earthing

5.3.1 Main Switchboard

The neutral of three-wire dual-voltage direct-current systems is to be solidly earthed at the generator switchboard with a zero-center ammeter in the earthing connection. The zero-center ammeter is to have a full-scale reading of 150% of the neutral-current rating of the largest generator and be marked to indicate the polarity of earth. The earth connection is to be made in such a manner that it will not prevent checking the insulation resistance of the generator to earth before the generator is connected to the bus. The neutrals of three-wire DC emergency power systems are to be earthed at all times when they are supplied from the emergency generator or storage battery. The earthed neutral conductor of a three-wire feeder is to be provided with a means for disconnecting and is to be arranged so that the earthed conductor cannot be opened without simultaneously opening the unearthed conductors.

5.3.2 Emergency Switchboard

No direct earth connection is to be provided at the emergency switchboard. The neutral bus or buses are to be solidly and permanently connected to the neutral bus of the main switchboard. No interrupting device is to be provided in the neutral conductor of the bus-tie feeder connecting the two switchboards.

5.5 Size of Neutral Conductor

The capacity of the neutral conductor of a dual-voltage feeder is to be 100% of the capacity of the unearthed conductors.

7 Electrical Plants of Less Than 75 kW

7.1 General (2006)

Electrical plants having an aggregate capacity of less than 75 kW are to comply with the following requirements and the requirements in this Part 4, Chapter 6, as applicable – except 4-6-1/17, 4-6-2/1.3, 4-6-2/1.5, 4-6-2/3, 4-6-2/5, 4-6-2/7.1.6(b), 4-6-2/9.1.5, 4-6-2/11.5, 4-6-2/11.7, 4-6-2/13.3, 4-6-2/15, 4-6-2/17.1, 4-6-2/17.3, 4-6-2/19.3, 4-6-3/1.1, 4-6-3/3.9, 4-6-4/7.15.2, 4-6-4/13 and 4-6-5/1.

7.3 Standard Details

Standard wiring practices and details, including such items as cable supports, earthing details, bulkhead and deck penetrations, cable joints and sealing, cable splicing, watertight and explosion-proof connections to equipment, earthing and bonding connections, etc., as applicable, are to be indicated on the submitted plans or may be submitted in a booklet format.

7.5 Calculations of Short-circuit Currents

In the absence of precise data, the following short circuit currents at the machine terminals are to be assumed:

7.5.1 Direct Current System

Ten times the full load current for generators normally connected (including spare) for each generator capable of being simultaneously connected.

Six times full load current for motors simultaneously in service.

7.5.2 Alternating Current System

Ten times the full load current for generators normally connected (including spare) for each generator capable of being simultaneously connected-symmetrical rms.

Three times full load current of motors simultaneously in service.

7.7 Lightning Protection

A lightning-protection system consisting of a copper spike and a copper conductor of at least 8 mm² (No. 8 AWC) is to be installed on each nonmetallic mast. The spike is to project at least 150 mm (6 in.) above the uppermost part of the vessel, the conductor is to run clear of metal objects and as straight as practicable to the metallic steel structure of the vessel.

7.9 Temperature Ratings

In the requirements contained in 4-6-5/7, an ambient temperature of 40°C (140°F) has been assumed for all locations. Where the ambient temperature is in excess of this value, the total temperature specified is not to be exceeded. Where equipment has been rated on ambient temperature less than that contemplated, consideration will be given to the use of such equipment, provided the total temperature for which the equipment is rated will not be exceeded.

7.11 Generators

Vessels using electricity for propulsion auxiliaries or preservation of cargo are to be provided with at least two generators. These generators are not to be driven by the same engine. The capacity of the generating sets is to be sufficient to carry the necessary load essential for the propulsion and safety of the vessel and preservation of the cargo (if applicable) with any one generator set in reserve. Vessels having only one generator are to be provided with a battery source to supply sufficient lighting for safety.

7.13 Emergency Source of Power

7.13.1 Capacity

The emergency source of electrical power is to have adequate capacity to provide emergency lighting for a period of at least six hours.

7.13.2 Sources

The emergency power source may be any of the following:

- i) An automatically connected or manually controlled storage battery; or
- ii) An automatically or manually started generator; or
- iii) Relay-controlled, battery-operated lanterns.

7.13.3 Battery Sources

Where the source of electrical power is a battery connected to a charging device with an output of more than 2 kW, the battery is to be located as near as practicable to, but not in the same space as, the emergency switchboard, distribution board or panel.

7.15 Cable Construction

Cables are to have copper conductors constructed in accordance with a recognized standard and are to be of the stranded type, except sizes not exceeding 1.5 mm² (16 AWG) may have solid conductors.

7.17 Switchboards, Distribution Boards and Panels

7.17.1 Installation

Switchboards, distribution box panels and panels are to be installed in dry, accessible and well-ventilated areas. Not less than 610 mm (24 in.) clearance is to be provided in front of switchboards, distribution box panels and panels. When located at the helm or other area adjacent to or part of an open cockpit or weather deck, they are to be protected by a watertight enclosure.

7.17.2 Instrumentation

A voltmeter, ammeter, frequency meter and voltage regulator are to be provided for each generator installed. Control equipment and measuring instruments are to be provided as necessary to insure satisfactory operation of the generator or generators.

7.19 Navigation Running Lights

Mast head, port, starboard and stem lights, when required, are to be controlled by a running light indicator panel. A fused-feeder disconnect switch is to be provided. The rating of the fuses is to be at least twice that of the largest branch fuse and greater than the maximum panel load.

TABLE 1
High Voltage Equipment Locations and Minimum Degree of Protection (2014)

Example of Location	Condition of Location	Switchboards, Distribution Boards, Motor Control Centers and Controllers				
		Generators				
		Motors				
		Transformers, Converters				
		Junction/Connection Boxes				
Dry control rooms Authorized Personnel Only	Danger of touching live parts only	IP32	N/A	N/A	IP23	IP44
Dry control rooms		IP42	N/A	N/A	IP44	IP44
Control rooms Authorized Personnel Only	Danger of dripping liquid and/or moderate mechanical damage	IP32	N/A	N/A	IP23	IP44
Control Rooms		IP42	N/A	N/A	IP44	IP44
Above floor plates in machinery spaces Authorized Personnel Only ⁽¹⁾		IP32	IP23	IP23	IP23	IP44
Above floor plates in machinery spaces		IP42	IP23	IP43	IP44	IP44
Emergency machinery rooms Authorized Personnel Only		IP32	IP23	IP23	IP23	IP44
Emergency machinery rooms		IP42	IP23	IP43	IP44	IP44
Below floor plates in machinery spaces Authorized Personnel Only	Increased danger of liquid and/or mechanical damage	N/A	N/A	*	*	IP44
Below floor plates in machinery spaces		N/A	N/A	*	N/A	IP44
Ballast pump rooms Authorized Personnel Only	Increased danger of liquid and mechanical damage	IP44	N/A	IP44	IP44	IP44
Ballast pump rooms		IP44	N/A	IP44	IP44	IP44
Holds for general cargo	Danger of liquid spray presence of cargo dust, serious mechanical damage, and/or aggressive fumes	*	*	*	*	IP55
Open decks ⁽²⁾	Not exposed to seas	N/A	IP56	IP56	IP56	IP56
Open decks ⁽²⁾	Exposed to seas	N/A	N/A	*	*	*

“*” indicates that equipment in excess of 1000 V is not normally permitted in these locations

Notes:

- See 4-6-3/3.1.1 where the equipment is located within areas affected by local fixed pressure water-spraying or water-mist fire extinguishing systems
- For High Voltage Shore Connections (HVSC) see the requirements in the *ABS Guide for High Voltage Shore Connection*
- Where the IP rating of the high voltage electrical equipment has been selected on the basis that it is only accessible to authorized personnel, the entrance doors to the spaces in which such equipment is located, are to be marked accordingly.

PART

4

CHAPTER 6 Electrical Installations

SECTION 6 Specialized Vessels and Services

1 Oil Carriers

1.1 Application (2007)

- i) In addition to the foregoing requirements of this Section, the following requirements are applicable to vessels carrying oil having a flash point not exceeding 60°C (140°F).

Note: Vessels of this type are subject to the applicable requirements of 3-4-1/5.1 and 3-4-1/5.3.1. The electric installation on bulk-oil vessels carrying oil having a flash point above 60°C (140°F), closed-cup test, will be subject to special consideration and 4-6-6/1.21, in each case.

- ii) Oil carriers subject to SOLAS are to comply with the requirements of IEC 60092-502 (1999) “Electrical Installations in Ships – Tankers – Special Features” in lieu of the electrical safety requirements associated with hazardous areas contained in 4-6-6/1 in accordance with SOLAS Chapter II-1, Regulation 45.11.
- iii) Vessels carrying oil having a flashpoint above 60°C subject to SOLAS are to comply with the requirements of Clause 4.3.1 of IEC 60092-502 (1999) “Electrical Installations in Ships – Tankers – Special Features” in accordance with SOLAS Chapter II-1, Regulation 45.11.
- iv) Vessels carrying oil having a flashpoint above 60°C subject to SOLAS are to comply with the requirements of Clause 4.3.2 of IEC 60092-502 (1999) “Electrical Installations in Ships – Tankers – Special Features” when cargoes are heated to a temperature within 15°C of their flashpoint in accordance with SOLAS Chapter II-1, Regulation 45.11.

1.3 Earthed Distribution Systems

An earthed distribution system is not to be used, except for the following applications.

- i) Earthed intrinsically-safe circuits.
- ii) Power supplied, control circuits and instrumentation circuits where technical or safety reasons preclude the use of a system without an earthing connection, provided the current in the hull is limited to 5 amperes or less in both normal and fault conditions.
- iii) Limited and locally earthed systems, provided that any possible resulting current does not flow directly through any hazardous areas.
- iv) Alternating-current power networks of 1 kV root mean square (rms) (line to line) and over, provided that any possible resulting current does not flow directly through any hazardous areas.

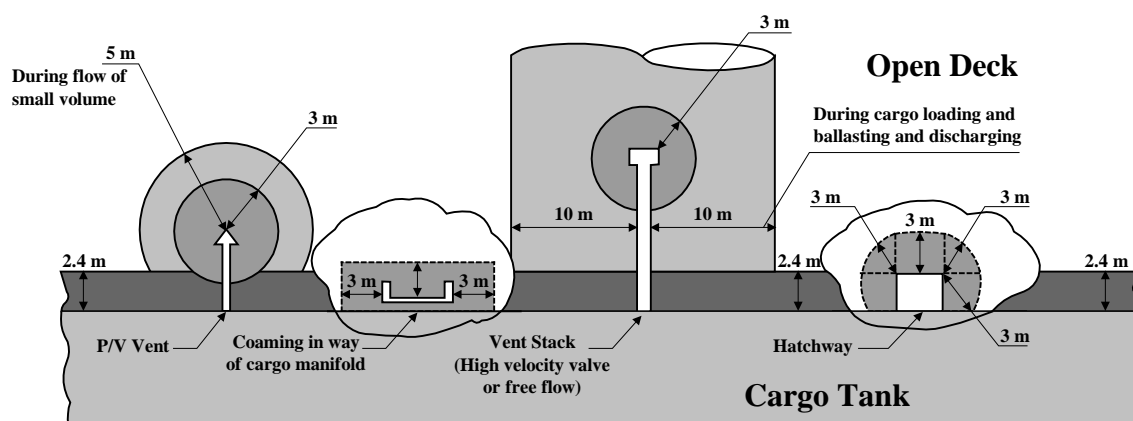
1.5 Hazardous Areas

The hazardous areas include: (see also 4-6-6/Figure 1)

- i) Cargo tanks and cargo piping
- ii) Cofferdams, and permanent (for example, segregated) ballast tanks adjacent to cargo tanks
- iii) Cargo pump rooms
- iv) Compartments for cargo hoses

- v) Enclosed or semi-enclosed spaces immediately above cargo pump rooms or having bulkheads above and in line with cargo bulkheads, where permitted by Reg. II-2/56 of SOLAS 1974, as amended
- vi) Enclosed or semi-enclosed spaces, immediately above cargo pump rooms, or above vertical cofferdams adjacent to cargo tanks, unless separated by a gas-tight deck and suitably mechanically ventilated, where permitted by Reg. II-2/56 of SOLAS 1974, as amended
- vii) Spaces, other than cofferdams, adjacent to and below the top of a cargo tank (for example, trunks, passageways and holds)
- viii) Areas on open decks, or semi-enclosed spaces on open decks, within 3 m of any cargo tank outlets, gas or vapor outlet, cargo manifold valve, cargo valve, cargo pipe flange, cargo pump room entrances or cargo pump room ventilation openings
Note: Such areas are, for example, all areas within 3 m of cargo tank hatches, sight ports, tank cleaning opening, valve openings, sounding pipes, cargo vapor outlets, cofferdam of cargo tanks.
- ix) Areas on open deck within spillage coaming surrounding cargo manifold valves and 3 m beyond these and other coamings intended to keep spillages clear of accommodation and service spaces, up to a height of 2.4 m above the deck
- x) Areas on open deck over all cargo tanks (including all ballast tanks within cargo tank area) and to the full breadth of the vessel plus 3 m fore and aft on open deck, up to a height of 2.4 m above the deck which do not belong to the hazardous areas defined in 4-6-6/1.5viii) and 4-6-6/1.5ix)
- xi) Enclosed or semi-enclosed spaces, having an opening into any hazardous area unless 4-6-6/1.7 is applicable
- xii) Enclosed or semi-enclosed spaces containing no source of hazard and having openings (including those for ventilating systems) into a hazardous area described in 4-6-6/1.5xiii)
- xiii) Areas on open deck:
 - A spherical-shaped area within 3 m to 5 m of pressure/vacuum valves used for small flow of vapor due to normal thermal variations in the tanks, or
 - A cylindrical-shaped area of infinite height within 3 m to 10 m of vent outlets for free flow of vapor mixtures and high velocity vent outlets for passage of large amounts of vapor, air or inert gas mixtures, which do not belong to the hazardous areas defined in 4-6-6/1.5viii), 4-6-6/1.5ix) and 4-6-6/1.5x).

FIGURE 1
Typical Hazardous Areas on Open Deck [See 4-6-6/1.5]



1.7 Enclosed Spaces Separated from Hazardous Areas by Air Locks

Equipment in enclosed spaces other than category A machinery spaces having access from open deck areas (4-6-6/1.5viii), 4-6-6/1.5ix), 4-6-6/1.5x) and 4-6-6/1.5xiii) need not be of a certified safe type, provided the access is through a double door air lock and the arrangements comply with either type 1 or type 2 as follows:

1.7.1 Type 1

1.7.1(a) The air lock is to consist of two gas tight steel doors of self-closing type with no holding back arrangement, spaced at least 1.5 m (5 ft) but not more than 2.5 m (8 ft) apart and is to be provided with mechanical ventilation.

1.7.1(b) The nonhazardous space is to be maintained at overpressure relative to the external hazardous area.

1.7.1(c) The relative overpressure or air flow is to be continuously monitored and so arranged that in the event of ventilation failure, an audible and visual alarm is given at a manned control station and the electrical supply to all equipment not of an approved explosion-proof or intrinsically-safe type is automatically disconnected. A time delay on the disconnect will be considered, where necessary.

1.7.1(d) Equipment for maneuvering, anchoring and mooring, as well as the emergency fire pump and any other electrical equipment, the shutdown of which could in itself introduce a hazard, is not to be located in spaces covered by this section unless the equipment is of an approved explosion-proof or intrinsically-safe type.

1.7.2 Type 2

1.7.2(a) The air lock is to consist of two gas tight steel doors of self-closing type with no holding back arrangement, spaced at least 1.5 m (5 ft) but not more than 2.5 m (8 ft) apart.

1.7.2(b) The non-hazardous space and the air lock are to be maintained at overpressure relative to the external hazardous area by independent mechanical ventilation systems arranged such that a single failure will not result in the simultaneous loss of overpressure in both the nonhazardous space and the air lock.

1.7.2(c) Failure of either ventilation system described in 4-6-6/1.7.2(b) is alarmed at a normally manned control station.

1.9 Installation of Equipment and Cables

1.9.1 General

Electrical equipment and wiring are not to be installed in any hazardous areas unless essential for operation purposes. In such cases, the installation of equipment and wiring are to comply with 4-6-6/Table 1.

1.9.2 Cables

All cables installed within the hazardous areas described in 4-6-6/1.5 are to be sheathed with a nonmetallic external impervious sheath over a metallic braiding or a metallic armoring or to be of mineral-insulated copper- or stainless steel-sheathed type. A nonmetallic impervious sheath is to be applied over the metallic braiding, armoring or sheathing of all cables which may be subject to corrosion. Cables installed on open deck or on fore and aft gangways are to be protected against mechanical damage. Cable and protective supports are to be so installed as to avoid strain or chafing and due allowance made for expansion or working of the structure.

1.9.3 Sea Depth Sounder, Speed Log, and Impressed Current Cathodic Protection Systems (2005)

Hull fittings containing transducers for electrical depth sounding or speed log devices or containing terminals or shell penetrations for anodes or electrodes of an impressed current cathodic protection system for underwater hull protection are not to be installed in any cargo tanks of an oil carrier. However, it may be installed in hazardous areas, as permitted by 4-6-6/Table 1, provided the following are complied with:

1.9.3(a) Hull fittings containing terminals or shell-plating penetrations are to be housed within a gas-tight enclosure and are not to be located adjacent to cargo tank bulkhead

1.9.3(b) The box containing actual electrical connection of the cable, such as terminal box or junction box, is to be filled with insulating material, such as silicon grease, silicon sealing or equivalent and also to be of gastight construction;

1.9.3(c) All associated cables passing through these spaces are to be installed in extra-heavy steel pipe with gas-tight joints (no flanged joints), and with corrosion resistant coating up to, and including the underside of the main deck;

1.9.3(d) Cable gland with gastight packing is to be provided for the cable at both ends of the cable conduit pipe; and

1.9.3(e) Cable inside the vertical cable conduit pipe is to be suitably supported, e.g., by sand-filling, or by strapping to a support-wire. Alternatively, the cable inside the vertical conduit pipe may be accepted without provided support if the mechanical strength of the cable is sufficient to prevent cable damage due to the cable weight within the conduit pipe under continuous mechanical load. Supporting documentation is to be submitted to verify the mechanical strength of the cable with respect to the cable weight inside the conduit.

1.11 Spaces Above Forepeak Tank

Equipment located in enclosed spaces above forepeak tanks is to be of an approved explosion-proof or intrinsically-safe type if there is direct access from the space into the forepeak tank with any of the following arrangements:

- i) The forepeak tank is not separated from cargo oil tanks by a cofferdam.
- ii) The forepeak tank is served by piping which also serves other spaces or tanks adjacent to cargo oil tanks, unless the only opening to the forepeak tank from the space above is through a gastight manhole and all other penetrations (i.e., sounding pipes) are led to the weather.

1.13 Cargo Oil Pump Room

1.13.1 Ventilation

1.13.1(a) *System and Arrangement.* Cargo oil pump rooms are to have a mechanical extraction ventilating system and ducting, in accordance with 4-6-6/1.13.1i), 4-6-6/1.13.1ii), 4-6-6/1.13.1iii), and 4-6-6/1.13.1iv) below.

- i) *Lower Intake.* Lower (main) intakes are to be located at the lowest floor level. The number of air changes through the main intake with the damper in item ii) closed is to be at least twenty changes per hour based on the gross volume of the pump room.
- ii) *Emergency Intake.* An emergency intake is to be provided at approximately 2 m (6.5 ft) above the lowest floor with damper capable of being opened or closed from the exposed main deck and lowest floor level so that it can be used when the lower intakes are not available. The air changes in that condition is to be at least fifteen changes per hour.
- iii) *Dampers.* Where the ratio of areas of the upper emergency intake and lower main intakes is such that the required number of respective air changes in items i) and ii) above can be obtained, the dampers may not be required.
- iv) *Floor Plate.* Floors are to be open grating type to allow the free flow of air. See 5C-1-1/5.25 and 5C-2-1/5.23 of the *Steel Vessel Rules*.

1.13.1(b) *Fan Motors and Fans.* Fan motors are to be located outside of the pump room and outside of the ventilation ducts. Fans are to be of nonsparking construction in accordance with 4-6-3/11.7. Provision is to be made for immediate shutdown of the fan motors upon release of the fire extinguishing medium.

1.13.2 Gas Detection (1998)

A system for continuously monitoring the concentration of hydrocarbon gases in the pump room is to be fitted. A system utilizing sequential sampling is acceptable, provided the system is dedicated solely to the pump room, thereby minimizing the sampling cycle. Sampling points or detector heads are to be located in the exhaust ventilation duct and lower parts of the pump room at the floor level. The system is to give a visual indication of the level of concentration of hydrocarbon gases and an audible alarm if the concentration exceeds 10% of the lower explosive limit. Such alarm is to be provided in the cargo control room and on the navigation bridge.

1.13.3 Lighting (2002)

1.13.3(a) Lighting fitted outside the pump room. As far as practicable, the lighting fixtures for pump room spaces are to be permanently wired and fitted outside of the pump room, except as noted below. Pump rooms adjacent to engine rooms or similar safe spaces may be lighted through substantial glass lenses or ports permanently fitted in the bulkhead or deck.

The construction of the glass lens port is to be as follows:

- Capable of maintaining watertight and gastight integrity of the bulkhead and deck.
- Suitably protected from mechanical damage.
- Provided with a steel cover capable of being closed and secured on the side of the safe space.
- Both the glass lens and its sealing arrangement will not be impaired by working of the hull.
- Structural strength of the pierced bulkhead or deck is suitably reinforced.

See also 5C-1-1/5.11 and 5C-2-1/5.9 of the *Steel Vessel Rules*.

1.13.3(b) Lighting fitted inside the pump room. As an alternative to 4-6-6/1.13.3(a), certified safe lighting fixtures (see 4-6-6/Table 1) may be installed in the pump room, provided they are wired with moisture-resisting jacketed (impervious-sheathed) and armored or mineral-insulated metal-sheathed cable. Lighting circuits are to be so arranged that the failure of any one branch circuit will not leave these spaces in darkness. All switches and protective devices are to be located outside of the pump room. See also 4-6-3/11.1.2 for lighting circuits in hazardous areas.

1.13.3(c) Lighting/Ventilation Interlock (1 July 2002). For oil carriers 500 GT and over, lighting in cargo pump rooms, except emergency lighting, is to be interlocked with the ventilation system such that the ventilation system is to be in operation when switching on the lighting. Failure of the ventilation system is not to cause the lighting to go out.

1.13.4 Cable Installation

Where it is necessary for cables, other than those of intrinsically-safe circuits and those cables supplying lighting fixtures in the pump room, to pass through cargo pump rooms, they are to be installed in extra-heavy steel pipes or other arrangements providing the same degree of gas tightness and protection.

1.15 Gas Monitoring System Installation (1998)

For gas monitoring of the cargo area, sampling type gas analyzing units which are not intended for a hazardous location may be located outside of cargo areas (e.g., in cargo control room, navigation bridge or engine room) when mounted on the inside of the front bulkhead and subject to compliance with the following:

- i)* Sampling lines are not to pass through gas safe spaces, unless permitted by 4-6-6/1.15v).
- ii)* The non-safe type gas analyzing unit is to be installed in a safe area and the gas sampling lines are to be fitted with flame arresters. Sample gas is to be led to the atmosphere. The outlets are to be fitted with flame screens and are to be located in a safe location away from ignition sources. The area within 3 m (10 ft) of the outlet pipe is to be considered a hazardous location. See 4-6-6/1.5viii) and 4-6-6/Table 1, item f1.
- iii)* Where sampling pipes pass through bulkheads separating safe and dangerous areas, the penetrations are to be of an approved type having fire integrity at least as effective as the bulkhead. A manual isolation valve is to be fitted at each penetration on the gas safe side.

- iv) The gas detection equipment, including sampling piping, sampling pumps, solenoids, analyzing units, etc., are to be contained in a gas-tight steel cabinet monitored by its sampling point. The entire gas analyzing unit is to be shut down when the gas concentration inside of the cabinet reaches 30% of the lower flammability limit.
- v) Where it is impracticable to mount the cabinet on the front bulkhead, sampling pipes are to be of steel or other equivalent material and without any detachable connections except for the isolating valves at the bulkhead and analyzing units. Runs of sampling pipes within safe space are to be of the shortest possible length.

1.17 Pipe Tunnel or Duct Keel

1.17.1 Ventilation

Where a permanent lighting system is installed, a mechanical ventilating system capable of providing at least eight air changes per hour based on the gross volume of the space is to be provided. The system is to have mechanical exhaust, natural or mechanical supply and ducting as required to effectively purge this space and all connecting access trunks. Fan motors are to be located outside of the space in question and outside the ventilation ducts. Fans are to be of non-sparking construction, in accordance with 4-6-3/11.7.

1.17.2 Lighting (2015)

Where a permanent lighting system is installed in enclosed spaces such as pipe tunnels, double bottoms or duct keels, it is to be in accordance with 4-6-6/1.13.3(a) and 4-6-6/1.13.3(b). The switches are to be accessible to authorized personnel only. See also 4-6-3/11.1.2.

1.17.3 Gas Detection System

An approved gas detection system with a visual indication of the gas concentration and an alarm for the high level is to be provided in accordance with 4-6-6/1.13.2 so as to adequately monitor the double bottom (pipe trunk) spaces.

1.19 Gas Detection for Double Hull and Double Bottom Spaces in the Cargo Area (1999)

Suitable portable instruments for measuring oxygen and flammable vapor concentrations are to be provided. Where the atmosphere in double hull spaces cannot be reliably measured using flexible gas sampling hoses, such spaces are to be fitted with permanent gas sampling lines. The materials of construction and dimensions of gas sampling lines are to be such as to prevent restriction. Where plastic materials are used, they are to be electrically conductive.

1.21 Integrated Cargo and Ballast Systems – All Cargo Flash Points (2004)

1.21.1 Application

The following requirements are applicable to integrated cargo and ballast systems installed on tankers (i.e., cargo ships constructed or adapted for the carriage of liquid cargoes in bulk), regardless of the flash point of the cargoes. The integrated cargo and ballast system means any integrated hydraulic and/or electric system used to drive both cargo and ballast pumps (including active control and safety systems and excluding passive components, e.g., piping).

1.21.2 Functional Requirements

The operation of cargo and/or ballast systems may be necessary, under certain emergency circumstances or during the course of navigation, to enhance the safety of tankers. As such, measures are to be taken to prevent cargo and ballast pumps becoming inoperative simultaneously due to a single failure in the integrated cargo and ballast system, including its control and safety systems.

1.21.3 Design Features

The following design features are to be fitted:

- i) The emergency stop circuits of the cargo and ballast systems are to be independent from the circuits for the control systems. A single failure in the control system circuits or the emergency stop circuits are not to render the integrated cargo and ballast system inoperative.
- ii) Manual emergency stops of the cargo pumps are to be arranged in such a way that they do not cause the ballast pump power pack to stop and thus make the ballast pumps inoperable.
- iii) The control systems are to be provided with a backup power supply, which may be satisfied by a duplicate power supply from the main switchboard. The failure of any power supply is to provide audible and visible alarm activation at each location where the control panel is fitted.
- iv) In the event of failure of the automatic or remote control systems, a secondary means of control is to be made available for the operation of the integrated cargo and ballast system. This is to be achieved by manual overriding and/or redundant arrangements within the control systems.

3 Vessels Carrying Coal in Bulk

3.1 Application

3.1.1 General (1998)

The foregoing requirements in this Section and the requirements in 4-6-6/3.3 and 4-6-6/3.5 are applicable to vessels intended to carry coal in bulk by which an explosive and flammable atmosphere may be created.

3.1.2 Flag Administration (1998)

Attention is directed to the requirements for the carriage of coal in bulk in the IMO BC Code and their application as may be prescribed by the vessel's flag Administration. If requested by the vessel's Owner and authorized by the Administration, ABS will review the plans and carry out surveys in accordance with the above Code on behalf of the Administration.

3.3 Hazardous Areas

Space in which combustible and explosive dust/gas and air mixture is likely to occur in normal operation are to be identified as hazardous areas, such as cargo hold spaces, spaces with a direct opening to cargo hold spaces, or areas within 3 m (10 ft) of cargo hold ventilation outlets.

3.5 Installation of Equipment

3.5.1 Classified Electrical Equipment in Hazardous Area

Machinery, all electrical power, control and safety devices and wiring installed in locations where an explosive and flammable atmosphere (as may occur in spaces for coal) is expected to exist are to have a temperature classification T4 or higher (maximum surface temperature 132°C (275°F) or lower) and are to be suitable for operation in at least a Group IIA environmental classification, as defined in IEC Publication 60079-12.

3.5.2 Internal Combustion Engines in Hazardous Area

Where essential for operational purposes, the installation of internal combustion engines in hazardous areas will be subject to special consideration. In all instances, exhaust outlets are to be outside of all hazardous areas, excluding that produced by the exhaust outlet itself, and air intakes are to be not less than 3 m (10 ft) from hazardous areas.

3.5.3 Cargo Hold (1998)

3.5.3(a) *Instruments for Measuring (1998)*. Readings are to be obtainable without entry into the cargo hold and without endangering the cargo and cargo hold's atmosphere. Instruments for measuring the following are to be provided:

- i) Concentration of methane in the atmosphere,
- ii) Concentration of oxygen in the atmosphere,
- iii) Concentration of carbon monoxide in the atmosphere,
- iv) pH value of cargo hold bilge samples.

Note: In addition to the instruments specified in 4-6-6/3.5.3(a), it is recommended that consideration should be given by the Owner/designers to provide the means for measuring the temperature of the cargo in the range of 0°C (32°F) to 100°C (212°F), where it is intended to carry self-heating coal. Such arrangements should permit the temperature of the coal to be measured during the loading operations and during the voyage without requiring entry into the cargo space.

3.5.3(b) *Cargo Atmosphere Measuring Equipment (1998)*. An instrument for measuring methane, oxygen and carbon monoxide concentrations is to be provided, together with an aspirator, flexible connection, a length of tubing and means for sealing the sampling hole in order to enable a representative sample to be obtained from within the hatch cover surroundings. Alternative means for obtaining a representative sample will be considered.

3.5.3(c) *Sampling Points (1998)*. Sampling points are to be provided for each hold, one on the port side and another on the starboard side of the hatch cover, as near to the top of the hatch cover as possible. Each sampling point is to be fitted with a screw cap and a threaded stub of approximately 12 mm (0.5 in.) bore, welded to the side of the hatch cover to prevent ingress of water and air. Alternative sampling point arrangements/details will be considered.

3.5.3(d) *Warning Plate (1998)*. Permanent warning plate is to be installed in conspicuous places in cargo areas to state that smoking, naked flames, burning, cutting, chipping, welding or other sources of ignition are prohibited.

5 Cargo Vessels Carrying Motor Vehicles with Fuel in Their Tank

5.1 Application

In addition to the foregoing requirements in this Section, the following requirements are applicable to the cargo spaces carrying motor vehicles with fuel in their tanks.

5.3 Ventilation System

5.3.1 Arrangement

The ventilating system for enclosed spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion is to be independent from other ventilation systems and is to be capable of being controlled from a position outside of the space.

5.3.2 Capacity

An effective power ventilation system, sufficient to give at least six air changes per hour based on the volume of empty enclosed spaces in which vehicles are to be transported or stored, is to be provided. See also 4-6-6/5.5.2.

5.3.3 Fans

Exhaust fans are to be of non-sparking construction in accordance with 4-6-3/11.7.

5.3.4 Material and Arrangement of Ducts

Ventilation ducts, including dampers, are to be of steel. Ducts serving spaces capable of being sealed are to be separated for such space.

5.3.5 Exhaust Inlet and Outlet

Inlet for exhaust ducts are to be located within 450 mm (17.75 in.) above the vehicle deck. The outlet is to be sited in a safe position, having regard to the source of ignition near the outlet.

5.3.6 Emergency Shutdown

Arrangements are to be provided to permit a rapid shutdown and effective closure of the ventilation system in case of fire, taking into account the weather and sea conditions. See also 4-6-6/5.3.1.

5.3.7 Navigation Bridge Indication

Means are to be provided on the navigation bridges or other appropriate locations to indicate any loss of the ventilating capacity.

5.3.8 Passenger Vessels

For passenger vessels, the following requirements are to be complied with, as applicable.

5.3.8(a) Special Category Spaces. The protection of all special category spaces, as defined below, is to comply with Regulations II-1/17-1, II-1/42-1 and II-2/20 of 1974 SOLAS, as amended.

Special Category Spaces are those enclosed 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.

5.3.8(b) Protection of Cargo Spaces, Other than Special Category Spaces, Intended for the Carriage of Motor Vehicles with Fuel in Their Tanks for Their Own Propulsion. All cargo spaces (other than special category spaces) containing motor vehicles with fuel in their tanks for their own propulsion are to comply with Regulations II-1/17-1, II-1/42-1 and II-2/20 of 1974 SOLAS, as amended.

5.5 Location and Type of Equipment

5.5.1 Certified Safe Type Equipment

Except as provided for in 4-6-6/5.5.2 below, electrical equipment and wiring within the enclosed vehicle spaces referred to in 4-6-6/5.3.1 are to be increased-safety, explosion-proof or intrinsically-safe type.

5.5.2 Alternative Arrangements

Except for a distance within 450 mm (17.75 in.) above a platform that does not have openings of sufficient size permitting penetration of petroleum gases downward, electrical equipment of a type so enclosed and protected as to prevent the escape of sparks, e.g., protection degree of IP55 or equivalent may be permitted as an alternative, provided the ventilating system is so designed as to provide continuous ventilation of the cargo spaces at the rate of at least ten air changes per hour and on the assumption that the system will be so operated whenever vehicles are carried onboard.

5.5.3 Equipment in Ducts from Vehicle Space

Electrical equipment and wiring installed within an exhaust duct are to be increased-safety, explosion-proof or intrinsically-safe type.

7 Ro-Ro Vessels

7.1 Application

In addition to the foregoing requirements in this Section, the following requirements are applicable to the vessels of roll-on/roll-off (ro-ro) type.

7.3 Ro-Ro Cargo Spaces

7.3.1 Ventilation

Closed ro-ro cargo spaces, as defined in Regulation II-2/3.12 of SOLAS 1974 as amended, are to have ventilation systems in compliance with the applicable requirements in 4-6-6/5.3.

7.3.2 Carriage of Motor Vehicles with Fuel in Their Tank

Closed ro-ro spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion are to meet the requirements in 4-6-6/5.

9 Gas Carriers or Chemical Carriers

9.1 Gas Carriers

For vessels carrying liquefied gases at or near atmospheric pressure and at temperature below atmospheric, electrical installations are to be in accordance with Part 5C, Chapter 8 of the *Steel Vessel Rules*.

9.3 Chemical Carriers

For vessels carrying hazardous chemicals in bulk, electrical installations are to be in accordance with Part 5C, Chapter 9 of the *Steel Vessel Rules*. See also 4-6-6/1.9.3 of these Rules.

TABLE 1
Electrical Equipment in Hazardous Areas for Oil Carriers [See 4-6-6/1.9.1]

<i>Hazardous Area</i>	<i>Acceptable Electrical Equipment</i>	
Cargo tanks and cargo piping as defined by 4-6-6/1.5.	a1	Category “ia” intrinsically-safe apparatus and its associated wiring only.
Cofferdams and permanent (for example, segregated) ballast tanks adjacent to cargo tanks, as defined by 4-6-6/1.5ii).	b1	Category “ia” intrinsically-safe apparatus and its associated wiring.
	b2	Hull fittings containing transducers for electrical depth sounding or log devices or containing the terminals. See 4-6-6/1.9.3.
	b3	Shell penetrations for anodes or electrodes of an impressed current cathodic protection system for underwater hull protection. See 4-6-6/1.9.3.
Cargo pump rooms, as defined by 4-6-6/1.5iii).	c1	Intrinsically-safe apparatus.
	c2	Electrical devices as described in items b2 and b3 above this Table.
	c3	Explosion-proof lighting fixtures. See 4-6-3/11.1.2 and 4-6-6/1.13.3.
	c4	Explosion-proof type audible and/or visual devices for communication, general alarm and fire extinguishing medium release alarm.
	c5	Through-run of cables in extra-heavy pipe. See 4-6-6/1.13.4.
Compartments for cargo hoses, as defined by 4-6-6/1.5iv). Enclosed or semi-enclosed spaces, as defined by 4-6-6/1.5v) and 4-6-6/1.5vi).	d1	Intrinsically-safe apparatus.
	d2	Explosion-proof type lighting fixtures. See 4-6-3/11.1.2.
	d3	Through-runs of cable.
Spaces adjacent to and below the top of cargo tank, except for cofferdams, as defined by 4-6-6/1.5vii).	e1	Intrinsically-safe apparatus.
	e2	Electrical devices as described in items b2 and b3 of this Table.
	e3	Explosion-proof type lighting fixtures. See 4-6-3/11.1.2 and 4-6-6/1.17.2.
	e4	Explosion-proof type audible and/or visual devices for communication, general alarm and fire extinguishing medium release alarm.
	e5	Through-run of cable; excepting those for intrinsically-safe circuits, such cables require special consideration.
Areas on open deck or semi-enclosed spaces on open deck, as defined by 4-6-6/1.5viii). Areas on open deck as defined by 4-6-6/1.5ix)	f1	Explosion-proof, intrinsically-safe, increased safety or pressurized type equipment suitable for use on open deck.
	f2	Through-runs of cables without expansion bends in these areas.
Areas on open deck over all cargo tanks, including all ballast tanks within cargo tank area, as defined by 4-6-6/1.5x).	g1	Explosion-proof, intrinsically safe, increased safety or pressurized type equipment suitable for use on open deck.
	g2	Through-runs of cables.
Enclosed or semi-enclosed spaces having an opening into any hazardous area, as defined by 4-6-6/1.5xi).	h1	Explosion-proof or intrinsically-safe type equipment.
Enclosed or semi-enclosed spaces (not containing a source of hazard) having openings to hazardous areas, as defined by 4-6-6/1.5xii). Areas on open deck, as defined by 4-6-6/1.5xiii), which are outside the hazardous areas in 4-6-6/1.5viii), 4-6-6/1.5ix) and 4-6-6/1.5x).	i1	Explosion-proof, intrinsically safe, increased safety or pressurized type equipment suitable for use on open deck.

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PART

4

CHAPTER 7 Shipboard Automatic or Remote Control and Monitoring Systems

SECTION 1 General

1 Scope (1998)

The requirements contained in this section are intended for unrestricted vessels of under 90 m (295 ft) in length fitted with control and monitoring systems that embody various degrees of automatic or remote control and monitoring of the propulsion machinery and propulsion-machinery space. These requirements are in addition to those in other sections of the Rules. The following table indicates the applicability of the relevant requirements:

Vessel's Length (L)	Gross Tonnage (GT)		
	Under 500	500 or over/not assigned optional ACCU or ABCU symbol	500 or over/assigned optional ACCU or ABCU symbol
$L < 20 \text{ m (65 ft)}$	Will be specially considered	Will be specially considered	—
$20 \text{ m (65 ft)} \leq L \leq 46 \text{ m (150 ft)}$	Use Section 4-7-6	Use Sections 4-7-1 to 4-7-3	Use Section 4-7-4 or 4-7-5, as applicable
$L > 46 \text{ m (150 ft)}$	Use Section 4-7-6	Use Sections 4-9-1 and 4-9-2 of the <i>Steel Vessel Rules</i>	Use Sections 4-9-1 to 4-9-9 of the <i>Steel Vessel Rules</i> , for ACCU or Sections 4-9-1 to 4-9-9 of SVR plus 4-7-5 for ABCU as applicable

Consideration will be given to vessels of special design such as surface effect vessels, air cushion vessels, etc., upon submission of manufacturer's specification and drawings.

3 Propulsion Class Notations (1998)

Where requested by the Owner, automatic or remote control and monitoring systems for propulsion and monitoring systems of propulsion-machinery space that comply with the relevant requirements of this Section will be distinguished in the *Record* as follows. A certificate indicating the degree of automation, particulars and operating limitations, if any, will be issued. A notation preceded by ☒ (Maltese cross) signifies that the installations have been assembled and installed under survey by the Surveyor. A notation without ☒ (Maltese cross) symbol signifies that pertinent automatic or remote control and monitoring systems have not been assembled and installed under survey but have subsequently been surveyed and satisfactorily reported upon by the Surveyor.

3.1 Vessels ≥ 500 GT and ≤ 46 m (150 ft) in Length

3.1.1 ACCU Notation

Automatic or remote control and monitoring systems complying with Section 4-7-4 will be distinguished in the *Record* by the notation **ACCU**.

3.1.2 ABCU Notation

Automatic or remote control and monitoring systems complying with Section 4-7-5 will be distinguished in the *Record* by the notation **ABCU**.

Note: **ACCU** or **ABCU** class notation may be granted to vessels of < 500 GT and a length of 20 m (65 ft) $\leq L \leq$ 46 m (150 ft), provided that the applicable requirements in Sections 4-7-1 through 4-7-5 of this Section are met.

5 Definitions

The following definitions apply for the purpose of this Chapter:

5.1 Machinery Space

See 4-1-1/13.

5.3 Manned Space

Means any space assigned at all times with crew members needed to locally supervise the operation of the specific machinery or system installed in the space.

5.5 Automatic Control

Type of control which is self-regulating in carrying out ordered instruction without action by the operator.

5.7 Remote Control

Control of a device by an operator from a distance through mechanical, electrical, electronic, pneumatic, hydraulic, electromagnetic (radio) or optical means or their combination.

5.9 Local Control

Control by an operator of machinery through a device located on or adjacent to the controlled machinery.

5.11 Remote Station

A permanent installation fitted with effective control and/or monitoring means and located at a distance from the specific machinery.

5.13 Centralized Control and Monitoring Station

A remote station designated as the central location where the necessary instrumentation required to maintain the control and monitoring of the specific machinery is fitted, and which is equivalent at least as if the machinery were under local supervision.

5.15 Instrumentation

A monitoring device including sensing and transmitting component.

5.17 Monitoring

The display and alarming of the operational status of a specific machinery/system.

5.19 Display Systems

Display systems are those which display operating machinery parameter values such as pressure, temperature, liquid flow, motor running, etc., or the sequential operation of the system's process.

5.21 Alarm

A visual and audible signal of a predetermined out of limits parameter for the controlled and/or monitored machinery or system.

5.23 Summary-alarm

A common alarm activated by any abnormal condition of the monitored machinery or system.

5.25 Safety Systems

Systems which provide automatic actions in response to faults that may develop too fast to be countered by manual intervention. The safety systems are intended to operate automatically in case of faults within the machinery plant for the purpose of:

- i) Temporarily adjusting the operation of the machinery to the prevailing conditions (by reducing the output of the machinery), or
- ii) Restoring the normal operating conditions (by starting of standby units), or
- iii) Protecting the machinery from critical conditions by stopping the machinery (shutdown).

5.27 Emergency Shutdown Systems

Systems intended for manual activation in an emergency to stop a particular system's function or machinery operation.

5.29 Fail-safe

Fail-safe means that upon failure or malfunction of a component, subsystem or system, the output automatically reverts to a predetermined design state of least critical consequence.

5.31 Independent

As applied to two systems, means that one system will operate with the failure of any part of the other system including power sources and its supply connection. However, for electrical systems which are not required to have an emergency source of power as the standby power source, failure of the power source may be excluded from this criteria.

5.33 Programmable Electronic System (PES) (2017)

A Programmable Electronic System is a system based on one or more programmable electronic devices, connected to (and including) input devices (e.g., sensors) and/or output devices/final elements (e.g., actuators), for the purposes of control, protection or monitoring. The term "PES" includes all elements in the system, including power supplies, extending from sensors or other input devices, via data highways or other communicating paths, to the actuators, or other output devices, associated software, peripherals and interfaces.

5.35 Nonvolatile Memory

Memory which does not require power to retain the stored data.

5.37 Computer Monitor (Video Display Unit)

A device where computer information or data is displayed.

5.39 ABS Type Approval Program (2003)

Certification scheme whereby ABS certifies, at the request of the equipment manufacturer, that the specific equipment conforms to cited standards and to cited ratings which ABS has verified by engineering analysis, and that an appropriate quality system is in place to manufacture a product of consistent quality. See the *ABS Type Approval Program* in Appendix 1-1-A3 of the *ABS Rules for Conditions of Classification (Part 1)*. The *ABS Type Approval Program* and the indicated references are available for download from the ABS website at <http://www.eagle.org>.

5.41 Integrated Propulsion Machinery

A propulsion machinery having its auxiliaries (fuel oil pumps, cooling water pumps, etc.), necessary for normal operation driven by the engine, the reduction gear or the propulsion shaft.

5.43 Data Communication Link (2017)

A data communication link is a connection between one location to another for the purpose of transmitting and receiving data which can be further segmented into several communication layers, according to international standards such as IEC 61158, ISO/IEC 7498-1 and IEC 61784.

5.45 System Security (2017)

Programmable electronic systems are to be provided with effective physical and/or logical security arrangements to prevent unintentional or unauthorized access to functions or alteration of configuration, programs or data by unauthorized personnel.

7 Required Plans and Data

Plans and data associated with automatic or remote control and monitoring of machinery and systems are to be submitted for approval in accordance with 4-1-1/7, and are to include the following:

7.1

A list of electrical, pneumatic or hydraulic equipment associated with the particular systems. This is to include manufacturer's name, model number, material, ratings, degree of protection, permissible angles of inclination and location of installation within the vessel.

7.3

A list of all major components installed within the particular equipment (i.e., control console, etc.) and the data as required in 4-7-1/7.1.

7.5

Certificates or test reports, as appropriate, attesting to the suitability of the particular equipment in compliance with the environmental criteria set forth in 4-7-2/15 and 4-7-2/17, 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 4-7-2/17.3.

7.7

Plans showing the location of control and monitoring stations, controlled equipment and piping/cable runs, etc.

7.9

Arrangements and details of the control consoles and panels, including plan views and elevation details, installation details and wiring data (rating, construction standard, insulation type, armored/unarmored/shielded/non-shielded, temperature rating, flame-retardant properties, etc.).

7.11

A list of all cables connecting equipment associated with the systems. This is to include construction standard, electrical rating, insulation type, armored/unarmored/shielded/non-shielded, temperature rating, size and connected load's power consumption requirements.

7.13

A complete operational description of the automatic or remote control and monitoring systems, including a list of alarms and displays and functional sketches or description of all special valves, actuator, sensors and relays.

7.15

A simplified one-line diagram (electrical and piping) of all power and automatic or remote control and monitoring systems. This is to include power supplies, circuit or piping protection ratings and settings, cable or pipe sizes and materials, rating of connected loads, etc.

7.17

A schematic diagram of all control, alarm, display and safety systems.

7.19

For computer-based systems, the following is to be included:

- i) Overall description and specification of the systems and equipment.
- ii) Block diagrams for the computer hardware showing interfacing between the work stations, input/output (I/O) units, local controllers, traffic controllers, data highways, etc.
- iii) Logic flow chart or ladder diagrams.
- iv) Description of the alarm system indicating the ways it is acknowledged, displayed on the monitor or mimic display board, etc.
- v) Description of the system redundancy and backup equipment, if any.
- vi) Description of the data communication protocol, including anticipated data process response delays.
- vii) Description of the system's security protocol to prevent unauthorized program changes which may compromise the integrity of the automatic or remote systems.
- viii) Description of the system with regard to the degree of independence or redundancy provided for the control systems, alarm/display systems and safety systems.
- ix) Description of system's task priorities.
- x) Where applicable, description of UPS (uninterruptible power supply) and their capacities, including system's power consumption.
- xi) Equipment ratings and environmental parameters.

7.21

Installation methods (electrical, pneumatic and hydraulic). This is to include details of cable or pipe runs, separation of cables of different voltage rating and insulating rating, cable tray laying, deck or bulkhead penetration, prevention of magnetic interference, etc. See also 4-7-2/15.9.

7.23

A matrix chart for each of the systems indicating the following, as applicable, upon activation of a given alarm or safety action:

- i) Name, device designations and type, and location of alarms.
- ii) Preset parameter values, if any.
- iii) Automatic tripping and other safety provisions of controlled equipment.
- iv) Location of control stations where shutdown, and control and monitoring power supply transfer devices are fitted.
- v) Special remarks, if any.

9 Tests and Surveys

9.1 Installation Tests

Automatic or remote control and monitoring systems are to be subjected to tests witnessed by the Surveyor during and after installation onboard, as outlined in this Section.

9.3 Periodical Surveys (1998)

The continuance of **ACCU** or **ABCU** certification is subject to periodic survey of the automatic or remote control and monitoring systems installation, as outlined in Chapter 8 of the *ABS Rules for Survey After Construction (Part 7)*.

PART

4

CHAPTER 7 Shipboard Automatic or Remote Control and Monitoring Systems

SECTION 2 General Systems Design and Arrangement Requirements

1 General

Automatic or remote controls and monitoring systems as referenced in this Section include control, alarm/display and safety systems. For computer-based systems, see 4-7-2/9.

3 Automatic or Remote Control Systems

3.1 Characteristics

Automatic or remote control systems are to be of the fail-safe type and designed to preclude detrimental mechanical or thermal overloads to the controlled machinery.

3.3 Interlocks

To preclude damage to the controlled machinery, means are to be fitted to disable the starting mechanism after designated unsuccessful starting attempts. Similarly, controlled machinery or systems fitted with more than one remote control station are to be provided with interlocking means to preclude simultaneous control or unauthorized transfer to associated remote stations not in control. However, control units interconnected with a specific associated remote control station and which are within sight of each other may be accepted without interlocks.

3.5 Transfer of Control

Transfer of controls from a remote control station under operation to other associated remote stations is to be possible by a request from the receiving station and acceptance by the station in operation, or vice versa. See also 4-7-3/7. All control stations are to have indicators showing which station is in control.

3.7 Automatic Controls

Automatic control systems are to be designed to maintain the controlled machinery within pre-set parameters and to ensure that the machinery operates in the correct sequence and time intervals. Deviation from these pre-set conditions is to force the sequential controls to a safe sequence stage that will not be detrimental to the machinery and overall safety of the vessel. Additionally, adequate arrangements are to be included to disable the automatic control mode and restore manual controls.

3.9 Remote Controls

Remote controls are to be arranged to provide the same degree of safety and operability as those provided for local controls. Upon a given control input, the controlled device is to respond according to a pre-established sequence of events and results.

3.11 Local Controls

Remotely operated machinery or systems are to be provided with effective means of independent controls at or in the proximity to the machinery or systems. Means are to be provided locally to disconnect or override other associated remote stations or disable automatic control, if any.

3.13 Suitability of Equipment

Equipment associated with automatic or remote control systems is to be suitable for the intended location. Control systems are to comply with the requirements contained in 4-7-2/15 and 4-7-2/17.

5 Alarm Systems

5.1 Characteristics

Alarm systems are to be of the self-monitoring type and designed so that a fault in the alarm system is to cause it to fail to the alarmed condition. Additionally, they are not to react to normal transient conditions or spurious signals.

5.3 Independence

Alarm systems are to be independent of control and safety systems, except that common sensors will be acceptable, as permitted in 4-7-2/7.5.

5.5 Visual and Audible Alarm

Alarms are to be both audible and visual and are to be provided at the control stations, as required in this Section. Alarms are to clearly identify the system and service of the faulted machinery or machinery components. Visual alarms are to be displayed in a distinguishable manner such that alarms for similar machinery or systems are grouped together and the colors representing a particular function or condition remain uniform. Visual alarms are to flash when first activated. Audible alarms associated with machinery are to be of distinctive tone from other alarms, such as fire-alarm, general alarm, gas detection, etc., and they are to be of sufficient loudness to attract the attention of duty personnel. For spaces of unusually high noise levels, a beacon light or similar, installed in a conspicuous place, is to supplement any of the audible alarms in such spaces. However, red light beacons are only to be used for fire alarms.

A fault in the visual alarm circuits is not to affect the operation of the audible alarm circuits. For computer-based system, see 4-7-2/9.

5.7 Acknowledgment of Alarms

Alarms are to be acknowledged by manually changing the flashing display of the incoming alarm to a steady display and by silencing the audible signal. The steady state light display is to remain activated until the fault condition is rectified. Alarming of other faults that may occur during the acknowledgment process is not to be suppressed by such action and is to be alarmed and displayed accordingly. The silencing of the audible alarm from an associated remote control station is not to lead automatically to the silencing of the original alarm at the centralized control and monitoring station.

5.9 Disconnection and Resumption of Alarm Functions (2010)

Alarm circuits may be temporarily disabled for maintenance purposes or during initial start-up of machinery, provided that such action is clearly indicated at the associated station in control. For **ACCU** fire alarm system, see 4-7-4/29.5.2.

5.11 Summary-alarms

In addition to required alarms to be fitted at the centralized control and monitoring station, visual alarms may be displayed and alarmed at other associated remote control stations as summary-alarms.

5.13 Built-in Testing

Alarm systems are to be provided with effective means for testing all audible and visual alarms and indicating lamps without disrupting the normal machinery or system operation. Such means are to be fitted in the associated remote stations.

5.15 Suitability of Equipment

Equipment associated with automatic or remote alarm systems is to be suitable for the intended location. Alarm systems are to comply with the requirements contained in 4-7-2/15 and 4-7-2/17.

7 Safety Systems

7.1 General

Safety systems are to be provided as required in this Section. Considerations will be given to the manual activation of safety systems, provided that measures are taken, by the inherent design of the system or by suitable arrangements, to retard the escalation of the abnormal condition and to alert personnel to take the appropriate action prior to the developing of a dangerous condition.

7.3 Characteristics

Safety systems are to be of the fail-safe type and are to respond automatically to fault conditions that may endanger the machinery or safety of the crew. Unless otherwise required in this Section or specially approved, this automatic action is to cause the machinery to take the least drastic action first, as appropriate, by reducing its normal operating output or switching to a stand-by machinery and last, by stopping it, i.e., disrupting source of fuel or power supply, etc.

7.5 Independence

Safety systems for different parts of the machinery plant are to be independent of each other. The safety system intended for the functions specified in 4-7-1/5.25iii) (shutdown) is to be completely independent of the control and alarms systems so that a failure in these systems will not prevent the safety system from operating. However, for the functions specified in 4-7-1/5.25i) and 4-7-1/5.25ii), complete independence of the safety systems from the control and alarm systems is not required.

7.7 Activation

Each safety action is to be alarmed at the associated remote station. When both an alarm and a safety action are required for a specific failure condition, the alarm is to be activated first.

7.9 Resumption of Operation

Machinery that is stopped as a result of a safety action is not to resume operation unless it is reset manually.

7.11 Override of Safety Provisions

Remote overrides are not to override those safety actions specified in other Sections (i.e., Part 4, Chapter 2 of these Rules and Part 4, Chapters 2, 3 and 4 of the *Steel Vessel Rules*). For safety action specified in subject Part 4, Chapter 7, any overrides of safety provisions are to be so arranged that they cannot go unnoticed and their activation and condition are to be alarmed and indicated at the associated remote station. The override is to be arranged to preclude inadvertent operation and is not to deactivate alarms associated with safety provisions. The override mechanism to disconnect safety provisions is to be fitted at the associated remote station, except that same may be fitted at the centralized control and monitoring station instead. Overrides fitted on the bridge are to be operable only when in the bridge control mode.

7.13 Suitability of Equipment

Equipment associated with safety systems is to be suitable for the intended location. Safety systems are to comply with the requirements contained in 4-7-2/15 and 4-7-2/17.

9 Computer-based Systems

9.1 General

Computer-based systems are to be designed so that failure of any of the system's components will not cause unsafe operation of the system. Hardware and software serving vital and non-vital systems are to be arranged to give priority to vital systems.

9.3 Independence

Control, alarm and safety shutdown system functions are to be arranged such that a single failure or malfunction of the electronic computer equipment will not affect more than one of these system functions. This is to be achieved by dedicated equipment for each of these functions within a single system, or by the provision of back-up equipment, or by other suitable means considered not less effective.

9.5 Visual Display of Alarm

9.5.1 Incoming Signals

In addition to the requirements contained in 4-7-2/5, and when displayed by way of a computer monitor (video display unit), alarms are to be presented in an identifiable manner, and when displayed, alarms are to appear in the sequence as the incoming signals are received. Alarming of incoming fault signals are to automatically appear on the screen to alert the on-duty personnel, regardless of whether the computer and monitor (video display unit) are in a mode other than the monitoring mode (i.e., computing or displaying other system's mimic or schematic diagrams).

9.5.2 Unrectified Alarms

Alarms associated with faults which have not been rectified may be displayed in a summarized fashion until all of the faults have been dealt with.

9.5.3 Computer Monitor (Video Display Unit)

Displays on the computer monitor (video display unit) are to be clearly visible under ambient lighting conditions. Computer monitors on the navigation bridge are to be provided with dimmers to control display lighting. Data displayed on computer monitors are to be readable by the operator from the normal operating position.

9.5.4 Response Delay

The time limit on response delays for safety and alarm displays is not to exceed two seconds.

9.7 Memory Capacity and Response Time

Computer system's memory is to be of sufficient capacity to handle the operation of all computer programs (software) as configured in the computer system. The time response for processing and transmitting data is to be such that undesirable chain of events may not arise as a result of unacceptable data delay or response time during the computer system's worst data overload operating condition (multi-tasking mode).

9.9 Data Loss and Corruption

To preclude the possible loss or corruption of data as a result of power disruption, program and associated memory data considered to be essential for the operation of the specific system is to be stored in non-volatile memory or a volatile memory with a secure uninterruptible power supply (UPS).

9.11 Power Supply Disruption

The system's software and hardware is to be designed so that upon restoration of power supply after power failure, automatic or remote control and monitoring capabilities can immediately be available after the pre-established computer control access (sign-in) procedure has been completed.

9.13 Parameters and Program Changes

Alteration of parameters that may affect the system's performance are to be limited to authorization personnel by means of keyswitch, keycard, password or other approved methods. Similarly, computer program or system's configuration changes are to be effected only by authorized personnel.

11 Supply, Arrangement and System Protection of Automatic or Remote Control and Monitoring System

11.1 Supply and Arrangement

11.1.1 General

The power distribution to control systems, alarm/display systems (considered as one for the purpose of this requirement) and safety systems is to be provided with their individual circuits so that a fault in one of the systems cannot cause loss of the other systems. Their supply status and failure condition is to be displayed and alarmed at the associated remote propulsion station.

11.1.2 Electrical (2005)

11.1.2(a) Power Source. Power supply requirements provided in 4-7-2/11.1.1, as applicable, are to be complied with. Electric power for control, monitoring and safety systems is to be fed from two feeders, one from the main switchboard or other suitable distribution board and the other from the emergency switchboard or an emergency distribution board. The supply status of these feeders is to be displayed and the main power supply failure is to be alarmed. The electric power supply to each of the control, monitoring and safety systems is to be individually monitored. For vessels whose propulsion machinery spaces are intended for unattended operation (**ACCU** or **ABCU** notation), 4-7-4/11 is to be complied with.

In the event of power supply failure, the propulsion prime movers are to continue to operate at the last ordered speed and the propellers at the last ordered direction of thrust until local control is in operation or control power is safely resumed.

11.1.2(b) Power Supply Transfer. The two feeders are to be connected to a transfer switch in the remote control station. Power supply to controls, monitoring and safety systems may be commonly connected to the transfer switch. The transfer between the power supplies may be effected by manual means at the remote control station. For vessels whose propulsion machinery spaces are intended for unattended operation (**ACCU** or **ABCU** notation), 4-7-4/11 is to be complied with.

11.1.3 Hydraulic

The hydraulic pumps for control and monitoring systems are to be fitted in duplicate. The pump suction is to be from a reservoir of sufficient capacity to contain all of the fluid when drained from the system, maintain the fluid level at an effective working height and allow air and foreign matter to separate out. The pump suction is to be sized and positioned to prevent cavitation or starvation of the pump. The hydraulic fluid is to be suitable for its intended operation.

11.1.4 Pneumatic (2010)

Compressed air for control and monitoring systems is to be supplied from at least two air compressors. The starting air system, where consisting of two air compressors, may be used for this purpose. The system is to be arranged such that a single failure will not result in the loss of air supply. The required air pressure is to be automatically maintained.

Means are to be provided to assure that the compressed air for control and monitoring systems is clean, dry and oil-free to a specification compatible with the control and monitoring equipment. In this regard, the compressors, cooling equipment, filters and dryers are to be selected and arranged as necessary to ensure the quality of the air supplied will comply with the standards or criteria identified by the manufacturers of the pneumatic equipment being installed in the system (e.g., max. solid particle size/density, max. dew point, max. oil content, etc.).

Air supplies to safety systems and control systems may be derived from the same source, but are to be by separate lines incorporating shutoff valves.

11.3 System Protection

11.3.1 Electrical

Circuits are to be arranged so that a fault in one circuit will not cause maloperation or failure on another circuit or system. It is to be possible to isolate the faulted circuit. Additionally, systems are to be protected against accidental reversal of power supply polarities, voltage spikes and harmonic interference, and in no case is the system's total harmonic distortion to exceed 5%.

11.3.2 Hydraulic

Pipe systems subject to pressure build-up that may exceed the rated pressure of the pipe and associated components are to be provided with suitable pressure relief devices fitted on the pump's discharge side. Each relief valve is to be capable of relieving not less than full pump flow with a maximum pressure rise of not more than 10% of the relief valve setting.

11.3.3 Pneumatic

The requirements in 4-7-2/11.3.2 are to be complied with, as applicable.

13 Communications Systems

For communication systems associated with propulsion control stations, the requirements in 4-6-2/15.5.1 are applicable.

15 Equipment Construction, Design and Installation

15.1 General

Equipment associated with remote or automatic control and monitoring systems is to meet compliance with the requirements contained herein. Deviation from the environmental requirements such as temperature, humidity and corrosion will be considered for equipment intended for installation in ambient controlled rooms or enclosures. See also 4-7-2/15.9.2 and 4-7-2/15.9.7. Similarly, where equipment is installed in environments having parameters other than those as specified in 4-7-2/Table 1 (i.e., cryogenic or highly corrosive environments, etc.), special consideration corresponding to those of the operating environment will be required.

15.3 Electrical

Equipment is to be constructed of robust, durable and flame-retardant material. It is to be designed to incorporate the degree of enclosure protection as required in 4-6-3/Table 1. Wiring and cables are to meet the requirements contained in 4-6-4/7.11.4 and 4-6-4/13, respectively.

Non-current carrying metal parts are to be effectively earthed.

15.5 Hydraulic

Hydraulic pumps, actuators, motors and accessories are to be suitable for the intended service, compatible with the working fluid and are to be designed to operate safely at full-power conditions. In general, the hydraulic fluid is to be nonflammable or have a flash point above 157°C (315°F).

15.7 Pneumatic

Air compressors, actuators, motors and accessories are to be suitable for the intended service and have working and other parts that will not be damaged or rendered ineffective by corrosion.

15.9 Installations

15.9.1 General

The installation of equipment associated with automatic or remote control and monitoring systems is to be carried out taking into consideration adverse effects that may be introduced by their exposure to unintended temperatures, weather, vibration conditions, falling objects or liquid, electromagnetic interference, high voltage systems, electric noise, etc. Additionally, the installation is to facilitate the checking, adjustment and replacement of components, including filters and sensing devices, without disrupting the normal operation of the system, as far as practicable.

15.9.2 Ranges in Ambient Temperatures

For the selection and installation of equipment associated with control and monitoring systems, a temperature range of 5°C (41°F) to 55°C (131°F) is to be considered for machinery space, control rooms, accommodations and navigation bridge. When equipment is located inside panels or cubicles, consideration is to be given to the temperature rise inside those panels due to the dissipation of heat from its own components. See also 4-7-2/Table 1, Note 1.

Where compliance with the above temperature ranges cannot be met, consideration will be given to the installation of equipment per 4-7-2/15.9.7.

15.9.3 Electromagnetic and Conducted Interference

In general, the installation of equipment associated with automatic or remote control and monitoring systems in areas of unusual electromagnetic systems in areas of unusual electromagnetic sources is to be avoided. Where the values per 4-7-2/Table 1 may be exceeded, appropriate measures are to be implemented to reduce the effects of electromagnetic and conducted interference. To avoid electromagnetic noise caused by circulating currents, the conductive shield and cable armor is to be earthed only at one end of the cable. Description of the preventive measures to be followed is to be submitted for review.

15.9.4 Shielded Cables

To avoid possible signal interference, cables for automatic or remote control and monitoring systems occupying the same cable tray, trunk or conduit with power cables are to be of the shielded type.

15.9.5 Electrical Grounding

Automatic or remote control and monitoring systems are not to have common earth conductors with systems of higher voltage level.

15.9.6 Condensation

Electrical equipment liable to be exposed to ambient temperature fluctuations is to be provided with means to prevent accumulation of moisture inside of the component's enclosure (i.e., by the provisions of space heaters that automatically energize upon shutdown or disconnection of the electrical component).

15.9.7 Cold Environment

Electrical equipment which may be adversely affected by the exposure to temperatures lower than those for which they are designed are to be provided with suitable heating arrangements so that they may be readily operated when needed. See 4-7-2/15.9.2.

15.9.8 Protection Against Falling Liquids or Leakage of Fluid Medium

Electrical equipment is not to be installed in the same compartment or cabinet containing equipment or pipes carrying water, oil or steam unless effective measures are taken in order to protect the electrical equipment from possible fluid leakage (i.e., welded connections, physical isolation together with suitable draining arrangements, etc.).

15.9.9 Measuring and Sensing Devices

The installation of measuring and sensing elements is to permit their easy access for functional testing or replacement.

15.9.10 Marking

All units, controllers, actuators, displays, terminal strips, cable and test points, etc. are to be clearly and permanently marked. Their systems and system's functions are to be included so that they can be easily identified in associated drawings and instrument lists.

17 Equipment/Components Qualifications and Trials

17.1 Equipment/Components Qualifications

The manufacturers and assemblers of automatic or remote control and monitoring equipment/ components associated with main propulsion engines are to provide documented evidence showing that the equipment/ components have been tested individually or by acceptable sampling to establish their suitability for the intended service.

17.3 Type Approval of Automatic or Remote Control and Monitoring Equipment

Equipment that meets the requirements contained in this subsection or 4-7-4/3 is eligible to be certified under the ABS Type Approval Program upon formal request by the equipment manufacturer. See also 4-7-1/5.39 and 4-7-1/7.5.

17.5 Trials

Automatic or remote control and monitoring systems and associated equipment are to be tested in the presence of the Surveyor, under normal operating conditions and for the period that the Surveyor may deem necessary or otherwise specified in other Subsections.

TABLE 1
Type Tests for Control, Monitoring and Safety Equipment (2016)

No	TEST	PROCEDURE ACCORDING TO: [See Note 7]	TEST PARAMETERS	OTHER INFORMATION																														
1.	Power supply variations (a) electric	---	<p style="text-align: center;"><i>AC Supply</i></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 33%;">Combination</th> <th style="width: 33%;">Voltage variation permanent (%)</th> <th style="width: 33%;">Frequency variation permanent (%)</th> </tr> </thead> <tbody> <tr><td style="text-align: center;">1</td><td style="text-align: center;">+ 6</td><td style="text-align: center;">+ 5</td></tr> <tr><td style="text-align: center;">2</td><td style="text-align: center;">+ 6</td><td style="text-align: center;">- 5</td></tr> <tr><td style="text-align: center;">3</td><td style="text-align: center;">- 10</td><td style="text-align: center;">- 5</td></tr> <tr><td style="text-align: center;">4</td><td style="text-align: center;">- 10</td><td style="text-align: center;">+ 5</td></tr> </tbody> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 33%;">Combination</th> <th style="width: 33%;">Voltage transient 1.5 s (%)</th> <th style="width: 33%;">Frequency transient 5 s (%)</th> </tr> </thead> <tbody> <tr><td style="text-align: center;">5</td><td style="text-align: center;">+ 20</td><td style="text-align: center;">+ 10</td></tr> <tr><td style="text-align: center;">6</td><td style="text-align: center;">- 20</td><td style="text-align: center;">- 10</td></tr> </tbody> </table> <p style="text-align: center;"><i>DC Supply</i></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td style="width: 66%;">Voltage tolerance continuous</td><td style="width: 34%; text-align: center;">± 10%</td></tr> <tr><td>Voltage cyclic variation</td><td style="text-align: center;">5 %</td></tr> <tr><td>Voltage ripple</td><td style="text-align: center;">10 %</td></tr> </tbody> </table> <p><i>Electric battery supply:</i> + 30% to - 25% for equipment connected to charging battery or as determined by the charging/discharging characteristics, including ripple voltage from the charging device; + 20% to - 25% for equipment not connected to the battery during charging</p>	Combination	Voltage variation permanent (%)	Frequency variation permanent (%)	1	+ 6	+ 5	2	+ 6	- 5	3	- 10	- 5	4	- 10	+ 5	Combination	Voltage transient 1.5 s (%)	Frequency transient 5 s (%)	5	+ 20	+ 10	6	- 20	- 10	Voltage tolerance continuous	± 10%	Voltage cyclic variation	5 %	Voltage ripple	10 %	
Combination	Voltage variation permanent (%)	Frequency variation permanent (%)																																
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Voltage cyclic variation	5 %																																	
Voltage ripple	10 %																																	
2	Power supply variations (Continued) (b) Pneumatic and hydraulic	---	Pressure: ± 20% Duration: 15 minutes																															
3.	Dry heat (2016)	IEC 60068-2-2	Temperature: 55°C (131°F) ± 2°C (3.6°F) Duration: 16 hours Or Temperature: 70°C (158°F) ± 2°C (3.6°F) Duration: 16 hours [See Note 1]	Equipment operating during conditioning and testing; Functional test during the last hour at the test temperature. For equipment specified for increased temperature the dry heat test is to be conducted at the agreed test temperature and duration.																														
3A.	Dry heat – Higher Temp (see Note 8) (Optional Test) (2015)	IEC 60068-2-2	Temperature: 70°C (158°F) ± 2°C (3.6°F) Duration: 16 hours [See Note 8]	Equipment operating during conditioning and testing; Functional test during the last hour at the test temperature;																														

TABLE 1 (continued)
Type Tests for Control, Monitoring and Safety Equipment (2016)

No	TEST	PROCEDURE ACCORDING TO: [See Note 7]	TEST PARAMETERS	OTHER INFORMATION
4.	Damp heat (2016)	IEC 60068-2-30 - Test Db	Temperature: 55°C (131°F) Humidity: 95% Duration: 2 cycles 2 x (12 + 12 hours)	Measurement of insulation resistance before test; The test shall start with 25°C ± 3°C and at least 95% humidity; Equipment operating during the complete first cycle and switched off during second cycle, except for functional test; Functional test during the first 2 hours of the first cycle at the test temperature and during the last 2 hours of the second cycle at the test temperature. Duration of the second cycle can be extended due to more convenient handling of the functional test. Recovery at standard atmosphere conditions; Insulation resistance measurements and performance test.
5.	Vibration (2016)	IEC 60068-2-6, Test Fc	2.0 (+3/-0) Hz to 13.2 Hz – amplitude ±1 mm (0.039 in.) 13.2 Hz to 100 Hz – acceleration ±0.7 g For severe vibration conditions, e.g., on diesel engines, air compressors, etc.: 2.0 Hz to 25 Hz – amplitude ±1.6 mm (0.063 in.) 25.0 Hz to 100 Hz – acceleration ±4.0 g <i>Note:</i> <i>More severe conditions may exist for example on exhaust manifolds or fuel oil injection systems of diesel engines. For equipment specified for increased vibration levels, the vibration test is to be conducted at the agreed vibration level, frequency range and duration.</i> <i>Values may be required to be in these cases</i> <i>40 Hz to 2000 Hz – acceleration ± 10.0g at 600 °C duration 90 min.</i>	Duration: 90 minutes at 30 Hz in case of no resonance conditions; Duration: 90 minutes for each resonance frequency at which $Q \geq 2$ is recorded; During the vibration test, functional tests are to be carried out; Tests to be carried out in three mutually perpendicular planes; It is recommended as guidance that Q does not exceed 5; Where sweep test is to be carried out instead of the discrete frequency test and a number of resonant frequencies are detected close to each other duration of the test is to be 120 min. Sweep over a restricted frequency range between 0.8 and 1.2 times the critical frequencies can be used where appropriate. <i>Note: Critical frequency is a frequency at which the equipment being tested may exhibit:</i> <ul style="list-style-type: none">• malfunction and/or performance deterioration• mechanical resonances and/or other response effects occur, for example, chatter

TABLE 1 (continued)
Type Tests for Control, Monitoring and Safety Equipment (2016)

No	TEST	PROCEDURE ACCORDING TO: [See Note 7]	TEST PARAMETERS		OTHER INFORMATION		
6.	Inclination	IEC 60092-504	Static 22.5°		a) Inclined at an angle of at least 22.5° to the vertical; b) Inclined to an angle of at least 22.5° on the other side of the vertical and in the same plane as in (a); c) Inclined to an angle of at least 22.5° to the vertical and in plane at right angles to that used in (a); d) Inclined to an angle of at least 22.5° on the other side of the vertical and in the same plane as in (c) <i>Note: The duration of testing in each position should be sufficient to fully evaluate the behavior of the equipment.</i>		
			Dynamic 22.5°		Using the directions defined in a) to d) above, the equipment is to be rolled to an angle of 22.5° each side of the vertical with a period of 10 seconds. The test in each direction is to be carried out for not less than 15 minutes <i>Note: These inclination tests are normally not required for equipment with no moving parts.</i>		
7.	Insulation resistance (2016)	---	Rated supply voltage (V)	Test voltage (DC voltage) (V)	Min. Insulation Resistance	Insulation resistance test is to be carried out before and after: damp heat test, cold test, salt mist test, and high voltage test; <ul style="list-style-type: none"> between all phases and earth; and where appropriate, between the phases. U_n is the rated (nominal) voltage. <i>Note: Certain components, e.g., for EMC protection, may be required to be disconnected for this test. For high voltage equipment, reference is made to 4-6-5/1.</i>	
			$U_n \leq 65$	$2 \times U_n$ (min. 24 V)	Before test (MΩ)		After test (MΩ)
			$U_n > 65$	500	100		10
8.	High voltage	---	Rated voltage U_n (V)	Test voltage [AC voltage 50 or 60 Hz] (V)		Separate circuits are to be tested against each other and all circuits connected with each other tested against earth; Printed circuits with electronic components may be removed during the test; Period of application of the test voltage: one minute	
			Up to 65	$2 \times U_n + 500$			
			66 to 250	1500			
			251 to 500	2000			
			501 to 690	2500			

TABLE 1 (continued)
Type Tests for Control, Monitoring and Safety Equipment (2016)

No	TEST	PROCEDURE ACCORDING TO: [See Note 7]	TEST PARAMETERS	OTHER INFORMATION
9.	Cold (2008)	IEC 60068-2-1	Temperature: +5°C (41°F) ± 3°C (5.4°F) Duration: two hours Or Temperature: -25°C (-13°F) ± 3°C (5.4°F) Duration: two hours [See Note 2]	Initial measurement of insulation resistance; Equipment not operating during conditioning and testing, except for functional test; Functional test during the last hour at the test temperature; Insulation resistance measurement and the functional test after recovery
10.	Salt mist (2016)	IEC 60068-2-52 Test Kb	Four spraying periods with a storage of 7 days after each.	Initial measurement of insulation resistance and initial functional test; Equipment not operating during conditioning of the test specimen; Functional test on the 7 th day of each storage period; Insulation resistance measurement and performance test: 4 to 6 hours after recovery [See Note 3] On completion of exposure, the equipment shall be examined to verify that deterioration or corrosion (if any) is superficial in nature.
11.	Electrostatic discharge (2016)	IEC 61000-4-2	Contact discharge: 6 kV Air discharge: 2 kV, 4 kV, 8 kV Interval between single discharges: 1 sec. Number of pulses: 10 per polarity According to test level 3.	To simulate electrostatic discharge as may occur when persons touch the appliance; The test is to be confined to the points and surfaces that can normally be reached by the operator; Performance Criterion B [See Note 4].
12.	Electro-magnetic field (2016)	IEC 61000-4-3	Frequency range: 80 MHz to 2 GHz Modulation*: 80% AM at 1000 Hz Field strength: 10 V/m Frequency sweep rate: ≤ 1.5 × 10 ⁻³ decades/s (or 1% / 3 sec) According to test level 3.	To simulate electromagnetic fields radiated by different transmitters; The test is to be confined to the appliances exposed to direct radiation by transmitters at their place of installation. Performance criterion A [See Note 5] * If for tests of equipment, an input signal with a modulation frequency of 1000 Hz is necessary, a modulation frequency of 400 Hz may be chosen.

TABLE 1 (continued)
Type Tests for Control, Monitoring and Safety Equipment (2016)

No	TEST	PROCEDURE ACCORDING TO: [See Note 7]	TEST PARAMETERS	OTHER INFORMATION
13	Conducted Low Frequency (2016)		<p>AC: Frequency range: rated frequency to 200th harmonic; Test voltage (rms): 10% of supply to 15th harmonic reducing to 1% at 100th harmonic and maintain this level to the 200th harmonic, minimum 3 V (rms), maximum 2 W</p> <p>DC: Frequency range: 50 Hz – 10 kHz; Test voltage (rms): 10% of supply, maximum 2 W</p>	<p>To simulate distortions in the power supply system generated, for instance, by electronic consumers and coupled in as harmonics; Performance criterion A [See Note 5] See 4-7-2/Figure 1 for test set-up. For keeping max. 2 W, the voltage of the test signal may be lower.</p>
14.	Conducted Radio Frequency (2016)	IEC 61000-4-6	<p>AC, DC, I/O ports and signal/control lines: Frequency range: 150 kHz – 80 MHz Amplitude: 3 V rms [See Note 6] Modulation ** : 80% AM at 1000 Hz Frequency sweep range: $\leq 1.5 \times 10^{-3}$ decades/sec. (or 1% / 3 sec.) According to test level 2.</p>	<p>Equipment design and the choice of materials are to simulate electromagnetic fields coupled as high frequency into the test specimen via the connecting lines. Performance criterion A [See Note 5]. ** If for tests of equipment, an input signal with a modulation frequency of 1000 Hz is necessary, a modulation frequency of 400 Hz should be chosen.</p>
15.	Electrical Fast Transients/ Burst (2016)	IEC 61000-4-4	<p>Single pulse rise time: 5ns (between 10% and 90% value) Single pulse width: 50 ns (50% value) Amplitude (peak): 2 kV line on power supply port/earth; 1kV on I/O data control and communication ports (coupling clamp); Pulse period: 300 ms; Burst duration: 15 ms; Duration/polarity: 5 min According to test level 3.</p>	<p>Arcs generated when actuating electrical contacts; Interface effect occurring on the power supply, as well as at the external wiring of the test specimen; Performance criterion B [See Note 4].</p>
16.	Surge (2016)	IEC 61000-4-5	<p>Test applicable to AC and DC power ports Open-circuit voltage: Pulse rise time: 1.2 μs (front time) Pulse width: 50 μs (time to half value) Amplitude (peak): 1 kV line/earth; 0.5 kV line/line Short-circuit current: Pulse rise time: 8 μs (front time) Pulse width: 20 μs (time to half value) Repetition rate: ≥ 1 pulse/min Number of pulses: 5 per polarity Application: continuous According to test level 2.</p>	<p>Interference generated for instance, by switching “ON” or “OFF” high power inductive consumers; Test procedure in accordance with figure 10 of the standard for equipment where power and signal lines are identical; Performance criterion B [See Note 4].</p>

TABLE 1 (continued)
Type Tests for Control, Monitoring and Safety Equipment (2016)

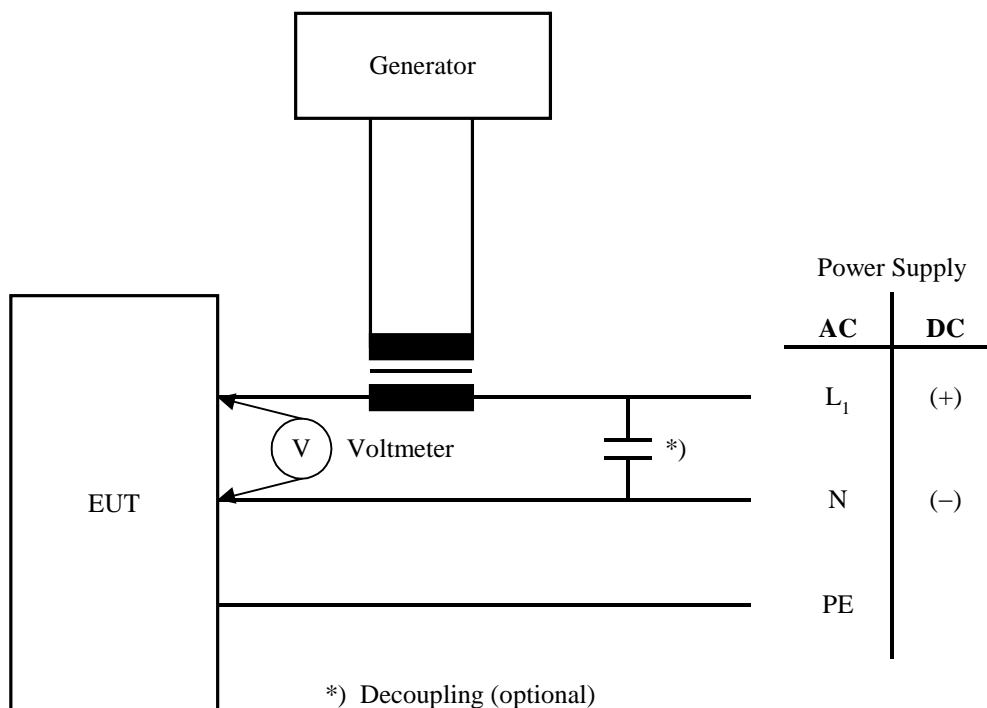
No	TEST	PROCEDURE ACCORDING TO: [SEE NOTE 7]	TEST PARAMETERS	OTHER INFORMATION																				
17.	Radiated Emission (2016)	CISPR 16-2-3	<p>For equipment installed in the bridge and deck zone:</p> <table border="0"> <tr> <td>Frequency range:</td> <td>Quasi peak Limits:</td> </tr> <tr> <td>0.15 – 0.3 MHz</td> <td>80 – 52 dBμV/m</td> </tr> <tr> <td>0.3 – 30 MHz</td> <td>52 – 34 dBμV/m</td> </tr> <tr> <td>30 – 2000 MHz</td> <td>54 dBμV/m</td> </tr> </table> <p>except for:</p> <table border="0"> <tr> <td>156 – 165 MHz</td> <td>24 dBμV/m</td> </tr> </table> <p>For equipment installed in the general power distribution zone:</p> <table border="0"> <tr> <td>Frequency range:</td> <td>Quasi peak Limits:</td> </tr> <tr> <td>0.15 – 30 MHz</td> <td>80 – 50 dBμV/m</td> </tr> <tr> <td>30 – 100 MHz</td> <td>60 – 54 dBμV/m</td> </tr> <tr> <td>100 – 2000 MHz</td> <td>54 dBμV/m</td> </tr> </table> <p>except for:</p> <table border="0"> <tr> <td>156 – 165 MHz</td> <td>24 dBμV/m</td> </tr> </table>	Frequency range:	Quasi peak Limits:	0.15 – 0.3 MHz	80 – 52 dB μ V/m	0.3 – 30 MHz	52 – 34 dB μ V/m	30 – 2000 MHz	54 dB μ V/m	156 – 165 MHz	24 dB μ V/m	Frequency range:	Quasi peak Limits:	0.15 – 30 MHz	80 – 50 dB μ V/m	30 – 100 MHz	60 – 54 dB μ V/m	100 – 2000 MHz	54 dB μ V/m	156 – 165 MHz	24 dB μ V/m	<p>Procedure in accordance with the standard but distance 3 m (10 ft) between equipment and antenna</p> <p>Alternatively, the radiation limit at a distance of 3 m from the enclosure port over the frequency 156 MHz to 165 MHz shall be 30 dB micro-V/m peak.</p>
Frequency range:	Quasi peak Limits:																							
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18.	Conducted Emission (2016)	CISPR 16-2-1	<p>Test applicable to AC and DC power ports</p> <p>For equipment installed in the bridge and deck zone:</p> <table border="0"> <tr> <td>Frequency range:</td> <td>Limits:</td> </tr> <tr> <td>10 – 150kHz</td> <td>96 – 50 dBμV</td> </tr> <tr> <td>150 – 350 kHz</td> <td>60 – 50 dBμV</td> </tr> <tr> <td>350 kHz – 30 MHz</td> <td>50 dBμV</td> </tr> </table> <p>For equipment installed in the general power distribution zone:</p> <table border="0"> <tr> <td>Frequency range:</td> <td>Limits:</td> </tr> <tr> <td>10 – 150 kHz</td> <td>120 – 69 dBμV</td> </tr> <tr> <td>150 – 500 kHz</td> <td>79 dBμV</td> </tr> <tr> <td>0.5 – 30 MHz</td> <td>73 dBμV</td> </tr> </table>	Frequency range:	Limits:	10 – 150kHz	96 – 50 dB μ V	150 – 350 kHz	60 – 50 dB μ V	350 kHz – 30 MHz	50 dB μ V	Frequency range:	Limits:	10 – 150 kHz	120 – 69 dB μ V	150 – 500 kHz	79 dB μ V	0.5 – 30 MHz	73 dB μ V					
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150 – 500 kHz	79 dB μ V																							
0.5 – 30 MHz	73 dB μ V																							
19.	Flame retardant (2008)	IEC 60092-101 or IEC 60695-11-5	<p>Flame application: 5 times 15 sec each. Interval between each application: 15 sec. or 1 time 30 sec.</p> <p>Test criteria based upon application.</p> <p>The test is performed with the Equipment Under Test (EUT) or housing of the EUT applying needle-flame test method.</p>	<p>The burnt out or damaged part of the specimen by not more than 60 mm long.</p> <p>No flame, no incandescence or in the event of a flame or incandescence being present, it shall extinguish itself within 30 sec. of the removal of the needle flame without full combustion of the test specimen.</p> <p>Any dripping material shall extinguish itself in such a way as not to ignite a wrapping tissue. The drip height is 200 mm \pm 5 mm.</p>																				

TABLE 1 (continued)
Type Tests for Control, Monitoring and Safety Equipment (2016)

Notes:

- 1 Equipment to be mounted in consoles, housing, etc., together with other equipment is to be tested with 70°C (158°F).
- 2 For equipment installed in non-weather protected locations or cold locations, test is to be carried out at -25°C (-13°F).
- 3 Salt mist test is to be carried out for equipment installed in weather exposed areas.
- 4 Performance criterion B (for transient phenomena): The equipment under test is to continue to operate as intended after the tests. No degradation of performance or loss of function is allowed, as defined in the technical specification published by the manufacturer. During the test, degradation or loss of function or performance which is self-recoverable is, however, allowed but no change of actual operating state or stored data is allowed.
- 5 Performance criterion A (for continuous phenomena): The equipment under test is to continue to operate as intended during and after test. No degradation of performance or loss is allowed, as defined in relevant equipment standard and the technical specification published by the manufacturer.
- 6 For equipment installed on the bridge and deck zone, the test levels are to be increased to 10 V rms for spot frequencies, in accordance with IEC 60945 at 2, 3, 4, 6.2, 8.2, 12.6, 16.5, 18.8, 22, 25 MHz.
- 7 Alternative equivalent testing procedures may be accepted, provided the requirements in the other columns are complied with.
- 8 (2015) When requested, equipment which has undergone the higher temperature and duration test will be recognized accordingly in the PDA certificate (see Appendix 1-1-A3 of the *ABS Rules for Conditions of Classification (Part 1)*). The purpose of introducing the optional 3HT test is for the convenience of equipment manufacturers should their clients request evidence that the equipment has been tested to the higher temperature requirements noted in Item 3A of the Table.
- 9 (2016) As used in this document, and in contrast to a complete performance test, a functional test is a simplified test sufficient to verify that the EUT has not suffered any deterioration caused by the individual environmental tests.

FIGURE 1
Test Set-up for Conducted Low Frequency Test
 (See Test No. 13 of 4-7-2/Table 1) (2008)



PART

4

CHAPTER 7 Shipboard Automatic or Remote Control and Monitoring Systems

SECTION 3 Automatic or Remote Propulsion Control and Monitoring Systems

1 General

The requirements contained in this section are applicable to propulsion machinery/systems intended for automatic operation or operation from a remote propulsion control station. Except as noted herein, the requirements in Sections 4-7-1 and 4-7-2, as applicable, are to be complied with.

3 Propulsion Control Capability (*1 July 1998*)

Vessels with the keel laid or in similar stage of construction on or after 1 July 1998 are to meet the following requirements. Under all sailing conditions, including maneuvering, the speed, direction of thrust and, where applicable, the pitch of the propeller, is to be fully controllable from the remote propulsion control station. The remote control is to be performed by a single control device for each independent propeller, with automatic performance of all associated services, including, where necessary, means of preventing overload of the propulsion machinery.

5 Propulsion Control Orders and Indicators (*1 July 1998*)

Vessels with the keel laid or in similar stage of construction on or after 1 July 1998 are to meet the following requirements. Propulsion machinery orders from the navigation bridge are to be indicated in the main machinery control room and at the maneuvering platform. See 4-6-2/15. The navigation bridge, main machinery control room and maneuvering platform is to be fitted with indication of the following:

- i) Propeller speed and direction of rotation in the case of fixed pitch propeller, or
- ii) Propeller speed and pitch position in the case of controllable propellers.

7 Propulsion Control Command

The remote propulsion control stations in the propulsion machinery space, as described in 4-7-3/5, are to be capable of assuming control at all times and to block orders from other associated remote control stations, if fitted. Considerations will be given to cases where, due to the intended vessel's service and operational requirements, it may be necessary for other associated stations to have override controls over the remote propulsion control stations in the propulsion-machinery space. See 4-7-2/3.3 and 4-7-2/3.5.

9 Propulsion Control Settings Deviation

Control transfer arrangements are to include means to prevent the propelling thrust from altering significantly when transferring control from one propulsion control station to another.

11 Propulsion Control Power Failure

In the event of power failure of the propulsion control system, the propulsion units are to continue to operate at the last ordered speed and direction of thrust of the propellers until local control is in operation or control power is safely resumed. However, considerations will be given to special cases, where due to the intended vessel's propulsion design and operational requirements, it may be necessary to automatically reduce the propulsion engine speed and reset the propeller pitch to zero upon control power failure.

13 Propulsion Starting

13.1

An alarm is to be provided in the propulsion-machinery space and at any propulsion control station fitted outside of the propulsion-machinery space to indicate a low level starting condition which is to be set at a level to permit further main engine starting operations. Where automatic starting of the propulsion machinery is fitted, the number of consecutive attempts to automatically start an engine is to be limited in order to safeguard sufficient capacity for local starting from the propulsion-machinery space. See also 4-2-1/13.

13.3

Propulsion machinery control system is to be designed so that it will automatically inhibit the starting of the propulsion machinery where conditions exist which may damage the propulsion machinery, i.e., shaft turning gear engaged, insufficient lubricating oil pressure, etc.

15 Remote Override of Safety Provisions

Remote override of safety provisions is not permitted for the following:

15.1

Shutdown of propulsion gas turbines upon failure or loss of the oil lubricating system. See 4-6-5/5.3.3 of the *Steel Vessel Rules*.

15.3

Shutdown of prime-movers for propulsion and ship's service diesel-generators upon activation of overspeed mechanism. See 4-6-4/3.19 of these Rules and 4-2-1/7.3 of the *Steel Vessel Rules*. However, considerations will be given to specific cases where due to the vessel's design and operational requirements, it may be necessary to momentarily override the propulsion machinery over the overspeed automatic shutdown.

15.5

Shutdown of prime-movers upon failure or loss of oil lubricating system to forced-lubricated propulsion or ship's service diesel-generators. See 4-6-4/3.15.

17 Critical Speeds

Adequate means are to be provided at the remote propulsion control station to alert the station operator of prolonged operation of the propulsion drives within barred speed ranges.

19 Emergency Shutdown

The propulsion machinery is to be provided with an emergency stopping device on the navigation bridge which is to be independent of the navigation bridge control system.

21 Automatic Shutdown Alarm

If the control system automatically shuts down the main propulsion machinery for any reason, this is to be alarmed at the remote propulsion control station.

23 Automatic Propulsion Control System

23.1 Integrity and Manual Control Functions

The automatic propulsion control system is to be designed and arranged so that a failure in the system is not to compromise the integrity nor the manual operation of the propulsion machinery.

23.3 Threshold Warning for Safety System Activations (*1 July 2004*)

Where the propulsion machinery is capable of remote control from the navigation bridge, regardless of manned or unmanned machinery space, automation systems are to be designed in a manner such that a threshold warning of impending or imminent slowdown or shutdown of the propulsion system is given to the officer in charge of the navigational watch in time to assess navigational circumstances in an emergency.

In particular, the systems are to control, monitor, report, alert and take safety action to slow down or shut down propulsion while providing the officer in charge of the navigational watch an opportunity to manually intervene (override), except for those cases where manual intervention will result in total failure of the engine and/or propulsion equipment within a short time, for example, in the case of over speed.

25 Controls and Instrumentation on Remote Propulsion Control Stations

Remote propulsion control stations fitted in vessels having the propulsion-machinery space manned are to be provided with the controls, alarms and displays as listed in 4-7-4/Table 2, as a minimum. This requirement is not applicable to portable propulsion control units interconnected with and arranged for operation within sight from the associated remote propulsion control station.

27 Trials

27.1 Automatic/Remote Control

The ability to effectively control the propulsion from the remote propulsion control station is to be demonstrated to the satisfaction of the Surveyor during sea trials or at dockside. These trials are to include propulsion control transfer, propulsion starting, verification of propulsion control responses, propulsion control power failure and actuation of propulsion emergency stop device.

27.3 Independent Manual Control

Independent manual control of the propulsion machinery is to be demonstrated during the tests or trials to the satisfaction of the Surveyor. This is to include demonstration of independent manual control through the full maneuvering range and transfer from automatic control.

PART

4

CHAPTER 7 Shipboard Automatic or Remote Control and Monitoring Systems

SECTION 4 Vessels Classed with ACCU Notation

1 General

Vessels having the means to control and monitor the propulsion machinery and propulsion-machinery space from the navigation bridge and from a centralized control and monitoring station installed within, or adjacent to, a periodically unattended propulsion-machinery space are to comply with the requirements contained in this subsection. Except as noted herein, the requirements in Sections 4-7-1 through 4-7-3, as applicable, are to be complied with. The requirements in this subsection cover the operation required for propulsion machinery start-up, safe sailing during open sea and maneuvering conditions, and do not cover operations after anchoring or mooring.

3 Equipment (2003)

Equipment associated with the remote or automatic control and monitoring of the propulsion machinery is to comply with the following requirements.

3.1 Application

Requirements of 4-7-4/3 apply to equipment that are components of the control, monitoring and safety systems of propulsion machinery, propulsion boilers, vital auxiliary pumps and the electrical power generating plant, including its prime mover, for vessels to be assigned with **ABCU** or **ACCU** notation.

3.3 Environmental Test Conditions

Control, safety and monitoring equipment is to be designed such that it will successfully withstand the test conditions stipulated in 4-7-2/Table 1, as applicable.

Upon request by the manufacturer, equipment designed to environmental conditions in excess of those in 4-7-2/Table 1 may be tested to such conditions and certified accordingly.

3.5 Environmentally Controlled Space

Where equipment is designed to operate only in a temperature regulated environment, the temperature regulating system (such as air-conditioner) is to be backed up by a stand-by unit. Failure of the system is to be alarmed.

3.7 Electric and Electronic Equipment

Electric and electronic equipment that are components of control, safety and monitoring systems are to be designed and constructed in accordance with the provisions of 4-7-2/15.

3.9 Equipment Tests

3.9.1 Prototype Environmental Testing

The following tests are to be carried out as a prototype testing in the presence of the Surveyor:

- i) Power supply variation test (item 1 in 4-7-2/Table 1)
- ii) Vibration test (item 5 in 4-7-2/Table 1)
- iii) Inclination test (item 6 in 4-7-2/Table 1)

Other prototype environmental tests specified in 4-7-2/Table 1 are to be conducted by the manufacturers. Acceptance will be based on review of the manufacturer's certified test reports by ABS. Omission of certain tests may be considered, taking into consideration the location of installation, functionality, contained devices, etc. of the equipment.

In general, field sensors (e.g., pressure transmitters) and field devices (e.g., solenoid valves), circuit breakers and cables may be exempted from the tests specified in 4-7-2/Table 1.

For computer-based systems, the equipment to be tested includes microprocessors, storage devices, power supply units, signal conditioners, analog/digital converters, computer monitors (visual display units), keyboards, etc., but may exclude printer, data recording or logging device not required in this section.

3.9.2 Production Unit Certification

After assembled to a complete assembly unit or subassembly unit, each production unit of equipment used in control, monitoring and safety systems is to be tested at the manufacturer's shop in the presence of the Surveyor to verify the tests in 4-7-4/Table 1.

3.9.3 Type Approval Program

At the request of the manufacturer, equipment, subassemblies or complete assemblies of control, monitoring and safety systems may be considered for Type Approval in accordance with the provisions of 1-1-A3/5.3 (RQS) or 1-1-A3/5.5 (PQA) of the *ABS Rules for Conditions of Classification (Part 1)*. Where qualified, they may be listed on the ABS website as Type Approved Products.

Those products type-approved under 1-1-A3/5.3 (RQS) of the *ABS Rules for Conditions of Classification (Part 1)* will be acceptable, subject to renewal and updating of the certificates, for the purposes of Part 4, Chapter 7 without the need for the Surveyor's attendance at the production tests and inspections specified in 4-7-4/3.9.2. Production unit certification in such instances will be carried out as described in 1-1-A3/5.7.1(a) of the above-referenced Part 1.

For the updating or renewal of type approval, please refer to 1-1-A3/5.7.2 and 1-1-A3/5.7.4 of the *ABS Rules for Conditions of Classification (Part 1)*.

5 Automatic Propulsion Controls

Effective control of the propulsion machinery from the navigation bridge is to be performed with automatic performance of all associated functions, including, where necessary, means of preventing overload of the propulsion machinery. The required automatic control means to operate the propulsion machinery are to be capable of meeting load demands from standby to full system rated load under all operating conditions without the need for manual adjustment or manipulation.

7 Station in Navigation Bridge

The navigation bridge propulsion control station is to include the following: controls, displays and alarms (see also 4-7-4/Table 2).

- i) The means to alarm excessive rise of water in the propulsion-machinery space bilges.
- ii) A summary-alarm for the propulsion and its associated machinery. Any of the alarm conditions as listed in 4-7-4/Table 4A through 4-7-4/Table 7 is to activate the summary-alarm.
- iii) Means of remote starting of any one of the main fire pumps unless the fire main is permanently pressurized.

9 Centralized Control and Monitoring Station

The centralized control and monitoring station is to include adequate controls, displays and alarms needed to maintain normal and safe operation of the propulsion machinery and monitor associated ship's service systems, electrical power generating machinery and propulsion-machinery space. The installed control and monitoring system is to provide the same degree of control as if the propulsion-machinery space was manned. See 4-7-4/Table 3 through 4-7-4/Table 7 for required controls, alarms and displays to be fitted at such station.

11 Power Supply for Control and Monitoring Systems

11.1 General

The power supply arrangement is to be in accordance with 4-7-2/11.1.1. In addition, an emergency feeder or pipe is to be provided for control systems, display/alarm systems and safety systems.

11.3 Electrical

The emergency feeder as well as the main supply feeder for control systems, alarm/display systems and safety are to be connected to the emergency switchboard and main switchboard (distribution boards), respectively, and are to be provided with short-circuit protection at such boards. Their supply status is to be displayed at the remote propulsion stations.

11.5 Power Supply Transfer

Transfer of power supply for the systems is to be effected automatically. The power supply transfer device (switch or valve) is to be arranged for manual operation.

13 Continuity of Power

13.1 General

Provision is to be made for automatic starting and connecting to the main switchboard of a standby generator of sufficient capacity to permit propulsion and steering and to ensure the safety of the vessel with automatic restarting of the essential auxiliaries, including, where necessary, sequential operations. This standby electric power is to be available in no more than 45 seconds.

13.3 Reduced Power

To satisfy 4-7-4/13.1, the operation of propulsion machinery and vital services may be at reduced power.

15 Automatic Transferring of Vital Auxiliary Pumps (2007)

The means for the automatic starting and transferring of required standby vital auxiliary pumps associated with propulsion are to be provided. The automatic starting and transferring of vital auxiliary pumps, where fitted is to be alarmed at the centralized control and monitoring station. The centralized control and monitoring station is to be provided with means to remotely start and stop vital auxiliary pumps associated with the following machinery/systems:

- i) Propulsion Machinery
- ii) Electrical Power Generating Machinery
- iii) Controllable Pitch Propellers (C.P.P)
- iv) *Fuel Oil Transfer or Service System.* This is applicable to pumps associated with settling and daily service tanks.

17 Propulsion Gas Turbines (1999)

The centralized control and monitoring station is to be provided with the safety provisions, alarms and displays as listed in 4-7-4/Table 5. Special consideration may be given for vessels in restricted service. See 4-2-3/7.7 of the *Steel Vessel Rules*.

19 Propulsion Diesel Engines

19.1 Lubricating Oil

In the event of loss of lubricating oil, there is to be an automatic shutdown of the main engine.

19.3 Overspeed

An overspeed condition is to cause the automatic shutdown of the main engine.

19.5 Controls and Instrumentation

The centralized control and monitoring station is to be provided with the safety provisions, alarms and displays as listed in 4-7-4/Table 4A and 4-7-4/Table 4B.

21 Electric Propulsion

For electric propulsion driven vessels, in order to prevent nuisance tripping of the main generator circuit breakers, a power management system is to be provided and arranged so that when the power requirement for the propulsion motors exceeds the on-line generating capacity, the power management system is to automatically take a corrective action, such as reduction of power, shedding of non-essential loads, etc. The centralized control and monitoring station is to be provided with the alarms and displays as listed in 4-7-4/Table 6.

23 Electrical Power Generating Machinery

The centralized control and monitoring station is to be provided with the alarms and displays as listed in 4-7-4/Table 7.

25 Fuel Oil Settling and Daily Service Tanks

25.1 General

Low level conditions of fuel oil settling and daily service tanks are to be alarmed at the centralized control and monitoring station. Additionally, adequate interlock means to prevent tank overpressurization or overflow spillages are to be provided.

25.3 Automatic Filling

The fuel oil settling or daily service tanks are to be of a capacity sufficient for at least eight hours operation at normal power. The arrangements are to include high level alarm together with automatic filling pump shutdown and automatic pump start-up at a predetermined low level, in addition to the arrangements per 4-7-4/25.1.

25.5 Heating Arrangements

See 4-7-4/29.3.3.

27 Propulsion and Associated Machinery Start-up

Starting of the propulsion and associated machinery or preparing the engines for sea may be performed manually, but if done automatically, this is to be programmed that the propulsion machinery cannot be started until all engine auxiliaries are functioning correctly.

29 Arrangement and Monitoring of Machinery Space

29.1 Bilges

29.1.1 General

The propulsion-machinery space is to be provided with a bilge water-level system to detect excessive water influx or rise in the propulsion-machinery space bilges at the various angles of vessel's heel and trim. The bilge wells are to be large enough to accommodate the normal drainage. Excessive water influx or rise in the bilge wells is to be alarmed at the centralized control and monitoring station. See also 4-7-4/Table 2 and 4-7-4/Table 3 for alarms and displays.

29.1.2 Excessive Automatic Starting of Bilge Pumps

Means are to be provided to indicate at the centralized control and monitoring station when the influx of liquid is greater than the pump capacity or when the pump is operating more frequently than would normally be expected. Additionally, special attention is to be given to oil pollution prevention requirements.

29.3 Fire Prevention

To minimize the outbreak of fire, the following is to be provided:

29.3.1

In high pressure fuel-oil piping (see 4-2-1/7.3 of these Rules and 4-6-5/3.7.1 of the *Steel Vessel Rules*), an oil leakage condition is to be alarmed at the centralized control and monitoring station.

29.3.2

Drip trays for collecting oil, as required in 4-4-1/9.23, are to be of suitable height and provided with suitable drainage to a collecting tank incorporating a high level alarm audible at the centralized control and monitoring station.

29.3.3

Where heaters are provided in fuel systems, the required alarms in 4-4-4/1.5 are to be located at the centralized control and monitoring station.

29.3.4

Fuel oil heaters, purifiers, pumps and filters are to be shielded or grouped in a special room or location ventilated by suction.

29.5 Fire Detection and Alarm (2010)

29.5.1 General

The propulsion-machinery space is to be provided with a fixed fire detection and alarm system complying with Regulation II-2/7.4 of SOLAS 1974, as amended. This fixed fire detection and alarm system may be combined with other fire detection and alarm systems required onboard the vessel. The fire control panel is to be located on the navigation bridge or in the fire fighting station. If located in the fire fighting station, a repeater panel is to be fitted on the navigation bridge. Propulsion machinery space fire is to be alarmed in the centralized control station.

29.5.2 Temporarily Disconnecting Alarms

A fire detector loop or detector(s) covering the unattended machinery space may be temporarily disabled, for example, for maintenance purposes and such action is to be clearly indicated at the fire control panel and at the centralized control station described in 4-7-4/29.5.1. Disabled loop or detectors are to be reactivated automatically after a preset time period.

31 Monitoring Station in Engineers' Accommodation

The following is applicable to vessels fitted with engineers' accommodations.

31.1 General (2006)

At least one alarm monitoring station is to be provided in the engineers' public spaces, such as the officers' lounge or officers' mess room. Where the engineer on-duty is assigned to work in a specific space, such as the ship's office or engineers' office, then such a space is also to be provided with an alarm monitoring station. Each such station is to be provided with alarms for fire, high bilge-water level in the propulsion-machinery space, and summary-alarms for the propulsion and its associated machinery. Any of the alarm conditions as listed in 4-7-4/Table 4A through 4-7-4/Table 7, as applicable, are to activate the specific machinery summary-alarm. Additionally, alarm monitoring stations through a selector switch are to be provided in each individual engineer's stateroom and arranged so that at least one alarm monitoring station is active at all times. Selective switching is not to be provided for the fire alarms. The fire alarm is to be separate and distinct from the alarms of any other systems. Fire, high bilge-water level and the specific machinery summary-alarms are to be audible in the engineers' public spaces and staterooms until manually silenced at the centralized control and monitoring station in the propulsion-machinery space.

31.3 Alternative Arrangement

The arrangements in 4-7-4/31.1 may be modified to permit the audible machinery summary-alarm and high bilge water level alarm to be silenced locally at the alarm monitoring stations in the engineers' public spaces and staterooms, provided the associated visual alarm is not extinguished. Also, the arrangements are to be such that if the audible alarm is not also silenced manually at the centralized control and monitoring station in a reasonable period of time, the system is to activate the engineers' alarm audible in the engineers' accommodations. The means for silencing locally at the alarm monitoring stations is not to be provided for fire alarms.

33 Firefighting Arrangements for Propulsion Machinery Space Fires

33.1 Location

The firefighting arrangements are to be centralized in a location outside of the propulsion-machinery space.

33.3 Fire-fighting Controls

Firefighting arrangements are to be provided with remote manual controls for the operations detailed in the following list. These controls are to be capable of being tested to the satisfaction of the Surveyor.

33.3.1 (2010)

Stopping of ventilation fans serving the machinery-space. See 4-6-2/19.1.1.

33.3.2 (2010)

Stopping of fuel oil, lubricating oil and thermal oil system pumps. See 4-6-2/19.1.2.

33.3.3 (2010)

Stopping of forced and induced draft fans of boilers, inert gas generators and incinerators, and of auxiliary blowers of propulsion diesel engines. See 4-6-2/19.1.2.

33.3.4

Closing propulsion-machinery space fuel oil tanks suction valves. (See 4-5-1/5.5).

33.3.5 (2010)

Closing machinery-space skylights, openings in funnels, ventilator dampers and other openings.

33.3.6 (2014)

Closing machinery-space watertight and fire-resistant doors. Self-closing doors with no hold-back arrangements may be excluded.

33.3.7

Starting the emergency generator or connecting a source of emergency power, unless automatic operation is provided.

33.3.8 (2004)

Operation of a fire pump located outside of the propulsion-machinery space, including associated valves necessary to deliver the required capacity to the fire main. However, valves located near the pump need not be provided with remote operation from the fire fighting station if they are kept locked open (LO) or closed (LC), as appropriate, to provide immediate water supply to the fire main. The position of the valves (open or closed) is to be clearly marked. Where the sea chest valve is located in the same compartment as the fire pump and the sea chest valve is kept locked open, a high-level bilge alarm is to be fitted in the fire pump space. If the sea chest is located in a different space than the compartment containing the fire pump, then a high-level bilge alarm is to be fitted in the fire pump space, as well as the compartment containing the sea chest, in order to detect possible flooding in each of these spaces. The high-level bilge alarm is to sound in the centralized control station.

33.3.9

Releasing of the fire-fighting media for the propulsion-machinery space. This release is to be manual and not initiated automatically by signals from the fire-detecting system.

33.3.10 (2012)

Shutdown of fixed local application fire fighting systems, see 4-5-2/9.1, before activation of a high-expansion foam fire extinguishing system, see 4-5-2/11.5.1, to avoid adverse water action on the foam.

33.5 Fire Detection and Alarm Systems

See 4-7-4/29.5.

33.7 Fire Alarm Call Points

Manually operated fire alarm call points are to be provided in, and in the passageways leading to, the propulsion-machinery space.

35 Communications

The communication system required by 4-7-2/13 is to include the engineer's accommodations area, if provided.

37 Sea Trials

In addition to the requirements in 4-7-3/27, effective operation of the following is to be demonstrated to the satisfaction of the Surveyor. With the exception of 4-7-4/37.9, it is recommended that these demonstrations or tests be carried out before sea trials and are to include simulated failures so that proper corrective actions may be carried out and witnessed by the Surveyor.

37.1 Automatic or Remote Control and Monitoring System for Propulsion Machinery and Electrical Power Generating Machinery

In addition to the verification of required control responses, alarms and displays, this demonstration is to include the automatic transferring of the required standby vital auxiliary pumps.

37.3 Local Control

Local control of the propulsion machinery is to be demonstrated.

37.5 Fire Control and Alarm System

In addition to the verification of required detectors, displays and call points and where the fire main is not maintained pressurized, it is to be demonstrated that at least one of the main fire pumps can be started from the station in the navigation bridge.

37.7 Bilge Detection System

Where provided, automatic starting of the propulsion-machinery space bilge pumps is to be demonstrated.

37.9 Operational Test of Propulsion Machinery

After the propulsion machinery has been running for at least two hours, the ability to control the machinery functions correctly for all loads and engine maneuvers without any manual intervention in the propulsion-machinery space is to be demonstrated for an additional period of four hours. Propulsion machinery or engine response to throttle control demands is to be tested during the trials and after final adjustments to demonstrate that no part of the plant or engine is jeopardized by the rate at which the throttle is moved from one extreme position to the other. The loss of electric power is to be simulated with the main engine running.

TABLE 1
Tests for Unit Certification of Control, Monitoring and Safety Equipment (2016)

<i>No</i>	<i>TEST</i>	<i>PROCEDURE ACCORDING TO: [See Note]</i>	<i>TEST PARAMETERS</i>	<i>OTHER INFORMATION</i>
1.	Visual inspection	---	---	Conformance to drawings, design data Quality of workmanship and construction
2.	Performance test (2016)	Manufacturer's performance test program based upon specification and relevant Rule requirements. When the EUT is required to comply with an international performance standard (e.g., protection relays), verification of requirements in the standard are to be part of the performance testing required in this initial test and subsequent performance tests after environmental testing where required by 4-7-2/ Table 1.	Standard atmosphere conditions Temperature: 25°C (77°F) ± 10°C (18°F) Relative humidity: 60% ± 30% Air pressure: 96 kPa (0.98 kgf/cm ² , 13.92 psi) ± 10 kPa (0.10 kgf/cm ² , 1.45 psi)	Confirmation that operation is in accordance with the requirements specified for particular systems or equipment; Checking of self-monitoring features; Checking of specified protection against an access to the memory; Checking against effect of unerroneous use of control elements in the case of computer systems.
3.	External Power supply failure (2008)	---	3 interruptions during 5 minutes; switching-off time 30 s each case	The time of 5 minutes may be exceeded if the equipment under test (EUT) needs a longer time for startup, for example, booting sequence. For equipment which requires booting, one additional power supply interruption during booting is to be performed. Verification of: the specified action of equipment upon loss and restoration of supply; possible corruption of program or data held in programmable electronic systems, where applicable.

Note: Alternative equivalent testing procedures may be accepted, provided the requirements in the other columns are complied with.

TABLE 2
Control Station in Navigation Bridge
(Applicable to All Classed Vessels) (2011)

		<i>Item</i>	<i>Alarm (, 9)</i>	<i>Display (12)</i>	<i>Provisions of Device on Station (1)</i>	<i>Remarks</i>
Required for All Vessels (8)						
Control and Monitoring System	A1	Failure or malfunctioning of system	x			See Notes 2, 10.
	A2	(2005) Failure, power supply	x	Main/Standby		See Note 2 For non- ACCU vessels, the failure alarm is applicable to main power source only. For ACCU vessels, applicable to main and emergency power sources. Automatic transfer for ACCU vessels only. (See 4-7-2/11.1.2.)
	A3	(2005) Failure, individual power supply to control, monitoring and safety systems	x	x		See Notes 2, 10.
	A4	Control station in operation		Station		
	A5	(1998) Control transfer acknowledgement switch			x	
	A6	Alarm, disabled (override)		Disabled		See Note 4.
	A7	Safety, activation	x			See Notes 3, 10.
	A8	Safety disabled	x	Disabled		See Notes 4, 10.
	A9	(1 July 2004) Threshold warning for safety system activations	x			For navigation bridge only (See 4-7-3/23.3)
Propulsion, General	B1	Remote controls			x	For each propelling unit and all units, as applicable
	B2	(1998) Propeller shaft, speed		Speed		See Note 11.
	B3	Propeller shaft, direction (1998)		Direction		See Note 11.
	B4	(1998) Propeller, pitch		Pitch		For controllable-pitch propeller See Note 11.
	B5	(1998) Telegraph or similar			x	See Note 11.
Propulsion, Starting	C1	Starting medium, pressure or level, low	x	Pressure or level		See Note 5.
	C2	Hazardous condition present	x			See 4-7-3/13.3
Emergency Shutdown	D1	Propulsion			x	See 4-7-3/19
Required for ACCU or ABCU Classed Vessels						
Propulsion	E1	Prime movers, prolonged operation within critical speed range	x			Visual display may be acceptable
Fire Pump	F1	Start/stop switch			x	Not required if the fire main is maintained pressured
Propulsion, Starting	G1	Start/stop switch for starting system			x	Not required for non-reversing engines

TABLE 2 (continued)
Control Station in Navigation Bridge
(Applicable to All Classed Vessels) (2011)

Item			Alarm (1, 9)	Display (12)	Provisions of Device on Station (1)	Remarks
Controllable- Pitch Propeller (CPP)	H1	Start/stop switch for CPP hydraulic motor			x	If provided
	H2	CPP hydraulic motor running		Running		If provided
	H3	Automatic starting of required standby pump	x			If provided
Electric Propulsion	I1	Propulsion generator load-share overload	x			See 4-6-4/3.21.3 & 4-6-4/3.23.3 and 4-7-4/19
Summary- alarms	J1	Propulsion and associated machinery failure	x			See Notes 6, 7.
Bilges In Machine Space	K1	Level, bilges, high	x			See 4-7-4/29.1.1 (7)
Fire in Machinery Space	L1	Fire control panel	x	Fire	x	See 4-7-4/29.5 (7)
Vital Auxiliary Pumps	M1	Start/stop and transfer switches			x	For ABCU vessels having non-integrated propulsion machinery

Notes:

- 1 Required actuation device or alarm is denoted by a (x).
- 2 For each system: control systems, alarm/display systems and safety systems. See 4-7-2/11.1.1 and 4-7-4/11.
- 3 Actuation of propulsion safeties is to either reduce output or shutdown the propulsion machinery, as required. See also 4-7-2/7, 4-7-3/15 and 4-7-4/Table 4A through 4-7-4/Table 7.
- 4 Deactivation means are to be arranged so that such action cannot be done inadvertently. Alternative means to indicate disabling of safety actions or alarms will be considered.
- 5 This alarm is also to be provided in the machinery space.
- 6 This summary-alarm is to be activated by any of the alarm conditions as listed in 4-7-4/Table 4A through 4-7-4/Table 7. See 4-7-4/31.
- 7 These alarms are also to be alarmed at the engineer's accommodations, see 4-7-4/31.
- 8 The listed instrumentation is also applicable to other remote propulsion control stations installed outside of the navigation bridge. See 4-7-3/25.
- 9 Provided the audible alarms reactivate automatically after a preset time, audible alarms may be bypassed or deactivated during machinery start-up.
- 10 May be arranged as a summary-alarm (common).
- 11 (1 July 1998) To be provided also at the maneuvering platform.
- 12 (2011) Display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered.

TABLE 3
Centralized Control and Monitoring Station
(Applicable to ACCU or ABCU Vessels) (2011)

	<i>Item</i>	<i>Alarm (1, 6)</i>	<i>Display (7)</i>	<i>Provisions of Device on Station (1)</i>	<i>Remarks</i>	
Control and Monitoring System	A1	Failure or malfunctioning of system	x		See Notes 2, 5.	
	A2	Failure, supply	x	Main/Standby	Automatic transfer to standby supply (2, 5)	
	A3	Control station in operation		Station		
	A4	(1998) Control transfer acknowledgement switch			x	
	A5	Control power available, pressure or level		Pressure/Level		See Note 5.
	A6	Alarm, disabled (override)		Disabled		See Notes 4, 5.
	A7	Safety, activation	x			See Notes 3, 5.
	A8	Safety disabled	x	Disabled		See Notes 4, 5.
	A9	Safety, disabled (override) switch			x	See 4-7-2/7.11 (5)
Propulsion, General	B1	Remote controls			x	
	B2	Propeller shaft, speed		Speed		See Note 5.
	B3	Propeller shaft, direction		Direction		See Note 5.
	B4	Propeller, pitch		Pitch		For controllable-pitch propeller (6)
	B5	Prime movers, critical speed	x			Visual display may be acceptable (6)
	B6	Engine order telegraph or similar			x	Not applicable to certain vessels < 500 GT. See 4-6-2/15.1.2
Propulsion, Starting	C1	Starting medium, pressure or level, low	x	Pressure or Level		See Note 5.
	C2	Hazardous condition present	x			See 4-7-3/15.5 (5)
Diesel Propulsion	D1	Alarms and displays				See 4-7-4/Table 4A & B
Gas Turbine Propulsion	E1	Alarms and displays				See 4-7-4/Table 5
Electric Propulsion	F1	Alarms and displays				See 4-7-4/Table 6
	F2	Propulsion generator load-share overload	x			See 4-6-4/3.21.3 & 4-6-4/3.23.3 and 4-7-4/19
Elect. Gen. Machinery	G1	Alarms and displays				See 4-7-4/Table 7
FO Settling and Daily Service Tanks	H1	Level, tank, low	x			See Note 5.
	H2	Level, tank, high	x			If automatic filling provided (5)
	H3	Oil temperature, high or oil flow, low	x			Includes L.O. systems (5)
FO and LO Collect. Tank	I1	Level, tank, high	x			See 4-7-4/29.3.2 (5)
High Pres. FO System	J1	Leakage	x			See 4-7-4/29.3.1 (5)

TABLE 3 (continued)
Centralized Control and Monitoring Station
(Applicable to ACCU or ABCU Vessels) (2011)

<i>Item</i>			<i>Alarm (1, 6)</i>	<i>Display (7)</i>	<i>Provisions of Device on Station (1)</i>	<i>Remarks</i>
LO Stern Tube Tank	K1	Level, oil, low	x			See Note 5.
Bilges in Machinery Space	L1	Level, bilges, high	x			See 4-7-4/29.1.1 ⁽⁵⁾
	L2	Excessive running of bilge pump motor	x			If auto, starting provided. See 4-7-4/29.1.2 ⁽⁵⁾

Notes:

- 1 Required actuation device or alarm is denoted by a (x).
- 2 For each system: control systems, alarm/display systems and safety systems. See 4-7-2/11.1.1 and 4-7-4/11.
- 3 Actuation of propulsion safeties is to either reduce output or shutdown the propulsion machinery, as required. See 4-7-3/15 and 4-7-4/Table 4A through 4-7-4/Table 7.
- 4 Deactivation means are to be arranged so that such action cannot be done inadvertently. Alternative means to indicate disabling of safety actions or alarms will be considered.
- 5 For **ABCU** vessels, only these items and the alarms and displays per 4-7-4/Table 4A through 4-7-4/Table 7, as applicable, need to be provided on such station.
- 6 Provided the audible alarms reactivate automatically after a preset time, audible alarms may be bypassed or deactivated during machinery start-up.
- 7 (2011) Display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered.

TABLE 4A
Monitoring of Propulsion Machinery – Slow Speed (Crosshead) Diesel Engines
(See also 4-7-4/Table 3) (2011)

		<i>Item⁽¹¹⁾</i>	<i>Alarm⁽¹⁾</i>	<i>Display⁽¹⁶⁾</i>	<i>Automatic Start of Required Standby Vital Auxiliary Pump with Alarm⁽¹⁾</i>	<i>Remarks⁽¹²⁾</i>
Fuel Oil System	A1	Fuel oil after filter (engine inlet) pressure – low	x	Pressure	x	See Note 3.
	A2	Fuel oil before injection pumps, temperature – high (or viscosity – low), and Fuel oil before injection pumps, temperature – low (or viscosity – high)	x			
	A3	Leakage from high pressure pipes	x			
	A4	Fuel oil in daily service tank, low-level	x			See also 4-7-4/25
	A5	(2010) Common rail fuel oil pressure – low	x			
Lube Oil System	B1	Lube oil to main bearing and thrust bearing, pressure-low	x	Pressure	x	See Notes 2, 3, 4.
	B2	Lube oil to crosshead bearing, pressure – low	x	Pressure	x	See Notes 2, 3, 4, 5.
	B3	Lube oil to camshaft, pressure – low	x		x	Automatic engine shutdown ^(3, 4, 5)
	B4	Lube oil to camshaft, temperature – high	x			See Note 5.
	B5	Lube oil inlet, temperature – high	x			
	B6	Thrust bearing pads or Bearing outlet, excessive temperature – high	x			Automatic engine shutdown/shutdown ^(2, 3)
	B7	(2009) Oil mist in crankcase, mist concentration – high; or Bearing temperature - high; or Alternative arrangements	x			Automatic engine shutdown ^(2, 6)
	B8	Flow rate cylinder lubricator, flow – low. Each apparatus	x			Automatic engine slowdown ⁽²⁾
	B9	Lubricating tanks, level – low	x			See Note 7.
	B10	(2010) Common rail servo oil pressure – low	x			
Turbocharger System	C1	(2010) Lube oil inlet, pressure – low	x			See Note 13
	C2	(2010) Lube oil outlet (each bearing), temperature – high	x			See Note 14
	C3	Turbocharger speed		Speed		
Piston Cooling System	D1	Coolant inlet, pressure – low	x		x	Automatic engine slowdown ^(2, 3, 8)
	D2	Coolant outlet (each cylinder), temperature – high	x			Automatic engine slowdown ⁽²⁾
	D3	(2010) Coolant outlet (each cylinder), flow – low	x			Automatic engine slowdown ^(2, 15)
	D4	Coolant in expansion tank, level – low	x			
S. W. Cooling	E1	Sea water cooling, pressure – low	x		x	See Note 3.

TABLE 4A (continued)
Monitoring of Propulsion Machinery –Slow Speed (Crosshead) Diesel Engines
(See also 4-7-4/Table 3) (2011)

		<i>Item⁽¹¹⁾</i>	<i>Alarm⁽¹⁾</i>	<i>Display⁽¹⁶⁾</i>	<i>Automatic Start of Required Standby Vital Auxiliary Pump with Alarm⁽¹⁾</i>	<i>Remarks⁽¹²⁾</i>
Cylinder Fresh Cooling Water System	F1	Water inlet, pressure-low	x		x	Automatic engine slowdown ^(2,3)
	F2	Water outlet (for each cylinder), temperature-high, or Water outlet (general), temperature-high	x			Automatic engine slowdown ^(2,9)
	F3	Oily contamination of engine cooling water system	x			See Note 10.
	F4	Cooling water in expansion tank, level – low	x			
Air System	G1	Starting air before main shut-off valve, pressure – low				See item C1 in 4-7-4/Table 3
	G2	Control air, pressure – low	x			
	G3	Safety air, pressure – low	x			
Scavenge Air Systems	H1	Scavenge air receiver		Pressure		
	H2	Scavenge air box, temperature – high (fire)	x			Automatic engine shutdown ⁽²⁾
	H3	Scavenge air receiver water, level – high	x			
Exhaust Gas System	I1	Exhaust gas after each cylinder, temperature – high	x	Temp.		Automatic engine slowdown ⁽²⁾
	I2	Exhaust gas after each cylinder, deviation from average, temperature – high	x			
	I3	Exhaust gas before each T/C, temperature – high	x	Temp.		
	I4	Exhaust gas after each T/C, temperature – high	x	Temp.		
Fuel Valve Coolant	J1	Fuel valve coolant, pressure – low	x		x	See Note 3.
	J2	Fuel valve coolant, temperature – high	x			
	J3	Fuel valve coolant in expansion tank, level – low	x			
Engine	K1	Engine speed/direction of rotation		Speed/rotation		
	K2	Engine overspeed	x			Automatic engine shutdown ⁽³⁾
	K3	(1998) Direction of rotation – Wrong way	x			
Power Supply	L1	Control, alarm or safety system, power supply	x			

TABLE 4A (continued)
Monitoring of Propulsion Machinery – Slow Speed (Crosshead) Diesel Engines
(See also 4-7-4/Table 3) (2011)

Notes:

- 1 Required alarm or starting of standby pump is denoted by a (x).
- 2 A common sensor for alarm/display and automatic slowdown is acceptable.
- 3 Separate sensors are required for *a*) alarm/automatic starting of required standby pump, and *b*) automatic engine shutdown.
- 4 Automatic engine shutdown is to be alarmed and effected upon loss of oil pressure.
- 5 If separate lube oil systems are installed.
- 6 (2009) For engines having a power of 2250 kW (3000 hp) and above or having a cylinder bore of more than 300 mm (11.8 in.). See 4-2-1/7.2 of the *Steel Vessel Rules*.
- 7 Where separate lubricating oil systems are installed (e.g., camshaft, rocker arms, etc.), individual level alarms are required for the tanks.
- 8 The slowdown is not required if the coolant is oil taken from the main cooling system of the engine.
- 9 Where one common cooling space without individual stop valves is employed for all cylinder jackets.
- 10 Where main engine cooling water is used in fuel and lubricating oil heat exchangers.
- 11 For **ABCU** vessels having integrated propulsion machinery, exemption from the listed instrumentation and safety provisions will be considered.
- 12 (1998) Instead of automatic slowdown, manual slowdown will be acceptable, provided visual/audible alarm with illumination sign "Reduced Power" is located in the navigation bridge.
- 13 (2010) Unless provided with a self-contained lubricating oil system integrated with the turbocharger.
- 14 (2010) Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
- 15 (2010) Where outlet flow cannot be monitored due to engine design, alternative arrangements may be accepted.
- 16 (2011) Display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered.

TABLE 4B
Monitoring of Propulsion Machinery –
Medium/High Speed (Trunk Piston) Diesel Engines
(See also 4-7-4/Table 3) (2013)

		<i>Item</i> ⁽¹¹⁾	<i>Alarm</i> ⁽¹⁾	<i>Display</i> ⁽¹⁴⁾	<i>Automatic Start of Required Standby Vital Auxiliary Pump with Alarm</i> ⁽¹⁾	<i>Remarks</i> ⁽¹²⁾
Fuel Oil System	A1	Fuel oil after filter (engine inlet), pressure – low	x	Pressure	x	See Note 3
	A2	Fuel oil before injection pumps, temperature – high (or viscosity – low), and Fuel oil before injection pumps, temperature – low (or viscosity – high)	x			See Note 5
	A3	Leakage from high pressure pipes	x			
	A4	Fuel oil in daily service tank, level – low	x			See also 4-7-4/25
	A5	(2010) Common rail fuel oil pressure – low	x			
Lube Oil System	B1	Lube oil to main bearing and thrust bearing, pressure – low	x	Pressure	x	Automatic engine shutdown ^(3, 4)
	B2	(1998) Lube oil filter differential, pressure – high	x	Pressure	x	See Note 3
	B3	Lube oil inlet, temperature – high	x	Temp.		
	B4	(2009) Oil mist in crankcase, mist – concentration high; or Bearing temperature – high; or Alternative arrangements	x			Automatic engine shutdown ⁽⁶⁾
	B5	Flow rate cylinder lubricator, flow – low. Each apparatus	x			(1997) Automatic engine slowdown ^(2, 10)
	B6	(2010) Common rail servo oil pressure – low	x			
Turbocharger	C1	Turbocharger lube oil inlet, pressure – low	x	Pressure		See Note 7
	C2	(2013) Turbocharger oil outlet temp., each bearing – high	x	Temp.		See Note 13
S. W. Cooling	D1	Sea water cooling, pressure – low	x	Pressure	x	See Note 3
Cylinder Fresh Cooling Water System	E1	Water inlet, pressure-low or flow – low	x	Press. or flow	x	Automatic engine slowdown ^(2, 3)
	E2	Water outlet (general), temperature – high	x	Temp.		Automatic engine slowdown ⁽⁸⁾
	E3	Cooling water in expansion tank, level – low	x			
Air System	F1	Starting air before main shut-off valve, pressure – low				See item C1 in 4-7-4/Table 3
	F2	Control air, pressure – low	x	Pressure		
Scavenge Air System	G1	Scavenge air receiver, temperature – high	x			
Exhaust Gas System	H1	Exhaust gas after each cylinder, temperature – high	x	Temp.		Automatic engine slowdown ^(2, 9)
	H2	Exhaust gas after each cylinder, deviation from average, temperature – high	x			See Note 9

TABLE 4B (continued)
Monitoring of Propulsion Machinery –
Medium/High (Trunk Piston) Speed Diesel Engines
(See also 4-7-4/Table 3) (2013)

		<i>Item</i> ⁽¹¹⁾	<i>Alarm</i> ⁽¹⁾	<i>Display</i> ⁽¹⁴⁾	<i>Automatic Start of Required Standby Vital Auxiliary Pump with Alarm</i> ⁽¹⁾	<i>Remarks</i> ⁽¹²⁾
Engine	I1	Engine speed		Speed		
	I2	Engine overspeed	x			Automatic engine shutdown ⁽³⁾
Power Supply	J1	Control, alarm or safety system, power supply failure	x			

Notes:

- 1 Required alarm or starting of standby pump is denoted by a (x).
- 2 A common sensor for alarm/display and automatic slowdown is acceptable.
- 3 Separate sensors are required for *a*) alarm/automatic starting of required standby pump, and *b*) automatic engine shutdown.
- 4 Automatic engine shutdown is to be alarmed and effected upon loss of oil pressure.
- 5 For heavy fuel oil burning engines only.
- 6 (2009) For engines having a power of 2250 kW (3000 hp) and above or having a cylinder bore of more than 300 mm (11.8 in.). Single sensor having two independent outputs for initiating alarm and for shutdown will satisfy for independence of alarm and shutdown. See 4-2-1/7.2 of the *Steel Vessel Rules*.
- 7 (2010) Unless provided with a self-contained lubricating oil system integrated with the turbocharger.
- 8 Two separate sensors are required for alarm and slowdown.
- 9 For engine power > 500 kW/cyl.
- 10 If necessary for the safe operation of the engine.
- 11 For **ABCU** vessels having integrated propulsion machinery, exemption from the listed instrumentation and safety provisions will be considered.
- 12 (1998) Instead of automatic slowdown, manual slowdown will be acceptable, provided visual/audible alarm with illumination sign "Reduced Power" is located in the navigation bridge.
- 13 (2010) Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
- 14 (2011) Display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered.

TABLE 5
Monitoring of Propulsion Machinery – Gas Turbine
(See also 4-7-4/Table 3) (2013)

		<i>Item</i>	<i>Alarm⁽¹⁾</i>	<i>Display⁽⁶⁾</i>	<i>Automatic Starting of Required Standby Pump^(1,5)</i>	<i>Remarks</i>
Lube Oil ⁽²⁾	A1	Pressure, low	x	Pressure	x	(1999)
	A2	(1999) Pressure, low-low	x			Turbine automatic shutdown ⁽³⁾
	A3	Temperature, inlet – high	x	Temperature		
	A4	Differential pressure, filter – high	x			
	A5	Level, tank – low	x			In gravity tank and sump
Bearings	B1	Temperature – high	x			Main bearings
Cooling Medium	C1	(2013) Pressure or flow – low	x	x		
	C2	Temperature – high	x			
Fuel	D1	Pressure or flow – low	x	Pressure or flow		
	D2	(1999) Temperature – low or viscosity – high	x	Temperature or Viscosity		For heavy fuel
	D3	(1999) Temperature – high or viscosity – low	x			For heavy fuel
Exhaust Gas	E1	Temperature – high	x	Temperature (1999)		
	E2	Temperature – high-high	x			(1999) Turbine automatic shutdown ⁽³⁾
	E3	Temperature deviation – high	x			
Turbine	F1	Vibration level – high	x			
	F2	Vibration level – high-high	x			(1999) Turbine automatic shutdown ⁽³⁾
Rotor	G1	Axial displacement – high	x			
	G2	(1999) Axial displacement – high-high	x			Turbine automatic shutdown ^(3,4)
	G3	Overspeed	x			(1999) Turbine automatic shutdown
Automatic Starting	H1	(1999) Failure	x			
Ignition and Flame	I1	(1999) Failure	x			Turbine automatic shutdown ⁽³⁾
Compressor	J1	(1999) Pressure, inlet – low	x			
	J2	(1999) Pressure, inlet – low-low	x			Turbine automatic shutdown ⁽³⁾
Control System	K1	(1999) Failure	x			

TABLE 5 (continued)
Monitoring of Propulsion Machinery – Gas Turbine
(See also 4-7-4/Table 3) (2013)

Notes:

- 1 Required alarm or starting of standby pump is denoted by a (x).
- 2 Individual alarms are required where separate systems (e.g., reduction gear, bearing, etc.) are installed.
- 3 (1999) The automatic shutdown is to be effected upon reaching the preset level (high-high or low-low, where applicable) or the event.
- 4 (1999) Automatic shutdown is not required where roller bearings are provided.
- 5 For **ABCU** vessels having non-integrated propulsion machinery, starting of required standby pump is to be alarmed.
- 6 (2011) Display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered.

TABLE 6A
Monitoring of Propulsion Machinery – Electric
(See also 4-7-4/Table 3) (2011)

	<i>Item</i>	<i>Alarm</i> ⁽¹⁾	<i>Display</i> ⁽³⁾	<i>Remarks</i>	
Propulsion Generator	A1	Pressure, bearing, lube oil inlet – low	x	Pressure	Prime mover automatic shutdown
	A2	Voltage – off-limits	x	Voltage	To read all phases and at least one bus ⁽²⁾
	A3	Frequency – off-limits	x	Frequency	
	A4	Current		Current	To read all phases ⁽²⁾
	A5	Temperature, stationary windings – high	x	Temperature	To read all phases; for generators > 500 kW
	A6	Transfer of standby generator	x		
Propulsion A.C. Motor	B1	Pressure, bearing, lube oil inlet – low	x	Pressure	
	B2	Voltage, armature – off-limits	x	Voltage	To read all phases and at least one bus
	B3	Voltage, field		Voltage	
	B4	Frequency – off-limits	x	Frequency	
	B5	Current, armature		Current	To read all phases
	B6	Current field		Current	For synchronous motors
	B7	Ground lights or similar		Status	
	B8	Temperature, stationary windings – high	x	Temperature	To read all phases; for motors >500 kW
	B9	Motor running		Running	
	B10	Transfer of standby motor	x		
	B11	Motor cooling medium temperature – high	x	Temperature	If required
Propulsion D.C. Motor	C1	Pressure, bearing, lube oil inlet – low	x	Pressure	Automatic shutdown
	C2	Voltage armature	x	Voltage	
	C3	Voltage, field		Voltage	
	C4	Current, armature		Current	
	C5	Current, field		Current	
	C6	Ground lights or similar		Status	
	C7	Motor running		Running	
	C8	Failure of on-line motor	x		
	C9	Transfer of standby motor	x		
	C10	Motor cooling medium temperature – high	x	Temperature	If required
Propulsion Semi-conductor Rectifier (SCR)	D1	Voltage, SCR		Voltage	
	D2	Current, SCR		Current	
	D3	Overloading conditions, high current	x		Alarms before protective device is activated
	D4	Open/close position for assignment switches		Position	
	D5	SCR cooling medium temperature – high	x	Temperature	If required

Notes:

- 1 Required alarm is denoted by a (x).
- 2 For D.C. generators. Additionally, field voltmeters and ammeters are to be included.
- 3 (2011) Display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered.

TABLE 6B
Instrumentation and Safety System Functions in Centralized Control Station –
Generator Prime Mover for Electric Propulsion (2013)

Systems	Monitored parameters		A	D	Auto start	Auto shut down	Notes [A = alarm. D = display. x = apply.]
<i>Trunk Piston Type Diesel Engines</i>							
Fuel Oil	E1	Fuel oil after filter (engine inlet), Pressure – low	x	x	x		
	E2	Fuel oil before injection pumps, temp. – high (or viscosity – low)	x				For heavy fuel oil burning engines only.
	E3	Fuel oil before injection pumps, temp. – low (or viscosity – high)	x				For heavy fuel oil burning engines only.
	E4	Leakage from high pressure pipes	x				
	E5	Fuel oil service tank, level – low	x				High level alarm is also required if without suitable overflow arrangements.
	E6	(2010) Common rail fuel oil pressure – low	x				
Lubricating Oil	F1	Lub. oil to main bearing, pressure – low	x	x	x	x	
	F2	Lub. oil filter differential, pressure – high	x	x			
	F3	Lub. oil inlet, temp. – high	x	x			
	F4	(2009) Oil mist in crankcase, mist concentration – high; or Bearing temperature – high; or Alternative arrangements	x			x	(2009) For engines having power of 2250 kW (3000 hp) and above or having cylinder bore of more than 300 mm (11.8 in.). Single sensor having two independent outputs for initiating alarm and for shutdown will satisfy independence of alarm and shutdown. See 4-2-1/7.2 of the <i>Steel Vessel Rules</i> .
	F5	Each cylinder lubricator, flow rate – low	x				If necessary for the safe operation of the engine.
	F6	(2010) Common rail servo oil pressure - low	x				
Sea Cooling Water	G1	Sea water cooling system pressure – low	x	x	x		
Cylinder Fresh Water Cooling	H1	Water inlet, pressure – low or flow – low	x	x	x		
	H2	Water outlet (general), temp. – high	x	x			
	H3	Cooling water expansion tank, level – low	x				
Compressed Air	J1	Starting air before shut-off valve, pressure – low	x	x			
	J2	Control air pressure – low	x	x			
Exhaust Gas	K1	Exhaust gas after each cylinder, temp. – high	x	x			For engine power > 500 kW/cylinder

TABLE 6B (continued)
Instrumentation and Safety System Functions in Centralized Control Station –
Generator Prime Mover for Electric Propulsion (2013)

Systems	Monitored parameters		A	D	Auto start	Auto shut down	Notes
							[A = alarm. D = display. x = apply.]
Turbocharger (2010)	L1	Turbocharger oil inlet pressure – low	x				Unless provided with a self-contained lubricating oil system integrated with the turbocharger
	L2	(2013) Turbocharger oil outlet temp., each bearing – high	x				Where outlet temperature from each bearing cannot be monitored due to the engine/ turbocharger design, alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
Engine	M1	Over speed	x			x	
Power Supply	N1	Main	x	x			
	N2	Emergency	x				
<i>Gas Turbines</i>							
Fuel Oil	O1	Pressure or flow – low	x	x			
	O2	Temperature – high and low (or viscosity – low and high)	x	x			For heavy fuel oil.
Lubricating Oil	P1	Inlet pressure – low	x	x	x	x	
	P2	Inlet temperature – high	x	x			
	P3	Bearing temp. or bearing oil outlet temp. – high	x	x			
	P4	Filter differential pressure – high	x				
	P5	Tank level – low	x	x			
Cooling Medium	Q1	Pressure or flow – low	x	x			
	Q2	Temperature – high	x				
Starting	R1	Stored starting energy level – low	x				
	R2	Ignition failure	x			x	
Combustion	S1	Combustion or flame failure	x			x	
Exhaust Gas	T1	Temperature – high	x	x		x	
Turbine	U1	Vibration level – high	x			x	
	U2	Rotor axial displacement – large	x			x	Auto shutdown may be omitted for rotors fitted with roller bearings
	U3	Overspeed	x			x	
	U4	Vacuum at compressor inlet – high	x			x	
Power Supply	V1	Main	x	x			
	V2	Emergency	x				

(2011) Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered.

Auto start = automatic starting of a standby pump, along with activation of suitable alarm.

Auto shut down = automatic stopping of the diesel engines and gas turbine, along with activation of suitable alarm.

TABLE 7
Monitoring of Auxiliary Prime-movers and Electrical Generators
(See also 4-7-4/Table 3) (2011)

			<i>Item</i>	<i>Alarm</i> <i>(1)</i>	<i>Display</i> <i>(4)</i>	<i>Remarks</i>
Diesel Engine	Lube Oil	A1	Pressure, lube oil inlet – low	x	Pressure	Automatic engine shutdown
		A2	Temperature, inlet – high	x	Temperature	
		A3	(2010) Common rail servo oil pressure – low	x		
	Cooling Medium	B1	Pressure or flow – low	x	Pressure, or flow	
		B2	Temperature, outlet – high	x		
		B3	Level, expansion tank – low	x		If separate from main system
	Fuel Oil	C1	Fuel oil leakage from pressure pipe	x		
		C2	Level, in fuel oil daily service tank – low	x		See also 4-7-4/25
		C3	(2010) Common rail fuel oil pressure – low	x		
	Crankcase	D1	Oil mist in crankcase, mist concentration – high; or Bearing temperature – high; or Alternative arrangements	x		Automatic engine shutdown ⁽²⁾
	Starting Medium	E1	Pressure or level – low	x	Pressure, or level	
Overspeed	F1	Device activated	x		Automatic shutdown. See 4-2-1/7.5.3 and 4-2-1/7.3 of the <i>Steel Vessel Rules</i>	
Electrical Generator	G1	Pressure, bearing, lube oil inlet – low	x	Pressure	Prime mover automatic shutdown	
	G2	Voltage – off-limits	x	Voltage	To read all phases and at least one bus ⁽³⁾	
	G3	Frequency – off-limits	x	Frequency		
	G4	Current – high	x	Current	To read all phases ⁽³⁾	
	G5	Transfer of standby generator	x			

Notes:

- 1 Required alarm is denoted by a (x).
- 2 (2009) For engines having a power of 2250 kW (3000 hp) and above or having a cylinder bore of more than 300 mm (11.8 in.). Single sensor having two independent outputs for initiating alarm and for initiating alarm and for shutdown will satisfy independence of alarm and shutdown. See 4-2-1/7.2 of the *Steel Vessel Rules*.
- 3 For D.C. generation. Additionally, field voltmeters and ammeters are to be included.
- 4 (2011) Display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered.

PART

4

CHAPTER 7 Shipboard Automatic or Remote Control and Monitoring Systems

SECTION 5 Vessels Classed with ABCU Notation

1 General

The requirements in this subsection apply to vessels capable of operating as **ACCU** classed vessels but because of their compact propulsion-machinery space design are not fitted with the means to control the propulsion and its associated machinery from a centralized location within the propulsion-machinery space. Except as noted herein, the requirements in Sections 4-7-1 through 4-7-4, as applicable, are to be complied with.

3 Station in Navigation Bridge

Controls, alarms and displays as listed in 4-7-4/7 are to be provided on the station in the navigation bridge. See 4-7-4/Table 2. For vessels having nonintegrated propulsion machinery, the means for starting, stopping and transferring vital auxiliary pumps (see 4-7-4/15) are to be fitted at the station in the navigation bridge and may also be fitted in the centralized station. See 4-7-1/5.41 for definition of integrated propulsion machinery.

5 Centralized Monitoring Station

The requirements in 4-7-4/9 are applicable, except that the centralized station need not be provided with propulsion controls, but is to include displays and alarms needed for the monitoring of the propulsion machinery and associated ship's service systems, electrical power generating machinery, and monitoring of propulsion-machinery space. The monitoring system is to provide the same degree of equivalency as if the propulsion-machinery space was manned. See 4-7-4/Table 3 through 4-7-4/Table 7 for required alarms and displays to be fitted at this station.

7 Communications

Communications, as required in 4-7-2/13, are also to include the centralized monitoring station in the propulsion-machinery space.

9 Sea Trials

In addition to the trials per 4-7-4/37, successful operation of the propulsion machinery is to be demonstrated with the propulsion-machinery space unattended for a period of at least 12 hours.

PART

4

CHAPTER 7 Shipboard Automatic or Remote Control and Monitoring Systems

SECTION 6 Vessels Less Than 500 GT Having a Length Equal or Greater Than 20 m (65 ft)

1 General

The requirements contained in this Section are intended for vessels less than 500 GT having a length equal to or greater than 20 m (65 ft). Vessels having a length less than 20 m (65 ft) will be specially considered.

Note: **ACCU** or **ABCU** class notation may be granted to vessels of < 500 GT and a length of $20\text{ m (65 ft)} \leq L \leq 46\text{ m (150 ft)}$, provided that the applicable requirements in Sections 4-7-1 through 4-7-5 are met.

3 Definitions

See 4-7-1/5.

5 Plans to be Submitted

Plans and specifications are to be submitted in accordance with 4-1-1/7 for approval and are to include the following information.

- i)* Machinery arrangement plans showing location of control stations in relation to controlled units;
- ii)* Arrangements and details of control consoles, including front views, installation arrangements together with schematic diagrams for all power, control and monitoring systems, including their functions; and a list of alarms/displays, as required in 4-7-6/15.5.
- iii)* Type and size of all electrical cables and wiring associated with the control systems, including voltage rating, service voltage and currents together with overload and short-circuit protection;
- iv)* Description of all alarm and emergency tripping arrangements; functional sketches or description of all special valves, actuators, sensors and relays;
- v)* Schematic plans and supporting data of fire-protection and extinguishing systems, including fire-detection and alarm systems and bilge high water alarms.
- vi)* Schematic plans of hydraulic or pneumatic control systems.

7 Electrical Cables and Console Wiring

In general, cables are to be used external to the consoles and they are to be of the marine type in accordance with the applicable parts of Part 4, Chapter 6. Cables in accordance with other standards which are not less effective will be considered. Cables and console wiring for control and monitoring are to be of the flame-retarding type and are to be stranded, except that solid conductors may be used in low-energy circuit where they are properly supported and not subject to undue vibration or movements.

9 Alarms

The alarm system is to be able to indicate more than one fault at the same time and be so arranged that acceptance of one fault is not to inhibit another alarm. Audible alarms are to be maintained until they are acknowledged, and visual indication is to remain until the fault is corrected.

11 Safety System

Safety systems are to be of the fail-safe type and are to respond automatically to fault conditions that may endanger the machinery or safety of the crew. This automatic action is to cause the machinery to take the least drastic action first, as appropriate, by reducing its normal operating output or switching to a stand-by machinery and last, by stopping it, i.e., disrupting source of fuel or power supply, etc. However, the propulsion machinery is to automatically shut down upon a loss of lubricating oil or an overspeed condition, and such conditions are to be alarmed. Where arrangements for overriding the shutdown of the main propelling machinery are fitted, these are to be as to preclude inadvertent activation. Visual means shall be provided to show whether or not it has been activated.

13 Bridge Control of Propulsion Machinery

13.1 General

The requirements in 4-7-3/3 through 4-7-3/7 and 4-7-3/19 are applicable.

13.3 Local Control

It is to be possible to control the propelling machinery locally in the case of failure in any part of the automatic or remote control systems.

13.5 Bridge Control Indicators

Indicators for the following items are to be fitted on the navigation bridge:

- i) Propeller speed and direction where fixed pitch propellers are fitted;
- ii) Propeller speed and pitch position where controllable pitch propellers are fitted;
- iii) For air-started engines, an alarm is to be provided to indicate low starting air pressure and is to be set at a level which still permits main engine starting operation;
- iv) An alarm is to be provided for low control fluid pressure for controllable pitch propellers.

15 Requirements for Periodically Unattended Propulsion Machinery Spaces

15.1 Fire Protection

15.1.1 Fire Prevention

15.1.1(a) Piping for high pressure fuel injection and return piping on main and auxiliary engines is to be effectively shielded and secured to prevent fuel or fuel mist from reaching a source of ignition on the engine or its surroundings. Leakages from such piping are to be collected in a suitable drain tank provided with high level alarm audible at the navigation bridge.

15.1.1(b) Drip trays for collecting fuel and lubricating oil are to be fitted below pumps, heaters, burners, tanks not forming part of the vessel's structure, etc., with connections to a suitable drain tank with high level alarm audible at the navigation bridge.

15.1.1(c) Where daily service fuel oil tanks are filled automatically or by remote control, means are to be provided to prevent overflow spillages. Similar consideration is to be given to other equipment which treat flammable liquids automatically (e.g., fuel oil purifiers), which whenever practicable shall be installed in special space reserved for purifiers and their heaters.

15.1.1(d) Where fuel oil daily service tanks or settling tanks are fitted with heating arrangements, a high temperature alarm, audible at the navigation bridge, is to be provided if the flashpoint of the fuel oil can be exceeded.

15.1.2 Fire Detection

A fire detection system is to be provided for the machinery spaces.

15.3 Protection Against Flooding

Bilges in machinery spaces are to be provided with a high level alarm in such a way that the accumulation of liquids is detected at normal angles of trim and heel. The detection system is to initiate an audible and visual alarm on the navigation bridge.

15.5 Alarms and Displays

The following alarms and displays are to be provided at the navigation bridge.

	<i>Items</i>	<i>Display</i>	<i>Alarm</i>
1	L.O. Pressure to main engine and reduction gear	Pressure	Low
2	Engine coolant	Temperature	High
3	Starting air (if applicable) pressure		Low
4	Propeller Speed	RPM	
5	Propeller Direction	Ahead	
6	or	Astern	
7	Pitch	Pitch	
8	Steering gear motor		Stopped
9	Control power	Available	Failure
10	Generator voltage	Volt ⁽¹⁾	
11	Generator current	Amps ⁽¹⁾	
12	Fuel oil day tanks	Level ⁽¹⁾	Low
13	Fuel oil tanks heater temperature [see 4-7-6/15.1.1(d)]		High
14	Oil collection tank [see 4-7-6/15.1.1(a) & 4-7-6/15.1.1(b)]	Level ⁽¹⁾	High
15	Bilge level	Light ⁽¹⁾	High
16	Fire alarm	Light ⁽¹⁾	Fire

Note:

1 As an alternative, these displays may be provided locally.