# PART 4

## CHAPTER 8
## Electrical Systems

CONTENTS

PART 4

CHAPTER 8

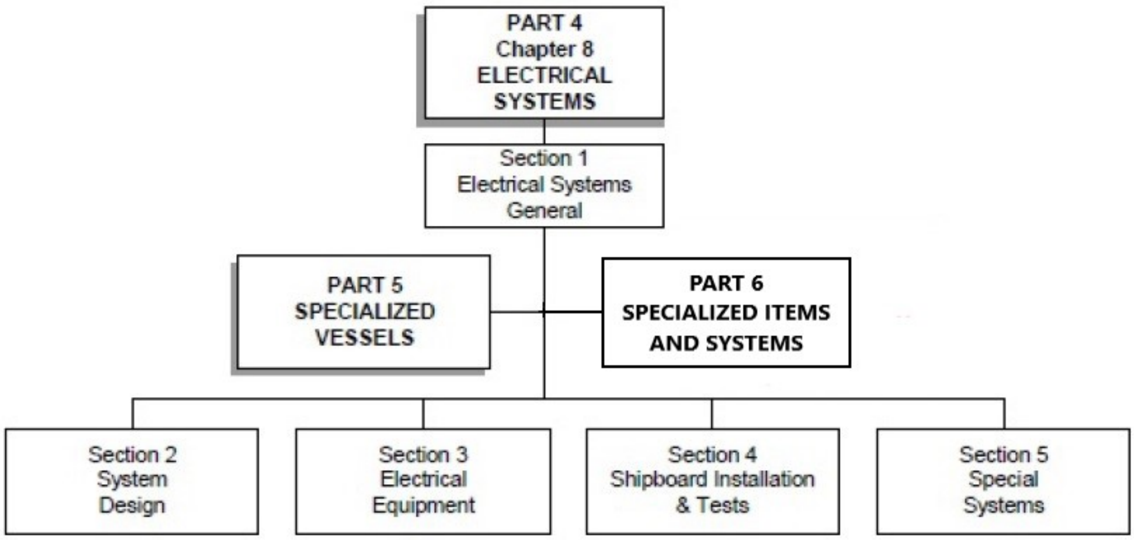
## Electrical Systems

SECTION 1

## General Provisions

# 1 Organization of Electrical Systems Requirements *(2024)*

The requirements for electrical systems are organized as follows:




Section 4-8-1 deals with general issues and provides, for example, the required submittals and definitions for terms used throughout the electrical systems sections.

Section 4-8-2 provides requirements for system design.

Section 4-8-3 provides requirements for equipment design and tests.

Section 4-8-4 provides requirements for shipboard installation and tests.

Section 4-8-5 provides special requirements for system design, equipment and installation of high voltage systems and electric propulsion systems.

Requirements applicable to specialized vessel types, such as oil carriers, vehicle carriers, passenger vessels etc., are provided in Part 5C and Part 5D of the Rules.

Requirements applicable to navigation in ice, vessels intended to carry refrigerated cargoes, and other specialized systems are provided in Part 6 of the Rules.

## 2 Objective *(2024)*

The goals and functional requirements for the topics covered in this chapter are included in the respective sections.

## 3 Application *(24 January 2024)*

The requirements in this chapter are applicable for electrical systems and equipment on unrestricted ocean-going vessels.

Arrangements and details that can be shown to comply with other recognized standards that are not less effective than the Rules may be considered, see 4-1-1/1.7.

## 5 Plans and Data to be Submitted

### 5.1 System Plans *(2024)*

The following plans and data are to be submitted for review.

#### 5.1.1 One Line Diagram

One line diagram of main and emergency power distribution systems, to show:

- *Generators*: kW rating, voltage, rated current, frequency, number of phases, power factor.
- *Motors*: kW or hp rating, voltage and current rating, remote stops (when required).
- *Motor controllers*: type (direct-on-line, star-delta, etc.), disconnect devices, overload and under-voltage protections, remote stops, as applicable.
- *Transformers*: kVA rating, rated voltage and current, winding connection.
- *Circuits*: designations, type and size of cables, trip setting and rating of circuit protective devices, rated load of each branch circuit, emergency tripping and preferential tripping features.
- *Batteries*: type, voltage, rated capacity, conductor protection, charging and discharging boards.

#### 5.1.2 Schematic Diagrams

Schematic diagrams for the following systems are to be submitted. Each circuit in the diagrams is to indicate type and size of cable, trip setting and rating of circuit protective device, and rated capacity of the connected load.

- General lighting, normal and emergency
- Navigation lights
- Interior communications
- General emergency alarm
- Intrinsically safe systems
- Emergency generator starting
- Steering gear system

- Fire detection and alarm system
- Inert gas control, monitoring and alarm

#### 5.1.3 Short-circuit Data *(2024)*

- Maximum calculated short-circuit current values, both symmetrical and asymmetrical values, available at the main and emergency switchboards and the downstream distribution boards.
- Rated breaking and making capacities of the protective devices.

***Commentary:***

Refer 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.

**End of Commentary**

#### 5.1.4 Protective Device Coordination Study

This is to be an organized time-current study of all protective devices, taken in series, from the utilization equipment to the source, under various conditions of short circuit. The time-current study is to indicate settings of long-time delay tripping, short-time delay tripping, and instantaneous tripping, as applicable. Where an overcurrent relay is provided in series and adjacent to the circuit protective devices, the operating and time-current characteristics of the relay are to be considered for coordination. Typical thermal withstanding capacity curves of the generators are to be included, as appropriate.

#### 5.1.5 Load Analysis *(2019)*

An electric-plant load analysis is to cover all operating conditions of the vessel, such as conditions in normal sea going, cargo handling, harbor maneuver, emergency,and dynamic positioning operations.

The analyses are to include:

- The simultaneous operation of loads on the emergency switchboard as per 4-8-2/5.5. 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/low voltage ship service transformers or converters, where applicable per 4-8-2/3.7 showing they have sufficient capacity to support the connected loads.
- Identifying the loads to be tripped to ensure continuity of supply per 4-8-2/3.5.2.iii., 4-8-2/3.11.1, 4-8-2/9.1, 4-8-2/9.9.
- Where **DPS-2** or **DPS-3** notation is requested, the load analysis is to include a detailed analysis for all dynamic positioning modes and including during and following a single bus section failure in its different configuration (open or closed bus).

#### 5.1.6 Other Information

A description of the power management system, including equipment fitted with preferential trips, schedule of sequential start of motors, etc. as applicable.

Voltage-drop for the longest run of each cable size for vessels having a length of 61 m (200 ft) and over.

Maintenance schedule of batteries for essential and emergency services. See 4-8-4/5.1.5.

Plans showing details and arrangements of oil mist detection/monitoring and alarm arrangements. See 4-2-1/7.2.2(c).viii..

Information on alarms and safeguards for emergency diesel engines. See 4-8-2/5.19.1.

#### 5.1.7 High Voltage Systems

*5.1.7(a) Documents*. High Voltage Design Operating Philosophy Document (See 4-8-5/3.15)

*5.1.7(b) Analysis*. Arc-flash hazard analyses (See 4-8-5/3.7.4(e))

*5.1.7(c) Operating Manual*. Preliminary Operation Manual for the high voltage system and equipment (See 4-8-5/3.17)

*5.1.7(d) General Arrangement*. General Arrangement of the switchboards and distribution boards

*5.1.7(e) Spaces*. General Arrangement of spaces containing high voltage switchboards showing the location of:

***i)*** Access and operating locations

***ii)*** The equipment in 4-8-1/5.1.7(d) above, with equipment access doors closed, open, maximum extent of withdrawable circuit breakers and associated cradles/dollies

***iii)*** Doors to the room

***iv)*** Location of work areas associated with the activities described in 4-8-5/3.15.3

***v)*** Location and inventory of personal protective equipment (PPE) and safety equipment

***vi)*** First aid equipment

*5.1.7(f) Analysis and Data*. An analysis or data for the estimated voltage transients to show that the insulation of power transformers is capable of withstanding the estimated voltage transients.

*5.1.7(g) Standards*. The applicable standard of construction and the rated withstand voltage of the insulation for power transformers. (This information is in addition to the information required in 4-8-3/7)

#### 5.1.8 Harmonic Analysis *(2024)*

Harmonic distortion calculations for vessels with electric propulsion. See 4-8-5/5.3.5.

### 5.3 Installation Plans *(2024)*

The following plans and data as applicable are to be submitted for review before proceeding with the work.

#### 5.3.1 Booklet of Standard Wiring Practice

This is to contain standard wiring practices and installation details. They are to include, but not limited to, cable supports and retention, typical radii of cable bends, bulkhead and deck penetrations, cable joints and sealing, cable splicing, earthing details, watertight and certified safe connections, earthing and bonding connections, cable tray and bunch configurations showing clearance and segregation of cables. For cable penetrations through watertight, gastight, and fire-rated bulkheads and decks, evidence of penetration design approval is to be submitted. For watertight and gastight cable penetrations, certificates issued by a competent independent testing laboratory are acceptable. For fire-rated cable penetrations, certificates issued by an Administration signatory to SOLAS 1974 as amended are acceptable.

For high voltage systems see installation requirements given in 4-8-5/3.9.

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.

### 5.3.2 Hazardous Area Plan and Equipment Data

*5.3.2(a) Hazardous Area Plan (2021)*

Hazardous area plan is to show the delineation of hazardous areas. The plan is to include general arrangement of the vessel with plan and section views of each deck, space, tanks and process equipment of interest, the recognized standard used for the development of hazardous area, Class or Group, Temperature Class and extent of associated hazardous area delineation (e.g. Division 1, 2 or Zone 0, 1 or 2). In addition, spaces held at over-pressure/under-pressure, sources of release, ventilation openings, airlocks, bulkheads, structures, etc. are to be indicated. Other conditions which can affect the extent of zones are also to be indicated.

*5.3.2(b) Hazardous Area Equipment Booklet (2025)*

When the selection of the equipment has been finalized, a booklet identifying all equipment in the hazardous areas and the particulars of the equipment is to be submitted for review and to be maintained on board for future reference. The booklet is to include a list of all electrical equipment/instruments in the hazardous areas along with evidence of certification. The list is also to include electrical equipment in spaces which may become hazardous upon loss of pressurization and any associated safe-area apparatus (such as zener safety barriers) required for the protection of the intrinsically safe type equipment.

The hazardous area equipment list is to include the following particulars of the equipment:

***i)*** Description of equipment,

***ii)*** Manufacturer's name and model,

***iii)*** Location and hazardous area classification of the location,

***iv)*** Method of protection (flameproof, intrinsically safe, etc.),

***v)*** Rating (flammable gas group and temperature class),

***vi)*** Name of testing laboratory and certificate number,

***vii)*** Design ambient temperature,

***viii)*** Iingress protection (IP rating), etc.

For intrinsically-safe systems, the booklet is also to include wiring plans, installation instructions with any restrictions imposed by the certification agency.

Details of installation for echo sounder, speed log and impressed current cathodic protection system are to be included in the booklet where located in these areas.

### 5.3.3 Special Hull Penetrations

Details of hull penetrations for installations such as echo sounder, speed log, and impressed current cathodic protection system.

### 5.3.4 Arrangements of Electrical Equipment *(2024)*

Arrangement plans showing the locations of the following equipment and systems and their enclosure protection rating:

- Generators, main switchboard, motor control centers, transformers/converters
- Batteries and battery charging and discharging boards
- Emergency source of power, emergency lights
- Interior communication systems
- Emergency alarm system, public addresses system, fire detection and alarm system
- Locations of cable splices, cable connectors, and cable junction boxes

#### 5.3.5 Cable Transit Seal Systems Register *(2024)*

A Cable Transit Seal systems Register is to submitted to the attending Surveyor. See 4-8-4/21.13.

***Commentary:***

This requirement is based on IACS Unified Requirement (UR) Z28 "Surveys of Watertight Cable Transits".

**End of Commentary**

### 5.5 Equipment Plans *(2024)*

The following plans and data as applicable are to be submitted for review before proceeding with the work.

#### 5.5.1 Rotating Machines *(1 July 2023)*

For rotating machines of 100 kW (135 hp) and over intended for essential services (primary and secondary) or for services indicated in 4-8-3/15 TABLE 7, plans showing the following particulars are to be submitted:

*i)* General arrangement and assembly details

*ii)* Bill of materials

*iii)* Seating arrangements

*iv)* Terminal arrangements

*v)* Shafts

*vi)* Coupling

*vii)* Coupling bolts

*viii)* Stator and rotor details together with data of complete rating

*ix)* Details of exciter

*x)* Torsional vibration calculations for AC Generators with power rating equal to or above 100 KW

*xi)* Limits of vibration amplitudes per an internationally recognized standard

*xii)* Class of insulation

*xiii)* Designed ambient temperature and temperature rise

*xiv)* Degree of protection for enclosures

*xv)* Weights and speeds of rotating parts

*xvi)* Type test procedures per 4-8-3/15 TABLE 3

*xvii)* Type test results, as applicable, per 4-8-3/15 TABLE 3

In addition to the above, for single screw vessels having permanent magnet shaft generators as per 4-8-3/3.14, the following are to be submitted:

- A risk assessment to identify the worst case failure applicable to the installation. The risk assessment is also to take into account the time required to stop the shaft, as well as any cool down time (in case of fire or overheating) for the calculation of the maximum time required to restore propulsion after the fault occurred (the maximum time is not to exceed three hours).
- FEM simulation, or similar, and calculation of an interturn fault inside the windings to determine the magnitude of the currents that can occur during this fault.

#### 5.5.2 Switchboards, Distribution Boards

Plans showing arrangements and details as indicated below are to be submitted for main and emergency switchboards, distribution boards, battery charger units, uninterruptible power system (UPS) units intended for essential services (primary and secondary), services indicated in 4-8-3/15 TABLE 7, battery charging and discharging boards for emergency or transitional source of power:

- Front view
- Schematic diagram
- Pprotective device rating and setting
- Eemergency tripping and preferential tripping features
- Internal power for control and instrumentation
- Type and size of internal control and instrumentation wiring
- Size, spacing, bracing arrangements, rated current carrying capacity and rated short circuit current of bus bars and bus bar disconnecting device
- Written description of automated functions and operations of the electrical plant.

#### 5.5.3 Motor Controllers *(2024)*

For motor controllers of 100 kW (135 hp) and over intended for essential services (primary and secondary) or for services indicated in 4-8-3/15 TABLE 7, plans showing the following particulars are to be submitted, as applicable:

- Front view
- Degree of protection for enclosure
- Schematic diagram
- Protection setting
- Monitoring arrangement
- Cooling arrangement
- Written description of automated functions and operations.

#### 5.5.4 Motor Control Centers

For motor control centers with aggregate loads of 100 kW (135 hp) and over intended for essential services (primary and secondary) or for services indicated in 4-8-3/15 TABLE 7, plans showing the following particulars are to be submitted: front view, degree of protection for enclosure, schematic diagram, current rating of running protection of motor, and type and size of internal wiring.

#### 5.5.5 Semiconductor Converters for Adjustable Speed Motor Drives *(2024)*

For 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 7.3.3) or for services indicated in 4-8-3/15 TABLE 7, plans showing the following particulars are to be submitted:

- Front view
- Degree of protection for enclosure
- Schematic diagram
- Protection setting
- Monitoring arrangement
- Cooling arrangement

- Written description of automated functions and operations

# 7 Definitions

## 7.1 General

The definitions of terms used are in agreement with SOLAS 1974, as amended, and IEC Publication 60092-101, paragraph 1.3, 61439-1 and IEEE 1584, except as provided in 4-8-1/7.3.

### 7.1.1 Nominal Voltage

*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, 480/277V, 600V). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

$U_0$ (as relates to cable voltage rating) – The rated power frequency voltage between conductor and earth or metallic screen for which the cable is designed.

### 7.1.2 Earth

*Earth* - A large conducting body, such as the metal hull of the ship, used as an arbitrary zero of potential.

### 7.1.3 Pollution Degree

*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.

### 7.1.4 Overvoltage Category

*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.

### 7.1.5 Inhomogeneous Field

*Inhomogeneous Field* - An electric field which does not have a constant voltage gradient between electrodes.

### 7.1.6 Overvoltage Withstand Test

*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).

### 7.1.7 Non Sparking Fans *(2024)*

A fan is considered as non-sparking if in either normal or abnormal conditions it is unlikely to produce sparks.

## 7.3 Specific

The following terms are specifically defined for the purposes of Part 4, Chapter 8.

### 7.3.1 Low Voltage

*Low voltage* in these Rules refers to voltages up to and including 1000 V AC; and 1500 V DC.

#### 7.3.2 High Voltage

*High voltage* in these Rules refers to voltages above 1000 V up to and including 15 kV AC.

#### 7.3.3 Essential Services

*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 4-8-2/5.5; (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 4-8-1/7.3.3 TABLE 1 and 4-8-1/7.3.3 TABLE 2, respectively.

### TABLE 1
### Primary Essential Services *(2021)*

| | |
|---|---|
| (a) | Steering gears |
| (b) | Pumps for controllable pitch propellers |
| (c) | 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) | Fuel gas supply pumps, 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. |
| (n) | Fire pumps and other fire extinguishing medium pumps. |
| (o) | Navigation lights, aids and signals. |
| (p) | Internal safety communication equipment. |
| (q) | Lighting system. |

### TABLE 2
### Secondary Essential Services *(2022)*

| | |
|---|---|
| (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) | Ventilating fans for engine and boiler rooms |
| (h) | 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.) |
| (i) | Methods used to comply with 5C-8-7/1 on liquefied gas carriers |
| (j) | Fire detection and alarm system |
| (k) | Electrical equipment for watertight and fire-tight closing appliances |
| (l) | Electric generators and associated power sources supplying secondary essential equipment |
| (m) | Hydraulic pumps supplying secondary essential equipment |
| (n) | Control, monitoring and safety systems for cargo containment systems |
| (o) | Control, monitoring and safety devices/systems of equipment for secondary essential services. |
| (p) | Ambient temperature control equipment required by 4-8-3/1.17.2 |
| (q) | Watertight Doors (see Section 3-2-9, 3-2-15 and 3-2-16) |

#### 7.3.4 Minimum Comfortable Condition of Habitability

A condition in which at least services such as cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water are adequately provided.

#### 7.3.5 Cascade Protection

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.

#### 7.3.6 Electrical Power Critical Notations

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: Refrigeration notations as per 6-2-1/7.1.

## 9 <No Text>

# PART 4

## CHAPTER 8
## Electrical Systems

## SECTION 2
## System Design

## 1 General *(1 July 2022)*

The requirements of this section apply to shipboard electrical power generation and distribution systems. High voltage systems and electric propulsion systems are subject additionally to the provisions of 4-8-5. For DC systems, unless specifically stated in this Section, and 4-8-5/7, see the ABS *Requirements for Direct Current (DC) Power Distribution Systems For Marine and Offshore Applications*, and IEC Publications 60092-201, 60092-202 and 60092-301.

### 1.1 Objective *(2024)*

#### 1.1.1 Goal

Electrical systems addressed in this Section are to be designed, constructed, operated, and maintained to:

| *Goal No.* | *Goals* |
|---|---|
| POW 1 | Provide safe and reliable storage and supply of fuel/energy/power. |
| POW 2 | Provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel. |
| POW 3 | Enable *all electrical services necessary for maintaining the vessel in normal operational and habitable conditions to be available without recourse to the emergency source of power.* (SOLAS II-1 Reg 3-7 and SOLAS II-1 Reg 40-1.1) |
| POW 4 | Enable *all electrical services required for safety to be available during emergency conditions.* (SOLAS II- 1 Reg 40-1.2) |
| POW 5 | Enable supply/power for essential services to be restored after malfunction |
| SAFE 1-1 | Minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems. |
| SAFE 2 | Provide suitable and readily available illumination. |
| FIR 1 | *Prevent the occurrence of fire and explosion*. (SOLAS II-2/Reg 2.1.1) |
| FIR 3 | *Reduce the risk of damage caused by fire to the ship, its cargo and the environment.* (SOLAS II-2/Reg 2.1.3) |

| *Goal No.* | *Goals* |
|---|---|
| AUTO 5 | be provided with a safety system that automatically leads the machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/equipment or environment |
| COMM 2 | Provided with means for internal communications |

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

### 1.1.2 Functional Requirements *(1 July 2024)*

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

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Power Generation and Distribution (POW)** | |
| POW-FR1 | Provide sufficient power capacity and quantity to achieve continuity of power with at least one source of power in standby. |
| POW-FR2 | Power generation and distribution equipment to be designed with redundancy to prevent loss of essential/emergency services upon a single failure |
| POW-FR3 | Means to be provided to protect the main source of power from sustained overload. |
| POW-FR4 | Provide starting arrangement for the restoration of propulsion when no stored energy is available |
| POW-FR5 | Provide arrangement and location provisions for emergency power such that a casualty of the space containing the main source of power will not affect the emergency power |
| POW-FR6 | Provide a power source independent of the main source of power to support emergency services for applicable duration. |
| POW-FR7 | Provide transitional power to supply essential safety systems that are not to be interrupted upon loss of either the main or emergency source of power |
| POW-FR8 | Maintain the integrity of emergency power and associated electrical distribution equipment |
| POW-FR9 | Provide redundancies for emergency generator starting |
| POW-FR10 | Provide arrangements and operational details to protect the emergency generator when used in port |
| POW-FR11 | Provide electrical distribution scheme for Alternating Current (AC) and Direct Current (DC) systems |
| POW-FR12 | Provide cables with sufficient current carrying capacity to support connected loads and within the ratings of overload protection . |
| POW-FR13 | Provide vessel service loads with dedicated power supply feeders from main or emergency power distribution as applicable. |
| POW-FR14 | Provide redundancy for steering gear power supply feeders such that a single failure will not result in loss of steering. |
| POW-FR15 | The main and emergency lighting systems are to be independent such that a single failure of one system will not result in loss of the other. |
| POW-FR16 | Primary essential services and secondary essential services necessary for safety are to be provided with arrangement to automatically restart upon restoration of main source of power |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| POW-FR17 | Provide sufficient stored power and redundancies for propulsion and auxiliary engine starting |
| POW-FR18 | Provide system/equipment redundancy such that a single failure will not disable the essential and emergency services. |
| POW-FR19 | Duplicated equipment are to be arranged such that failure to one power distribution section does not prevent power supply to equipment necessary for propulsion. |
| POW-FR20 | Provide limit of electric space heaters circuits to prevent overloading |
| POW-FR21 | The total harmonic distortion in the distribution system is not to exceed the design limits of the distribution equipment and consumers. |
| **Fire Safety (FIR)** | |
| FIR-FR1 | The location of the switchboard, distribution equipment and main source of power is to be arranged such that the integrity of main electrical power may be affected only by a fire, flooding or similar casualty in one space |
| FIR-FR2 | Provide means to shutdown the power ventilation system covering high fire risk areas in the event of a fire. The shutdown means are to be in a location outside the affected space and in location not likely to be cut off in the event of fire and in centralized fire fighting stations |
| **Safety of Personnel (SAFE)** | |
| SAFE-FR1 | Provide conditions for the safe use of hull return and earthing systems |
| SAFE-FR2 | Provide adequate illumination to the vessel for safe working conditions in all modes of vessel operation |
| SAFE-FR3 | Provide segregation of accommodation, cargo, and machinery space ventilation circuits such that shutdown of one system will not affect the other |
| SAFE-FR4 | Provide control of electrical loads within cargo space from outside location. |
| SAFE-FR5 | Provide visual indication of cargo space lighting circuits to enable identification of live circuits at switch |
| SAFE-FR6 | Provide a control panel for navigation lighting system with safety measures and alarms to alert the crew of any failures of the navigation lights |
| **Communications (COMM)** | |
| COMM-FR1 | Provide means of communication from the navigation bridge to essential interior locations |
| COMM-FR2 | Provide means of visual indication of the orders and responses in the bridge and machinery space control stations |
| COMM-FR3 | Provide a general alarm that is audible throughout all accommodation and normal crew working areas for summoning passengers and crew to muster stations |
| COMM-FR4 | Provide means to initiate alarm from the centralized propulsion machinery control stations to alert the engineers not on duty |
| COMM-FR5 | Provide means to initiate alarm from the refrigerated space and elevator such that the normally manned control station is alerted of an emergency |
| COMM-FR6 | Provide a broadcast system that is audible in all spaces where passengers and personnel are normally present to notify them of an emergency and actions to be taken |
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| AUTO-FR1 | Provide overload protection to emergency generator when arranged for feedback operation. |
| AUTO-FR2 | Provide safety measures and alarms to protect the emergency generator |
| AUTO-FR3 | Provide protection against overload, undervoltage and short circuit conditions to prevent damage to equipment and maintain continuity of power to remaining circuits |
| AUTO-FR4 | The circuit protection devices are to be able to withstand the prospective short circuit current values at the point of installation. |
| AUTO-FR5 | Provide coordination for all protective devices to allow the system to open the protective device closest to the fault first to protect the healthy portion of the system |
| AUTO-FR6 | Provide arrangements for reverse power and undervoltage protection when generators are arranged for parallel operation |
| AUTO-FR7 | Provide safety measures and alarms to protect the electrical distribution system from harmonics |
| AUTO-FR8 | Provide means to initiate shutdown of equipment and be designed such that a single failure will not result in the loss of duplicated essential equipment |
| AUTO-FR9 | Provide means to monitor the emergency shutdown circuits to alert the crew of any failures |

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

#### 1.1.3 Compliance

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

## 3 Main Source of Electrical Power

### 3.1 Number and Capacity of Generators

#### 3.1.1 General *(2020)*

The number and capacity of generating sets is to be sufficient under normal seagoing conditions with any one generator in reserve to carry:

- Those electrical loads for essential services and for minimum comfortable conditions of habitability, as defined in 4-8-1/7.3.3 and 4-8-1/7.3.4, as applicable and
- The electrical loads related to the electric power critical notations listed in 4-8-1/7.3.6.

In addition, where electrical power is necessary to restore propulsion, the capacity is to be sufficient to restore propulsion to the vessel in conjunction with other machinery, as appropriate, from a dead ship condition within thirty minutes, as defined in 4-1-1/1.9.6. See also 4-8-2/3.1.3.

For vessels of 500 GT and above, where the main source of electrical power is necessary for propulsion and steering of the vessel, the system is to be so arranged so 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 provide safety of the vessel will be maintained or restored in accordance with the provision in 4-8-2/3.11.2 or 4-8-2/3.11.3.

#### 3.1.2 Consideration for Motor Starting Current

In selecting the capacity of a generating set, particular attention is to be given to the starting current of motors forming part of the system. With any one generator held in reserve as a standby, the remaining generator sets, operating in parallel and initially carrying the loads in 4-8-2/3.1.1, are to have sufficient capacity with respect to the largest idle essential 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. The limits of transient voltage variation under suddenly applied loads are to be in accordance with 4-8-3/3.13.2(c).

For vessels fitted with electric motor driven athwartship thrusters to assist maneuvering, the starting and running of this motor may be supported by all the installed generators, provided arrangements are made such that its starting is conditional upon the requisite generators being available and that it will not cause inadvertent load shedding.

#### 3.1.3 Starting from Dead Ship Condition *(2019)*

In restoring the propulsion from a dead ship condition (see 4-1-1/1.9.6), 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 other available sources of electrical power is sufficient to provide at the same time those services required to be supplied by 4-8-2/5.5.

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 from a dead ship condition, as defined in 4-1-1/1.9.6. 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).

For steam ships, the 30 minute time limit is to be taken as the time from a dead ship condition to light-off of the first boiler.

See also 4-8-2/3.11 and 4-8-2/3.13 below.

### 3.3 Power Supplied by Propulsion Generators

For vessels propelled by electric power and having two or more constant voltage propulsion generating sets, the vessel's service electric power may be derived from this source. See 4-8-5/5.5.1.

### 3.5 Generators Driven by Propulsion Machinery

#### 3.5.1 Constant Speed Drive

A generator driven by propulsion machinery capable of operating continuously at a constant speed, e.g., those fitted with controllable-pitch propellers, may be considered one of the generators required by 4-8-2/3.1.1, 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 4-8-3/3.13.2 and 4-8-3/1.9 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 4-8-2/3.1.1 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 4-8-2/3.11.

#### 3.5.2 Variable Speed Drive *(2020)*

A generator driven by propulsion machinery 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 4-8-2/3.1.1.

*i)* When the frequency variations at the main bus bar exceeds the following limits due to the speed variation of the propulsion machinery which drives the generator, arrangements are made to comply with 4-8-2/3.11.

| | |
|---|---|
| Permanent frequency variation: | ±5.5% |
| Transient frequency variation: | ±11% (5 sec) |

*ii)* The generators and the generating systems are capable of maintaining the voltage and frequency variation within the limits specified in 4-8-3/3.13.2 and 4-8-3/1.9.

*iii)* Where load-shedding arrangements are provided, they are fitted in accordance with 4-8-2/9.9.

*iv)* Where the propulsion machinery is capable of being operated from the navigation bridge, means are provided or procedures are in place such that power supply to essential services are maintained during maneuvering conditions in order to avoid a blackout situation.

### 3.7 Transformers and Converters

#### 3.7.1 Continuity of Supply

Where transformers and/or converters form a part of the vessel's electrical system supplying to essential services and services necessary for minimum comfortable conditions of habitability, as defined in 4-8-1/7.3.3 and 4-8-1/7.3.4, the number and capacity of the transformers and/or converters is 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 4-8-5/3.3.3 for the additional requirements applicable for high voltage transformers.

#### 3.7.2 Arrangements *(2020)*

Each required transformer is to be located in a separate enclosure or equivalent, and is to be served by separate circuits on the primary and secondary sides. When installed in the same space, the transformers are to be adequately separated to suitably protect and preclude damage by fire or other incident at one of the transformers.

Each primary circuit is to be provided with switchgear protective devices in each phase. 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, to preclude its damage by fire or other incident at the transformer. A circuit breaker provided in the secondary circuit, in accordance with 4-8-2/9.19.2, will be acceptable in lieu of a multipole isolating switch.

#### 3.7.3 Continuity of Supply for Battery Charger *(2020)*

Where batteries connected to a single battery charger are the sole means of supplying DC power to equipment for essential services as defined in 4-8-1/7.3.3 or are used for battery starting systems in 4-8-2/11.11, failure of the single battery charger under normal operating conditions should not result in total loss of these services once the batteries are depleted. To provide continuity of the power supply to such equipment, one of the following arrangements is to be provided:

*3.7.3(a)* Duplicate battery chargers; or

*3.7.3(b)* 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

*3.7.3(c)* Duplicate transformer/rectifier (or switching converter) units within a single battery charger, provided with a changeover switch.

The above requirements are not applicable for the equipment for the essential services, which contains a single transformer/ rectifier with a single AC power supply feeder to such equipment.

For electric starting arrangement for main and auxiliary engines see 4-8-2/11.11.

#### 3.7.4 Automatic Bus Transfer *(2020)*

Where an Automatic Bus Transfer (ABT) is provided between the secondary side of the transformers and the load center panel connected directly without a multipole isolating switch or protective device, the ABT may be considered as the multipole isolating switch if it is provided with manual transfer operation lockable in either position and constructed to 4-8-3/1.3 and 4-8-3/1.5. Details of the ABT is to be submitted for reference upon request.

### 3.9 Location of Generators *(2023)*

The main switchboard is to be placed as near as practicable to the main generating station, within the same machinery space and the same vertical and horizontal A60 fire boundaries, so that the integrity of the normal electrical power supply may be affected only by a fire, flooding or similar casualty in one space. An environmental enclosure for the main switchboard such as may be provided by a centralized control room situated within the main boundaries of the space, is not to be considered as separating the switchboard from the generators.

Any bulkhead between the extreme main transverse watertight bulkheads is not regarded as separating the equipment in the main generating station provided there is access between the spaces.

The main generating station is to be situated within the machinery space, i.e. within the extreme main transverse watertight bulkheads. Where essential services for steering and propulsion are supplied from these main switchboards and any transformers, converters and similar appliances constituting an essential part of electrical supply system are also to satisfy the foregoing.

### 3.11 System Arrangement

#### 3.11.1 General *(2020)*

Load shedding of nonessential services and, where necessary, secondary essential services (see 4-8-1/7.3.3) or other arrangements, as may be necessary, are to be provided to protect the generators against sustained overload. See also 4-8-2/9.9.

#### 3.11.2 Single Generator Operation *(2024)*

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 standby generator(s) of sufficient capacity with automatic restarting of the essential auxiliaries in sequential operation, if necessary, to restore propulsion and steering for the safety of the vessel. Starting and connection to the main switchboard of the standby generator is to be preferably within 30 seconds after loss of the electrical power supply but in no case more than 45 seconds.

#### 3.11.3 Multiple Generators Operation *(2024)*

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 by the remaining generator(s) in service will be maintained for the safety of the vessel.

### 3.13 Main Switchboard *(2020)*

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 normally to be connected by circuit breakers or other approved means; so far as is practicable, the connection of generator sets and other duplicated equipment are 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.

"Other approved means" can be achieved by:

Circuit breaker without tripping mechanism; or disconnecting link or switch by which bus bars can be split easily and safely. Bolted links, for example bolted busbar sections, are not accepted.

### 3.15 Other Sources for Main Power Supply *(2024)*

When the main source of electrical power is lithium-ion batteries that are charged by fuel cells or other alternative energy sources such as wind, solar etc., the following ABS publications are to be referred to and complied with, as applicable:

***i)*** *Requirements for Fuel Cell Power Systems for Marine and Offshore Applications*

***ii)*** *Requirements for Use of Lithium-ion Batteries in the Marine and Offshore Industries.*

***iii)*** *Requirements for Hybrid Electric Power Systems for Marine and Offshore Installation*

***iv)*** *Requirements for Wind Assisted Propulsion System Installation*

***v)*** *Requirements for Use of Supercapcitors in the Marine and Offshore Industries.*

## 5 Emergency Source of Electrical Power

### 5.1 General

#### 5.1.1 Basic Requirement

A self-contained emergency source of electrical power is to be provided so that in the event of the failure of the main source of electrical power, the emergency source of power will become available to supply power to services that are essential for safety in an emergency. Passenger vessels are subject to the requirements in 5C-7-5/13.5.

#### 5.1.2 Scope of Provision

A self-contained emergency source of electrical power includes prime mover and its starting equipment, generator, fuel tank, emergency switchboard, associated transforming equipment, if any, transitional source of emergency power, if applicable, and emergency lighting switchboard and associated transformers, if applicable.

#### 5.1.3 Requirements by the Governmental Authority

Attention is directed to the requirements of governmental authority of the country, whose flag the vessel flies, for emergency services and accumulator batteries required in various types of vessels.

### 5.3 Location

#### 5.3.1 General

The self-contained emergency source of electrical power is to be located above the uppermost continuous deck, outside the machinery casing, and is to be readily accessible from the open deck. It is not to be located forward of the collision bulkhead. The space is to contain only machinery and equipment supporting the normal operation of the emergency power source.

#### 5.3.2 Separation from Machinery Space of Category A *(2019)*

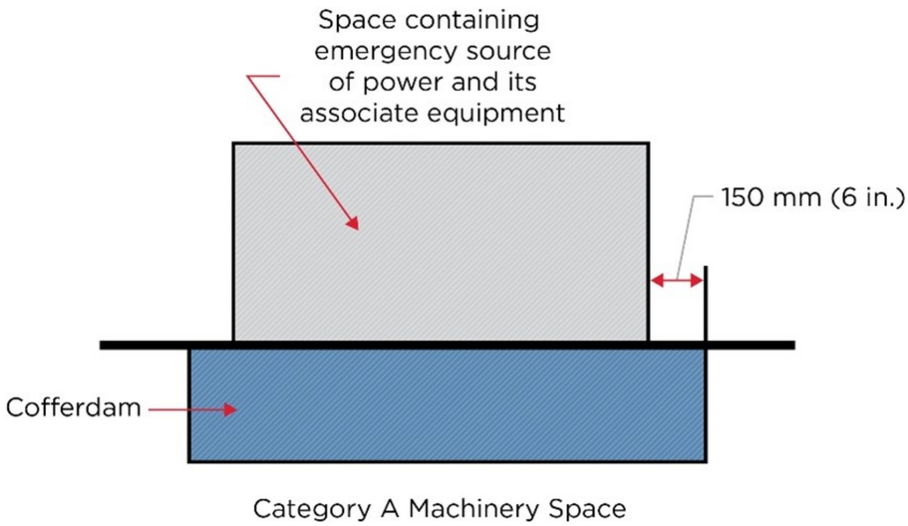
The location of the self-contained emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power, the emergency switchboard and emergency lighting switchboard in relation to the main source of electrical power is to be such that a fire or other casualty in the space containing the main source of electrical power or in any machinery space of category A will not interfere with the supply, control and distribution of emergency electrical power.

The space containing the self-contained emergency source of electrical power and its associated equipment as stated above 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.

The following alternative arrangements may be considered:

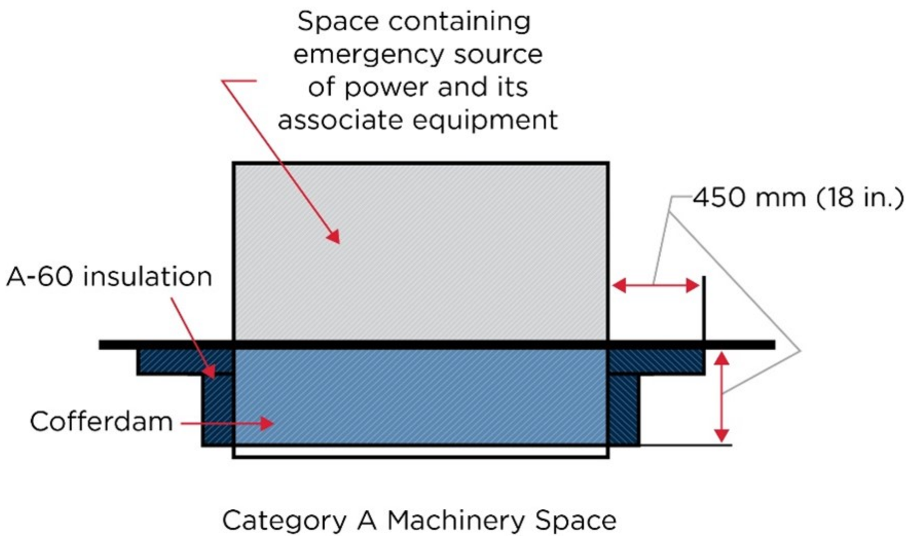
*i)* Separation by a cofferdam having dimensions as required for ready access and extending at least 150 mm (6 in.) beyond the boundaries of the space containing the self-contained emergency source of power and its associated equipment as stated above. See 4-8-2/5.3.2.i FIGURE 1 below. Except for cables feeding services located in the machinery space, flame retardant cables for emergency services are not to be installed in such cofferdams unless the cofferdam is insulated to A-60 or fire resistant type cables (rated minimum of 60 minutes of fire resistance) are to be used for the emergency services. See 4-8-4/21.17.2 and 4-8-4/21.17.3.

**FIGURE 1**
**Cofferdam with Extension Beyond the Boundaries of the Space Containing the Emergency Source**




*ii)* Separation by a cofferdam having dimensions as required for ready access between category A machinery space and the space containing emergency source of power and its associated equipment as stated above without extension beyond the boundaries. Any contiguous lines between these spaces at the corner of the cofferdam is to be insulated to A-60 for a length of 450 mm (18 in) at the category A machinery space side. See 4-8-2/5.3.2.ii FIGURE 2 below.

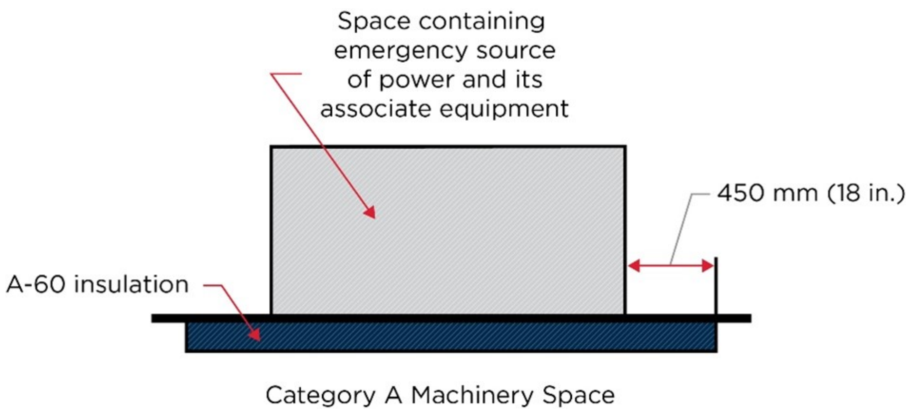
### FIGURE 2
### Cofferdam without Extension Beyond the Boundaries of the Space Containing the Emergency Source




*iii)* The contiguous boundaries insulated to A-60 with the insulation extending at least 450mm (18 in.) beyond the boundary of the space containing the self-contained emergency source of power and its associated equipment as stated above. See 4-8-2/5.3.2.iii FIGURE 3 below.

The arrangements indicated in 4-8-2/5.3.2.iii 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
### Boundaries insulated to A-60 with the Insulation Extending Beyond the Boundaries of the Space Containing the Emergency Source (*2008*)




#### 5.3.3 Separation from Other Spaces

Spaces containing the emergency sources of electrical power are to be separated from spaces other than machinery space of category A by fire rated bulkheads and decks in accordance with Part 3, Chapter 4 or Chapter II-2 of SOLAS.

### 5.5 Emergency Services

*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 4-8-2/5.5 TABLE 1 for the period specified.

## TABLE 1
## Services to be Powered by an Emergency Source and by a Transitional Source
*(2024)*

| *Service* | *Gross Tons* | *Duration (hours)* | | | | |
|---|---|---|---|---|---|---|
| | | *500 GT or over (1)* | | *Under 500 GT* | | |
| | *Electrical Plant's Capacity* | *---* | | *75 kW or over (2)* | | *Under 75 kW* |
| | *Emergency Power Consumers* | *Emergency Power* | *Transitional Power* | *Emergency Power* | *Transitional Power* | *Emergency Power (3)* |
| | At every muster and embarkation station for survival craft, their launching appliance, over the sides for launching | 3 | 0.5 | 2 | 0.5 | 2 |
| | At the area of water into which the survival craft is to be launched | 3 | 0.5 | 2 | 0.5 | 2 |
| Emergency lighting | In all service and accommodation alleyways, stairways, and exits, personnel lift cars, and personnel lift trunks | 18 | 0.5 | 6 | 0.5 | 6 |
| | In the machinery spaces and main generating stations including their control positions | 18 | 0.5 | 6 | 0.5 | 6 |
| | In all control stations, machinery control rooms, and at each main and emergency switchboard | 18 | 0.5 | 6 | 0.5 | 6 |
| | At all storage positions for fireman's outfits | 18 | 0.5 | 6 | 0.5 | 6 |
| | At the steering gear | 18 | 0.5 | 6 | 0.5 | 6 |
| | At the emergency fire pump, the sprinkler pump, the emergency bilge pump, their starting positions | 18 | 0.5 | 6 | 0.5 | 6 |
| | In all cargo pump rooms | 18 | 0.5 | 6 | 0.5 | - |
| | Floodlight and perimeter lights on helicopter landing decks | 18 | 0.5 | 6 | 0.5 | - |

| *Service* | *Gross Tons* | *Duration (hours)* | | | | |
|---|---|---|---|---|---|---|
| | | *500 GT or over* [1] | | *Under 500 GT* | | |
| | *Electrical Plant's Capacity* | *---* | | *75 kW or over* [2] | | *Under 75 kW* |
| | *Emergency Power Consumers* | *Emergency Power* | *Transitional Power* | *Emergency Power* | *Transitional Power* | *Emergency Power* [3] |
| Navigation lights | The navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea | 18 | 0.5 | 6 | 0.5 | - |
| Commun-ication | Radio equipment as required by Chapter IV of SOLAS | 18 | 1[9] | 6[10] | 0.5[10] | - |
| | All internal communication equipment as required in an emergency, see 4-8-2/11.5, 4-8-2/11.7 | 18 | 0.5 | 6 | 0.5 | - |
| | Intermittent operation of daylight signaling lamp, ship's whistle, manually operated call points, all internal signals that are required in an emergency, see 4-8-2/11.7 | 18 | 0.5 | 6 | 0.5 | - |
| Navigation Aids | Navigational equipment required by Regulation V/19 and V/20 of SOLAS | 18 [5] | - | - | - | - |
| Alarm Systems | Fire detection and alarm | 18 | 0.5 | 6 [8] | 0.5 | - |
| | Gas detection and alarm system | 18 | 0.5 | 6 | 0.5 | - |
| Fire pumps | Emergency fire pump (see 4-7-3/1.5.3); one of the fire pumps required by 4-7-3/1.5.1 and fixed pressure water-spray system pump (see 4-7-2/1.2.1.iii.) if dependent upon the emergency generator for its source of power | 18 | - | - | - | - |
| Steering gear | Steering gears required to comply with 4-3-4/11.9 | 0.5 [6,7] | - | 0.17 [7] | - | - |
| Navigation | Remote propulsion control and monitoring system for **ACC**, **ACCU** and **ABCU** notations, see 4-9-5/3.5 and 4-9-6/3.7 | 0.5 | - | 0.5 | - | - |
| Other emergency services | Free-full lifeboat secondary launching appliance, if not dependent on gravity, stored mechanical power or other manual means | 0.5 | - | 0.5 | - | - |
| | Power-operated watertight door, as required by 4-9-8/1.3.4 | 0.5 | - | 0.5 | - | - |

*Notes:*

1 See 4-8-2/5.5

2 See 4-8-2/5.11

3 See 4-8-2/5.21

4 See 4-8-5/9

5 Vessels less than 5,000 GT may be waived if approved by the Administration

6 Applicable for rudder stock diameter over 230 mm (9 in.)

7 10 minutes continuous operation on vessels of less than 10,000 GT

8 Where a fixed fire detection and fire alarm system is installed

9 Applies to ships 300 Gross Tonnage and over, 6 h on ships not provided with an emergency source of electrical power. The source of energy is to be independent of the propelling power of the ship and the ship's electrical system.

10 Applies to ships under 300 Gross Tonnage

For radio equipment, as required by SOLAS Chapter IV, Reg 13, a reserve source of power is to be provided that is in addition to the vessel's emergency source of power.

## 5.7 Vessels on Short Duration Voyages *(2024)*

In a vessel engaged regularly in voyages of short duration and an equivalent level of safety is assessed, a lesser period than the 18 hour period specified in 4-8-2/5.5 but not less than 12 hours may be accepted.

## 5.9 Power Source

Emergency source of electrical power may be a generator, an accumulator battery, or a combination of these.

### 5.9.1 Generator *(2020)*

Where the emergency source of electrical power is a generator, it is to be:

***i)*** Driven by a prime mover with all necessary auxiliary systems independent from the main source of electrical power systems. The auxiliary systems, which may include fuel system, starting equipment, cooling system, ventilation and lubricating oil system, are to be installed as near as is practicable to the generator prime mover, preferably located in the same space as the generator prime mover unless the safe operation of the generator prime mover would thereby impaired.

***ii)*** Started automatically upon failure of the main source of electrical power supply and automatically connected to the emergency switchboard supplying those services referred to in 4-8-2/5.5 in not more than 45 seconds. Where the emergency generator is not provided with automatic starting, a transitional source of emergency electrical power, as specified in 4-8-2/5.11, is to be fitted.

***iii)*** Provided with an adequate capacity of fuel with a flashpoint (closed cup test) of not less than 43°C (110°F) for the emergency generator prime mover. The use of fuel oil having a flashpoint of less than 60°C (140°F) but not less than 43°C (110°F) is to be subject to the provisions of 4-6-4/13.1.4.

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.

#### 5.9.2 Accumulator Battery

Where the emergency source of electrical power is an accumulator battery it is to be capable of:

*i)* Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power;

*ii)* Immediately supplying at least those services specified in 4-8-2/5.11; and

*iii)* 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.

#### 5.9.3 Lithium-Ion Batteries *(2024)*

Where the emergency source of electrical power is lithium-ion batteries, it is to comply with the requirements given in the ABS *Requirements for Use of Lithium-ion Batteries in the Marine and Offshore Industries* regardless of the battery capacity. [see 2/1.9 of that document]

### 5.11 Transitional Source of Power

The transitional source of emergency electrical power where required by 4-8-2/5.9.1 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 is to 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 emergency lighting and navigation lights required by 4-8-2/5.5 TABLE 1. 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)* Communication services and alarm systems required by 4-8-2/5.5 TABLE 1 unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

### 5.13 Emergency Switchboard

#### 5.13.1 Location of Emergency Switchboard *(2020)*

The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

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.

Accumulator battery fitted in accordance with 4-8-2/5.9.2 or 4-8-2/5.11 is not 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.

#### 5.13.2 Interconnector Feeder between Emergency and Main Switchboards

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 and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power.

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.

The circuit coordination is to be arranged such that all the outgoing circuits from the main ship service switchboard will coordinate with the step-down transformer protection.

*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.

#### 5.13.3 Feedback Operation

Where the emergency switchboard is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short circuit, which is to be coordinated with the emergency generator circuit breaker.

In addition, this interconnector feeder protective device is to trip to prevent overloading of the emergency generator which might be caused by the feedback operation.

#### 5.13.4 Non-emergency Services and Circuits *(2020)*

The emergency generator may be used, exceptionally and for short periods, to supply non-emergency circuits during the blackout situation (see 4-1-1/1.9.7), dead ship condition (see 4-1-1/1.9.6), and routine testing (to check its proper operation, see 4-8-2/5.13.5) provided that measures are taken to safeguard the independent emergency operation under all circumstances. 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.

For ready availability of the emergency source of electrical power, and to provide electrical power automatically to the emergency circuits, arrangements are to be made, where necessary, to disconnect automatically non-emergency circuits from the emergency switchboard.

For use of the emergency generator in port, see 4-8-2/5.17.

#### 5.13.5 Arrangements for Periodic Testing

Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting system.

### 5.15 Starting Arrangements for Emergency Generator Sets

#### 5.15.1 General

The emergency generator is 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 fitted.

#### 5.15.2 Number of Starts

Each emergency generator arranged to be automatically started is to be equipped with starting devices with a stored energy capability of at least three consecutive starts. The source of stored energy is to be protected to preclude critical depletion (i.e. not to be depleted beyond a level where starting by manual intervention is still possible) by the automatic starting system, unless a second independent means of starting is provided. In addition, a second source of energy is to be provided for an additional three starts within thirty minutes unless manual starting can be demonstrated to be effective.

#### 5.15.3 Stored Energy for Starting *(2020)*

The stored energy for each starting system of the emergency generator set is to be maintained at all times, as follows:

*i)* Electrical and/or hydraulic starting systems are to be maintained from the emergency switchboard.

*ii)* 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.

*iii)* 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 of the emergency generator in accordance with 4-8-2/5.9.1 is not required, manual starting is permissible, such as manual cranking, inertia starters, manually charged hydraulic accumulators, or power charge cartridges, where they can be demonstrated as being effective.

When manual starting is not practicable, the requirements of 4-8-2/5.15.2 and 4-8-2/5.15.3 above, are to be complied with except that starting may be manually initiated.

### 5.17 Use of Emergency Generator in Port (for Vessels 500 GT and Over)

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.

#### 5.17.1 Arrangements for the Prime Mover

*5.17.1(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 4-8-2/5.5. See also 5-1-2/7.3.1 for vessels under the provisions of the IMO Code for Safety for Special Purpose Ships (SPS Code).

*5.17.1(b) Rating.* The prime mover is to be rated for continuous service.

*5.17.1(c) Filters.* The prime mover is to be fitted with fuel oil and lubricating oil filters in accordance with 4-6-5/3.5.4 and 4-6-5/5.5.2, respectively.

*5.17.1(d) Monitoring.* The prime mover is to be fitted with alarms, displays and automatic shutdown arrangements as required in 4-9-6/23 TABLE 6, except that for fuel oil tank low-level alarm, 4-8-2/5.17.1(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 in 4-9-6/19.

*5.17.1(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 4-7-2/1.13 and may be a part of another system.

#### 5.17.2 System Arrangements

*5.17.2(a) Independence.*The power supply circuits, including control and monitoring circuits, for the use of an 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.

*5.17.2(b) Changeover arrangement.*Means are to be provided to readily change over to emergency operation.

*5.17.2(c) Overload prevention.*The generator is to be safeguarded against overload by automatically shedding such other loads that the supply to the required emergency loads is always available.

### 5.17.3 Operational Instruction

Operational instructions, such as that on fuel oil tank level, harbor/seagoing mode changeover arrangements, etc. are to be provided on board. Before the vessel is underway all valves, switches, etc. are to be in the positions for the 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.

## 5.19 Alarms and Safeguards for Emergency Diesel Engines *(2024)*

### 5.19.1 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.

### 5.19.2 Alarms and Safeguards

*5.19.2(a)* Alarms and safeguards are to be fitted in accordance with 4-8-2/5.19 TABLE 2.

*5.19.2(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.

*5.19.2(c) (2020)*

Regardless of the engine output, if shutdowns additional to those specified in 4-8-2/5.19 TABLE 2 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.

*5.19.2(d)* The alarm system is to function in accordance with 4-9-2/3.1.2 and 4-9-2/7, with additional requirements that grouped alarms are to be arranged on the bridge.

*5.19.2(e)* In addition to the fuel oil control from outside the space, a local means of engine shutdown is to be provided.

*5.19.2(f)* Local indications of at least those parameters listed in 4-8-2/5.19 TABLE 2 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 2
## Alarms and Safeguards for Emergency Diesel Engines [See 4-8-2/5.19] *(2024)*

| *Systems* | *Monitored Parameters* | | *A* | *Auto Shut down* | *Notes [ A = Alarm; x = apply ]* |
|---|---|---|---|---|---|
| Fuel oil | A1 | Leakage from high pressure pipes (fuel injection pipes and common rails) | *x* | | |
| Lubricating oil | B1 | Temperature – high | *x* | | For engines having a power of 220 kW or more. |
| | B2 | Lubricating oil pressure – low | *x* | | |
| | B3 | Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of:<br>- the engine main and crank bearing oil outlet; or<br>- the engine main and crank bearing) | *x* | | High oil mist concentration or bearing high temperature.<br>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.).<br>See 4-2-1/7.2 |
| 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. |

***Commentary:***

This requirement is based on IACS Unified Requirement (UR) M63, rev.1.

**End of Commentary**

## 5.21 Vessels Less than 500 GT Having Electrical Plants of 75 kW and Above

### 5.21.1 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. 4-8-2/5.3, and 4-8-2/5.9 through 4-8-2/5.13 are also applicable. Where the source of electrical power is a battery, see 4-8-4/5 for the installation. For emergency lighting, a relay-controlled, battery-operated lantern is acceptable.

### 5.21.2 Capacity

The emergency source of electrical power is to be capable of supplying simultaneously the services for the period as specified in 4-8-2/5.5 TABLE 1.

### 5.21.3 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 General

The following are recognized as standard systems of distribution. Distribution systems other than these will be considered.

- Two-wire direct current
- Two-wire single-phase alternating current
- Three-wire three-phase alternating current
- Four-wire three-phase alternating current with solidly earthed neutral but not with hull return

## 7.3 Hull Return Systems

### 7.3.1 General

A hull return system is not to be used, with the exception as stated below:

- Impressed current cathodic protection systems;
- Limited locally earthed system, provided that any possible resulting current does not flow through any hazardous locations;
- 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.

### 7.3.2 Final Subcircuits and Earth Wires *(2024)*

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, and precautions are to be taken to the satisfaction of Administration.

***Commentary:***

The following is from IACS UI SC8:

i) All final sub-circuits should consist of two insulated wires, the hull return being achieved by connecting to the hull one of the busbars of the distribution board from which they originate.ii) Earth wires should be in accessible locations to permit their ready examination and to enable their disconnection for testing of insulation.

**End of Commentary**

## 7.5 Earthed AC Distribution System

### 7.5.1 General Earthing Arrangement

For earthed distribution systems, regardless of the number of power sources, the neutral of each power source, including that of the emergency generator where applicable, is to be connected in parallel and earthed at a single point. Reference should be made to manufacturer-specified allowable circulating currents for neutral-earthed generators.

### 7.5.2 System Earthing Conductor

System earthing conductors are to be independent of conductors used for earthing of non-current carrying parts of electrical equipment. See 4-8-4/23.3 for installation details and earth conductor sizing. Four-wire three-phase AC systems having an earthed neutral are not to have protective devices fitted in the neutral conductors. Multipole switches or circuit breakers which simultaneously open all conductors, including neutral, are allowed. In multiple-generator installations, each generator's neutral connection to earth is to be provided with a disconnecting link for maintenance purpose. Transformer neutral is not to be earthed unless all corresponding generator neutrals are disconnected from the system (e.g., during shore supply). See 4-8-4/23.3.

## 7.7 Cable Sizing *(2020)*

### 7.7.1 Cable's Current Carrying Capacity *(2020)*

*7.7.1(a) General*. Cable conductor size is to be selected based on the current to be carried such that the conductor temperature, under normal operating conditions including any overload condition that may be expected, does not exceed the maximum rated temperature of the cable insulation material. The selected cable type is to have a maximum rated temperature at least 10°C (18°F) higher than the maximum ambient temperature likely to exist at the location where the cable is installed.

*7.7.1(b) Current carrying capacities*. The maximum current carrying capacities of cables are to be obtained from 4-8-3/15 TABLE 6. These values are applicable, without correction factors for cables installed either in single- or double-layer in cable tray, or in a bunch in cable trays, cable conduits or cable pipes where the number of cables in the bunch does not exceed six. The ambient temperature is to be 45°C (113°F) or less.

*7.7.1(c) Current carrying capacity correction* (2024)

Where more than six cables which may be expected to operate simultaneously at their full rated capacity are laid close together in a bunch in such a way that there is an absence of free air circulation around them a reduction factor of 0.85 is to be applied to the current carrying capacity of the cables.

The 0.85 correction factor is also to be applied in the case:

*i)* where fire stops forming a fire protective mat, with which cable runs are wrapped for a length of at least 500 mm every 14 m (19.7 inch/ 46 ft) of horizontal cable runs, or every 6 m (19.7 ft) of vertical cable runs where free air circulation around the length of wrapped cables is impeded, and;

*ii)* where fire stops by fire protection coating are applied on the cables laid and bunched, and;

*iii)* where the fire stops are used in installations where more than six cables are expected to be operated simultaneously at their full rated capacity.

***Commentary:***

Current carrying capacity correction for bunches of more than twelve cables will be subject to special consideration based on the type and services of the various cables in the bunch in accordance with IEC 60092-352 Annex A.

Aforementioned correction factor need not be applied where the conductor temperature for all cables meets the criteria of 4-8-2/7.7.1(a) by demonstrating through temperature rise calculations/heat transfer analyses or tests under the approved procedures in the worst case scenario of simultaneous cable operation in the bunch or wrapped together.

**End of Commentary**

*7.7.1(d) Voltage drop*. Voltage drop is to be taken into account in determining cable size. The voltage drop in the conductors while carrying the maximum current under normal steady condition is not to exceed 6% of the nominal voltage at any point of the installation. For cables connected to batteries with a voltage not exceeding 50 V this figure may be increased to 10%.

### 7.7.2 Minimum Conductor Sizes *(2023)*

For the minimum conductor size requirements, see 4-8-3/9.4.

#### 7.7.3 Generator Cable

Generator cable is to have a current carrying capacity of not less than the rated current or the rated continuous overload current of the generator.

#### 7.7.4 Transformer Cable

Cables provided for primary and secondary circuits of transformers are to have current carrying capacities not less than the rated primary and secondary currents respectively.

#### 7.7.5 Motor Control Center Feeder

Feeder cables supplying to motor control centers are to have a continuous current-carrying capacity not less than 100% of the sum of the rated current of all motors connected to the motor control center. Feeder cables of lesser current capacity are permitted, where the design is such that connected consumers are not operated simultaneously, under any operating mode.

#### 7.7.6 Distribution Panel Feeder

Feeder cables supplying to distribution panels or to any sub-distribution panels are to have current-carrying capacity of not less than 100% of the sum of the rated currents of all connected consumers. Where connected consumers are not operated simultaneously, feeder cables of lesser current capacity are permitted provided that they are protected in accordance with 4-8-2/9.13 below.

#### 7.7.7 Motor Branch Circuit

A separate circuit is to be provided for each motor having a full-load current of 6 A or more. The cables are to have a carrying capacity of not less than 100% of the motor full-load current rating. Branch circuit conductor for each motor is not to be less than 1.5 mm$^2$. Circuit-disconnecting devices are to be provided for each motor branch circuit and to be in accordance with 4-8-3/5.7 and 4-8-4/9.3.

#### 7.7.8 Lighting Circuits

Cable for a branch lighting circuit is to have the current carrying capacity of not less than the sum of the full load currents of the connected lighting fixtures.

#### 7.7.9 Protection of Feeder Size Reduction

The size of feeder conductors is normally to be uniform for the total length, but may be reduced beyond any intermediate distribution board, provided that the reduced size section of the feeder is protected by the overload device at the board at which the feeder size is reduced.

### 7.9 Segregation of Power Circuits

Separate feeders are to be provided for normal vessels service loads and emergency service loads.

### 7.11 Steering Gear Power Supply Feeders *(2020)*

For vessels fitted with electric or electro-hydraulic steering gear the system is to comply with 4-3-4/11 and 4-3-4/13.

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.

### 7.13 Lighting System

#### 7.13.1 Main Lighting System *(2020)*

A main electric lighting system served by the main source of electric power is to be provided. This lighting system is to provide illumination throughout those parts of the vessel normally accessible to and used by personnel on board. 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 any emergency electric lighting systems and navigation lights required by 4-8-2/7.13.2 inoperative.

#### 7.13.2 Emergency Lighting System *(2020)*

An emergency electric lighting system served by the emergency source of electric power is to be provided for the spaces indicated in 4-8-2/5.5 TABLE 1. 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 systems required by 4-8-2/7.13.1 inoperative.

#### 7.13.3 Lighting Distribution *(2020)*

To prevent the simultaneous loss of the main and emergency lighting see 4-8-4/11.5.

#### 7.13.4 Lighting Circuits in Machinery Spaces and Accommodation Spaces

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, arranged in such a way that failure of any one circuit does not leave these spaces in darkness. One of the circuits may be supplied from the emergency switchboard.

### 7.15 Ventilation System Circuits

Ventilation fans for cargo spaces are to have feeders separate from those for accommodations and machinery spaces. In general, power ventilation is to be capable of being stopped from a location outside the space ventilated as indicated in 4-8-2/11.9. See also, 4-7-2/3.7.3.

### 7.17 Cargo Space Circuits

All lighting and power circuits for cargo space are to be controlled by multiple-pole switches situated outside the space. Light indicator or other means is to be provided on the multipole-linked switch to show whether the circuit is live.

### 7.19 Electric Space Heater Circuits

Each heater is to be connected to a separate final branch circuit. However, a group of up to 10 heaters with aggregate current not exceeding 16 A may be connected to a single final branch circuit.

### 7.21 Harmonics

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. This relaxation on THD limits is to be documented (harmonic distortion calculation report) and made available on board as a reference for the Surveyor at each periodical survey. 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. See also 4-8-2/9.22 and 4-8-2/9.23.

# 9 System Protection

## 9.1 General

Each electrical system is to be protected against overload and short circuit by automatic protective devices, so that in the event of an overload or a short circuit the device will operate to isolate it from the systems:

- To maintain continuity of power supply to remaining essential circuits; and
- To minimize the possibility of fire hazards and damage to the electrical system.

These automatic protective devices are to protect each non-earthed phase conductors (e.g., multipole circuit breakers or fuses in each phase).

In addition, where possibility exists for generators to be overloaded, load-shedding arrangements are to be provided to safeguard continuity of supply to essential services.

The following are exceptions:

- Where it is impracticable to do so, such as engine starting battery circuits.
- Where, by design, the installation is incapable of developing overload, in which case, it may be protected against short circuit only.
- Steering circuits; see 4-8-2/9.17.5.

## 9.3 Protection Against Short Circuit

### 9.3.1 General

Protection against short circuit is to be provided for each non-earthed conductor (multipole protection) by means of circuit breakers, fuses or other protective devices.

### 9.3.2 Short Circuit Data *(2020)*

In order to establish that protective devices throughout the electrical system (e.g. on the main and emergency switchboards and sub-distribution panels) have sufficient short circuit breaking and making capacities or short circuit interrupting capacities, short circuit data as per 4-8-1/5.1.3 are to be submitted.

### 9.3.3 Rated Breaking Capacity

The rated breaking capacity of every protective device is not to be less than the maximum prospective short circuit current value at the point of installation. For alternating current (AC), the rated breaking capacity is not to be less than the root mean square (rms) value of the prospective short circuit current at the point of installation. The circuit breaker is to be capable of breaking 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.

### 9.3.4 Rated Making Capacity

The rated making capacity of every circuit breaker which may be closed on short circuit is to be adequate for the maximum peak value of the prospective short circuit current at the point of installation. The circuit breaker is to be capable of closing onto a current corresponding to its making capacity without opening within a time corresponding to the maximum time delay required.

### 9.3.5 Interrupting Capacity *(2020)*

The interrupting capacity is the prospective current at which the circuit breaker is required to perform its short-circuit current duty cycle at rated maximum voltage. This current is expressed as the rms symmetrical value envelope at a time half-cycle after short-circuit is initiated. (For dc breakers, the rated interrupting current is the maximum value of direct current.)

#### 9.3.6 Backup 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. Current-limiting fuses for short circuit protection may be without limitation on current rating, see 4-8-2/9.5.

#### 9.3.7 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 4-8-2/9.3.3). All circuit protective devices are to comply with the requirements for making capacity (see 4-8-2/9.3.4). 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.

### 9.5 Protection Against Overload *(2020)*

Circuit breakers and fuses for overload protection are to have tripping characteristics (over-current trip time) which adequately protects all elements in the system during normal and overload conditions having regard to overload capacity of each of these elements.

Fuses of greater than 320 A are not to be used for overload protection. However, current-limiting fuses may be used for short circuit protection without current rating limitation.

The rating or setting of the overload protective device for each circuit is to be permanently indicated on or at the location of the protective device.

### 9.7 Coordination of Protective Devices

#### 9.7.1 General Requirements

Protective devices are to be selected such that, where considered in series, their tripping characteristics will allow, in the event of a fault (overload or short circuit), the protective device nearest to the fault to open first, thus eliminating the faulted portion from the system.

Protective devices upstream of the fault are to be capable of carrying for the necessary duration the short circuit current and the overload current, without opening, to allow the device nearest to the fault to open.

Coordination is to be provided for the following:

- Between generator protective device, bus tie, bus feeder protective device, and feeder protective devices;
- Between feeder and branch circuit protective devices for essential services except for cascade protection in 4-8-2/9.3.7; and
- Between protective devices of emergency generator, emergency feeders and branch circuits.

For main and emergency generators, the circuit breakers are to open to prevent the generators from being damaged by thermal stress due to the fault current.

## 9.9 Load Shedding Arrangements

### 9.9.1 Provision for Load Shedding Arrangements

In association with the provision of 4-8-2/3.11, and in order to safeguard continuity of 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 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).

### 9.9.2 Services not Allowed for Shedding

Automatic load-shedding arrangements or other equivalent arrangements are not to automatically disconnect the following services. See 4-8-1/7.3.3 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 4-8-2/5.5, 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 4-8-2/11.5, 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.

*iv)* Service operations critical to the safety of the vessel.

## 9.11 Protection of Generators

### 9.11.1 Overload Protection *(2020)*

Generators are to be protected by circuit breakers providing long-time delay over-current protection not exceeding 115% of the full-load rating current of continuous-rated machines or the overload rating of special-rated machines. Alternatively generators of less than 25 kW not arranged for parallel operation may be protected by fuses.

### 9.11.2 Short Circuit Protection *(2020)*

Generators are to be protected for short circuit by circuit breakers provided with short-time delay trips. For coordination with feeder circuit breakers, the short-time delay trips are to be set at the lowest values of current and time which will coordinate with the trip settings of feeder circuit breakers. The current setting of the short time delay trip is to be less than the steady state short-circuit current of the generator.

Where two or more AC generators are arranged for parallel operation, each generator's circuit breaker is, in addition, to be provided with instantaneous trip set in excess of the maximum (asymmetrical) short-circuit contribution of the individual generator. (See 4-8-3/3.13.2(d)).

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.

For generators of less than 200 kW driven by diesel engines or gas turbines which operate independently of the electrical system, consideration may be given to omission of the short-time delay trips if instantaneous trips and long-time overcurrent protection (see 4-8-2/9.11.1) 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.

#### 9.11.3 Thermal Damage Protection

Generator circuit breakers at the main and emergency switchboard are to have tripping characteristics and to be set such that they will open before the generator sustains thermal damages due to the fault current. See 4-8-2/9.7.

#### 9.11.4 Reverse Power Protection

A reverse power protection device is to be provided for each generator arranged for parallel operation. The setting of the protective devices is to be in the range 2% to 6% of the rated power for turbines and in the range 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.

#### 9.11.5 Prime Mover Shutdown

The shutting down of the prime mover is to cause the tripping of the generator circuit breaker.

#### 9.11.6 Undervoltage Protection

Generators arranged for parallel operation are to be provided with means 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.

### 9.13 Protection of Feeder Cables

Each feeder conductor is to be protected by a circuit breaker, or fuse with disconnecting switchgear, from short circuit and overload at the supply end.

Fuse ratings and rating of time-delay trip elements of circuit breakers are not to exceed the rated current capacity of the feeder cables, except as otherwise permitted for motor and transformer circuits where starting in-rush current need be taken into account.

If the standard rating or setting of the overload protective device does not correspond to the current rating of the feeder cable, the next higher standard rating or setting may be used, provided it does not exceed

150% of the allowable current carrying capacity of the feeder cable, where permitted by the Standard to which the feeder cables have been constructed.

## 9.15 Protection for Accumulator Batteries *(2019)*

Accumulator 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 batteries for emergency lighting instead of circuit breakers up to and including 320 A rating. The charging equipment, except rectifiers, for all batteries with a voltage of more than 20% of the line voltage is to be provided with reverse current protection.

Where equipment or DC distribution panel is fed from two feeders or sources of DC battery power connected in parallel from separate battery charger systems, the batteries are to be protected from reverse power by means of:

- Manual change over switch as applicable
- Automatic change over from one source to the other provided in the equipment as required
- Power diodes in the feeder circuit
- Diode relay switching units

## 9.17 Protection of Motor Circuits

Overload and short-circuit protection is to be provided for each motor circuit in accordance with the following requirements.

### 9.17.1 Motor Branch Circuit Protection

*9.17.1(a) General.* (2020)

Motor branch circuits are to be protected with fuses or circuit breakers having both instantaneous and long-time delay trips. The setting is to be such that it will permit the passage of starting currents without tripping. Normally, the protective device is to be set in excess of the motor's full load current but not more than the limitations given in the table below. If that rating or setting is not available, the next higher available rating or setting may be used.

| *Type of Motor* | *Rating or Setting, % Motor Full-load Current* |
|---|---|
| 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, they are to be arranged to protect against single-phasing.

*9.17.1(b) Short circuit protection only.*

Where the motor branch circuit is protected with circuit breaker fitted with instantaneous trip only (e.g. 4-8-2/9.17.5), the motor controller is to have short circuit rating matching at least that of the circuit breaker instantaneous trip setting, and the motor overload protection (see 4-8-2/9.17.2) is to be arranged to open all conductors.

### 9.17.2 Motor Overload Protection

The overload protective devices of motors are to be compatible with the motor overload thermal characteristics, and are to be set at 100% of the motor rated current for continuous rated motor. If this is not practicable, the setting may be increased to, but in no case exceeding, 125% of the motor rated current. This overload protective device may also be considered the overload protection of the motor branch circuit cable.

For athwartship thrusters, a motor overload alarm in the wheelhouse is acceptable in lieu of the overload protection.

### 9.17.3 Undervoltage Protection

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.

### 9.17.4 Undervoltage Release *(2022)*

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 4-8-1/7.3.3 TABLE 1).

*ii)* Only those secondary essential services (see 4-8-1/7.3.3 TABLE 2) necessary for safety, such as:

- Ventilating fans for engine and boiler rooms where their failure to restart may prevent the normal operation of the propulsion machinery (See Note 1 below)

***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.

*iii)* Where the design of the consumers listed in 4-8-2/9.17.4.i and 4-8-2/9.17.4.ii are demonstrated to show that the operation of such consumers is not immediately essential to maintain the vessel's propulsion, steering and a minimum level of safety, undervoltage protection in lieu of undervoltage release may be acceptable.

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.

### 9.17.5 Protection of Steering Gear Circuits

*9.17.5(a) AC motors*. The steering gear feeder is to be provided with short-circuit protection only, which is to be located at the main or emergency switchboard. However, overload protection may be permitted if it is set at a value not less than 200% of the full load current of the motor (or of all the loads on the feeder), and is to be arranged to permit the passage of the starting current.

*9.17.5(b) DC motors*. The feeder circuit breaker on the main switchboard is to be set to trip instantaneously between 300% and 375% of the rated full-load current of the steering-gear motor. The feeder circuit breaker on the emergency switchboard may be set to trip instantaneously between 200% and 375%.

*9.17.5(c) Fuses* *(2024)*

The use of fuses for steering gear motor circuits is not permitted.

***Commentary:***

Steering gear motor circuits obtaining their power supply via an electronic converter, e.g. for speed control, and which are limited to full load current are exempt from the requirement to provide protection against excess current, including starting current, of not less than twice the full load current of the motor. The required overload alarm is to be set to a value not greater than the normal load of the electronic converter.

Normal load is the load in normal mode of operation that aproximates as close as possible to the most severe conditions of normal use in accordance with the manufacture's operating instructions.

Refer to IACS Unified Interpretation (UI) SC187 "Electric steering gear overload alarm":

**End of Commentary**

## 9.19 Protection of Transformer Circuits

### 9.19.1 Protection at Primary Side Only

Each power and lighting transformer along with its feeder is to be provided with short circuit and overload protection. The protective device is to be installed on the primary side of the transformer and is to be set at 100% of the rated primary currents of the transformer. If this setting is not practicable, it may be increased to, but in no case exceeding 125% of the rated primary current.

The instantaneous trip setting of the protective device is not to be activated by the in-rush current of the transformer when switching into service.

### 9.19.2 Protection at Both Primary and Secondary Sides

Where the secondary side of the transformer is fitted with a protective device set at not more than 125% of the rated secondary current, the transformer primary side protective device may be set at a value less than 250% of the rated primary current.

### 9.19.3 Parallel Operation

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.

## 9.21 Protection for Branch Lighting Circuits

Branch lighting circuits are to be protected against overload and short circuit. In general, overload protective devices are to be rated or set at not more than 30 A. 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.

## 9.22 Harmonic Distortion for Ship Electrical Distribution System including Harmonic Filters

### 9.22.1 Monitoring

Where the electrical distribution system on board a ship includes harmonic filters, such ships are to be fitted with facilities to continuously monitor the levels of harmonic distortion experienced on the main bus bar as well as alert the crew should the level of harmonic distortion exceed the acceptable limits. Where the engine room is provided with automation systems, this reading is to be logged electronically, otherwise it is to be recorded in the engine log book for future inspection by the Surveyor. However, harmonic filters installed for single application frequency drives such as pump motors may be excluded from the requirements of this section.

#### 9.22.2 Measurement

As a minimum, harmonic distortion levels of main bus bar on board such existing ships are to be measured annually under seagoing conditions as close to the periodical machinery survey as possible so as to give a clear representation of the condition of the entire plant to the Surveyor. Harmonic distortion readings are to be carried out when the greatest amount of distortion is indicated by the measuring equipment. An entry showing which equipment was running and/or filters in service is to be recorded in the log so this can be replicated for the next periodical survey. Harmonic distortion levels are also to be measured following any modification to the ship's electrical distribution system or associated consumers by suitably trained ship's personnel or from a qualified outside source. Records of all the above measurements are to be made available to the surveyor at each periodical survey in accordance with the ABS *Rules for Survey After Construction (Part 7)*.

#### 9.22.3 Validation of Calculated Harmonic

Where the electrical distribution system on board a ship includes harmonic filters, the system integrator of the distribution system is to show, by calculation, the effect of a failure of a harmonic filter on the level of harmonic distortion experienced.

The system integrator of the distribution system is to provide the ship owner with guidance documenting permitted modes of operation of the electrical distribution system while maintaining harmonic distortion levels within acceptable limits during normal operation as well as following the failure of any combination of harmonic filters.

The calculation results and validity of the guidance provided are to be verified by the Surveyor during sea trials.

#### 9.22.4 Filter Protection Alarm

Arrangements are to be provided to alert the crew in the event of activation of the protection of a harmonic filter circuit.

A harmonic filter is to be arranged as a three-phase unit with individual protection of each phase. The activation of the protection arrangement in a single phase is to result in automatic disconnection of the complete filter. Additionally, there is to be installed a current unbalance detection system independent of the overcurrent protection alerting the crew in case of current unbalance.

Consideration is to be given to additional protection for the individual capacitor element as (e.g., relief valve or overpressure disconnector) in order to protect against damage from rupturing. This consideration is to take into account the type of capacitors used.

### 9.23 Protection of Harmonic Filter Circuits Associated with Electric Propulsion

Notwithstanding the requirements of 4-8-2/9.22 above, harmonic filters circuits are to 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 is to be alarmed in a continuously manned location. If the current imbalance exceeds the ratings of the individual filter circuit components, the appropriate circuits are to 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 4-7-2/5.11 for additional requirements. Detection of capacitor(s) deterioration is to be alarmed locally at the equipment and in a continuously manned location. Power to the harmonic filter circuit containing the deteriorated capacitor(s) are to 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 are to be automatically disconnected and prevented from interacting with the rest of the electrical network.

# 11 Specific Systems

## 11.1 Shore Connection *(1 July 2024)*

Vessels equipped with a low voltage shore connection system (LVSC) or high voltage shore connection system (HVSC) designed to power the vessel with the shore power alone, enabling the shipboard generators to be shut down while in port, are to comply with the requirements given in Part 6, Chapter 4.

## 11.3 Navigation Light System

### 11.3.1 Power Supply *(1 July 2021)*

Navigation lights (mast head, side and stern lights) are to be controlled by its own exclusive control panel located on the navigation bridge. The control panel is to be supplied from the main as well as from the emergency source of power (see 4-8-2/5.5 TABLE 1). A means to transfer between the two power sources is to be fitted at the control panel. Where an automatic power change-over switch is provided, a fault in this switch is not to result in the loss of both power supplies.

### 11.3.2 Branch Circuit *(2020)*

Each navigation light is to have its own branch circuit fitted with a protective device.

### 11.3.3 Duplicate Lamp *(2020)*

For vessels of 50 meters in length or greater, the mast head, side and stern lights are to be fitted with duplicate lamps. The duplicate lamps are to be independently connected to separate branch circuits.

### 11.3.4 Control Panel *(2024)*

The navigation light control panel is to be fitted with the following:

- A means to disconnect each navigation light.
- An indicator for each navigation light.
- Alarm for the failure of main or emergency power supply.
- Automatic visual and audible warning in the event of failure 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 audible alarm may still be activated in the event of power or circuit failure to the navigation lights.

***Commentary:***

A separate source of power supply to the audible device required by 4-8-2/11.3.4 is not necessary where the audible device is integral with the indicator panel which also contains a visual alarm.

End of Commentary

## 11.5 Interior Communication Systems *(2020)*

### 11.5.1 General

Means of communication are to be provided between the navigation bridge and the following interior locations:

***i)*** Radio room, if separated from the navigation bridge.

***ii)*** Centralized propulsion machinery control station, if fitted.

***iii)*** Propulsion machinery local control position.

***iv)*** *(2006)* For vessels intended to be operated with unattended propulsion machinery spaces, each engineer's cabin and at least one public space where the alarm monitoring station is provided. See 4-8-2/11.5.3.iii and 4-9-6/19.1.

***v)*** Steering gear compartment.

***vi)*** Any other positions where the speed and direction of thrust of the propellers may be controlled, if fitted.

***vii)*** DP control stations and applicable control stations subject to specialized offshore services, see Part 5D.

### 11.5.2 Engine Order Telegraph

An engine order telegraph system which provides visual indication of the orders and responses both in the machinery space (the centralized control station, if fitted, otherwise propulsion machinery local control position) and on the navigation bridge is to be provided. 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.

A means of communication is to be provided between the centralized propulsion machinery control station, if fitted, and the propulsion machinery local control position. This can be a common talking means of voice communication and calling or an engine order telegraph repeater at the propulsion machinery local control position

### 11.5.3 Voice Communication

Means of voice communication are to be provided as follows. A common system capable of serving all the following will be acceptable.

***i)*** A common talking means of voice communication and calling is to be provided among the navigation bridge, centralized control station, if fitted (otherwise the propulsion machinery local control position), and any other position where the speed and direction of thrust of the propellers may be controlled. Simultaneous talking among these positions is to be possible at all times and the calling to these positions is to be always possible, even if the line is busy.

***ii)*** A means of voice communication is to be provided between the navigation bridge and the steering gear compartment.

***iii)*** For vessels intended to be operated with an unattended propulsion machinery space, the engineers' accommodation is to be included in the communication system in *i)*.

*iv)* For bunkering operations, a means of voice communication is to be provided between the bunkering stations and the machinery spaces controlling and monitoring the receiving and transferring of fuel oil.

#### 11.5.4 Power Supply

The above communication systems are to be supplied with power (not applicable to sound powered telephones) from the emergency switchboard. The final power supply branch circuits to these systems are to be independent of other electrical systems.

For sound powered telephone systems where the calling device or any peripheral devices are electrically powered, the above requirements are applicable to the electrically powered devices.

### 11.7 Manually Operated Alarms

#### 11.7.1 General Emergency Alarm System *(2020)*

Each vessel over 100 GT is to be fitted with a general emergency alarm (GA) system for purpose of summoning passengers and crew to the muster stations. The (GA) system is to be supplemented by a public address system in 4-8-2/11.8 or other suitable means of communication. Any entertainment sound system is to be automatically turned off when the general alarm system is activated. The system is to comply with the following requirements:

*11.7.1(a)* *(2020)*

The (GA) 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 vessel's whistle or siren and, additionally, on an electrically operated bell or klaxon or other equivalent system, which is to be powered from the vessel's main supply and the emergency source of power.

*11.7.1(b)*

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 without passing through any other distributing switchboard. The automatic change-over switch is to be situated in, or adjacent to, the main general emergency alarm control panel.

*11.7.1(c)* *(2020)*

An audible alarm or visual indication 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 4-8-2/11.7.1(b).

*11.7.1(d)* *(2020)*

As an alternative to two feeders as described in 4-8-2/11.7.1(b), a continuously charged battery may be considered as one of the required sources, provided fully charged 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 alarm for failure of the battery charger are to be provided. The battery charger is to be supplied from the emergency switchboard.

*11.7.1(e)* *(2022)*

The general emergency alarm signal 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. A flashing light or rotating beacon may be included for spaces with high ambient noise.

***Note:*** "Normal crew working spaces" are defined as those spaces where routine maintenance tasks or local control of machinery operated at sea are undertaken.

*11.7.1(f)* *(2023)*

The system is to be capable of activation from the navigation bridge and, except for the vessel's whistle, also from at least one other strategic location from which emergency situations are intended to be controlled. Fire control station, muster station, or cargo control station, etc. are examples of spaces that may be regarded as strategic location, provided they are fitted with the means of operating the general alarm systems. Attention is drawn to the Flag Administration, which may require additional stations or limit the number of alarm activating locations.

*11.7.1(g)* *(2023)*

The minimum sound pressure level for the emergency alarm tone in interior and exterior spaces and 1 m (3.3 ft) from the source is to be 80 dB(A) and 10 dB(A) above ambient noise level existing during normal equipment operation with the ship underway in moderate weather.

*11.7.1(h)*

The sound pressure level at the sleeping position in cabins and in cabin bathrooms is to be at least 75 dB(A) and at least 10 dB(A) above ambient noise level.

Reference is to be made to IMO Resolutions A.1021(26) *Codes on Alarms and Indicators, 2009*.

#### 11.7.2 Engineers' Alarm

On vessels of 500 gross tons and over, intended for international voyages or unrestricted ocean services, an engineers' alarm operable at the centralized propulsion machinery control station, the propulsion machinery local control position or offshore service operation control station, as appropriate, is to be provided. It is to be clearly audible in each engineer's cabin, and the sound pressure level is to comply with 4-8-2/11.7.1.

#### 11.7.3 Refrigerated Space Alarm

Each refrigerated space is to be fitted with means to activate an audible and visual alarm in a normally manned control station, operable from within such spaces for the protection of personnel.

#### 11.7.4 Elevator's Alarm

Each elevator car is to be fitted with means to activate an alarm in a normally manned control station or with means of voice communication with that station.

#### 11.7.5 Power Supply

The alarm systems in 4-8-2/11.7.2, 4-8-2/11.7.3 and 4-8-2/11.7.4 are to be supplied with power from the emergency switchboard. The final power supply branch circuits to the alarm systems in 4-8-2/11.7.1 and 4-8-2/11.7.2 are to be independent of other electrical systems.

### 11.8 Public Address System *(2020)*

#### 11.8.1 General *(2023)*

A public address (PA) system is to be provided to supplement the general emergency alarm system in 4-8-2/11.7.1, unless other suitable means of communication is provided. The system is to comply with the following requirements:

*i)* The PA system is to have loudspeakers to broadcast messages to all spaces where crew members or passengers, or both, are normally present, and to muster stations.

*Note:* "Spaces where crew members or passengers or both are normally present" include all accommodation spaces. With respect to spaces where a public address system may not be required, these may be spaces such as under deck passageways, including passageways in the car hold between an accommodation space and an engine-room, bosun's lockers and pump-rooms.

*ii)* The system is to be designed for broadcasting from the navigation bridge and at least one other emergency alarm control station situated in location when the navigation bridge is rendered inaccessible due to the emergency [see 4-8-2/11.7.1(f)]. The broadcasting stations are to be provided with an override function so that emergency messages can be broadcast even if any loudspeaker has been switched off, its volume has been turned down, or the loudspeakers are being used for other purposes.

*iii)* With the vessel under way in normal conditions, the minimum sound pressure level for broadcasting messages is to be: in interior spaces, 75 dB(A) and at least 20 dB(A) above the corresponding speech interference level; in exterior spaces, 80 dB(A) and at least 15 dB(A) above the corresponding speech interference level, which is to be maintained without action from addressees.

*iv)* The broadcasting station of the PA system is to be protected against unauthorized use.

*v)* Where a combined system is provided to serve both public address and general emergency alarm functions, the system is to be designed so that a single component failure is not to cause the loss of both functions and that the effect of any single failure is minimized. The major system components, such as power supply unit, amplifier, alarm tone generator, etc., are to be duplicated. Power supply for a combined system is to comply with 4-8-2/11.7.1(b) and 4-8-2/11.7.1(c).

#### 11.8.2 Power Supply

The public address system is to be supplied with power by a dedicated branch circuit from the emergency switchboard.

#### 11.8.3 Cargo Vessels

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.

#### 11.8.4 Passenger Vessels

For passenger vessels, a single system serving both public address and general emergency alarm functions is required to have speakers connected to two loops sufficiently separated throughout their length. The two loops are to be connected to separate amplifiers. (See 5C-7-5/13.15.ii).

### 11.9 Emergency Shutdown Systems *(2021)*

Wiring break monitoring device is to be provided for normally de-energized (i.e., normaly open circuits) emergency shutdown systems. The arrangement of the emergency shutdown system is to be such that no single failure will cause loss of duplicated essential equipment such as fuel and luricating oil pumps which may cause loss of main power generation or main propulsion.

#### 11.9.1 Ventilation Systems

*11.9.1(a) Propulsion machinery spaces*. Power ventilation systems serving machinery 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 machinery spaces is to be entirely separate from the means for stopping the ventilation of spaces in 4-8-2/11.9.1(b), 4-8-2/11.9.1(c) and 4-8-2/11.9.1(d). See 4-7-2/1.9.5.

*11.9.1(b) 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 4-8-2/11.9.1(a), 4-8-2/11.9.1(c) and 4-8-2/11.9.1(d). See 4-7-2/1.9.5

*11.9.1(c) Cargo spaces.* *(2020)*

Power ventilation systems serving cargo spaces are to be fitted with remote means of control so that the ventilation fan motors can be stopped in the event of a fire in the cargo space. These means are to be outside the cargo spaces and in a location not likely to be cut off in the event of a fire in the cargo spaces. Particular attention is to be directed to specific requirements applicable to the ventilation systems of cargo spaces of each vessel type provided in Part 5C.

*11.9.1(d) Accommodation spaces, service spaces, control stations and other spaces.* *(2020)*

The means for stopping all other power ventilation systems including the small/independent ventilation fans in accommodation spaces is to be located on the navigation bridge, in firefighting station, if fitted, or in an accessible position leading to, but outside of, the space ventilated. See 4-7-2/3.7.3.

#### 11.9.2 Fuel Oil, Lubricating Oil and Thermal Oil Systems

Fuel oil transfer pumps, fuel oil unit pumps and other similar fuel pumps, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers, but not including oily water separators) are to be fitted with remote means of stopping. These means are to be located outside the space where these pumps and separators are installed or at the firefighting station, if fitted, so that they may be stopped in the event of a fire arising in that space.

#### 11.9.3 Forced-draft Fans *(2020)*

Forced- or induced-draft fans for boilers, incinerators, thermal oil heaters and similar fired equipment are to be fitted with remote means of stopping. These means are to be located outside the space in which this equipment is located or at the fire fighting station, if fitted, so that the fans may be stopped manually and remotely in the event of a fire arising in that space.

#### 11.9.4 Unattended Machinery Spaces

For vessels intended to be operated with unattended propulsion machinery space, the emergency shutdowns of equipment in 4-8-2/11.9.1 through 4-8-2/11.9.3 associated with the propulsion machinery space are to be located in the fire-fighting station as required by 4-9-6/21.3.

### 11.11 Battery Starting Systems

#### 11.11.1 Propulsion Engine *(2020)*

Where the propulsion engine is arranged for electric starting, at least two sets of batteries are to be fitted. The arrangement is to be such that the batteries cannot be connected simultaneously and each battery set is to be capable of starting the propulsion engine. The combined capacity of the battery sets is to be sufficient without recharging to provide within 30 minutes the number of starts of propulsion engines required for the starting in 4-6-5/9.5.1. If the propulsion engine starting batteries are arranged to include starting of auxiliary engines, the battery capacity is to be increased accordingly.

#### 11.11.2 Auxiliary Engines *(2020)*

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

#### 11.11.3 Use of Engine Starting Battery for Engine Control *(2020)*

The starting batteries (or set of batteries) may also be used for engine's own control and monitoring. When the starting batteries are being used for these purposes, 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 maintain continuously the stored energy at all times. Battery systems for engine starting may be of the one-wire type and the earth lead is to be carried to the engine frame.

#### 11.11.4 Battery Connections *(2020)*

Battery connection for engine starting may be of the one-wire type and the earth lead is to be carried to the engine frame.

#### 11.11.5 VRLA and AGM Batteries Used for Engine Starting *(1 July 2022)*

Where Valve Regulated Lead Acid (VRLA) or Absorbed Glass Mat (AGM) batteries are installed for engine starting, temperature compensating battery chargers are to be provided. Additionally, the battery float charging voltage is to be between 2.25 and 2.3 Volts Per Cell (VPC) unless specified otherwise by the battery manufacturer.

***Commentary:***

Engine starting batteries are typically arranged and used with float charging in order to maintain a full charge state of the batteries over long periods of time. VRLA and AGM batteries have advantages over traditional lead acid batteries, such as producing less hydrogen gas emissions. VRLA and AGM batteries do not tolerate overcharging, particularly in long periods of float charging.

IEC 62485-2, 7.2, Table 1 specifies 2.27 VPC for charging of VRLA and AGM batteries.

**End of Commentary**

# PART 4

## CHAPTER 8
## Electrical Systems

## SECTION 3
## Electrical Equipment

## 1 General

The provisions of this section apply to all equipment in general. Additional requirements applicable to high voltage systems and electric propulsion systems are given in Section 4-8-5. For DC systems, unless specifically stated in this Section and Section 4-8-5, see IEC Publications 60092-201, 60092-202 and 60092-301. Requirements applicable to specific vessel types, particularly with regard to equipment in hazardous areas, are given in Part 5C and Part 5D.

### 1.1 Objective *(2024)*

#### 1.1.1 Goals *(2025)*

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

| *Goal No.* | *Goals* |
|---|---|
| POW 1 | Provide safe and reliable storage and supply of fuel/energy/power. |
| POW 2 | Provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel. |
| POW 3 | *Enable all electrical services necessary for maintaining the vessel in normal operational and habitable conditions to be available without recourse to the emergency source of power.* |
| POW 4 | *Enable all electrical services required for safety to be available during emergency conditions.* |
| POW 5 | Enable supply/power for essential services to be restored after malfunction |
| POW 6 | Have fail-safe features that prevent progressive failure in the event of failure of any single component. |
| FIR 1 | *Prevent the occurrence of fire and explosion* |
| FIR 2 | *Reduce the risk to life caused by fire* |
| FIR 3 | *Reduce the risk of damage caused by fire to the ship, its cargo and the environment* |
| FIR 4 | *Detect, contain, control and suppress or swiftly extinguish a fire in the compartment of origin.* |
| SAFE 1-1 | Minimize danger to persons on board, the vessel, and surrounding equipment / installations from hazards associated with machinery and systems. |

| *Goal No.* | *Goals* |
|---|---|
| MGMT 5-1 | Design and construct vessel, machinery, and electrical systems to facilitate safe access, ease of inspection, survey, and maintenance. |
| AUTO 1 | Perform its functions as intended and in a safe manner |
| AUTO 2 | Indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance |
| AUTO 3 | Have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |
| AUTO 6 | Independently perform different functions, such that a single failure in one system will not render the others inoperative. |

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

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

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

### 1.1.2 Functional Requirements *(2025)*

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

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

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Power Generation and Distribution (POW)** | |
| POW-FR1 | Electrical equipment is to withstand normal occurring variations in voltage and frequency. |
| POW-FR2 | Electrical equipment are to be designed to withstand all loads that would be imposed during the intended operation. |
| POW-FR3 | Provide suitable insulation based on maximum continuous operating temperatures. |
| POW-FR4 | Provide means to automatically maintain the speed of prime movers driving the main and auxiliary power generation systems. |
| POW-FR5 | Electrical generators are to be provided with means to automatically regulate the output voltage to the rated value. |
| POW-FR6 | When it is intended that two or more generators be operated in parallel, means are to be provided to divide the reactive power equally between the generators in proportion to the generator capacity. |
| POW-FR7 | The generating set is to maintain torsional vibration levels within the design values rated for the power generation system. |
| POW-FR8 | Provide sufficiently sized main and branch busbars to carry all of the simultaneous loads that they supply. |
| POW-FR9 | Provide arrangement of busbar so that the temperature rise will not affect the normal operation of electrical loads connected. |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| POW-FR10 | Provide under-voltage protection to prevent the malfunction of the electrical power consumers. |
| POW-FR11 | Provide starting sequence for auto-starters to prevent erroneous operation. |
| POW-FR12 | Battery systems and UPS are to be designed to maintain continuity of load power for essential and emergency electrical power consumers. |
| POW-FR13 | Provide reverse current protection to prevent a malfunction of Direct Current (DC) systems. |
| POW-FR14 | Provide cables with sufficient current carrying capacity to support connected loads and their overload protection. |
| **Materials (MAT)** | |
| MAT-FR1 | Electrical equipment is to be constructed of durable, flame-retardant, moisture-resistant materials to withstand the marine environment and maximum design ambient temperature and stresses without any deterioration. |
| MAT-FR2 | Cables and electrical conductor are to be constructed of high conductivity and flame retardant material and sized to prevent any damage due to temperature rise during normal operation. |
| MAT-FR3 (FIR) | The materials used for moving parts and its housing in the fan are not to produce sparks during normal operation. |
| **Fire Safety (FIR)** | |
| FIR-FR1 | Electrical and electronic equipment within areas affected by fire extinguishing media are to be suitable for use in the affected area. |
| FIR-FR2 | Cable splices are to withstand the possible fire conditions. |
| FIR-FR3 | All electrical cables are to be able to reduce the propagation of fire. Cables supporting safety critical services are to be able to operate during a fire condition for an adequate time based on the risk assessment. |
| FIR-FR4 | Provide sufficient gap between moving and non moving parts of the non-sparking fan to avoid accidental contact during normal operation. |
| FIR-FR5 | Provide means to prevent ingress of combustible particles into the fan casing. |
| FIR-FR6 | Non sparking fans are to be provided with measures to prevent accumulation of electrostatic charges that could cause sparks when installed in hazardous areas. |
| FIR-FR7 | Electrical equipment installed in hazardous areas are to be designed to eliminate the presence of at least one of the three elements i.e., source of ignition, fuel and oxygen in the equipment that could lead to fire and explosions or to contain the explosion to prevent propagation of fire (i.e., contain within the housing). |
| FIR-FR8 | Electrical equipment installed in hazardous areas are to be suitable for the environment (gas group and temperature classification) in which they operate. |
| **Safety of Personnel (SAFE)** | |
| SAFE-FR1 | Provide protection to prevent accidental contact with live parts of the assembly. |
| SAFE-FR2 | Provide enclosure with suitable degree of protection against ingress of foreign objects and liquids based on location of installation. |
| SAFE-FR3 | Provide arrangement to prevent electric shock. |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| SAFE-FR4 | Provide means to prevent slips, trips and falls while working on the equipment with panels for operation. |
| SAFE-FR5 | Cable connector are to withstand the marine environment and maximum design ambient temperature. |
| SAFE-FR6 | Circuit protection devices are to be able to withstand fault currents. |
| **Safety Management (MGMT)** | |
| MGMT-FR1 | Provide accessibility to all the parts of the equipment requiring inspection or adjustment or replacement. |
| MGMT-FR2 | Provide means of disconnecting the electrical equipment from power source for maintenance. |
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Rotating electrical machines are to be able to withstand over load, over current and short circuit conditions so that the overall operational integrity of the motor is not affected during service. |
| AUTO-FR2 | Provide means to prevent circulating currents from passing between the rotor shaft and the bearings. |
| AUTO-FR3 | Provide the required lubrication for rotating machine's shaft bearings at all rated operating conditions. |
| AUTO-FR4 | Provide means to prevent moisture condensation in the machine when idle. |
| AUTO-FR5 | Instrumentation to control the main and emergency switchboards are to be provided to maintain the power supply for the required loads. |
| AUTO-FR6 | Provide monitoring and alarm systems for the safe operation of equipment. |
| AUTO-FR7 | Provide safety measures and alarms to protect the electrical distribution system from harmonics. |

### 1.1.3 Compliance *(2024)*

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

## 1.3 Standard

Electrical equipment is to be designed, constructed and tested to a national, international or other recognized standard and in accordance with requirements of this section.

## 1.5 Certification of Equipment

The electrical equipment indicated below are required to be certified by ABS for complying with the appropriate provisions of this section (see also 4-1-1/9 TABLE 3 ):

- Generators and motors of 100 kW (135 hp) and over intended for essential services (see definition in 4-8-1/7.3.3) or for services indicated in 4-8-3/15 TABLE 7. See 4-8-3/3.
- Main, propulsion and emergency switchboards. See 4-8-3/5.
- Motor controllers of 100 kW (135 hp) and over intended for essential services or for services indicated in 4-8-3/15 TABLE 7. See 4-8-3/5.7.

- Motor control centers with aggregate load of 100 kW (135 hp) and over intended for essential services or for services indicated in 4-8-3/15 TABLE 7. See 4-8-3/5.7.
- Semiconductor converters used to control motor drives having a rated power of 100 kW(135 hp) and over intended for essential services or for services indicated in 4-8-3/15 TABLE 7. See 4-8-3/8.
- Battery charging and discharging boards for emergency and transitional source of power. See 4-8-3/5.9.
- Uninterruptible power system (UPS) units of 50 kVA and over. See 4-8-3/5.9.
- Propulsion controls, propulsion semiconductors and propulsion cables. See 4-8-3/9 and 4-8-5/5.11.3, 4-8-5/5.17.8 and 4-8-5/5.17.11.

Other electrical equipment items are to be designed, constructed and tested in accordance with established industrial practices, manufacturer's specifications and applicable requirements in this Section. Acceptance will be based on manufacturer's documentation which is to be made available upon request and on satisfactory performance after installation. Mass produced items can, at the discretion of the manufacturers, be certified under the Type Approval Program, Appendix 1A-1-A3 of the ABS *Rules for Conditions of Classification (Part 1A)* and 4-1-1/9 TABLE 3.

## 1.7 Materials and Design

Electrical equipment is to be constructed of durable, flame-retardant, moisture resistant materials, which are not subject to deterioration in the marine environment and at the temperatures to which it is likely to be exposed.

Electrical equipment is to be designed such that current-carrying parts with potential to earth are protected against accidental contact.

## 1.9 Voltage and Frequency Variations

The electrical characteristics of electrical equipment supplied from the main or emergency systems, other than battery supplies, are to be capable of being operated satisfactorily under normally occurring variations in voltage and frequency. Unless otherwise specified in national or international standards, the following variations from the rated value are to be assumed:

| *Voltage and Frequency Variations for AC Distribution Systems* | | |
|---|---|---|
| *Quantity in Operation* | *Permanent Variation* | *Transient Variation (Recovery Time)* |
| Frequency | ±5% | ±10% (5 s) |
| Voltage | +6%, -10% | ±20% (1.5 s) |

| *Voltage Variations for DC Distribution Systems (such as systems supplied by DC generators or rectifiers)* | |
|---|---|
| *Parameters* | *Variations* |
| Voltage Tolerance (continuous) | ±10% |
| Voltage cyclic variation deviation | 5% |
| Voltage ripple (AC r.m.s over steady DC voltage) | 10% |

| *Voltage Variations for Battery Systems* | |
|---|---|
| *Type of System* | *Variations* |
| 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, are to be considered.

Any special ystem, such as electronic circuits, whose function cannot operate satisfactorily within the limits shown in the above tables, is not to be supplied directly from the system but by alternative means, such as through a stabilized supply.

For generators, see 4-8-3/3.13.1(a), 4-8-3/3.13.1(b) and 4-8-3/3.13.2.

## 1.11 Enclosures

### 1.11.1 General

Electrical equipment is to have a degree of enclosure for protection against the intrusion of foreign objects and liquids appropriate for the location in which it is installed. The minimum degree of protection is to be in accordance with 4-8-3/15 TABLE 2.

For the purpose of defining protection levels used in 4-8-3/15 TABLE 2, the following conventions apply. The degree of protection by an enclosure with respect to the intrusion of foreign particles and water is defined by the designation 'IP' followed by two digits: the first digit signifies the protection degree against particles, and the second digit signifies the protection degree against water. For complete details, see 4-8-3/15 TABLE 1A and 4-8-3/15 TABLE 1B. These designations are identical to that specified in IEC Publication 60529. For high voltage equipment see 4-8-5/3 TABLE 1.

### 1.11.2 Equipment in Areas Affected by Local Fixed Pressure Water-Spraying or Local Water-mist Fire Extinguishing Systems in Machinery Spaces

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 4-8-3/1.11.2 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.

***Notes:***

Additional precautions may be required to be taken with respect to:

***a)*** Tracking as the result of water entering the equipment

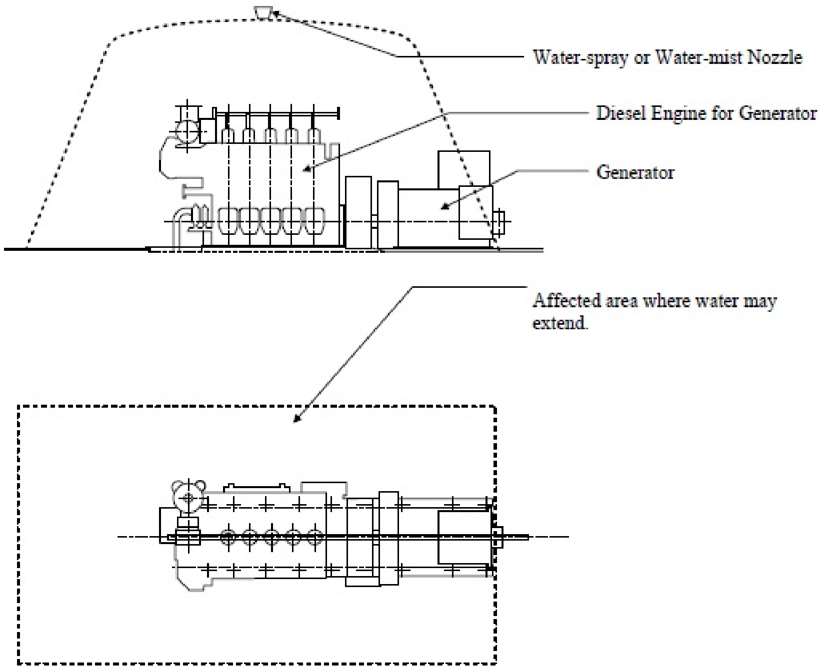
***b)*** Potential damage as the result of residual salts from sea water systems

***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




## 1.13 Accessibility

Electrical equipment is to be designed and arranged with a view to provide accessibility to parts requiring inspection or adjustment.

## 1.15 Insulation

### 1.15.1 Insulation Material *(2024)*

Insulating materials are to be classified by their maximum continuous operating temperatures in accordance with the following table:

| *Class* | *Maximum Continuous Temperature* | |
|---|---|---|
| | *°C* | *°F* |
| E | 120 | 248 |
| B | 130 | 266 |
| F | 155 | 311 |
| H | 180 | 356 |

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. In this regard, supporting background information, reports, tests conducted, etc. ascertaining their suitability for the intended application and operating temperature are to be submitted for review.

### 1.15.2 Insulated Handrails or Handles *(2024)*

Insulated handrails or handles are to be provided for the equipment which are required to be operated safely during motion or inclination of the vessel. This include the main and emergency switchboards, motor control centers, distribution boards for essential and emergency services, as well as deck mounted electrical equipment necessary for specific Class notations (such as refrigerated cargo notation, dynamic positioning system, etc.). See also 4-8-3/5.5.3, 4-8-3/8.5.5.

***Commentary:***

Handrails or handles are required on the front of equipment only, unless normal operation is expected at the rear or sides of the equipment.

**End of Commentray**

## 1.17 Ambient Temperatures

### 1.17.1 General

For purposes of rating of equipment, a maximum ambient temperature of 45°C (113°F) is to be applied.

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 can 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.

### 1.17.2 Reduced Ambient Temperature for Electrical Equipment in Environmentally Controlled Spaces

*1.17.2(a) Environmentally-controlled Spaces.*

Where electrical equipment is installed within environmentally-controlled spaces, the ambient temperature for which the equipment is to be rated can 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.

*1.17.2(b) 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 rated for the maximum ambient temperature to which they are exposed along their length.

*1.17.2(c) 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 4-8-1/7.3, and the capability of cooling is to be witnessed by the Surveyor at sea trial.

# 3 Rotating Electrical Machines *(2024)*

## 3.1 Application *(2024)*

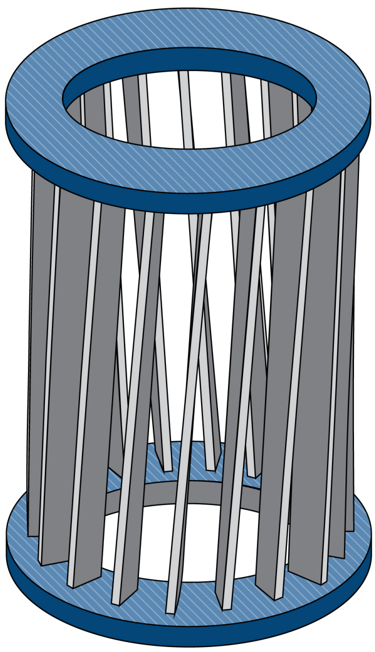
All generators and motors of 100 kW (135 hp) and over intended for essential services (see 4-8-1/7.3.3) or for services indicated in 4-8-3/15 TABLE 7 are to be designed, constructed and tested in accordance with the requirements of 4-8-3/3.

Furthermore, their design and construction are to withstand all loads (e.g., mechanical, electrical, thermal, cyclic, etc.) that would be imposed during the intended operation.

For squirrel cage electric motors serving essential services, special attention is also to be given to the method of attachment of the rotor bars to the rotor so that the overall operational integrity of the motor will not be affected during service. The common arrangement is with the shorting ring in full contact, via brazing or welding, with the ends of the rotor bars. A less common arrangement is with the shorting ring only in partial contact with the ends of the rotor bars. For these less common arrangements, calculations, analyses, tests and/or operational service history data are to be provided in this regard substantiating the design and construction of the rotating machine for its intended application and service. See 4-8-3/Figure 2.

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 electrical machines less than 100 kW (135 hp) for essential services or for services indicated in 4-8-3/15 TABLE 7 are to include at least the tests described in 4-8-3/3.15.2 through 4-8-3/3.15.11, 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 after installation.

**FIGURE 2**
**Example of Rotor Bar and Short Ring** *(2024)*



## 3.3 Definitions

### 3.3.1 Periodic Duty Rating

The periodic duty rating of a rotating machine is the rated kW load at which the machine can operate repeatedly, for specified period (N) at the rated load followed by a specified period (R) of rest and de-energized state, without exceeding the temperature rise given in 4-8-3/15 TABLE 4; where N+R = 10 minutes, and cyclic duty factor is given by N/(N+R) %.

### 3.3.2 Short Time Rating

The short time rating of a rotating electrical machine is the rated kW load at which the machine can operate for a specified time period without exceeding the temperature rise given in 4-8-3/15 TABLE 4. A rest and de-energized period sufficient to re-establish the machine temperature to within 2°C (3.6°F) of the coolant prior to the next operation is to be allowed. At the beginning of the measurement the temperature of the machine is to be within 5°C (9°F) of the coolant.

### 3.3.3 Non-periodic Duty Rating *(2024)*

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.

### 3.3.4 Continuous Rating

The continuous rating of a rotating electrical machine is the rated kW load at which the machine can continuously operate without exceeding the steady state temperature rise given in 4-8-3/15 TABLE 4.

## 3.5 Rating

Generators are to be of continuous rating. Motors are to be of continuous rating unless utilized on an application which definitely imposes an intermittent duty on the motor.

For maximum ambient temperatures to be used when rating rotating machines, see 4-8-3/1.17.

To satisfy the requirements of 4-8-3/3.1, 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.

## 3.7 Overload and Over-current Capability *(1 July 2019)*

Overload and over-current capabilities for AC and DC generators and motors are to be in accordance with IEC Publication 60034-1. For convenience, the following requirements for AC generators and motors are provided.

### 3.7.1 AC Generators

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 is to 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) Over-current capacity.*

Three phase induction motors having rated output not exceeding 315 kW (422 hp) and rated voltage not exceeding 1 kV are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 2 minutes. For three phase induction motors having rated outputs above 315 kW (422 hp) the over-current capacity is to be in accordance with the manufacturer's specification. The test can be performed at a reduced speed.

*3.7.2(b) Overload capacity for induction motors.*

Three phase induction motors, regardless of duty, are to be capable of withstanding for 15 seconds without stalling, or abrupt change in speed, an excess torque of 60% above the rated torque; the voltage and frequency being maintained at the rated values. For windlass motors, see 4-5-1/5.1.3.

*3.7.2(c) Overload capacity for synchronous motors.*

Three phase synchronous motors, regardless of duty, 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.

Synchronous motors fitted with automatic excitation are to meet the same excess torque values with the excitation equipment operating under normal conditions.

## 3.9 Short Circuit Capability

Short circuit capabilities of generators are to be in accordance with IEC Publication 60034-1. Under short circuit conditions, generators are to be capable of withstanding the mechanical and thermal stresses induced by short circuit current of at least three times the full load current for at least 2 seconds.

## 3.11 Construction

### 3.11.1 Shafting

*3.11.1(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: | 4-3-2/5.3 |
| • Key: | 4-3-2/5.7 and 4-2-4/5.3.2 |
| • Coupling flanges and bolts: | 4-3-2/5.19 |

*3.11.1(b) Rotors of integrated auxiliary machinery.* (1 July 2021)

The shaft diameters of the shaft motors and shaft generators, which are an integral part of the line shafting, are to be evaluated per 4-3-1/5.9.1, 4-3-1/5.9.7.i., and 4-3-1/5.9.7.ii., for maximum torsional moment (steady and vibratory) acting within the operating speeds, instead of torsional moment at rated speed.

The shaft diameter of the motors and generators, that are an integral part of the line shafting, are to also be designed per 4-3-2/5 and are to be evaluated based on engineering analyses per 4-3-2/1.1.

The following components intended for propulsion installations are to be tested in the presence of a Surveyor per 4-3-2/3: 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 requirements of Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*.

### 3.11.2 Shaft Circulating Current

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, due to the unbalance of magnetic fields. Where such protection is required, a warning plate is to be provided in a visible, stationary location cautioning against the removal of such protection.

### 3.11.3 Lubrication

Rotating machine's shaft bearings are to have the required lubrication at all rated operating conditions, and with the vessel inclined as specified in 4-1-1/7.9. Where forced lubrication is employed, generators are to be fitted with means to shut down their prime movers automatically upon failure of the generator's lubricating system. Each self-lubricating sleeve bearing is to be fitted with a means for visual indication of oil level.

### 3.11.4 Cooling

Where water cooling is used, the cooler is to be so arranged to avoid entry of water into the machine, whether through leakage or condensation in the heat exchanger.

### 3.11.5 Moisture Condensation Prevention

All generators, and each propulsion motor, are to be provided with a means to prevent moisture condensation in the machine when idle.

Motors, rated 50kW and over, used for essential services and located in damp spaces or exposed to weather are to be provided with a means to prevent moisture condensation in the machine when idle.

### 3.11.6 Stator Temperature Detection

AC propulsion generators and motors rated above 500 kW (670 hp) are to be provided with means of obtaining the temperatures at each phase of the stationary windings.

### 3.11.7 Enclosure and Terminal Box

Cable terminal boxes are to be fitted with means to secure the cables. Enclosures of rotating machines including the cable terminal boxes are to be such as to eliminate mechanical injury and the risk of damage from water, oil and shipboard atmosphere. The minimum degree of protection is to be in accordance with 4-8-3/15 TABLE 2.

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. Terminal leads are to be terminated securely with a vibration resistant means of termination. Cable glands or similar are to be provided where cable penetrations may compromise the protection property of terminal enclosures.

### 3.11.8 Nameplate Data *(1 July 2020)*

Nameplates of corrosion-resistant material are to be provided and are to indicate at least the following, as applicable (for AC generating sets, see 4-8-3/3.19.4):

| | |
|---|---|
| The manufacturer's serial number (or identification mark) | The manufacturer's name |
| | The year of manufacture |
| Type of machine | Degree of protection by IP code |
| Rating | The rated output |
| The rated voltage | The rated current |
| The rated speed | The class of insulation |
| The rated ambient temperature | Number of phase |
| The rated frequency | The rated power factor |
| Type of winding connections | Rated exciter voltage |
| Rated exciter current | |

## 3.13 Generator Control

### 3.13.1 Operating Governors

An operating governor is to be fitted to each prime mover driving a main or emergency generator and is to be capable of automatically maintaining the speed within the following limits.

*3.13.1(a)* Steam or gas turbine prime movers:

***i)*** The transient frequency variations in the electrical network when running at the indicated loads below is to be within ±10% of the rated frequency when:

- 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 can be acceptable, provided the overspeed protective device, fitted in addition to the governor, as required by 4-2-3/7.1 or 4-2-4/7.1, is not activated.

- Running at no load and 50% of the full load of the generator is suddenly thrown on, followed by the remaining 50% after an interval sufficient to restore the frequency to steady state.

In all instances, the frequency is to return to within ±1% of the final steady state condition in no more than five (5) seconds.

***ii)*** The permanent frequency variation is to be within ±5% of the rated frequency at any load between no load and the full load.

***iii)*** For gas turbines driving emergency generators, the requirements of 4-8-3/3.13.1(a).i and 4-8-3/3.13.1(a).ii above are to be met. However, for purpose of 4-8-3/3.13.1(a).i, 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.

*3.13.1(b)* Diesel engine prime mover:

***i)*** The transient frequency variations in the electrical network when running at the indicated loads below is to be within ±10% of the rated frequency when:

- 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 can be acceptable, provided the overspeed protective device, fitted in addition to the governor, as required by 4-2-1/7.5.3, is not activated.

- Running at no load and 50% of the full load of the generator is suddenly thrown on, followed by the remaining 50% after an interval sufficient to restore the frequency to steady state.

In all instances, the frequency is to return to within ±1% of the final steady state condition in no more than five (5) seconds. Considerations can be given to alternative method of load application as provided in 4-2-1/7.5.1(b) for electrical systems fitted with power management systems and sequential starting arrangements.

***ii)*** The permanent frequency variation is to be within ±5% of the rated frequency at any load between no load and the full load.

***iii)*** For emergency generators, the requirements of 4-8-3/3.13.1(b).i and 4-8-3/3.13.1(b).ii above are to be met. However, for purpose of 4-8-3/3.13.1(b).i, 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

### 3.13.2 Automatic Voltage Regulation System

The following requirements are for AC generators. For DC generators, refer to IEC Publications 60092-202 and -301.

*3.13.2(a) General.*

An automatic voltage regulator is to be fitted for each generator. Excitation current for generators is to be provided by attached rotating exciters or by static exciters deriving their source of power from the machines being controlled.

*3.13.2(b) Variation from rated voltage - steady state.*

The automatic voltage regulator is to be capable of maintaining the voltage under steady conditions within ± 2.5% of the rated voltage for all loads between zero and rated load at rated power factor, taking the governor characteristics of generator prime movers into account. These limits may be increased to ±3.5% for generators for emergency services.

*3.13.2(c) Variation from rated voltage - transient.*

Momentary voltage variations are to be within the range of –15% to +20% of the rated voltage, and the voltage is to be restored to within ±3% of the rated voltage in not more than 1.5 seconds when:

- A load equals 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 can be calculated values based on the previous type test records, and need not to be tested during factory testing of a generator.

Consideration may be given to performing the test required by 4-8-3/3.15.4 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.

*3.13.2(d) Short circuit condition.*

Under short-circuit conditions, the 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 2 seconds or for such magnitude and duration as required to properly actuate the electrical protective devices. See 4-8-3/3.9.

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 can be used where this has been validated through the previous type test on the same model.

### 3.13.3 Parallel Operation

*3.13.3(a) General.*

When it is intended that two or more generators be operated in parallel, means are to be provided to divide the reactive power equally between the generators in proportion to the generator capacity.

*3.13.3(b) 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 smallest generator, whichever is the less.

*3.13.3(c) kW load sharing.*

In the range 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 kW of the largest generator, or 25% of the rated output kW of the individual generator, 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 load with each generator carrying its proportionate share.

## 3.14 Permanent Magnet Shaft Generators on Single Screw Vessels *(1 July 2022)*

### 3.14.1 General *(2025)*

In addition to any applicable requirements under 4-8-3/3.1 to 4-8-3/3.17, permanent magnet generators installed in line with propulsion shaft on single screw vessels, and in cases where the navigational or operational needs of the vessel do not allow the propulsion to be stopped, are to be capable to maintain propulsion under a faulty condition, in accordance with the following requirements:

***i)*** The internal phase to phase short circuit is to be protected by circuit breakers or fuses at both in the neutral side and the converter side of each winding. These protective devises may be installed externally to the machine.

***ii)*** Earth fault protection is to be provided, opening two circuit breakers at each side of the winding in case of earth fault.

***iii)*** The stator winding is to be vacuum impregnated and fitted with form-wound windings.

***iv)*** The manufacturer of the form wound windings is to have a quality system and be certified in accordance with 1A-1-A3/5.3 and 1A-1-A3/5.5 of the ABS *Rules for Conditions of Classification (Part 1A)* or ISO 9001 (or equivalent) and have a quality control plan for the production and testing of the windings.

***v)*** The winding heads are to have a physical separation of at least 5 mm. Also, the two ends of the windings, including the wiring between the form-wound windings and the terminals, are to run with a physical separation between all phases from the winding heads to the terminals. There is to be physical separation of arc proof material between the neutral side terminals and the converter side terminals.

*vi)* When conditions allow a repair to be performed, it is to be possible to bring the air gap flux to zero, or to prevent the permanent magnets from rotating by mechanical means and complete a repair procedure within three hours. It is to be possible to ensure a standstill of the shaft during this procedure, if necessary. It is to be possible to reverse the procedure (e.g., physically reconnect the rotor) in order to bring the machine mechanically back to working conditions without dismantling the shaft. An instruction manual for the repair procedure is to be provided on board.

*vii)* Generators with water cooling, either fitted with heat exchangers or jacket water cooled, are to have water-leakage detection and drain holes. For generators with two winding systems that rely on common cooling systems, means are to be provided to isolate the cooling systems individually. In addition, provision is to be made for an alternative supply of cooling water.

*viii)* Means for stopping the shaft after any internal fault are to be provided, even under the event of wind milling. A risk study is to also to be submitted as per 4-8-1/5.5.1.

*ix)* The shipbuilder is to inform the vessel's owner of the particular arrangement and provide the appropriate operational information that will include the following:

*a)* An inter-turn short circuit fault in the permanent magnet shaft generator will necessitate the need to stop propulsion for three hours, for the crew to disconnect the rotor hub from the main shaft.

*b)* In cases where the navigational or operational needs of the vessel do not allow the propulsion to be stopped, propulsion can be continued. The procedure to disconnect the rotor hub from the propulsion shaft will need to be performed as soon as navigational and operational parameters allow. Also, the permanent magnet shaft generator will be assumed to require overhaul

#### 3.14.2 Prototype Design

The acceptance of the arrangement and equipment covered by 4-8-3/3.14.1, is based on successful verification that the propulsion can be maintained, in cases where the navigational or operational needs of the vessel do not allow the propulsion to be stopped, under worst case failure of the generator as defined by the required risk assessment as per 4-8-1/5.5.1. Accordingly, with regards to the interturn fault, the following are required:

*i)* FEM simulation, or similar, and calculation of an interturn fault as per 4-8-1/5.5.1.

*ii)* Prototype testing as per 4-8-3/3.15.12.

### 3.15 Testing

#### 3.15.1 Machines to be Tested and Test Schedule

*3.15.1(a) Machines of 100 kW and Over.* *(1 July 2022)*

Each design of generator and motor of 100 kW (135 hp) and over, intended for essential services (see 4-8-1/7.3.3), or for services indicated in 4-8-3/15 TABLE 7, is to be assessed by testing in accordance with the "type tests" schedule indicated in 4-8-3/15 TABLE 3. Each subsequent production unit of an accepted design is to be tested in accordance with the "routine tests" schedule indicated also in 4-8-3/15 TABLE 3.

Permanent magnet shaft generators on single screw vessels, as per 4-8-3/3.14, are to comply with the requirements of this section.

*3.15.1(b) Machines Below 100 kW.*

All rotating machines of less than 100 kW intended for essential services or for services indicated in 4-8-1/7.3.3, or for services indicated in 4-8-3/15 TABLE 7, are to be tested in accordance with 4-8-3/15 TABLE 3 (item 2 through item 10 and item 12). The tests are to be carried out by the manufacturer whose certificate of tests is acceptable and is to be submitted upon request from ABS.

*3.15.1(c) Other Machines.*

For machines not intended for essential services or for services indicated in 4-8-3/15 TABLE 7, 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.

*3.15.1(d) 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.

### 3.15.2 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.

Immediately after the high voltage tests, the insulation resistance is to be measured using a direct current insulation tester between:

***i)*** all current carrying parts connected together and earth;

***ii)*** all current carrying parts of different polarity or phase, where both 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, an approved method of calculation is to be used:

| *Rated Voltagem, $U_n$ (V)* | *Minimum Test Voltage (V)* | *Minimum Insulation Resistance (MΩ)* |
|---|---|---|
| $U_n \le 250$ | $2U_n$ | 1 |
| $250 < U_n \le 1000$ | 500 | 1 |
| $1000 < U_n \le 7200$ | 1000 | $U_n/1000 + 1$ |
| $7200 < U_n \le 15000$ | 5000 | $U_n/1000 + 1$ |

### 3.15.3 Winding Resistance Measurement

The resistance of the machine winding is to be measured and recorded, using an appropriate bridge method or voltage and current method.

### 3.15.4 Verification of Voltage Regulation System

Tests are to be conducted on generators to verify that the automatic voltage regulation system is capable of achieving the performance described in 4-8-3/3.13.2

### 3.15.5 Rated Load Test and Temperature Rise Measurements *(1 July 2023)*

The temperature rises are to be measured after running at the output, voltage, frequency and duty for which the machine is rated in accordance with the testing methods specified in IEC 60034-1 or a national, international or other recognized standard. The limits of temperature rise are to be as specified in 4-8-3/15 TABLE 4.

For rotating electrical machines covered by IEC 60034-1, when they can not be tested at rated conditions, an indirect testing to determine the temperature rise in accordance with IEC 60034-29 can be carried out by agreement between the manufacture and the purchaser. Simulation tests specified in IEEE Standard 115 for temperature rise measurements can also be accepted for induction motors and synchronous generators.

### 3.15.6 Overload and Over-current Tests *(1 July 2019)*

Tests are to be conducted on generators and motors to demonstrate that their overload and over-current capabilities are as described in 4-8-3/3.7.

### 3.15.7 Short Circuit Capability Tests

Tests are to be conducted on AC generators to demonstrate that the generator and its automatic voltage regulation system are capable of sustaining without damage, under steady-state short-circuit condition, a current of three times the rated current for 2 seconds. See 4-8-3/3.9 and 4-8-3/3.13.2(d).

### 3.15.8 Overspeed Test *(2019)*

AC generators and, where specified and agree upon between purchaser and manufacturer, AC motors are to withstand without damage a test run at 1.2 times the rated speed for at least 2 minutes. This test is not applicable to squirrel cage motors.

Where specified and agreed upon between purchaser and manufacturer, DC generators and motors are to withstand a test run without damage for the following overspeed tests for at least 2 minutes:

| *Item* | *DC Machine Type* | *Overspeed Requirements* |
|---|---|---|
| 1 | Generators | 1.2 times the rated speed |
| 2 | Shunt-wounded and separately excited motors | 1.2 times the highest rated speed, or<br>1.15 times the corresponding no-load speed,<br>whichever is the greater |
| 3 | Compound-wounded motors having speed regulation of 35% or less | 1.2 times the higher rated speed, or<br>1.15 times the corresponding no-load speed,<br>whichever is the greater but not exceeding 1.5 times the highest rated speed |
| 4 | Compound-wounded motors having speed regulation greater than 35% and series-wounded motors | The manufacturer is to assign a maximum safe operating speed which is to be marked on the rating plate. The overspeed for these motors is to be 1.1 times the maximum safe operating speed. |
| 5 | Permanent magnet excited motors | Overspeed as specified in item 2 unless the motor has a series winding and, in such a case, they are to withstand the overspeeds specified in items 3 or 4 as appropriate |

### 3.15.9 Dielectric Strength Test

The dielectric strength of all rotating machines is to be tested with all parts assembled and in a condition equivalent to normal working condition. The following requirements apply to those machines other than high voltage systems covered by 4-8-5/3.13.1. The test voltage is to be applied between the windings under test and the frame of the machine, with the windings not under test and the core connected to the frame.

The test voltage is to be a voltage of sinusoidal wave form and a frequency of 25 Hz to 60 Hz. It is to be applied continuously for 60 seconds. The standard test voltage for all rotating machines is twice the rated voltage plus 1000 V, with a minimum of 1500 V, except for machine parts specified in the table below:

| *Machine Part* | *Test Voltage (rms)* |
|---|---|
| Field windings of synchronous generators, synchronous motors and synchronous condensers:<br>a) For all machines except that in b)<br>b) For motors started with field winding connected across resistance of more than ten times of the field winding resistance | <br>a) Ten times the rated field voltage with a minimum of 1500 V and a maximum of 3500 V<br>b) 1000 V + twice the maximum value of the voltage with a minimum of 1500 V |
| Phase-wound rotors of induction motors: | |
| a) For non-reversing motors or motors reversible from standstill only | a) 1000 V + twice the open-circuit standstill secondary voltage |
| b) For motors reversible by reversing the primary supply while running | b) 1000 V + four times the open-circuit standstill secondary voltage |

Where temperature rise test is to be performed, such as when performing type tests, the dielectric strength test is to be carried out immediately after this test.

Test voltage for other machines are to be in accordance with IEC Publication 60034-1, Table 16.

### 3.15.10 Running Balance Test *(1 July 2023)*

Motors are to be operated at no load and at rated speed while being supplied with a rated voltage and frequency; and in the case of a generator, driven by a suitable means and excited to give rated terminal voltage. The vibration of the machine and operation of the bearing lubrication system, where applicable, are to be checked and found satisfactory. Vibration measurements are to be taken and results are to be verified to be within acceptable limits in accordance with a national, international or other recognized standard.

### 3.15.11 Bearings

Upon completion of tests in 4-8-3/3.15.10, machines having sleeve bearings are to be opened to establish that the shaft is properly seated in the bearings.

### 3.15.12 Type Tests for Permanent Magnet Shaft Generators *(1 July 2022)*

A type test to demonstrate the effects of an interturn fault current is required for permanent magnet shaft generators of single screw vessels. A mock-up model of one slot can be accepted to demonstrate the effects of an interturn fault current. Prior to insertion in the slot model, a fault between two windings is introduced to the model. The calculated interturn fault current (from simulation and calculation as per 4-8-3/3.14.2.i)) is fed into the mock-up model. In this way, the effects of the fault current on all materials can be demonstrated.

The expected results for the test are:

- Local overheating of the faulty area.
- Insulation breaks.
- Leads to an earth fault.

The simulated fault and resulting temperature rise are not to be detrimental to the insulation of any other part adjacent to the fault.

## 3.17 Certification *(1 July 2023)*

Each generator and motor of 100 kW (135 hp) and over intended for essential services (see 4-8-1/7.3.3), or for services indicated in 4-8-3/15 TABLE 7 is to be certified based on design review and type and routine tests performed in accordance with 4-8-3/15 TABLE 3 in the presence of a Surveyor.

At the option of the manufacturer, each machine design or type may be maintained on record as design-assessed product in accordance with the provisions of 1A-1-A3/5.1 of the ABS *Rules for Conditions of Classification (Part 1A)*. In which case, each production unit of the type may be certified based only on routine test carried out to the satisfaction of a Surveyor at the manufacturer's facilities.

Shafting material to be used for propulsion application, material tests are to be tested in the presence of a Surveyor in accordance with the provisions of 4-8-3/3.11. Shafting material to be used for non-propulsion application, will be accepted on the basis of the manufacturer's certified material test reports and a satisfactory surface inspection and hardness check witnessed by the Surveyor upon request .

Further, at the option of the manufacturer, the quality assurance system of the manufacturing facilities may also be assessed in accordance with 1A-1-A3/5.5 of the ABS *Rules for Conditions of Classification (Part 1A)*. In which case, and along with approval of the design, the machine can be deemed type approved, and each production unit may be certified based on an audit, by a Surveyor, of the quality records maintained by the manufacturer. The machine may be posted on the ABS website, http://www.eagle.org/typeapproval.

## 3.19 AC Generating Sets *(1 July 2020)*

### 3.19.1 General

Notwithstanding the requirements in 4-2-1 and 4-8-3, the provisions of this subsection are applicable to AC generating sets driven by reciprocating internal combustion engines irrespective of their types (i.e. diesel engine, dual fuel engine, gas-fuel engine), except for those sets consisting of a propulsion engine which also drives power take off (PTO) generator(s).

### 3.19.2 Torsional vibration levels

The generating set is to show torsional vibration levels which are compatible with the allowable limits for the alternator, shafts, coupling and damper. The coupling selection for the generating set is to take into account the stresses and torques imposed on it by the torsional vibration of the system.

Torsional vibration calculations are to be submitted to ABS for approval when the engine rated power is 110 kW or above.

### 3.19.3 Rated power *(2024)*

The rated power is to be determined in accordance with the actual use of the generator set.

### 3.19.4 Rating plate

The alternator manufacturer or the entity responsible of assembling the generating set is to install a rating plate marked with at least the following information:

*i)* the generating set manufacturer's name or mark;

*ii)* the set serial number;

*iii)* the set date of manufacture (month/year);

*iv)* the rated power (both in kW and KVA) with one of the prefixes COP, PRP (or, only for emergency Generating sets, LTP) as defined in ISO 8528-1;

*v)* the rated power factor;

*vi)* the set rated frequency (Hz);

*vii)* the set rated voltage (V);

*viii)* the set rated current (A);

*ix)* the mass (kg)

# 5 Switchboards, Motor Controllers, etc.

## 5.1 Application *(1 July 2021)*

Main and emergency switchboards, power and lighting distribution boards, motor control centers and motor controllers, and battery charging and discharging boards are to be designed, constructed and tested in accordance with the provisions of this Subsection.

Low-voltage switchboards should meet the requirements of UL 891 or IEC 61439-1 for dead-front switchboards or IEEE Std C37.20.1, UL 1558, or IEC 61439-1 for low-voltage, metal-enclosed power circuit breaker switchgear. Other alterative recognized standards will be specially considered.

## 5.3 Construction, Assembly and Components

### 5.3.1 Enclosures *(1 July 2021)*

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 short circuit fault conditions.

Enclosures are to be of the closed type. The degree of the protection is to be in accordance with 4-8-3/15 TABLE 2.

All wearing parts are to be accessible for inspection and be readily renewable. Equipment manufacturer is to identify the wearing parts, and this is to be agreed upon by ABS.

Arrangement of bus bars, connection bars and switchboard wiring are to be such that accessibility is provided for cable connections. Equipment manufacturer in conjunction with the system integrator (shipyard) is to provide equipment arrangement drawing and details of the cable connections to verify accessibility for maintenance and overhauls.

### 5.3.2 Bus Bars

*5.3.2(a) General.*

Bus bars are to be copper; bus bars of other materials will require special consideration, such as aluminum bar covered by a properly bonded layer copper. Bus bars are to be sized and arranged such that the temperature rise will not affect the normal operation of electrical devices mounted in the switchboard. The design maximum ambient temperature is to be in accordance with 4-8-3/1.17.

*5.3.2(b) Bracing of bus bars.*

Bus bars and circuit breakers are to be mounted, braced and located so as to withstand thermal effects and magnetic forces resulting from the maximum prospective short circuit current.

*5.3.2(c) Bolted connections.*

Bolted bus bar connections are to be suitably treated (e.g., silver plating) to avoid deterioration of electrical conductivity over time. Nuts are to be fitted with means to prevent loosening.

*5.3.2(d) Cable connections.*

Cable connections are to be made by the use of crimp lugs or equivalent. Soldered connections are not to be used for connecting or terminating any cable of 2.5 mm$^2$ or greater. Soldered connections, where used, are to have a solder contact length at least 1.5 times the diameter of the conductor.

*5.3.2(e) Bus Bar Connections. (1 July 2021)*

Demonstration of proper alignment, fastening, connecting, and torque of the bus bar connections are to be witnessed by the attending Surveyor.

*5.3.2(f) Clearance and creepage.*

Minimum clearances and creepage distances between live parts of different potential, i.e., between phases and between phase and the ground, are to be in accordance with the following table.

| *Rated Insulation Voltage $U_n$ (V)* | *Minimum Clearance (mm)* | *Minimum Creepage Distance (mm)* |
|---|---|---|
| $U_n \le 250$ | 15 | 20 |
| $251 < U_n \le 690$ | 20 | 25 |
| $690 < U_n \le 1000$ | 25 | 35 |

*5.3.2(g) Alternative.*

Alternatively, reduced creepage and clearance distances can 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 is not to be less than 8 mm

***iii)*** The minimum creepage distance is not to 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 4-1-1/9 TABLE 8.

***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.

| ***Rated Operational Voltage V*** | ***Rated Impulse Withstand Test Voltage kV*** |
|---|---|
| 50 | 0.8 |
| 100 | 1.5 |
| 150 | 2.5 |
| 300 | 4 |
| 600 | 6 |
| 1000 | 8 |

### 5.3.3 Circuit Breakers

*5.3.3(a) Compliance with a standard. (2024)*

Circuit breakers are to be designed, constructed and tested to IEC Publication 60947-2 or other recognized standard. The certificates of tests are to be submitted upon request by ABS. Circuit breakers of the thermal type are to be calibrated for an ambient-air temperature, as provided in 4-8-3/1.17.

***Commentary:***

Where thermal-type breakers are mounted within enclosures, should be considered that the temperature within the enclosure may exceed the specified ambient temperature.

**End of Commentary**

*5.3.3(b) Short circuit capacity.*

Circuit breakers are to have sufficient breaking and making capacities as specified in 4-8-2/9.3.

*5.3.3(c) Removable mounting.*

Circuit breakers are to be mounted or arranged in such a manner that the breakers can be removed from the front of the switchboard without first de-energizing the bus bars to which the breakers connect. Draw-out or plug-in type circuit breakers are acceptable for this purpose. Alternatively, an isolation switch can be fitted upstream (line or supply side) of the breaker. Consideration will be given to arrangements where portions can be isolated to allow circuit breaker removal, provided that this will not interrupt services for propulsion and safety of the vessel.

### 5.3.4 Fuses

Fuses are to be designed, constructed and tested in accordance with IEC Publication 60269 or other recognized standard. The certificates of tests are to be submitted upon request from ABS.

The requirements of 4-8-3/5.3.3(b) and 4-8-3/5.3.3(c) are to be complied with. Where disconnecting means are fitted they are to be on the line or supply side. Where voltage to earth or between poles does not exceed 50V DC or 50V AC rms, fuses may be provided without switches.

All fuses, except for instrument and control circuits are to be mounted on or accessible from the front of switchboard.

### 5.3.5 Disconnecting Device

The rating of the disconnecting devices is to be equal to or be higher than the voltage and current ratings of connected load. The device is to have indicator for its open or closed position.

### 5.3.6 Internal Wiring

*5.3.6(a) Wires.*

Internal instrumentation and control wiring is to be of the stranded type and is to have flame-retarding insulation. They are to be in compliance with a recognized standard.

*5.3.6(b) Protection.*

Internal instrumentation and control wiring is to be protected by fuse or circuit breaker with the following exception:

- Generator voltage regulator circuits;
- Generator circuit breaker tripping control circuits; and
- Secondary circuit of current transformer.

These circuits, however, except that of the current transformer, are to be fitted with short circuit protection.

*5.3.6(c) Terminals.*

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 can be grouped together. Each terminal is to have a nameplate indicating the circuit designation.

#### 5.3.7 Circuit Identification

Identification plates for feeders and branch circuits are to be provided and are to indicate the circuit designation and the rating or settings of the fuse or circuit breaker of the circuit.

### 5.5 Main and Emergency Switchboards

In addition to the foregoing requirements, main and emergency switchboards are to be complied with the following requirements.

#### 5.5.1 Bus Bars

Generator bus bars are to be designed to meet the maximum generator rating based on ambient temperature of 45°C (113°F). Main bus bars are to be sized to the combined rated generator current that can flow through. Distribution bus bars and bus-bar connections are to be designed for at least 75% of the combined full-load rated currents of all loads they supply, or the combined current of the generators that can supply to that part of the bus, whichever is less. When a distribution bus bar supplies to one unit or one group of units in simultaneous operation, it is to be designed for full load.

#### 5.5.2 Subdivision of Bus Bars

Refer to 4-8-2/3.13 for requirements for the division of main bus bars.

#### 5.5.3 Hand Rails

Insulated handrail or insulated handles are to be provided for each front panel of the switchboard. Where access to the rear is required, insulated handrails or insulated handles are to be fitted to the rear of the switchboard also.

#### 5.5.4 Instrumentation

Equipment and instrumentation are to be provided in accordance with 4-8-3/15 TABLE 5. They are to be suitable for starting, stopping, synchronizing and paralleling each generator set from the main switchboard. They are to be mounted on the centralized control console if the main switchboard is located in the centralized control station.

#### 5.5.5 Door Latching *(2024)*

Hinged doors which are to be opened for operation, maintenance or similar purposes are to be provided with a latching or locking facility to keep the door open during normal movement of the vessel.

### 5.7 Motor Controllers

In addition to the applicable requirements in 4-8-3/5.3, motor controllers are to comply with the following.

#### 5.7.1 Overload and Under-voltage Protection

Overload protection and under-voltage protection where provided in the motor controllers are to be in accordance with 4-8-2/9.17.2 and 4-8-2/9.17.3.

#### 5.7.2 Disconnecting Means

A circuit-disconnecting device is to be provided for each branch circuit of motor rated 0.5 kW or above so that the motor and the controller can be isolated from the power supply for maintenance purposes. However, for pre-assembled or skid-mounted units having two or more motors (e.g., fuel oil blender), a single disconnecting device in its feeder may be accepted in lieu of individual disconnecting devices for the motors, provided that the full load current of each motor is less than 6 A. The circuit-disconnecting device is to be operable externally. See also 4-8-4/9.3.

Where the controlgear is mounted on or adjacent to a main or auxiliary distribution switchboard, a disconnecting switch in the switchboard can be used for this purpose in accordance with 4-8-4/9.3.2. Otherwise, a disconnecting switch within the controlgear enclosure or a separate enclosed disconnecting switch is to be provided.

#### 5.7.3 Resistor for Control Apparatus

Resistors are to be protected against corrosion either by rust-proofing or embedding in a protective material. Where fitted, the enclosure is to be well-ventilated and so arranged that other electrical equipment and wiring within will not be exposed to a temperature in excess of that for which they are designed.

#### 5.7.4 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.

### 5.9 Battery Systems and Uninterruptible Power Systems (UPS)

In addition to the applicable requirements in 4-8-3/5.3, equipment for essential, emergency and transitional sources of power is to comply with the following. Such equipment would include:

- Battery charging and discharging units of 25 kW and over and the associated distribution boards.
- Uninterruptible power supply (UPS) units of 50 kVA and over and the associated distribution boards.

#### 5.9.1 Definitions

*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).

#### 5.9.2 Battery Charging Rate

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 4-8-3/5.9.6(c).

### 5.9.3 Reversal of Charging Current

An acceptable means, such as reverse current protection, for preventing a failed component in the battery charger unit or uninterruptible power system (UPS) unit from discharging the battery, is to be fitted.

### 5.9.4 Design and Construction

*5.9.4(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

*5.9.4(b) Operation.*

The operation of the UPS is not to depend upon external services

*5.9.4(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.

*5.9.4(d) Continuity of Supply.* (2019)

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 4-8-2/3.7.3. A UPS with an integral Maintenance Bypass Switch allowing for battery replacement or repair of the inverter converter is acceptable as an alternative to an external bypass.

*5.9.4(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 4-8-2/3.7.3.

### 5.9.5 Location

*5.9.5(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 4-8-4/5, 4-8-4/7 and 4-8-4/9 for location of electrical equipment.

*5.9.5(b) Ventilation.*

UPS units utilizing valve regulated sealed batteries can be located in compartments with normal electrical equipment, provided the ventilation arrangements are in accordance with the requirements of 4-8-4/5.3 and 4-8-4/5.5. Since valve regulated sealed batteries are considered low-hydrogen-emission batteries, calculations are to be submitted in accordance with 4-8-4/5.5 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.

*5.9.5(c) Battery Installation.*

For battery installation arrangements, see 4-8-4/5.

### 5.9.6 Performance

*5.9.6(a) Duration.*

The output power is to be maintained for the duration required for the connected equipment as stated in 4-8-2/5.5 for emergency services and 4-8-2/5.11 of transitional source of power, as applicable.

*5.9.6(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 4-8-3/5.9.6(a).

*5.9.6(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 4-8-3/5.9.2.

### 5.9.7 Testing and Survey

*5.9.7(a) Surveys.*

Equipment units are to be surveyed during manufacturing and testing in accordance with 4-8-3/5.11.

*5.9.7(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

*5.9.7(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.

## 5.11 Testing and Certification

### 5.11.1 Certification

*5.11.1(a) Essential and emergency services and services indicated in 4-8-3/15 TABLE 7.* (1 July 2021)

Switchboards and associated motor control centers and distribution board, motor controllers of 100 kW and over, battery charger units of 25 kW and over, uninterruptible power system (UPS) units of 50 KVA and over, and distribution boards [associated with the charging and discharging of the battery system or unnterruptible power system (UPS)], where required for essential services (see 4-8-1/7.3.3), and services indicated in 4-8-3/15 TABLE 7, transitional source of power (see 4-8-2/5.11) and for distribution of emergency source of power (see 4-8-2/5), are to be inspected by, tested in the presence of and certified by the Surveyor, preferably at the plant of the manufacturer.

Switchboards are to be tested in accordance with the standards applied during design and construction (refer to 4-8-3/5.1). The prototype and routine tests are to be witnessed by ABS Surveyor.

Small distribution boards required for similar services, but not forming a part of the switchboards or the battery charging and discharging boards referred to above, such as lighting distribution boards, are to be treated as in 4-8-3/5.11.1(b). See also application of Type Approval Program in 1A-1-A3 of the ABS *Rules for Conditions of Classification (Part 1A)* and 4-1-1/3.5 through 4-1-1/3.7.

*5.11.1(b) Other services.*

Switchboards, distribution boards, motor controllers, etc., where required for services other than those in 4-8-3/5.11.1(a), are to be tested by the manufacturers. Test certificates are to be submitted upon request by ABS.

### 5.11.2 Insulation Resistance Measurement

The insulation resistance between current-carrying parts and earth and between current-carrying parts of opposite polarity is to be measured at a DC voltage of not less than 500 V 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 (MΩ).

### 5.11.3 Dielectric Strength Test *(2025)*

The dielectric strength of the insulation is to be tested for 60 seconds by an AC voltage applied, in accordance with the voltage values given in the following table, between

- Each electric circuit, and
- All other electric circuits and metal parts earthed.

| *Rated Voltage $U_n$ (V)* | *AC Test Voltage rms (V)* |
|---|---|
| $U_n \le 12$ | 250 |
| $12 < U_n \le 60$ | 500/1000 (see note) |
| $60 < U_n \le 300$ | 1500 |
| $300 < U_n \le 690$ | 1890 |
| $690 < U_n \le 800$ | 2000 |
| $800 < U_n \le 1000$ | 2200 |
| $1000 < U_n \le 1500$ | 2700 |

***Note:***

For power circuits $12 < U_n \le 60$ , the test voltage is 1000. For control circuits, the test voltage is 500.

The test voltage at the moment of application is not to exceed 50% of the values given in the above table. 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. Certain devices such as potential transformers having inherently lower insulation strength are to be disconnected during the test.

Equipment and apparatus produced in large quantities for which the standard test voltage is 2500 V or less may be tested for one second with a test voltage 20% higher than the 60-second test voltage.

### 5.11.4 Operational Tests *(1 July 2021)*

Operational tests are to be carried out including but not limited to the testing of protective devices (over current, under-voltage, and preferential trippings, etc.), electrical interlocks, synchronization of generators, earth detection, alarms.

With the UPS unit initially switched off and with no external power supply to the UPS itself, it is to be demonstrated that the UPS can be switched on to supply the load.

# 7 Transformers

## 7.1 Enclosures

Transformers are to be provided with enclosures with a minimum degree of protection as specified in 4-8-3/15 TABLE 2.

## 7.3 Transformers for Essential Services

Transformers for essential services and for emergency source of power are to be constructed in accordance with the following requirements. Other transformers, including auto-transformers for starting motors and isolation transformers, may be constructed in accordance with good commercial practice.

### 7.3.1 Rating

Transformers are to be continuously rated based the maximum expected ambient temperature to which they are subjected, but not less than 45°C (113°F). Temperature rises in accordance with alternative transformer construction standards may also be considered. Also, refer to 4-8-3/1.17 for electrical equipment installed spaces considered to have lower ambient temperatures and in environmentally controlled spaces.

### 7.3.2 Temperature Rise

The maximum temperature rise of the transformer insulated windings based on an ambient temperature of 45°C (113°F) is not to exceed that in the following table:

| *Insulation Class* | *Average Winding-temperature Rise Limits at Rated Current, °C (°F)* |
|---|---|
| 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) |

### 7.3.3 Cooling Medium

Transformers are to be of the dry and air cooled type. The use of liquid immersed type transformers will be subject to special consideration. Where forced circulation of cooling medium is employed, high temperature condition is to be alarmed.

### 7.3.4 Prevention of the Accumulation of Moisture

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.

#### 7.3.5 Testing

Single-phase transformers rated 1 kVA and above and three-phase transformers rated 5 kVA and above intended for essential or emergency services are to be tested by the manufacturer whose certificate of tests will be acceptable and are to be submitted upon request by ABS. The tests are to include at least the following:

- 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.
- Dielectric strength.
- Temperature rise (required for transformer of each size and type).

#### 7.3.6 Nameplate

Nameplates of corrosion-resistant material are to be provided in an accessible position of the transformer and are to indicate at least the following information:

- 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

## 8 Semiconductor Converters for Adjustable Speed Motor Drives

### 8.1 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 4-8-1/7.3.3) or for services indicated in 4-8-3/15 TABLE 7 are to be designed, constructed and tested in accordance with the requirements of 4-8-3/8.

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 4-8-1/7.3.3) or for services indicated in 4-8-3/15 TABLE 7 are to include at least the tests described in 4-8-3/8.7. 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.

### 8.3 Standards of Compliance

The design of semiconductor converters for adjustable speed motor drives, unless otherwise contradicted by ABS Rules, is to 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.

## 8.5 Design, Construction and Assembly Requirements

### 8.5.1 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, is not to cause harmonic distortion and voltage and frequency variations in excess of the values mentioned in 4-8-2/7.21 and 4-8-3/1.9, respectively.

The semiconductor converter circuits are to 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 4-1-1/9 TABLE 7 and 4-1-1/9 TABLE 8.

### 8.5.2 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 4-8-3/15 TABLE 2. For HV converters, the enclosure is to satisfy the requirements in 4-8-5/3 TABLE 1.

All wearing parts are to be accessible for inspection and be readily replaceable.

### 8.5.3 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

### 8.5.4 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.

### 8.5.5 Personnel Safety *(2024)*

*8.5.5(a) Hand Rails* (2024)

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.

*8.5.5(b) Door Latching* (2024)

Hinged doors which are to be opened for operation, maintenance or similar purposes are to be provided with a latching or locking facility to keep the door open during normal movement of the vessel.

### 8.5.6 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.

### 8.5.7 Capacitor Discharge

Capacitors within a semiconductor converter assembly are to 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 are to be placed on the assembly.

### 8.5.8 Cooling Arrangements

Design of cooling systems is to be based on an ambient air temperature of 45°C (113°F) indicated in 4-1-1/7.11 and 4-1-1/9 TABLE 8.

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.

Semiconductor 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.

### 8.5.9 Emergency Stop

When required, semiconductor converter assemblies are to be provided with an emergency stop function. The emergency stop circuit is to be hard-wired and independent of any control system signal.

### 8.5.10 Electrical Protection

*8.5.10(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.

*8.5.10(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.

*8.5.10(c) Short Circuit Protection.*

Semiconductor converters and the associated semiconductor devices are to be protected against short circuit.

*8.5.10(d) Filter Circuits.*

Filter circuits are to be protected against overvoltage, overcurrent and short circuit.

*8.5.10(e) Alarms.*

Visual and audible alarms are to be provided at the control station in the event of operation of the protection system.

### 8.5.11 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.

| *System Voltage (V)* | *Minimum Clearance Distance (mm)* |
|---|---|
| ≤ 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.

| *Working Voltage (rms) (V)* | *Minimum Creepage Distance (mm)* |
|---|---|
| 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.

### 8.5.12 Protection and Monitoring Requirements *(2024)*

Semiconductor assemblies, as a minimum, are to have alarm functions for the following parameters:

*i)* Overcurrent

*ii)* Overload

*iii)* Overvoltage

*iv)* Ground fault

*v)* Loss of cooling

*vi)* Increase in conductivity 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 4-8-2/9.23 for additional protection requirements.

For vessels with electric propulsion, refer to 4-9-6/23 TABLE 4A.

#### 8.5.13 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.

#### 8.5.14 EMC Emission Requirements *(2024)*

If requested by the customer, EM immunity and EM emissions testing of the semiconductor assembly is to 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').

***Commentary:***

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 is to 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.

**End of Commentary**

#### 8.5.15 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 4-8-2/9.23.

#### 8.5.16 Performance

The converter control system is to be able to control the motor by speed ramp, torque or power, as per customer specification.

Upon loss of the reference signal, the converter is to 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 is to 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 is tol be capable of catching an already spinning motor.

### 8.7 Inspection and Testing

Semiconductor assemblies for motor drives are to 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 are to be conducted in the presence of and witnessed by an ABS Surveyor. Type tests are to be carried out one prototype of a converter or the first of a batch of identical converters. Routine tests are to be carried on each assembly. A summary of the required type tests and routine tests are given in the table below:

| *No.* | *Tests (see 4-8-3/8.7)* | *Type Test* | *Routine Test* | *MVR Reference* | *IEC Test Reference* |
|---|---|---|---|---|---|
| 1 | Visual inspection | X | X | 4-8-3/8.7.1 | 61800-5-1/5.2.1 |
| 2 | Insulation test (AC or DC voltage test) | X | X | 4-8-3/8.7.2 | 61800-5-1/5.2.3.2 |
| 3 | Insulation resistance test | X | X | 4-8-3/8.7.4 | 60146-1-1/7.2.3.1 |
| 4 | Impulse voltage test | X | | 4-8-3/8.7.3 | 61800-5-1/5.2.3.1 |
| 5 | Cooling system test | X | X | 4-8-3/8.7.5 | 61800-5-1/5.2.4.5 |
| 6 | Breakdown of components test | X | | 4-8-3/8.7.6 | 61800-5-1/5.2.3.6.4 |
| 7 | Light load and functional test | X | X | 4-8-3/8.7.7 | 60146-1-1/7.3.1 |
| 8 | Rated current test | X | | 4-8-3/8.7.8 | 60146-1-1/7.3.2 |
| 9 | Temperature rise test | X | | 4-8-3/8.7.9 | 61800-5-1/5.2.3.8 |
| 10 | Capacitor discharge test | X | | 4-8-3/8.7.10 | 61800-5-1/5.2.3.7 |

### 8.7.1 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 4-8-3/8.5.3

*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

### 8.7.2 Insulation Test (AC or DC Voltage Test)

Semiconductor assemblies are to be subject to insulation tests to verify 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.

### 8.7.3 Impulse Voltage Test

Semiconductor assemblies are to 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 is to be treated as belonging to overvoltage category III.

Impulse voltage tests are to be done as a routine test on assemblies that do not satisfy the clearance and creepage distance requirements of 4-8-3/8.5.11.

### 8.7.4 Insulation Resistance Test

One minute after the insulation test, insulation resistance is to be measured by applying a direct voltage of at least 500 V.

### 8.7.5 Cooling System Test

Semiconductor assemblies are to 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 is to be subject to a coolant leak pressure test. The cooling system piping is to be hydrostatically tested to 1.5 times the design pressure for a period of 30 minutes. The pressure relief mechanism is to also be checked for proper calibration and operation. The cooling system is to 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., are to be checked to verify correct calibration and functionality.

### 8.7.6 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.

### 8.7.7 Light Load and Functional Test

Semiconductor assemblies are to be subject to a light load and functional test to verity 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..

### 8.7.8 Rated Current Test

The test is carried out to verify that the equipment will operate satisfactorily at rated current. The DC terminals are to 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, are to be connected to the AC terminals of the converter and operation of the assembly is to be checked.

#### 8.7.9 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.

| *Materials and Components* | *Thermometer Method (°C)* | *Resistance Method (°C)* |
|---|---|---|
| Rubber/Thermoplastic-insulated conductors | 55 | – |
| User terminals | Note 1 | – |
| Copper bus bars and connecting straps | 120 | – |
| Winding Insulation<br>Class A<br>Class E<br>Class B<br>Class F<br>Class H<br>Class N | <br>95<br>100<br>105<br>115<br>135<br>175 | <br>105<br>115<br>125<br>135<br>155<br>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 is not to exceed 15°C more than the insulation temperature rating of the conductor or cable specified by the manufacturer.

**2** Maximum temperature is to be as specified by the manufacturer.

#### 8.7.10 Capacitor Discharge Test

Verification of the capacitor discharge time as required in 4-8-3/8.7.7 is required to be done by a test and/or by calculation.

### 8.9 Integration Requirements

#### 8.9.1 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 are to 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.

#### 8.9.2 Reactors and Transformers for Semiconductor Converters

*8.9.2(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.

*8.9.2(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 4-8-3/7.3.2.

#### 8.9.3 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 (± 20%).

## 9 Cables

### 9.1 Standard of Compliance *(2025)*

Electric cables constructed of stranded copper conductors, thermoplastic, elastomeric or other insulation, moisture-resistant jackets, and, where applicable, armoring and outer-sheathing are to be in accordance with IEC Publication 60092-350, 60092-352, 60092-353, 60092-354, 60092-360, 60092-370, 60092-376, IEEE Std-45 or other marine standards of an equivalent or higher safety level, acceptable to ABS. Network cables are to comply with a recognized industry standard. Cables such as flexible cable, fiber-optic cable, etc., used for special purposes may be accepted provided they are manufactured and tested in accordance with recognized standards accepted by ABS.

### 9.3 Current Carrying Capacity

#### 9.3.1 Current Carrying Capacity

Maximum current carrying capacities of cables conforming to IEC Publications 60092-353 are to be in accordance with the values given in 4-8-3/15 TABLE 6. These values are applicable for cables installed double-banked on cable trays, in cable conduits or cable pipes. The values, however, are to be reduced for installations where there is an absence of free air circulation around the cables. See 4-8-2/7.7.1 and Note 4 of 4-8-3/15 TABLE 6.

### 9.4 Minimum Cable Conductor Size *(2023)*

Conductors are not to be less than the following in cross sectional size:

- 1.0 mm$^2$ (1,973.5 circ. mils) for power and lighting,
- 1.5 mm$^2$ (2960.3 circ. mils) for motor feeder cables,
- 0.5 mm$^2$ (986.8 circ. mils) for control cables,
- 0.5 mm$^2$ (986.8 circ. mils) for essential or emergency signaling and communications cables, except for those assembled by the equipment manufacturer, and
- 0.35 mm$^2$ (690.8 circ. mils) for nonessential communication cables, except for those assembled by the equipment manufacturer.

### 9.5 Flame Retardant Standard *(2025)*

Electric cables are to be flame retardant and complying with any of the following:

*i)* 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

*ii)* Cables constructed to IEEE Std 45 are to comply with the flammability criteria contained therein.

*iii)* Cables constructed to other standards, where accepted by ABS, 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.

Flame-retardant marine cables which have not passed the bunched cable flammability criteria as per IEC Publication 60332-3-22 or 60332-3-21 may be considered provided that the cable is treated with approved flame retardant material or the installation is provided with approved fire stop arrangements.

***Commentary:***

Where fire stop arrangements are provided, installation details are to follow Method 2 of IACS UI SC10.

**End of Commentary**

Consideration will be also given to the special types of cables, such as radio frequency cable, which do not comply with the above requirements.

Where the network cables are installed in bunched configuration and they do not comply with IEEE Std 45 or IEC Publication 60332-3-22 or 60332-3-21, Category A or A F/R, the installation is to be provided with approved fire stop arrangements.

## 9.7 Fire-Resistant Standard

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 4-8-4/1.9 and 4-8-4/21.17.

## 9.9 Insulation Temperature Rating

All electrical cables for power and lighting circuits are to have insulation suitable for a conductor temperature of not less than 60°C (140°F), See 4-8-3/15 TABLE 6, Note 1.

## 9.11 Armor for Single Core Cables

The armor is to be non-magnetic for single-conductor alternating-current cables. See also 4-8-4/21.7 for installation arrangements of single conductor cables.

## 9.13 Fiber Optic Cables

Fiber optic cables are to comply with a standard acceptable to ABS. The flame-retardant standard for electrical cables is also applicable to fiber optic cables.

## 9.15 Mineral-insulated Metal-sheathed Cables

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 V, 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.

### 9.17 Test and Certification *(1 July 2022)*

Electric cables are to be tested by the manufacturers in accordance with the standards of compliance. Records of test are to be maintained and are to be submitted to ABS for design review. Alternatively, electric cables may be accepted with ABS product design assessment, see 4-1-1/3.7 and4-1-1/9 TABLE 3. For propulsion cables, see 4-8-5/5.17.11.

### 9.19 Cable Splices *(2020)*

Cable splice is to be made of fire resistant or flame retardant replacement insulation 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 the splice kit, which is to contain the following:

- Connector of correct size and number
- Replacement insulation
- Replacement jacket
- Instructions for use

All cable splices are to be type-tested and approved for fire resistance, watertightness, dielectric strength, etc., or type approved (see 1A-1-A3/1 of the ABS *Rules for Conditions of Classification (Part 1A)*) before use.

### 9.21 Cable Junction Boxes

Junction box is to be constructed of durable, flame-retardant, moisture-resistant material as described in 4-8-3/1.7. Live parts within the box are to be provided with suitable clearances and creepage distances, or with shielding by flame retarding insulation material. Junction boxes having compartments for different voltage levels are to have each compartment appropriately identified as to its rated voltage. Cables within the junction boxes are to be well supported so as not to put stress on the cable contacts. In general, junction boxes are to comply with a recognized standard or type approved (see 1A-1-3/1 of the ABS *Rules for Conditions of Classification (Part 1A)*).

### 9.23 Cable Connectors *(2019)*

Cable (wiring) connectors may be accepted in shipboard cabling systems. Other than normal (main source of power) lighting, cable connectors are not to be used in shipboard cabling serving essential services. Electrical connectors used within equipment are to be designed, constructed and installed according to appropriate industry standards.

Cable connectors used in shipboard cabling systems are to be constructed of material as described in 4-8-3/1.7. Live parts within the connector are to be provided with suitable clearances and creepage distances, or with shielding by flame retarding insulation material. Cable connectors are to have a locking arrangement so that the connector is not easily disconnected during installation and under operating condition. Cables within the connector are to be well supported so as not to put stress on the cable contacts. Cable connectors are not to be used for high voltage cables having a rated voltage exceeding 1 kV. Cable connectors are to be rated for the voltage, current, and short circuit current expected in the system at the connection points.

In general, cable connector is to be type tested and at least Tier 2 level (PDA) approved (see 1A-1-A3/1 and 1A-1-A4/Tier 2), unless it complies with a recognized standard. The type test is to contain at least the following tests.

- Electrical property tests for insulation resistance test, high voltage withstanding test, IP rating (see 4-8-3/15 TABLE 2);
- Flame retardant test as equivalent to the flame retardant cables;
- In case of power service, short circuit current capacity test to verify if the connector is capable of withstanding for the short circuit current at the location where it is installed;
- Vibration test in accordance with item 5 “Vibration” of 4-9-9/15.7 TABLE 1, and
- Salt mist test in accordance with item 10 “Salt Mist” of 4-9-9/15.7 TABLE 1, where the connector is installed on open deck space.

## 11 Non-sparking Fans *(2024)*

A fan is considered as non-sparking if in either normal or abnormal conditions it is unlikely to produce sparks.

### 11.1 Design

#### 11.1.1 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, in any case, not to be less than 2 mm (0.08 in.). It need not be more than 13 mm (0.5 in.).

#### 11.1.2 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 object into the fan casing.

### 11.3 Materials

#### 11.3.1 Impeller and its Housing

Except as indicated in 4-8-3/11.3.3, the impeller and the housing in way of the impeller are to be made of alloys which are recognized as being spark proof by means of appropriate test procedures.

#### 11.3.2 Electrostatic Charges

Electrostatic charges both in the rotating body and the casing are to be prevented by the use of anti-static materials. Furthermore, the installation of the ventilation fan is to provide its bonding to the hull.

#### 11.3.3 Acceptable Combination of Materials

Materials tests referred to in 4-8-3/11.3.1 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.

#### 11.3.4 Unacceptable Combination of Materials

The following impellers and housings are considered as spark-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 impellers and housings with less than 13 mm (0.5 in.) design tip clearance.

### 11.5 Type Test *(2024)*

Type tests on the finished product are to be carried out in accordance with an acceptable national or international standard. Such type test reports are to be made available when requested by the Surveyor.

***Commentary:***

The above requirements for non-sparking fans are based on IACS Unified Requirement (UR) F29 "Non-sparking fans".

**End of Commentary**

## 13 Certified Safe Equipment

### 13.1 General

Certified safe equipment is equipment intended for installation in hazardous areas where flammable or explosive gases, vapors, or dust are normally or likely to be present. The equipment is to be type-tested and certified by a competent, independent testing laboratory for complying with IEC Publication 60079 series or equivalent standard, and rated according to its enclosure and the types of flammable atmosphere in which it is safe to install. If desired, the manufacturer may have such equipment type approved (see 1A-1-A3/1 of the ABS *Rules for Conditions of Classification (Part 1A)*).

### 13.3 Acceptable Types of Certified Safe Equipment

The following type of electrical equipment, expressed in IEC Publication 60079 series nomenclature, is acceptable for installation in hazardous areas identified in the Rules. Other types, as well as equipment complying with another recognized standard, will also be considered.

#### 13.3.1 Intrinsically Safe Equipment - 'Ex ia' and 'Ex ib'

An intrinsically safe equipment is one which is supplied by a low energy circuit which when sparking, produced normally by breaking or making the circuit or produced accidentally (i.e., by short circuit or earth-fault), is incapable under prescribed test conditions of causing ignition of a prescribed gas or vapor.

#### 13.3.2 Flameproof (Explosion-proof) Equipment - 'Ex d'

Flameproof equipment is one which possesses an enclosure capable of withstanding, without damage, an explosion of a prescribed flammable gas or vapor within the enclosure and prevent the transmission of flame or sparks which would ignite the external prescribed flammable gas or vapor for which it is designed, and which normally operates at an external temperature that will not ignite the external prescribed flammable gas or vapor. A flameproof enclosure may not necessarily or ordinarily be weatherproof or dustproof.

#### 13.3.3 Increased Safety Equipment - 'Ex e'

Increased safety equipment is designed with a method of protection in which measures additional to those adopted on ordinary industrial practice are applied, so as to give increased security against the possibility of excessive temperatures and the occurrence of arcs or sparks in electrical apparatus which does not produce arcs or sparks in normal service.

#### 13.3.4 Pressurized or Purged Equipment - 'Ex p'

Pressured equipment is designed with an enclosure in which the entry of flammable gases or vapors is prevented by maintaining the air (or other non-flammable gas) within the enclosure at a specified pressure above that of the external atmosphere. Purged equipment is designed with an enclosure in which a sufficient flow of fresh air or inert gas is maintained through the enclosure to prevent the entry of any flammable gas or vapor which may be present in the ambient atmosphere.

### 13.5 Flammable Gas Groups and Temperature Classes *(2020)*

Certified safe equipment is to be rated for the flammable atmosphere in which it is safe to install. Each flammable atmosphere is to be identified with respect to the flammable gas, vapor or dust and its self-ignition temperature; the latter is used to limit the maximum permissible external surface temperature of the equipment. The following tables show the typical flammable gas groups and the temperature classes as in ISO/IEC 80079-20-1:

| *Gas Group* | *Representative Gas* |
|---|---|
| I | Methane (see note below) |
| IIA | Propane |
| IIB | Ethylene |
| IIC | Hydrogen |

| *Temperature Class* | *Maximum Surface Temperature, °C.* |
|---|---|
| T1 | ≤450 |
| T2 | ≤300 |
| T3 | ≤200 |
| T4 | ≤135 |
| T5 | ≤100 |
| T6 | ≤85 |

*Note:* While methane of firedamp and mining applications, such as methane generated from coal, is classified as Group I, industrial methane, such as natural gas, is to be classified as Group IIA with temperature Class T1, if it does not contain more than 15% (V/V) of hydrogen. A mixture of industrial methane with other compounds from Group IIA, in any proportion, is also classified as Group IIA with temperature Class T1.

## 15 Computer-based Systems

Equipment covered by Part 4, Chapter 8 which relies on computer-based systems/components for control, monitoring or safety functions, is to comply with Section 4-9-3.

### TABLE 1A
### Degree of Protection of Electrical Equipment (First IP Numeral)

| *First IP numeral* | *Short description* | *Definition* |
|---|---|---|
| 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. |

| *First IP numeral* | *Short description* | *Definition* |
|---|---|---|
| 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 |

## TABLE 1B
## Degree of Protection of Electrical Equipment (Second IP Numeral)

| *Second IP numeral* | *Short description* | *Definition* |
|---|---|---|
| 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.<br>***Note:***<br>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 | Protected against high pressure and temperature water jets | Water projected at high pressure and high temperature against the enclosure from any direction are not to have harmful effects. |

## TABLE 2
## Minimum Degree of Protection *(2024)*

(For high voltage equipment see 4-8-5/3 TABLE 1)

| *Example of Location* | *Condition of Location* | *Switchboards, Distribution Boards, Motor Control Centers & Controllers* | *Generators* | *Motors* | *Transformers, Converters* | *Lighting Fixtures* | *Heating Appliances* | *Accesories (2)* |
|---|---|---|---|---|---|---|---|---|
| Dry accommodation space | Danger of touching live parts only | IP20 | - | IP20 | IP20 | IP20 | IP20 | IP20 |
| Dry control rooms(4) | | IP20 | - | IP20 | IP20 | IP20 | IP20 | IP20 |
| Control rooms | 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 & Showers | Increased danger of liquid and/or mechanical damage | - | - | - | - | IP34 | IP44 | IP55 (7) |
| Machinery spaces below floor plates | | - | - | IP44 | - | IP34 | IP44 | IP55 (3) |
| Closed fuel oil or lubricating oil separator rooms | | IP44 | - | IP44 | - | IP34 | IP44 | IP55 (3) |
| 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) |

| *Example of Location* | *Condition of Location* | *Switchboards, Distribution Boards, Motor Control Centers & Controllers* | *Generators* | *Motors* | *Transformers, Converters* | *Lighting Fixtures* | *Heating Appliances* | *Accesories* (2) |
|---|---|---|---|---|---|---|---|---|
| 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:*

1 Empty spaces shown with "-" indicate installation of electrical equipment is not recommended.

2 "Accessories" include switches, detectors, junction boxes, etc.

3 Socket outlets are not to be installed in machinery spaces below the floor plate, enclosed fuel and lubricating oil separator rooms. Plugs and sockets that are present in a hazardous area are to be certified for use in the particular zone.

4 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.

5 See 4-8-3/1.11.2 where the equipment is located within areas protected by local fixed pressure water-spraying or water-mist fire extinguishing system and its adjacent areas.

6 Socket outlets in galleys and laundries are to maintain their protection against splashed water when not in use.

7 Lower degree of protection may be accepted provided the equipment is not directly exposed to water splash.

8 Electrical equipment used for the power operation, remote control and status indication of watertight doors and located below the worst damage waterline is to provide suitable protection against the ingress of water, as follows:

***i)*** Electrical motors, associated circuits and control components: protected to IPX7 standard

***ii)*** Door position indicators and associated circuit components: protected to IPX8 standard (The water pressure testing of the enclosure is to be based on the pressure that may occur at the location of the component during flooding for a period of 36 hours)

***iii)*** Door movement warning signals: protected to IPX6 standard.

## TABLE 3 [8, 9]
## Factory Test Schedule for Generators and Motors ≥ 100 kW (135 hp)
*(1 July 2023)*

| *Tests (see 4-8-3/3.15)* | | *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, see 4-8-3/3.15.2. | x | x | x | x | x | x |
| 3 | Winding resistance measurement, see 4-8-3/3.15.3. | x | x | x | x | x | x |
| 4 | Verification of voltage regulation system, see 4-8-3/3.15.4. | x | x [3] | | | | |
| 5 | Rated load test and temperature rise measurement, see 4-8-3/3.15.5. | x | | x | | x | |
| 6 | *(2003)* Overload and over-current test, see 4-8-3/3.15.6. | x | x [4] | x | x [4] | x | x [4] |
| 7 | Verification of steady short circuit condition, see 4-8-3/3.15.7.[3] | x | | | | | |
| 8 | Over-speed test, see 4-8-3/3.15.8. | x | x | x [6] | x [6] | x [6] | x [6] |
| 9 | Dielectric strength test, see 4-8-3/3.15.9. | x | x | x | x | x | x |
| 10 | Running balance test, see 4-8-3/3.15.10[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 applies to prototype machines or to at least the first of a batch of machines. After type test, generator components, randomly selected at the discretion of the Surveyor, are to be presented for inspection.

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.

8 The tests in 4-8-3/Table 3 are to be documented. The documentation is to include information on make, type, serial number, insulation class, all technical data necessary for the application of the machine, as well as the results of the required tests.

9 The result of type tests, and the serial number of the type tested machine, are to be specified in the documentation of test results for routine tests.

## TABLE 4
## Limit of Temperature Rise for Air Cooled Rotating Machines

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) | A.C. 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) | A.C. 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) | A.C. windings of machines having rated outputs of 200 kW (or kVA) or less [(1)] | Resistance | 55 | 70 | 75 | 100 | 120 |
| 2 | | Windings of armatures having commutators | Thermometer | 45 | 60 | 65 | 80 | 100 |
| | | | Resistance | 55 | 70 | 75 | 100 | 120 |
| 3 | | Field windings of A.C. and D.C. machines having D.C. excitation, other than those in item 4 | Thermometer | 45 | 60 | 65 | 80 | 100 |
| | | | Resistance | 55 | 70 | 75 | 100 | 120 |
| 4 | a) | Field winding of synchronous machines with cylindrical rotors having D.C. excitation winding embedded in slots, except synchronous induction motors | Resistance | - | - | 85 | 105 | 130 |
| | b) | Stationary field windings of A.C. machines having more than one layer | Thermometer | 45 | 60 | 65 | 80 | 100 |
| | | | Resistance | 55 | 70 | 75 | 100 | 120 |
| | | | Embedded temp. detector. | - | - | 85 | 105 | 130 |
| | c) | Low resistance field winding of A.C. and D.C. machines and compensating windings of D.C. machines having more than one layer | Thermometer | 55 | 70 | 75 | 95 | 120 |
| | | | Resistance | 55 | 70 | 75 | 95 | 120 |
| | d) | Single-layer windings of A.C. and D.C. machines with exposed bare or varnished metal surfaces and single layer compensating windings of D.C. machines [(2)] | Thermometer | 60 | 75 | 85 | 105 | 130 |
| | | | Resistance | 60 | 75 | 85 | 105 | 130 |

| *Item No.* | *Part of Machine* | *Temperature Measuring Method* | *Limit of temperature rise, °C for class of insulation* | | | | |
|---|---|---|---|---|---|---|---|
| | | | *A* | *E* | *B* | *F* | *H* |
| 5 | Permanently short-circuited windings | 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. | | | | | |
| 6 | Magnetic cores and all structural components, whether or not in direct contact with insulation (excluding bearings) | | | | | | |
| 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.<br>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 5
## Equipment and Instrumentation for Switchboards

| *Instrumentation and Equipment* | | *Alternating-current (AC) Switchboard* | *Direct-current (DC) Switchboard* |
|---|---|---|---|
| 1. | Indicator light | An indicator light for each generator, connected between generator and circuit breaker.(3) | An indicator light 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. | 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) (5) | A means for continuously monitoring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values.(3) |
| 4. | 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. |

| *Instrumentation and Equipment* | | *Alternating-current (AC) Switchboard* | *Direct-current (DC) Switchboard* |
|---|---|---|---|
| 5. | 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, and bus 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 |
| 6. | Space heater indicator light | Where electric heaters are provided for generators, a heater indicator light is to be fitted for each generator. | Where electric heaters are provided for generators, a heater indicator light is to be fitted for each generator. |
| 7. | Synchroscope or Lamps | A synchroscope or synchronizing lamps with selector switch for paralleling in any combination.(3) | Not applicable |
| 8. | Prime mover Speed Control | Control for prime mover speed for paralleling.(3) | Not applicable |
| 9. | Wattmeter | Where generators are arranged for parallel operation, an indicating wattmeter is to be fitted for each generator.(3) | Not applicable |
| 10. | Frequency Meter | A frequency meter with selector switch to connect to any generator.(3) | Not applicable |
| 11. | Field Switch | A double-pole field switch with discharge clips and resistor for each generator.(2) | Not applicable |
| 12. | Voltage Regulator | A voltage regulator.(3) | Not applicable |
| 13. | 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 rectifier exciters, each controlled by voltage-regulator unit acting on the exciter field, the field switch and the discharge resistor and may be omitted.

3 Where vessels have centralized control systems in accordance with Part 4, Chapter 9 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 4-8-3/5.5.4.

4 For high voltage systems, see also 4-8-5/3.7.3(c).

5 For high voltage systems, see 4-8-5/3.3.2.

## TABLE 6
## Maximum Current Carrying Capacity for Cables

| *Conductor Size* | | *Maximum Current in Amperes (see 4-8-3/9.3) 45°C (113°F) Ambient; 750 V and Less, AC or DC; see Notes* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *1-core* | | | | *2-core* | | | | *3- or 4-core* | | | |
| *mm²* | *10³ circ mils* | *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 | 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 |

| *Conductor Size* | | *Maximum Current in Amperes (see 4-8-3/9.3) 45°C (113°F) Ambient; 750 V and Less, AC or DC; see Notes* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *1-core* | | | | *2-core* | | | | *3- or 4-core* | | | |
| *mm²* | *10³ circ mils* | *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* |
| **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 | 379 | | 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 |
| **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 to Table 6:***

1 The nomenclature of cable insulation types used in 4-8-3/15 TABLE 6 is as follows:

| *Insulation Type Designation* | | *Insulation Materials* | *Maximum Conductor Temperature, °C* |
|---|---|---|---|
| *IEC 60092-353* | *IEC 60092-3* | | |

| | | | |
|---|---|---|---|
| --- | V75 | Polyvinyl chloride - heat resisting | 75 |
| XLPE | R85 | Cross-linked polyethylene | 85 |
| EPR | E85 | Ethylene propylene rubber | 85 |
| XLPE | R90 | Cross-linked polyethylene | 90 |
| EPR | E90 | Ethylene propylene rubber | 90 |
| --- | M95 | Mineral (MI) | 95 |
| S95 | S95 | Silicone rubber | 95 |

2 The maximum current values given in 4-8-3/15 TABLE 6 have been derived from IEC Publication 60092-353 and are based on ambient temperature of 45°C (113°F) and on the assumption that when a group of four cables bunched together and laid in free air the conductors will attain and operate continuously at a temperature equal to the maximum rated temperature of the insulation.

3 The maximum current values given in 4-8-3/15 TABLE 6 (and those derived therefrom) may be used, without correction factors, for cables installed double-banked in cable conduits or cable pipes, except as noted in Note (4).

4 Where more than six cables expected to be operated simultaneously are laid together in a bunch in such a way that there is an absence of free air circulation around them, a correction factor of 0.85 is to be applied to the values given in 4-8-3/15 TABLE 6.

5 The maximum current values given in 4-8-3/15 TABLE 6 are applicable to both armored and unarmored cables.

6 If ambient temperature differs from 45°C (113°F), the maximum current values in 4-8-3/15 TABLE 6 are to be multiplied by the following factors.

| *Maximum Conductor Temperature* | *Ambient Correction Factor* | | | | | |
|---|---|---|---|---|---|---|
| | *40°C* | *50°C* | *55°C* | *60°C* | *65°C* | *70°C* |
| 75°C | 1.08 | 0.91 | 0.82 | 0.71 | 0.58 | --- |
| 85°C | 1.06 | 0.94 | 0.87 | 0.79 | 0.71 | 0.61 |
| 90°C | 1.05 | 0.94 | 0.88 | 0.82 | 0.74 | 0.67 |
| 95°C | 1.05 | 0.95 | 0.89 | 0.84 | 0.77 | 0.71 |

7 Where the number of conductors in a cable exceeds 4, the maximum current value is to be corrected by factors as indicated in the following table.

| *No. of Conductors* | *Correction Factor for 3- or 4-Core Values in Table 6* |
|---|---|
| 5 - 6 | 0.8 |
| 7 - 24 | 0.7 |
| 25 - 42 | 0.6 |
| ≥ 43 | 0.5 |

8 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).

9 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 7
## Additional Services Requiring Electrical Equipment to be Designed, Constructedand Tested to the Requirements in Section 4-8-3
## [See 4-8-1/5.5, 4-8-3/1.5, 4-8-3/3.1, 4-8-3/3.15.1, 4-8-3/3.17 and 4-8-3/5.11.1 ]

| | |
|---|---|
| (a) | Equipment necessary for specific class notations (Such as refrigerated cargo notations, dynamic positioning systems, etc.) |
| (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 |

# PART 4

## CHAPTER 8
## Electrical Systems

## SECTION 4
## Shipboard Installation and Tests

## 1 General *(2024)*

The provisions of this section apply to all electrical installations on board vessels. Additional requirements applicable to high voltage systems (systems exceeding 1 kV) and electric propulsion systems are given in Section 4-8-5. Requirements applicable to specific vessel types, particularly with regard to installations in hazardous areas, are given in Part 5C and Part 5D.

### 1.1 Objective *(2024)*

#### 1.1.1 Goals *(2024)*

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

| *Goal No.* | *Goal* |
|---|---|
| POW 1 | Provide safe and reliable storage and supply of fuel/energy/power. |
| POW 2 | Provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel. |
| POW 4 | *Enable all electrical services required for safety to be available during emergency conditions.* |
| SAFE 1-1 | Minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems. |
| SAFE 2 | Provide suitable and readily available illumination. |
| FIR 1 | *Prevent the occurrence of fire and explosion.* |
| FIR 2 | *Reduce the risk to life caused by fire.* |
| FIR 3 | *Reduce the risk of damage caused by fire to the ship, its cargo and the environment.* |
| MGMT 1 | *Provide for safe practices in ship operation and a safe working environment.* |
| MGMT 5 | Design and construct vessel, machinery, and electrical systems to facilitate safe access, ease of inspection, survey, and maintenance. |
| AUTO 1 | Perform its functions as intended and in a safe manner. |
| AUTO 7 | Enable rational human machine interface without unintended errors due to the layout or arrangement of machinery/equipment |

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

### 1.1.2 Functional Requirements *(2024)*

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

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Power Generation and Distribution (POW)** | |
| POW-FR1 | Machinery is to recover from dead ship condition without external aid. |
| POW-FR2 | Provide proper storage locations for lead-acid or alkaline batteries as well as low-hydrogen-emission batteries according to the total output of battery chargers. |
| POW-FR3 | Batteries are to be segregated and identified by the battery types and maintained regularly to supply essential and emergency services when required. |
| **Fir e S a fety (FIR)** | |
| FIR-FR1 | Electrical equipment and cables installed in hazardous areas are to be suitable for the environment (gas group and temperature classification) in which they operate |
| FIR-FR2 | Provide cable routing such that emergency and essential services are operable under a fire condition. |
| FIR-FR3 | Provide adequate ventilation to maintain the flammable gases within the battery room to a level below the lower explosive limit. |
| FIR-FR4 | Prevent shock, fire and other hazards of electrical origin where operations or maintenance are expected. |
| FIR-FR5 | Cables are to be protected from damage due to hot surfaces, fire or explosion hazards and mechanical damage. |
| FIR-FR6 | Cable penetrations of approved type are to be used for passing through watertight or fire-rated bulkheads or decks to maintain the watertight integrity or fire rating of the bulkheads or decks. |
| FIR-FR7 | Plastic cable support systems are to be designed to support safe working load and to be prevented from falling in a fire and causing injuries or obstruction. |
| **Safety of Personnel (SAFE)** | |
| SAFE-FR1 | Provide enclosure with suitable degree of protection against ingress of foreign objects and liquids based on location of installation. |
| SAFE-FR2 | Provide fastening of accumulation batteries to prevent and withstand spillage of internal chemicals. |
| SAFE-FR3 | Prevent shock, fire and other hazards of electrical origin where operations or maintenance are expected. |
| SAFE-FR4 | Protect against accidental contact and unauthorized operation of essential and emergency equipment boards. |
| SAFE-FR5 | Prevent simultaneous loss of main and emergency lighting distribution boards which causes machinery spaces and accommodation spaces to be in darkness. |
| SAFE-FR6 | Cable supports are to withstand the safe working load and secure the cables to prevent them from falling onto personnel or obstruct escape routes. |
| SAFE-FR7 | Provide equipment earthing and system earthing for protection against electrical shock. |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| SAFE-FR8 | Electrical installations in hazardous areas are to be restricted to minimize the potential risks that might affect the safety of the ship, persons on board and equipment. |
| SAFE-FR9 | Electrical equipment and cables installed in hazardous areas are to be certified as suitable for the location of installation by an accredited laboratory. |
| SAFE-FR10 | Bus bar trunking systems serving essential consumers are to be designed with redundancy such that failure of one trunking system does not impair the operation of the essential service. |
| **Safety Management (MGMT)** | |
| MGMT-FR1 | The installation of apparatus and wiring in the vicinity of magnetic compasses is to prevent disturbance from external magnetic fields and to avoid the effects of unwanted electromagnetic interference. |
| MGMT-FR2 | Provide connection of single conductor or multiple conductor cables to avoid the harmful effects of electromagnetic induction. |
| MGMT-FR3 | Provide support for cable installation to avoid chafing and undue stress in the cable. |
| MGMT-FR4 | Plastic cable support systems are to be designed to support safe working load and to be prevented from falling in a fire and causing injuries or obstruction. |
| MGMT-FR5 | Cable installation is not to exceed the permitted bending radii to avoid the damage to cables. |
| MGMT-FR6 | Cable penetrations of approved type are to be used for passing through watertight or fire-rated bulkheads or decks to maintain the watertight integrity or fire rating of the bulkheads or decks. |
| MGMT-FR7 | Means used to connect lengths of cables are to be suitable for the intended purposes, maintain the watertightness, fire tightness and integrity of the cables. |
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Electrical equipment is to operate satisfactorily within the design inclination limits of the vessel. |
| AUTO-FR2 | Electrical equipment is to be in well supported location with adequate clearance for ease of operation and maintenance. |
| AUTO-FR3 | Provide means of disconnecting the electrical power circuits from power source for maintenance, or to isolate faults in electrical circuits. |
| AUTO-FR4 | Busbar trunking systems are to withstand the vibration and normal mechanical forces expected on board. |

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

### 1.1.3 Compliance *(2024)*

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

### 1.1.4 Installations Subject to Surveyor Satisfaction *(2020)*

In general, equipment is to be installed in accordance with the manufacturer installation instructions, as applicable.

Location of electrical equipment is to account for access for operation, maintenance, repair, inspection and proper ergonomics of the equipment for operation and maintenance. (Guidance notes of the Application of Ergonomics to Marine Systems, Publication no. 86, provides guidance for proper installations).

In general, bulkhead mounted equipment are not to be installed in passageways and stairwells. If installed, the equipment are not to impede the egress for personnel or danger to personnel transiting the area subject to motions of the vessel.

Bulkhead mounted equipment in passageways are not to reduce the required passageway width as required by SOLAS, as applicable.

Splices or junction boxes located behind joiner bulkheads are to be provided with hinged or removable access covers for accessibility and inspection.

Location of splices or junction boxes located above drop down ceiling panels are to have nameplates by the closest removable panels indicating the location of equipment.

Where cable entrance to equipment needs to be from the top or side, the enclosure cable penetrations are not to reduce the required degree of protection of the enclosure.

Location requirements for optional Class notations, as applicable.

Located as not to interfere or require removal within structural Welded Equipment Removal Plate (WERP) and Bolted Equipment Removal Plate (BERP) areas.

Electrical receptacles and switches in dry accommodation areas are not to be located immediately adjacent to routinely used exterior doors allowing rain, sleet, snow or splashing sea water entering the space and damage to equipment, or be provided with a higher degree of protection.

## 1.3 Degree of Enclosure

Electrical equipment is to be protected from the intrusion of foreign matter during service. For this purpose the degree of enclosure of electrical equipment is to be adequate for its location of installation. The minimum degrees of enclosure required for typical locations on board vessels are given in 4-8-3/15 TABLE 2 and are to be complied with.

For electrical and electronic equipment located within areas protected by Local Fixed Pressure Water-spraying or Water-mist Fire Extinguishing System and in adjacent areas where water can extend, see 4-8-3/1.11.2.

## 1.5 Hazardous Areas

Areas where flammable or explosive gases, vapors, or dust are normally or likely to be present are known as hazardous areas. Electrical equipment intended for installation in hazardous areas are to have suitable enclosures or are to be of the low energy type. See 4-8-4/27.

## 1.7 Inclination

Electrical equipment is to be installed such that its inclination, in both the longitudinal and athwartship directions, and in static and dynamic operating conditions, will not exceed that to which it is designed, and in any case, is to operate satisfactorily up to the inclinations defined in 4-1-1/7.9.

## 1.9 Services Required to be Operable Under a Fire Condition *(2024)*

For the purpose of 4-8-4/21.17.2, services required to be operable under a fire condition include, but not limited thereto, 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 support the propagation of fire and/or explosion

*x)* For passenger vessels, see 5C-7-5/13.7.2(b).

***Commentary:***

Above requirements are based on IACS Unified Requirement (UR) E15 "Electrical services required to be operable under fire conditions and fire resistant cables".

**End of Commentary**

## 1.11 High Fire Risk Areas *(2022)*

For the purpose of 4-8-4/21.17, the examples of the high fire risk areas are the following:

*i)* Machinery spaces as defined by 4-7-1/11.15 and 4-7-1/11.17, 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)* Galleys and pantries containing cooking appliances, saunas, paint lockers and store rooms having areas of 4 $m^2$ or more, spaces for the storage of flammable liquids, and workshops other than those forming part of the machinery spaces.

*iv)* Laundry containing drying equipment

*v)* For passenger vessels, see 5C-7-5/13.7.2(c).

## 1.13 Installation Requirements for Recovery from Dead Ship Condition *(2024)*

Means are to be provided such that machinery can be brought into operation from the dead ship condition without external aid. See 4-1-1/1.9.6.

Where the emergency source of power is an emergency generator which complies with 4-8-2/5.15 and 4-8-2/3.1.3, this emergency generator can 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 from a dead ship condition.

Subject to the applicable statutory requirements of the flag Administration, alternate arrangements to those specified in this section may be considered for vessels that are less than 500 gross tonnage and compliance to SOLAS II-1/42.3.4 and II-1/43.3.4 is not required.

# 3 Generators and Motors

Generators, motors and other rotating machines are to be installed preferably with their shafts in a fore-and-aft direction of the vessel and are to operate satisfactorily in accordance with the inclination requirements of 4-1-1/7.9. Where it is not practicable to mount the generators with the armature shafts in the fore-and-aft direction, their lubrication requires special consideration. Arrangements are to be made to protect generator and motors from bilge water. Precautions are also to be taken to preclude any oil which may escape under pressure from entering machine windings.

# 5 Accumulator Batteries

## 5.1 General

### 5.1.1 Application *(2024)*

These requirements are applicable to batteries in D.C. power distribution systems which emit hydrogen gas while in use such as vented (flooded) batteries or Low Hydrogen Emission (LHE) such as Absorbent Glass Mat (AGM), Valve Regulated Lead Acid (VRLA), Sealed Lead Acid (SLA), Maintenance Free, Nickel-cadmium (NiCd), Nickel Metal Hydride (NiMH) and Lithium-ion (Li-ion) etc.

This section does not apply to lead acid based batteries in relay-controlled Battery lanterns.

*i)* Designs and construction standards of other battery types are to be submitted for consideration in each case along with operational hazards of the batteries.

*ii)* Batteries for engine start and engine own operation required to be located near the engine in the main propulsion machinery space will be specially considered regardless of the aggregate battery sizes in the space.

*iii)* For batteries in UPS Systems refer to 4-8-3/5.9.

*iv)* Installation design of other battery types is to be submitted for consideration in each case along with operational hazards of the batteries."

***Commentary:***

For general information on battery types, refer to Appendix 1 of the ABS *Requirements for Use of Lithium-ion Batteries in the Marine and Offshore Industries*.

**End of Commentary**

### 5.1.2 Battery Cells

Battery cells are to be constructed to prevent spillage of electrolyte due to motions of the vessel at sea. Batteries are to be secured to their trays or shelves to prevent their movement.

### 5.1.3 Nameplate *(2020)*

Nameplates of corrosion-resistant material are to be provided in an accessible position of the trays or shelves, battery box or battery locker, and are to indicate at least the following information:

- 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).

### 5.1.4 Referenced Requirements *(1 July 2022)*

The following requirements are also applicable to battery installations:

| | |
|---|---|
| • Accumulator batteries as emergency source of electrical power | 4-8-2/5.9.2 |
| • Accumulator batteries as transitional source of electrical power | 4-8-2/5.11 |
| • Protection of accumulator batteries | 4-8-2/9.15 |
| • Battery starting systems | 4-8-2/11.11 |
| • ABS *Requirements for Use of Lithium-ion Batteries in the Marine and Offshore Industries* | |

### 5.1.5 Maintenance of Batteries *(2024)*

*5.1.5(a) Maintenance Schedule of batteries.* 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 at least the following information regarding the batteries, which is to be submitted for review, during plan approval or the new building survey.

- 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)

***Commentary:***

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. Refer to IACS Unified Requirement (UR) E18 "Recording of the type, location and maintenance cycle of batteries".

**End of Commentary**

*5.1.5(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.

### 5.1.6 Replacement of Batteries *(2024)*

Where a vented type battery (See item 1 in Commentary) replaces a valve-regulated, sealed type battery (See item 2 in Commentary), the requirements in 4-8-4/5.3 are to be complied with on the basis of the charging capacity. Where a valve-regulated, sealed type battery replaces a vented type battery used for engine starting, the battery charging requirements are to be verified with the battery manufacturer and the requirements in 4-8-2/11.11.5 applied.

***Commentary:***

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.

**End of Commentary**

## 5.3 Lead-acid or Alkaline Battery Storage Locations

### 5.3.1 Battery Room

*5.3.1(a) General.* *(2020)*

Where a group of accumulator batteries is connected to charging devices with total output of more than 2 kW, they are to be installed in a battery room dedicated to batteries only. No other electrical equipment is to be installed in the battery room except that necessary for operational purposes. Each of such equipment is to be of a certified safe type for battery room atmosphere. See also 4-8-4/27.5.3.

*5.3.1(b) Ventilation of battery room.* *(2025)*

Battery room is to be ventilated to avoid accumulation of flammable gas. Natural ventilation can be employed for moderate and small battery installations if ducts can be led directly from the top of the battery room to the open air above, with an opening for air inlet near the floor.

If natural ventilation is impractical, mechanical exhaust ventilation is to be provided with fan intake at the top of the room. Fan motor is to be of certified safe type, and fan is to be of non-sparking construction (see 4-8-3/11). The fan is to be capable of completely changing the air in the battery room in not more than two minutes. An alternative fan capacity can be provided if it is able 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 capacity is based on low-hydrogen emission type batteries (see also 4-8-4/5.5), a warning notice to this effect is to be displayed in a visible place in the battery room. Openings for air inlet are to be provided near the floor. The battery chargers are to be interlocked with the power ventilation system to prevent charging and release of gas when the fan is not running.

***Commentary:***

Where only low-hydrogen-emission (LHE) batteries are installed in a dedicated battery room, natural ventilation may be employed if hydrogen emissions under all charging conditions do not exceed the emissions of standard lead-acid batteries connected to a 2 kW charging device. Also, where a power ventilation system is employed in such a space, the battery chargers need not be interlocked with the power ventilation system.

**End of Commentary**

*5.3.1(c) Corrosion protection in battery room.* *(2020)*

Interior of the battery room including structural members, shelves, ventilation inlets and outlets are to be coated with paint resistant to the electrolyte used in the batteries. Shelves for lead acid batteries are to have watertight lining of corrosion resistant material or sheet lead not less than 1.6 mm ($^{1}/_{8}$ in.) thick, and carried up not less than 75 mm (3 in.) on all sides; and that for alkaline batteries of sheet steel not less than 0.8 mm ($^{1}/_{16}$ in.) thick. Alternatively, the entire battery room can be fitted with a watertight corrosion resistant material or lead pan (or steel for alkaline batteries), over the entire deck, carried up not less than 150 mm (6 in.) on all sides. Details of manufactured corrosive resistant materials are to be provided upon request.

*5.3.1(d) Battery trays and battery locker shelves .* *(2020)*

For purposes of heat dissipation during equalizing charge, appropriate air spaces are to be provided around each battery. Where placed in trays or shelves, batteries are to be chocked with wood strips or equivalent to prevent movement and each battery is to be supported in the tray with nonabsorbent insulator on the bottom and at the sides or with equivalent provision to secure air-circulation space all around each tray.

### 5.3.2 Deck Boxes, Lockers and Racks *(2020)*

*5.3.2(a) General (1 July 2022)*

Where a group of accumulator batteries is connected to a charging devices with a total output of 0.2 kW up to and including 2 kW, these moderate battery installations can be installed in the battery room or, alternatively, in deck boxes, battery lockers or a battery rack in well ventilated machinery spaces. Deck boxes or lockers can be located in machinery spaces, or other well ventilated locations. Batteries are to be protected from mechanical damage, dripping water and condensation where necessary. In general, batteries are to be installed away from sources of ignition.

Where engine starting batteries are installed in open racks, the arrangement is to provide for personnel protection from the batteries where an operator is stationed to start the engine, either for testing or normal operations. This can be accomplished by the arrangement of the space or by provision of a partition between the battery racks and the engine starting location.

***Notes:***

In order for the space considered "well ventilated" in the context of battery installation, the following requirements are to be met:

**i** A detailed calculation showing adequate ventilation for the space is to be submitted to the ABS technical office for review and approval.

**ii** The ventilation system would be considered adequate if the calculation indicates a liberated hydrogen gas concentration not exceeding 1 percent by volume of the proposed space. Please refer to IEC standards 62485-2 or 60079-10.

**iii** The calculation is to represent worst case scenario assuming all batteries are releasing gases at the same time.

**iv** The ventilation system is to be arranged to provide adequate air movement in the general battery areas to diffuse generation of hydrogen gas and to prevent pockets of trapped hydrogen gas from occurring particularly at the top of the space (or ceiling).

*5.3.2(b) Ventilation of deck boxes or lockers (1 July 2022)*

Deck boxes or lockers are to be provided with a duct from the top of the box, terminating with a means to prevent entrance of water such as goose-neck or mushroom head. At least two air inlets are to be provided at the lower part and opposite sides of the deck box. Louvers or equivalent are to be fitted at the air inlets at the lower part of the box. Where located in the weather, deck boxes including openings for ventilation are to be weathertight, and ducting extended 1.3m (4 feet) above the box.

A minimum of 25 mm (1 inch) of air circulation space is to be provided around and in between the batteries.

*5.3.2(c) Corrosion protection in deck boxes*

Deck boxes are to be fitted with watertight trays with coaming heights not less than 150 mm (6 in.) as in 4-8-4/5.3.1(c).

### 5.3.3 Small Battery Boxes

Batteries not covered in 4-8-4/5.3.1 and 4-8-4/5.3.2 are to be installed in battery boxes and can be located as desired, except they are not to be located in sleeping quarters unless hermetically sealed. Small battery boxes require no ventilation other than openings near the top to allow escape of gas. For corrosion protection, the boxes are to be lined to a depth of 75 mm (3 in.) consistent with the method in 4-8-4/5.3.1(c).

#### 5.3.4 Batteries for Engine Starting *(2020)*

Engine starting batteries are to be installed in the same well ventilated space where the engine is installed, and are to be located close to the engine.

#### 5.3.5 Batteries of Different Electrolyte

Where batteries of different types, for which different electrolyte are used, are installed in the same room, they are to be segregated and effectively identified.

#### 5.3.6 Summary *(2024)*

The battery storage requirements in 4-8-4/5.3.1 to 4-8-4/5.3.3 are summarized below:

| *Battery Chargers with Total Output (P) of:* | *Acceptable Battery Spaces/Enclosures* | | | |
|---|---|---|---|---|
| | *Battery Room* | *Deck Box* | *Small Battery Box* | *Small Battery Box Located in Sleeping Quarters* |
| P > 2 kW | Yes | No | No | No |
| 0.2 kW ≤ P ≤ 2 kW<br>Or LHE batteries P > 2 kW | Yes | Yes | No | No |
| P < 0.2 kW<br>Or LHE batteries 0.2 kW ≤ P ≤ 2 kW | n/a | Yes | Yes | No |
| P < 0.2 kW and when Battery is hermetically sealed | n/a | Yes | Yes | Yes |

### 5.5 Low-hydrogen-emission Battery Storage Locations

A battery is considered low-hydrogen-emission (LHE) if it does not emit more hydrogen under similar charging condition than a standard lead-acid battery. LHE batteries connected to charging devices with total output of more than 2 kW can be installed as in 4-8-4/5.3.2 provided calculations are submitted demonstrating that under similar charging condition hydrogen emission does not exceed that of standard lead-acid batteries connected to a 2 kW charging device. Similarly, LHE batteries connected to charging device with total output of 2 kW or less can be installed as in 4-8-4/5.3.3 provided calculations are submitted demonstrating that under similar charging condition hydrogen emission does not exceed that of standard lead-acid batteries connected to charging device of 0.2 kW.

For such installations, a warning-notice is to be displayed to notify maintenance personnel that additional batteries are not to be installed and any replacement battery is to be the LHE type.

## 7 Switchboard and Distribution Boards

### 7.1 Switchboard

#### 7.1.1 Location and Clearance for Maintenance *(2024)*

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.

Switchboards are to be arranged to give easy access to apparatus and equipment, without danger to personnel. Switchboards are to be located in a dry place. 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 are to be provided. The clearance at the rear can be reduced to 457 mm (18 in.) in way of stiffeners or frames so long as they do not impair the operability and serviceability of the switchboards. For switchboards enclosed at the rear and fully serviceable from the front, clearance at the rear will not be required, except that necessary for cooling. For high voltage equipment accessibility, see 4-8-5/3.15.4.

#### 7.1.2 Precaution Against Electrical Shock *(2025)*

Unless the main and emergency switchboards are installed on an electrically-insulated floor, non-conducting mats or gratings are to be provided at the front and the rear of switchboards where operations or maintenance are expected. 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.

#### 7.1.3 Protection for Leakage of Liquid

Pipes are not to be routed in the vicinity of switchboards. Where this cannot be avoided, such piping is to be of all welded joints or means are to be provided to prevent any joint leakage under pressure to impinge on the switchboard.

### 7.3 Distribution Boards

#### 7.3.1 Location and Protection

Distribution boards are to be installed in accessible locations, but not in such spaces as bunkers, storerooms or, cargo holds. Distribution boards can be located behind panels/linings within accommodation spaces, including stairway enclosures, without the need to categorize the space for fire integrity standard, provided no provision is made for storage.

#### 7.3.2 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.

#### 7.3.3 Safety-type Panels

Unless installed in machinery spaces or in compartments assigned exclusively to electric equipment and accessible only to authorized personnel, the distribution boards are to be of the safety type. This type of distribution boards are 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.

#### 7.3.4 Reference Requirements *(2020)*

The following requirements are also applicable to distribution boards:

*i)* Lighting distribution boards 4-8-4/11.5 and 4-8-2/5.9.2

*ii)* High voltage distribution boards 4-8-5/3.11

## 9 Motor Controllers and Motor Control Centers

### 9.1 Location

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.

## 9.3 Disconnecting Arrangements

### 9.3.1 General

A circuit-disconnecting device is to be provided for each branch circuit of motor rated 0.5 kW or above so that the motor and the controller can be isolated from the power supply for maintenance purposes. However for pre-assembled or skid-mounted unit having two or more motors (e.g. fuel oil blender) a single disconnecting device in its feeder may be accepted in lieu of individual disconnecting devices for the motors, provided that the full load current of each motor is less than 6A. See also 4-8-3/5.7.2.

### 9.3.2 Location of the Disconnecting Device

The disconnecting device can be in the same enclosure with the controller, in which case it is to be externally operable. The branch-circuit switch or circuit breaker on the power-distribution panel or switchboard can serve as the disconnect device if it is located in the same compartment as the controller. In any case, if the disconnecting device is not within sight of both the motor and the controller, or if it is more than 15 m (50 ft) from either, it is to be arranged for locking in the open position. The disconnect switch, if not adjacent to the controller, is to be provided with an identification plate.

### 9.3.3 Open/Close Indication

The disconnect device is to be provided with indication of whether it is open or close.

### 9.3.4 Supply Voltage of Indicating Light Circuit

Where indicating light is fitted to a motor controller to indicate the availability of the power supply, and if the required disconnecting device does not de-energize the indicating light circuits, the voltage of indicating light circuits is not to exceed 150 V.

## 9.5 Resistors for Control Apparatus *(2024)*

Controllers fitted with resistors are to be located in well-ventilated compartments and are to be mounted with ample clearances of at least 300 mm (12 in.) from vessel structures and unprotected combustible materials.

# 11 Lighting Systems

## 11.1 General

### 11.1.1 Hot Surfaces

Lighting fixtures are to be so installed as to prevent their hot surfaces from damaging cables and wiring, and from igniting surrounding materials.

### 11.1.2 Referenced Requirements

The following referenced requirements are applicable:

| | |
|---|---|
| • Emergency lighting | 4-8-2/5.5 |
| • Lighting system arrangement | 4-8-2/7.13 |
| • Cable for branch lighting circuit | 4-8-2/7.7.8 |
| • Protection of branch lighting circuit | 4-8-2/9.21 |
| • Wiring insulation within fluorescent light fixtures | 4-8-4/21.1.8 |

## 11.3 Lighting Installation in Cargo Spaces

Fixed lighting circuits in the bunker or cargo spaces are to be controlled by multipole-linked switches situated outside the bunker or cargo spaces.

### 11.5 Lighting Distribution Boards *(2021)*

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.), are to have these lighting distribution boards installed at locations which are separated by a boundary wall. The boundary wall separation is to be a non-combustible partition complying with as a minimum a C-class panel division.

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 4-8-2/7.13.2.

The emergency lights in the engine room enclosed escape route are not to be fed from the engine room lighting distribution boards, if located in the engine room. This requirement cannot be waived based on the use of fire resistant cables.

## 13 Heating Equipment

### 13.1 Electric Radiators

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.

## 15 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.

## 17 Flexible Cables and Portable Equipment *(1 July 2024)*

Portable apparatus served by a flexible cord (excluding intrinsically safe circuits) are not to be used in cargo oil pump rooms or other hazardous areas unless the following conditions are met:

- Portable apparatus are to have cables with a heavy polychloroprene or other equivalent synthetic elastomeric sheath, cables with a heavy tough rubber sheath, or cables having an equally robust construction.
- The conductors for the supply cable are to be stranded and are to have a minimum cross-sectional area of 1.0 mm$^2$.
- If a protective earthing (PE) conductor is necessary, it is to be separately insulated in a manner similar to the other conductors and shall be incorporated within the supply cable sheath.

If a metallic flexible armor or screen is incorporated in the cable, this is not to be used as the only protective conductor. The cable is to be suitable for the circuit protective arrangements.

Flexible cables are not permitted for portable equipment exposed to heavy mechanical stresses, for example hand-lamps, foot-switches, barrel pumps, etc.

***Note:***

Design and classification of the hazardous area is to be based on IEC Publication 60092-502. See 4-8-4/27.3.

# 19 Power Receptacles

Receptacles and plugs of different voltage systems are not to be interchangeable, e.g., receptacles for 230 V system are to be of a type which will not permit attaching 115 V equipment.

# 21 Cable Installation

## 21.1 General Requirements

### 21.1.1 Continuity *(2024)*

Electric cables are to be installed, as far as practicable, in continuous lengths between termination points. Where necessary, the use of cable junction boxes is acceptable; see 4-8-4/21.25. Cable splices and cable connectors will be permitted during construction for joining cables between modules, or when extending or truncating the lengths of cables during repair or alteration. See 4-8-4/21.23 and 4-8-4/21.26, respectively.

### 21.1.2 Restricted Locations

Cables are to be located with a view to avoiding, as far as practicable, spaces where excessive heat and flammable gases may be encountered, and also spaces where they can be exposed to mechanical damage. Cables are not to be installed in 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. Where this cannot be avoided, special measures are to be made for effective protection of cables. See also 4-8-4/21.1.9 and 4-8-4/21.15 , and 5C-2-3/31.13 for cables used for echo sounder, speed log and impressed current cathodic protection system in hazardous area.

### 21.1.3 Choice of Insulation

The rated operating temperature of the insulating material is to be at least 10°C higher than the maximum ambient temperature in the space where the cable is installed.

### 21.1.4 High Voltage Cable

Cables containing high voltage circuits (>1 kV) and cables for circuits of 1 kV or less are not to be installed on the same cable tray, or in the same bunch, duct or box.

### 21.1.5 Signal Cables

Except for fiber optic cables, non-shielded signal cables for control, monitoring and safety systems essential for propulsion and maneuvering of the vessel which can be affected by electromagnetic interference are not to be run in the same bunch with power or lighting cables.

### 21.1.6 Paint on Cables

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 4-8-3/9.5.

*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.

#### 21.1.7 Cable Installation above High Voltage Switchgear and Control-gear

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.

#### 21.1.8 Ultraviolet (UV) Light Protection for Wiring Insulation within Fluorescent Light Fixtures

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.

#### 21.1.9 Protection of Cables in Tanks *(2020)*

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 is acceptable 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.

*iv)* For cables terminating inside the tank, special type cable may be considered without protection provided supporting documents are appropriately reviewed.

### 21.3 Cable Current Carrying Capacity

Cables sized in accordance with the current carrying capacities of 4-8-3/15 TABLE 6, where installed on cable trays, are not to exceed double-banked. Cables sized in accordance with the current carrying capacities of 4-8-3/15 TABLE 6 are to be installed in such a manner as to provide sufficient air space around each cable to allow for heat dissipation. See also 4-8-2/7.7.1(c).

### 21.5 Cable Voltage Drop *(2024)*

Voltage drop at any point of the electrical installation is not to exceed 6% of the nominal voltage. For supplies from batteries with a voltage not exceeding 50 V this limit can be increased to 10%. Where the length of the cable installed is such that, while the conductors are carrying the maximum current under steady state condition of service, this voltage drop limit is exceeded, the cable size is to be increased appropriately reduce the voltage drop. See also 4-8-2/7.7.1.

### 21.7 Protection for Electric-magnetic Induction

#### 21.7.1 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.

#### 21.7.2 Single Conductor Cables

As far as possible, twin or multi-conductor cables are to be used in AC power distribution systems. However, where it is necessary to use single-conductor cables in circuits rated more than 20 A, arrangements are to be made to account for the harmful effect of electromagnetic induction as follows:

*i)* The cable is to be supported on non-fragile insulators;

*ii)* The cable armoring (to be non-magnetic, see 4-8-3/9.11) or any metallic protection (non-magnetic) is to be earthed at mid span or supply end only;

*iii)* There is to be no magnetic circuits around individual cables and no magnetic materials between cables installed as a group; and

*iv)* As far as practicable, cables for three-phase distribution are to be installed in groups, each group is to comprise cables of the three phases (360 electrical degrees). Cables with runs of 30 m (100 ft.) or longer and having cross-sectional area of 185 mm$^2$ (365,005 circ. mils) or more are to be transposed throughout the length at intervals of not exceeding 15 m (50 ft.) in order to equalize to some degree the impedance of the three phase circuits. Alternatively such cables are to be installed in trefoil formation.

### 21.9 Cable Support

#### 21.9.1 General *(2021)*

Cables are to be installed and supported in ways to avoid chafing and undue stress in the cable. Cable supports and associated accessories are to be robust and are to be of materials that are corrosion-resistant or suitably treated to resist corrosion.

Single conductor cables run in triangulated patterns (or Trefoil Formation) for three phase systems susceptible to high short circuit conditions (i.e., cables from generator to switchboards) are not to be fastened with zip ties, cable ties or banding. Cable clamps or cleats rated for short circuit condition are to be used.

#### 21.9.2 Spacing for Cable Support

The distance between cable supports are to be suitably chosen according to the type of cable and the degree of vibration the installation is subjected to. In general, cables are to be supported and fixed at an interval not to exceed 400 mm (16 in.). For horizontal runs where cables are laid on tray plates, individual support brackets or hanger ladders, the distance between the fixing points can be up to 900 mm (36 in.), provided that there are supports with maximum spacing as specified above. This relaxation however does not apply to cable runs on weather decks where forces from sea water washing over the deck is expected.

Alternatively, cable support systems complying with a recognized standard other than IEC 60092-352 can be used where the installed cables also comply with that standard. Specifically, cable support systems meeting the requirements of IEEE 45 can be used where IEEE 45 cables are installed.

#### 21.9.3 Cable Ties (Including Zip Ties, Cable Ties and Banding)

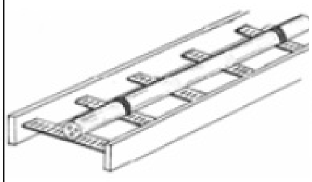
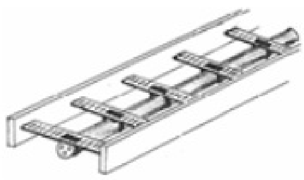
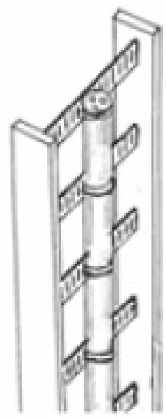
*21.9.3(a) Size.*

Cable ties are to have surface area so wide and shaped that the cables are fixed tight without their covering being damaged.

*21.9.3(b) Non-metallic materials.* *(2021)*

Cable ties made from approved materials other than metal (such as polyamide, PVC) can be used provided that they are flame-retardant in accordance with IEC Publication 60092-101. Where used for cables not laid on top of horizontal cable trays or similar, suitable metal cable ties are to be added at regular intervals not exceeding 2 m (6.5 ft) in order to prevent the release of cables during a fire. This requirement however need not be apply to one or up to a few small diameter cables connecting to lights, alarm transducers, etc.

The requirements for maximum distance between cable support in 4-8-4/21.9.2 and 4-8-4/21.9.3 are summarized in the following Table:

| *Cable Ties Maximum Installation Distances* | | | |
|---|---|---|---|
| | ↓ *Orientation* ↓ | | |
| | *Horizontal* | | *Vertical* |
| *Function* | *Fixing Only* | *Fixing and Support* | *Fixing and Support* |
| Example Installations | Cable support (400 mm max) provided by cable ladder  |  |  |
| Metallic Cable Ties | 900 mm | 400 mm | 400 mm |
| Non-metallic Cable Ties | 900 mm | 400 mm plus metal at least every 2 m | 400 mm plus metal at least every 2 m |

### 21.9.4 Plastic Cable Trays and Protective Casings

*21.9.4(a) Installations* . 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 4-8-4/21.9.3(b). Cable trays and protective casings made of plastic materials are to be flame retardant (see Appendix 4-8-4-A1). 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.

***Commentary:***

"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.

**End of Commentary**

*21.9.4(b) Safe Working Load.* 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 4-8-4-A1). In general, the spacing is not to exceed 2 meters.

***Notes:***

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.

*21.9.4(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.

*21.9.4(d) Hazardous areas*. Cable trays and protective casings passing through hazardous areas are to be electrically conductive (see Appendix 4-8-4-A1).

*21.9.4(e) Type Testing.* Cable trays and protective casings made of plastic materials are to be type-tested in accordance with Appendix 4-8-4-A1. 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 4-8-4-A1. The type test reports are to be submitted for review.

***Commentary:***

Requirements in 4-8-4/21.9 are based on IACS (UR) E16 “Cable trays/protective casings made of plastic materials” and IACS Recommendation no. 73 “Type approval procedure for cable trays/protective casings made of plastic materials”.

**End of Commentary**

## 21.11 Cable Bending Radii

Cable bending radii can adhere to manufacturer's recommendations or the cable construction standard. Notwithstanding that, the bending radii are to be in accordance with the following table:

<table>
<tr><th colspan="2">Cable Construction</th><th rowspan="2">Overall Diameter, D</th><th rowspan="2">Minimum Internal Bending Radius</th></tr>
<tr><th>Insulation</th><th>Outer Covering</th></tr>
<tr><td rowspan="6">Thermoplastic or thermosetting with circular copper conductor</td><td rowspan="2">Unarmored or unbraided</td><td>$D \leq 25$ mm (1 in.)</td><td>4 D</td></tr>
<tr><td>$D > 25$ mm</td><td>6 D</td></tr>
<tr><td>Metal braid screened or armored</td><td>Any</td><td>6 D</td></tr>
<tr><td>Metal wire or metal-tapearmored or metal-sheathed</td><td>Any</td><td>6 D</td></tr>
<tr><td>Composite polyester/metal laminate tape screened units or collective tape screening</td><td>Any</td><td>8 D</td></tr>
<tr><td>Thermoplastic or thermosetting with shaped copper conductor</td><td>Any</td><td>Any</td><td>8 D</td></tr>
<tr><td>Mineral</td><td>Hard metal-sheathed</td><td>Any</td><td>6 D</td></tr>
</table>

## 21.13 Deck and Bulkhead Penetrations

### 21.13.1 General

Where cables pass through watertight or fire-rated 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 materials are not to cause damage to the cable and are to be examined and tested as specified in 3-7-1/3.5.7 TABLE 1 and 4-8-4/29.15.

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

*21.13.1(a) New Construction* (1 July 2021)

A Cable Transit Seal Systems Register (Register) is to be provided by the shipbuilder for all watertight cable transits fitted to the vessel. The Register can be in either a hard copy or digitized media. It is to include a marking / identification system, documentation referencing manufacturer manual(s) for each type of cable transit installed, the Type Approval certification for each type of transit system, applicable installation drawings, and a recording of each installed transit documenting the as built condition after final inspection in the shipyard. It is to include sections to record any inspection, modification, repair and maintenance.

The Register is to be reviewed by the attending Surveyor to confirm it contains a list of the watertight cable transits, applicable cable transit information and sections to maintain in-service maintenance and survey records.

For manned vessels, the Register is to be held on board the vessel. For unmanned vessels, if a suitable storage location does not exist on board, the Register is to be held ashore. The Register is to be readily available to the attending Surveyor.

*21.13.1(b) Vessels in Service* (2024)

The owner or operator is to maintain the Register to record any disruption (repair, modification or opening out and closing) to a cable transit or to record the installation of a new cable transit.

***Commentary:***

The requirements in 4-8-4/21.13.1 are based on IACS Unified Requirement (UR) Z28 "Surveys of Watertight Cable Transits", .

**End of Commentary**

### 21.13.2 Structural Insulation

Cables are not to be installed behind, or imbedded in, structural insulation. They can, however, pass through such insulation at approximately right angle. The penetration design is to preserve the insulation rating. Cable conduit or recess integral with B or C class fire-walls can be used for installing cables for accommodation purposes subject to the following conditions:

*i)* Such fire-walls are of an approved type (e.g., by an Administration for meeting SOLAS), and

*ii)* Arrangements are made to prevent the propagation of smoke through the conduit.

### 21.13.3 Non-watertight Penetrations

When cables pass through non-watertight bulkheads, decks or structural members, the length of the bearing surface for the cable is to be at least 6.4 mm (0.25 in.). All burrs and sharp edges are to be removed in way of the penetration.

### 21.13.4 Collision Bulkhead

No cable is allowed to penetrate the collision bulkhead.

#### 21.13.5 Refrigerated Spaces

For penetration through insulated refrigerated space bulkheads, cables are to be installed in phenolic pipes or similar heat-insulating material. The pipe can be inserted through the bulkhead stuffing tube or joined directly to the bulkhead penetration piece.

### 21.15 Mechanical Protection for Cables

#### 21.15.1 General

Electrical cables exposed to risk of mechanical damage during normal operation of the vessel are to be of the type provided with metallic armor or otherwise suitably protected from mechanical injury.

#### 21.15.2 Additional Protection

Cables installed in locations such as within cargo holds, in way of cargo hatch openings, open decks subjected to seas, etc., even of the armored type, are to be protected by substantial metal shields, structural shapes, pipe or other equivalent means, which are to be of sufficient strength to provide effective protection to the cables. Metallic protections are to be electrically continuous and earthed to the hull. Non-metallic protections are to be flame retardant. Expansion bellows or similar where fitted are to be accessible for maintenance.

#### 21.15.3 Drainage

Cable protective casings, pipes, and similar fixtures are to be provided with drainage.

### 21.17 Installation of Cables and Apparatus for Emergency and Essential Services

#### 21.17.1 Emergency and Essential Feeders

As far as practicable, cables and wiring for emergency and essential services, including those listed in 4-8-4/1.9, are not to pass through high fire risk areas (see 4-8-4/1.11). For Emergency Fire Pumps, see requirements in 4-8-4/21.17.3.

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 can be caused by a fire in an adjacent space.

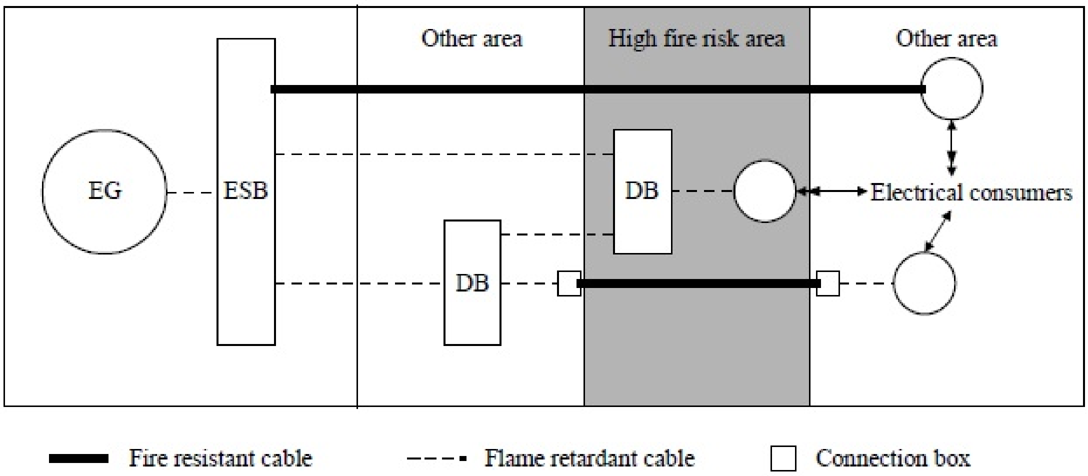
#### 21.17.2 Services Necessary under a Fire Condition

Where cables for services required to be operable under a fire condition (see 4-8-4/1.9) including their power supplies pass through high fire risk areas (see 4-8-4/1.11) 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 4-8-4/21.17.3. For passenger vessels, see 5C-7-5/13.7.2(a). This can be achieved by either of the following measures:

*21.17.2(a)*

Fire resistant cables in accordance with 4-8-3/9.7 are installed and run continuous to keep the fire integrity within the high fire risk area. See 4-8-4/21.17.2(a) FIGURE 1.

## FIGURE 1
## Cables within High Fire Risk Areas




*21.17.2(b)*

At least two routes/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.

*21.17.2(c)*

Systems that are self-monitoring, fail safe or duplicated with cable runs separated as widely as practicable, may be exempted from the requirements in 4-8-4/21.17.2(a) and 4-8-4/21.17.2(b).

#### 21.17.3 Electric Cables For The Emergency Fire Pump

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 4-8-3/9.7, where they pass through other high fire risk areas.

#### 21.17.4 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.

### 21.19 Mineral Insulated Cables

At all points where a 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 and, in addition, the conductors extending beyond the sheath are to be insulated with an approved insulating material. When a 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 manufacturers installation recommendation.

### 21.21 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.

### 21.23 Installation of Cable Splices

All splices are to be made with approved splice kit, see 4-8-3/9.19. No splice is permitted in hazardous areas, except for cables of intrinsically safe circuits. Neither is splice permitted in propulsion cables. Where permitted, the following installation details are to be complied with:

*i)* All splices are to be made after the cables are in place and are to be in locations accessible for inspection.

*ii)* The conductor splice is to be made using a pressure type butt connector by means of an one-cycle compression tool.

*iii)* Armored cables having splices are not required to have the armor replaced provided that the armor is made electrically continuous.

*iv)* Splices are to be so arranged that mechanical stresses are not carried by the splice.

Splicing of fiber optic cables is to be by means of mechanical or fusion methods as recommended by the manufacturer.

## 21.25 Installation of Cable Junction Boxes

Junction boxes can be employed to connect cables provided they are of approved design, see 4-8-3/9.21. Junction boxes are not to be used in propulsion cables. However, where junction boxes are permitted, the following installation details are to be complied with:

*i)* The junction box enclosures are to be suitable for the locations of installation.

*ii)* Junction boxes are to be in locations accessible for inspection.

*iii)* For low voltage systems (50 V, 110 V, etc. up to 1 kV AC, see 4-8-3/7.3.1), each voltage level is to be provided with its own junction box or separated by physical barriers within the same junction box. For high voltage systems (> 1 kV) a separate junction box is to be used for each of the voltage levels.

*iv)* Emergency circuits and normal circuits are not to share the same junction box.

*v)* Armored cables are to have their armoring made electrically continuous.

*vi)* Cables arranged for connection at a junction box are to be well-supported and fastened so that conductor contacts are not subjected to undue stress.

## 21.26 Installation of Cable Connectors *(2019)*

Cable connectors can be employed to connect cables, provided they are of approved design. See 4-8-3/9.23. Cable connectors are not to be used in essential services or for high voltage cables having a rated voltage exceeding 1 kV. Where permitted, the following installation details are to be complied with:

*i)* Cable connectors are to be suitable for the locations of installation in accordance with the designated IP degree for the configuration of connector and cable combined.

*ii)* Cable connectors are not to be installed in bilge space nor in hazardous area.

*iii)* Cable connectors are to be arranged after the cables are in place and are to be in locations accessible for inspection.

*iv)* Cable connector is to be arranged at a location where the prospected short circuit current at the circuit does not exceed the short circuit current capacity of the connector.

*v)* Armored cables are to have their armoring made electrically continuous at the connector or the cable armor is appropriately earthed.

*vi)* Cable connectors are to be rated for the voltage, current, and short circuit current expected in the system at the connection points.

*vii)* Cables arranged for connection with cable connector are to be well-supported and fastened so that conductor contacts are not subjected to undue stress.

### 21.27 Cable Termination

Cables stripped of 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. Cable conductors for connection to terminals are to be fitted with crimp lugs of corresponding current rating, or equivalent. Soldered lugs are permitted for conductors up to 2.5 $mm^2$ only. Cables are to be secured to the terminal box or other sturdy structure in such a manner that stresses are not transmitted to the terminal. Cable's moisture resistant jacket is to extend through the outermost cable clamp of the terminal box. Where applicable, other properties of the cable, e.g. flame retarding, fire resistant, etc. are to be retained through to the terminal box.

## 22 Busbar Trunking System Installation *(1 July 2021)*

### 22.1 Component Requirements

#### 22.1.1 Ambient Temperatures

Temperatures are to be considered in the range from 0 to 45 °C.

#### 22.1.2 Protection Against Foreign Bodies and Water

Systems are to be designed to comply with the following minimum degrees of protection:

*i)* Dry spaces, IP 54

*ii)* Wet spaces, IP 56

#### 22.1.3 Mechanical Design

The system is to be designed to withstand a vibration level of 1 mm amplitude in the frequency range of 2 Hz to 13.2 Hz and of 0.7g acceleration in the frequency range of 13.2 Hz to 10.0 Hz

The arrangement is to be suitable for automatic draining where condensation is possible.

The enclosure of the system is to be designed to be sufficiently robust, or alternatively additionally protected, to withstand normal mechanical forces which can be expected on board ships.

#### 22.1.4 Fire Protection, Bulkhead and Deck Penetrations

The complete system is to comply with the fire test requirements as specified in IEC 60332-1-1 & IEC 60332-1-2. Bulkhead and deck penetrations are to conform to categories laid down by SOLAS and are not to impair the mechanical, watertight and/or fire integrity of the bulkheads or decks through which they pass.

The internal arrangements of the ducts are to have the same fire integrity arrangements as the divisions which they pierce.

### 22.3 System Requirements

#### 22.3.1 Installation Configuration

Redundant essential consumers are to be supplied by separate systems. The installation is to be such that a failure in one system does not impair the operation of the redundant one.

Where a system is arranged below the uppermost continuous deck, the vessel’s maneuverability as well as the safety of the crew and passengers are not not be impaired in the event of one or more watertight compartments outside the engine room being flooded.

Main and emergency supplies are not to be installed in a common duct.

The system is to be fitted with means for separation to enable maintenance works and the segregation of damaged parts.

Where systems are led through fire sections, the separation units should be installed on the supply side.

#### 22.3.2 Protection Devices

The propagation of electric arcs along the busbars should be prevented by arc barriers or other suitable means, such as, in the case of systems with uninsulated busbars, the use of current limiting circuit breakers.

### 22.5 Tests

#### 22.5.1 Type Testing

The following tests are to be carried out, as a minimum, on a typical and representative sample:

*i)* Temperature rise test in accordance with IEC 61439-6

*ii)* Short-circuit strength test in accordance with IEC 61439-6

*iii)* Verification of resistance and reactance in accordance with IEC 61439-6

*iv)* Verification of structural strength in accordance with IEC 61439-6

*v)* Insulation resistance test for main and auxiliary circuits in accordance with 4-9-9/15.7 TABLE 1, item no.7

*vi)* High-voltage test for main and auxiliary circuits in accordance with 4-9-9/15.7 TABLE 1, item no.8

*vii)* Vibration test in accordance with 4-9-9/15.7 TABLE 1, item no.5

*viii)* Bulkhead and deck penetrations tests in accordance with IMO Res. MSC.307(88)

*ix)* Fire test in accordance with IEC 60332-1-1 & 60332-1-2

*x)* Verification of protection degree in accordance with IEC 60529

*xi)* EMC tests in accordance with 4-9-9/15.7 TABLE 1, item no. 11 to 18, where electronic devices form part of the system

#### 22.5.2 Onboard Survey *(2024)*

The installation of the system is to be to the satisfaction of the Surveyor and according to documentation and installation requirements.

***Commentary:***

The above requirements in 4-8-4/22 are based on IACS recommendation no. 67 “Test and installation of busbar trunking systems” arranged outside of switchboards for supplying section and/or distribution boards or consumers, instead of cables.

**End of Commentary**

## 23 Equipment Earthing

### 23.1 General Requirements

#### 23.1.1 Equipment

For protection against electrical shock, exposed metal parts of electrical machine 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 machine or equipment is:

*i)* Supplied at a voltage not exceeding 50 V (DC or 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) by safety isolating transformers supplying only one consuming device; or

*iii)* Constructed in accordance with the principle of double insulation.

#### 23.1.2 Cables

Metallic armor of cables and metallic sheath of mineral-insulated, metal-sheathed cables 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 can 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.

#### 23.1.3 Receptacles

Receptacles operating at more than 50 V are to have an earthing pole. Attachment plugs for non-permanently fitted equipment operating at more than 50 V are to have an earthing pole and an earthing conductor in the portable cord to earth the dead metal parts of the equipment.

### 23.3 Earthing Methods

The metal frames or enclosure of permanently installed electrical equipment may be earthed through metallic contact with the vessel's structure where the arrangement and method of installation assure positive earthing. Otherwise, they are to be connected to the hull by a separate conductor as follows:

*i)* Earthing conductor is to be of copper or other corrosion resistant material.

*ii)* The nominal cross-sectional area of every copper earthing conductor is to be not less than that required by 4-8-4/25 TABLE 1.

*iii)* Connection of an earthing conductor to the hull is to be made in an accessible location, protected from mechanical damage, and secured by a screw of corrosion-resistant material having cross-sectional area equivalent to the required earthing conductor but, in any case, not less than 4 mm (0.16 in.) in diameter.

### 23.5 Lightning Earth Conductors

Each wooden mast or topmast is to be fitted with lightning earth conductors. They need not be fitted to steel masts.

## 25 System Earthing

System earthing is to be in accordance with 4-8-2/7.5 for low voltage system, and with 4-8-5/3.3.1 for high voltage system. Earthing method as described in 4-8-4/23.3 is to be complied with.

### TABLE 1
### Size of Earthing Conductors (Equipment and System Earthing)

| *Type of Earthing Connection* | | *Cross-sectional Area, A, of Associated Current Carrying Conductor* | *Minimum Cross-sectional Area of Copper Earthing Connection* |
|---|---|---|---|
| Earth-continuity conductor | A1 | $A \leq 16$ mm$^2$ | $A$ |
| in flexible cable or | A2 | 16 mm$^2$ $< A \leq 32$ mm$^2$ | 16 mm$^2$ |
| flexible cord | A3 | $A > 32$ mm$^2$ | $^{A}/_{2}$ |

<table>
<tr><th colspan="2">Type of Earthing Connection</th><th>Cross-sectional Area, A, of Associated Current Carrying Conductor</th><th>Minimum Cross-sectional Area of Copper Earthing Connection</th></tr>
<tr><td rowspan="8">Earth-continuity conductor incorporated in fixed cable</td><td colspan="3">For cables having an insulated earth-continuity conductor</td></tr>
<tr><td>B1a</td><td>$A \leq 1.5\ \text{mm}^2$</td><td>$1.5\ \text{mm}^2$</td></tr>
<tr><td>B1b</td><td>$1.5\ \text{mm}^2 < A \leq 16\ \text{mm}^2$</td><td>$A$</td></tr>
<tr><td>B1c</td><td>$16\ \text{mm}^2 < A \leq 32\ \text{mm}^2$</td><td>$16\ \text{mm}^2$</td></tr>
<tr><td>B1d</td><td>$A > 32\ \text{mm}^2$</td><td>$^A/_2$</td></tr>
<tr><td colspan="3">For cables with bare earth wire in direct contact with the lead sheath</td></tr>
<tr><td>B2a</td><td>$A \leq 2.5\ \text{mm}^2$</td><td>$1\ \text{mm}^2$</td></tr>
<tr><td>B2b</td><td>$2.5\ \text{mm}^2 < A \leq 6\ \text{mm}^2$</td><td>$1.5\ \text{mm}^2$</td></tr>
<tr><td rowspan="5">Separate fixed earthing conductor</td><td>C1a</td><td rowspan="2">$A \leq 3\ \text{mm}^2$</td><td>Stranded earthing connection:<br>$1.5\ \text{mm}^2$ for $A \leq 1.5\ \text{mm}^2$<br>$A$ for $A > 1.5\ \text{mm}^2$</td></tr>
<tr><td>C1b</td><td>Unstranded earthing connection:<br>$3\ \text{mm}^2$</td></tr>
<tr><td>C2</td><td>$3\ \text{mm}^2 < A \leq 6\ \text{mm}^2$</td><td>$3\ \text{mm}^2$</td></tr>
<tr><td>C3</td><td>$6\ \text{mm}^2 < A \leq 125\ \text{mm}^2$</td><td>$^A/_2$</td></tr>
<tr><td>C4</td><td>$A > 125\ \text{mm}^2$</td><td>$64\ \text{mm}^2$, see Note 1</td></tr>
</table>

*Note:*

1 For earthed distribution systems, the size of earthing conductor is not to be less than $^A/_2$.

## 27 Electrical Equipment in Hazardous Areas

### 27.1 General *(2024)*

Hazardous areas are spaces where flammable or explosive gases, vapors or dust are normally present, or likely to be present. Hazardous areas are to be classified based on the likelihood of presence and the concentration and type of flammable atmosphere, as well as in terms of the extent of the space. Electrical equipment is not to be installed in hazardous areas unless it is essential for safety or for operational purposes. Where the installation of electrical equipment in such location is necessary, it is to be selected based on its suitability for the hazardous area so classified. Such equipment is to be as specified in the appropriate sections of the Rules, as indicated below.

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.

Ventilation for hazardous areas is to be completely separate from that for non-hazardous areas.

Fans used for the ventilation of the hazardous areas are to be of non-sparking construction in accordance with 4-8-3/11.

***Commentary:***

The standard atmospheric conditions defined in IEC Publication 60079-0 relate to the explosion characteristics of the atmosphere and not the operating range of the equipment.

**End of Commentary**

## 27.3 Hazardous Areas

### 27.3.1 General

The following spaces are, in general, to be regarded as hazardous areas:

*i)* Tanks containing flammable liquids having a flash point of 60°C (140°F) or below.

*ii)* Holds containing solid bulk cargoes liable to release flammable gases or dust.

*iii)* Holds or enclosed cargo spaces containing cargoes that are likely to emit flammable gases or vapors (e.g. dangerous goods, vehicles with fuel in their tanks, etc.)

*iv)* An enclosed or semi-enclosed space:

- Having a direct access or opening into the hazardous areas defined in i), ii) or iii), through a door, a ventilation opening, etc.;
- Immediately adjacent to the hazardous areas defined in i); or
- Containing pumps or piping used for conveying liquid described in i).

*v)* A defined zone in open space:

- 3 m (10 ft) from an opening to the hazardous areas defined in i), ii), iii) or iv), such as a door, a ventilation opening, a tank vent, etc., unless as otherwise indicated in 4-8-4/27.3.2 and 4-8-4/27.3.3;
- Immediately adjacent to the hazardous area defined in i); or
- In way of pumps or piping used for conveying liquid described in i).

### 27.3.2 Specific Vessel Types *(2025)*

Due to the nature of the cargoes carried, or the types of operation performed at sea, hazardous areas are defined for the following vessel types in the appropriate sections of the Rules:

*i)* Oil carriers carrying crude oil or refined oil products having a flash point of 60°C (140°F) or below. See 5C-2-3/31.

*ii)* Bulk carriers carrying coal or other dangerous cargoes in bulk. See 5C-3-7/3.

*iii)* Container carriers or dry cargo vessels carrying dangerous goods or vehicles with fuel in their tanks. See 5C-5-7/3.

*iv)* Roll-on/roll-off vessels carrying vehicles with fuel in their tanks. See 5C-10-4/3 and 5C-10-4/5.

*v)* Liquefied gas carriers carrying flammable gases. See 5C-8-1/2.24.

*vi)* Chemical carriers carrying flammable liquid having a flash point of 60°C or below. See 5C-9-10/1.4.

*vii)* Drilling vessels performing exploratory or production drilling of hydrocarbon deposits. See 8-2-1/13 of the ABS *Offshore Rules*.

*viii)* Floating hydrocarbon production facilities. See the ABS *Rules for Building and Classing Offshore Units*.

*ix)* Vessels Using Gases or other Low-Flashpoint Fuels. See 5C-13-12/5.

*x)* Vessels with hybrid electric power systems. See ABS *Requirements for Hybrid Electric Power Systems for Marine and Offshore Applications*.

### 27.3.3 Miscellaneous Spaces *(2024)*

Hazardous areas for the miscellaneous spaces in this subsection are subdivided into Zones 1 and 2 defined as follows according to IEC 60079-10 and IEC 60092-502:

- Zone 1, A zone in which ignitable concentrations of flammable gases or vapors are likely to occur in normal operating conditions.
- Zone 2, A zone in which ignitable concentrations of flammable gases or vapors are not likely to occur, and if they occur will exist only for a short time.

The following spaces are to be regarded as hazardous areas:

*27.3.3(a) Paint stores. (2024)*

*i)* Hazardous Areas Zone 1

- Within the paint store;
- Ventilation ducts serving such spaces if any.

*ii)* Hazardous Areas Zone 2

- Open deck area within 1 m (3 ft) from inlet and natural ventilation outlet;
- Open deck area within 3 m (10 ft) from power ventilation outlet.

Enclosed spaces giving access to the paint store can be considered as non-hazardous, 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.

***Commentary:***

A watertight door may be considered as being gastight.

**End of Commentary**

*27.3.3(b) Battery rooms. (2024)*

*i)* Hazardous Areas Zone 1:

- Within the battery room;
- Ventilation ducts serving such spaces if any.

*ii)* Hazardous Areas Zone 2:

- Open deck area within 1 m (3 ft) from inlet and natural ventilation outlet,
- Open area within 3 m (10 ft) from power ventilation outlet. See 4-8-4/5.3.1.

*27.3.3(c) Helicopter refueling facilities. (2024)*

*i)* Hazardous Areas Zone 1:

- Enclosed space containing components of the refueling pump/equipment;

*ii)* Hazardous Areas Zone 2:

- Open deck area within 1 m (3 ft) from inlet natural ventilation outlet enclosed space containing refueling pump/equipment,
- Open deck area within 3 m (10 ft) from ventilation outlet of enclosed space containing refueling pump/equipment,
- 3 m (10 ft) from tank vent outlet,
- 3 m (10 ft) from refueling pump/equipment.

*27.3.3(d) Acetylene storage room.* *(2024)*

***i)*** Hazardous Area Zone 1:

- Within the storage room;
- Ventilation ducts serving such spaces if any.

***ii)*** Hazardous Areas Zone 2:

- Open deck area within 1 m (3 ft) from inlet and natural ventilation outlet;
- Open area within 3 m (10 ft) from power ventilation outlet. See 4-6-7/7.3;
- Open area within 3 m (10 ft) of the gas cylinders pressure relief device discharge outlet. See 4-6-7/7.5.4.

*27.3.3(e) Heated Fuel Oil Service and Settling Tank.* *(2024)*

***i)*** Hazardous Areas Zone 2:

- The area within 3 m (10 ft) of the outlet of the vent pipes of Fuel Oil Tanks in the supply system where the tanks are heated and the length of the vent pipes from the tank top to the vent outlet is not sufficient for cooling the vapors to below 60°C. See 4-6-4/13.5.7.

***Commentary:***

Provisions of 4-6-4/13 apply to fuel oils having a flash point (closed cup test) above 60°C (140°F). Fuel oil in storage tanks is not to be heated within 10°C (18°F) below its flash point as per 4-6-4/13.5.7(a).

**End of Commentary**

## 27.5 Certified Safe Equipment in Hazardous Areas

### 27.5.1 General *(2024)*

Only certified safe electrical equipment of the following types complying with IEC Publication 60079 series, or other recognized standards, as described in 4-8-3/13 is to be considered for installation in hazardous areas.

| *Type* | *Symbol* | *Typical Zones* | *IEC standard* |
|---|---|---|---|
| Intrinsically safe type | Ex ia | 0,1,2 | IEC60079-11 |
| | Ex ib | 1,2 | IEC60079-11 |
| Flameproof type | Ex d | 1,2 | IEC60079-1 |
| Increased safety type | Ex e | 1,2 | IEC 60079-7 |
| Pressurized or purged type | Ex p | 1,2 | IEC60079-2 |
| Encapsulated type | Ex m | 1,2 | IEC 60079-18 |
| Sand (powder) filled type | Ex q | 1,2 | IEC 60079-5 |
| Oil-immersed type | Ex o | 1,2 | IEC 60079-6 |
| Special protection type | Ex s | 1,2 | IEC60079-33 |

| *Type* | *Symbol* | *Typical Zones* | *IEC standard* |
|---|---|---|---|
| Protection type "n" | Ex n | 2 | IEC 60079-15 |
| Simple apparatus | NA | 0,1,2 | IEC60079-11 and 60079-14 |

*Notes:*

**1** Simple electrical apparatus and components of simple construction with well-defined electrical parameters and which is compatible with the intrinsic safety of the circuit in which it is used (e.g., passive components such as switches, junction boxes, resistors and simple semiconductor devices; sources of stored energy consisting of single components in simple circuits with welldefined parameters, for example capacitors or inductors, whose values are to be considered when determining the overall safety of the system; sources of generated energy, for example thermocouples and photocells, which do not generate more than 1.5 V, 100 mA and 25 mW. Refer to IEC Publications 60079-11 and 60079-14)

**2** Other types of protection, selected in accordance with the requirements of IEC Publications 60092-502 and 60079-14, can be considered

**3** Consideration is to be given to the flammability group and the temperature class of the equipment for suitability for the intended hazardous area, see ISO/IEC 80079-20-1and 4-8-3/13.5

**4** Where equipment is required to be of a certified safe type, evidence is to be furnished that the equipment has been certified by an appropriate authority to confirm its safety with regard to explosion hazard when used in the relevant explosive atmosphere.

**5** Verification of Ex certified equipment suitability is to include checking that special conditions for safe use given in the Ex certificates are complied with.

### 27.5.2 Paint Stores *(2024)*

Electrical equipment installed in paint stores hazardous areas Zone 1 can be one of the following types: intrinsically safe (Ex i), flameproof (explosion-proof) (Ex d), increased safety (Ex e), pressurized or purged (Ex p) and special protection (Ex s) indicated in 4-8-4/27.5.1 and is to be at least ISO/IEC 80079-20-1 group IIB class T3.

In defined hazardous areas Zone 2 on open deck outside paint stores, the following electrical equipment can be installed:

- Electrical equipment with the type of protection as permitted in paint stores Zone 1 areas;
- Eequipment of protection class Exn;
- Electrical equipment with IP 55 enclosure or better, whose surfaces do not reach unacceptable high temperature.

***Commentary:***

The above requirement is based on IACS Unified Requirement (UR) E12 "Electrical equipment allowed in paint stores and in the enclosed spaces leading to the paint stores"

**End of Commentary**

### 27.5.3 Battery Room *(2024)*

Electrical equipment installed in the battery room is to be ISO/ IEC 80079-20-1 Group IIC Class T1 and can be any of the types suitable for Zone 1 hazardous area as indicated in 4-8-4/27.5.1.

### 27.5.4 Acetylene Storage Room *(2024)*

Electrical equipment installed in the acetylene storage room is to be ISO/IEC 80079-20-1 Group IIC Class T2 and can be any of the types suitable for Zone 1 hazardous area as indicated in 4-8-4/27.5.1.

In explosive gas atmospheres containing acetylene, equipment protection by flameproof (explosion proof) enclosures "Ex d" for external mounting, where constructed of copper or copper alloys is to be:

*i)* Coated with tin, nickel, or other coating; or

*ii)* Alternatively the maximum copper content of the alloy is to be limited to 60%.

Flameproof entry devices are not considered an enclosure surface requiring coating or copper content restriction.

#### 27.5.5 Helicopter Refueling Facilities *(2024)*

Electrical equipment installed in areas defined for helicopter refueling facilities is to be at least ISO/IEC 80079-20-1 Group IIA Class T3 and can be any of the types suitable for Zone 1 hazardous area as indicated in 4-8-4/27.5.1.

#### 27.5.6 Heated Fuel Oil Service and Settling Tank *(2024)*

Electrical equipment is not to be fitted in the vapor space of the tanks, unless it is certified to be intrinsically safe, see 4-6-4/13.5.7.iv.

#### 27.5.7 Other Spaces *(2025)*

Electrical equipment allowable in hazardous areas defined in 4-8-4/27.3.2 is given in appropriate sections in Part 5C of these Rules and the ABS *Rules for Building and Classing Offshore Units*.

### 27.7 Intrinsically-safe Systems

#### 27.7.1 Installation of Cables and Wiring

*27.7.1(a) General*. 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.

*27.7.1(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 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.

*27.7.1(c) (2020)*

For separation distances of different (separate) intrinsically safe circuits in terminal boxes, the requirements in IEC 60079-14 , and IEC 60079-11, Clause 6.21, are to be complied with.

*27.7.1(d)* (2020)

The segregation between the intrinsically safe wiring terminals and between bare conducting parts of connection facilities are to comply with IEC 60079.

### 27.7.2 Arrangements of Common Enclosure

*27.7.2(a) 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.

*27.7.2(b) 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.

*27.7.2(c) 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.

## 27.9 Cables in Hazardous Areas

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 4-8-4/21.15. Where cables pass through boundaries of such locations, they are to be run through gastight fittings. No splices are allowed in hazardous areas, except in intrinsically safe circuits.

## 27.11 Lighting Circuits in Hazardous Areas

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 can 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 swtiches need not to open the grounded conductor. The switches and protective devices for lighting fixtures are to be suitably labeled for identification purposes.

## 27.13 Permanent Notice and Booklet of Certified Safe Equipment

A booklet containing the list of certified safe equipment, as installed, along with the particulars of the equipment (see 4-8-1/5.3.2), is to be maintained on board. Permanent notices are to be posted in the vicinity of hazardous areas in which such electrical equipment is installed to advise crew of the availability of the booklet so that it can be reference during repair or maintenance.

# 29 Shipboard Tests

## 29.1 General

Upon completion of the installation, electrical systems are to be tested under working conditions to the satisfaction of the Surveyor.

## 29.3 Generators

Each generator is to be operated for a time sufficient to show satisfactory operation, individually and in parallel, and with all possible load combinations.

## 29.5 Switchboards

Generator protective devices e.g., over load protection, reverse power protection, under voltage protection, preferential trip, and auxiliary motor sequential starting, as applicable are to be tested.

## 29.7 Motors

Each motor is to be operated for a time sufficient to show satisfactory performance at such load as can readily be obtained.

## 29.9 Interior Communications System

Satisfactory operation of the interior communications system as required by 4-8-2/11.5 is to be demonstrated. Particular attention is to be paid to the voice communication system for its audibility while the vessel is underway.

## 29.11 Voltage Drop Measurement

Voltage drop along power and lighting cables is to be measured. Voltage drop at any part of the installation is not to exceed the limits specified in 4-8-2/7.7.1(d).

## 29.13 Insulation Resistance Measurements *(2024)*

Insulation resistance of power and lighting cables is to be measured. Appliances connected to the circuits are to be disconnected for this test. Each power and each lighting circuit is to have an insulation resistance between conductors and between each conductor and earth of not less than the following values.

| *Load (A)* | *Insulation Resistance (MΩ)* |
|---|---|
| ≤ 5 | 2 |
| ≤ 10 | 1 |
| ≤ 25 | 0.4 |
| ≤ 50 | 0.25 |
| > 50 | 0.10 |

Cable insulation resistance is to be measured using a direct current insulation tester by applying a DC voltage of 500 V. For cables with normal operating voltage less than 100V, a DC insulation tester of appropriate voltage is to be used. For cables with normal operating voltage more than 500V, the DC insulation tester is to apply a DC voltage equal to the cables normal operating voltage.

***Commentary:***

The above test is applicable for complete power and lighting circuits and is not meant for isolated cables that are disconnected from equipment at both ends.

End of Commentary

## 29.15 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 3-7-1/3.5.7 TABLE 1.

# 31 Guidance for Spare Parts

While spare parts are not required for class, the spare parts listed below are for unrestricted service and are provided as a guidance to assist in ordering spare parts for the intended service. The maintenance of spare parts aboard each vessel is the responsibility of the owner.

## 31.1 Spare Parts of Electrical Equipment

One complete set of bearings for each size and type of generator and motor.

## 31.3 Measuring Instrument

A 500 V insulation-resistance measuring instrument (megger).

# PART 4

## CHAPTER 8
## Electrical Systems

## SECTION 4
## Appendix 1 - Guidance for Type Test Procedure for Plastic Cable Tray and Protective Casing

## 1 General *(2024)*

Cable trays and protective casings made of plastic materials are to be type-tested in accordance with Appendix 4-8-4-A1, as per 4-8-4/21.9.4. 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 in lieu of the tests specified in Appendix 4-8-4-A1.

This Appendix includes requirements for type test procedure to verify conformance to goals and functional requirements outlined in the cross referenced sections.

***Commentary:***

Requirements in this section are based on IACS Recommendation no. 73 "Type approval procedure for cable trays/protective casings made of plastic materials"

**End of Commentary**

## 3 General Design Requirements

### 3.1 Ambient Temperatures

Cable trays and protective casings are to be designed for the following ambient temperatures:

–25°C to 90°C for outdoor use

+5°C to 90°C for indoor use.

***Note:***

Consideration will be given to the use of plastic cable trays and protective casings in cold environments where the ambient temperature is below –25°C, provided the mechanical properties of the plastics required for the intended purpose and location of installation can be maintained at such temperatures. In this particular instance, the cold bend and cold impact properties of the material are also to be considered.

### 3.3 Test Temperature

#### 3.3.1 Impact Test *(2024)*

Impact tests are to be carried out at the lowest (coolest) of the following temperatures:

*i)* lowest (coolest) range of the outdoor ambient, where applicable,

*ii)* lowest (coolest) range of the indoor ambient, where applicable, or

*iii)* any other temperature specified by the manufacturer.

#### 3.3.2 Safe Working Load (SWL) Test

At the option of the manufacturer, the SWL tests are to be carried out in any of the following conditions:

*i)* at any temperature within the declared range if documentation is available which states that the relevant structural properties of the materials as used within the system do not differ by more than 5% of the average between the maximum and minimum property values,

*ii)* only at the maximum temperature within the range if documentation is available which states that the relevant structural properties of the materials, as used within the system, decrease when the temperature is increasing, or

*iii)* at the maximum and minimum temperature only.

In all instances, the tests are to be carried out for the smallest and largest sizes of cable tray lengths or cable ladder lengths, having the same material, joint and topological shape.

### 3.5 Safe Working Load

Cable tray and protective casings are to be assigned a Safe Working Load, in accordance with 4-8-4-A1/5.3.

## 5 Mechanical Requirements

### 5.1 Impact Resistance Test

The test is to be performed in accordance with IEC 60068-2-75 using the pendulum hammer.

*i)* The test is to be carried out on test samples of cable tray lengths or cable ladder lengths of 250 mm ±5 mm long. Test samples of ladder are to consist of two side-members with one rung positioned centrally. Test sample of mesh trays is to be prepared in such a way that there will be a wire in the center.

*ii)* Before the test, plastic components are to be aged at a temperature of 90°C ±2°C for 240 hours continuously.

*iii)* The test sample is to be mounted on wooden fiberboard of thickness 20 mm ±2 mm.

*iv)* The test sample to be tested is to be placed in a refrigerator, the temperature within which is maintained at the test temperature in accordance with 4-8-4-A1/3.3.1 above with a tolerance of ±2°C.

*v)* After 2 h, the test sample is to be removed from the refrigerator and immediately placed in the test apparatus.

*vi)* At 10 s ±1 s after removal of each test sample from the refrigerator, the hammer is to be allowed to fall with impact energy, the mass of the hammer and the fall height:

| *Approximate Energy (J)* | *Mass of Hammer (kg)* | *Fall Height (mm)* |
|---|---|---|
| 10 | 5.0 | 200 ± 2 |

*vii)* The impact is to be applied to the base or the rung in the first test sample, to one of the side members in the second test sample, and to the other side member in the third test sample. In each case, the impact is to be applied to the center of the face being tested.

*viii)* After the test, the test sample is to show no signs of disintegration and/or deformation that will impair safety.

## 5.3 Safe Working Load (SWL) Test

*i)* Cable trays and protective casings and joints are to be assigned a Safe Working Load (SWL) satisfying the following criteria and to be tested at the test temperatures according to 4-8-4-A1/3.1 and 4-8-4-A1/3.3.2 above:

- The maximum deflection under SWL is not to exceed $L/100$, where $L$is the distance between the supports, and
- No mechanical defects or failures are observed when tested to 1.7 ×SWL.

*ii)* All loads are to be uniformly distributed over the length and width of the test samples, as shown in 4-8-4-A1/5.3 FIGURE 1.

The loads are to be applied in such a way that a uniform distribution is maintained even in the case of extreme deformation of the test samples.

To allow for settlement of the test samples, a pre-load of 10% of SWL, unless otherwise specified, is to be applied and held for at least five (5) minutes, after which the measurement apparatus is to be calibrated to zero.

*iii)* Then, the load is to be gradually increased evenly, longitudinally and transversely up to the SWL continuously. When a continuous increase is impractical, the load can be increased by increments. These increments are not to exceed about a quarter of the SWL. The load increments are to be distributed through the load plates longitudinally and transversely as evenly as is practical.

*iv)* After loading, the deflection is to be measured at the points specified to give a practical mid-span deflection.

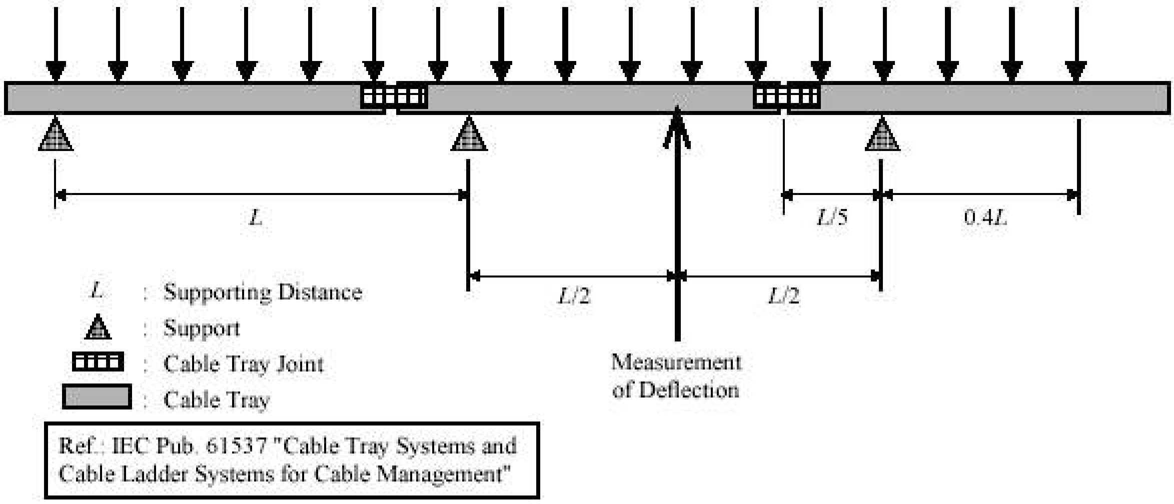
*v)* The test sample with load is to be left and the deflections measured every five (5) minutes until the difference between two consecutive sets of readings becomes less than 2% of the first set of the two readings. The maximum deflection for the purpose of 4-8-4-A1/5.3.i is the first set of the readings measured at this point under the test load.

*vi)* When subject to SWL, the test sample, their joints and internal fixing devices are to show no damage or crack visible to normal view or corrected vision without magnification.

*vii)* Then, the load is to be increased to l.7 times SWL.

The test sample with the load are to be left and the deflections measured every five (5) minutes until the difference between two consecutive sets of readings becomes less than 2% of the first set of the two readings. The test sample is to sustain the increased loading without collapsing. However, buckling and deformation of the test sample are allowable at this excess loading.

**FIGURE 1**
**SWL Loading Test Procedure**




# 7 Fire Properties

## 7.1 Flame Retardant Test

The cable trays and protective casings are to be at least flame retardant. They are to be tested in accordance with the following Table.

| *Procedure According To* | *Test Parameters* | *Other Information* |
|---|---|---|
| IEC Publication 60092-101, or IEC Publication 60695-11-5 | – *Flame application:* 5 times 15 sec each. – *Interval between each application:* 15 sec., or 1 time 30 sec. Test criteria based upon application. | – The burnt out or damaged part of the test sample by not more than 60 mm long. – Equipment design and the choice of materials are to reduce the likelihood of fire, ensuring that the surfaces of the test sample do not contribute to the fire growth where they are exposed to the flame. |

## 7.3 Smoke and Toxicity Test

The cable tray and protective casings are to be tested in accordance with the IMO Fire Test Procedures Code (FTPC), Resolution MSC.307(88), Part 2 —Smoke and Toxicity Test, or any international or national standard.

# 9 Electrical Properties

## 9.1 Resistivity Test *(2020)*

Cable trays and protective casings passing through a hazardous area are to be electrically conductive.

The volume resistivity level of the cable trays and protective casings and fittings are to be below 100kΩm ($1\times10^5$Ωm) and the surface resistivity is to be below 100 MΩ ($1\times10^8$Ω). The cable tray and protective casings are to be tested in accordance with IEC 62631-3-1 and IEC 62631-3-2.

*Note:* The resistance to earth from any point in these appliances is not to exceed 1 MΩ ($1\times10^6$Ω).

# PART 4

## CHAPTER 8
## Electrical Systems

## SECTION 5
## Special Systems

## 1 Application *(2024)*

The provisions of this Section apply to (a) high voltage systems; (b) electric propulsion systems; and (c) three-wire dual-voltage DC systems; and (d) electric plants of less than 75 kW; (e) energy storage systems. Unless stated otherwise, the applicable requirements of 4-8-4 are also to be complied with.

### 1.1 Objective *(2024)*

#### 1.1.1 Goals

The electrical systems addressed in this Section are to be designed, constructed, operated, and maintained to:

| *Goal No.* | *Goal* |
|---|---|
| PROP 1 | Provide sufficient thrust/power to move or maneuver the vessel when required |
| PROP 2 | Provide redundancy and/or reliability to maintain propulsion |
| POW 2 | Provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel. |
| POW 3 | Enable *all electrical services necessary for maintaining the vessel in normal operational and habitable conditions to be available without recourse to the emergency source of power*. |
| POW 4 | Enable all *electrical services* required *for safety* to be available during *emergency conditions*. |
| POW 5 | Enable supply/power for essential services to be restored after malfunction |
| FIR 1 | *Prevent the occurrence of fire and explosion.* |
| SAFE 1-1 | Minimize danger to persons on board, the vessel, and surrounding equipment / installations from hazards associated with machinery and systems. |
| MGMT 5-1 | Design and construct vessel, machinery, and electrical systems to facilitate safe access, ease of inspection, survey, and maintenance. |
| AUTO 1 | Perform its functions as intended and in a safe manner |

| *Goal No.* | *Goal* |
|---|---|
| AUTO 2 | Indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance |
| AUTO 3 | Have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |

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

### 1.1.2 Functional Requirements

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

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Propulsion, Maneuvering, Station Keeping (PROP)** | |
| PROP-FR1 | Have suitable arrangements such that the integrity/continuity of supplies to services required for propulsion and steering as well as the safety of the ship is maintained. |
| PROP-FR2 | Provide redundancy for electrical equipment forming part of the electric propulsion drive train such that a single failure will not completely disable the propulsion of the vessel |
| PROP-FR3 | Provide means to activate the propulsion control to avoid maloperation of equipment |
| PROP-FR4 | Provide means for controlling the prime mover speed at the control assembly for safe operation |
| PROP-FR5 | Opening of the control system assemblies or compartments is not to cause inadvertent or automatic loss of propulsion |
| PROP-FR6 | The design of propulsion control system is to prevent a dangerous situation due to a control failure |
| PROP-FR7 | Provide protection measures to prevent voltage variations and over speeding of the propulsion system due to regenerative power |
| PROP-FR8 | Provide overspeed protection for propulsion motors to avoid loss of propulsion |
| **Power Generation and Distribution (POW)** | |
| POW-FR1 | Provide winding connection methods for high voltage transformers to achieve redundancy of power supply upon a single failure |
| POW-FR2 | The capacity of the main source of power is to be such that in the event of any one power source being stopped it will still be possible to supply services necessary to provide normal operational conditions of propulsion and safety |
| POW-FR3 | Provide protection against overload, short circuit, earth-fault and overvoltage conditions and other hazards to prevent damage to equipment and maintain continuity of power to remaining circuits |
| POW-FR4 | Provide means of storing energy for the safe operation of high voltage circuit breakers and switches |
| POW-FR5 | Provide measures to protect equipment from internal damages |
| POW-FR6 | Provide means to distribute loads such that blackouts are avoided, and power is always maintained to essential services and propulsion loads |
| POW-FR7 | Provide protection again loss of excitation to avoid dangerous operation |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| POW-FR8 | To withstand all loads that would be imposed during the intended operation |
| POW-FR9 | Provide means to shutdown the propulsion machinery in case of emergency operation. |
| POW-FR10 | Provide means to regulate transformer output voltage to achieve necessary performance characteristics of the converter unit in which the transformer is used |
| POW-FR11 | Circuit disconnecting devices are to be constructed to withstand vibration or shock encountered during normal marine environmental conditions and avoid deterioration |
| POW-FR12 | Circuit disconnecting devices used for generators and motors are to be designed to operate at full load conditions and are to be constructed to prevent flammability due to any damage. |
| POW-FR13 | Provide method to absorb the excessive regenerated energy. |
| POW-FR14 | Provide a power source independent of the main source of power to support emergency services for the applicable duration |
| POW-FR15 | Provide instrumentation to control generator(s) for safe operation. |
| **Fire Safety (FIR)** | |
| FIR-FR1 | Provide fire-extinguishing systems for effective containment and extinction of fire in electrical equipment. |
| **Safety of Personnel (SAFE)** | |
| SAFE-FR1 | Provide conditions for the safe use of hull return and earthing systems |
| SAFE-FR2 | Provide means to monitor and alarm the earth fault in the high voltage electric power systems |
| SAFE-FR3 | Provide protection to prevent accidental contact with live parts of the assembly. |
| SAFE-FR4 | Provide an external insulation enclosure for switchgear and control gear assemblies for protection of the equipment from electric hazards |
| SAFE-FR5 | Provide locking arrangements for circuit protection devices to keep the position. |
| SAFE-FR6 | Provide means of protection for persons operating the switchgear and control gear assemblies in the event of internal arc. |
| SAFE-FR7 | Provide enclosure with suitable degree of protection against ingress of foreign objects and liquids based on location and personnel accessibility of installation |
| SAFE-FR8 | Provide measures to prevent hazards and injuries due to high voltage cable penetrations in the accommodation spaces. |
| SAFE-FR9 | Provide segregation for high voltage cables and equipment to avoid potential electric hazard and injuries |
| SAFE-FR10 | Provide means of effective electrical bonding to earth for safe operation of high voltage cables |
| SAFE-FR11 | Provide working space for high voltage equipment to prevent potential severe injuries to personnel performing maintenance activities |
| SAFE-FR12 | Provide measures to avoid exposure of high voltage equipment to damaging environments |
| SAFE-FR13 | HV electrical system is to 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. |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| SAFE-FR14 | Provide safety measures and alarms to detect and to protect from the earth leakage in AC and DC systems |
| SAFE-FR15 | Provide enclosed ventilation or other means of protection for electric rotating machine to prevent personal injury or entrance of foreign matter |
| SAFE-FR16 | Provide safety design for water-air cooler to prevent the water leakage. |
| SAFE-FR17 | Provide lightning protection methods on nonmetallic mast for protection against electrical shock |
| SAFE-FR18 | Provide neutral earthing methods of three-wire dual-voltage direct-current systems at the generator switchboards for protection against electrical shock |
| SAFE-FR19 | High voltage equipment is to be able to withstand the marine environment and maximum or lower ambient temperature without any deterioration |
| SAFE-FR20 | Navigation lighting system is to be provided with safety measures and alarms to alert the crew of any failures of the navigation lights |
| SAFE-FR21 | Provide protection for DC propulsion circuits to avoid a damaging flashover |
| **Safety Management (MGMT)** | |
| MGMT-FR1 | Provide accessibility to all the parts of the equipment requiring inspection or adjustment or replacement |
| MGMT-FR2 | Provide means of disconnecting the electrical equipment from power source for maintenance |
| MGMT-FR3 | Cables are to be constructed to withstand marine environment and support connected loads and their overload protection |
| MGMT-FR4 | Provide means to seal the propulsion cables to prevent from admission of moisture or air |
| MGMT-FR5 | To determine the authorizations required for each operation or task involving high voltage equipment and for access to the equipment location. |
| MGMT-FR6 | To identify the tools and PPE for HV equipment inspection, calibration and maintenance |
| MGMT-FR7 | Electrical equipment installations are to be well supported and provided with adequate clearance for ease of operation and maintenance |
| MGMT-FR8 | Provide suitable marking for high voltage cables, equipment and spaces containing them for ready identification of danger. |
| MGMT-FR9 | Provide means to prevent moisture condensation in the machine when idle. |
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Provide safety measures and alarms to protect the electrical distribution system from harmonics |
| AUTO-FR2 | Provide means to monitor internal temperatures of the equipment and alarm when the normal operating temperatures are exceeded to prevent damage to the equipment |
| AUTO-FR3 | Provide means to prevent reversal of generator rotation upon failure of the driving power of its prime mover |
| AUTO-FR4 | Interlock arrangements are to be provided for propulsion control levers to avoid improper operation |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| AUTO-FR5 | All critical parameters for power generation, distribution equipment are to be monitored and protections are to be provided to avoid damage to equipment and onboard personnel |
| AUTO-FR6 | The control station is to be provided with means to monitor the parameters and status of propulsion system for normal operation of propulsion machinery |
| AUTO-FR7 | Provide means to control the prime mover speed within the preset range under all operating conditions |
| AUTO-FR8 | Provide measures to safeguard the reduction gear against lubrication supply failure. |

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

#### 1.1.3 Compliance

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

# 3 High Voltage Systems

## 3.1 Application

The requirements in this subsection are applicable to AC systems with nominal voltage (phase to phase) exceeding 1 kV. For systems with nominal voltages exceeding 11 kV a recognized relevant standard will be considered. Unless stated otherwise, the applicable requirements of Sections 4-8-1 through 4-8-4 are also to be complied with.

The nominal standard voltage is not to exceed 15 kV. A higher voltage may be considered for special applications.

## 3.3 System Design

### 3.3.1 Earthed Neutral Systems

*3.3.1(a) Neutral Earthing*. 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.

An earth connection is to be available when any part of the system is in the energized mode.

*3.3.1(b) Equipment.* 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.

*3.3.1(c) Neutral Disconnection*. Each generator neutral is to be provided with means for disconnection for maintenance purposes.

*3.3.1(d) Hull Connection of Earthing Impedance*. 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.

#### 3.3.2 Earth Fault Detection and Indication

*i)* In unearthed or high impedance earthed systems an earth fault is to be indicated by visual and audible means at the centralized control station.

*ii)* In low impedance or direct earthed systems, provision is to be made to automatically disconnect the faulty circuits. Audible and visual indication is to be provided at the centralized control station to indicate that a ground fault had occurred and has been cleared by ground fault protection. An audible alarm is to be provided if the ground fault was not successfully cleared.

*iii)* 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.

#### 3.3.3 Number and Capacity of Transformers *(2024)*

Requirements for the number and capacity of transformers are given in 4-8-2/3.7.1.

For transformers with a high voltage winding rated 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.

### 3.5 Circuit Protection

#### 3.5.1 Protection of Generator

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.

#### 3.5.2 Protection of Power Transformers

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 4-8-2/9.19. In addition, the following means for protecting the transformers or the electric distribution system are to be provided:

*3.5.2(a) Coordinated Trips of Protective Devices.* Discriminative tripping is to be provided for the following. See 4-8-2/9.7.

*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.

*3.5.2(b) Load Shedding Arrangement* . Where the power is supplied through a single set of three-phase transformer 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 4-8-1/5.1.5 and 4-8-2/9.9.

*3.5.2(c) Protection from Electrical Disturbance* . 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.

*3.5.2(d) Protection from Earth-faults* .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.

*3.5.2(e) Transformers Arranged in Parallel.* Refer to 4-8-2/9.19.3 for requirements.

### 3.5.3 Voltage Transformers for Control and Instrumentation

Voltage transformers are to be provided with overload and short circuit protection on the secondary side.

### 3.5.4 Fuses

Fuses are not to be used for overload protection.

### 3.5.5 Over Voltage Protection

Lower voltage systems supplied through transformers from high voltage systems are to be protected against overvoltages. This can 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

### 3.5.6 Coordination of Protective Devices

Regardless of the neutral arrangement, coordination of protective devices in accordance with the intent of 4-8-2/9.7 is to be provided.

## 3.7 Equipment Design

### 3.7.1 Air Clearance and Creepage Distance

*3.7.1(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.

| *Nominal Voltage kV* | *Minimum Air Clearance mm (in.)* |
|---|---|
| 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.

*3.7.1(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.

| *Rated Voltage* *kV* | *Rated Impulse Withstand Voltage* *kV (peak value)* |
|---|---|
| 3.6 | 40 |
| 7.2 | 60 |
| 12 | 75 |
| 15 | 95 |

*3.7.1(c) Isulating 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.

*3.7.1(d) Creepage Distance.* 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 are to be subject to consideration.

***ii)*** *Creepage Distances*. 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 are to be subject to consideration.

### 3.7.2 Circuit Breakers and Switches – Auxiliary Circuit Power Supply Systems

*3.7.2(a) 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 undervoltage is to be independent of any stored electrical energy sources. This does not preclude the use of stored energy for shunt tripping, provided that alarms are activated upon loss of continuity in the release circuits and power supply failures. The stored energy can be supplied from within the circuit in which the circuit breakers or switches are located.

*3.7.2(b) 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.

### 3.7.3 Rotating Machines

*3.7.3(a) Protection* . Refer to 4-8-5/3 TABLE 1 for ingress protection (IP) requirements.

*3.7.3(b) Windings*. Generator stator windings are to have all phase ends brought out for the installation of the differential protection.

*3.7.3(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 overvoltage.

*3.7.3(d) Space Heater*. Effective means are to be provided to prevent the accumulation of moisture and condensation within the machines when they are idle.

### 3.7.4 Switchgear and Control-gear Assemblies

Switchgear and control gear assemblies are to be constructed according to the IEC Publication 62271-200 and the following additional requirements:

*3.7.4(a) Mechanical Construction and Configuration*

*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 4-8-2/3.13 for requirements for the division of main bus bars.

*3.7.4(b) 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 are to be possible. Withdrawable circuit breakers, when in the service position, are to have no relative motion between fixed and moving parts.

*3.7.4(c) Shutters* . 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 can be achieved with the use of colors or labels.

*3.7.4(d) Earthing and Short-circuiting Facilities*. 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.

*3.7.4(e) Arc Flash and Associated Installation Requirements* *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 $cm^2$ 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.

### 3.7.5 Transformers

*3.7.5(a) Application.* The provisions of 4-8-5/3.7.5 are applicable to power transformers for essential services. See also 4-8-3/7.3. Items 4-8-5/3.7.5(c) and 4-8-5/3.7.5(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

*3.7.5(b) Plans* . In addition to the details required in 4-8-3/7, the applicable standard of construction and the rated withstanding voltage of the insulation are also to be submitted for review.

*3.7.5(c) Enclosure* . Transformers are to have a degree of protection in accordance with 3 TABLE 1 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 4-8-5/3.11.

*3.7.5(d) Space heater*. Effective means to prevent accumulation of moisture and condensation within the transformers (when de-energized) is to be provided.

*3.7.5(e) Testing.* 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. In addition, the tests required in 4-8-3/7.3.5 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 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 4-8-5/3.5.2(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.

*3.7.5(f) Nameplate.* In addition to the requirements in 4-8-3/7.3.5, 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

### 3.7.6 Cables

*3.7.6(a) Standards*. Cables are to be constructed to IEC Publication 60092-353, 60092-354, or other recognized standard. See also 4-8-3/9.

## TABLE 1
## High Voltage Equipment Locations and Minimum Degree of Protection

| *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 |

| *Example of Location* | *Condition of Location* | *Switchboards, Distribution Boards, Motor Control Centers and Controllers* | *Generators* | *Motors* | *Transformers, Converters* | *Junction/ Connection Boxes* |
|---|---|---|---|---|---|---|
| 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 roomsAuthorized 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:*

*1)* See 4-8-3/1.11.2 where the equipment is located within areas affected by local fixed pressure water-spraying or water-mist fire extinguishing systems

*2)* For High Voltage Shore Connections (HVSC) see the requirements in Part 6, Chapter 4.

*3)* 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.

## 3.9 Cable Installation

### 3.9.1 Runs of Cables

In accommodation spaces, high voltage cables are to be run in enclosed cable transit systems.

### 3.9.2 Segregation

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 4-8-5/3.7.1(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.

### 3.9.3 Installation Arrangements

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.

### 3.9.4 Termination and Splices

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.). See also 4-8-3/9.19 and 4-8-4/21.3.

Splices and joints are not permitted in propulsion cables, (See 4-8-5/5.15.3). For purposes of this Rule, propulsion cables are those cables whose service is related only to propulsion.

### 3.9.5 Marking

High voltage cables are to be readily identifiable by suitable marking.

### 3.9.6 Cable Rating *(2019)*

The rated phase to earth voltage ($U_o$) of high voltage cables is not to be less than shown in the Table below:

| *Nominal System Voltage ($U_n$) (kV)* | *Highest System Voltage ($U_m$) (kV)* | *Minimum Rated Voltage of Cable ($U_o$/$U$) (kV)* | |
|---|---|---|---|
| | | *Systems with Automatic Disconnection Upon Detection of an Earth Fault* | *Systems without Automatic Disconnection Upon Detection of an Earth Fault* |
| 3.0/3.3 | 3.6 | 1.8/3.0 | 3.6/6.0 |
| 6.0/6.6 | 7.2 | 3.6/6.0 | 6.0/10.0 |
| 10.0/11.0 | 12.0 | 6.0/10.0 | 8.7/15.0 |
| 15.0/16.5 | 17.5 | 8.7/15.0 | 12.0/20.0 |
| 20.0/22.0 | 24.0 | 12.0/20.0 | 18.0/30.0 |
| 30.0/33.0 | 36.0 | 18.0/30.0 | --- |

*Notes:*

**1** Nominal System Voltage ($U_n$) in 50 Hz and 60 Hz.

**2** Cables being accepted based on an approved alternate standard may have voltage ratings of that standard provided the cables are in full compliance with that standard.

#### 3.9.7 Cable Current Carrying Capacities *(2019)*

The maximum current carrying capacity of high voltage cables is to be in accordance with 4-8-3/15 TABLE 6.

### 3.10 High Voltage Shore Connection (HVSC)

Vessels equipped with a high voltage shore connection designed to power the vessel with the shore power alone, enabling the shipboard generators to be shut down while in port, are to comply with the requirements given in Part 6, Chapter 4.

### 3.11 Equipment Installation

#### 3.11.1 Voltage Segregation

Higher voltage equipment is not to be combined with lower voltage equipment in the same enclosure, unless segregation or other suitable measures are taken for safe access to lower voltage equipment.

#### 3.11.2 Large Equipment Enclosure

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. 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 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.

#### 3.11.3 Spaces Containing High Voltage Equipment

All entrances to spaces containing high voltage equipment are to have suitable marking indicating the danger of high voltage and the maximum voltage inside the space.

Where the spaces contain high voltage switchgear the marking at the entrances is also to include marking indicating that the space is only accessible to authorized personnel only.

#### 3.11.4 Exposure of HV Equipment to Damaging Environments

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.

### 3.13 Tests

#### 3.13.1 Rotating Machine Tests

Each design of HV generator and motor is to be assessed by testing in accordance with the "type tests" schedule indicated in 4-8-3/15 TABLE 3. Each subsequent production unit of and accepted design is to be tested in accordance with the "routine tests" schedule also indicated in 4-8-3/15 TABLE 3.

*3.13.1(a) 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.

*3.13.1(b)* Immediately after the high voltage test the insulation resistance is to be measured using a direct current insulation test meter between:

***i)*** All current carrying parts connected together and earth

***ii)*** 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 (MΩ)*** |
|---|---|---|
| $1000 < U_n \leq 7200$ | 1000 | $U_n/1000 + 1$ |
| $7200 < U_n \leq 15000$ | 5000 | $U_n/1000 + 1$ |

### 3.13.2 Switchgear Tests

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.

### 3.13.3 Cable Test after Installation

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 can be carried out upon advice from high voltage cable manufacturer. One of the following test methods is 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 $4U_o$ 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 $4U_o$ is to 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.

An 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.

## 3.15 Design Operating Philosophy

### 3.15.1 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).

### 3.15.2 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.

### 3.15.3 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.

#### 3.15.4 Accessibility *(1 July 2021)*

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) at the front/side and 1 m (3.3 ft) at the rear 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.

#### 3.15.5 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.

#### 3.15.6 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 4-8-5/3.15.2 and still meet the requirements of 4-8-2/3.1.1 with one generator in reserve, then the activity associated with that failure is not required to be included.

### 3.17 Preliminary Operations Manual

#### 3.17.1 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.

#### 3.17.2 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.

#### 3.17.3 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.

#### 3.17.4 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.

#### 3.17.5 Inspection and Maintenance of Test Equipment Tools and PPE *(2024)*

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.

***Commentary:***

The above requirements in 3 are based on IACS UR E11 Unified requirements for systems with voltages above 1 kV up to 15 kV.

**End of Commentary**

# 5 Electric Propulsion Systems

## 5.1 General

### 5.1.1 Application

The 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 .

### 5.1.2 Plans and Data to be Submitted

In addition to the plans and data to be submitted in accordance with 4-8-1/5 as applicable, the following plans and data are to be submitted for review.

- One-line diagrams of 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 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 converter enclosure for propulsion system, including data for semiconductor converter, cooling system with its interlocking arrangement.

## 5.3 System Design

### 5.3.1 General

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 can 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.

### 5.3.2 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 loads for vessel services (essential services, normal services and for minimum comfortable conditions of habitability) and the propulsion loads to provide for a speed of not less than 7 knots or one half of the design speed, whichever is the lesser.

### 5.3.3 Power Management System

For vessels with an integrated electric propulsion system, a power management system is to be provided. The power management system is to be designed 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.

#### 5.3.4 Regenerative Power

For systems where regenerative power may be developed, the regenerative power is not to cause over speeding of the prime mover or variations in the system voltage and frequency which exceeds the limits of 4-8-3/1.9. See also 4-8-5/5.17.4(a) and 4-8-5/5.17.4(e).

#### 5.3.5 Harmonics

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 4-8-2/7.21.

The harmonic distortion levels at dedicated propulsion buses are also to be within the limits of 4-8-2/7.21, 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 are to be provided, including alarms at the main generation switchboard and at continuously manned stations, 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 4-8-2/9.23.

### 5.5 Electric Power Supply Systems

#### 5.5.1 Propulsion Generators

*5.5.1(a) Power supply*. The power for the propulsion equipment can be derived from a single generator. If a vessel 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 4-8-2/3.3.

*5.5.1(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 can be common for the vessel.

*5.5.1(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 can be taken out of service and disconnected electrically without preventing the operation of the remaining units.

*5.5.1(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 can 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 the design speed whichever is the lesser.

*5.5.1(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.

### 5.5.2 Propulsion Excitation

*5.5.2(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.

*5.5.2(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, they are not to interrupt the field discharge resistor circuit upon rupturing.

*5.5.2(c) Ship service generator connection.* Where the excitation supply is obtained from the ship 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.

## 5.7 Circuit Protection

### 5.7.1 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.

### 5.7.2 Direct-current (DC) Propulsion Circuits

*5.7.2(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.

*5.7.2(b) Protection for reversal of the rotation*. Where separately driven DC generators are connected electrically in series, means are to be provided to prevent reversal of the rotation of a generator upon failure of the driving power of its prime mover.

### 5.7.3 Excitation Circuits

An overload protection is not to be provided for opening of the excitation circuit.

### 5.7.4 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 can endanger the plant.

### 5.7.5 Direct-current (DC) Propulsion Motors Supplied by Semiconductor Converters

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.

## 5.9 Protection for Earth Leakage

### 5.9.1 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.

### 5.9.2 Excitation Circuits *(2024)*

Means are to be provided for earth leakage detection in excitation circuits of propulsion machines rated 500 kW or more, other than in circuits of brushless excitation systems.

### 5.9.3 Alternating-current (AC) Systems *(2024)*

Alternating-current propulsion circuits are to be provided with an earthing detector alarm or indicator. If the neutral is earthed for this purpose, the current at full-rated voltage is not to exceed 20 A upon a fault to earth in the propulsion system. An unbalance relay is to be provided to open the generator and motor-field circuits upon detection of an unbalanced fault.

### 5.9.4 Direct-current (DC) Systems

The earthing detector can 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.

## 5.11 Propulsion Control

### 5.11.1 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.

### 5.11.2 Automatic and Remote Control Systems

Where two or more control stations are provided outside the engine room, or where the propulsion machinery space is intended for centralized control or unattended operation, the provisions of Part 4, Chapter 9 are to be complied with.

### 5.11.3 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.

### 5.11.4 Initiation of Control *(2024)*

The control of the propulsion system is to be enabled only when the delegated control lever is in zero position and the system is ready for operation.

### 5.11.5 Emergency Stop

Each control station is to have an emergency stop device which is independent of the control lever.

### 5.11.6 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.

#### 5.11.7 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.

#### 5.11.8 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 steam and oil gauges are mounted on the main-control assembly, provision is to be made so that the steam or oil will not come in contact with the energized parts in case of leakage.

#### 5.11.9 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 circuits 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.

### 5.13 Instrumentation at the Control Station

#### 5.13.1 Indication, Display and Alarms

Instruments to continuously indicate existing conditions 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.

*i)* For AC systems: ammeter, voltmeter, indicating wattmeter and field ammeter (not required for brushless generators) for each propulsion generator and for each synchronous motor. See also 4-9-6/Table 4.

*ii)* 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 4-9-6/Table 4.

*iii)* For electric slip couplings: an ammeter for the coupling excitation circuit.

#### 5.13.2 Indication of Propulsion System Status

The control stations of the propulsion systems are to have at least the following indications for each propeller:

*i)* "Ready for operation": power circuits and necessary auxiliaries are in operation.

*ii)* "Faulty": propeller is not controllable.

*iii)* "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.

### 5.15 Equipment Installation and Arrangements

#### 5.15.1 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 distances are to be provided between parts of opposite polarity and between live parts and earth to prevent arcing; see 4-8-3/5.3.2 for low voltage systems and 3.7.1 for high voltage systems.

### 5.15.2 Accessibility and Facilities for Repairs

*5.15.2(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.

*5.15.2(b) Facility for supporting*. Facilities are to be provided for supporting the shaft to permit inspection and withdrawal of bearings.

*5.15.2(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.

### 5.15.3 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 900 mm (36 in.) apart and are to be arranged to prevent chafing of the cable. See 4-8-4/21.9.2 for cable hangers and cable straps.

## 5.17 Equipment Requirements

### 5.17.1 Material Tests

The following materials intended for main propulsion installations are to be tested in the presence of a Surveyor: 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 requirements of Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*.

### 5.17.2 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 4-8-3/15 TABLE 4 are not to be exceeded.

### 5.17.3 Protection Against Moisture Condensation

Means for preventing moisture condensation as specified in 4-8-3/3.11.5 is applicable for rotating machines and converters regardless of the weight of the machines.

### 5.17.4 Prime Movers

*5.17.4(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 ship making full way ahead, the prime mover is to be capable of absorbing a proportion of the regenerated power without tripping due to overspeed.

*5.17.4(b) Speed control*. Prime movers of any type are to be provided with a governor capable of maintaining the pre-set steady speed within a range not exceeding 5% of the rated full-load speed for load changes from full-load to no-load.

*5.17.4(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.

*5.17.4(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.

*5.17.4(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 can be limited by the action of the control system.

### 5.17.5 Rotating Machines for Propulsion

The following requirements are applicable to propulsion generators and propulsion motors.

*5.17.5(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 recirculating systems are used.

*5.17.5(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, unless the machinery insulation is certified to be self-extinguishing in accordance with a recognized standard.

*5.17.5(c) Air Coolers*. Air cooling systems for propulsion generators are to be in accordance with 4-6-5/7.5 for sea chest and 4-6-5/7.7 for two means of circulation. Water-air heat exchangers of rotating propulsion machines for single systems (single generator and single motor), as specified in 4-8-5/5.5.1(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 detection of such water leakage.

*5.17.5(d) Temperature Sensors*. Stator windings of AC machines and interpole windings of DC machines, rated above 500 kW, are to be provided with temperature sensors. See 4-9-6/Table 4.

*5.17.5(e) Generator Excitation*. Excitation current for propulsion generators can be derived from attached rotating exciters, static exciters, excitation motor-generator sets or special purpose generating units. Power for these exciters can be derived from the machine being excited or from any ship service, emergency or special purpose generating units.

*5.17.5(f) Propulsion Motors* . Propulsion motors are to be designed to be capable of withstanding the mechanical and thermal effects of a short-circuit at its terminals.

### 5.17.6 Direct-current (DC) Propulsion Motors

*5.17.6(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.

*5.17.6(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.

### 5.17.7 Electric Couplings

*5.17.7(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.

*5.17.7(b) Accessibility for repairs*. The coupling is to be designed to permit removal as a unit without moving the engine. See also 4-8-5/5.15.2(a).

*5.17.7(c) Temperature rating*. The limits of temperature rise are to be the same as for alternating-current generators given in 4-8-3/15 TABLE 4, 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 4-8-3/15 TABLE 4 when operated continuously at 70% of full-load rpm, full excitation and rated torque. Temperature rises for insulation materials above 180°C will be considered provided they are in accordance with a recognized standard.

*5.17.7(d) Excitation*. Excitation is to be provided as required for propulsion generators. See 4-8-5/5.17.5(e).

*5.17.7(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.

*5.17.7(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

### 5.17.8 Semiconductor Converters for Propulsion

Semiconductor converters are to comply with the requirements in 4-8-3/8.

### 5.17.9 Reactors and Transformers for Semiconductor Converters

*5.17.9(a) General*. Interphase reactors and transformers used with semiconductor converters are to conform with the requirements of 4-8-3/7 and the following.

*5.17.9(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.

*5.17.9(c) High Temperature Alarm*. See 4-8-3/8.9.2(b).

### 5.17.10 Switches

*5.17.10(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, can be operated pneumatically, by solenoids, or other means in addition to the manual method which is to be provided unless otherwise approved.

*5.17.10(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 can be used if provided with leak-proof, nonspilling tanks.

*5.17.10(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 earth relay.

#### 5.17.11 Propulsion Cables

*5.17.11(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 $mm^2$ (2,960 circ. mils).

*5.17.11(b) Insulation Materials.* *(2019)*

Ethylene-propylene rubber, cross-linked polyethylene, or silicone rubber insulated cables are to be used for propulsion power cables. PVC insulated cables are not acceptable as per IEC 60092-360.

*5.17.11(c) Impervious Metallic Sheath.*

Impervious metallic sheaths will be considered but are not to be used with single-conductor alternating-current cables.

*5.17.11(d) Inner Wiring.* *(2024)*

The insulation of internal wiring in main control gear, including switchboard wiring, is to be of flame-retardant quality as per a recognized standard.

*5.17.11(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.

#### 5.17.12 Reduction Gear Safety – Lubrication

Where reduction gears are driven by electric motors, an automatic means is to be fitted to stop the motors in the event of failure of the lubricating oil supply to the reduction gear, (see 4-6-5/5.3.4)

### 5.19 Trials

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 are to include a reversal of the vessel from full speed ahead to full speed astern during which important measurements such as system currents, voltages and speed are to 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.

## 7 Three-wire Dual-voltage DC Systems

### 7.1 Three-wire DC 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.

### 7.3 Neutral Earthing

#### 7.3.1 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.

#### 7.3.2 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.

#### 7.3.3 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.

## 9 Electrical Plants of Less Than 75 kW

### 9.1 General

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 8, as applicable – except, 4-8-3/1.17, 4-8-1/5.1.3, 4-8-1/5.1.4, 4-8-2/3.1, 4-8-2/3.3, 4-8-2/3.5, 4-8-2/3.9, 4-8-2/3.11, 4-8-2/3.13, 4-8-2/5, 4-8-2/3.7.2, 4-8-2/9.7, 4-8-2/11.3, 4-8-2/11.5, 4-8-2/11.7.1, 4-8-2/11.7.2, 4-8-1/5.3.1, 4-8-4/7.1, 4-8-3/5.3.2, 4-8-3/9 and 4-8-5/3.

### 9.3 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, as applicable, are to be indicated on the submitted plans or may be submitted in a booklet format.

### 9.5 Calculations of Short-circuit Currents

In the absence of precise data, the following short circuit currents at the machine terminals are to be assumed:

#### 9.5.1 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.

#### 9.5.2 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.

### 9.7 Lightning Protection

A lightning-protection system consisting of a copper spike and a copper conductor of at least 8 $mm^2$ (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.

### 9.9 Temperature Ratings

In the requirements contained in 4-8-5/9, 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.

### 9.11 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.

### 9.13 Emergency Source of Power

#### 9.13.1 Capacity

The emergency source of electrical power is to have adequate capacity to provide emergency lighting for a period of at least six hours, see 4-8-2/5.5 TABLE 1.

#### 9.13.2 Sources

The emergency power source can 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.

#### 9.13.3 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.

### 9.15 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 $mm^2$ (16 AWG) can have solid conductors.

### 9.17 Switchboards, Distribution Boards and Panels

#### 9.17.1 Installation *(2020)*

Switchboards, distribution boards 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 boards 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.

#### 9.17.2 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.

### 9.19 Navigation Lights *(2020)*

Mast head, port, starboard and stern 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.

## 11 Energy Storage Systems *(2019)*

### 11.1 Lithium-ion Batteries

For vessels installed with lithium-ion batteries, see the requirements in the ABS *Requirements for Use of Lithium-ion Batteries in the Marine and Offshore Industries*.

### 11.3 Supercapacitors

For vessels installed with supercapacitors, see the requirements in the ABS *Requirements for Use of Supercapacitors in the Marine and Offshore Industries*.

# PART 4

## CHAPTER 9

## Automation and Computer Based Systems

### CONTENTS

# PART 4

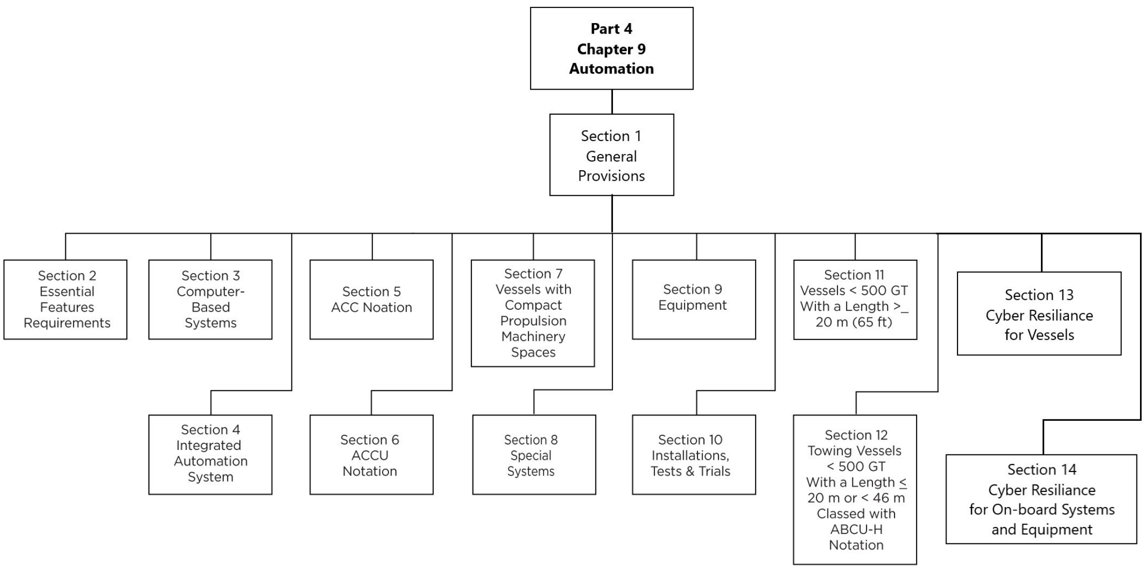
## CHAPTER 9
## Automation and Computer Based Systems

## SECTION 1
## General Provisions

# 1 Application

## 1.1 Organization of Chapter 9 *(2024)*

Part 4, Chapter 9 contains classification requirements for automation. The requirements for automation are organized as follows:




Section 4-9-1 addresses general issues and provides, for example, the required submittals and definitions for terms used throughout the automation systems.

Section 4-9-2 provides the essential features requirements which are all generic requirements for control system, monitoring/alarm system, safety system, power supply, remote propulsion control on navigation bridge and other than on navigation bridge.

Section 4-9-3 provides requirements for computer-based systems which include system categories, software and hardware requirements.

Section 4-9-4 provides Integrated Automation System (IAS) requirements.

Section 4-9-5 provides **ACC** Notation.

Section 4-9-6 provides **ACCU** Notation.

Section 4-9-7 provides the requirements for vessels with compact machinery spaces (no machinery control room and propulsion machinery are controlled only from the navigation bridge), including **ABCU** notation.

Section 4-9-8 provides requirements for control and monitoring of watertight doors and hatches.

Section 4-9-9 provides requirements for equipment.

Section 4-9-10 provides requirements for installations, tests and trials.

Section 4-9-11 provides the requirements for vessels less than 500 GT having a length equal or greater than 20 m (65 ft).

Section 4-9-12 provides requirements for towing vessels less than 500GT having a length equal or greater than 20 m (65 ft) and equal or less than 46 m (150 ft), including **ABCU-H** notation.

Section 4-9-13 provides cyber resilience requirements for vessels.

Section 4-9-14 provides cyber resilience requirements for onboard systems and equipment .

### 1.2 Objective *(2024)*

The goals and functional requirements for the topics covered in this chapter are included in the respective sections.

### 1.3 Scope

This section applies to electrical, hydraulic, electronic, computer-based systems and equipment for control, monitoring, alarm and safety on board vessels.

## 3 Class Notations *(2024)*

### 3.1 ACC Notation *(2024)*

Where, in lieu of manning the propulsion machinery space locally, it is intended to monitor it and to control and monitor the propulsion and auxiliary machinery by qualified personnel from a continuously manned centralized control station, the provisions of Section 4-9-5 are to be complied with. And upon verification of compliance, the class notation **ACC** will be assigned. This notation is optional.

### 3.3 ACCU Notation *(2024)*

Where it is intended that propulsion machinery space be periodically unmanned and that propulsion machinery be controlled from the navigation bridge and a centralized location, the provisions of Section 4-9-6 are to be complied with. And upon verification of compliance, the class notation **ACCU** will be assigned. This notation is optional.

### 3.5 ABCU Notation *(2024)*

Where it is intended that propulsion machinery space be periodically unmanned and that propulsion machinery be controlled from the navigation bridge, the provisions of Section 4-9-7 are to be complied with. And upon verification of compliance, the class notation **ABCU** will be assigned. This notation is optional.

### 3.7 ABCU-H Notation *(2024)*

Where it is intended that a towing vessel be operated with unmanned engine room limited to restricted operations in harbor, the provisions of Section 4-9-12 are to be complied with. Upon verification of compliance, the class notation **ABCU-H** will be assigned. This notation is optional.

## 5 Definitions

### 5.1 General Definitions

#### 5.1.1 Alarm *(2024)*

Visual and audible signals indicating an abnormal condition of a monitored parameter.

***Commentary:***

An alarm is a high priority form of an alert. Alarms indicate conditions requiring immediate attention and action to maintain safe navigation or operation of the ship. Alerts are divided into four priorities: emergency alarms, alarms, warnings and cautions. IMO Assembly Resolution A.1021(26), “Code on Alarms and Indicators" may be referred for additional guidance.

**End of Commentary**

#### 5.1.2 Control

The process of conveying a command or order to enable the desired action be effected.

#### 5.1.3 Control System

An assembly of devices interconnected or otherwise coordinated to convey the command or order.

#### 5.1.4 Automatic Control

A means of control that conveys predetermined orders without action by an operator.

#### 5.1.5 Instrumentation

A system designed to measure and to display the state of a monitored parameter and which include one or more sensors, read-outs, displays, alarms and means of signal transmission.

#### 5.1.6 Local Control

A device or array of devices located on or adjacent to a machine to enable it be operated within sight of the operator.

#### 5.1.7 Remote Control *(2024)*

A device or array of devices connected to a machine by mechanical, electrical, pneumatic, hydraulic or other means and by which the machine can be operated from a remote location on board the vessel, and not necessarily within sight of, the operator.

#### 5.1.8 Remote Control Station

A location fitted with means of remote control and monitoring.

#### 5.1.9 Monitoring System

A system designed to supervise the operational status of machinery or systems by means of instrumentation, which provides displays of operational parameters and alarms indicating abnormal operating conditions.

#### 5.1.10 Safety System

An automatic control system designed to automatically lead machinery being controlled to a predetermined less critical condition in response to a fault which can endanger the machinery or the safety of personnel and which can develop too fast to allow manual intervention.

To protect an operating machine in the event of a detected fault, the automatic control system is to be designed to automatically:

- Slow down the machine or to reduce its demand;
- Start a standby support service so that the machine can resume normal operation; or
- Shut down the machine.

For the purposes of this Chapter, automatic shutdown, automatic slowdown and automatic start of standby pump are all safety system functions. Where "safety system" is stated hereinafter, it means any or all three automatic control systems.

#### 5.1.11 Fail-safe

A designed failure state which has the least critical consequence. A system or a machine is fail-safe when, upon the failure of a component or subsystem or its functions, the system or the machine automatically reverts to a designed state of least critical consequence.

#### 5.1.12 Systems Independence

Systems are considered independent where they do not share components such that a single failure in any one component in a system will not render the other systems inoperative.

#### 5.1.13 Propulsion Machinery

Propulsion machinery includes the propulsion prime mover, reduction gear, clutch, and controllable pitch propellers, as applicable.

#### 5.1.14 Unmanned Propulsion Machinery Space *(1 July 2024)*

Propulsion machinery space which can be operated without continuous attendance by the crew locally in the machinery space.

#### 5.1.15 Centralized Control Station

A propulsion control station fitted with instrumentation, control systems and actuators to enable propulsion and auxiliary machinery be controlled and monitored, and the state of propulsion machinery space be monitored, without the need of regular local attendance in the propulsion machinery space.

#### 5.1.16 Failure Mode and Effect Analysis (FMEA)

A failure analysis methodology used during design to postulate every failure mode and the corresponding effect or consequences. Generally, the analysis is to begin by selecting the lowest level of interest (part, circuit, or module level). The various failure modes that can occur for each item at this level are identified and enumerated. The effect for each failure mode, taken singly and in turn, is to be interpreted as a failure mode for the next higher functional level. Successive interpretations will result in the identification of the effect at the highest function level, or the final consequence. A tabular format is normally used to record the results of such a study.

#### 5.1.17 Vital Auxiliary Pumps

Vital auxiliary pumps are those directly related to and necessary for maintaining the operation of propulsion machinery. For diesel propulsion engines, fuel oil pumps, lubricating oil pumps and cooling water pumps are examples of vital auxiliary pumps.

#### 5.1.18 Compact Machinery Spaces

Machinery spaces with no machinery control room and therefore propulsion machinery being controlled only from the navigation bridge.

#### 5.1.19 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.

#### 5.1.20 Worst Case Execution Time (WCET)

The WCET of a computational task is the maximum length of time the task could take to execute on a specific hardware platform.

#### 5.1.21 Worst Case Response Time (WCRT)

The WCRT is the maximum time taken from the input to the sensor (or input device), to the output device (final element) completing its required action. This time period includes the time taken for the Programmable Electronic System to carry out any software processing under WCET and communicate with the sensors and final elements.

## 7 Plans and Data

The following plans and data are to be submitted for review, as applicable. For vessels less than 500 GT having a length equal or greater than 20 m (65 ft), the required plan submissions are in accordance with 4-9-11/5.

### 7.1 Specifications

A general description of the operation of the system is to be provided. This is to include the system configuration, general arrangements for the vessel and the layout of the propulsion machinery with essential auxiliaries, specifications of main equipment with information of manufacturer's name, type, rating and number of the equipment.

### 7.3 System Design Plans

#### 7.3.1 Propulsion Control System

*7.3.1(a)* Schematic diagrams showing connections between all main components (units, modules) of the system, human machine interfaces (HMI) and interfaces with other systems.

- Propulsion control stations (e.g. from navigation bridge, centralized control station, etc.)
- Type and size of propulsion prime movers and auxiliary machinery and electric propulsion motors (if applicable)
- Independent local manual control
- Shaft turning gear interlocking arrangements
- Propulsion manual emergency shutdown
- Control station instrumentation
- Communications systems
- Essential auxiliary machinery and their controls, such as electrical power generating plant, hydraulic or pneumatic power generation, storage, vital auxiliary pumps, etc.
- Power supply arrangement

*7.3.1(b)* Operational descriptions for the following items:

- Starting of propulsion machinery
- Control transfer
- Critical speeds
- Essential auxiliary machinery automatic starting arrangement if fitted

- Power management arrangements where specially required by the Rules

### 7.3.2 Propulsion Machinery Safety System

Safety systems descriptions are to include a list of all monitored parameters with settings for implemented protective actions (e.g., automatic shutdown and automatic slowdown), schematic diagrams showing the connections between the safety devices, control and display units, alarm devices, human machine interface (HMI) and power supply arrangement, as appropriate, and operational descriptions for the following items:

- Initiation of automatic shutdown
- Initiation of automatic slowdown
- Initiation of automatic starting of standby units
- Override of automatic shutdown
- Override of automatic slowdown
- Re-start of propulsion machinery

### 7.3.3 Propulsion Machinery Monitoring System

Schematic diagrams showing the connections between the sensing devices, control and display units, alarm devices, human machine interfaces (HMI) and power supply arrangement, and description of monitoring systems including a list of alarms and displays including preset parameters for the propulsion machinery and all essential auxiliary machinery and systems the following stations:

- Centralized control station alarm and instrumentation
- Monitoring station in the engineers accommodation
- Navigation bridge instrumentation

### 7.3.4 Propulsion Boiler

Schematic diagrams and operational descriptions for the following:

- Prevention of excessive steam
- Automatic shutdown
- Automatic ignition
- Trial-for-ignition period
- Automatic burner light off
- Burner primary-air or atomizing steam
- Post purge
- Boiler limit systems
- Modulated air-fuel ratio

### 7.3.5 Failure Modes and Effect Analysis (FMEA) *(2024)*

Failure modes and effect analysis is to be submitted for review for vessels receiving **ACC**, **ACCU**, **ABCU**, **DPS-2** and **DPS-3** notations, and vessels with an integrated propulsion control and automation system. The FMEA is to contain at least the following:

- System block diagrams showing system breakdown and components of interests.
- A tabulation of the following:
  - Systems and components of interests

– Potential failures modes
– Predictable cause associated with each failure mode
– Failure detection means
– Responses of the system to the failures
– Possible consequences of the failures
– Conclusions, comments or recommendations

***Commentary:***

ABS *Guidance Notes on Failure Mode and Effects Analysis (FMEA) for Classification* provides guidance and insight into the development process for FMEAs to comply with ABS Rule requirements.

**End of Commentary**

#### 7.3.6 Fire Safety Arrangements

Schematic diagrams and descriptions of the fire detection and alarm systems, fire precautions, fire extinguishing equipment, and fire fighting station arrangements.

#### 7.3.7 Communication Systems

Schematic diagrams and arrangements of the internal communication systems.

#### 7.3.8 Oil Mist Detection/Monitoring and Alarm

See 4-2-1/7.2.2 for the requirements.

#### 7.3.9 Compute-based System (CBS) *(2024)*

The following are to be submitted as appropriate:

- Block diagram showing the system configuration including the user interface, (input and output devices) description of hardware specifications, hardware FMEA, fail-safe features, security arrangements, power supply, and independence of systems (control, monitoring and safety shutdown).
- System description as per 4-9-3/8.3.3 including Software logic flow chart, description of software functions, self-test features and documentation on quality standard of software development and testing and software test reports.
- Calculations and/or methods used to determine the Worst Case Response Time (WCRT) for 4-9-3/7.1 TABLE 1 Category III Systems' alarms with respect to design data volume and CPU(s) capability including: data communication protocol(s) and the Worst Case Execution Time (WCET) of the alarm processing task(s). This requirement is also applicable to Category III Systems reduced to Category II, due to independent effective back up or other means of averting danger for the control functions (such as mitigation of alarms missing deadlines).
- For integrated systems the documentation are to be submitted verifying independence of the regular alarm, control and safety functions for each of the essential services. Refer to 4-9-1/7.3.5, 4-9-2/3.1.5, 4-9-9/15.3, 4-9-3/5.3, 4-9-3/13.1.2, 4-9-4/3, 4-9-4/5 and 4-9-4/7 of the Rules.
- For documentation of software, hardware, test plans and reports, refer to 4-9-3/15 TABLE 3 and 4-9-3/15 TABLE 4.

#### 7.3.10 Wireless Data Communication Equipment

The following documentation is to be submitted for wireless data communication equipment.

*i)* Documentation which demonstrates that the wireless data communication equipment provides an improvement in the safety of the vessel, compared to wired data communication. See 4-9-3/13.3.3.

*ii)* General details of the wireless system and equipment.

*iii)* Risk analysis. See 4-9-3/13.3.3(a).

*iv)* Evidence of type testing. See 4-9-3/13.3.3(b).

*v)* On-board test schedule. See 4-9-3/13.3.3(c).

*vi)* Details of manufacturer's recommended installation and maintenance practices. Network plan with arrangement and type of antennas and identification of location. Details of the wireless data communication network. See 4-9-3/13.3.3(d).

*vii)* Specification of wireless communication system protocols and management functions. See 4-9-3/13.3.3(e).

*viii)* Details of radio-frequency and power levels. See 4-9-3/13.3.3(f).

*ix)* For functions that are provided with an alternative means of control, a description of the functions and a description of the alternative means of control. See 4-9-3/13.3.3(g).

#### 7.3.11 Cyber Resilience *(2024)*

Documentation to be submitted is covered in 4-9-13/9 and 4-9-14/7, as applicable .

### 7.5 Equipment Plans

Schematic diagrams with a list of major electrical, electronic, hydraulic and pneumatic equipment/ components (including manufacturer's names, model names, material, ratings, degree of protection and permissible angles of inclination), function descriptions, construction plans, outline view and elevation details, certificates or test reports as appropriate attesting to the suitability to the intended services and operating conditions in compliance with the environmental criteria set forth in Section 4-9-8.

- Navigation bridge console
- Centralized control and monitoring console
- Safety systems and devices
- Computer based systems, see Section 4-9-3
- Hydraulic equipment
- Pnuematic equipment

### 7.7 Installation Plans

#### 7.7.1 Installation Arrangements

Locations of centralized control station and remote control stations on the navigation bridge; arrangements of the centralized control station containing control consoles and other equipment, including glass windows, doors, and ventilation fitting, as applicable.

#### 7.7.2 Electrical One-line Diagrams

Type, size and protection of cables between control and monitoring equipment.

#### 7.7.3 Installation Methods

Installation methods for all power and automatic or remote control and monitoring (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.

### 7.9 Test Programs and Operation Manuals

The requirements in this section are applicable for vessels with integrated propulsion control and automation systems installed.

#### 7.9.1 Factory Acceptance Tests

Factory acceptance tests (FAT) are the test programs for testing at the manufacturers, to include “description of test configuration and test simulation methods, initial test condition, steps to perform the test, observations during the test and acceptance criteria for each test.

#### 7.9.2 Test Program for Dock and Sea Trials

Test program for dock and sea trials is to include initial test condition, steps to perform the test, observations during the test and acceptance criteria for each test.

#### 7.9.3 Operations Manual

For each vessel, operations manual is to be prepared and submitted solely for verification that the information in the manual, relative to the propulsion control system, is consistent with the design and information considered in the review of the system. One copy of the operations manual is to be kept onboard.

The operations manual is intended to provide guidance for the operator about the specific propulsion control installations and arrangements of the specific vessel. The operations manual is to include but not be limited to the following information.

- A description of all the systems associated with the propulsion control of the vessel, including backup systems and communication systems
- The block diagram showing how the components are functional related, as described in 4-9-1/7.3.1
- A description of the different operational modes and transition between modes.
- Operating instructions for the normal operational mode (and the operational modes after a failure) of the electrical or computer control systems, manual control system, manual local control to each equipment (thrusters, electric motors, electric drives or converters, electric generators, etc.)
- Operating instructions for the systems and equipment, indicated in the above paragraph, during failure conditions
- Maintenance and periodical testing procedure, acceptance criteria, fault identification and repair, list of the suppliers’ service net, maintenance log.

## 9 Tests and Surveys

### 9.1 Installation Tests *(2024)*

Computer based systems are to be subjected to tests witnessed by the Surveyor during and after installation on board, as covered in 4-9-3/17.

In addition to the above, automatic or remote control and monitoring systems are to be subjected to tests witnessed by the Surveyor during and after installation on board, as outlined in this Chapter.

### 9.3 Periodical Surveys *(2024)*

Applicable annual survey requirements for computer based systems are covered in 7-6-2/1.1.19 of the ABS *Rules for Survey After Construction (Part 7)*.

The continuance of **ACC**, **ACCU**, **ABCU-H** 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 9

# Automation and Computer Based Systems

SECTION 2

# Essential Features Requirements

## 1 General *(2024)*

The provisions of Section 4-9-2 apply to control systems, monitoring systems, alarm systems, safety systems, and automatic or remote controls on board vessels, where fitted.

### 1.1 Objective *(2024)*

#### 1.1.1 Goals

The automation (control, monitoring and safety systems) is to be designed, constructed, operated and maintained to:

| *Goal No.* | *Goals* |
|---|---|
| SAFE 1.1 | Minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems. |
| AUTO 1 | Perform its functions as intended and in a safe manner. |
| AUTO 2 | Indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance. |
| AUTO 3 | Have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |
| AUTO 4 | Provide the equivalent degree of safety and operability from a remote location as those provided by local controls. |
| AUTO 5 | Be provided with a safety system that automatically leads the machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/equipment or environment. |
| AUTO 6 | Independently perform different functions, such that a single failure in one system will not render the others inoperative. |
| AUTO 7 | Enable rational human machine interface without unintended errors due to the layout or arrangement of machinery/equipment. |
| POW 2 | Provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel. |

| *Goal No.* | *Goals* |
|---|---|
| PROP 7 | be provided with means to reduce the risk *of impending or imminent slowdown or shutdown*. |
| SAFE 12 | Provide means to minimize the risk of strikes against objects/equipment, slips, trips, and falls within the vessel and overboard. |

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

### 1.1.2 Functional Requirements

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

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Power Generation and Distribution (POW)** | |
| POW-FR1 | Provide continuous power supply for control, monitoring and safety systems. |
| POW-FR2 | Automated control systems which use stored energy to start essential machinery are to be configured not to exhaust the stored energy completely and to provide an alert when the stored energy is below a critical limit. |
| **Propulsion, Maneuvering, Station Keeping (PROP)** | |
| PROP-FR1 | *Provide threshold warning of impending or imminent slowdown or shutdown of the propulsion system in time to assess navigational circumstances in an emergency*. (SOLAS II-1) |
| PROP-FR2 | Provide individual alarm at remote propulsion control station for safety system activations. |
| **Safety of Personnel (SAFE)** | |
| SAFE-FR1 | Provide means to manually shutdown propulsion machinery from navigation bridge during an emergency |
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Apply fail-safe design for all control systems, manual emergency control systems and safety systems to prevent dangerous situations due to a single point failure. |
| AUTO-FR2 | System independence is to be applied to automation systems performing different functions, failure of one function should not lead to loss of other functions. |
| AUTO-FR3 | Where provided with remote control, the remote control station(s) is (are) to be as effective as local control. |
| AUTO-FR4 | Manual control of the automated system is to be provided in the event of an emergency or failure of automation. |
| AUTO-FR5 | Safety interlocks are to be provided to preclude damage to the controlled machinery. |
| AUTO-FR6 | For vessels with more than one control station, control hierarchy and the transfer logic of control between different control stations is to be provided to avoid control command conflicts. |
| AUTO-FR7 | Provide visual and audible notification at control and monitoring stations upon occurrence of fault/faults in the system to enable personnel to take appropriate actions. |
| AUTO-FR8 | Provide means to manually override automated safety functions other than those intended to avert rapid deterioration of propulsion and auxiliary machinery. |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| AUTO-FR9 | Remote propulsion control stations are to provide means to control/operate and monitor the associated propulsion machinery. |
| AUTO-FR10 | Location and design of work stations are to follow ergonomic principles to clearly identify system components and provide ease of usage. |
| AUTO-FR11 | Visual display units are to be provided with means to adjust the display for all operating lighting conditions. |
| AUTO-FR12 | Monitoring and control systems are to provide indication of state of equipment and activation of controls. |
| **Safety of Personnel (SAFE)** | |
| SAFE-FR1 | Provide means to physically support the operator using the workstations during rough weather. |

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

#### 1.1.3 Compliance

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

## 3 Control Systems

### 3.1 Conceptual Requirements

The following are conceptual requirements for control system design and are to be complied with, except where specially exempted.

#### 3.1.1 Fail-safe

A fail-safe concept is to be applied to the design of all control systems, manual emergency control systems and safety systems. In consideration of its application, due regard is to be given to the safety of individual machinery, the system of which the machinery forms a part and the vessel as a whole. 4-9-2/3.1.1 TABLE 1 shows the example of typical fail-safe states but is not exhaustive. Refer to 4-9-1/5.1.11 and 4-9-3/5.1.8 of the Rules.

**TABLE 1**
**Typical Fail-safe States Example**

| *System or Component* | *Typical Fail-safe States* |
|---|---|
| Propulsion speed control | Maintain state |
| Controllable pitch propeller | Maintain state |
| Propulsion safety shut down | Maintain state and alarm |
| Alarm system | Annunciated |
| Cooling water valve | In most cases open |

#### 3.1.2 System Independence *(2024)*

Systems performing different functions (e.g., monitoring systems, control systems, and safety systems) are to be, as much as practicable, independent of each other such that a single failure in one will not render the others inoperative. Specifically, the shutdown function of the safety system is to be independent of control and monitoring systems. Common sensors will be acceptable for any functions other than shutdown functions and automatic start/changeover of the required pumps as listed in 4-9-6/23 TABLE 1A through 4-9-6/23 TABLE 5A.

***Commentary:***

The separate sensor requirement in 4-9-2/3.1.2 is based on IACS Unified Requirement (UR) M29 "Alarm systems for vessels with periodically unattended machinery spaces" and M35 "Alarms, remote indications and safeguards for main reciprocating internal combustion engines installed in unattended machinery spaces".

**End of Commentary**

#### 3.1.3 Local Control

In general, local manual controls are to be fitted to enable safe operation during commissioning and maintenance, and to allow for effective control in the event of an emergency or failure of remote control. The fitting of remote controls is not to compromise the level of safety and operability of the local controls.

#### 3.1.4 Remote Controls

Remote controls are to be arranged to provide the same degree of safety and operability as those provided for local controls. The effects of a control input are to be continuously receivable at the remote control station being in command.

#### 3.1.5 Failure Mode and Effect Analysis (FMEA)

Failure modes and effects analysis (FMEA) is to be carried out during system design to investigate if any single failure in control systems would lead to undesirable consequences such as loss of propulsion, loss of propulsion control, etc. The analysis can be qualitative or quantitative.

#### 3.1.6 Transfer of Control *(2020)*

In general, and where command locations are of the same priority level (or same hierarchy), actual control is not to be transferred before being acknowledged by the receiving command location unless the command locations are located close enough to allow direct visual and audible contact. Transfer of control is to be indicated.

#### 3.1.7 Interlocks

Safety interlocks are to be provided to preclude damage to the controlled machinery, such as means fitted to disable the starting mechanism after designated unsuccessful starting attempts, or when the propulsion shaft turning gear is engaged. Safety interlocks in different parts of the systems are not to conflict with each other.

#### 3.1.8 Automatic Controls

Automatic control systems are to be designed to maintain the controlled machinery within pre-set parameters under normal working conditions such that the machinery operates in the correct sequence, time intervals, and stable over the entire control range. 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. In closed loop system, feedback failures are to initiate an alarm and to keep the system operating either at its present state or moving controlled to zero state. Additionally, adequate arrangements are to be included to disable the automatic control mode and restore manual controls.

### 3.3 Control System Design *(2020)*

Where an automatic control system is provided, it is to be designed to achieve safe and effective operation.

The design of automatic control systems for systems of essential services is to be such that loss of any automatic control features will automatically lead to shifting the level of control to the next lower step, or to the state of least consequences. See control station hierarchy (3.5) for lower steps or decreasing authority.

### 3.5 Control Station Hierarchy

A decreasing authority is to be assigned according to the following orders for ships with more than one control station:

*i)* Local controls at the controlled equipment

*ii)* Machinery space(s) control station(s), closest to the controlled equipment

*iii)* Remote control station(s) outside of machinery spaces

*iv)* Navigation bridge (or bridge wing) control station

The control station of higher authority is to be designed to include a supervisory means for transferring control from a station of lower authority at all times, and to block any unauthorized request from any station of lower authority.

For transfer of control between the control stations and the preference of the stations refer to 4-9-2/13.11 of the Rules.

### 3.7 Control Console Instrumentation

Control console instrumentation is to be clearly arranged to provide for adequate control and status indication of the controlled machinery. Alarm indicators are to have a physical differentiation from other instrumentation.

## 5 Power Supply

### 5.1 General *(2020)*

Where an independent power source is required for the functions of control, monitoring and safety systems, power supply is to be arranged so as to maintain the functionalities and the degree of independencies defined in 4-9-2/3.1.2 for these systems at all time during operation. Power source for control, monitoring and safety systems can be electric, hydraulic, or pneumatic or a combination thereof. Each power supply is to be monitored and its failure is to be alarmed.

### 5.3 Electric

Where power supply is electric, each of the control, monitoring and safety systems is to be supplied by a separate circuit. Each of these circuits is to be protected for short circuit and monitored for voltage failure.

### 5.5 Hydraulic

Where power supply is hydraulic, hydraulic pumps are to be fitted in duplicate. The reservoir is to be of sufficient capacity to contain all of the fluid when drained from the system, maintain the fluid level at an effective working level and allow air and foreign matter to separate out. The pump suctions are to be sized and positioned to prevent cavitation or starvation of the pump. A duplex filter, which can be cleaned without interrupting the oil supply, is to be fitted on the discharge side of pumps. The hydraulic fluid is to be suitable for its intended operation. Hydraulic supplies to safety and control systems can be derived from the same source but are to be by means of separate lines.

### 5.7 Pneumatic

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, can 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 to provide 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 can be derived from the same source, but are to be by separate lines incorporating shutoff valves.

## 7 Monitoring/Alarm Systems

Monitoring/Alarm systems are to have the following detail features.

### 7.1 Independence of Visual and Audible Alarm Circuits

As much as practicable, a fault in the visual alarm circuits is not to affect the operation of the audible alarm circuits.

### 7.3 Audible Alarms

Audible alarms associated with machinery are to be distinct from other alarms such as the fire-alarm, general alarm, gas detection alarm, etc., and are to be of sufficient loudness to attract the attention of duty personnel. For spaces of unusually high noise level, a beacon light or similar, installed in a conspicuous place, is to supplement the audible alarm. However, red light beacons are only to be used for fire alarms.

### 7.5 Visual Alarms

Visual alarms are to be a flashing signal when first activated. The flashing display is to change to a steady display upon acknowledgment. The steady display is to remain activated, either individually or in the summarized fashion, until the fault condition is rectified. Other arrangements capable of attracting the operator’s attention to an alarm condition in an effective manner will be considered.

### 7.7 Acknowledgment of Alarms *(1 July 2019)*

Newly activated alarms are to be acknowledged by manual means. This means is to mute the audible signal and change the flashing visual display to steady display. Other alarm conditions, occurring during the process of acknowledgment, are to be alarmed and displayed. The latter alarm is not to be suppressed by the acknowledgment of the former alarm.

Acknowledgement is to be possible only from the local controls or the centralized control position station.

The silencing of the alarm at an associated remote control station is not to automatically mute and steady, or acknowledge, the same alarm signals at the centralized control station.

### 7.9 Temporarily Disconnecting Alarms

Alarm circuits may be temporarily disabled, for example, for maintenance purposes, provided that such action is clearly indicated at the associated station in control and at the centralized control station, if fitted. Temporarily disabled alarm for initial startup of machinery is to be automatically reactivated after a preset time period. For **ACCU** fire alarm systems, see 4-9-6/21.5.2.

### 7.11 Built-in Alarm Testing

Audible alarms and visual alarm indicating lamps are to be provided with means of testing that can be operated without disrupting the normal operation of the monitoring systems. Such means are to be fitted in the associated remote stations.

### 7.13 Self-Monitoring

The monitoring system is to include a self-monitoring mechanism such that a fault (e.g., power failure, sensor failure, etc.) can be detected and alarmed. Additionally, the alarm systems are not to react to normal transient conditions or spurious signals.

## 9 Safety System

### 9.1 General Requirements

In addition to complying with 3.1.1 through 3.1.3 and 4-9-2/7, safety systems are also to comply with the following:

*i)* Means are to be provided to indicate the detected abnormal parameters which cause the safety action.

*ii)* Alarms are to be given on the navigation bridge, at the centralized control station and at local manual control position, as applicable, upon the activation of a safety system. Activation of a safety system is to be recorded.

*iii)* Propulsion machinery shutdown by a safety system is not to be designed to restart automatically, unless first actuated by a manual reset.

*iv)* A safety system for the protection of one machine unit is to be independent of that of the other units.

### 9.3 Automatic Safety Shutdown

To avert rapid deterioration of propulsion and auxiliary machinery, the following automatic shutdowns are to be provided, regardless of the mode of control: manual, remote or automatic. These shutdowns are not to be fitted with manual override.

*i)* For all diesel engines:

- Overspeed
- Lube oil system failure

*ii)* For all gas turbines (see 4-2-3/7.7.5 TABLE 4):

- Failure of lubricating oil system
- Failure of flame or ignition
- High exhaust gas temperature
- High compressor vacuum
- Overspeed
- Excessive vibration
- Excessive axial displacement of rotors

*iii)* For all steam turbines:

- Failure of lubricating oil system
- Overspeed

- Back-pressure for auxiliary turbines

*iv)* For all boilers:

- Failure of flame
- Failure of flame scanner
- Low water level
- Failure of forced draft pressure
- Failure of control power

*v)* For propulsion reduction gears:

- Shutdown prime movers upon failure of reduction gear lubricating oil system.
- Where prime movers are diesel engines, shutdown is mandatory for high speed or medium speed diesel engines coupled to a reduction gear.

*vi)* For generators:

- For generators fitted with forced lubrication system only: shutdown prime movers upon failure of generator lubricating oil system (see 4-8-3/3.11.3).

*vii)* For propulsion DC motor

- Overspeed [see 4-8-5/5.17.6(b)]

## 9.5 Remote Propulsion Control Safety System

### 9.5.1 General

In all cases, automatic safety shutdowns in 4-9-2/9.3 are to be provided. Other safety system functions, such as automatic startup of standby pump or automatic slowdown, can be provided.

### 9.5.2 Safety System Alarms

*9.5.2(a) Threshold Warning for Safety System Activations*. 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 slowdown or shutdown 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.

*9.5.2(b) Alarms for Safety System Activations*. Activation of safety system to automatic slowdown or automatic shutdown of propulsion machinery is each to be arranged with individual alarm at remote propulsion control station. Audible alarm may be silenced at the control station, however visual alarm is to remain activated until it is acknowledged in the machinery space.

### 9.5.3 Override of Safety System Functions *(2024)*

Automatic slowdowns and automatic shutdowns indicated in 4-9-6/23 TABLE 1A through 4-9-6/23 TABLE 6 may be provided with override except that specified in 4-9-2/9.3. Automatic slowdowns and automatic shutdowns where provided in excess of those indicated in 4-9-6/23 TABLE 1A through 4-9-6/23 TABLE 6 are to be provided with override. Overrides are to be as follows:

*i)* The activation of the override is to be alarmed and clearly identifiable at the remote propulsion control station and is to be so designed that it cannot be left activated.

*ii)* Overrides fitted on the navigation bridge are to be operable only when the propulsion control is from the navigation bridge.

*iii)* The override actuator is to be arranged to preclude inadvertent operation.

***Commentary:***

For multi-engine propulsion or power generating plants, override of automatic shutdowns and automatic slowdowns, where provided in excess of those indicated in 4-9-6/23 TABLE 1A through 4-9-6/23 TABLE 6 may be not required if maneuverability and operation of the vessel is maintained after activation of shutdown or slowdown on one of the engines. A risk analysis, or equivalent, demonstrating the safety system design is to be submitted. Alternatively, it may be demonstrated by testing that propulsion and maneuverability is maintained following a safety function (shutdown) on one of the propulsion plants in the presence of an ABS Surveyor.

**End of Commentary**

#### 9.5.4 Restart of Propulsion Machinery

Propulsion machinery shutdown by safety system is not to resume operation until it is reset manually.

## 11 Remote Propulsion Control System Requirements

### 11.1 Propulsion and Maneuvering Application

The provisions of this section are applicable:

- Where it is intended that the propulsion machinery be directly controlled from the navigation bridge or from any remote propulsion control station within or outside the propulsion machinery space;
- Where, in lieu of manning the propulsion machinery space locally, it is intended to monitor it and to control and monitor the propulsion and auxiliary machinery by qualified personnel from a continuously manned centralized control station; or
- Where it is intended that the propulsion machinery space be periodically unmanned.

Provisions for remote control of steering gears and of athwartship or positioning thrusters are given in Sections 4-3-4 and 4-3-5, respectively.

### 11.3 General Requirements

The remote propulsion control station is to be:

*i)* As effective as local control

*ii)* Provided with control of speed and direction of thrust of the propeller

*iii)* Provided with instrumentation sufficient to provide the operator with information about the state of the propulsion machinery and the control system itself

### 11.5 System Design

In general, conceptual requirements in 4-9-2/3.1 are to be applied. Further requirements are provided in 4-9-2/9.5, 4-9-2/13, and 4-9-2/15.

### 11.7 System Power Supply

#### 11.7.1 Power Source

Power supply requirements provided in 4-9-2/5, 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. Alternatively, one of the feeders can be connected to a standby power supply from battery and uninterruptible power systems (UPS) having capacity for a service duration of at least 30 minutes, see 4-8-2/5.5, 4-8-3/5.9. 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 centralized or unattended operation (**ACC**, **ACCU** or **ABCU** notation), 4-9-5/3.5 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.

#### 11.7.2 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 can commonly connected to the transfer switch, where power supply transfer for safety system is independent. 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 centralized or unattended operation (**ACC**, **ACCU** or **ABCU** notation), 4-9-5/3.5 is to be complied with.

#### 11.7.3 System Protection

*11.7.3(a) Electrical.* *(2020)*

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 the values as specified in section 4-8-2/7.21 of the MVR Rules.

*11.7.3(b) 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.

*11.7.3(c) Pneumatic.* The requirements in 4-9-2/11.7.3(b) are to be complied with, as applicable.

## 13 Remote Propulsion Control on Navigation Bridge

### 13.1 General

Where propulsion machinery is to be controlled from the navigation bridge, means for control and monitoring are to be as provided in 4-9-2/15.3 TABLE 2. The following control and monitoring features are also to be provided. These requirements do not apply to bridge wing propulsion control stations.

### 13.3 Propeller Control

The speed, direction of thrust and, where applicable, the pitch of the propeller, are to be fully controllable from the navigation bridge under all sailing conditions, including maneuvering. The 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. Where multiple propellers are designed to operate simultaneously, they can be controlled by one control device.

## 13.5 Ordered Speed and Direction

When under navigation bridge control, ordered speed and direction of propulsion machinery, including pitch of propellers, where applicable, are to be indicated at the local propulsion machinery control position, and at the centralized control station if fitted.

## 13.7 Emergency Shutdown

A manually operated emergency-stopping device for the propulsion machinery is to be provided on the navigation bridge. This device is to be independent of the remote propulsion control system. The shutdown may only be activated by the deliberate action of the operator, and is to be so arranged as to prevent its inadvertent operation.

## 13.9 Starting of Propulsion Machinery

Where it is necessary to restart the propulsion machinery in order to reverse it to go astern, means to start the propulsion machinery is to be provided on the navigation bridge. In such cases, and in other cases where propulsion machinery can be started from a remote control station, the following are to be provided:

*i)* An alarm to indicate a low level starting medium energy condition (e.g. a low starting air pressure) which is to be set at a level to permit further starting operation.

*ii)* A display to indicate starting medium energy level (e.g. starting air pressure).

*iii)* Where automatic starting of the propulsion machinery is fitted, the number of consecutive automatic attempts is to be limited in order to safeguard sufficient capacity for local manual starting.

*iv)* Starting of the propulsion machinery is to be automatically inhibited where conditions exist which may damage the propulsion machinery (e.g., shaft-turning gear engaged, insufficient lubricating oil pressure, etc.). The activation of such inhibition is to be alarmed at the remote control station.

## 13.11 Transfer Between Remote Control Stations *(2024)*

Remote control of the propulsion machinery is to be possible only from one location at a time. At each location there is to be an indicator showing which location is in control of the propulsion machinery. The following protocol is to be observed for transfer of control between stations:

*i)* The transfer of propulsion control between stations is to take effect only with acknowledgment by the receiving station. This, however, does not apply to transfer of control between the centralized control station and the local manual control.

*ii)* The transfer of propulsion control between the navigation bridge and the propulsion machinery space is to be possible only in the propulsion machinery space (i.e. at either the centralized control station or the local manual control position).

*iii)* The centralized control station as required for **ACC** per 4-9-5/3.1 or engine room remote propulsion control station, if fitted (see 4-9-2/11.1), is to be capable of assuming propulsion control at any time or blocking orders from other remote control stations. However, where special operating requirements of the vessel prevail, override control over the centralized control station will be considered.

***Commentary:***

Where engine room takeover is not desired taking into account the following, override control over the centralized control station can be accepted:

- Mission deck over-the-side operations
- Azimuth drives providing both propulsion and steering control
- Itemized alarms in the navigation bridge instead of the required summary alarm for **ACCU** per Line D1 of 4-9-2/15.3 TABLE 2

- **DPS** class notation where all thruster controls are to be available to the DP operator at all times
- **ACCU** unattended machinery spaces
- Proximity of distance between the remote control station and local controls
- The proposal may subject to flag State acceptance with respect to the requirements of the governmental authority whose flag the vessel flies.

**End of Commentary**

*iv)* Propeller speed and direction of thrust are to be prevented from altering significantly when propulsion control is transferred from one control station to another.

### 13.13 Local Manual Control

Means are to be provided for local manual control so that satisfactory operation of the propulsion machinery can be exercised for lengthy periods in the event of the failure of the remote propulsion control system. For this purpose, indicators for propeller speed and direction of rotation (for fixed pitch propellers) or pitch position (for controllable pitch propellers) are to be provided at this local manual control station. The means of communication as required by 4-8-2/11.5 is to be fitted also at this manual control station.

It is also to be possible to control auxiliary machinery, which are essential for propulsion and safety of the vessel, at or near the machinery concerned.

### 13.15 Communications Systems

For communication systems associated with propulsion control stations, the requirements in 4-8-2/11.5 are applicable.

## 15 Remote Propulsion Control Station Other than Navigation Bridge

### 15.1 General

Where remote propulsion control station is provided at a location other than the navigation bridge, such station is to comply with requirements applicable to that at the navigation bridge, with the exception of the provision of telegraph.

### 15.3 Propulsion Machinery Space

Remote propulsion control stations fitted in vessels having the propulsion machinery space manned are to be provided with the alarms, displays and controls as listed in 4-9-2/15.3 TABLE 2, items A1 through C2 as a minimum.

Where a remote propulsion control station is provided in or in the vicinity of the propulsion machinery space for the purpose of full remote operation of a locally manned propulsion machinery space, such a station is to be fitted with:

- Remote propulsion control station as in 4-9-2/15.1
- Alarms, displays and controls as required in 4-9-5/17 TABLE 1

  Alarms and displays of 4-9-6/23 TABLE 1A through 4-9-6/23 TABLE 6, as applicable.

## TABLE 2
## Instrumentation and Controllers on Remote Propulsion Control Stations

| *System* | *Monitored/Controlled Parameter* | | *A* | *D* | *C* | *Notes:*<br>*[ A = Alarm; D = Display;*<br>*C = Controller/Actuator ]*<br>*[ x = applies ]* |
|---|---|---|---|---|---|---|
| Propulsion control & monitoring | A1 | Propeller speed | | x | x | |
| | A2 | Propeller direction | | x | x | |
| | A3 | Propeller pitch | | x | x | As applicable |
| | A4 | Telegraph | | x | x | Not applicable to certain vessels < 500 GT, see 4-8-2/11.5.2 |
| | A5 | Emergency shutdown of propulsion engine | | | x | To be protected from accidental tripping |
| | A6 | Starting of propulsion engine | | | x | For reversible engines only |
| | A7 | Stored starting energy level -low | x | x | | For reversible engines and engines fitted with means of starting at remote control station |
| | A8 | Inhibition of starting of propulsion engine | x | | | Where remote engine starting is fitted |
| | A9 | Automatic shutdown activated | x | | | |
| | A10 | Automatic slowdown activated | x | | | If provided |
| | A11 | Safety system override | x | x | x | If fitted (see 4-9-2/9.5). To be of a design that cannot be left activated |
| | A12 | Shaft turning gear engaged | | x | | To automatically inhibit starting of engine |
| | A13 | Operating in barred speed range | x | | | |
| | A14 | Threshold warning for safety systems activations | x | | | For navigation bridge only (see 4-9-2/9.5.2(b)) |
| System monitoring | B1 | Power source -fails | x | x | | For non-**ACC** vessels, the failure alarm is applicable to main power source only.<br>For **ACC** vessels, applicable to main and emergency power sources. See 4-9-5/3.5. |
| | B2 | Individual power supply to control, monitoring and safety systems -fails | x | x | | Alarm may be common.<br>(See 4-2-1/7.3.3.i for main power supply failure alarm for governor control system (no display is required) |
| | B3 | Alarm system -disconnected | | x | | |
| | B4 | Integrated computer-based system: data highway abnormal conditions | x | | | Alarm is to be activated before critical data overload. |
| | B5 | Integrated computer-based system: duplicated data link -failure of one link | x | | | |

| *System* | *Monitored/Controlled Parameter* | | *A* | *D* | *C* | *Notes: [ A = Alarm; D = Display; C = Controller/Actuator ] [ x = applies ]* |
|---|---|---|---|---|---|---|
| Others | C1 | Control station transfer | | x | x | Display: to indicate the station in control.<br>Control: to provide 1) transfer switch & 2) acknowledgment switch. |
| | C2 | Air conditioning system -fails | x | | | If necessary for equipment environment control |
| Additional requirements for Navigation Bridge for vessels assigned with **ACCU**, **ABCU** | | | | | | |
| **ACCU**, **ABCU** | D1 | Summary alarms -activated by alarm conditions in 4-9-5/17 TABLE 1 and 4-9-6/ Table 1A through 4-9-6/Table 6. | x | | | |
| | D2 | High voltage rotating machine -Stationary windings temperature -high | x | | | 4-8-5/3.7.3(c) |
| | D3 | Controllable pitch propeller hydraulic power unit run/start/stop | | x | x | If standby unit is provided with automatic starting, such starting is to be alarmed. |
| | D4 | Steam turbine automatic shaft rollover -activated | | x | x | Control: to deactivate automatic shaft rollover. |
| | D5 | Steam turbine shaft stopped -in excess of set period | x | | | |
| | D6 | Boiler steam pressure -low | x | | | For propulsion and associated electric power generating machinery |
| | D7 | Boiler control power -failure | x | | | For propulsion and associated electric power generating machinery |
| | D8 | System power source: main and emergency feeder -status and failure | x | x | | |
| | D9 | Propulsion machinery space -fire detected | x | | | |
| | D10 | Start main fire pump and pressurize fire main | | x | x | 4-7-3/1.5.5 |
| | D11 | Propulsion machinery space -bilge level high | x | | | |
| | D12 | Start/stop and transfer switches | | | x | For **ABCU** vessels having non-integrated propulsion machinery |

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.

# 17 Ergonomics *(2024)*

## 17.1 General

### 17.1.1

The layout and design of the control (work) stations are to be based on ergonomic principles covered in ASTM F1166 or other recognized standards.

Alarms, displays and control devices are to be arranged in a functional and logical manner to allow the operator an easy and clear means of identification of each of the components or systems included therein.

***Commentary:***

*Grouping Relationships* - There are two general ergonomic principles for arranging controls and displays on a console or panel. The first set of principles applies to determining the general location of the controls or displays, and the second set of principles is for their specific arrangement within a given panel area.

- *General Location* - The more important or frequently used controls and displays should be located in the center of a console or panel. The location of recurring functional groups and individual items should be similar from console to console.
- *Control and Display Arrangement and Grouping* - Controls and displays should be arranged according to task requirements (e.g., by the sequence of use, precision, and frequency of use) and by common function (e.g., locating two sets of auxiliary power generator unit controls and displays in two adjacent areas on a panel or console)

*Segregation of Groups of Controls and Displays* - Groups of controls and displays should be physically and visually segregated (e.g., a group of controls and displays associated with Generator Set A are adjacent to, but physically and visibly separated from, Generator Set B).

**End of Commentary**

### 17.1.2

Instruments providing visual information to more than one person on duty are to be located for easy viewing by all users concurrently, or if this is not possible, the instruments are to be duplicated.

### 17.1.3

The color schemes of system alarms, displays, and devices are to be consistent for all systems onboard and in accordance with IMO Assembly Resolution A.1021(26), “Code on Alarms and Indicators”or other recognized international standards.

## 17.2 Design for Ease of Maintenance

The design and layout of the hardware is to provide ease of access to interchangeable parts for repairs and maintenance. Each replaceable part is to be simple to replace and is to be constructed for easy and safe handling. All replaceable parts are to be so designed that it is not possible to connect them incorrectly or to use incorrect replacements. Where this is not practicable, the replaceable parts, their mounting location, including their means of electrical connection, are to be clearly marked.

## 17.3 User Interface and Input Devices

### 17.3.1 General

*17.3.1(a)*

Control/input devices are to have clearly marked functions and, as far as practicable, are to be arranged to avoid conceivable inadvertent errors in their operations.

*17.3.1(b)*

Controls/input devices are to be placed so that simultaneous operation of two controls will not require a crossing or interchanging of hands.

*17.3.1(c)*

Input devices/controls are to be located adjacent to (e.g., normally under or to the right of) their associated displays and positioned such that the operation of input devices/controls will not obscure displays where observation of these displays is necessary to allow control adjustments to be made.

*17.3.1(d)*

The direction of movement of a display is to be the same as the direction of movement of the controls/input device and is to be consistent with the related movement of an equipment component or vessel.

*17.3.1(e)*

Users are to be notified when invalid or out of range values are entered as input commands.

### 17.3.2 Security

Input devices, such as keyboard, which can be used to effect changes to equipment or processes under control, are to be provided with security arrangement, such as password, so as to limit access to authorized personnel only.

Where a single action of, for example, pressing of a key is able to cause dangerous operating conditions or malfunctions, measures are to be taken to prevent execution by a single action such as use of two or more keys.

### 17.3.3 Control Status

*17.3.3(a)*

Where control action can be effected from more than one station, conflicting control station actions are to be prevented by means of interlock or warning. Control status is to be indicated at all stations.

*17.3.3(b)*

Personnel are to be provided with a positive indication of control activation. All the effects of an action or command on the process are to be simultaneously observable on associated displays. If the response time of the equipment is slow, then, feedback is to be provided indicating that the action has been initiated and is progressing (e.g., rudder position and rate of turn indicators).

## 17.5 Visual Display Unit

### 17.5.1 General

*17.5.1(a)*

The visual displays are to provide a positive indication of the state of the equipment such as: ready, running , not running or “out-of-tolerance.” is to be provided. The absence, or non-activated state, of a visual display is not to be relied upon to convey status information.

*17.5.1(b)*

Where equipment status must always be available (e.g., stop/start, on/off, etc.), it is appropriate to provide status indication of each state.

*17.5.1(c)*

The size, color and density of text and graphic information displayed on a visual display unit are to be such that it may be easily read from the normal operator position under all operational lighting conditions.

*17.5.1(d)*

The brightness and contrast are to be capable of being adjusted.

#### 17.5.2 Alarm Display

Where alarms are displayed by means of a visual display unit, they are to appear in the sequence as the incoming signals are received. Alarming of the incoming fault signals are to appear on the screen regardless of the mode the computer or the visual display unit is in.

#### 17.5.3 Propulsion Monitoring

Where a computer is used as the operator interface to display monitored parameters, the centralized control station is to be provided with at least two computers, including keyboards and monitors, unless other means of display are provided capable of displaying the same information.

#### 17.5.4 Color Monitor

The failure of a primary color is not to prevent an alarm from being distinctly indicated.

### 17.7 Graphical Display

#### 17.7.1 General

Information is to be presented clearly and intelligibly according to its functional relations. Display presentations are to be restricted to the data which is directly relevant for the user.

#### 17.7.2 Alarms

Alarms are to be clearly distinguishable from other information and are to be visually and audibly presented with priority over other information regardless of the mode the computer or the visual display unit is in.

### 17.9 Safety of Personnel

#### 17.9.1 Sharp Edges and Protuberances

There are to be no sharp edges or protuberances which could cause injury to personnel.

#### 17.9.2 Handrails or Grab Rails

Sufficient handrails or grab rails are to be fitted to the workstations to enable personnel to move or stand safely in bad inclement weather.

#### 17.9.3 Seat Securing

Where provisions for seating is made, means for securing the same are to be provided, having regard to storm conditions.

***Commentary:***

Further guidelines on ergonomic design of computer-based systems can be found in the following publications:

- ABS *Guidance Notes for the Application of Ergonomics to Marine Systems*
- ABS *Guidance Notes on Ergonomic Design of Navigation Bridges*
- IACS Recommendation 94 “Recommendation for the Application of SOLAS Regulation V/15 – Bridge Design, Equipment Arrangement and Procedures (BDEAP)”
- IMO MSC.Circ.982 *Guidelines on Ergonomic Criteria for Bridge Equipment and Layout*

In addition, ABS offers **NBL/NIBS/NBLES/NBLES(COS)** optional notations for vessels where the navigational bridge design, design and arrangement of navigational equipment and bridge operational procedures are developed based on requirements in the ABS *Guide for Bridge Design and Navigational Equipment/Systems*.

**End of Commentary**

PART 4

CHAPTER 9

# Automation and Computer Based Systems

SECTION 3

# Computer-based Systems

## 1 General *(2024)*

### 1.1 Scope *(1 July 2024)*

Computer based systems (CBSs) which provide control, alarm, monitoring, safety, or internal communicationfunctions are to comply with the provisions of Section 4-9-3, and are subject to the classification requirements regardless of **ACC**, **ACCU** or **ABCU** notation. The requirements apply to the design, construction, commissioning, and maintenance of computer-based systems where they depend on software for the proper achievement of their functions.

See 4-9-1/7.3.9 and 4-9-1/7.3.10 for plans and data to be submitted for review.

***Commentary:***

For vessels contracted for construction between 1 January 2024 and 30 June 2024, compliance with Section 4-9-3 of the 2023 *Marine Vessel Rules* in lieu of the current Rules may be specially considered.

This section is based on IACS UR E22.

**End of Commentary**

### 1.3 Exclusion *(2024)*

Computer-based systems that are addressed by the statutory regulations are excluded from the scope of this Section, 4-9-3.

***Commentary:***

Examples of systems that are excluded from the scope of this section are:

- Navigation systems and Radio communication systems required by SOLAS Chapter V and IV
- Vessel loading instrument/stability computer

For loading instrument/stability computer, IACS recommendation no. 48 may be considered.

**End of Commentary**

## 1.5 Objective *(2024)*

### 1.5.1 Goals

The computer-based systems addressed in this section are to be designed, constructed, operated and maintained to:

| *Goal No.* | *Goal* |
|---|---|
| AUTO 1 | perform its functions as intended and in a safe manner. |
| AUTO 2 | indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance. |
| AUTO 3 | have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |
| AUTO 4 | provide the equivalent degree of safety and operability from a remote location as those provided by local controls. |
| AUTO 5 | have a safety system that automatically leads machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/equipment or the environment. |
| AUTO 6 | independently perform different functions, such that a single failure in one system will not render the others inoperative. |

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

### 1.5.2 Functional Requirements *(1 July 2024)*

In order to achieve the above stated goals, the design, construction, installation and maintenance of the computer-based systems covered in the scope of this section are to be in accordance with the following functional requirements:

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Provide notification upon power supply failure to the CBS. |
| AUTO-FR2 | Provide protection against short circuits to the system. |
| AUTO-FR3 | Arrangements are to be made such that the software programs and associated memory data are not lost or corrupted due to power disruption. The system should resume its monitoring/control capabilities as soon as the power supply is restored. |
| AUTO-FR4 | Category II and III CBSs and their data communication networks are to be continuously monitored and the abnormalities are to be alarmed at the manned centralized control station. |
| AUTO-FR5 | System independence is to be applied to automation systems performing different functions. Failure of one function should not lead to the loss of other functions. |
| AUTO-FR6 | CBS's memory and throughput are to be of sufficient capacity to handle the designed operations in a timely manner to prevent any undesirable event due to delays in processing and transmitting data. |
| AUTO-FR7 | Apply fail-safe design for all control systems, manual emergency control systems and safety systems to prevent a dangerous situation due to a single point failure. |
| AUTO-FR8 | Emergency means of stopping equipment under control and system are to be provided independent of the computer based control system. |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| AUTO-FR9 | CBSs are to be able to identify its details (like the name, software version, manufacturer, etc). |
| AUTO-FR10 | The CBS is to be developed following a quality standard. The intended functionality, performance, robustness, failure response and correctness of the software are to be verified at each level of the system development . |
| AUTO-FR11 | Management of software master files is to be clearly defined to maintain its integrity. |
| AUTO-FR12 | Change management procedures are to be developed and followed throughout the lifecycle of CBS. Any changes to the system are to be analysed and tested before and after installation such that there is no negative impact on the functionality. Change records are to be maintained for traceability of changes to support post incident analysis. |
| AUTO-FR13 | CBSs are to have the capability to roll back to the previously installed software during a failed maintenance update to the system. |
| AUTO-FR14 | Provide redundant and interchangeable human machine interface hardware to prevent loss of monitoring and/or control of Category II and III CBS. |
| AUTO-FR15 | Data communication networks for CBS of Category II and III are to be continuously monitored. |
| AUTO-FR16 | Abnormalities and overload in the data communication network are to be alarmed at the manned centralized control stations. |
| AUTO-FR17 | Network overload protection is to be provided to prevent denial of service. |
| AUTO-FR18 | Means are to be provided to maintain data integrity during transmission. |
| AUTO-FR19 | Data communication networks are to be designed such that single failures in the network do not lead to loss of functionality of the CBS. |
| AUTO-FR20 | Local means of control are to be available for CBS of Category II and III in case of loss of remote control. |
| AUTO-FR21 | Wireless data communication, when used for vessel services, is to provide improvement in the safety of the vessel compared to the wired data communication and not cause any detrimental effect on the essential services. |
| AUTO-FR22 | Hardware components are to be suitable for stable operation in all designed operating conditions. |

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

#### 1.5.3 Compliance

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

### 1.7 Structure of the Section *(2024)*

The requirements of this section cover the lifecycle of computer-based systems from design through operations. The requirements are split into groups representing the different phases of the life cycle and the roles responsible for fulfilling the requirements.

The activities related to the development and delivery of a computer based system is in 4-9-3/8, while the activities related to the maintenance in the operational phase are described in 4-9-3/9.

Management of changes to software and systems is given special attention and the main aspects of a management of change process are covered in 4-9-3/10.

The general certification requirements for computer based systems and the relation to type approval is described in 4-9-3/11.The requirements and the extent of verification of a computer based system depend on its categorization into one of three categories. The categories are described in 4-9-3/7.

Most requirements in this section, 4-9-3, are related to the way of working, and thus focus on activities to be performed, but it also contains some technical requirements. The technical requirements on computer based systems are provided in 4-9-3/5 and 4-9-3/13.

Each activity contains a requirement part which describes the minimum *requirements* on the role in question, and a part which describes the *ABS verification* of the activity in question.

## 3 Definitions

### 3.1 ABS Report *(2024)*

Compliance document issued by ABS stating:

- Conformity with applicable rules and requirements
- That the tests and inspections have been carried out on:
- The finished certified component itself; or
- On samples taken from earlier stages in the production of the component, when applicable.
- That the inspection and tests were performed in the presence of the Surveyor or in accordance with special agreements, (i.e., Production Quality Assurance (PQA))

***Commentary:***

ABS Report is defined as the "Society Certificate" in IACS UR E22, Rev.3.

**End of Commentary**

### 3.3 Application software *(2024)*

*Application software* is ship specific software to accomplish specific tasks other than just running the computer system and supported by the basic software.

### 3.5 Basic software *(1 July 2021)*

*Basic software* is software such as operating systems or other such software supporting application software for multiple functions (i.e., middleware or firmware), which enables:

***i)*** Running several modules under allocated priorities;

***ii)*** Detection of execution failures of individual modules;

***iii)*** Discrimination of faulty modules to allow for maintained operation of modules at least of the same or of a higher priority.

### 3.7 Black-box description *(2024)*

A description of a system's functionality and behavior and performance as observed from outside the system in question.

### 3.9 Black-box test methods *(2024)*

*Verification of the functionality, performance, and robustness of a system, sub-system or component by only manipulating the inputs and observing the outputs. This does not require any knowledge of the system's inner workings and focuses only on the observable behaviour of the system/component under test in order to achieve the desired level of verification.*

### 3.11 Communication node *(1 July 2021)*

*Communication node* is a point of interconnection to a data communication link.

### 3.13 Computer-based system (CBS) *(2024)*

A programmable electronic device, or interoperable set of programmable electronic devices, organized to achieve one or more specified purposes such as collection, processing, maintenance, use, sharing, dissemination, or disposition of information. CBSs on board include IT and OT systems. A CBS may be a combination of subsystems connected via network. Onboard CBSs may be connected directly or via public means of communications (e.g., Internet) to ashore CBSs, other vessels' CBSs and/or other facilities.

### 3.15 Failure mode description *(2024)*

A document describing the effects due to failures in the system, not failures in the equipment supported by the system. The following aspects are to be covered:

- List of failures which are subject to assessment, with
- Description of the system response to each of the above failures
- Comments to the consequence of each of these failures

### 3.17 Interface *(2024)*

A transfer point at which information is exchanged. Examples of interfaces include: input/output interface (for interconnection with sensors and actuators); communications interface (to enable serial communications/networking with other computers or peripherals).

### 3.19 Owner *(2024)*

The organization or person which orders the vessel in the construction phase or the organization which owns or manages the vessel in service. In the context of this section this is a defined role with specific responsibilities.

### 3.21 Parameterization *(2024)*

To configure and tune system and software functionality by changing parameters. It does not usually require-computer programming and is normally done by the system supplier or a service provider, not the operator or end-user.

### 3.23 Peripheral *(2024)*

A device performing an auxiliary function in the system (e.g., printer, data storage device).

### 3.25 Programmable device *(2024)*

Physical component where software is installed.

### 3.27 Robustness *(2024)*

The ability to respond to abnormal inputs and conditions.

### 3.29 Service supplier *(2024)*

A person or company, not employed by ABS, who at the request of an equipment manufacturer, shipyard, vessel's owner or other client acts in connection with inspection work and provides services for a ship or a mobile offshore unit such as measurements, tests or maintenance of safety systems and equipment, the results of which are used by Surveyors in making decisions affecting classification or statutory certification and services

### 3.31 Simulation test *(2024)*

Monitoring, control, or safety system testing where the equipment under control is partly or fully replaced with simulation tools, or where parts of the communication network and lines are replaced with simulation tools.

### 3.33 Software component *(2024)*

A standalone piece of code that provides specific and closely coupled functionality.

### 3.35 Software master files *(2024)*

The computer-files that constitutes the original source of the software. For custom made software this may be readable source- code files, and for commercial off-the-shelf (COTS) software it may be different forms of binary files.

### 3.37 Software module *(2024)*

A standalone group of program or code intended to accomplish a function.

### 3.39 Software-structure *(2024)*

Overview of how the different software components interact and is commonly referred to as the Software Architecture, or Software Hierarchy.

### 3.41 Sub-system *(2024)*

Identifiable part of a system, which may perform a specific function or set of functions.

### 3.43 Supplier *(2024)*

A generic term used for any organisation or person that is a contracted or a subcontracted provider of services, system components, or software under the coordination of the Systems integrator.

### 3.45 System *(1 July 2024)*

A combination of components, equipment and logic which has a defined purpose, functionality, and performance.

In the context of this section, a specific system is delivered by one system supplier.

### 3.47 System of systems *(2024)*

A system which is made up of several systems, typically from different suppliers.

In the context of this section, the system of systems encompasses all monitoring, control and safety systems delivered from the Shipyard as a part of a vessel.

### 3.49 System supplier *(2024)*

An organisation or person that is contracted or a subcontracted provider of system components or software under the coordination of the Systems integrator. In the context of this section this is a defined role with specific responsibilities.

### 3.51 Systems integrator *(2024)*

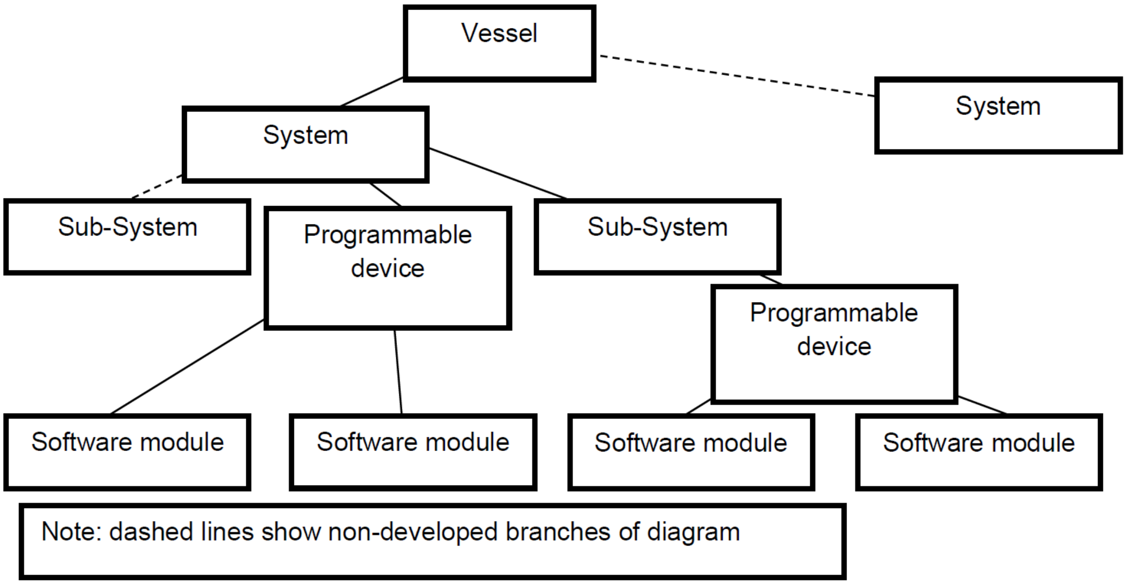
Single organization or a person coordinating interaction between suppliers of systems and sub-systems on all stages of life cycle of computer-based systems in order to integrate them into a verified vessel-wide system of systems and to provide proper operation and maintenance of the computer- based systems. In the context of this section, this is a defined role with specific responsibilities.

During the design and delivery phase the Shipyard is the default Systems integrator, during operations phase the Owner is the default.

### 3.53 Type approval Certificate *(1 July 2024)*

Compliance document issued by ABS by which a product design is declared as meeting minimum set of technical requirements.

**FIGURE 1**
**Illustrative System Hierarchy**




## 4 References *(1 July 2024)*

### 4.1 Normative References

The following IACS standards are considered normative for this Section 4-9-3:

- IACS E10 Test specification for type approval
- IACS UR E26 Cyber resilience of ships
- IACS UR E27 Cyber resilience of on-board systems and equipment

### 4.3 Informative Standards

The following standards are listed for information and can be used for the development of hardware/ software of computer-based systems:

- IEC 61508:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems.
- ISO/IEC 12207:2017 Systems and software engineering - Software life cycle processes
- ISO 9001:2015 Quality Management Systems – Requirements

- ISO/IEC 90003:2018 Software engineering - Guidelines for the application of ISO 9001:2015 to computer software
- IEC 60092-504:2016 Electrical installations in ships - Part 504: Special features - Control and instrumentation
- ISO/IEC 25000:2014 Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - Guide to SQuaRE
- ISO/IEC 25041:2012 Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - Evaluation guide for developers, acquirers and independent evaluators
- IEC 61511:2016 Functional safety - Safety instrumented systems for the process industry sector
- ISO/IEC 15288:2015 Systems and software engineering - System life cycle process
- ISO 90007:2017 Quality management - Guidelines for configuration management
- ISO 24060:2021 Ships and marine technology - Ship software logging system for operational technology

Other industry standards may also be considered.

***Commentary:***

Designs based on any of the standards listed above will be evaluated on a case-by-case basis.

**End of Commentary**

# 5 Systems Requirements

## 5.1 General Requirements

### 5.1.1 System Security *(2024)*

Computer-based 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. See Section 4-9-13 and Section 4-9-14 for detailed requirements.

Alteration of parameters that may affect the system's performance are to be limited to authorized personnel by means of keyswitch, keycard, password or other approved methods.

### 5.1.2 Program and Memory Data

To preclude the possible loss or corruption of data as a result of power disruption, programs and associated memory data considered to be essential for the operation of the specific system are to be stored in non-volatile memory or a volatile memory with a secure uninterruptible power supply (UPS).

### 5.1.3 Start-up After Power Failure

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.

### 5.1.4 Self-Monitoring

*5.1.4(a) Function*. Computer-based systems are to be self-monitoring and any incorrect operation or abnormal condition is to be alarmed at the computer work station.

*5.1.4(b) Temperature*. The processing hardware (CPU, microprocessor etc.) of computer-based systems is to be designed to operate satisfactorily at an ambient temperature of 55°C (131°F), preferably without forced ventilation.

Where forced ventilation is necessary, an alarm warning of high temperature in the processing hardware is to be given.

### 5.1.5 Power Supply

The power supply is to be monitored for voltage failure and protected for short circuit. Where redundant computer systems are provided to satisfy 4-9-3/5.1.6, they are to be separately fed.

### 5.1.6 System Independence

Control, monitoring and safety systems are to be arranged such that a single failure or malfunction of the 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 redundancy, or by other suitable means considered not less effective.

### 5.1.7 Response Time

Computer system's memory is to be of sufficient capacity to handle the operation of all computer programs as configured in the computer system. The time response for processing and transmitting data is to be such that an 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. For propulsion related system applications, the time limit on response delays for safety and alarm displays is not to exceed two (2) seconds. (The response delay is to be taken as the time between detection of an alarm or safety critical condition and the display of the alarm or actuation of the safety system.)

### 5.1.8 Fail-safe

Computer-based system is to be designed such that failure of any of the system's components will not cause unsafe operation of the process or the equipment it controls. Hardware and software serving vital and non-vital systems are to be arranged to give priority to vital systems.

### 5.1.9 Modifications *(2024)*

Any significant modification to the software or hardware for system category II and III is to be submitted for approval. In addition, modifications of parameters for system Category III by the manufacturer are to be approved by ABS. See 4-9-3/10.

***Note:***

A significant modification is a modification which influences the functionality and/or safety of the system.

### 5.1.10 Emergency Stops

Emergency stops, where required, are to be hard-wired and independent of any computer-based system.

### 5.1.11 System Identification *(2024)*

The computer-based system is to be able to identify its name, version, identifier and manufacturer.

***Commentary:***

It is recommended that the system is able to automatically report the status of its software to a ship software logging system (SSLS) as specified in the international standard ISO 24060.

**End of Commentary**

## 5.3 Failure Modes and Effects Analysis (FMEA) *(2024)*

### 5.3.1 General Requirements

*5.3.1(a)*

FMEA is to be used to determine that any component failure will not result in the complete loss of control, the unsafe shutdown of the process or equipment, or other undesirable consequences. Also see 4-9-3/13.1.3.

*5.3.1(b)* *(2024)*

For Category II and III systems, failure analysis for safety related functions is to be performed.

***Commentary:***

See additional FMEA or FMECA requirements in 4-9-1/7.3.5 and 4-9-2/3.1.1, 4-9-2/3.1.5 for **ACC**, **ABCU** or **ACCU** notations and applicable ABS Guides and Requirements for other notations such as DPS.

**End of Commentary**

## 5.5 Cyber Resilience *(2024)*

Computer-based systems are to comply with the cyber resilience requirements in Sections 4-9-13 and 4-9-14.

***Commentary:***

ABS supports the marine and offshore communities by compiling best practices, deriving new methods, and developing the standard for marine and offshore cybersecurity in a commitment to safety and security of life and property and preservation of the environment. ABS offers optional notations based on the level of cyber security provided. Additional information and requirements for the optional notations can be found in the publications listed below that are available on the ABS website:

- Volume 2 - *Guide for Cybersecurity Implementation for the Marine and Offshore Industries*
- Volume 7 - *Guide for ABS Cybersafety for Equipment Manufacturers*

**End of Commentary**

## 5.7 Integrated Automation Systems *(2024)*

Integrated automated systems are to comply with the requirements in Section 4-9-4 in addition to the requirements in this section.

## 5.9 Verification of System Requirements *(2024)*

The implementation of the technical requirements provided in 4-9-3/5.1 to 4-9-3/5.3 are verified by ABS as part of the system description (4-9-3/8.3.3), factory acceptance test (FAT) (4-9-3/8.3.7) and system acceptance test (SAT) (4-9-3/8.5.6).

# 7 Systems Configuration

## 7.1 System Category Definitions *(2024)*

Computer-based systems subject to classification requirements are to be assigned into the appropriate system category (I, II or III) according to the potential severity of the consequences,if the system serving the function fails. 4-9-3/7.1 TABLE 1 provides the definitions of the categories.

*Note:* System Categories are defined as per IACS E22. Rev.3.

**TABLE 1**
**System Categories and Examples** *(2024)*

| *System Category* | *Effects of Failure* | *Typical System Functionality* |
|---|---|---|
| I | Those systems, failure of which will not lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment. | • Monitoring, informational/administrative functions |
| II | Those systems, failure of which could eventually lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment. | • Alarm and monitoring functions<br>• Control functions that are necessary to maintain the ship in its normal operational and habitable conditions |
| III | Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment. | • Control functions for maintaining the vessel's propulsion and steering<br>• Vessel safety functions |

### 7.3 Scope *(2024)*

Category I systems are normally not subjected to verification by ABS, as failure of these systems do not lead to dangerous situations. However, information pertinent to category I systems is to be provided upon request to determine the correct category or confirm that they do not influence the operation of systems in category II and category III.

Category II and III systems require verification by ABS.

### 7.5 System Category Examples *(1 July 2024)*

The category of a system is to be evaluated in the context of the specific vessel in question; thus, the categorization of a system may vary from one vessel to the next. For determining the categorization of systems for a specific vessel, see 4-9-3/8.5.3. Following examples of categories are given as guidance only.

*i)* **Examples of Category I Systems**

Fuel monitoring system, maintenance support system, diagnostics and troubleshooting system, closed circuit television, cabin security, entertainment system, fish detection system.

*ii)* **Examples of Category II Systems**

Fuel oil treatment system, alarm monitoring and safety systems for propulsion and auxiliary machinery, Inert gas system, control, monitoring and safety system for cargo containment system.

*iii)* **Examples of Category III Systems**

Propulsion control system, steering gear control system, electric power system (including power management system), dynamic positioning system (vessels with DPS 2, DPS 3 notations).

## 8 Requirements for Development and Delivery Certification of Computer Based Systems *(2024)*

### 8.1 General Requirements

#### 8.1.1 Life Cycle Approach with Appropriate Standards *(2024)*

*8.1.1(a) Requirement*

A global top-down approach is to be undertaken in the design and development of both hardware and software and the integration in sub-systems, systems, and system of systems, spanning the complete system lifecycle. This approach is to be based on the standards as listed in 4-9-3/7 or other recognized international standards.

*8.1.1(b) ABS Verification (1 July 2024)*

The above requirement is verified as a part of the quality management system verification in 4-9-3/8.1.2 by ABS.

### 8.1.2 Quality System *(2024)*

*8.1.2(a) Requirement (1 July 2024)*

*i)* System suppliers and integrators, in the development of computer based systems for category II and category III, are to comply to a recognised quality standard such as ISO 9001; also incorporating principles of IEC/ISO 90003.

*ii)* For Category II and Category III systems, the quality management system as a minimum is to include the following topics covered in 4-9-3/8.1.2(a) TABLE 2.

## TABLE 2
## Quality System *(1 July 2024)*

| *Area* | | *Role* | |
|---|---|---|---|
| *#* | *Topic* | *System Supplier* | *Systems Integrator* |
| 1 | Responsibilities and competency of the staff | X | X |
| 2 | The complete lifecycle of delivered software and of associated hardware | X | X |
| 3 | Specific procedure for unique identification of a computer based system, its components and versions | X | |
| 4 | Creation and update of the vessel's system architecture | | X |
| 5 | Organization set in place for acquisition of software and related hardware from suppliers | X | X |
| 6 | Organization set in place for software code writing and verification | X | |
| 7 | Organization set in place for system validation before integration in the vessel | X | |
| 8 | Specific procedure for conducting and approving of systems at factory acceptance test (FAT) and system acceptance test (SAT) | X | X |
| 9 | Creation and update of system documentation | X | |
| 10 | Specific procedure for software modification and installation on board the vessel, including interactions with shipyard and owner | X | X |
| 11 | Specific procedures for verification of software code | X | |
| 12 | Procedures for integrating systems with other systems and testing of the system of systems for the vessel | X | X |
| 13 | Procedures for managing changes to software and configurations before FAT | X | |

| *Area* | | *Role* | |
|---|---|---|---|
| *#* | *Topic* | *System Supplier* | *Systems Integrator* |
| 14 | Procedures for managing and documenting changes to software and configurations after FAT | X | X |
| 15 | Checkpoints for the organization's own follow-up of adherence to the quality management system | X | X |

*8.1.2(b) ABS Verification* (1 July 2024)

*i)* The quality management system is to be certified as compliant to a recognized standard by an organization with accreditation under a national accreditation scheme

*ii)* Alternatively, documentation confirming quality management system compliance to a recognized standard is to be submitted to ABS for review. The documentation requirements will be defined per case.

## 8.3 Requirements for the System Supplier (at the plant of the Manufacturer)

### 8.3.1 Define and Follow a Quality Plan

*8.3.1(a) Requirement* (1 July 2024)

*i)* The system supplier is to document that the quality management system is applied for the design, construction, delivery, and maintenance of the specific system to be delivered.

*ii)* All applicable items in 4-9-3/8.1.2 (for the system supplier role) are to be demonstrated to exist and being followed, as relevant.

*8.3.1(b) ABS Verification* (1 July 2024)

Category I: No documentation required

Category II and III: The quality plan is to be submitted for information (FI) and available during FAT survey.

### 8.3.2 Unique Identification of Systems and Software

*8.3.2(a) Requirement*

*i)* A method for unique identification of a system, its different software components and different revisions of the same software component is to be applied.

*ii)* The method is to be applied throughout the lifecycle of the system and the software. See also 4-9-3/5 for related requirements on the system in question.

*iii)* The documentation of the method is typically a part of the quality management system, see 4-9-3/8.1.2.

*8.3.2(b) ABS Verification* (1 July 2024)

*i)* Category I: Not required

*ii)* Category II and III: Application of the identification system is verified by ABS as a part of the system description (4-9-3/8.3.3), FAT (4-9-3/8.3.7) and SAT (4-9-3/8.5.6)

### 8.3.3 System Description

*8.3.3(a) Requirement*

*i)* The system's specification and design is to be determined and documented in a system description.

*ii)* The system description is to contain information of the following:

*a)* Purpose and main functions, including any safety aspects *b)* System category as defined

*c)* Key performance characteristics

*d)* Compliance with the technical requirements and ABS rules

*e)* User interfaces/mimics

*f)* Communication and Interface aspects

- Identification and description of interfaces to other vessel systems

*g)* Hardware-arrangement related aspects

- Network-architecture/topology, including all network components like switches, routers, gateways, firewalls, etc.
- Internal structure with regards to all interfaces and hardware nodes in the system (e.g., operator stations, displays, computers, programmable devices, sensors, actuators, I/O modules etc)
- I/O allocation (mapping of field devices to channel, communication link, hardware unit, logic function)
- Power supply arrangement
- Failure mode description

*8.3.3(b) ABS Verification (1 July 2024)*

Category I: The system description documentation upon request is to be submitted for information (FI).

Category II and III: The system description documentation is to be submitted for approval/review (AP).

***Commentary:***

The information listed in 4-9-3/8.3.3(a).ii is collectively referred to as the system description. It may however be divided into a number of different documents and models.

The purpose of the system description is to document that the entire system-delivery is according to the specifications and in compliance with applicable rules and regulations, in addition to serving as a specification for the detailed design and implementation.

The software modules functional description for programmable devices can also be in the form of SRS and SDS or FDD as follows:

**i** *Software Requirements Specification (SRS)*. The SRS is to specify the requirements for a software item and the methods to be used to confirm that each requirement has been met. It is used as the basis for design and qualification testing of a software item.

The SRS is to address the following information, at a minimum, recommended in IEEE 830 - IEEE Recommended Practice for Software Requirements Specifications (see 4-9-3/4 for alternative standards):

- Functionality. What is the software supposed to do?
- External Interfaces. How does the software interact with personnel, the system's hardware, other hardware, and other software?
- Performance. What is the speed, availability, response time, recovery time of various software functions, etc.?
- Attributes. What are the reusability, correctness, maintainability, security, etc., considerations?

- Design Constraints. What constraints are imposed on this implementation?
- Other. Are there any required standards in effect, implementation language, policies for database integrity, resource limits, operating environment(s), etc.?

**ii** *Software Design Specification (SDS)*. The SDS is to describe the design of the computer-based system software. Typical contents include software architecture, control logic, data structures, input/output formats, interface descriptions, and algorithms.

OR

**iii** *Functional Description Document (FDD)*. The FDD describes the capabilities and functions that a computer-based system must be able to perform successfully. This document may be called a Functional Design Specification (FDS), Technical Description Document DCO's manual, etc., by different organizations. It is to include the following aspects, as applicable:

- Sufficient functions descriptions
- Description of fail-safe states
- Number and description of Human Machine Interfaces
- Number and description of interfaces (data collection, SCADA systems…)

### 8.3.4 Environmental Compliance of Hardware Components

*8.3.4(a) Requirement*

***i)*** All computer hardware of module, sub-system or system level in Category II or III subject to classification requirements are to be qualified in accordance with 4-9-9/15.7 TABLE 1, except for printer, data recording, logging device or similar.

***ii)*** This requirement is not mandatory for Category I systems.

*8.3.4(b) ABS Verification*

***i)*** Category I: Reference to Type approval certificate or other evidence of type testing is to be submitted for information (FI) upon request. see 4-9-3/7.3

***ii)*** Category II and III: Reference to Type approval certificate or other evidence of type testing is to be submitted for information (FI). The test report witnessed and approved by another IACS Member Society for compliance with 4-9-9/15.7 TABLE 1 (or IACS UR E10) is acceptable except for the following:

Type tests according to 4-9-9/15.7 TABLE 1 and Surveyor's witness for the tests in 4-9-9/13.1.i. through 4-9-9/13.1.iii. are to be carried out for the computer hardware associated with optional automation related notations such as **ACC**, **ACCU**, **ABCU**, **DPS**, **BWT**, **SMART**, **AUTONOMOUS**, **REMOTE-CON**, etc. Surveyor's witness in 4-9-9/13 is not required for the computer hardware that is not associated with any specific optional class notations.

### 8.3.5 Software Code Creation, Parametrization, and Testing

*8.3.5(a) Requirement*

***i)*** The software created, changed, or configured for the delivery project is to be developed and have the quality assurance activities assessed according to the selected standard(s) as in the quality plan.

***ii)*** The quality assurance activities may be performed on several levels of the software-structure and are to include both custom-made software and configured components (e.g. software libraries) as appropriate.

***iii)*** The verification of the software is to as a minimum verify the following aspects based on black-box methods:

- Correctness, completeness and consistency of any parameterization and configuration of software components
- Intended functionality
- Intended robustness

Evidence of verification (detection and correction of software errors) for software modules, is to be in accordance with the selected software development standard. Evidence requirements of the selected software standard might differ depending on how critical the correct operation of the software is to the function it performs (i.e. IEC 61508 has different requirements depending on SILs, similar approaches are taken by other recognized standard). This is to be supplied by the Supplier and System Integrator.

*iv)* For components in systems of Category II and III, the scope, purpose, and results of all performed reviews, analysis, tests, and other verification activities are to be documented in test reports.

***Commentary:***

Some of the methods utilized in this activity are sometimes referred to as "software unit test" or "developer test" and may also include verification methods like code-reviews and static- or dynamic code analysis.

**End of Commentary**

*8.3.5(b) ABS Verification (1 July 2024)*

*i)* Category I: No documentation required

*ii)* Category II and III: Software test reports are to be submitted for information (FI)

### 8.3.6 Internal System Testing before Factory Acceptance Test (FAT )

*8.3.6(a) Requirement*

*i)* As far as practicable, the system is to be tested before the FAT. The main purpose of the system test is for the system supplier to verify that the entire system delivery is according to the specifications, approved documentation and in compliance with applicable rules and regulations: and further, that the system is completed and ready for the FAT.

*ii)* The testing is to at least verify the following aspects of the system:

- Functionality
- Effect of faults and failures (including diagnostic functions, detection, alert response)
- Performance
- Integration between software and hardware components
- Human-machine interfaces
- Interfaces to other systems

*iii)* Faults are to be simulated as realistically as possible to demonstrate appropriate system fault detection and system response.

*iv)* Some of the testing can be performed by utilizing simulators and replica hardware. Model in the Loop (MIL), Software-in-the-loop (SIL), and Hardware-in-the-loop (HIL) are some of the recognized methodologies for conducting simulation tests.

*v)* The test-environment is to be documented, including a description of any simulators, emulators, test-stubs, test-management tools, or other tools affecting the test environment and its limitations.

*vi)* Test cases and test results are to be documented in test programs and test reports respectively.

*8.3.6(b) ABS Verification (1 July 2024)*

*i)* Category I: No documentation required

*ii)* Category II and III: Internal system test report are to be submitted for information (FI) and made available during FAT

### 8.3.7 Factory Acceptance Testing (FAT) before Installation On Board

*8.3.7(a) Requirement*

*i)* A factory acceptance test (FAT) is to be arranged for the system in question. The main purpose of the FAT is to demonstrate to ABS that the system is completed and compliant with applicable classification rules, thus enabling issuance of a ABS Report for the system.

*ii)* The FAT test program is to cover a representative selection of the test items from the internal system test (in 4-9-3/8.3.6), including normal system functionality and response to failures.

*iii)* For category II and III systems, network testing to verify the network resilience requirements in 4-9-3/13 are to be performed. If agreed by all parties, the network testing may be performed as a part of the system test onboard the vessel.

*iv)* The FAT as a rule is to be performed with the project specific software operating on the actual hardware components to be installed on board, with necessary means for simulation of functions and failure responses. However other solutions such as replica hardware or simulated hardware (emulators) may be accepted on a case by case basis.

*v)* For each test-case, it is to be noted if the test passed or failed, and the test-results are to be documented in a test report. The test report is to also contain a list of the software (including software versions) that were installed in the system when the test was executed.

*8.3.7(b) ABS Verification (1 July 2024)*

*i)* Category I: FAT not required

*ii)* Category II and III: The FAT program is to be approved/reveiwed (AP) by ABS Engineering before the test is executed

*iii)* Cateory II and III: The FAT execution is to be witnessed by the ABS Surveyor

*iv)* Category II and III: The FAT report is to be submitted to ABS Engineering for information (FI)

*v)* Additional FAT documentation including (e.g., user manuals and internal system test report) are to be submitted for information (FI) and made available during FAT survey

### 8.3.8 Secure and Controlled Software Installation on the Vessel

*8.3.8(a) Requirement (1 July 2024)*

*i)* The initial installation and subsequent updates of the software components of the system are to be performed according to a management of change procedure which has been agreed between the system supplier and the systems integrator.

*ii)* The management of change procedure is to comply with the requirements in 4-9-3/10.

*iii)* Cyber security measures are to be observed as per Section 4-9-13 and Section 4-9-14.

*8.3.8(b) ABS Verification*

*i)* Category I: Not required

*ii)* Category II and III: The management of change procedure are to be submitted for information (FI) upon request

## 8.5 Requirements for the Systems Integrator

### 8.5.1 Responsibilities

For the purposes of this Section 4-9-3, the Shipyard is considered as the systems integrator in the development and delivery phase unless another organization or person is explicitly appointed by the Shipyard.

### 8.5.2 Define and Follow a Quality Plan

*8.5.2(a) Requirement* *(1 July 2024)*

*i)* The systems integrator is to document that the quality management system is applied for the installation, integration, completion and maintenance of the systems to be installed on board.

*ii)* All applicable items described in 4-9-3/8.1.2 (for the systems integrator role) is to be demonstrated to exist and being followed, as relevant.

*8.5.2(b) ABS Verification* *(1 July 2024)*

*i)* Category I: No documentation required

*ii)* Category II and III: The quality plan is to be submitted for information (FI) and demonstrated during survey (at SAT/SOST)

### 8.5.3 Determining the Category of the System in Question

*8.5.3(a) Requirement* *(1 July 2024)*

*i)* For each system delivery to a particular vessel, the system category is to be decided based on the failure effects of the system (as defined in 4-9-3/7)

*ii)* The category for a specific system is to be assigned by the System Integrator and conveyed to the relevant system supplier.

*iii)* ABS may decide that a risk-assessment is needed to verify the proper system category.

*8.5.3(b) ABS Verification* *(1 July 2024)*

Category I, II and III: The category for the different systems is to be documented and submitted to ABS for approval/review (AP).

### 8.5.4 Risk Assessment of the System

*8.5.4(a) Requirement*

If requested by ABS, a risk assessment of a specific system in context of the specific vessel in question is to be performed and documented in order to determine the applicable category for the system.

***Commentary:***

- The risks to the system throughout the lifecycle may be determined by identifying and evaluating the hazards associated with each function of the system.
- IEC/ISO31010 "Risk management - Risk assessment techniques" may be used as guidance in order to determine method of risk assessment.

**End of Commentary**

*8.5.4(b) ABS Verification* *(1 July 2024)* *i)* Category I, II and III: The risk assessment report is to be submitted for approval/review (AP) upon request.

### 8.5.5 Define the Vessel's System-architecture

*8.5.5(a) Requirement*

*i)* The system of systems (SoS) is to be specified and documented. This architecture specification is to provide the basis for category determination and development of the different integrated systems by allocating functionality to individual systems and by identifying the main interfaces between the systems. It also is to serve as a basis for the testing of the integrated systems on the vessel level (See 4-9-3/8.5.7).

*ii)* The vessel's system architecture is to at least contain description of:

*a)* Overview of the total systems architecture (the system of systems)

*b)* Each system's purpose and main functionality

*c)* Communication and interface aspects between different systems

***Commentary:***

See Section 4-9-13 for diagram of security zones and conduits.

**End of Commentary**

*8.5.5(b) ABS Verification*

Category I, II, and III: The vessel's system architecture is to be submitted for information (FI) upon request.

### 8.5.6 System Acceptance Test (SAT) On Board the Vessel

*8.5.6(a) Requirement*

*i)* A system acceptance test is to be arranged on board the vessel. The main purpose of the system acceptance test (SAT) is to verify the system functionality, after installation and integration with the applicable machinery/electrical/process systems on board including possible interfaces with other control and monitoring systems.

*ii)* For each test-case it is to be noted if the test passed or failed, and the test-results are to be documented in a test report. The test report is also contain a list of the software (including software versions) that were installed in the system when the test was executed.

*8.5.6(b) ABS Verification* *(1 July 2024)*

*i)* Category I: Not required.

*ii)* Category II and III: The SAT program is to be submitted for approval/review (AP) before the test is executed.

*iii)* The SAT execution is to be witnessed by the ABS Surveyor.

*iv)* The SAT report is to be submitted to ABS Engineering for information (FI).

### 8.5.7 Testing of Integrated Systems on Vessel-level (SOST)

*8.5.7(a) Requirement*

*i)* Integration tests are to be conducted after installation and integration of the different systems in their final environment on board. The purpose of the tests is to verify the functionality of the complete installation (system of systems) including all interfaces and inter-dependencies in compliance with requirements and specifications.

*ii)* The testing is to at least verify the following aspects of the system of systems:

*a)* The overall functionality of the interacting systems as a whole

*b)* Failure response between systems

*c)* Performance

*d)* Human-machine interfaces

*e)* Interfaces between the different systems

***Commentary:***

For complex systems there may be a large difference in scope between the "System acceptance test (SAT) onboard the vessel" activity and the SOST, while for some systems the scope may be overlapping or identical. It is possible to combine the two activities into one when the test scope is similar.

**End of Commentary**

*8.5.7(b) ABS Verification (1 July 2024)*

*i)* Category I: Not required

*ii)* Category II and III: The SOST program is to be submitted for approval/review (AP) before the test is executed.

*iii)* The SOST execution is to be witnessed by the ABS Surveyor.

*iv)* The SOST report is to be submitted to ABS Engineering for information (FI).

#### 8.5.8 Change Management

*8.5.8(a) Requirement*

The systems integrator is to follow procedures for management of change to the system as described in 4-9-3/10.

*8.5.8(b) ABS Verification (1 July 2024)*

*i)* Category I: No documentation requirements.

*ii)* Category II and III: The management of change procedure is to be submitted for information (FI).

## 9 Requirements for Maintenance of Computer Based Systems *(2024)*

### 9.1 Requirements for the Vessel Owner

#### 9.1.1 Responsibilities

For the purposes of this Section 4-9-3, the vessel owner is considered to be the systems integrator in the operations phase unless another organization or person is explicitly appointed by the owner. Accordingly, ABS is to be informed in a timely manner by the owner about the appointed systems integrator which is responsible for implementing any changes to the systems in conjunction with system supplier(s).

### 9.3 Requirements for the Systems Integrator

#### 9.3.1 Change Management

*9.3.1(a) Requirement*

*i)* The systems integrator is to verify that necessary procedures for software and hardware change management exist on board, and that any software modification/upgrade are performed according to the procedure(s). For details about change management, see 4-9-3/10.

*ii)* Changes to computer-based systems in the operational phase are to be recorded.

*iii)* The records are to contain information about the relevant software versions and other relevant information as described in 4-9-3/10.21

*9.3.1(b) ABS Verification*

*i)* Category I: No documentation requirements.

*ii)* Category II and III: See 4-9-3/10.23.

## 9.5 Requirements for the System Supplier

### 9.5.1 Change Management

*9.5.1(a) Requirement*

The system supplier is to follow procedures for maintenance of the system including procedures for management of change as described in 4-9-3/10.

*9.5.1(b) ABS Verification*

*i)* Category I: No documentation requirements.

*ii)* Category II and III: See 4-9-3/10.23.

### 9.5.2 Testing of Changes Before Installation On Board

*9.5.2(a) Requirement (1 July 2024)*

The system supplier is to verify that the planned changes to a system have passed relevant in-house tests before the change is made to systems on board.

*9.5.2(b) ABS Verification*

*i)* Category I: No documentation requirements.

*ii)* Category II and III: See 4-9-3/10.23.

# 10 Management of Change *(2024)*

## 10.1 General

This subsection (4-9-3/10) provides requirements for the management of change throughout the life cycle of a computer based system. Different procedures for the management of change may be defined for specific phases in a system's life cycle as the different phases typically involve different stakeholders. ABS verification is described in 4-9-3/10.23.

## 10.3 Documented Change Management Procedures

### 10.3.1 Requirement

*10.3.1(a)*

The organization in question is to have defined and documented change management procedures applicable for the computer based system in question covering both hardware and software.

*10.3.1(b)*

After FAT, the product supplier is to manage all changes to the system in accordance with the procedure. Examples could be qualification of new versions of acquired software, new hardware, modified control logic, changes to configurable parameters.

*10.3.1(c)*

The procedure(s) are to at least describe the activities listed in 4-9-3/10.5 through 4-9-3/10.21.

*10.3.1(d)*

The outcome of the impact analysis in 4-9-3/10.15 will determine to what extent the activities in 4-9-3/10.5 to 4-9-3/10.23 are to be performed.

*10.3.1(e)*

Change records as described in 4-9-3/10.21 are to be produced when any change is made to the computer based system hardware or software.

## 10.5 Agreement between Relevant Stakeholders

The management of change process is to be coordinated and agreed between the relevant stakeholders along the different stages of the lifecycle of the computer based system.

***Commentary:***

Typically, the management of change addresses at least three different stages:

*i)* Development and internal verification before FAT; involving the system supplier and sub-suppliers.

*ii)* From FAT to handover of the vessel to the owner; involving the system supplier, the systems integrator, ABS, and the owner.

*iii)* In operation; involving the system supplier, service providers, the owner, and ABS

**End of Commentary**

## 10.7 Approved Software Under Change Management

If changes are required to a system after it has been approved by applicable stakeholders (typically the systems integrator and the ABS at FAT) the modifications are to follow defined change management procedures.

## 10.9 Unique Identification of System and Software Versions

The system supplier is to confirm that each system and software version is uniquely identifiable, see 4-9-3/8.3.2.

## 10.11 Handling of Software Master Files

### 10.11.1

Mechanisms for handling of the files that constitutes the master-files for a software component are to be clearly defined.

### 10.11.2

Personnel authorities are to be clearly defined along with the tools and mechanisms used to maintain the integrity of the master files.

## 10.13 Backup and Restoration of Onboard Software

Backup and restoration procedures for the Software components of a computer based system onboard the vessel are to be provided.

## 10.15 Impact Analysis before Change is Made

Before a change to the system is made, an impact analysis is to be performed in order to:

*i)* Determine the criticality of the change.

*ii)* Determine the impact on existing documentation.

*iii)* Determine the needed verification and test activities.

*iv)* Determine the need to inform other stakeholders about the change.

*v)* Determine the need to obtain approval from other stakeholders (e.g., ABS and or Owner) before the change is made.

## 10.17 Roll-back in case of Failed Software Changes

### 10.17.1

When maintenance includes installation of new versions of the software in the system, it has to be possible be perform a roll-back of the software to the previously installed version with the purpose of returning the system to a known, stable state.

### 10.17.2

Roll-backs are to be documented and analysed to find and eliminate the root cause.

## 10.19 Verification and Validation of System Changes

### 10.19.1

To the largest degree practically possible, modifications are to be verified before being installed onboard.

### 10.19.2

After installation, the modification(s) are to be verified onboard according to a documented verification program containing:

*i)* Verification that the new functionalities and/or improvements have had the intended effect.

*ii)* Regression test to verify that the modification has not had any negative effects on functionality or capabilities that were not expected to be affected.

## 10.21 Change Records

### 10.21.1

Changes to systems and software are to be documented in change records to allow for visibility and traceability of the changes.

### 10.21.2

The change records are to contain at least the following items:

*i)* The purpose for a change

*ii)* A description of the changes and modifications

*iii)* The main conclusions from the impact analysis (see 4-9-3/10.15)

*iv)* The identity and version of any new system or software version(s) (see 4-9-3/10.9)

*v)* Test reports or tests summaries (see 4-9-3/10.19)

### 10.21.3

Documentation of the changes to software may be recorded in the planned maintenance system (PMS), in a software registry or equivalent.

## 10.23 Verification of Change Management by ABS

### 10.23.1 In Operation (vessel in service) Phase *(1 July 2024)*

The management of change in operation is generally verified during the annual survey of the vessel. Procedures for management of change and relevant change records as per 4-9-3/10.21 are to be sumitted to ABS Engineering for reveiw/information and made available at the time of survey.

#### 10.23.2 During Newbuilding *(1 July 2024)*

The verification of management of change in the newbuilding phase is divided into two; Procedures are verified as a part of the verification of the quality management system per 4-9-3/8.1.2, while project specific implementation of the procedures are verified during FAT per 4-9-3/8.3.7 and after FAT per 4-9-3/10.21.1.

## 11 Approval of Systems and Components *(2024)*

### 11.1 System Certification

Computer-based systems that are necessary to accomplish vessel-ship functions of category II or category III, as defined in 4-9-3/7.1 are to be delivered by the supplier to the integrator with a vessel specific ABS Report. The objective of the vessel-specific ABS report is to confirm that the design and manufacturing of the system have been completed and that the system complies with the applicable rules.

#### 11.1.1 *(1 July 2024)*

Vessel-specific ABS report is to consist of two main verification activities:

*i)* Assessment of vessel specific documentation (see 4-9-3/5,4-9-3/8.3 and 4-9-3/10)

*ii)* Survey and testing of the system to be delivered to the ship vessel (see 4-9-3/8.3.7)

#### 11.1.2 *(1 July 2024)*

Production Quality Assurance (PQA) is accepted provided the requirements are met, and the system is provided with a vessel-specific certificate.

### 11.3 Approval Under the Type Approval Program *(1 July 2024)*

#### 11.3.1 General *(1 July 2024)*

Computer based systems that are routinely manufactured and include standardized software functions can be type approved in accordance with applicable requirements in Section 4-9-3 and Section 4-9-14 as part of the ABS Type Approval Program (see 4-1-1/3.3). Hardware is to be documented according to the requirement in 4-9-3/8.3.4.

The type approval consists of two main verification activities:

*i)* Assessment of type-specific documentation

*ii)* Survey and testing of the standardized functions

***Commentary:***

The objective of type approval is to avoid document assessment of standardized features for each vessel. Type approval will normally not yield exemption from vessel-specific system certification since vessel specific functions, parameter configurations and installation-specific elements will still demand vessel specific verification.

**End of Commentary**

#### 11.3.2 Product design assessment *(1 July 2024)*

(PDA) Upon application by the manufacturer, each computer based system or component with standardized software functions may be design assessed as described in 1-1-A3/5.1 of the ABS *Rules for Conditions of Classification (Part 1)*. For this purpose, computer based systems or components are to be approved in accordance with requirements in 4-9-3/5, 4-9-3/ 8, 4-9-3/10 and 4-9-14. The prototype environmental tests (4-9-9/13.1) and FAT (4-9-3/8.3.7) are to be conducted in accordance with an approved test schedule and are to be witnessed by a Surveyor. Computer based systems or components so approved may be applied to ABS for listing on the ABS website as Products Design Assessed. Once listed, and subject to renewal and updating of certificate as required by 1-1-A3/5.7 of the ABS *Rules for Conditions of Classification (Part 1)*. See also 4-9-3/11.3.6.

#### 11.3.3 Mass produced products *(1 July 2024)*

Manufacturer of mass-produced computer-based system or its components, who operates a quality assurance system in the manufacturing facilities, may apply to ABS for quality assurance assessment described in 1-1-A3/5.5 (PQA) of the ABS *Rules for Conditions of Classification (Part 1)*.

Upon satisfactory assessment under 1-1-A3/5.5 (PQA) of the ABS *Rules for Conditions of Classification (Part 1)*, Computer based systems or components produced in those facilities will not require a Surveyor's attendance at the tests and inspections indicated in 4-9-9/13.1. Such tests and inspections are to be carried out by the manufacturer whose quality control documents will be accepted. Certification of computer-based system will be based on verification of approval of the design and on continued effectiveness of the quality assurance system. See 1-1-A3/5.7.1(a) of the ABS *Rules for Conditions of Classification (Part 1)*. See also 4-9-3/11.3.6.

#### 11.3.4 Non-mass Produced products *(1 July 2024)*

Manufacturer of non-mass produced computer-based system or its components, who operates a quality assurance system in the manufacturing facilities, may apply to ABS for quality assurance assessment described in 1-1-A3/5.3.1(a) (AQS) or 1-1-A3/5.3.1(b) (RQS) of the ABS *Rules for Conditions of Classification (Part 1)*. Certification to 1-1-A3/5.5 (PQA) of the ABS *Rules for Conditions of Classification (Part 1)* may also be considered in accordance with 4-1-1/9 TABLE 3.

#### 11.3.5 Type Approval Program *(1 July 2024)*

Computer based systems or components approved in accordance with 4-9-3/11.3.1 and the quality assurance system of their manufacturing approved in accordance with 4-9-3/11.3.3 or 4-9-3/11.3.4 will be deemed Type Approved and will be eligible for listing on the ABS website as Type Approved.

#### 11.3.6 Unit Certification *(1 July 2024)*

When a type approved computer based system or component is proposed for use onboard a vessel, a vessel-specific system certification is still required since vessel specific functions, parameter configurations and installation elements demand vessel specific verification are to be reviewed and tested.

Tests listed in 4-9-3/Table 5, 4-9-9/13.3 are to be witnessed by ABS Survey as part of the Unit Certification.

For Cyber resilience requirements refer to 4-9-13 and 4-9-14.

## 13 Data Communication

### 13.1 Data Communication

#### 13.1.1 Data Communication Network

*13.1.1(a) General*.

The requirements in 4-9-3/13.1 are applicable to the system of Category II and III using a shared data communication network to transfer data between distributed computer-based systems.

*13.1.1(b) Monitoring of the Network*. The data communication network is to be continuously monitored to detect failures on the communication network itself and data communication failure on nodes connected to the network. Any detected abnormal condition is to be alarmed at the centralized control station and on the navigation bridge.

*13.1.1(c) Prevention of Overloading*. Safeguards are to be provided to prevent unacceptable data transmission delays (overloading of network). Alarm is to be activated prior to a critical data overload condition.

*13.1.1(d) Integrity of Data*. Means are to be provided to maintain the integrity of data and provide timely recovery of corrupted or invalid data.

*13.1.1(e) Fail Safe Design.*

A single failure in a data communication network is not to cause loss of vessel- functions of category III. Any effect of such failures is to meet the principle of fail-to-safe for the vessel-function(s) being served.

For vessel-functions of category II and III, any loss of functionality in the remote control system is to be compensated by local/manual means.

#### 13.1.2 Duplicated Data Communication Network

*13.1.2(a) Duplication of the Network*. When the same data communication network is used for two or more essential functions (e.g., propulsion control and generator control), this network is to be duplicated, and each is to be routed as far apart from the other as practical. The duplicate network is for standby purpose only and not to be used to reduce traffic in the online network.

*13.1.2(b) Monitoring of the Network*. Duplicated data communication network is to be arranged so that upon the failure of the online network, the standby network is automatically connected to the system. Switching between duplicated networks is not to disturb data communication or continuous functioning of the system. The failure of one network is to be alarmed at the centralized control station and on the navigation bridge.

#### 13.1.3 Connection Failure *(2024)*

Loss of a data link (data communication) is to be specifically addressed in risk assessment analysis. See 4-9-3/5.3 and 4-9-3/8.3.3. A complete failure in connectivity between component systems and the data highway is not to affect individual functionality of the component systems.

Where a single component failure results in loss of data communication, means are to be provided to automatically restore data communication.

Loss of a data communication network is not to affect the ability to operate essential services by alternate means.

### 13.3 Wireless Data Communication *(2012)*

Wireless data communication will be specially considered depending upon the purpose.

#### 13.3.1 Non-essential and Recreational Purposes, Entirely Within the Living Accommodations

Wireless data communication used for non-essential and recreational purposes, entirely within the living accommodations, will be specially considered provided it is demonstrated that there is no detrimental effect on essential services. Further documentation is to be submitted for review which demonstrates compliance with 4-9-3/13.3.3(c), 4-9-3/13.3.3(e) and 4-9-3/13.3.3(f).

#### 13.3.2 Non-essential and Recreational Purposes

Wireless data communication used for non-essential and recreational purposes, within the living accommodations and outside of the living accommodations, will be specially considered provided there is no detrimental effect on essential services. Further documentation is to be submitted for review which demonstrates compliance with 4-9-3/13.3.3(a) through 4-9-3/13.3.3(f).

### 13.3.3 Vessel Services (Non-Recreational Purposes) *(2024)*

Wireless data communication used for vessel services (such as essential services, category I systems, category II systems, category III systems, etc.) will be specially considered provided the use of the wireless data communications results in an improvement in the safety of the vessel, compared to wired data communication. Documentation which demonstrates an improvement in safety is to be submitted for review. Further documentation is to be submitted for review which demonstrates compliance with 4-9-3/13.3.3(a) through 4-9-3/13.3.3(f).

***Commentary:***

For assignment of system categories, see 4-9-3/7.1. Since a failure of a category I system should not lead to a dangerous situation and failure of a category II system could eventually lead to a dangerous situation, an improvement in the safety of the vessel will be more difficult to demonstrate for wireless data communication used in category II system, compared to category I systems. Since a failure of a category III system may immediately lead to an accident with catastrophic severity, wireless systems and equipment are unlikely to be permitted in category III systems.

**End of Commentary**

*13.3.3(a) Risk Analysis*. A suitable risk analysis (such as an Failure Modes and Effects Analysis (FMEA)) is to be performed which demonstrates that an interruption or failure in the wireless data communication will not lead to a hazardous situation.

***Note:***

Consideration is to be given to the possibility of corrupted data and intermittent failures with comparatively long recovery times between interruptions.

*13.3.3(b) Type Testing*. The wireless equipment is to meet the environmental type testing requirements of 4-9-9/13.1 and 4-9-9/15.7 TABLE 1 based on the proposed location of installation.

*13.3.3(c) Wireless Data Communication Tests*. The wireless data communication is to not cause interference with any vessel systems. This is applicable to all wireless data communication equipment (even wireless data communication equipment for non-essential services). See the tests required by 4-9-3/13.3.4.

*13.3.3(d) Wireless Data Communication Network*. The wireless data communication network is to meet the requirements of 4-9-4/3.3, 4-9-3/13.1.1, 4-9-3/13.1.2 and 4-9-3/13.1.3.

*13.3.3(e) Wireless System Protocols*. Wireless data communication is to follow recognized international wireless system protocols that incorporate the following.

***i)*** *Message integrity*. Fault prevention, detection, diagnosis and correction so that the received message is not corrupted or altered when compared to the transmitted message.

***ii)*** *Configuration and device authentication*. Only devices that are included in the wireless system are to be permitted to connect to the wireless system.

***iii)*** *Message encryption*. Protection of the confidentiality and criticality of the data content.

***iv)*** *Security management*. Protection of network assets, and prevention of unauthorized access to network assets.

*13.3.3(f) Radio-Frequency and Power Level*. The wireless system is to comply with the radio-frequency and power level requirements of the International Telecommunications Union and flag state requirements.

***Note:***

Consideration is to be given to system operation in the event of port state and local requirements that pertain to the use of radio-frequency transmission prohibiting the operation of a wireless data communication system due to radio-frequency and power level restrictions.

*13.3.3(g) Alternative Means of Control*. Functions that are required to operate continuously to provide essential services dependent on wireless data communication are to be provided with an alternative means of control that can be brought into action within an acceptable period of time.

#### 13.3.4 Wireless Data Communication Tests *(2024)*

Tests during harbor and sea trials are to be conducted to demonstrate that radio-frequency transmission from wireless data communication equipment does not cause failure of any equipment and does not cause the wireless data communication equipment itself to fail as a result of electromagneticthe interference during expected operating conditions.

***Notes:***

***i)*** Where electromagnetic interference caused by wireless data communication equipment is found to be causing the failure of equipment or systems, the layout and/or equipment is to be changed to prevent further failures from occurring.

***ii)*** In the unlikely case when wireless data communication is permitted in systems of category III, the level of witnessing will be determined during review. The scope of the testing for systems of category III will be more extensive than for systems of category II.

#### 13.3.5 ABS Verification *(2024)*

The implementation of the technical requirements provided in 4-9-3/13.3.1 to 4-9-3/13.3.3 are verified by ABS as part of the system description (4-9-3/8.3.3), FAT (4-9-3/8.3.7), SAT (4-9-3/8.5.6) and wireless data communication tests (4-9-3/13.3.4).

## 15 Summary of Documentation Submittal *(1 July 2024)*

4-9-3/15 TABLE 3 and 4-9-3/15 TABLE 4 below summarize the documentation to be submitted to ABS Engineering.

### TABLE 3
### Summary of Documentation Submittal by the Supplier *(1 July 2024)*

| *Item* | | *Responsible Role* | *System Category* | | |
|---|---|---|---|---|---|
| *Rule Reference* | *Document* | | *CAT I* | *CAT II* | *CAT III* |
| 4-9-3/8.3.1 | Quality plan | System Supplier | - | FI | FI |
| 4-9-3/8.3.3 | System description | System Supplier | FI on request | AP | AP |
| 4-9-3/8.3.4 | Environmental compliance | System Supplier | FI on request | FI | FI |
| 4-9-3/8.3.5 | Software test reports | System Supplier | - | FI | FI |
| 4-9-3/8.3.6 | System test report | System Supplier | - | FI | FI |

| *Item* | | *Responsible Role* | *System Category* | | |
|---|---|---|---|---|---|
| *Rule Reference* | *Document* | | *CAT I* | *CAT II* | *CAT III* |
| 4-9-3/8.3.7 | FAT program | System Supplier | - | AP | AP |
| 4-9-3/8.3.7 | FAT report | System Supplier | - | FI | FI |
| 4-9-3/8.3.7 | Additional FAT docs. (e.g., user manual, etc.) | System Supplier | - | AP/FI | AP/FI |
| 4-9-3/8.3.8 | Management of change procedure | System Supplier | - | FI | FI |

***Note:***

AP = To be submitted to ABS for Approval/Review

FI = Provided to ABS for Information

"-" = No requirement

FI on req. = Document to be maintained by the responsible role and provided to ABS for information upon request

## TABLE 4
## Summary of Documentation Submittal by the System Integrator *(1 July 2024)*

| *Item* | | *Responsible Role* | *System Category* | | |
|---|---|---|---|---|---|
| *Rule Reference* | *Document* | | *CAT I* | *CAT II* | *CAT III* |
| 4-9-3/8.5.2 | Quality plan | Systems integrator | - | FI | FI |
| 4-9-3/8.5.3 | List of system categorizations | Systems integrator | AP | AP | AP |
| 4-9-3/8.5.4 | Risk assessment report | Systems integrator | AP on req. | AP on req. | AP on req. |
| 4-9-3/8.5.5 | Vessel's system architecture | Systems integrator | AP | AP | AP |
| 4-9-3/8.5.6 | SAT program | Systems integrator | - | AP | AP |
| 4-9-3/8.5.6 | SAT report | Systems integrator | - | FI | FI |
| 4-9-3/8.5.7 | SOST program | Systems integrator | - | AP | AP |
| 4-9-3/8.5.7 | SOST report | Systems integrator | - | FI | FI |
| 4-9-3/8.5.8 | Change management procedure for software | Systems integrator | - | FI | FI |

***Note:***

AP = To be submitted to ABS for Approval/Review

FI = Provided to ABS for Information

"-" = No requirement

on req. = Document to be maintained by the responsible role and provided to ABS for information upon request

# 16 Testing, Inspection and Certification of Computer Based Systems *(1 July 2024)*

## 16.1 Shop Inspection and Tests

The following shop inspection and tests are to be conducted by the manufacturer for Category I computer-based systems. Category II and III computer-based systems tests/inspections are to be witnessed by the Surveyor.

### 16.1.1 Quality Plan

The system supplier is to adhere to a quality system to ensure that the designer's specifications are met in accordance with 4-9-3/8.1.2, 4-9-3/Table 2 and 4-9-3/8.3, the reviewed quality system is to be verified by the attending ABS Surveyor.

### 16.1.2 Hardware Components

Hardware components utilized for the construction of the computer-based systems are to be certified in accordance with the provisions of 4-9-3/8.3.4 and 4-9-9/Table 1. The assembled unit or subassembly unit is to tested in accordance with 4-9-9/15.7 TABLE 2 as per 4-9-9/13.3.

### 16.1.3 Factory Acceptance Tests

*16.1.3(a)*

Prior to the Factory Acceptance Test with the Surveyor, hardware and software is to be tested by the manufacturer using their internal test procedure required by 4-9-3/8.3.6.

*16.1.3(b)*

Computer-based systems hardware and software are to be verified at the manufacturers' facilities by a Surveyor for arrangement and conformance with the approved plans.

*16.1.3(c)*

Factory acceptance tests, as specified in the specified standard of compliance, are to be witnessed by the Surveyor using the ABS approved test procedure and include the following tests as specified by 4-9-3/8.3.7 and other sections of the Rules:

***i)*** Demonstration that the system is complete and compliant with applicable rules.

***ii)*** A representative selection of the items from the manufacturer's internal test including:

- Normal system functionality
  - Testing of all functions of the system
  - Confirmation of interfaces with other systems including input and output
- Response to failures -e.g.:
  - Loss of data link
  - As described in the FMEA (when required)
  - Other applicable failures
- Representative testing for sub-systems and components that have been supplied and tested previously in the presence of a surveyor to verify functionality after integration.

***iii)*** Network testing to verify network resilience in accordance with 4-9-3/13.

- If a test network is not practicable at the manufacturer, this will require the approved test procedure to specify testing after installation onboard the vessel.

*iv)* Software and Hardware used for the test are to be the actual versions and components to be installed on board.

*v)* Evidence provided of a scan for malicious software in accordance with their Test Plan required in 4-9-14/15.

*vi)* Testing is to include means for simulation of functions and failure responses.

- Other methods may be accepted as described in the approved test procedure, so long as they are no less effective

All test results are to be recorded as pass or fail, and the results are to be documented in a test report.

The completed test report is to be provided to the Surveyor and is to include a list of the hardware with identifying markings listed and software with a listing of the software versions used.

### 16.2 Modifications

Modifications that change the functionality of the system require submittal and approval. Refer to 4-9-3/5.1.9 for details regarding modifications to computer-based systems.

### 16.3 Certification of Computer- Based Systems

#### 16.3.1 General

Computer Based Systems are to be delivered with:

*16.3.1(a) Category I Systems:*

A manufacturer's affidavit or ABS product design assessment in accordance with 4-9-3/11. Upon Installation, verification of computer-based system, manufacturer’s marking(s) is required.

*16.3.1(b) Category II and III Systems:*

ABS certificate which states the applicable ABS product design assessment in accordance with 4-9-3/11. Upon installation, verification of computer-based system ABS marking per 4-1-1/3.9 is required and subject to a satisfactory performance test after installation, conducted in the presence of the Surveyor in accordance with 4-9-10.

## 17 Summary of Test Witnessing and Survey *(2024)*

4-9-3/17 TABLE 5 below summarizes the activities that are to be witnessed by ABS Survey. The responsible role is to facilitate the activity.

**TABLE 5**
**Summary of Test Witnessing and Survey** *(1 July 2024)*

| *Item* | | *Responsible Role* | *System Category* | | |
|---|---|---|---|---|---|
| *Rule Reference* | *Document* | | *CAT I* | *CAT II* | *CAT III* |
| 4-9-9/13 | Prototype and Production Unit Certification Testing | System Supplier | - | x | x |
| 4-9-3/8.3.7 | FAT witnessing | System Supplier | - | x | x |
| 4-9-3/8.5.6 | SAT witnessing | Systems integrator | - | x | x |
| 4-9-3/8.5.7 | SOST witnessing | Systems integrator | - | x | x |

| *Item* | | *Responsible Role* | *System Category* | | |
|---|---|---|---|---|---|
| *Rule Reference* | *Document* | | *CAT I* | *CAT II* | *CAT III* |
| 4-9-3/10.23 | Verification of changes | Systems integrator | - | x | x |
| 4-9-3/13.3.4 | Wireless Data Communication Test | Systems integrator | - | x | x |

*Note:*

"x" = Witnessing by ABS Survey required

"-" = Witnessing by ABS Survey is not required

# PART 4

## CHAPTER 9
## Automation and Computer Based Systems

## SECTION 4
## Integrated Automation System

## 1 Definitions

### 1.1 IAS

An Integrated Automation System (IAS) is a combination of computer-based systems with redundant architecture,which are interconnected in order to allow communication between computer systems; between computer systems and monitoring, control, and vessel management systems; and to allow centralized access to information and/or command/control. For example, an integrated system may consist of systems capable of performing passage execution (e.g., steering, speed control, traffic surveillance, voyage planning); machinery management and control (e.g., power management, machinery monitoring, fuel oil/lubrication oil transfer); cargo operations (e.g., cargo monitoring, inert gas generation, loading/discharging); etc.

Functions are integrated to reduce the need for hardware and software functions and to reduce interface requirements.

### 1.3 Module Technology

The IAS comprises different functions modules and the system can be expandable by adding more modules of different functions. The function module includes hardware module and software module. Module technology is based on the identical basic software platform, free flow of information. It reduces spare parts.

## 2 Objective *(2024)*

### 2.1 Goals

The integrated automated systems are to be designed, constructed, operated and maintained to:

| *Goal No.* | *Goals* |
|---|---|
| AUTO 1 | perform its functions as intended and in a safe manner. |
| AUTO 2 | indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance. |
| AUTO 3 | have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |

| *Goal No.* | *Goals* |
|---|---|
| AUTO 4 | provide the equivalent degree of safety and operability from a remote location as those provided by local controls. |
| AUTO 5 | be provided with a safety system that automatically leads the machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/equipment or environment. |
| AUTO 6 | independently perform different functions, such that a single failure in one system will not render the others inoperative. |
| AUTO 7 | enable rational human machine interface without unintended errors due to the layout or arrangement of machinery/equipment. |

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

## 2.3 Functional Requirements

In order to achieve the above stated goal, the design, construction, installation and maintenance of the integrated automated systems are to be in accordance with the following functional requirements:

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Apply fail-safe design for all control systems, manual emergency control systems and safety systems to prevent dangerous situations due to a single point failure. |
| AUTO-FR2 | System independence is to be applied to automation systems performing different functions, failure of one function should not lead to loss of other functions. |
| AUTO-FR3 | Provide redundant and interchangeable human machine interface hardware to prevent loss of monitoring and control functionality |
| AUTO-FR4 | An independent alternative means of control is to provided to prevent loss of essential systems. |

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

## 2.5 Compliance

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

# 3 System Requirements

In addition to the relevant requirements in Section 4-9-2 and Section 4-9-3 the following is to be complied with:

## 3.1 Effective operation

Operation with an integrated automation system is to be at least as effective as it would be with individual stand-alone equipment or systems.

## 3.3 Integrated automation system failure

Failure of one part of the integrated automation system (individual module, equipment or subsystem) is to not affect the functionality of other parts, except for those functions directly dependent on the defective part.

### 3.5 Multi-function displays and controls

Where multi-function displays and controls are used, they are to be redundant and interchangeable. The number of units at control stations is to be sufficient such that all functions may be provided with any one unit out of operation, taking into account any functions which are required to be continuously available

### 3.7 Hardware redundancy

Common hardware in an integrated automation system serving many subsystems (e.g., monitor, keyboard, microprocessor, etc.) is to be duplicated or otherwise provided with a means of backup.

### 3.9 Interfaces

Standard interfaces are to be used for the data exchange between the different systems. The network is to be designed in compliance with an international standard such as IEC 61158 or IEC 61784. See also 4-9-3/13.

### 3.11 Control redundancy

An alternative means of operation, independent of the integration, is to be available for all essential functions.

## 5 FMEA

Where the integration involves control functions for essential services or safety functions, including fire, passenger, crew, and ship safety, an FMEA is to be carried out. The FMEA is to demonstrate that the integrated system will 'fail-safe', and that essential services in operation will not be lost or degraded.

## 7 Documentation

Documentation is to be submitted to demonstrate that the installed integrated automation system has been designed, manufactured and tested in accordance with 4-9-1/7 and 4-9-4/3. This documentation is to be submitted by a single party responsible for the integration.

# PART 4

## CHAPTER 9
## Automation and Computer Based Systems

## SECTION 5
## ACC Notation

### 1 General *(2024)*

Where, in lieu of manning the propulsion machinery space locally, it is intended to monitor the propulsion machinery space and to control and monitor the propulsion and auxiliary machinery from a continuously manned centralized control station, such a station is to meet the provisions of 4-9-5/3.1. These provisions cover propulsion machinery during start-up, navigating and maneuvering, and do not cover operations in port or at mooring or anchorage.

The optional notation **ACC** will be assigned upon verification of compliance and upon satisfactory tests and trails carried out in accordance with the provisions of 4-9-5/9 in the presence of a Surveyor.

For purposes of assigning **ACC**, remote propulsion control from the navigation bridge is not mandatory. However, if fitted, requirements of 4-9-5/3, as applicable to navigation bridge, are to be met.

### 1.1 Objective *(2024)*

#### 1.1.1 Goals

The automation systems in scope of **ACC** notation covered in this section are to be designed, constructed, operated and maintained to:

| *Goal No.* | *Goals* |
|---|---|
| POW 2 | provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel. |
| POW 6 | have fail-safe features that prevent progressive failure in the event of failure of any single component. |
| FIR 3 | *reduce the risk of damage caused by fire to the ship, its cargo and the environment.* |
| FIR 4 | *detect, contain, control and suppress or swiftly extinguish a fire in the compartment of origin.* |
| SAFE 1.1 | minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems. |
| AUTO 1 | perform its functions as intended and in a safe manner. |
| AUTO 2 | indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance. |

| *Goal No.* | *Goals* |
|---|---|
| AUTO 3 | have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |
| AUTO 4 | provide the equivalent degree of safety and operability from a remote location as those provided by local controls. |
| AUTO 5 | be provided with a safety system that automatically leads the machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/equipment or environment. |
| AUTO 6 | independently perform different functions, such that a single failure in one system will not render the others inoperative. |
| AUTO 7 | enable rational human machine interface without unintended errors due to the layout or arrangement of machinery/equipment. |

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

### 1.1.2 Functional Requirements

In order to achieve the above stated goal, the design, construction, installation and maintenance of the automation systems in scope of **ACC** notation are to be in accordance with the following Functional Requirements:

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Power Generation and Distribution (POW)** | |
| POW-FR1 | Provide continuous power for control, monitoring and safety systems such that power is available even after a single point failure. |
| POW-FR2 | Provide means to operate any standby power generation source for automatically restoring power to equipment necessary for propulsion, steering and safety of the vessel. |
| POW-FR3 | The control, monitoring and safety systems are to be designed such that a single point failure will not lead to an unsafe situation onboard. |
| **Fire Safety (FIR)** | |
| FIR-FR1 | Fire detection in propulsion machinery spaces is to be alarmed at all manned control stations to enable fast emergency response. |
| FIR-FR2 | Provide means to remotely start fire pumps from the navigation bridge and/or fire control station to deliver water immediately. |
| **Safety of Personnel (SAFE)** | |
| SAFE-FR1 (FIR) | The boundaries of the centralized control station are to be designed to withstand fire in adjacent spaces. |
| SAFE-FR2 | Provide means to alert personnel in the engineers' accommodation in case the alarms in central control station are not acknowledged. |
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | To obtain ACC notation, a centralized control station is to be provided with means to monitor the propulsion machinery space and to control and monitor all the parameters for normal operation of propulsion and auxiliary machinery. |
| AUTO-FR2 | Apply fail-safe design for all control systems, manual emergency control systems and safety systems to prevent a dangerous situation. |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| AUTO-FR3 | Where provided, the remote control is to be as effective as local control. |
| AUTO-FR4 | Location of the centralized control station is to be such that it is as effective as propulsion machinery space being controlled under local supervision and operation. |
| AUTO-FR5 | The centralized control station is to be provided with means to take corrective actions, manually or automatically, in the event of a fault in the machinery. |
| AUTO-FR6 | Provide visual and audible notification at the centralized control station upon occurrence of fault/faults in propulsion and auxiliary machinery, propulsion machinery space. |
| AUTO-FR7 | Monitoring in the centralized control station is to be available even after a single point failure. |
| AUTO-FR8 | Safety interlocks are to be provided to prevent damage to the controlled machinery. |
| AUTO-FR9 | Provide means to manually override automated safety functions except for safety functions that are intended to avert rapid deterioration of propulsion and auxiliary machinery. |
| AUTO-FR10 | Safety system functions are to be arranged and controlled such that the *machinery operation* can *be as safe and effective as if it were under direct supervision*. (SOLAS II-1) |
| AUTO-FR11 | Provide means to monitor the operational status of propulsion boilers and auxiliary boilers necessary to support operation of propulsion and activate the notification of abnormal conditions in the centralized control station. |
| AUTO-FR12 | The fuel oil system is to be monitored with alarms from the centralized control station to ensure normal operation. |
| AUTO-FR13 | Means are to be provided to remotely monitor the safety related functions of the liquified gas fuel supply system at the centralized control station. |
| AUTO-FR14 | Provide means to monitor the bilge level in the propulsion machinery space at various angles of vessel's heel and trim from the centralized control station to prevent the accumulation of bilge water. |
| AUTO-FR15 | The bilge monitoring and control system is to be fully functional even after a single point failure in the system. |
| AUTO-FR16 | Excessive or frequent operation of automated bilge pumps are to be notified at the centralized control station to monitor any potential leaks. |

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

#### 1.1.3 Compliance

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

## 3 System Requirements

### 3.1 General

In general, the centralized control station is to be:

*i)* As effective as a propulsion machinery space under local supervision and operation;

*ii)* Provided with remote control of propulsion machinery;

*iii)* Provided with means to monitor the states of the propulsion machinery space, the propulsion, auxiliary and other machinery, and

*iv)* Provided with means to effect, manually or automatically, corrective actions, such as starting of a standby pump, in the event of a fault in the machinery plant.

### 3.3 System Design

In general, conceptual requirements in 4-9-2/3.1 are applicable. Specific details are provided in 4-9-5/7 through 4-9-5/15. FMEA (4-9-2/3.1.5) is to be conducted to demonstrate that control, monitoring and safety systems are so designed that any single failure will not result in the loss of propulsion control, the loss of propulsion or other undesirable consequences. The FMEA report is to be submitted for review.

### 3.5 System Power Supply

#### 3.5.1 Power Source

Electrical power supply is to meet the requirements of 4-9-2/5.3. In addition, 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 their failure is to be alarmed at the centralized control station.

#### 3.5.2 Power Supply Transfer

The two feeders are to be connected to a transfer switch in the centralized control station. Power supply to controls, monitoring and safety systems can be commonly connected to the transfer switch. The transfer between the power supplies is to be effected automatically upon failure of a supply and by manual means at the centralized control station.Power transfer is to be achieved without a break in power supply.

## 5 Location of Centralized Control Station

The centralized control station is to be located within, or adjacent to, the propulsion machinery space. Consideration will be given to this station being located away from the propulsion machinery space, provided its operation and monitoring of the propulsion machinery and propulsion machinery space is to be as effective as if it is located either within or adjacent to the propulsion machinery space.

Where this station is in an enclosure located in or adjacent to machinery space, at least two means of access, separated as remote from each other as practicable, are to be provided. Where fitted, glass windows forming parts of the boundaries, are to be of shatter-resistance type (e.g. laminated glass or wire mesh embedded glass).

## 7 Remote Controls from Centralized Control Station

Necessary controls to operate the propulsion machinery and its associated auxiliary systems are to be provided in the centralized control station. This includes the following control functions.

*i)* Remote propulsion control as provided in Section 4-9-2.

*ii)* Put on-line a standby generator as described in 4-9-5/13.9.1.

*iii)* Start, stop and transfer auxiliaries necessary for the operation of propulsion and power generation machinery as described in 4-9-5/13.13.

All required controls are shown in the “C” column of 4-9-5/17 TABLE 1.

# 9 Monitoring in Centralized Control Station

## 9.1 Instrumentation

Alarms and displays for monitoring propulsion and auxiliary machinery and for propulsion machinery space are to be provided in the centralized control station as specified in "A" and "D" columns of 4-9-5/17 TABLE 1 and in "A" and "D" columns of 4-9-6/23 TABLE 1A through 4-9-6/23 TABLE 6, as applicable. Alternative monitored parameters, which may provide equal effectiveness, will be considered.

## 9.3 Operator Interface

Where a computer is used as the operator interface to display monitoring information, the centralized control station is to be provided with at least two computers, including keyboards and monitors, unless other means of display are provided capable of displaying the same information.

## 9.5 Engineer's Alarm

Where alarms are not acknowledged at the centralized control station in a pre-set period of time (e.g. 2 minutes), the system is to activate the engineers' alarm audible in the engineers' accommodations (see also 4-9-6/19.1).

# 11 Safety System

Safety system functions are to be in accordance with 4-9-2/9.5. As a minimum safety shutdowns specified in 4-9-2/9.3 are to be provided. Where desired, safety system functions specified in "Auto start", "Auto slowdown" and "Auto shutdown" columns in 4-9-6/23 TABLE 1A through 4-9-6/23 TABLE 6 is to be provided. Override of safety system functions is to be as in 4-9-2/9.5.3.

# 13 Specific Requirements for Propulsion and Auxiliary Machinery

The following are requirements for control, monitoring and safety systems applicable to individual propulsion and auxiliary machinery plant supplemental to those of 4-9-5/7 through 4-9-5/11 above.

## 13.1 Propulsion Diesel Engines

Alarms and displays ("A" and "D" columns) in 4-9-6/23 TABLE 1A and 4-9-6/23 TABLE 1B are applicable. Safety system functions (Auto start, Auto shutdown, and Auto slowdown columns) in these tables are not mandatory for assigning **ACC** notation, except for automatic shutdowns required in 4-9-2/9.3.

## 13.3 Propulsion Gas Turbines

Alarms and displays ("A" and "D" columns) in 4-9-6/23 TABLE 3 are applicable. Safety system functions (Auto start, Auto shutdown, and Auto slowdown columns) in these tables are not mandatory for assigning **ACC** notation, except for automatic shutdowns required in 4-9-2/9.3.

## 13.5 Propulsion Steam Turbines

Alarms and displays ("A" and "D" columns) in 4-9-6/23 TABLE 2 are applicable. Safety system functions (Auto start, Auto shutdown, and Auto slowdown columns) in these tables are not mandatory for assigning **ACC** notation, except for automatic shutdowns required in 4-9-2/9.3. The following are also to be complied with.

### 13.5.1 Guardian Valve Operation

The astern guardian valve is to open automatically as a result of a throttle trip or a maneuvering signal, such as the actuation of a specific switch or by movement of the throttle control into the maneuvering range. Failure of the guardian valve to open is to be alarmed at the centralized control station.

#### 13.5.2 Sea Water Main Circulating Pump

Where scoop circulation is provided for the main condenser, a low water supply situation is to be alarmed to allow manual starting of the main circulating pump. Alternatively, the pump can be automatically started as vessel speed reduces or as required by the design of the cooling system for satisfactory operation of the propulsion machinery.

### 13.7 Electric Propulsion

Alarms and displays ("A" and "D" columns) in 4-9-6/Table 4 are applicable. Safety system functions (Auto start, Auto shutdown, and Auto slowdown columns) in these tables are not mandatory for assigning **ACC** notation, except for automatic shutdowns required in 4-9-2/9.3.

### 13.9 Generators and Electrical Systems

Alarms and displays ("A" and "D" columns) in 4-9-5/17 TABLE 1 and 4-9-6/23 TABLE 6 are applicable. Safety system functions (Auto shutdown column) in 4-9-6/23 TABLE 6 are not mandatory for assigning **ACC** notation, except for automatic shutdowns required in 4-9-2/9.3. The following are also to be complied with.

#### 13.9.1 Starting of Generators

In addition to complying with 4-8-2/3.11 for automatically restoring power to equipment necessary for propulsion, steering and safety, arrangements are to be provided to enable manually starting, stopping, synchronizing, paralleling and placing in service any generator from a single location. This location is to be at the main switchboard or can be at the centralized control console, if the main switchboard is located in the centralized control station.

#### 13.9.2 Monitoring of Generators

Where the main switchboard is not located in the centralized control station alarms and displays for monitoring the generators and main switchboard, as indicated in 4-9-5/17 TABLE 1, are to be provided in the centralized control station.

### 13.11 Boilers and Fired Equipment

#### 13.11.1 Propulsion Boilers and Auxiliary Boilers Supporting Propulsion

In addition to the safety shutdowns required in 4-9-2/9.3 and 4-4-1/11.5.1 and 4-4-1/11.5.2, the following provisions are to be complied with:

*i)* For propulsion boilers, alarms and displays ("A" and "D" columns) in 4-9-6/23 TABLE 5A.

*ii)* For auxiliary boilers necessary to support operation of propulsion (including power generation), alarms and displays ("A" and "D" columns) in 4-9-6/23 TABLE 5B. See also 4-9-5/13.11.2.

*iii)* For boilers fitted with automatic control, the provisions of 4-4-1/11.5.3.

Except when in local control, remote override of safety shutdowns specified in 4-9-2/9.3 and 4-4-1/11.5.1 is not permitted.

#### 13.11.2 Monitoring of Auxiliary Boilers

Auxiliary boilers necessary to support operation of propulsion, including ship service electric power supply, is to be fitted with a summary alarm and display located in the centralized control and monitoring station in lieu of 4-9-5/13.11.1.ii, provided:

*i)* The boiler is fitted with automatic control.

*ii)* The boiler is fitted with local control station and is not intended for remote control.

*iii)* The local control station is fitted with all controls, safety provisions, alarms and displays in 4-9-6/23 TABLE 5B (except that salinity alarm and display is to be provided at the centralized control and monitoring station).

*iv)* The centralized control and monitoring station is provided with the display for "boiler running", and summary alarms for "boiler abnormal" and "boiler shutdown". The "boiler abnormal" alarm is to be activated by any of the alarms listed in 4-9-6/23 TABLE 5B.

#### 13.11.3 Other Fired Equipment

Fired auxiliary boilers not related to supporting the operation of propulsion machinery are to comply with the requirements in 4-4-1/11.5.1 and 4-4-1/11.5.2. If the boiler is fitted with automatic control, 4-4-1/11.5.3 is also to be complied with.

Thermal oil boilers and incinerators are to meet 4-4-1/13.3.2 and 4-4-1/15.3 respectively.

### 13.13 Propulsion Auxiliaries

The centralized control station is to be provided with means to remotely start and stop auxiliary pumps associated with the operation of the following:

- Propulsion engine
- Electrical power generators
- Controllable pitch propellers
- Propulsion boilers and boilers supporting propulsion (including power generation)
- Fuel oil transfer system

Automatic transferring of vital auxiliary pumps, where fitted, is to be alarmed at the centralized control station.

## 15 Propulsion Machinery Space

### 15.1 Fuel Oil System Arrangements

#### 15.1.1 Fuel Oil Settling and Service Tanks

Low level conditions of fuel oil settling and daily service tanks are to be alarmed at the centralized control station. Where automatic filling is provided, the arrangements are to include automatic pump shutdown and start-up at predetermined high and low levels respectively. In such cases, fuel oil high level alarm is also to be provided.

#### 15.1.2 Fuel Oil Overflow and Drain Tanks

Fuel oil overflow tanks and fuel oil drain tank receiving fuel oil from drip pans, spill trays and other leakage containment facilities are to be fitted with a high level alarm at the centralized control station.

#### 15.1.3 Fuel Oil Heating

Fuel oil tanks provided with heating arrangements and fuel oil heaters are to be fitted with the following alarms at the centralized control station. See also 4-6-4/13.5.7 and 4-6-4/13.7.4.

*i)* High temperature alarm and temperature display for the heated fuel oil in the settling and service tanks.

*ii)* Fuel oil high temperature (or low viscosity) alarm, or a low flow alarm at the heater outlet. This alarm can be omitted if a fuel oil high temperature alarm required by 4-9-6/23 TABLE 1A through 4-9-6/23 TABLE 6 monitors the fuel oil high temperature for the heaters also.

*iii)* High temperature alarm for the fluid heating medium (steam, thermal oil, etc.) for fuel oil tanks or fuel oil heater, where the maximum temperature of the heating medium would exceed 220°C (428°F).

#### 15.1.4 Use of Cargo as Propulsion Fuel

Vessels carrying liquefied natural gases that utilize methane as fuel in propulsion machinery spaces are to meet the provisions Section 5C-8-16. The monitoring of gas supply, shutoff valve and propulsion machinery space ventilation, as required therein, are to be fitted at the centralized control station.

### 15.3 Bilge Level Monitoring

#### 15.3.1 Bilge Level *(2025)*

The propulsion machinery space is to be provided with at least two independent alarm circuits to detect excessive rise of bilge water in the bilges or bilge wells. The arrangements including the number of sensors and locations are to be such that accumulation of bilge water can be detected at the various angles of vessel's heel and trim. The alarm is to be given in the centralized control station.

#### 15.3.2 Bilge Pump

Where the bilge pumps are arranged for automatic operation, means are to be provided to indicate, at the centralized control station, when the pump is operating more frequently than would normally be expected, or when the pump is operating for an excessive length of time. Additionally, attention is to be given to oil pollution prevention requirements.

### 15.5 Fire Safety

#### 15.5.1 Fire Detection and Alarm Systems

Propulsion machinery space is to be provided with a fixed fire detection and alarm system complying with 4-7-2/1.13.1 (or Regulation II-2/7 of SOLAS 1974). This fixed fire detection and alarm system can be combined with other fire detection and alarm systems required on board the vessel. The fire control panel is to be located on the navigation bridge or in the fire fighting station, if fitted. 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.

#### 15.5.2 Fire Main System

In order to provide immediate water delivery from the fire main system at a suitable pressure, provisions are to be made to remotely starting one of the main fire pumps at the navigation bridge, unless the fire main is permanently pressurized. See 4-7-3/1.5.5 (or Regulation II-2/10.2.1.2.2.2 of SOLAS).

The remote starting is to be provided also at the fire control station, if fitted. Alternatively, means provided at fire fighting station to start the emergency fire pump, as in 4-9-6/21.3.ix., may be considered as satisfying this requirement.

## 17 Equipment

Components, equipment, subsystems, etc. used in control, monitoring and safety systems of propulsion machinery, propulsion boilers and vital auxiliary pumps are to be designed and tested in accordance with the provisions in Section 4-9-9.

## TABLE 1
## Instrumentation and Controllers in Centralized Control Station - All Propulsion and Auxiliary Machinery

| *System* | *Monitored/Controlled Parameter* | | *A* | *D* | *C* | *Notes: [ A= Alarm; D= Display; C= Controller/Actuator ] [ x= applies ]* |
|---|---|---|---|---|---|---|
| Propulsion control and monitoring | A1 | As in 4-9-2/15.3 TABLE 2 items A1 through C2, with follow additional features | x | x | x | Following items of 4-9-2/15.3 TABLE 2 are to be modified:<br>- Item A4: additional telegraph is not required for centralized control station.<br>- Item A6: starting of propulsion engine is required for all engine types<br>- Item C1: acknowledgement switch for transfer of control station is not required in centralized control station |
| | A2 | System power supply main and emergency feeders: failure, status and transfer | x | x | x | |
| | A3 | Propulsion engine auxiliaries and boiler auxiliaries - status and start/stop | | x | x | Automatic start/stop, if fitted, is to be alarmed.<br>Applicable to propulsion boilers and boilers supporting propulsion. |
| | A4 | Controllable pitch propeller (CPP) hydraulic power unit start/stop | | x | x | |
| | A5 | CPP hydraulic oil pressure - low and high | X | | | High-pressure alarm is required only if required by design. See 4-3-3/5.13.4(b) |
| | A6 | CPP hydraulic oil temperature - high | x | | | If it is a system design feature |
| | A7 | CPP hydraulic oil tank level - low | x | | | |
| | A8 | Steam turbine shaft stopped - excess of set period | x | | | |
| | A9 | Steam turbine shaft rollover - activated | | x | x | To be activated automatically for **ACCU** |

| *System* | *Monitored/Controlled Parameter* | | *A* | *D* | *C* | *Notes: [ A= Alarm; D= Display; C= Controller/Actuator ] [ x= applies ]* |
|---|---|---|---|---|---|---|
| Electric Power Generating Plant | B1 | Starting, paralleling and putting generator on line | | | x | Not required if main switchboard is located in the centralized control station |
| | B2 | Generator running | | x | | |
| | B3 | Voltage - high and low | x | x | | |
| | B4 | Current - high | x | x | | |
| | B5 | Frequency - high and low | x | x | | |
| | B6 | Failure of on - line generator | x | | | |
| | B7 | Generator engine auxiliaries start/stop | | x | x | Automatic start/stop, if fitted, is to be alarmed |
| | B8 | Bearing lub oil inlet pressure - low | x | x | | Automatic shutdown prime mover. 4-8-3/3.11.3. |
| | B9 | Generator cooling inlet pump or fan motor - fails | x | | | 4-8-3/3.11.4 |
| | B10 | Generator cooling medium temp. - high | x | x | | 4-8-3/3.11.4 |
| High voltage rotating machine | C1 | Stationary windings temperature - high | x | | | 4-8-5/3.7.3(c) |
| Fuel oil system | D1 | Settling and service tank level - low and high | x | | | High level alarm required only if automatic filling is provided, or if **ACCU** |
| | D2 | Overflow tank and drain tank level - high | x | | | |
| | D3 | Transfer pump start/stop | | x | x | Start/stop can be automatic. |
| | D4 | Heated fuel oil in settling and service tank, fuel oil temperature – high | x | x | | 4-6-4/13.5.7(b), 4-9-5/15.1.3.i |
| | D5 | Fuel oil tank heating medium temperature - high | x | | | 4-6-4/13.5.7(c) , 4-9-5/15.1.3.iii |
| | D6 | Fuel oil heater, fuel oil temperature - high ( or viscosity low) or flow - low | x | | | 4-6-4/13.7.4(b), 4-9-5/15.1.3.ii |
| | D7 | Fuel oil heater, heating medium temperature - high | x | | | 4-6-4/13.7.4(c), 4-9-5/15.1.3.iii |
| Stern tube lub. oil | E1 | Tank level - low | x | | | |
| Boiler, thermal oil heater, incinerator, etc. | F1 | Automatic shutdown | x | | | Propulsion boilers and auxiliary boilers supporting propulsion are to meet 4-9-6/23 TABLE 5A and 4-9-6/23 TABLE 5B |

| *System* | *Monitored/Controlled Parameter* | | *A* | *D* | *C* | *Notes: [ A= Alarm; D= Display; C= Controller/Actuator ] [ x= applies ]* |
|---|---|---|---|---|---|---|
| Propulsion machinery space | G1 | Bilge level - high | x | | | |
| | G2 | Bilge pump status | x | x | | Alarm applicable to automatically started bilge pump that starts/stops excessively or running unduly long |
| | G3 | Fire detected | x | | | |
| | G4 | Air condition system - fails | x | | | If necessary for equipment environmental control |

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.

# PART 4

## CHAPTER 9
## Automation and Computer Based Systems

## SECTION 6
## ACCU Notation

### 1 General *(2024)*

Where it is intended that the propulsion machinery space be periodically unattended and that propulsion machinery be controlled primarily from the navigation bridge and from a centralized control and monitoring station installed within, or adjacent to, a periodically unattended propulsion-machinery space, the provisions of 4-9-6/3 and 4-9-6/5 are to be complied with. These provisions cover propulsion machinery during start-up, navigating and maneuvering, but do not cover operations in port or at mooring or anchorage.

The optional notation **ACCU** will be assigned upon verification of compliance and upon satisfactory tests and trails carried out in accordance with the provisions of Section 4-9-10 in the presence of a Surveyor.

### 1.1 Objective *(2024)*

#### 1.1.1 Goals

The automation systems in scope of **ACCU** notation addressed in this section are to be designed, constructed, operated and maintained to:

| *Goal No.* | *Goals* |
|---|---|
| POW 2 | provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel. |
| POW 6 | have fail-safe features that prevent progressive failure in the event of failure of any single component. |
| FIR 3 | *reduce the risk of damage caused by fire to the ship, its cargo and the environment.* |
| FIR 4 | *detect, contain, control and suppress or swiftly extinguish a fire in the compartment of origin.* |
| SAFE 1.1 | minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems. |
| COMM 2 | provided with means for internal communications. |
| NAV 2 | facilitate the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship. |
| AUTO 1 | perform its functions as intended and in a safe manner. |

| *Goal No.* | *Goals* |
|---|---|
| AUTO 2 | indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance. |
| AUTO 3 | have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |
| AUTO 4 | provide the equivalent degree of safety and operability from a remote location as those provided by local controls. |
| AUTO 5 | be provided with a safety system that automatically leads the machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/equipment or environment. |
| AUTO 6 | independently perform different functions, such that a single failure in one system will not render the others inoperative. |
| AUTO 7 | enable rational human machine interface without unintended errors due to the layout or arrangement of machinery/equipment. |

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

### 1.1.2 Functional Requirements

In order to achieve the above stated goals, the design, construction, installation and maintenance of the automation systems in the scope of **ACCU** notation are to be in accordance with the following functional requirements:

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Power Generation and Distribution (POW)** | |
| POW-FR1 | Provide continuous power supply for control, monitoring and safety systems such that power supply is available even after a single point failure. |
| POW-FR2 | Provide visual and audible notification at centralized control station upon occurrence of power failure in the system. |
| POW-FR3 | Control, monitoring and alarm systems are to be designed such that a single failure will not lead to an unsafe situation onboard. |
| POW-FR4 | Provide a sufficient capacity of fuel oil settling or service tanks for continuous operation of propulsion machinery during the unattended period. |
| **Fire Safety (FIR)** | |
| FIR-FR1 | Fire detection in propulsion machinery spaces is to be alarmed at all manned control stations to enable emergency response. |
| FIR-FR2 | Provide arrangements to reactivate/restore fire detection and alarm system after disconnection so that vessel is in the original state of readiness and continued protection of all spaces. |
| FIR-FR3 | Means are to be provided to manually activate a fire alarm due to a fire in the propulsion machinery space from remote propulsion control stations and passage ways leading to propulsion machinery space. |
| FIR-FR4 | A fire fighting station is to be provided with means to effect rapid response to control fire in the propulsion machinery space. |
| FIR-FR5 | The fire fighting station is to be located in a safe area away from high fire risk areas. |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| FIR-FR7 | Provide sufficient and *ready availability of fire-extinguishing appliances.* |
| **Safety of Personnel (SAFE)** | |
| SAFE-FR1 | The fire fighting station, if located within the room housing the centralized control station, is to have protected access to the open deck and its boundaries are to be designed to withstand fire in adjacent spaces. |
| **Communications (COMM)** | |
| COMM-FR1 | Provide means of communication between propulsion machinery space, remote control stations and the engineer's accommodation area to enable safe operations. |
| COMM-FR2 | Extension monitoring station is to be provided in the engineers' public spaces to alert personnel in the engineers' accommodation that assistance is needed in the engine-room. |
| COMM-FR3 | Monitoring system alarms are to be provided in all locations where engineer-on-duty is expected to work and in engineers' cabins for awareness on system status. |
| COMM-FR4 | All extension alarms are to be silenced at centralized control station and means are to be provided to alert personnel in the engineers' accommodation in case the alarms in central control station are not acknowledged. |
| **Navigation (NAV)** | |
| NAV-FR1 (AUTO) | To obtain ACCU notation, a centralized control station, a remote propulsion control station on the navigation bridge, a monitoring station in the engineers' quarters and a fire fighting station, is to be provided to allow the unattended propulsion machinery space operations. |
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Apply fail-safe design for all control systems, manual emergency control systems and safety systems to prevent a dangerous situation due to a single point failure. |
| AUTO-FR2 (NAV) | The centralized control station is to be provided with means to monitor the propulsion machinery space and to control and monitor all the parameters for normal operation of propulsion and auxiliary machinery. |
| AUTO-FR3 | The centralized control station is to be provided with means to take corrective actions, manually or automatically, in the event of a fault in the machinery plant. |
| AUTO-FR4 | Where provided the remote control, the remote control station(s) is to be as effective as local control. |
| AUTO-FR5 | Manual control of the automated system is to be provided in the event of an emergency or failure of automation. |
| AUTO-FR6 | Safety system functions are to be *arranged and controlled such that the machinery operation can be as safe and effective as if it were under direct supervision.* |
| AUTO-FR7 | Automatic startup of and change over to the standby pumps are to be provided to maintain the continuous operation of the propulsion machinery even though one of the essential auxiliaries becomes inoperative. |
| AUTO-FR8 | Automatic slowdown is to be provided in order to maintain the continuous operation of the propulsion machinery in the event of specified alarm conditions. |
| AUTO-FR9 | Automatic shutdowns are to be provided to protect the propulsion machinery from serious damage. |
| AUTO-FR10 | Automatic or manual means are to be provided to allow braking steam to be applied to the turbine due to unsafe conditions. |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| AUTO-FR11 | Propulsion boilers are to be provided with means to prevent excessive steam and to prevent boiler startup during unsafe firing conditions. |
| AUTO-FR12 | There are to be arrangements to prevent automatic restart of propulsion boilers after a shutdown and to provide programmed control for automatically started boilers. |

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

#### 1.1.3 Compliance

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

## 3 System Requirements

### 3.1 General

The vessel is to be fitted with:

*i)* a remote propulsion control station on the navigation bridge complying with 4-9-6/1 with capability to monitor the propulsion machinery space and the machinery plant

*ii)* a centralized control station complying with Section 4-9-5, which is to be further provided with safety system functions capable of taking automated corrective actions in the event of a fault in the machinery plant; such a station can be periodically unattended

*iii)* a monitoring station in the engineers' quarters capable of alarming any undesirable state of the propulsion machinery space and of the machinery plant

*iv)* a fire fighting station with means to effect rapid response to control fire in the propulsion machinery space

These stations are to comply also with the provisions of 5 through 21 hereunder.

### 3.3 Duration of Unattended Operation

The extent of automation, monitoring and remote control is to be such as to allow unattended propulsion machinery space operations for at least 24 hours. For duration less than 24 hours, the limitation will be noted in the classification record.

### 3.5 System Criteria

Conceptual requirements in 4-9-2/3.1 are applicable. Specific details are provided in 5 through 21. FMEA (4-9-2/3.1) is to be conducted to demonstrate that control, monitoring and safety systems are so designed that any single failure will not result in the loss of propulsion control, the loss of propulsion or other undesirable consequences. The FMEA report is to be submitted for review.

### 3.7 System Power Supply

System power supply is to comply with 4-9-5/3.5. In addition, the power supply status display and the alarm of the failure of either power source are to be provided at the navigating bridge.

## 5 Navigating Bridge *(2024)*

Remote propulsion control is to be provided on the navigating bridge. The required controls and associated alarms and displays are to comply with 4-9-2/13 and 4-9-2/15.3 TABLE 2. Additional alarms, displays and controls as specified at the lower half of 4-9-2/15.3 TABLE 2 are also to be provided.

*Commentary:*

Refer to IACS Unified Requirement (UR) M43 "Bridge control of propulsion machinery for unattended machinery spaces".

**End of Commentary**

# 7 Location of Centralized Control Station

Location of centralized control station is to comply with 4-9-5/5.

# 9 Remote Control from Centralized Control Station

Remote controls of propulsion and auxiliary machinery from the centralized control station are to comply with 4-9-5/7. See also “C” column of 4-9-5/17 TABLE 1.

# 11 Monitoring in Centralized Control Station

Monitoring in centralized control station is to comply with 4-9-5/9. Alarms and displays (“A” and “D” columns) in 23 TABLE 1A through 23 TABLE 6 and 4-9-5/17 TABLE 1, as applicable, are to be provided. Engineer's alarms are to comply with 4-9-6/19 hereunder.

# 13 Safety Systems

## 13.1 General

To allow for unattended operation, the centralized control station is to be provided with safety system functions specified in “Auto start”, “Auto slowdown” and “Auto shutdown” columns of 23 TABLE 1A through 23 TABLE 6. The following features are also applicable.

## 13.3 System Design

In addition to complying with 4-9-2/9.1 the following are applicable in order to safeguard continued operation of machinery:

*i)* Safety system is to be designed to take the least drastic action first in response to a fault, and when this fails to avert the situation, to intervene sequentially with more drastic actions. The system is to incorporate ability to automatically start a standby pump, or automatic slowdown or automatic shutdown of propulsion machinery, as applicable.

*ii)* For propulsion machinery (23 TABLE 1A through 23 TABLE 5A), automatic start/changeover, automatic slowdown and automatic shutdown systems are to be independent of monitoring and control systems. However, common sensors as specifically indicated in these tables are allowed.

*iii)* In lieu of automatic slowdown, illuminated warning sign “reduced power” with audible alarm can be provided on the navigation bridge to allow manual slowdown to be effected.

*iv)* Overrides for safety system actions are to comply with 4-9-2/9.5.3.

## 13.5 Automatic Start and Changeover

In the event of detecting low or the loss of system pressure as specified in 23 TABLE 1A through 23 TABLE 3 and 4-9-6/23 TABLE 5A (in “Auto start” column), automatic startup of and changeover to the standby pumps, which are essential to maintain the running of the propulsion machinery, are to be provided.

Where power is automatically restored following a blackout as per 4-8-2/3.11, auxiliaries that are essential for propulsion and maneuvering are to be automatically started. In order not to overload the generator while the motors are starting, means such as sequential starting are to be provided where necessary.

### 13.7 Automatic Slowdown

Automatic slow down, where indicated in 4-9-6/23 TABLE 1A, 4-9-6/23 TABLE 1B and 4-9-6/23 TABLE 2, is to be provided in order to maintain the continuous operation of the propulsion machinery in the event of specified alarm conditions.

### 13.9 Automatic Shutdown

Automatic shutdowns are to be provided, where indicated in 23 TABLE 1A through 23 TABLE 5A, to protect the propulsion machinery from serious damage. Where automatic shutdown is indicated in these tables as a requirement along with 4-9-6/13.5 or 4-9-6/13.7 or both, the intent is that either 4-9-6/13.5 or 4-9-6/13.7 or both is to be activated first; and if the state of the propulsion machinery does not improve, then 4-9-6/13.9 is to be activated.

## 15 Specific Requirements for Propulsion and Auxiliary Machinery *(2019)*

The following are requirements for control, monitoring and safety systems of individual propulsion and auxiliary machinery plant supplemental to those of 9 through 13 above.

### 15.1 Propulsion Steam Turbine

In addition to the safety system functions in 4-9-6/23 TABLE 2 and in the event of loss of lubricating oil, automatic or manual means are to be provided to allow braking steam to be applied to the turbine.

### 15.3 Boilers

#### 15.3.1 Propulsion Boilers

Propulsion boilers are to be capable of automatically and safely satisfying the steam requirements demanded from the boiler under normal evaporation between minimum and maximum firing rates and be able to maintain complete and stable combustion at the minimum rate of firing or during any sudden change in steam demand. In addition to 4-4-1/11.5.1 through 4-4-1/11.5.3 and 4-9-6/23 TABLE 5A, the following are to be complied with.

*15.3.1(a) Prevention of excessive steam*. To prevent a build-up of excessive propulsion boiler steam which could occur when all burners are in service and the burners are at the minimum firing rate, one of the following arrangements, or equivalent, is to be provided.

*i)* Burner sequencing, which require automatic control of one or more, but not necessarily all, burners in the boiler.

*ii)* An automatic steam dump system, unloading to a condenser of adequate size.

*iii)* For long-term port operation at low loads, the excess burner capacity can be secured.

*15.3.1(b) Starting inhibition*. Means are to be provided to prevent boiler start up whenever unsafe firing conditions (e.g. forced draft failure, low water level) exist. Such conditions are to be alarmed. Means are also to be provided to prevent startup following a shutdown, unless manually reset.

*15.3.1(c) Boiler control program*. Automatically started boilers are to be provided with a programmed control. The programmed control is to be designed to cycle the boiler in accordance with a predetermined sequence and, in addition to the automatic boiler purge in 4-9-6/15.3.1(b), is to include the following events:

*i)* Ignition timing: ignition (spark coming on) is to precede the opening of the fuel valve.

*ii)* Modulated air fuel ratio: where it is necessary to cut burners in and out to handle the load on the boiler and controls are provided to modulate the air-fuel ratio, the automatic boiler purge period is to start with the modulating control in the high-firing position (air registers in maximum opening position) and ignition is not to be turned on until the modulating control has returned to the low-firing position (air registers in minimum opening position).

#### 15.3.2 Other Boilers and Fired Equipment

Fired auxiliary boilers necessary to support operation of propulsion (including power generation) are to comply with 4-9-5/13.11.1.ii, 4-9-5/13.11.1.iii and 4-9-5/13.11.2. Other boilers and fired equipment are to comply with 4-9-5/13.11.3.

## 17 Propulsion Machinery Space

The provisions of 4-9-5/15 are to be met. In addition, where automatic filling is provided, each of the fuel oil settling or service tanks is to be of a capacity sufficient for at least eight (8) hours operation at normal power.

Where automatic filling is not provided, the capacity of each of these tanks is to be sufficient for at least 24 hours operation at normal power. Otherwise, a time limitation will be noted in the classification record.

## 19 Monitoring Station in the Engineers' Quarters

### 19.1 Engineers' Public Space and Engineers' Cabins

At least one alarm monitoring station is to be provided in the engineers' public space, 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 duty alarm monitoring station. In addition, duty alarm monitoring station is to be provided in each engineer's cabin hard-wired through a selector switch so that there is connection to at least one of these cabins. Each station is to be provided with:

- An alarm for fire in the propulsion machinery space;
- An alarm for high bilge water level in the propulsion machinery space; and
- A summary-alarm to be activated by any of the alarm conditions listed in 23 TABLE 1A through 23 TABLE 6 and 4-9-5/17 TABLE 1.

The fire alarm is to have a separate visual display and a distinct sound from the summary alarm, and other alarms where fitted. Selector switch is not to be provided for fire alarm.

### 19.3 Muting the Audible Alarms

All alarms in 4-9-6/19.1 are to be silenced only at the centralized control station. Alternatively, arrangements can be made to silence the summary and the bilge alarms at the alarm monitoring stations in the engineers' public space or at a selected engineer's cabin, provided the associated visual alarm is not extinguished. The arrangements are to be such that if the audible alarm is not also silenced manually at the centralized control station in a preset period of time (e.g. 2 minutes), the system is to activate the engineer's alarm (see 4-8-2/11.7.2).

### 19.5 Communication

The communication system required by 4-8-2/11.5.1 is to include the engineer's accommodation area.

## 21 Fire Safety

### 21.1 Fire Fighting Station

A fire-fighting station is to be provided and to be located outside the propulsion machinery space. However, consideration may be given to the installation of the fire-fighting control station within the room housing the centralized control station provided that the room's boundary common with the propulsion machinery space, including glass windows and doors, is insulated to A-60 standard. The doors opening into the propulsion machinery space are to be self-closing. The ventilation system to the room is to be separate from other systems serving the propulsion machinery space and the ventilation inlet is to be taken from a safe space outside the propulsion machinery space. There is to be a protected access, insulated to A-60 standard, from the room to the open deck.

## 21.3 Controls at Fire Fighting Station *(2024)*

The fire-fighting station is to be provided with remote manual controls for the operations detailed in the following list:

*i)* Shutdown of ventilation fans serving the machinery space. See 4-8-2/11.9.1.

*ii)* Shutdown of fuel oil, lubricating oil and thermal oil system pumps. See 4-8-2/11.9.2.

*iii)* Shutdown of forced and induced draft fans of boilers, inert gas generators and incinerators, and of auxiliary blowers of propulsion diesel engines. See 4-8-2/11.9.3.

*iv)* Closing of propulsion machinery space fuel oil tanks suction valves. This is to include other forms of fuel supply, such as gas supply valves in LNG carriers.

*v)* Shutdown of fixed local application fire fighting systems, see 4-7-2/1.11.2, before activation of a high-expansion foam fire extinguishing system, see 4-7-3/5.5, to avoid adverse water action on the foam.

*vi)* Closing of propulsion machinery space skylights, openings in funnels, ventilator dampers, and other openings. Where the propulsion machinery space is protected by a high-expansion foam fire extinguishing system complying with 4-7-3/5.5, the remote means of closing the upper level ventilation openings is not required from the fire-fighting station, provided the lower edge of the door is located 1 meter (3.3 ft) above the highest point of any fire risk objects. For closing of openings see 4-7-2/1.9.7.

*vii)* Closing of propulsion machinery space watertight, weathertight and fire-resistant doors. Self-closing doors with no hold back arrangements can be excluded. Where the propulsion machinery space is protected by a high-expansion foam fire extinguishing system complying with 4-7-3/5.5, the remote control of the doors fitted on machinery casings which are exposed to weather decks is not required, provided the lower edge of the door is located 1 meter (3.3 ft) above the highest point of any fire risk objects.

*viii)* Starting of emergency generator where it is not arranged for automatic starting.

*ix)* Starting of a fire pump located outside of the propulsion machinery space, including operation of all necessary valves, to pressurize the fire main. However, valves located near the pump need not be provided with remote operation from the firefighting 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. Starting of one of the main fire pumps is also to be provided on the navigating bridge (see 4-9-5/15.5.2).

*x)* Actuation of the fixed fire extinguishing system for the propulsion machinery space. This release is to be manual and not initiated automatically by signals from the fire-detecting system.

***Commentary:***

When the sea chest and sea inlet valve of the emergency fire pump is in compliance with the arrangement described in IACS Unified Interpretation (UI) SC245 "Suction and discharge piping of emergency fire pumps, which are run through the machinery space", the remote control of this valve at the fire fighting station is not necessary.

**End of Commentary**

## 21.5 Fire Detection and Alarm Systems

### 21.5.1 General *(2024)*

The propulsion machinery space is to be provided with a fixed fire detection and alarm system complying with 4-7-2/1.13.1. This fixed fire detection and alarm system can be combined with other fire detection and alarm system required on board the vessel. The fire control panel is to be located on the navigating bridge or in the fire fighting station. If located in the fire fighting station, a repeater panel is to be fitted on the navigating bridge. Propulsion machinery space fire is to be alarmed in the centralized control station.

***Commentary:***

Refer to IACS Unified Interpretation (UI) SC129 "Fire Detection in Unmanned Machinery Spaces (Reg. II-2/7.4)" and Unified Requirement (UR) F32 "Fire detecting system for unattended machinery spaces".

**End of Commentary**

### 21.5.2 Temporarily Disconnecting Alarms

A fire detector loop or detector(s) covering the unattended machinery space may be temporarily disabled, for example, for maintenance purposes, provided that such action is to be clearly indicated at the fire control panel and at the centralized control station described in 4-9-6/21.5.1. Disabled loop or detectors are to be reactivated automatically after a preset time period.

### 21.5.3 Fire Alarm Call Points

Manually operated fire alarm call points are to be provided at the following locations:

- Centralized control station
- Passageways leading to, the propulsion machinery spaces
- Navigating bridge

## 21.7 Portable Fire Extinguishers *(2023)*

In addition to the portable fire extinguishers located in the machinery space as required by 4-7-2/1 and the spare charges as required by 4-7-3/15.2.2, at least two B type and two C type portable extinguishers are to be provided, These extinguishers are to be stored in or in the vicinity of the fire-fighting station, or at each entrance to the propulsion machinery space.

Where, in lieu of spare charges, duplicated portable extinguishers are provided to satisfy the requirement of 4-7-3/15.2.2, these duplicated extinguishers can be considered to have satisfied the above requirement provided that they are stored as indicated above.

# 23 Equipment

Components, equipment, subsystems, etc., used in control, monitoring and safety systems of propulsion machinery, propulsion boilers and vital auxiliary pumps are to be designed and tested in accordance with the provisions of Section 4-9-9.

## TABLE 1A
## Instrumentation and Safety System Functions in Centralized Control Station - Slow Speed (Crosshead) Diesel Engines *(2023)*

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto slow down* | *Auto Start* | *Auto shut down* | *Notes: [ A = Alarm. D = Display. x = apply. ]* |
|---|---|---|---|---|---|---|---|---|
| Sensors | Common or separate | | c | c | c | s | s | c = common; s = separate |
| Fuel oil | A1 | Fuel oil after filter (engine inlet), pressure - low | x | x | | x | | |
| | A2 | Fuel oil before injection pumps, temp. - high (or viscosity - low) | x | | | | | For residual fuel oil burning engines only. |
| | A3 | Fuel oil before injection pumps, temp. - low (or viscosity - high) | x | | | | | For residual fuel oil burning engines only. |
| | A4 | Leakage from high pressure pipes | x | | | | | |
| | A5 | Fuel oil service tank, level - low | x | | | | | High level alarm is also required if without suitable overflow arrangements. |
| | A6 | Common rail fuel oil pressure – low | x | | | | | |

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto slow down* | *Auto Start* | *Auto shut down* | *Notes: [ A = Alarm. D = Display. x = apply. ]* |
|---|---|---|---|---|---|---|---|---|
| Lubricating oil | B1 | Lube oil to main bearing and thrust bearing, pressure -low | x | x | x | x | x | |
| | B2 | Lube oil to crosshead bearing, pressure - low | x | x | x | x | x | If of a different system. |
| | B3 | Lube oil to camshaft, pressure - low | x | | | x | x | If of a different system. |
| | B4 | Lube oil to camshaft, temp. - high | x | | | | | If of a different system. |
| | B5 | Lube oil inlet, temp. - high | x | | | | | |
| | B6 | Thrust bearing pads temp. or bearing outlet temp. - high | x | | x | | x | |
| | B7 | Oil mist in crankcase, mist concentration - high; or<br>Engine main and crank bearing temperature - high; or<br>Alternative arrangements (engine main and crank bearing oil outlet temperature – high) | x | | x | | | 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.).<br>See 4-2-1/7.2 |
| | B8 | Each cylinder lubricator, flow rate - low. | x | | x | | | |
| | B9 | Lube oil tanks, level - low | x | | | | | Where separate lubricating oil systems are installed (e.g. camshaft, rocker arms, etc.), individual level alarms are required for all the tanks. |
| | B10 | Common rail servo oil pressure – low | X | | | | | |

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto slow down* | *Auto Start* | *Auto shut down* | *Notes: [ A = Alarm. D = Display. x = apply. ]* |
|---|---|---|---|---|---|---|---|---|
| Turbocharger | C1 | Lube oil inlet, pressure - low | x | | | | | Unless provided with a self-contained lubricating oil system integrated with the turbocharger |
| | C2 | Lube oil outlet (each bearing), temp. - 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. |
| | C3 | Speed | x | x | | | | Alarm Activation for High Speed only required for turbochargers of categories B and C |
| Piston cooling | D1 | Coolant inlet, pressure - low | x | | x | x | | The slow down is not required if the coolant is oil taken from the main cooling system of the engine. |
| | D2 | Coolant outlet (each cylinder), temp. - high | x | | x | | | |
| | D3 | Coolant outlet (each cylinder), flow - low | x | | x | | | Where outlet flow cannot be monitored due to engine design, alternative arrangements may be accepted. |
| | D4 | Coolant in expansion tank, level - low | x | | | | | |
| Sea water cooling | E1 | Sea water cooling, pressure - low | x | | | x | | |
| Cylinder fresh water cooling | F1 | Water inlet, pressure - low | x | | x | x | | |
| | F2 | Water outlet from each cylinder, temp. - high; or common water outlet, temp. - high | x | | x | | | Sensing at common water outlet is permitted for cylinder jackets fitted with common cooling space without intervening stop valves. |
| | F3 | Oily contamination of engine cooling water system. | x | | | | | Where engine cooling water is used in fuel and lubricating oil heat exchangers. |
| | F4 | Cooling water expansion tank, level - low | x | | | | | |

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto slow down* | *Auto Start* | *Auto shut down* | *Notes: [ A = Alarm. D = Display. x = apply. ]* |
|---|---|---|---|---|---|---|---|---|
| Compressed air | G1 | Starting air before main shutoff valve, pressure - low | x | x | | | | |
| | G2 | Control air, pressure - low | x | | | | | |
| | G3 | Safety air, pressure - low | x | | | | | |
| Scavenge air | H1 | Scavenge air receiver, pressure | | x | | | | |
| | H2 | Scavenge air box, temp. - high (fire) | x | | x | | | |
| | H3 | Scavenge air receiver water level - high | x | | | | | |
| Exhaust gas | I1 | Exhaust gas after each cylinder, temp. - high | x | x | x | | | |
| | I2 | Exhaust gas after each cylinder, deviation from average, temp. - high | x | | | | | |
| | I3 | Exhaust gas before each turbocharger, temp. - high | x | x | | | | |
| | I4 | Exhaust gas after each turbocharger, temp. - high | x | x | | | | |
| Fuel valve coolant | J1 | Coolant, pressure - low | x | | | x | | |
| | J2 | Coolant, temp. - high | x | | | | | |
| | J3 | Coolant expansion tank, level - low | x | | | | | |
| Engine | K1 | Speed/direction of rotation | | x | | | | |
| | K2 | Rotation - wrong way | x | | | | | |
| | K3 | Engine overspeed | x | | | | x | |
| Power | L1 | Control, alarm or safety system, power supply failure | x | | | | | |

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 slowdown = automatic slowdown of diesel engine, along with activation of suitable alarm.

Auto start = automatic starting of a standby pump, along with activation of suitable alarm.

Auto shutdown = automatic stopping of the diesel engines, along with activation of suitable alarm.

## TABLE 1B
## Instrumentation and Safety System Functions in Centralized Control Station - Medium and High Speed (Trunk Piston) Diesel Engines *(2023)*

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto slow down* | *Auto Start* | *Auto shut down* | *Notes: [ A = Alarm. D = Display. x = apply. ]* |
|---|---|---|---|---|---|---|---|---|
| Sensors | Common or separate | | c | c | c | s | s | c = common; s = separate |
| Fuel oil | A1 | Fuel oil after filter (engine inlet), pressure - low | x | x | | x | | |
| | A2 | Fuel oil before injection pumps, temp. - high (or viscosity - low) | x | | | | | For residual fuel oil burning engines only. |
| | A3 | Fuel oil before injection pumps, temp. - low (or viscosity - high) | x | | | | | For residual fuel oil burning engines only. |
| | A4 | Leakage from high pressure pipes | x | | | | | |
| | A5 | Fuel oil service tank, level - low | x | | | | | High level alarm is also required if without suitable overflow arrangements. |
| | A6 | Common rail fuel oil pressure – low | x | | | | | |

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto slow down* | *Auto Start* | *Auto shut down* | *Notes: [ A = Alarm. D = Display. x = apply. ]* |
|---|---|---|---|---|---|---|---|---|
| Lubricating oil (diesel engine) | B1 | Lube oil to main bearing and thrust bearing, pressure - low | x | x | | x | x | |
| | B2 | Lube oil filter differential, pressure - high | x | x | | | | |
| | B3 | Lube oil inlet, temp. - high | x | x | | | | |
| | B4 | Oil mist in crankcase, mist concentration – high; or<br>Engine main and crank bearing temperature - high; or<br>Alternative arrangements (engine main and crank bearing oil outlet temperature – high) | x | | | | x | 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.).<br>Single sensor (for each engine) having two independent outputs for initiating alarm and for shutdown will satisfy independence of alarm and shutdown.<br>See 4-2-1/7.2 |
| | B5 | Each cylinder lubricator, flow rate - low | x | | x | | | If necessary for the safe operation of the engine. |
| | B6 | Common rail servo oil pressure – low | x | | | | | |
| Lubricating oil (other than diesel engine) | B7 | Reduction gear lube oil inlet pressure - low | x | x | x | x | x | Shutdown is to affect all power input to gear |
| Sea water cooling | C1 | Sea water cooling system pressure - low | x | x | | x | | |
| Cylinder fresh water cooling | D1 | Water inlet, pressure - low or flow - low | x | x | x | x | | |
| | D2 | Water outlet (general), temp. - high | x | x | x | | | Two separate sensors are required for alarm and slowdown. |
| | D3 | Cooling water expansion tank, level - low | x | | | | | |
| Compressed air | E1 | Starting air before shutoff valve, pressure - low | x | x | | | | |
| | E2 | Control air pressure - low | x | x | | | | |
| Scavenge air | F1 | Scavenge air receiver temp. - high | x | | | | | |

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto slow down* | *Auto Start* | *Auto shut down* | *Notes: [ A = Alarm. D = Display. x = apply. ]* |
|---|---|---|---|---|---|---|---|---|
| Exhaust gas | G1 | Exhaust gas after each cylinder, temp. - high | x | x | x | | | For engine power > 500 kW/ cylinder |
| | G2 | Exhaust gas after each cylinder, deviation from average, temp. - high | x | | | | | For engine power > 500 kW/ cylinder |
| Engine | H1 | Speed | | x | | | | |
| | H2 | Overspeed | x | | | | x | |
| Power | J1 | Control, alarm or safety system, power supply failure | x | | | | | |
| Turbocharger | K1 | Turbocharger lube oil inlet pressure – low | x | | | | | Unless provided with a self-contained lubricating oil system integrated with the turbocharger |
| | K2 | Turbocharger lube 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. |
| | K3 | Speed of turbocharger | x | x | | | | Alarm Activation for High Speed only required for turbochargers of categories B and C |

| | | |
|---|---|---|
| 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 slowdown | = | automatic slowdown of diesel engine, along with activation of suitable alarm. |
| Auto start | = | automatic starting of a standby pump, along with activation of suitable alarm. |
| Auto shutdown | = | automatic stopping of the diesel engines, along with activation of suitable alarm. |

## TABLE 2
## Instrumentation and Safety System Functions in Centralized Control Station - Propulsion Steam Turbines

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto slow down* | *Auto Start* | *Auto shut down* | *Notes (see also bottom of table) [A = Alarm. D = Display. x = apply]* |
|---|---|---|---|---|---|---|---|---|
| Sensors | Common or separate | | c | c | c | s | s | c = common; s = separate |
| Lubricating oil | A1 | Pressure at bearing inlets - low | x | x | | x | x | For turbines, gears and thrust bearings. |
| | A2 | Temp. at bearing inlet - high | x | x | | | | For turbines, gears and thrust bearings. |
| | A3 | Bearing temp. or bearing oil outlet temp. - high | x | x | | | | For turbines, gears and thrust bearings. |
| | A4 | Filter differential pressure - high | x | | | | | |
| | A5 | Gravity tank and sump levels - low | x | x | | | | |
| Lubricating oil cooling medium | B1 | Pressure or flow - low | x | x | | x | | |
| | B2 | Temp. at outlet - high | x | | | | | |
| | B3 | Expansion tank level - low | x | x | | | | |
| Sea water | C1 | Pressure or flow - low | x | x | | x | | |
| | C2 | Pump - auto starting and running | | x | | | | For vessels fitted with sea inlet scoops |
| | C3 | Scoop valve - open/ close | | x | | | | For vessels fitted with sea inlet scoops. |
| Steam | D1 | Pressure at throttle - low | x | | | | x | |
| | D2 | Pressure, ahead chest | | x | | | | |
| | D3 | Pressure, astern chest | | x | | | | |
| | D4 | Pressure, gland seal | | x | | | | |
| | D5 | Gland seal exhaust fan - failure | x | | | | | |
| | D6 | Astern guardian valve - position | | x | | | | |
| | D7 | Astern guardian valve - fail to open | x | | | | | In response to throttle trip or maneuvering signal. |

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto slow down* | *Auto Start* | *Auto shut down* | *Notes (see also bottom of table) [A = Alarm. D = Display. x = apply]* |
|---|---|---|---|---|---|---|---|---|
| Condensate | E1 | Condenser level - high | x | x | | | x | |
| | E2 | Condenser level - low | x | x | | | | |
| | E3 | Condensate pump pressure - low | x | | | x | | |
| | E4 | Condenser vacuum - low | x | x | | | x | |
| | E5 | Salinity - high | x | x | | | | |
| Turbine | F1 | Vibration Level - high | x | | x | | | |
| | F2 | Axial Displacement - large | x | | | | x | |
| | F3 | Speed | | x | | | | |
| | F4 | Overspeed | x | | | | x | |
| | F5 | Shaft rollover - activated | | x | | | | |
| | F6 | Shaft stopped - excess of set period | x | | | | | Shaft rollover to be activated manually or automatically |
| Power | G1 | Throttle control system power failure | x | | | | | |

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 slowdown = automatic slowdown of turbine, with activation of suitable alarm.

Auto start = automatic starting of standby pump in the system, with activation of suitable alarm.

Auto shutdown = automatic closing of ahead steam throttle valve, with activation of suitable alarm; but to allow admission of steam to astern turbine for braking purposes.

## TABLE 3
## Instrumentation and Safety System Functions in Centralized Control Station - Propulsion Gas Turbines *(2023)*

| *System* | *Monitored Parameter* | | *A* | *D* | *Auto start* | *Auto shut down* | *Notes (see also bottom of table) [ A = Alarm; D = Display, x = apply ]* |
|---|---|---|---|---|---|---|---|
| Sensors | Common/separate | | c | c | s | s | c = common sensor; s = separate sensor |
| Fuel oil | A1 | Pressure or flow - low | x | x | | | |
| | A2 | Temperature - high and low (or viscosity - low and high) | x | x | | | For residual fuel oil. |

| *System* | *Monitored Parameter* | | *A* | *D* | *Auto start* | *Auto shut down* | *Notes (see also bottom of table) [ A = Alarm; D = Display, x = apply ]* |
|---|---|---|---|---|---|---|---|
| Lubricating oil | B1 | Inlet pressure - low | x | x | x | x | For turbines, reduction gears and thrust bearings |
| | B2 | Inlet temperature - high | x | x | | | For turbines, reduction gears and thrust bearings |
| | B3 | Main bearing temp. or main bearing oil outlet temp. - high | x | x | | | For turbines, reduction gears and thrust bearings |
| | B4 | Filter differential pressure - high | x | | | | |
| | B5 | Tank level - low | x | x | | | |
| Cooling medium | C1 | Pressure or flow - low | x | x | | | |
| | C2 | Temperature - high | x | | | | |
| Starting | D1 | Stored starting energy level - low | x | | | | |
| | D2 | Ignition failure | x | | | x | |
| Combustion | E1 | Combustion or flame failure | x | | | x | |
| Exhaust gas | F1 | Temperature - high | x | x | | x | |
| Turbine | G1 | Vibration level - high | x | | | x | |
| | G2 | Rotor axial displacement - large | x | | | x | Auto shutdown can be omitted for rotors fitted with roller bearings |
| | G3 | Overspeed | x | | | x | |
| | G4 | Vacuum at compressor inlet - high | x | | | x | |
| Control System | H1 | Control, alarm or safety system, power supply failure | x | | | | |

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 standby pump in the system, with activation of suitable alarm.

Auto shutdown = automatic closing of main fuel valve, with activation of suitable alarm.

## TABLE 4A
## Instrumentation and Safety System Functions in Centralized Control Station - Electric Propulsion

| *System* | *Monitored Parameter* | | *A* | *D* | *Auto Shut down* | *Notes: [A = Alarm; D = Display; x = apply]* |
|---|---|---|---|---|---|---|
| Propulsion Generator | A1 | Bearing lub oil inlet pressure - low | x | x | x | Prime mover automatic shutdown |
| | A2 | Voltage - off-limits | x | x | | To read all phases and at least one bus |
| | A3 | Frequency - off-limits | x | x | | |
| | A4 | Current | | x | | To read all phases |
| | A5 | Stationary windings temperature - high | x | x | | To read all phases; for generators > 500kW |
| | A6 | Main generator circuit breakers - open/close | | x | | |
| | A7 | Generator running | | x | | |
| | A8 | Failure of on-line generator | x | | | |
| | A9 | Transfer of standby generator | x | | | |
| | A10 | Generator cooling medium temperature - high | x | x | | If applicable |
| | A11 | Failure of generator cooling pump or fan motor | x | | | If applicable |
| | A12 | Field voltage and current | | x | | For DC generator |
| | A13 | Inter-pole winding temperature - high | x | x | | For DC generator |

| *System* | *Monitored Parameter* | | *A* | *D* | *Auto Shut down* | *Notes: [A = Alarm; D = Display; x = apply]* |
|---|---|---|---|---|---|---|
| Propulsion Motor - AC | B1 | Bearing, lub. oil inlet pressure - low | x | x | x | |
| | B2 | Armature voltage - off-limits | x | x | | To read all phases and at least one bus |
| | B3 | Field voltage | | x | | |
| | B4 | Frequency - off-limits | x | x | | |
| | B5 | Armature current | | x | | To read all phases |
| | B6 | Field current | | x | | For synchronous motors |
| | B7 | Ground lights or similar | | x | | |
| | B8 | Stationary windings temperature - high | x | x | | To read all phases; for motors > 500kW |
| | B9 | Motor circuit breakers - open/close | | x | | |
| | B10 | Motor running | | x | | |
| | B11 | Failure of on-line motor | x | | | |
| | B12 | Transfer of standby motor | x | | | |
| | B13 | Motor cooling medium temperature - high | x | x | | If applicable |
| | B14 | Failure of cooling pump or fan motor | x | | | If applicable |
| Propulsion Motor - DC | C1 | Bearing lub oil inlet pressure - low | x | x | x | |
| | C2 | Armature voltage - off-limits | x | x | | |
| | C3 | Field voltage | | x | | |
| | C4 | Armature current | | x | | |
| | C5 | Field current | | x | | |
| | C6 | Ground lights or similar | | x | | |
| | C7 | Motor circuit breakers - open/close | | x | | |
| | C8 | Motor running | | x | | |
| | C9 | Motor overspeed | x | | x | |
| | C10 | Failure of on-line motor | x | | | |
| | C11 | Transfer of standby motor | x | | | |
| | C12 | Motor cooling medium temperature - high | x | x | | If applicable |
| | C13 | Failure of cooling pump or fan motor | x | | | If applicable |

| *System* | *Monitored Parameter* | | *A* | *D* | *Auto Shut down* | *Notes: [A = Alarm; D = Display; x = apply]* |
|---|---|---|---|---|---|---|
| Propulsion SCR | D1 | Voltage | | x | | |
| | D2 | Current | | x | | |
| | D3 | Overload (high current) | x | | | Alarms before protective device is activated |
| | D4 | Open/close position for assignment switches | | x | | |
| | D5 | SCR cooling medium temperature - high | x | x | | If applicable |
| | D6 | Failure of SCR cooling pump or fan motor | x | | | If applicable |
| | D7 | Inter-phase reactor temperature, high | x | x | | |
| Transformer | E1 | Transformer winding temperature - high | x | x | | For each phase |

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.

## TABLE 4B
## Instrumentation and Safety System Functions in Centralized Control Station – Generator Prime Mover for Electric Propulsion *(2023)*

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto Start* | *Auto Shut down* | *Notes: [ A = Alarm; D = Display; x = applies ]* |
|---|---|---|---|---|---|---|---|
| *Trunk Piston Type Diesel Engines* | | | | | | | |
| Fuel oil | F1 | Fuel oil after filter (engine inlet), Pressure – low | x | x | x | | |
| | F2 | Fuel oil before injection pumps, temp. – high (or viscosity – low) | x | | | | For residual fuel oil burning engines only. |
| | F3 | Fuel oil before injection pumps, temp. – low (or viscosity – high) | x | | | | For residual fuel oil burning engines only. |
| | F4 | Leakage from high pressure pipes | x | | | | |
| | F5 | Fuel oil service tank, level – low | x | | | | High level alarm is also required if without suitable overflow arrangements. |
| | F6 | Common rail fuel oil pressure - low | x | | | | |

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto Start* | *Auto Shut down* | *Notes: [ A = Alarm; D = Display; x = applies ]* |
|---|---|---|---|---|---|---|---|
| Lubricating oil | G1 | Lube oil to main bearing, pressure – low | x | x | x | x | |
| | G2 | Lube oil filter differential, pressure – high | x | x | | | |
| | G3 | Lube oil inlet, temp. – high | x | x | | | |
| | G4 | Oil mist in crankcase, mist concentration – high; or Engine main and crank bearing temperature - high; or Alternative arrangements (engine main and crank bearing oil outlet temperature – high) | x | | | x | For engines having a power of 2250 kW (3000 hp) and above or a cylinder bore of more than 300 mm (11.8 in.).<br>Single sensor (for each engine) having two independent outputs for initiating alarm and for shutdown will satisfy independence of alarm and shutdown.<br>See 4-2-1/7.2 |
| | G5 | Each cylinder lubricator, flow rate – low | x | | | | If necessary for the safe operation of the engine. |
| | G6 | Common rail servo oil pressure - low | x | | | | |
| Sea cooling water | H1 | Sea water cooling system pressure – low | x | x | x | | |
| Cylinder fresh water cooling | J1 | Water inlet, pressure – low or flow – low | x | x | x | | |
| | J2 | Water outlet (general), temp. – high | x | x | | | |
| | J3 | Cooling water expansion tank, level – low | x | | | | |
| Compressed air | K1 | Starting air before shutoff valve, pressure – low | x | x | | | |
| | K2 | Control air pressure – low | x | x | | | |
| Exhaust gas | L1 | Exhaust gas after each cylinder, temp. – high | x | x | | | For engine power > 500 kW/cylinder |

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto Start* | *Auto Shut down* | *Notes: [ A = Alarm; D = Display; x = applies ]* |
|---|---|---|---|---|---|---|---|
| Turbocharger | M1 | Turbocharger oil inlet pressure - low | x | | | | Unless provided with a self-contained lubricating oil system integrated with the turbocharger |
| | M2 | 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. |
| | M3 | Speed of turbocharger | x | | | | Alarm Activation for High Speed only required for turbochargers of categories B and C. |
| Engine | N1 | Over speed | x | | | x | |
| Power Supply | P1 | Main | x | x | | | |
| | P2 | Emergency | x | | | | |
| *Gas Turbines* | | | | | | | |
| Fuel oil | Q1 | Pressure or flow – low | x | x | | | |
| | Q2 | Temperature – high and low (or viscosity – low and high) | x | x | | | For residual fuel oil. |
| Lubricating oil | R1 | Inlet pressure – low | x | x | x | x | |
| | R2 | Inlet temperature – high | x | x | | | |
| | R3 | Bearing temp. or bearing oil outlet temp. – high | x | x | | | |
| | R4 | Filter differential pressure – high | x | | | | |
| | R5 | Tank level – low | x | x | | | |
| Cooling medium | S1 | Pressure or flow – low | x | x | | | |
| | S2 | Temperature – high | x | | | | |
| Starting | T1 | Stored starting energy level – low | x | | | | |
| | T2 | Ignition failure | x | | | x | |
| Combustion | U1 | Combustion or flame failure | x | | | x | |
| Exhaust gas | V1 | Temperature – high | x | x | | x | |

| *Systems* | *Monitored Parameters* | | *A* | *D* | *Auto Start* | *Auto Shut down* | *Notes: [ A = Alarm; D = Display; x = applies ]* |
|---|---|---|---|---|---|---|---|
| Turbine | W1 | Vibration level – high | x | | | x | |
| | W2 | Rotor axial displacement – large | x | | | x | Auto shutdown can be omitted for rotors fitted with roller bearings |
| | W3 | Overspeed | x | | | x | |
| | W4 | Vacuum at compressor inlet – high | x | | | x | |
| Power Supply | Z1 | Main | x | x | | | |
| | Z2 | Emergency | x | | | | |

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, mzy be considered.

Auto start = automatic starting of a standby pump, along with activation of suitable alarm.

Auto shutdown = automatic stopping of the diesel engines and gas turbine, along with activation of suitable alarm.

## TABLE 5A
## Instrumentation and Safety System Functions in Centralized Control Station - Propulsion Boiler

| *System* | *Monitored Parameters* | | *A* | *D* | *Auto start* | *Auto shut down* | *Notes: [ A = Alarm; D = Display; x = applies ]* |
|---|---|---|---|---|---|---|---|
| Sensors | Common/separate | | c | c | s | s | c = common sensor; s = separate sensor |
| Feed water | A1 | Atmospheric drain tank level - high and low | x | x | | | |
| | A2 | Dearator level - high and low | x | x | | | |
| | A3 | Dearator pressure - high and low | x | x | | | |
| | A4 | Feed water pump pressure - low | x | x | x | | |
| | A5 | Feed water temperature - high | x | x | | | |
| | A6 | Feed water outlet salinity - high | x | x | | | |
| Boiler Drum | B1 | Water level - high and low | x | x | | | |
| | B2 | Water level - low-low | x | | | x | |
| Steam | C1 | Pressure - high and low | x | x | | | |
| | C2 | Superheater outlet temperature - high | x | x | | | |

| *System* | *Monitored Parameters* | | *A* | *D* | *Auto start* | *Auto shut down* | *Notes: [ A = Alarm; D = Display; x = applies ]* |
|---|---|---|---|---|---|---|---|
| Air | D1 | Forced draft pressure - failure | x | | | x | See 4-9-2/9.3.iv. |
| | D2 | Rotating air heater motor - failure | x | | | | If provided |
| | D3 | Air register - open/close | | x | | | |
| | D4 | Fire in boiler casing | x | x | | | |
| Fuel oil | E1 | Pump pressure at outlet - low | x | x | x | | |
| | E2 | Heavy fuel oil temperature - high (or viscosity - low) | x | x | | | |
| | E3 | Heavy fuel oil temperature – low (or viscosity – high) | x | x | | | |
| | E4 | Master fuel oil valve - open/close | | x | | | |
| Burner | F1 | Burner valve - open/close | | x | | | Individual |
| | F2 | Atomizing medium pressure - off-limits | x | x | | | |
| | F3 | Ignition or flame of burners - fails | x | x | | x | For multiple burners, flame failure of a single burner is to shutdown the corresponding burner fuel valves. Shut down is to be achieved within 6 seconds following flame extinguishment. |
| | F4 | Flame scanner - fails | x | | | x | For multiple burners fitted with individual flame scanner, failure of flame scanner is to shut down the corresponding burner fuel valves. |
| | F5 | Uptake gas temperature - high | x | | | | For fire detection |
| Power | G1 | Control system power supply - fails | x | x | | x | Automatic closing of fuel valve(s) |

| | | |
|---|---|---|
| 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 standby pump in the system, with activation of suitable alarm. |
| Auto shutdown | = | automatic closing of fuel valve, with activation of suitable alarm. |

## TABLE 5B
## Instrumentation and Safety System Functions in Centralized Control Station - Auxiliary Boiler *(2023)*

| *System* | *Monitored Parameter* | | *A* | *D* | *Auto Shut down* | *Notes: [A = Alarm; D = Display; x = apply]* |
|---|---|---|---|---|---|---|
| Feedwater | A1 | Feedwater outlet salinity - high | x | x | | |
| Boiler drum | A2 | Water level - high | x | | | |
| | A3 | Water level - low | x | x | x | |
| Steam | A4 | Pressure - high and low | x | x | | |
| | A5 | Superheater outlet temperature - high | x | x | | |
| Air | A6 | Supply air pressure - failure | x | | x | See 4-9-2/9.3.iv., Alarm for draft fan failure is acceptable |
| | A7 | Fire in boiler air supply casing | x | | | Excessive high temperature alarm at boiler air supply casing is acceptable |
| Fuel oil | A8 | Pump outlet pressure - low | x | x | | |
| | A9 | Temperature - high and low (or viscosity - low and high) | x | x | | For residual fuel oil only |
| Burner | A10 | Fuel oil valves - open/close | | x | | Individual valves (see Note 1) |
| | A11 | Ignition or flame - fails | x | x | x | Individual; see 4-9-6/23 TABLE 5A |
| | A12 | Flame scanner - fails | x | | x | Individual; see 4-9-6/23 TABLE 5A |
| | A13 | Uptake gas temp. - high | x | | | |
| Power | A14 | Control system power supply - fails | x | | x | |

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.

*Notes:*

1 Applicable only to auxiliary boilers with multiple burners.

2 See also 4-9-5/13.11.2 for summary alarms.

## TABLE 6
## Instrumentation and Safety System Functions in Centralized Control Station - Auxiliary Turbines and Diesel Engines *(2023)*

| *System* | *Monitored System & Parameter* | | | *A* | *D* | *Auto shut down* | *Notes: [ A = Alarm; D = Display; x = apply ]* |
|---|---|---|---|---|---|---|---|
| Diesel Engine | Lubricating oil | A1 | Bearing oil inlet pressure - low | x | x | x | |
| | | A2 | Bearing inlet oil temperature - high | x | x | | |
| | | A3 | Oil mist in crankcase, mist concentration – high; or engine main and crank bearing temperature – high; or alternative arrangements (engine main and crank bearing oil outlet temperature – high) | x | | x | For engines having a power of 2250 kW (3000 hp) and above or having a cylinder bore more than 300 mm (11.8 in.). Single sensor (for each engine) having two independent outputs for initiating alarm and for shutdown will satisfy independence of alarm and shutdown. See 4-2-1/7.2 |
| | | A4 | Common rail servo oil pressure - low | x | | | |
| | Cooling medium | A5 | Pressure or flow - low | x | x | | |
| | | A6 | Temperature at outlet - high | x | x | | |
| | | A7 | Expansion tank level - low | x | | | |
| | Fuel oil | A8 | Fuel oil leakage from injection pipe | x | | | |
| | | A9 | Fuel oil temp. – high and low (or viscosity – low and high) | x | | | For residual fuel oil only |
| | | A10 | Service tank level - low | x | | | |
| | | A11 | Common rail fuel oil pressure - low | x | | | |
| | Starting medium | A12 | Energy level - low | x | x | | |
| | Exhaust | A13 | Exhaust gas temperature after each cylinder - high | x | | | For engines having a power of more than 500 kW/cyl. |
| | Speed | A14 | Overspeed | x | | x | |
| | Turbocharger | A15 | High speed | x | | | Alarm Activation for High Speed only required for turbochargers of categories B and C |

| *System* | *Monitored System & Parameter* | | | *A* | *D* | *Auto shut down* | *Notes: [ A = Alarm; D = Display; x = apply ]* |
|---|---|---|---|---|---|---|---|
| Steam Turbine | Lub oil | B1 | Bearing oil inlet pressure - low | x | x | x | |
| | | B2 | Bearing oil inlet temperature - high | x | x | | |
| | | B3 | Bearing temperature or bearing oil outlet temperature - high | x | x | | |
| | Lubricating oil cooling medium | B4 | Pressure or flow - low | x | x | | |
| | | B5 | Temperature at outlet - high | x | | | |
| | | B6 | Expansion tank level - low | x | | | |
| | Sea water | B7 | Pressure or flow - low | x | x | | |
| | Steam | B8 | Pressure at inlet - low | x | x | | |
| | Condensate | B9 | Condenser vacuum - low | x | x | x | |
| | | B10 | Condensate pump pressure - low | x | x | | |
| | Rotor | B11 | Axial displacement - large | x | | x | |
| | | B12 | Overspeed | x | | x | |

| *System* | *Monitored System & Parameter* | | | *A* | *D* | *Auto shut down* | *Notes: [ A = Alarm; D = Display; x = apply ]* |
|---|---|---|---|---|---|---|---|
| Gas Turbine | Lubricating oil | C1 | Inlet pressure inlet - low | x | x | x | |
| | | C2 | Inlet temperature - high | x | x | | |
| | | C3 | Bearing temp. or oil outlet temp. - high | x | x | | |
| | | C4 | Filter differential pressure | x | | | |
| | Cooling medium | C5 | Pressure or flow - low | x | x | | |
| | | C6 | Temperature - high | x | | | |
| | Fuel oil | C7 | Pressure, inlet - low | x | x | | |
| | | C8 | Temp. - high and low (or viscosity - low and high) | x | | | For residual fuel oil only |
| | Exhaust gas | C9 | Temperature - high | x | | | |
| | Combustion | C10 | Combustion or flame failure | x | | x | |
| | Starting | C11 | Ignition failure | x | | x | |
| | | C12 | Stored starting energy level - low | x | | | |
| | Turbine | C13 | Vibration level - high | x | | x | |
| | | C14 | Axial displacement - high | x | | x | Auto shutdown can be omitted for rotors fitted with roller bearings |
| | | C15 | Overspeed | x | | x | |
| | | C16 | Vacuum at compressor inlet - high | x | | x | |

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.

# PART 4

## CHAPTER 9

## Automation and Computer Based Systems

## SECTION 7

## Vessels with Compact Propulsion Machinery Spaces

## 1 General *(2024)*

The requirements in this Section 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 4-9-1, 4-9-2, 4-9-5, and 4-9-6, as applicable, are to be complied with.

The optional notation **ABCU** will be assigned upon verification of compliance and upon satisfactory tests and trials carried out in accordance with Section 4-9-10 in the presence of a Surveyor.

### 1.1 Objective *(2024)*

#### 1.1.1 Goals *(2024)*

The automation for vessels with compact propulsion machinery spaces covered in this section is to be designed, constructed, operated, and maintained to:

| *Goal No.* | *Goals* |
|---|---|
| AUTO 1 | perform its functions as intended and in a safe manner. |
| AUTO 2 | indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance |
| AUTO 3 | have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |
| AUTO 4 | provide the equivalent degree of safety and operability from a remote location as those provided by local controls. |

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

#### 1.1.2 Functional Requirements *(2024)*

In order to achieve the above stated goals, the design, construction and installation of the automation for vessels with compact propulsion machinery spaces are to be in accordance with the following functional requirements:

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Provide for monitoring of propulsion, power generation and associated machinery or space in a centralized station; equivalent to the propulsion machinery space being manned. |
| AUTO-FR2 | Provide for equivalent level of automation control and monitoring in the navigation bridge. |

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

#### 1.1.3 Compliance *(2024)*

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

### 1.3 Station in Navigation Bridge *(2024)*

Controls, alarms and displays required by 4-9-2/13, 4-9-6/5, and 4-9-2/15.3 TABLE 2 are to be provided on the station in the navigation bridge. For vessels having nonintegrated propulsion machinery, the means for starting, stopping and transferring vital auxiliary pumps (see 4-9-6/13.5) are to be fitted at the station in the navigation bridge and may also be fitted in the centralized station.

For vessels under 500 GT, the requirements in Section 4-9-11 are to be met.

### 1.5 Centralized Monitoring Station

The requirements in 4-9-6/11 are applicable. The station 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 4-9-6/23 TABLE 1 through 4-9-6/23 TABLE 4 and 4-9-5/17 TABLE 1 for required alarms and displays to be fitted at this station.

### 1.7 Communications *(2024)*

Interior communications, as required in 4-9-2/13.15, are also to include the centralized monitoring station.

PART 4

CHAPTER 9

# Automation and Computer Based Systems

SECTION 8

# Special Systems

## 1 Control and Monitoring of Doors and Hatches *(1 July 2022)*

### 1.1 General *(2024)*

This section provides requirements for monitoring and control of the doors (watertight bulkhead doors, shell doors and external doors) and hatches, as indicated below.

#### 1.1.1 Sliding Watertight Doors that are Used While at Sea, Meeting the Requirements in 3-2-9/9.1

The requirements in 4-9-8/1.3 are to be complied with.

#### 1.1.2 Watertight Access Doors and Access Hatch Covers, Normally Closed at Sea, Meeting the Requirements in 3-2-9/9.3 and 3-2-15/17.3

The requirements in 4-9-8/1.5 are to be complied with.

#### 1.1.3 Bow Doors, Inner Doors, Side Shell Doors and Stern Doors Meeting the Requirements in 3-2-16/3 *(1 July 2022)*

The requirements in 5C-10-1/5 are to be complied with.

#### 1.1.4 External Doors Meeting the Requirements in 3-2-15/17.1 and 3-2-16/1

The requirements in 1.7 are to be complied with.

The requirements for monitoring and control of the doors in passenger vessels are given in 5C-7-5/17.

### 1.2 Objective *(2024)*

#### 1.2.1 Goals

The control and monitoring systems of doors and hatches addressed in this Section are to be designed, constructed, operated and maintained to:

| *Goal No.* | *Goals* |
|---|---|
| POW 2 | provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel. |
| AUTO 1 | perform its functions as intended and in a safe manner. |

| *Goal No.* | *Goals* |
|---|---|
| AUTO 2 | indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance. |
| AUTO 3 | have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |
| AUTO 4 | provide the equivalent degree of safety and operability from a remote location as those provided by local controls. |
| AUTO 5 | be provided with a safety system that automatically leads the machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/equipment or environment. |
| AUTO 6 | independently perform different functions, such that a single failure in one system will not render the others inoperative. |
| MGMT 1 | provide for safe practices in ship operation and a safe working environment. |

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

### 1.2.2 Functional Requirements

In order to achieve the above stated goals, the design, construction, installation and maintenance of the control and monitoring system for doors and hatches are to be in accordance with the following functional requirements:

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Power Generation and Distribution (POW)** | |
| POW-FR1 | Provide continuous electrical power supply to the control and monitoring system for watertight accesses/openings. |
| POW-FR2 | Electrical installations are to be designed to protect components from ingress of water, mechanical damage and extreme weather conditions. |
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Provide means to indicate the operational status of the watertight accesses/openings that provide watertight integrity to the vessel at each control position. |
| AUTO-FR2 | Provide audible and visual alarm at manned space in the event of failure of control and monitoring system of watertight accesses/openings. |
| AUTO-FR3 | Apply fail-safe design for control and monitoring systems of watertight accesses/openings to prevent dangerous situation due to a single point of failure. |
| AUTO-FR4 | Apply a self-monitoring mechanism for the display and alarm systems of all watertight accesses/openings designed to maintain watertight integrity of the vessel such that a fault (e.g. power failure, sensor failure, etc.) can be detected and alarmed. |
| AUTO-FR5 | Power operated watertight accesses/openings that may be used while at sea are to be designed to be controlled from a remote manned control station and means of local operation independent of remote control is to be provided. |
| AUTO-FR6 | When closing watertight accesses/openings remotely, a warning alarm is to be provided locally to enable the recognition of this situation during operation. |
| AUTO-FR7 | Water leakages at the exterior watertight accesses/openings are to be detected and alarmed in the central control stations. |

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| AUTO-FR8 | All external watertight accesses that have openings to areas below freeboard are to be provided with monitoring and remote control from a position above the freeboard area. |
| AUTO-FR9 | Visual surveillance is to be provided to monitor water leakages between bow accesses/ openings and interior watertight accesses/openings to avoid dangerous situation onboard. |
| AUTO-FR10 | Local means of operation is to be provided at both sides of the watertight accesses/openings, except those which are to be permanently closed at sea, so that safety of the vessel is not impaired when the vessel is listed to either side. |
| AUTO-FR11 | Provide means to monitor the stored energy for operation of watertight accesses/openings and to alert the crew for the loss of stored energy. |
| **Safety Management (MGMT)** | |
| MGMT-FR1 | Notices are to be provided at both sides of the watertight accesses/openings to indicate and alert the crew for the correct frequency of use while at sea. |

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

### 1.2.3 Compliance

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

## 1.3 Doors Used While at Sea

### 1.3.1 Control of Doors

Where designed for power operation, doors are to be capable of being remotely closed from the bridge and are also to be operable locally from each side of the bulkhead. Each power-operated sliding door is to be provided with an individual hand-operated mechanism.

Where designed for power operation, a single failure in the electric or hydraulic power-operated system excluding the hydraulic actuator is not to prevent the hand operation of any door. Where necessary for power operation of the door, means to start hydraulic unit, or equivalent arrangement, is to be provided at the navigation bridge, and at each remote control position, if provided, and local control position.

### 1.3.2 Monitoring of Doors *(1 July 2022)*

Displays are to be provided at control position showing whether the doors are open or closed. Display and alarm systems are to be self-monitoring such that any failure in the system (e.g., power failure, sensor failure, etc.) will be detected and alarmed at the navigation bridge control position. Effective means of testing of monitoring systems are to be provided.

### 1.3.3 Closing Alarm of Doors

Each power-operated sliding door is to be provided with an audible alarm which will sound whenever the door is closed remotely and which is to sound for at least five seconds but no more than ten seconds before the door begins to move and is to continue sounding until the door is completely closed.

### 1.3.4 Electrical Power Supply

The electrical power required for power-operated doors is to be supplied from the emergency switchboard either directly or through a distribution board situated above the bulkhead deck. The associated control and monitoring circuits are to be supplied from the emergency switchboard either directly or through a distribution board situated above the bulkhead deck. The power circuits for power-operated doors are to be separate from power supply to any other systems.

Availability of the power supplies is to be continuously monitored on the load side of the feeder's protective device. Loss of any such power supply is to activate an audible and visual alarm at the navigation bridge control position.

#### 1.3.5 Arrangements of Electric Power, Control and Monitoring Circuits

Electric power, control and monitoring circuits are to be protected against fault in such a way that a failure in one door circuit is not to cause a failure in any other door circuits. Short circuits or other faults in alarm or display circuits of a door are not to result in a loss of power operation of that door.

A single electrical failure in the power operating or control system of a power-operated door is not to result in opening of a closed door.

#### 1.3.6 Electrical Equipment

As far as practicable, electrical equipment and components for watertight doors are to be situated above the freeboard deck and outside hazardous areas.

The enclosures of electrical components necessarily situated below the freeboard deck are to provide suitable protection against the ingress of water, as follows:

- Electrical motors, associated circuits and control components: protected to IPX7 standard
- Door position indicators and associated circuit components: protected to IPX8 standard (The water pressure testing of the enclosure is to be based on the pressure that is expected at the location of the component during flooding for a period of 36 hours)
- Door movement warning signals: protected to IPX6 standard

Enclosures of other electrical components are to be in accordance with 4-8-3/15 TABLE 2.

#### 1.3.7 Hydraulic System *(1 July 2022)*

The hydraulic system is to be in accordance with 4-6-7/3.

The hydraulic system is to be dedicated to the operation of the doors. The system is to be designed such that the possibility of a single failure in the hydraulic piping adversely affecting the operation of more than one door is minimized.

### 1.5 Watertight Access Doors/Hatches Normally Closed at Sea *(2024)*

Doors and hatches fitted with gaskets and dogs are to be provided with means of indicating locally and on the bridge whether they are open or secured closed. For this purpose all dogs are to be monitored individually. When all dogs are linked to a single acting mechanism, then only the monitoring of a single dog is required.

The power supply to the monitoring system is to be in accordance with 4-9-8/1.3.4 and the monitoring system is to be self-monitoring in accordance with 4-9-8/1.3.2.

***Commentary:***

IACS Unified Interpretation (UI) SC 156 "Doors in watertight bulkheads of cargo ships and passenger ships" provides guidance on requirements for doors in watertight bulkheads covered in 1.3 and 1.5.

**End of Commentary**

### 1.7 External Doors/Openings

#### 1.7.1 External Openings Below Damaged Waterline

External openings meeting the requirements in 3-2-15/17.1 are to be fitted with displays on the navigation bridge showing whether the closing appliances are open or secured closed.

For the openings fitted with gaskets and dogs, all dogs are to be monitored individually. When all dogs are linked to a single acting mechanism, then only the monitoring of a single dog is required.

The power supply to the monitoring system is to be in accordance with 4-9-8/1.3.4 and the monitoring system is to be self-monitoring in accordance with 4-9-8/1.3.2.

#### 1.7.2 Cargo, Gangway or Fueling Ports

The ports in the side shell below the freeboard or superstructure deck are to be fitted with displays on the navigation bridge showing whether the closing appliances are open or secured closed.

For ports fitted with gaskets and dogs, all dogs are to be monitored individually. When all dogs are linked to a single acting mechanism, then only the monitoring of a single dog is required.

For the compartment between the port and the second door, if provided, a water leakage detection system with audible alarm is to be arranged to provide an indication to the navigation bridge of leakage through any of the doors.

The power supply to the monitoring system is to be in accordance with 4-9-8/1.3.4 and the monitoring system is to be self-monitoring in accordance with 4-9-8/1.3.2.

## 3 Doors in Watertight Bulkheads of Cargo Ships *(1 July 2022)*

### 3.1 Types of Doors

The requirements in this section apply to four (4) types of doors

*i)* Power operated, sliding or rolling - POS

*ii)* Power operated, hinged - POH

*iii)* Sliding or Rolling - S

*iv)* Hinged - H

### 3.3 Operation Mode, Location and Outfitting

Doors are to be fitted in accordance with all requirements regarding their operation mode, location and outfitting, (i.e., provision of controls, means of indication, etc.), as shown in 11 TABLE 1 and 11 TABLE 2 below.

#### 3.3.1 Frequency of Use whilst at Sea

*3.3.1(a) Normally Closed*

Doors that are kept closed at sea but may be used if authorized. To be closed again after use.

*3.3.1(b) Permanently Closed*

The time of opening such doors in port and of closing them before the ship leaves port is to be entered in the log-book. Should such doors be accessible during the voyage, they are to be fitted with a device to prevent unauthorized opening.

*3.3.1(c) Used*

Doors that are kept closed, but may be opened during navigation when authorized by the Administration to permit the passage of passengers or crew, or when work in the immediate vicinity of the door necessitates it being opened. The door is to be immediately closed after use.

***Commentary:***

Doors in watertight bulkheads of small cargo ships, not subject to any statutory subdivision and damage stability requirements, may be hinged single action doors arranged to open out of the major space protected. They are to be constructed in accordance with ABS requirements and have notices affixed to each side stating, "To be closed at sea".

**End of Commentary**

## 5 Control *(1 July 2022)*

### 5.1 Local Control

All doors, except those which are to be permanently closed at sea, are to be capable of being opened and closed by hand (and by power, where applicable) locally from both sides of the doors, with the ship listed to either side.

For cargo ships, the angle of list at which operation by hand is to be possible is 30 degrees.

### 5.3 Remote Control

Where indicated in 11 TABLE 1 and 11 TABLE 2, doors are to be capable of being remotely closed by power from the bridge for all ships. Where it is necessary to start the power unit for operation of the watertight door, means to start the power unit is also to be provided at remote control stations. The operation of such remote control is to be in accordance with SOLAS II-1/13.8.1 to 13.8.3. For tankers, where there is a permanent access from a pipe tunnel to the main pump room, in accordance with Regulation II-2/4.5.2.4, the watertight door is to be capable of being manually closed from outside the main pump room entrance in addition to the requirements above.

## 7 Indication *(1 July 2022)*

*i)* Where shown in 4-9-8/Tables 1 and 2, position indicators are to be provided at all remote operating positions for all ships and provided locally on both sides of the internal doors for cargo ships, to show whether the doors are open and, if applicable, with all dogs/cleats fully and properly engaged.

*ii)* The door position indicating system is to be of self-monitoring type and the means for testing of the indiactor system are to be provided at the position where the indicators are fitted.

*iii)* A diagram showing the location of the door and an indication to show its position is to be provided at the central operating console located at the navigating bridge. A red light is to indicate the door is in the open position and a green light is to indicate the door is in the closed position. When the door is closed from this remote position, the red light is to flash when the door is in an intermediate position.

*iv)* Signboard/instructions should be placed in way of the door advising how to act when the door is in "doors closed" mode.

## 9 Alarms *(1 July 2022)*

*i)* For cargo ships, failure of the normal power supply of the required alarms is to be indicated by an audible and visual alarm at the navigation bridge.

*ii)* All door types, including power-operated sliding watertight doors which are to be capable of being remotely closed are to be provided with an audible alarm, distinct from any other alarm in the area, which will sound whenever such a door is remotely closed.

*iii)* All watertight doors,including sliding doors, operated by hydraulic door actuators, either a central hydraulic unit or an independent hydraulic unit for each door is to be provided with a low fluid level alarm or low gas pressure alarm, as applicable or some other means of monitoring loss of stored energy in the in the hydraulic accumulators. For cargo ships, this alarm is to be audible and located at the navigation bridge.

## 11 Notices *(1 July 2022)*

As shown in 11 TABLE 1 and 11 TABLE 2, doors which are normally closed at sea but not provided with means of remote closure, are to have notices fixed to both sides stating "To be kept closed at sea". Doors which are to be permanently closed at sea are to have notices fixed on both sides stating, "Not to be opened at sea".

### TABLE 1
### Doors in Internal Watertight Bulkhead

| *Position Relative to Bulkhead or Freeboard Deck* | *1. Regulation* | *2. Frequency of Use while at Sea* | *3. Type* | *4. Remote Closure* | *5. Remote Indication* | *6. Audible or Visual Alarm* | *7. Notice* | *8. Comments* |
|---|---|---|---|---|---|---|---|---|
| (1) Below | SOLAS II-1/10, 13-1.2, 16.2 and 22.3 MARPOL 1/28.3 ICLL66+A.320 1988 Protocol to ICLL66 IBC, and IGC | Used | POS | Yes | Yes | Yes (local) | No | |
| | SOLAS II-1/10, 13-1.3, 16.2, 22.3 and 24.4 | Norm. Closed | S, H | No | Yes | No | Yes | See Note 1 |
| | SOLAS II-1/10,13-1.4, 16.2, 24.3 and 24.4 | Perm. Closed | S, H | No | No | No | Yes | See Notes 3 & 4 |
| | SOLAS II-1/10,13-1.4, 13-1.5, 16.2, 22.2, 24.3, and 24.4 | Perm. Closed | S, H | No | No | No | Yes | See Notes 3 & 4 |

| *Position Relative to Bulkhead or Freeboard Deck* | *1. Regulation* | *2. Frequency of Use while at Sea* | *3. Type* | *4. Remote Closure* | *5. Remote Indication* | *6. Audible or Visual Alarm* | *7. Notice* | *8. Comments* |
|---|---|---|---|---|---|---|---|---|
| (2) At or above | SOLAS II-1/10, 13-1.2, 16.2 and 22.3 MARPOL 1/28.3 ICLL66+A.320, 1988 Protocol to ICLL66 IBC, and IGC | Used | POS | Yes | Yes | Yes (local) | No | See Notes 2 & 5 |
| | SOLAS II-1/10, 13-1.3, 16.2, 22.3 and 24.4 | Norm. Closed | S, H | No | Yes | No | Yes | See Note 1 |
| | SOLAS II-1/10,13-1.4, 13-1.5, 16.2, 24.3, and 24.4 | Perm. Closed | S, H | No | No | No | Yes | See Notes 3 & 4 |

*Notes:*

1 If hinged, this door is to be of single action type.

2 Under ICLL66, doors separating a main machinery space from a steering gear compartment may be hinged single action type provided the lower sill of such doors is above the Summer Load Line and the doors remain closed at sea whilst not in use.

3 The time of opening such doors in port and closing them before the ship leaves port is to be entered in the logbook, in case doors in watertight bulkheads subdividing cargo spaces.

4 Doors are to be fitted with a device which prevents unauthorized opening.

5 Under MARPOL, hinged watertight doors may be acceptable in watertight bulkhead in the superstructure.

## TABLE 2
## Doors in External Watertight Boundaries below Equilibrium or Intermediate Waterplane

| *Position Relative to Bulkhead or Freeboard Deck* | *1. Regulation* | *2. Frequency of Use while at Sea* | *3. Type* | *4. Remote Closure* | *5. Remote Indication* | *6. Audible or Visual Alarm* | *7. Notice* | *8. Comments* |
|---|---|---|---|---|---|---|---|---|
| (1) Below | SOLAS II-1/15.9, 15-1.2, 15-1.3, 15-1.4, 22.6, 22.12 and 24-1 | Perm. Closed | S, H | No | Yes | No | Yes | See Notes 2 & 3 |
| (2) At or above | SOLAS II-1/15-1.2 | Norm. Closed | S, H | No | Yes | No | Yes | See Note 1 |
| | SOLAS II-1/15-1.2 and 15-1.4 | Perm. Closed | S, H | No | Yes | No | Yes | See Notes 2 & 3 |

*Notes:*

1. If hinged, this door is to be of single action type.
2. The time of opening such doors in port and closing them before the ship leaves port is to be entered in the logbook.
3. Doors are to be fitted with a device which prevents unauthorized opening.

# PART 4

## CHAPTER 9
## Automation and Computer Based Systems

## SECTION 9
## Equipment

## 1 General *(1 July 2024)*

The requirements of 4-9-9/1 through 4-9-9/13 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 the optional notations **ACC**, **ACCU** or **ABCU**.

Remote propulsion controls fitted on vessels not receiving notations are to be in accordance with 4-9-9/15.

Refer to Section 4-9-3 for Computer Based System requirements with/without optional notations such as **ACC**, **ACCU** or **ABCU**.

Refer to Section 4-9-14 for Cyber Resilience requirements with/without optional notations such as **ACC**, **ACCU** or **ABCU**.

### 1.1 Objective *(2024)*

#### 1.1.1 Goals

The monitoring, control and safety systems of propulsion, associated machinery and electrical power generating plant are to be designed, constructed, operated and maintained to:

| *Goal No.* | *Goals* |
|---|---|
| SAFE 1 | minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems |
| AUTO 1 | perform its functions as intended and in a safe manner |

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

#### 1.1.2 Functional Requirements

In order to achieve the above stated goals, the design, construction, installation and maintenance of control, monitoring and safety systems of propulsion, associated machinery and electrical power generating plant are to be in accordance with the following functional requirements:

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Safety of Personnel (SAFE)** | |
| SAFE-FR1 | Component of control, monitoring and safety systems are to be able to withstand the marine and electromagnetic environment without any deterioration. |
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Equipment designed to operate only under special environmental conditions is to be installed in a space provided with a back-up unit to maintain the environmental conditions . |

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

### 1.1.3 Compliance

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

## 3 Environmental Test Conditions

Control, safety and monitoring equipment is to be designed such that it will successfully withstand the test conditions stipulated in 4-9-9/15.7 TABLE 1, as applicable.

Upon request by the manufacturer, equipment designed to environmental conditions in excess of those in 4-9-9/15.7 TABLE 1 can be tested to such conditions and certified accordingly.

## 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.

## 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 Section 4-8-3, and specifically as follows:

| | |
|---|---|
| Material design | as per 4-8-3/1.7 |
| Electrical characteristics | as per 4-8-3/1.9 |
| Enclosures | as per 4-8-3/1.11 |
| Accessibility | as per 4-8-3/1.13 |
| Insulation | as per 4-8-3/1.15 |
| Wiring and cables | as per 4-8-3/5.3.6 and 4-8-3/9 |

## 9 Hydraulic Equipment

Hydraulic equipment is to be suitable for the intended service, compatible with the working fluid and is to be in accordance with the provisions of 4-6-7/3. The hydraulic fluid is to be non-flammable or have a flash point above 157°C (315°F).

## 11 Pneumatic Equipment

Pneumatic equipment is to be suitable for the intended service and is to be in accordance with the provisions of 4-6-7/5.

## 13 Equipment Tests

### 13.1 Prototype Environmental Testing *(2024)*

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 4-9-9/15.7 TABLE 1)

*ii)* Vibration test (item 5 in 4-9-9/15.7 TABLE 1)

*iii)* Inclination test (item 6 in 4-9-9/15.7 TABLE 1)

Other prototype environmental tests specified in 4-9-9/15.7 TABLE 1 are to be conducted by the manufacturers; acceptance will be based on review of manufacturer's certified test reports by ABS. Omission of certain tests may be considered taking into consideration of the location of installation, functionality, contained devices, etc. of the equipment.

Circuit breakers and cables are exempted from tests specified in 4-9-9/15.7 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, instrumentation, but may exclude printer, data recording or logging device not required in this section.

Simple/passive sensors, gauges used for local displays and instrumentation for Category I computer-based systems are exempted from prototype testing.

***Commentary:***

1 The scope of prototype testing for instrumentation in computer-based systems is limited to electrical/ electronic or computer-based field devices (e.g., electrical/ electronic sensors, transmitters, transducers, solenoid valves, actuators, etc.,) that are used for Category II, III computer-based systems or essential services listed in 4-8-1/7.3.3 TABLE 2 and 4-8-1/Table 3.

2 The test specifications covered in 4-9-9/15.7, 4-9-9/15.7 TABLE 1 and 4-9-9/15.7 TABLE 2 are based on IACS Unified Requirement (UR) E10 "Test specification for type approval".

**End of Commentary**

### 13.3 Production Unit Certification *(1 July 2024)*

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 4-9-9/15.7 TABLE 2.

Requirements in Section 4-9-3 for Computer Based Systems are applicable.

Requirements in Section 4-9-14 for Cyber Resilience are applicable.

Test of security capabilities are to be conducted in accordance with an approved test schedule per 4-9-14/9.1.4 and are to be witnessed by a Surveyor. Documentation to verify the secure lifestyle development is to be inspected in accordance with 4-9-14/21.1.4.

### 13.5 Type Approval Program *(1 July 2024)*

Refer to 4-1-1/3.3 and for:

- Computer Based Systems specific requirements, see Section 4-9-3/11.3.

- Cyber Resilience specific requirements, see Section 4-9-14/19.1.1 to 4-9-14/19.1.5.

# 15 Equipment

Remote propulsion controls fitted on vessels not receiving notations are to be in accordance with the following requirements.

## 15.1 Electrical Equipment

The requirements in 4-9-9/7 are applicable.

## 15.3 Computer Based Systems - Equipment *(1 July 2024)*

Requirements in Section 4-9-3 are applicable. Equipment type tests in 4-9-3/13.3, duplication of equipment and duplication of data links in integrated systems in 4-9-3/5.3 and duplication of monitor in centralized control station in 4-9-3/11.5 are not applicable.

## 15.4 Cyber Resilience - Equipment *(1 July 2024)*

Requirements in Section 4-9-14 for Cyber Resilience are applicable. Refer to sections:

***i)*** 4-9-13/15 for Test Plan for performance evaluation and testing.

***ii)*** 4-9-14/19.1.1 to 19.1.5 for Cyber Resilience equipment Type Tests for Type Approval

***iii)*** 4-9-14/19.1.6 for Type Approval specific Unit Certification requirements

***iv)*** 4-9-14/21 for Shop Survey and Factory Acceptance Test (FAT)

## 15.5 Hydraulic and Pneumatic Equipment

The requirements of 4-9-9/9 and 4-9-9/11 are applicable. However, flash point limitation on hydraulic fluids is applicable only to vessels to be assigned with **ACC**, **ACCU**, or **ABCU** notations.

## 15.7 Acceptance Tests

All equipment is to be performance tested in the presence of a Surveyor in accordance with 4-9-9/15.7 TABLE 2 either in the shop or after installation. All installations are to be functionally tested to the satisfaction of the surveyor on board and during sea trials, see Section 4-9-10.

## TABLE 1
## Type Tests for Control, Monitoring and Safety Equipment *(2020)*

<table>
<tr><th>No</th><th>TEST</th><th>PROCEDURE ACCORDING TO [See note 7]:</th><th colspan="3">TEST PARAMETERS</th><th>OTHER INFORMATION</th></tr>
<tr><td rowspan="17">1.</td><td rowspan="17">Power supply variations (a) electric</td><td rowspan="17">---</td><td colspan="3">AC Supply</td><td rowspan="17"></td></tr>
<tr><td>Combination</td><td>Voltage variation permanent (%)</td><td>Frequency variation permanent (%)</td></tr>
<tr><td>1</td><td>+6</td><td>+5</td></tr>
<tr><td>2</td><td>+6</td><td>-5</td></tr>
<tr><td>3</td><td>-10</td><td>-5</td></tr>
<tr><td>4</td><td>-10</td><td>+5</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Combination</td><td>Voltage Transient 1.5 s (%)</td><td>Frequency Transient 5 s (%)</td></tr>
<tr><td>5</td><td>+20</td><td>+10</td></tr>
<tr><td>6</td><td>-20</td><td>-10</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">DC Supply</td></tr>
<tr><td colspan="2">Voltage tolerance continuous</td><td>±10%</td></tr>
<tr><td colspan="2">Voltage cyclic variation</td><td>5%</td></tr>
<tr><td colspan="2">Voltage ripple</td><td>10%</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Electric battery supply:<br>+30% to -25% for equipment connected to charging battery or as determined by the charging/discharging characteristics,including ripple voltage from the charging device;<br>+20% to -25% for equipment not connected to the battery during charging</td></tr>
<tr><td>2.</td><td>Power supply variations (Continued) (b) Pneumatic and hydraulic</td><td>---</td><td colspan="3">Pressure: ±20%<br>Duration: 15 minutes</td><td></td></tr>
</table>

| *No* | *TEST* | *PROCEDURE ACCORDING TO [See note 7]:* | *TEST PARAMETERS* | *OTHER INFORMATION* |
|---|---|---|---|---|
| 3. | Dry heat [see note 1], [see note 10] | IEC 60068-2-2 Test Bb for non-heat dissipating equipment | Temperature: 55°C (131°F) ± 2°C (3.6°F)<br>Duration: 16 hours<br>Or<br>Temperature: 70°C (158°F) ± 2°C (3.6°F)<br>Duration: 16 hours | Equipment operating during conditioning and testing;<br>Functional test during the last hour at the test temperature;<br>For equipment specified for increased temperature the dry heat test is to be conducted at the agreed test temperature and duration. |
| | | IEC 60068-2-2 Test Be for heat dissipating equipment | Temperature: 55°C (131°F) ± 2°C (3.6°F)<br>Duration: 16 hours<br>Or<br>Temperature: 70°C (158°F) ± 2°C (3.6°F)<br>Duration: 16 hours | Equipment operating during conditioning and testing with cooling system on if provided;<br>Functional test during the last hour at the test temperature;<br>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) | IEC 60068-2-2 | Temperature: 70°C (158°F) ± 2°C (3.6°F)<br>Duration: 16 hours<br>[See Note 8] | Equipment operating during conditioning and testing;<br>Functional test during the last hour at the test temperature; |

| *No* | *TEST* | *PROCEDURE ACCORDING TO [See note 7]:* | *TEST PARAMETERS* | *OTHER INFORMATION* |
|---|---|---|---|---|
| 4. | Damp heat | IEC 60068-2-30 - Test Db. | Temperature: 55°C (131°F)<br>Humidity: 95%<br>Duration: 2 cycles 2×(12 + 12 hours) | Measurement of insulation resistance before test;<br>The test is to start with 25°C ± 3°C and at least 95% humidity;<br>Equipment operating during the complete first cycle and switched off during second cycle except for functional test;<br>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;<br>Recovery at standard atmosphere conditions;<br>Insulation resistance measurements and performance test. |

| *No* | *TEST* | *PROCEDURE ACCORDING TO [See note 7]:* | *TEST PARAMETERS* | *OTHER INFORMATION* |
|---|---|---|---|---|
| 5. | Vibration | IEC 60068-2-6, Test Fc | 2.0 (+3/-0) Hz to 13.2 Hz - amplitude ±1 mm (0.039 in)<br>13.2 Hz to 100 Hz - acceleration ±0.7g<br>For severe vibration conditions, e.g., on diesel engines, air compressors, etc.:<br>2.0 Hz to 25 Hz - amplitude ±1.6 mm(0.063 in)<br>25.0 Hz to 100 Hz - acceleration ±4.0g<br>*Note:*<br>*More severe conditions may exist for example on exhaust manifolds or fuel oil injection systems of diesel engines. For equipment specified especially for increased vibration levels, the vibration test is to be conducted at the agreed vibration level, frequency range and duration. Values may be required to be in these cases 40 Hz to 2000 Hz - acceleration ± 10.0g at 600°C duration 90 min.* | Duration: 90 minutes at 30 Hz in case of no resonance conditions;<br>Duration: 90 minutes for of each resonance frequency at which Q ≥2 is recorded;<br>During the vibration test, functional tests are to be carried out;<br>Tests to be carried out in three mutually perpendicular planes;<br>It is recommended as guidance that Q does not exceed 5;<br>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. *Note: Critical frequency is a frequency at which the equipment being tested exhibits:*<br>● *malfunction and/or performance deterioration*<br>● *mechanical resonances and/or other response effects occur, for example, chatter* |

<table>
<tr><th>No</th><th>TEST</th><th>PROCEDURE ACCORDING TO [See note 7]:</th><th colspan="4">TEST PARAMETERS</th><th>OTHER INFORMATION</th></tr>
<tr><td rowspan="2">6.</td><td rowspan="2">Inclination</td><td rowspan="2">IEC 60092-504</td><td colspan="4">Static 22.5°</td><td>a) Inclined at an angle of at least 22.5° to the vertical;<br>b) Inclined to at an angle of at least 22.5° on the other side of the vertical and in the same plane as in (a);<br>c) Inclined to at an angle of at least 22.5° to the vertical and in plane at right angles to that used in (a);<br>d) Inclined to at an angle of at least 22.5o on the other side of the vertical and in the same plane as in (c)<br>Note: The duration of testing in each position is to be sufficient to fully evaluate the behavior of the equipment.</td></tr>
<tr><td colspan="4">Dynamic 22.5°</td><td>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.<br>The test in each direction is to be carried out for not less than 15 minutes<br>Note: These inclination tests are normally not required for equipment with no moving parts</td></tr>
<tr><td rowspan="4">7.</td><td rowspan="4">Insulation resistance</td><td rowspan="4">---</td><td rowspan="2">Rated supply voltage (V)</td><td rowspan="2">Test voltage (DC voltage) (V)</td><td colspan="2">Min. insulation resistance</td><td rowspan="4">Insulation resistance test is to be carried out before and after: damp heat test, cold test, and salt mist test, and high voltage test;<br>• between all phases and earth;<br>• and where appropriate, between the phases,<br>$U_n$ is the rated (nominal) voltage.<br>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 4-8-5/3.</td></tr>
<tr><td>Before test (MΩ)</td><td>After test (MΩ)</td></tr>
<tr><td>$U_n \leq 65$</td><td>$2 \times U_n$ (min. 24 V)</td><td>10</td><td>1.0</td></tr>
<tr><td>$U_n > 65$</td><td>500</td><td>100</td><td>10</td></tr>
</table>

<table>
<tr><th>No</th><th>TEST</th><th>PROCEDURE ACCORDING TO [See note 7]:</th><th colspan="2">TEST PARAMETERS</th><th>OTHER INFORMATION</th></tr>
<tr><td rowspan="5">8.</td><td rowspan="5">High voltage</td><td rowspan="5">---</td><td>Rated voltage $U_n$ (V)</td><td>Test voltage [AC voltage 50 or 60 Hz] (V)</td><td rowspan="5">Separate circuits are to be tested against each other and all circuits connected with each other tested against earth;<br>Printed circuits with electronic components may be removed during the test;<br>Period of application of the test voltage: 1 minute</td></tr>
<tr><td>Up to 65</td><td>$2 \times U_n + 500$</td></tr>
<tr><td>66 to 250</td><td>1500</td></tr>
<tr><td>251 to 500</td><td>2000</td></tr>
<tr><td>501 to 690</td><td>2500</td></tr>
<tr><td>9.</td><td>Cold</td><td>IEC 60068-2-1</td><td colspan="2">Temperature: +5°C (41°F) ±3°C (5.4°F)<br>Duration: 2 hours<br>Or<br>Temperature: -25°C (-13°F) ±3°C (5.4°F)<br>Duration: 2 hours<br>[See Note 2]</td><td>Initial measurement of insulation resistance;<br>Equipment not operating during conditioning and testing except for functional test;<br>Functional test during the last hour at the test temperature;<br>Insulation resistance measurement and the functional test after recovery</td></tr>
<tr><td>10.</td><td>Salt mist</td><td>IEC 60068-2-52 Test Kb</td><td colspan="2">Four spraying periods with a storage of 7 days after each.</td><td>Initial measurement of insulation resistance and initial functional test;<br>Equipment not operating during conditioning of the test specimen;<br>Functional test on the 7th day of each storage period;<br>Insulation resistance measurement and performance test: 4 to 6 hours after recovery<br>[See Note 3]<br>On completion of exposure, the equipment is to be examined to verify that deterioration or corrosion (if any) is superficial in nature.</td></tr>
<tr><td>11.</td><td>Electrostatic discharge</td><td>IEC 61000-4-2</td><td colspan="2">Contact discharge: 6kV<br>Air discharge: 2 kV, 4 kV, 8 kV<br>Interval between single discharges: 1 sec.<br>Number of pulses: 10 per polarity<br>According to test level 3</td><td>To simulate electrostatic discharge as can occur when persons touch the appliance;<br>The test is to be confined to the points and surfaces that can normally be reached by the operator;<br>Performance Criterion B<br>[See Note 4].</td></tr>
</table>

| No | TEST | PROCEDURE ACCORDING TO [See note 7]: | TEST PARAMETERS | OTHER INFORMATION |
|---|---|---|---|---|
| 12. | Electro-magnetic field | IEC 61000-4-3 | Frequency range: 80 MHz to 6 GHz<br>Modulation*: 80 % AM at 1000 Hz<br>Field strength: 10 V/m<br>Frequency sweep rate: $\leq 1.5 \times 10^{-3}$ decades/sec. (or 1% / 3 sec.)<br>According to test level 3 | To simulate electromagnetic fields radiated by different transmitters;<br>The test is to be confined to the appliances exposed to direct radiation by transmitters at their place of installation.<br>Performance criterion A<br>[See Note 5]<br>***Note:***<br>* *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.*<br>If an equipment is intended to receive radio signals for the purpose of radio communication (e.g. Wi-Fi router, remote radio controller), then the immunity limits at its communication frequency do not apply, subject to the requirements in 4-9-3/13.3 [see Note 10]. |
| 13. | Conducted Low Frequency | | **AC:**<br>Frequency range: rated frequency to 200th harmonic;<br>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<br>**DC:**<br>Frequency range: 50 Hz - 10 kHz;<br>Test voltage (rms): 10% of supply, maximum 2 W | To simulate distortions in the power supply system generated for instance, by electronic consumers and coupled in as harmonics;<br>Performance criterion A<br>[See Note 5]<br>See 4-9-9/15.7 FIGURE 1 for test set-up.<br>For keeping max. 2 W, the voltage of the test signal can be lower. |

| *No* | *TEST* | *PROCEDURE ACCORDING TO [See note 7]:* | *TEST PARAMETERS* | *OTHER INFORMATION* |
|---|---|---|---|---|
| 14. | Conducted Radio Frequency | IEC 61000-4-6 | **AC, DC, I/O ports and signal/control lines:**<br>Frequency range: 150 kHz - 80 MHz<br>Amplitude: 3 V rms [See Note 6]<br>Modulation ** : 80% AM at 1000 Hz<br>Frequency sweep range: $\leq 1.5 \times 10^{-3}$ decades/sec. (or 1% / 3 sec.)<br>According to Test level 2 | Equipment design and the choice of materials are to simulate electromagnetic fields coupled as high frequency into the test specimen via the connecting lines.<br>Performance criterion A<br>[See Note 5].<br>***Note:***<br>** *If for tests of equipment an input signal with a modulation frequency of 1000 Hz is necessary, a modulation frequency of 400 Hz is to be chosen.* |
| 15. | Electrical Fast Transients/ Burst | IEC 61000-4-4 | Single pulse rise time: 5ns (between 10% and 90% value)<br>Single pulse width: 50 ns (50% value)<br>Amplitude (peak): 2kV line on power supply port/earth; 1kV on I/O data control and communication ports (coupling clamp);<br>Pulse period: 300 ms;<br>Burst duration: 15 ms;<br>Duration/polarity: 5 min<br>According to test level 3 | Arcs generated when actuating electrical contacts;<br>Interface effect occurring on the power supply, as well as at the external wiring of the test specimen;<br>Performance criterion B<br>[See Note 4]. |
| 16. | Surge | IEC 61000-4-5 | Test applicable to AC and DC power ports<br>Open-circuit voltage:<br>Pulse rise time: 1.2 μs (front time)<br>Pulse width: 50 μs (time to half value)<br>Amplitude (peak): 1 kV line/earth;<br>0.5 kV line/line<br>Short-circuit current:<br>Pulse rise time: 8 μs (front time)<br>Pulse width: 20 μs (time to half value)<br>Repetition rate: ≥1 pulse/min<br>Number of pulses: 5 per polarity<br>Application: continuous<br>According to test level 2 | Interference generated for instance, by switching "ON" or "OFF" high power inductive consumers;<br>Test procedure in accordance with figure 10 of the standard for equipment where power and signal lines are identical;<br>Performance criterion B<br>[See Note 4]. |

| *No* | *TEST* | *PROCEDURE ACCORDING TO [See note 7]:* | *TEST PARAMETERS* | | *OTHER INFORMATION* |
|---|---|---|---|---|---|
| 17. | Radiated Emission [see Note 10] | CISPR 16-2-3<br>IEC 60945 for 156-165 MHz | **Limits below 1000 MHz**<br>**For equipment installed in the bridge and deck zone:**<br>Frequency range:<br>0.15 – 0.3 MHz<br>0.3 – 30 MHz<br>30 – 1000 MHz<br>except for:<br>156 – 165 MHz<br>**For equipment installed in the general power distribution zone:**<br>Frequency range:<br>0.15 – 30 MHz<br>30 – 100 MHz<br>100 – 1000 MHz<br>except for: | <br><br>Quasi peak Limits:<br>80 – 52 dBµV/m<br>52 – 34 dBµV/m<br>54 dBµV/m<br><br>24 dBµV/m<br><br>Quasi peak Limits:<br>80 – 50 dBµV/m<br>60 – 54 dBµV/m<br>54 dBµV/m | Procedure in accordance with the standard but distance 3 m (10 ft) between equipment and antenna<br>For the frequency band 156 MHz to 165 MHz the measurement is to be recorded with a receiver bandwidth of 9 kHz (as per IEC 60945)<br>Alternatively, the radiation limit at a distance of 3 m from the enclosure port over the frequency 156 MHz to 165 MHz is to be 30 dB micro-V/m peak (as per IEC 60945) |
| | | | 156 – 165 MHz | 24 dBµV/m | |
| | | | **Limit above 1000 MHz**<br>Frequency range:<br>1000 - 6000 MHz | -<br>Average limit:<br>54 dBµV/m | Procedure in accordance with the standard (distance 3 m between equipment and antenna)<br>Equipment intended to transmit radio signals for the purpose of radio communication (e.g. Wi-Fi router, remote radio controller) may be exempted from limit, within its communication frequency range, subject to the requirements in 4-9-3/13.3. |

| *No* | *TEST* | *PROCEDURE ACCORDING TO [See note 7]:* | *TEST PARAMETERS* | *OTHER INFORMATION* |
|---|---|---|---|---|
| 18. | Conducted Emission | CISPR 16-2-1 | Test applicable to AC and DC power ports<br>**For equipment installed in the bridge and deck zone:**<br>Frequency range: Limits:<br>10 – 150kHz 96 – 50 dBμV<br>150 – 350 kHz 60 – 50 dBμV<br>350 kHz – 30 MHz 50 dBμV<br>**For equipment installed in the general power distribution zone:**<br>Frequency range: Limits:<br>10 – 150 kHz 120 – 69 dBμV<br>150 – 500 kHz 79 dBμV<br>0.5 – 30 MHz 73 dBμV | |
| 19. | Flame retardant | IEC 60092-101 or IEC 60695-11-5 | Flame application: 5 times 15 sec each.<br>Interval between each application: 15 sec. or 1 time 30 sec.<br>Test criteria based upon application.<br>The test is performed with the Equipment Under Test (EUT) or housing of the EUT applying needle-flame test method. | The burnt out or damaged part of the specimen by not more than 60 mm long.<br>No flame, no incandescence or in the event of a flame or incandescence being present, it is to extinguish itself within 30 sec. of the removal of the needle flame without full combustion of the test specimen.<br>Any dripping material is to extinguish itself in such a way as not to ignite a wrapping tissue. The drip height is 200 mm ±5 mm. |

*Notes:*

1 Dry heat at 70°C is to be carried out to automation, control and instrumentation equipment subject to high degree of heat, for example mounted in consoles, housings, etc. together with other heat dissipating power equipment.

2 For equipment installed in non-weather protected locations or cold locations test is to be carried out at-25°C (-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.

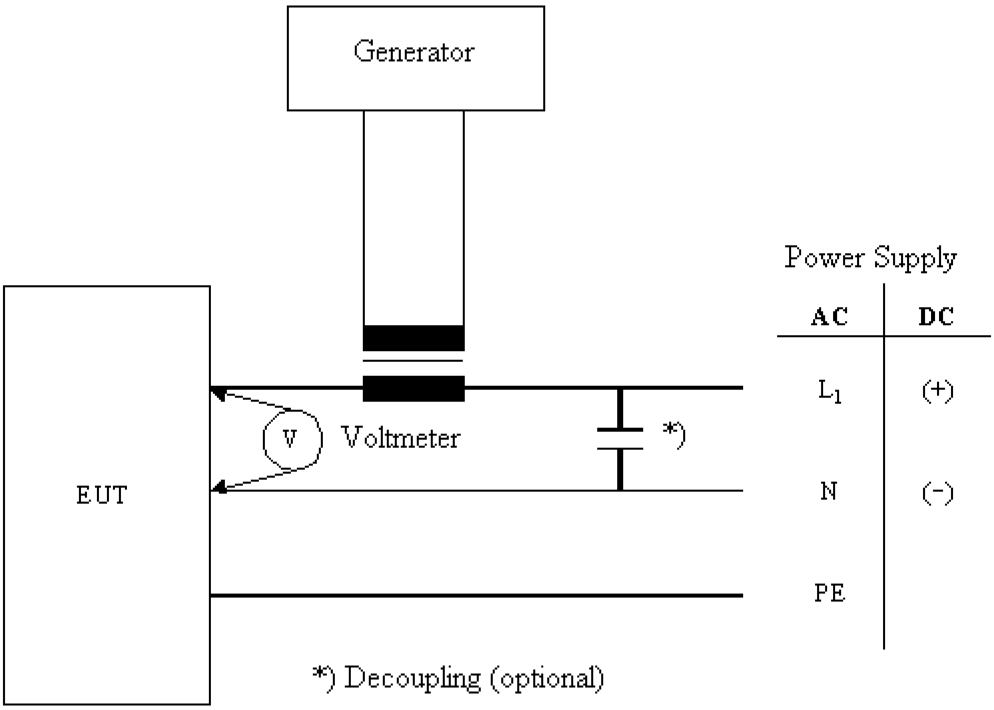
7 Alternative equivalent testing procedures may be accepted provided the requirements in the other columns are complied with.

8 When requested, equipment which has undergone the higher temperature and duration test can be recognized accordingly in the PDA certificate (see Appendix 1A-1-A3 of the ABS *Rules for Conditions of Classification (Part 1A)*). 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 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.

10 Equipment for which the date of application for type approval certification is dated on or after 1 January 2020 or intended to be installed on ships contracted for construction on or after 1 January 2022. For equipment of earlier dates (as applicable), the corresponding dry heat, electromagnetic field and radiated emission tests of the 2019 edition of the Rules apply.

## FIGURE 1
## Test Set-up for Conducted Low Frequency Test
## (See Test No. 13 of 4-9-9/Table 1)



## TABLE 2
## Tests for Unit Certification of Control, Monitoring and Safety Equipment

| *No* | *TEST* | *PROCEDURE ACCORDING TO: [See Note]* | *TEST PARAMETERS* | *OTHER INFORMATION* |
|---|---|---|---|---|
| 1. | Visual inspection | --- | --- | Conformance to drawings, design data, quality of workmanship and construction |
| 2. | Performance test | Manufacturer's performance test program based upon specification and relevant Rule requirements<br>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 4-9-9/15.7 TABLE 1. | Standard atmosphere conditions<br>Temperature: 25°C (77°F) ± 10°C (18°F)<br>Relative humidity: 60% ± 30%<br>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 system or equipment;<br>Checking of self-monitoring features;<br>Checking of specified protection against an access to the memory;<br>Checking against effect of unerroneous use of control elements in the case of computer systems. |
| 3. | External Power supply failure | --- | 3 interruptions during 5 minutes; switching-off time 30 s each case | The time of 5 minutes can be exceeded if the equipment under test (EUT) needs a longer time for startup, for example, booting sequence.<br>For equipment which requires booting, one additional power supply interruption during booting is to be performed.<br>Verification of:<br>the specified action of equipment upon loss and restoration of supply;<br>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.

# PART 4

## CHAPTER 9
## Automation and Computer Based Systems

## SECTION 10
## Installation, Tests and Trials

# 1 General

Control equipment and instrumentation are to be so placed or protected as to minimize the likelihood of sustaining damage from the accumulation of dust, oil vapors, steam or dripping liquids, or from activities around their location.

## 1.1 Objective *(2024)*

### 1.1.1 Goals

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

| *Goal No.* | *Goals* |
|---|---|
| SAFE 1.1 | Minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems. |
| AUTO 1 | Perform its functions as intended and in a safe manner. |
| MGMT 5.1 | Design and construct vessel, machinery, and electrical systems to facilitate safe access, ease of inspection, survey, and maintenance. |

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

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

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

### 1.1.2 Functional Requirements

In order to achieve the above stated goal, the design, construction, installation and maintenance of the electrical equipment are to be in accordance with the following functional requirements:

| *Funct ional Requirement No.* | *Funct ional Requirements* |
|---|---|
| **Safety of Personnel (SAFE)** | |
| SAFE-FR1 | There are to be arrangements to protect the electrical equipment from possible fluid leakages. |
| **Materials (MAT)** | |
| MAT-FR1 | To be constructed of durable, flame-retardant, moisture resistant materials that are able to withstand the marine environment and maximum design ambient temperature without any deterioration. |
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Provide means to reduce the interference from external electro-magnetic fields to a value within the design limit of the equipment. |
| AUTO-FR2 | Provide means to prevent moisture condensation in the equipment when it is idle. |
| AUTO-FR3 | Provide electrical grounding segregation for different voltage levels. |
| AUTO-FR4 | When equipment exposed to a harsh environment, measures are to be provided to adjust the ambient temperature to a value wihtin the design temperature of the equipment |
| **Safety Management (MGMT)** | |
| MGMT-FR1 | Provide easy access for testing and replacing the measuring and sensing devices. |
| MGMT-FR2 | Provide markings for electrical equipment parts, cables and terminals for easy identification. |

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

#### 1.1.3 Compliance

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

## 3 Equipment Arrangements and Installation

### 3.1 Ranges in Ambient Temperatures *(2020)*

For the selection and installation of electronic 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 4-9-9/15.7 TABLE 1, Note 1.

Where compliance with the above temperature ranges cannot be met, consideration will be given to the installation of equipment as per 4-9-10/3.11.

### 3.3 Electromagnetic Avoidance

In general, the installation of equipment associated with automatic or remote control and monitoring systems in areas of unusual electromagnetic sources is to be avoided. Where the values per 4-9-9/15.7 TABLE 1 are exceeded, measures are to be implemented to reduce the effects of electromagnetic and conducted interference. Description of the preventive measures followed is to be submitted for review.

### 3.5 Moisture Condensation

Installation of equipment in locations where ambient temperature fluctuations can lead to accumulation of moisture condensation inside equipment enclosure is to be avoided unless the equipment is protected by, for instance, space heaters, or such equipment is to be designed and constructed to function in this environment.

### 3.7 Signal Cables Installation

To avoid electromagnetic noise caused by circulating currents, the conductive shield and cable armor is to be grounded only at one end of the cable.

To avoid possible signal interference, signal cables occupying the same cable tray, trunk or conduit with power cables are to be effectively shielded.

### 3.9 Electrical Grounding

Automatic or remote control and monitoring systems are not to have common earth conductors with systems of higher voltage level.

### 3.11 Harsh Environment

Electrical equipment which can 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 can be readily operated when needed. See 4-9-10/3.1.

### 3.13 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.).

### 3.15 Measuring and Sensing Devices

The installation of measuring and sensing elements is to permit their easy access for functional testing or replacement.

### 3.17 Marking

All units, controllers, actuators, displays, terminal strips, cable and test points, etc., are to be clearly and permanently marked. Their systems and functions are to be included so that they can be easily identified in associated drawings and instrument lists.

## 5 Sea Trials and Dockside Trials

During sea trial, or dockside trials, as applicable, the following tests, as appropriate, are to be carried out to the satisfaction of the Surveyor.

### 5.1 Computer Based Systems (CBS) *(1 July 2024)*

Testing of computer based systems is to be carried out in accordance with 4-9-3/17 Table 5 and the following requirements:

#### 5.1.1 Individual on Board System Acceptance Tests (SATs)

Tests are to be conducted by the system integrator for Category I computer-based systems.

Category II and III computer-based systems tests/inspections are to be witnessed by a Surveyor.

***Commentary:***

The main purpose of the system acceptance test (SAT) is to verify the system functionality after installation and integration, with the applicable machinery/electrical/process systems on board, including possible interfaces with other control and monitoring systems.

**End of Commentary**

*5.1.1(a) Certification*

Category II and III computer-based systems are to be supplied with ABS certification, the reports and accompanying documents are to be provided to the attending Surveyor for review prior to commencement of testing.

*5.1.1(b) Documentation*

The following documents are to be provided to the attending Surveyor prior to commencement of testing.

***i)*** Quality Plan in accordance with 4-9-3/8.1.2

***ii)*** List of hardware components required by 4-9-14/9.1.1 with certifications as required by 4-9-3/8.3.4

***iii)*** List of software and versions supplied and tested in the FAT (4-9-3/8.3.6) along with any changes and updates made in accordance with management of change required by 4-9-3/10

***iv)*** ABS Approved SAT Program

*5.1.1(c) System Acceptance Test*

SATs for Category II and III are to be witnessed by the Surveyor using the ABS approved test procedure and are to include the following tests as specified by 4-9-3/17 and other sections of the Rules:

***i)*** Normal system functionality

- Testing of all functions of the system
- Confirmation of interfaces with other systems including input and output

***ii)*** Reponse to failures, e.g.:

- Loss of data link
- Other applicable failures

***iii)*** Test of Wireless Systems

- Radio-frequency transmission does not cause failure of any equipment and does not cause the wireless data communication equipment itself to fail as a result of electromagnetic interference during expected operating conditions

***iv)*** Representative testing for subsystems and components that have been supplied to verify functionality after installation

***v)*** Network testing to verify network resilience in accordance with 4-9-3/13

***vi)*** Evidence provided of a scan for malicious software in accordance with their Test Plan required in 4-9-14/15.

***vii)*** Testing is to include actual functioning of the system and failure responses

- Other methods may be accepted as described in the approved test procedure, so long as they are no less effective.

*5.1.1(d) SAT Results*

All test results are to be recorded as pass or fail, and the results are to be documented in a test report.

The completed test report is to be submitted to ABS Engineering for Information, a copy provided to the Surveyor, and is to include a list of the hardware with identifying markings listed and software with a listing of the software versions used.

*5.1.1(e) Modifications*

Modifications that change functionality of the system are to be submitted for approval. Refer to 4-9-3/5.1.9 for details regarding modifications of computer-based systems.

#### 5.1.2 Integrated Systems of Systems Testing (SOST)

Computer-based systems that incorporate the controls, data, or output from other computer-based systems are to be tested as integrated systems.

Integration tests are to be conducted after installation and integration of the different systems in their final environment on board as required by 4-9-3/17.

Tests are to be conducted by the integrator for Category I computer-based systems.

Category II and III computer-based systems tests/inspections are to be witnessed by a Surveyor.

***Commentary:***

The purpose of the tests is to verify the functionality of the complete installation (system of systems) including all interfaces and inter-dependencies in compliance with requirements and specifications.

**End of Commentary**

### 5.2 Cyber Resilience *(1 July 2024)*

Testing of Cyber Reseilence is to be carried out in accordance with the following requirements:

#### 5.2.1 Vessel Comissioning

*5.2.1(a)*

The Shipyard and the incoming Shipowner together are to verify that the information contained in the final version of the Vessel Cyber Resilience Test Procedure is updated and placed under change management; that it is aligned with the latest configurations of CBSs and networks connecting such systems together onboard the vessel and to other CBSs not onboard (e.g., ashore); and that the tests documented in the Vessel Cyber Resilience Test Procedure are sufficiently detailed as to allow verification of the installation and operation of measures adopted for the fulfilment of relevant requirements on the final configuration of CBSs and networks onboard.

*5.2.1(b)*

The Shipyard or System Integrator is to maintain a test report where results of execution of tests described in the Vessel Cyber Resilience Test Procedure , following the relevant testing procedure, and to be provided to the incoming Shipowner and to ABS upon vessel commissioning, where test results are recorded. Surveyors are to witness the execution of tests and may request execution of additional tests.

*5.2.1(c)*

The final Vessel Cyber Resilience Test Procedure updated according to the actual CBSs configuration and implementation testing onboard are to be made available to ABS engineering and to be verified to the satisfaction of the attending surveyor.

*5.2.1(d)*

The Vessel Cyber Resilience Test Procedure is to be tested to the satisfaction of the attending surveyor, including:

*i)* Vessel asset inventory:

- Vessel asset inventory is updated and completed at delivery.
- CBSs in the scope of applicability of Secion 4-9-13 are correctly represented by the vessel asset inventory.
- Software of the CBSs in the scope of applicability of Section 4-9-13 has been kept updated (e.g., by vulnerability scanning or by checking the software versions of CBSs while switched on).

*ii)* Security Zones and Network Segmentation:

- The security zones on board are implemented in accordance with the approved documents (i.e., zones and conduit diagram, cyber security design description, asset inventory, and relevant documents provided by the supplier).

*iii)* Network protection safeguards:

- Test denial of service (DoS) attacks targeting zone boundary protection devices, as applicable.
- Test denial of service (DoS) to ensure protection against excessive data flow rate, originating from inside each network segment. Such denial of service (DoS) tests shall cover flooding of network (i.e., attempt to consume the available capacity on the network segment), and application layer attack (i.e., attempt to consume the processing capacity of selected endpoints in the network).
- Test e.g. by analytic evaluation and port scanning that unnecessary functions, ports, protocols and services in the CBSs have been removed or prohibited in accordance with hardening guidelines provided by the suppliers.

*iv)* Antivirus, antimalware, antispam and other protections from malicious code:

- Approved anti-malware software or other compensating countermeasures is effective (test e.g., with a trustworthy anti-malware test file).

*v)* Access control:

- Components of the CBSs are located in areas or enclosures where physical access can be controlled to authorized personnel.
- User accounts are configured according to the principles of segregation of duties and least privilege and that temporary accounts have been removed.

*vi)* Wireless communication:

- Only authorized devices can access the wireless network.
- Secure wireless communication protocol is used as per approved documentation by the respective supplier (demonstrate e.g. by use of a network protocol analyzer tool).

*vii)* Remote access control and communication with untrusted networks:

- Communication with untrusted networks is secured and that the communication protocols cannot be negotiated to a less secure version (demonstrate e.g., by use of a network protocol analyzer tool)
- Remote access requires multifactor authentication of the remote user.
- A limit of unsuccessful login attempts is implemented, and that a notification message is provided for the remote user before session is established.
- Remote connections must be explicitly accepted by responsible personnel on board.

- Remote sessions can be manually terminated by personnel on board or that the session will automatically terminate after a period of inactivity.
- Remote sessions are logged.
- Instructions or procedures are provided by the respective product suppliers.

*viii)* Use of Mobile and Portable Devices:

- Use of mobile and portable devices is restricted to authorized users.
- Interface ports can only be used by specific device types.
- Files cannot be transferred to the system from such devices.
- Files on such devices will not be automatically executed (by disabling autorun).
- Network access is limited to specific MAC or IP addresses.
- Unused interface ports are disabled.
- Unused interface ports are physically blocked.

*ix)* Network operation monitoring:

- Test that disconnected network connections will activate alarm and that the event is recorded.
- Test that abnormally high network traffic is detected, and that alarm and audit record is generated. This test may be carried on together with the test in 4-9-10/5.2.2.d.xii Network Isolation.
- Verify that the CBS will respond in a safe manner to network storm scenarios, considering both unicast and broadcast messages (see also 4-9-10/5.2.2.d.iii Network protection safeguards)
- Verify the generation of audit records (logging of security-related events)
- If Intrusion detection systems are implemented, verify that this is passive and will not activate protection functions that may affect intended operation of the CBSs

*x)* Verification and diagnostic functions of CBS and networks:

- Verify effectiveness of security functions provided by the suppliers.

*xi)* Local, independent and/or manual operation:

- Verify that the required local controls needed for safety of the ship can be operated independently of any remote or automatic control systems.
- The tests shall be carried out by disconnecting all networks from the local control system to other systems/devices.

*xii)* Network isolation:

- Verify all networks traversing security zone boundaries, that the CBSs in the security zone will maintain adequate operational functionality without network communication with other security zones or networks.

*xiii)* Fallback to a minimal risk condition:

- Verify response to cyber incidents can be performed in a safe manner by maintaining its outputs to essential services and allowing operators to carry out control and monitoring functions by alternative means.
- The tests shall at least include denial of service (DoS) attacks and may be done together with related test in 4-9-10/5.2.2.d.ix Network operation monitoring

*xiv)* Recovery plan:

- Verify response procedures to cyber incidents as specified in 4-9-10/5.2.2.d.

***xv)*** Backup and restore capability:

- Verify backup and restore procedure provided by the suppliers for CBSs.

***xvi)*** Controlled shutdown, reset, roll-back and restart:

- Verify procedures for shutdown, reset and restore of the CBSs.

*5.2.1(e)*

Following Vessel cyber security and resilience program procedures (may be included in the vessels Safety Management System under IMO Resolution 428 (98)) are to be submitted by the owner and verified to the satisfaction of the attending surveyor:

***i)*** Vessel hardware/software Asset inventory:

***a)*** Management of change process.

***b)*** Hardware and software modifications.

***c)*** Hardware and software asset inventory is maintained.

***d)*** Vulnerabilities and cyber risks.

***e)*** Security patching.

***ii)*** Security Zones, Network Segmentation & conduit diagram:

***a)*** Principle of Least Functionality.

***b)*** Explicitly allowed traffic.

***c)*** Protection against denial of service (DoS) events.

***d)*** Inspection of security audit records.

***iii)*** Malware protection (Antivirus, antimalware, antispam and other protections from malicious code):

***a)*** Maintenance/update.

***b)*** Operational procedures, physical safeguards.

***c)*** Use of mobile, portable, removable media.

***d)*** Access control.

***iv)*** Access control (logical and physical access):

***a)*** Physical access control.

***b)*** Physical access control for visitors.

***c)*** Physical access control of network access points.

***d)*** Management of credentials.

***e)*** Least privilege policy.

***f)*** Confidential information.

***g)*** Information allowed to authorized personnel.

***h)*** Information transmitted on the wireless network.

***v)*** Remote access control and communication with untrusted networks:

***a)*** User's manual.

***b)*** Roles and permissions.

***c)*** Patches and updates.

*d)* Confirmation prior to undertaking remote software update.

*e)* Interrupt, abort, roll back.

*vi)* Mobile and Portable Devices:

*a)* Policy and procedures.

*b)* Physical block of interface ports.

*c)* Use by authorized personnel.

*d)* Connect only authorized devices.

*e)* Consider risk of introducing malware.

*vii)* CBS Network operation routine monitoring/detection of anomalies, including:

*a)* Reveal and recognize anomalous activity.

*b)* Inspection of security audit records.

*c)* Instructions or procedures to detect incidents.

*viii)* Diagnostic functions of CBS and networks:

*a)* Test and maintenance periods.

*b)* Periodic maintenance.

*ix)* Incident Response Plan:

*a)* Description of who, when and how to respond to cyber incidents.

*b)* Procedures or instructions for local/manual control.

*c)* Procedures or instructions for isolation of security zones.

*d)* Description of expected behavior of the CBSs in the event of cyber incidents.

*x)* Incident Recovery Plan:

*a)* Description of who, when and how to restore and recover from cyber incidents.

*b)* Policy for backup addressing frequency, maintenance and testing of the backups, considering acceptable downtime, availability of alternative means for control, vendor support arrangements and criticality of the CBSs.

*c)* Reference to user manuals or procedures for backup, shutdown, reset, restore and restart of the CBSs.

## 5.3 Propulsion Remote Control

### 5.3.1 Control Functions

The ability to effectively control the propulsion from the remote propulsion control station is to be demonstrated during sea trials, or at dockside. These trials are to include:

- Propulsion control transfer
- Propulsion starting
- Verification of propulsion control responses
- Response to propulsion control power failure
- Automatic propulsion shutdown
- Automatic propulsion slowdown
- Actuation of propulsion emergency stop devices
- For turbine-driven vessel, actuation of the shaft turning device.

#### 5.3.2 Throttle Control *(1 July 2024)*

Response of propulsion machinery to throttle control demands is to be tested to demonstrate during sea-trial 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.

### 5.3 Local Manual Control

#### 5.3.1 Propulsion Machinery

Independent manual local control of the propulsion machinery is to be demonstrated during trials. This is to include demonstration of independent manual control through the full maneuvering range and transfer from automatic control.

#### 5.3.2 Propulsion Boiler

Independent manual local control of the boilers is to be demonstrated during the tests or trial 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.

### 5.5 Vessels Receiving ACC Notation

In addition to the tests required in 4-9-10/5.1 through 4-9-10/5.4, vessels with a centralized control station are to be tested as follows, during sea trial or during the dock trial as appropriate.

After the propulsion machinery has been running for at least two (2) hours, the machinery is to be operated over its full range of power to demonstrate the adequacy of all control systems. The propulsion machinery is to be run for at least an additional four (4) hours, for a total minimum of six (6) hours duration. The following tests are to be included:

- All alarm points and displays
- Operations of automatic controlled machinery
- Transfer of standby auxiliary
- Remote control of auxiliary machinery
- Fire detection system
- Bilge alarm

### 5.7 Vessels Receiving ACCU Notation

In addition to the tests required in 4-9-10/5.1 through 4-9-10/5.5, vessels intended to be operated with periodically unattended machinery space are to be tested as follows.

#### 5.7.1 Loss of Generator Tests

The loss of electric power (see 4-9-6/13.5) is to be simulated with the main engine running and simulated loss of generator to test:

- Automatic restoration of electric power by standby generator(s);
- Automatic starting of vital auxiliaries; and
- Starting and restoration of control of propulsion prime mover from the centralized control station or the navigation bridge, as appropriate.

#### 5.7.2 Fire Fighting Control Function Tests

All controls provided at the fire fighting station (4-9-6/21.3) are to be functionally tested.

#### 5.7.3 Full Functional Test

After the propulsion machinery has been running for at least two (2) hours, the machinery is to be operated over its full range of power to demonstrate the adequacy of all control systems. The propulsion machinery is to be run for at least four (4) more hours; in total a minimum duration of six (6) hours. During this period, the ability to control the machinery functions correctly for all loads and engine maneuvers without any manual intervention in the propulsion machinery space for four (4) hours is to be demonstrated.

### 5.9 Vessels Receiving ABCU Notation

In addition to the trials per 4-9-10/5.7, 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 9

# Automation and Computer Based Systems

SECTION 11

# Vessels Less than 500 GT Having a Length Equal or Greater than 20 m (65 ft)

## 1 General *(2024)*

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).

Optional **ACCU** or **ABCU** class notation may be granted to vessels of < 500 GT and a length of 20 m (65 ft) ≤ *L* ≤ 46 m (150 ft), provided that the applicable requirements in Sections 4-9-1, 4-9-2, 4-9-5, 4-9-6, 4-9-7 and 4-9-10 are met.

Optional **ACC** class notation may be granted to vessels of < 500 GT and a length of 20 m (65 ft) ≤ *L* ≤ 46 m (150 ft), provided that the applicable requirements in Sections 4-9-1, 4-9-2, 4-9-5, and 4-9-10 are met.

The requirements in Sections 4-9-1 to 4-9-8 are not applicable to vessels less than 500 GT if the optional notations **ACCU**/**ACC**/**ABCU** are not requested, and such requirements are not specifically referred to in this Section.

Vessels having a length less than 20 m (65 ft) will be subjected to ABS technical assessment and special consideration.

### 1.1 Objective *(2024)*

#### 1.1.1 Goal

The remote control, monitoring, alarm and safety systems for vessels less than 500 GT having a length equal or greater than 20 m (65 ft) are to be designed, constructed, operated and maintained to:

| *Goal No.* | *Goals* |
|---|---|
| AUTO 1 | perform its functions as intended and in a safe manner. |
| AUTO 2 | indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance. |
| AUTO 3 | have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |
| AUTO 4 | provide the equivalent degree of safety and operability from a remote location as that provided by local controls. |

| *Goal No.* | *Goals* |
|---|---|
| AUTO 5 | be provided with a safety system that automatically leads the machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/equipment or environment. |
| FIR 1 | prevent *the occurrence of fire and explosion.* |
| STAB 4 | detect accumulated liquids. |

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

### 1.1.2 Functional Requirements

In order to achieve the above stated goal, the design, construction and installation of remote control, monitoring, alarm and safety systems for vessels less than 500 GT having a length equal or greater than 20 m (65 ft) are to be in accordance with the following functional requirements:

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Cables are to be suitable for the marine/intended services. |
| AUTO-FR2 | Alarms are to be effective in notifying the operators of abnormal conditions and tracking of multiple alarms until faults are corrected. |
| AUTO-FR3 | Safety systems to be fail-safe type. |
| AUTO-FR4 | Safety systems are to respond automatically to fault conditions by taking the least severe action first and activating safety interlocks to preclude damage of machinery. |
| AUTO-FR5 | Means are to be provided to prevent accidental activation of overrides of automatic safety shutdowns for main propelling machineryand to notify operators when such overrides are activated. |
| AUTO-FR6 | Provide suitable information at the bridge for control of propulsion machinery. |
| AUTO-FR7 | Local controls to be provided in case of failure of automatic or remote control systems. |
| AUTO-FR8 | Provide means of detection of oil spillage in periodically unattended propulsion machinery space and notification at the bridge. |
| AUTO-FR9 | Provide monitoring of heated fuel oil temperature and notification to personnel at navigation bridge when the flashpoint of fuel oil can be exceeded. |
| AUTO-FR10 | Provide monitoring and alarms for essential parameters of propulsion, power generation, and associated machinery at the navigation bridge. |
| AUTO-FR11 (STAB) | Provide means to detect flooding in periodically unattended propulsion machinery spaces and alarms at the navigation bridge. |
| **Fire Safety (FIR)** | |
| FIR-FR1 | Provide protection and arrangements to prevent fuel oil from igniting with due regard to leakages, spillage, and hot surfaces. |
| FIR-FR2 | Provide means of fire detection in periodically unattended propulsion machinery spaces and notification at the navigation bridge. |

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

#### 1.1.3 Compliance

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

## 3 Definitions

See 4-9-1/5.

## 5 Plans to be Submitted

Plans and specifications are to be submitted in accordance with 4-9-1/7 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 4-9-11/15.5.

*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 *(2024)*

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 8. Cables in accordance with other standards which are not less effective are acceptable. 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 are to 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 are to be provided to show whether or not it has been activated.

# 13 Bridge Control of Propulsion Machinery

## 13.1 General

The requirements in 4-9-2/13.1 through 4-9-2/13.9 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, are to 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.

| | *Items* | *Display* | *Alarm* |
|---|---|---|---|
| 1 | L.O. Pressure to main engine & reduction gear | Pressure | Low |
| 2 | Engine coolant | Temperature | High |
| 3 | Starting air (if applicable) pressure | | Low |
| 4 | Propeller Speed | RPM | |
| 5 | Propeller Direction or Pitch | Ahead | |
| 6 | | Astern | |
| 7 | | 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 15.1.1(d)] | | High |
| 14 | Oil collection tank [see 15.1.1(a) and 4-9-11/15.1.1(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.

# PART 4

## CHAPTER 9

## Automation and Computer Based Systems

## SECTION 12

## Towing Vessels Less Than 500 GT Having a Length Equal or Greater Than 20 m (65 ft) and Equal or Less than 46 m (150 ft) Classed with ABCU-H Notation *(1 July 2021)*

### 1 General *(2024)*

The requirements in this Section apply to ABS classed towing vessels capable of operating with unmanned engine rooms limited to restricted operations in Harbor. These vessels can be assigned the optional notation **ABCU-H** provided they meet the requirements of this section. Except as noted herein, the requirements in Sections 4-9-1 and 4-9-2, as applicable, are to be complied with.

***Note:***

Requirements in Sections 4-9-1 to 4-9-10 are not applicable to towing vessels less than 500 GT having a length equal or greater than 20 m and equal or less than 46 m classed with **ABCU-H** notation if such requirements are not specifically referred to in this Section.

### 1.1 Objective *(2024)*

#### 1.1.1 Goal

The remote control, monitoring and alarm systems for towing vessels less than 500 GT and a length of 20 m (65 ft) ≤ L ≤ 46 m (150 ft) are to be designed, constructed, operated and maintained to:

| *Goal No.* | *Goals* |
|---|---|
| AUTO 1 | perform its functions as intended and in a safe manner. |
| AUTO 2 | indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance |
| AUTO 3 | have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |
| AUTO 4 | provide the equivalent degree of safety and operability from a remote location as that provided by local controls. |
| AUTO 5 | be provided with a safety system that automatically leads the machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/equipment or environment. |

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

#### 1.1.2 Functional Requirements

In order to achieve the above stated goal, the design, construction and installation of the remote control, monitoring and alarm systems for towing vessels less than 500 GT and a length of 20 m (65 ft) ≤ L ≤ 46 m (150 ft) are to be in accordance with the following functional requirements:

| *Functional Requirement No.* | *Functional Requirements* |
|---|---|
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Equipment associated with the remote or automatic control and monitoring of the propulsion machinery are to be suitable to withstand operating conditions. |
| AUTO-FR2 | Provide means of flooding detection in periodically unattended propulsion machinery spaces and alarm at the navigation bridge. |
| AUTO-FR3 | Safety interlocks are to be provided to preclude damage to the controlled machinery. |
| AUTO-FR4 | Manual overrides are not to be provided for safety systems that are intended to avert rapid deterioration of propulsion and auxiliary machinery. |
| AUTO-FR5 | Provide means to operate the fire mains system at the navigation bridge to deliver required firewater. |
| AUTO-FR6 | Provide means of detection of possible flooding in compartments containing the fire pumps and their associated controls. |
| AUTO-FR7 | Provide monitoring and alarms of essential parameters of propulsion, power generation, and associated machinery at the navigation bridge. |

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

#### 1.1.3 Compliance

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

## 3 Equipment

Equipment associated with the remote or automatic control and monitoring of the propulsion machinery is to comply with the following requirements.

### 3.1 Equipment Tests

#### 3.1.1 Prototype Environmental Testing *(2024)*

Prototype environmental tests specified in 4-9-9/15.7 TABLE 1 are to be conducted by the manufacturers. Acceptance is 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.

Circuit breakers and cables are exempted from the tests specified in 4-9-9/15.7 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, instrumentation but may exclude printer, data recording or logging devices not required by this section.

***Commentary:***

1 The scope of prototype testing for instrumentation in computer-based systems is limited to electrical/ electronic or computer-based field devices (e.g., electrical/ electronic sensors, transmitters, transducers, solenoid valves, actuators, etc.,) that are used for Category II, III computer-based systems or essential services listed in 4-8-1/7.3.3 TABLE 2 and 4-8-1/Table 3.

2 The test specifications covered in 4-9-9/15.7, 4-9-9/15.7 TABLE 1 and 4-9-9/15.7 TABLE 2 are based on IACS Unified Requirement (UR) E10 "Test specification for type approval".

**End of Commentary**

#### 3.1.2 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 requirements of 1A-1-A3/5.3 (MA) or 1A-1-A3/5.5 (PQA) of the ABS *Rules for Conditions of Classification (Part 1A)*. Where qualified, they may be listed on the ABS website as Type Approved Products.

For the updating or renewal of type approval, please refer to 1A-1-A3/5.7.2 and 1A-1-A3/5.7.4 of the ABS *Rules for Conditions of Classification (Part 1A)*.

## 5 Station in Navigation Bridge *(2024)*

The navigation bridge propulsion control station is to include controls, displays and alarms as listed in 4-9-2/15.3 TABLE 2 as applicable. Local indication of item in 4-9-2/13.9.iv. is acceptable if a summary alarm is provided in the navigation bridge. The monitoring of diesel engines and support equipment is to be as listed in 17 TABLE 1 and 17 TABLE 2.

For vessels having nonintegrated propulsion machinery, the means for starting, stopping and transferring vital auxiliary pumps are to be fitted at the station in the navigation bridge.

***Commentary:***

As an alternative to providing means for starting, stopping and transferring vital auxiliary pumps, a summary-alarm for the propulsion and its associated machinery may be provided at the station in the navigation bridge. Any of the alarm conditions as listed in 17 TABLE 1 and 17 TABLE 2 are to activate the summary-alarm, as applicable.

**End of Commentary**

## 7 Continuity of Power

The requirements in 4-9-5/13.9 are applicable.

## 9 Propulsion Diesel Engines

### 9.1 Lubricating Oil

In the event of loss of lubricating oil, there is to be an automatic shutdown of the main engine.

### 9.2 Overspeed

An overspeed condition is to cause the automatic shutdown of the main engine.

## 11 Electric Propulsion

For electric propulsion driven vessels, the specific requirements in 4-9-5/13.7 are to be complied with, as applicable.

## 13 Fire Protection and Firefighting Arrangements

The requirements in 4-9-11/15.1 are applicable. In addition, operation of a fire pump, including associated valves necessary to deliver the required capacity to the fire main, is to be provided in the navigation bridge. However, valves located near the pump need not be provided with remote operation from the navigation bridge 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 navigation bridge.

## 15 Protection against Flooding

The requirement in 4-9-11/15.3 is applicable.

## 17 Alarms and Displays

The following controls, alarms and displays are to be provided at the navigation bridge, as applicable.

### TABLE 1
### Monitoring of Propulsion Machinery –Diesel Engines

| *Item* | | | *Alarm (1)* | *Display* | *Automatic Start of Required Standby Vital Auxiliary Pump with Alarm* (1) | *Remarks* (7) |
|---|---|---|---|---|---|---|
| Fuel Oil System | A1 | Leakage from high pressure pipes | x | | | |
| | A2 | Fuel oil in daily service tank, level - low | x | | | See Note 10 |
| Lube Oil System | B1 | Lube oil pressure to main engine and reduction gear | x | Pressure | x | Automatic Engine Shutdown (2,3) |
| | B2 | Oil mist in crankcase, mist – concentration high; or Bearing temperature – high; or Alternative arrangements | x | | | Automatic Engine Shutdown (4) |
| Turbocharger | C1 | Turbocharger lube oil inlet, pressure – low | x | Pressure | | See Note 5, 10 |
| | C2 | Turbocharger oil outlet temp., each bearing – high | x | Temp. | | See Note 8, 10 |
| | C3 | Speed | x | x | | Alarm Activation for High Speed only required for turbochargers of categories B and C See note 10 |

| *Item* | | | *Alarm (1)* | *Display* | *Automatic Start of Required Standby Vital Auxiliary Pump with Alarm (1)* | *Remarks (7)* |
|---|---|---|---|---|---|---|
| Cylinder Fresh Cooling Water System | E1 | Water outlet (general), temperature – high | x | Temp. | | Automatic engine slowdown (6) |
| | E2 | Cooling water in expansion tank, level – low | x | | | See Note 10 |
| Air System | F1 | Starting air, pressure – low | x | | | See Note 10 |
| Scavenge Air System | G1 | Scavenge air receiver, temperature – high | x | | | See Note 10 |
| Engine | H1 | Engine Speed | | Speed | | |
| | H2 | Engine Overspeed | x | | | Automatic Engine Shutdown (2) |
| Power Supply | I1 | Control, alarm or safety system, power supply failure | x | | | |

***Notes:***

**1** Required alarm or starting of standby pump is denoted by a (x).

**2** Separate sensors are required for a) alarm/automatic starting of required standby pump, and b) automatic engine shutdown.

**3** Automatic engine shutdown is to be alarmed and effected upon loss of oil pressure.

**4** 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 for independence of alarm and shutdown satisfies. See 4-2-1/7.2.

**5** Unless provided with a self-contained lubricating oil system integrated with the turbocharger.

**6** Two separate sensors are required for alarm and slowdown.

**7** Instead of automatic slowdown, manual slowdown is acceptable, provided visual/audible alarm with illumination sign "Reduced Power" is located in the navigation bridge.

**8** Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design, alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.

**9** 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.

**10** A local indication of alarm is acceptable if a summary alarm in the navigation bridge station to alert operator is provided.

## TABLE 2
## Monitoring of Auxiliary Prime-Movers and Electrical Generators

| *Item* | | | | *Alarm* | *Display* | *Remarks* |
|---|---|---|---|---|---|---|
| Diesel Engine | Lube Oil | A1 | Pressure, lube oil inlet – low | x | Pressure | Automatic engine shutdown See Note 3 |
| | Cooling Medium | B2 | Temperature, outlet – high | x | | See Note 3 |
| | | B3 | Level, expansion tank – low | x | | If separate from main system See Note 3 |
| | Fuel Oil | C1 | Fuel oil leakage from pressure pipe | x | | See Note 3 |
| | | C2 | Level, in fuel oil daily service tank – low | x | | See Note 3 |
| | Starting Medium | E1 | Pressure or level – low | x | Pressure, or level | See Note 3 |
| | Overspeed | F1 | Device activated | x | | Automatic Shutdown. See Note 3 |
| | Turbocharger | G1 | High speed | x | | Alarm Activation for High Speed only required for turbochargers of categories B and C |
| Electrical Generator | | H1 | Pressure, bearing, lube oil inlet – low | x | Pressure | Prime mover automatic shutdown See Note 3 |
| | | H2 | Voltage – off-limits | x | Voltage | See Note 3 |
| | | H3 | Frequency – off-limits | x | Frequency | See Note 3 |
| | | H4 | Current – high | x | Current | See Note 3 |
| | | H5 | Transfer of standby generator | x | | |

*Notes:*

**1** Required alarm is denoted by a (x).

2 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.

3 A local indication of alarm is acceptable if a summary alarm in the navigation bridge to alert operator is provided.

## 19 Sea Trials

In addition to the trials required by 4-9-10/5, successful operation of the propulsion machinery is to be demonstrated with the propulsion-machinery space unattended for a period of at least 6 hours.

# PART 4

## CHAPTER 9

## Automation and Computer Based Systems

## SECTION 13

## Cyber Resilience for Vessels *(1 July 2024)*

## 1 General

This section covers the requirements for cyber resilience of vessels and is based on IACS Unified Requirement, UR E26.

A vessel that complies with the requirements in this Section is eligible to be assigned the **CR** notation. **CR** notation is mandatory for all passenger vessels and other vessels of 500 GT and over.

***Note:***

For vessels with "contracted for construction" date before 1 July 2024, the requirements in this section may be used as non-mandatory guidance.

## 3 Objective

### 3.1 Goals

#### 3.1.1 Primary Goal

The primary goal is to support safe and secure shipping, which is operationally resilient to cyber risks. This goal can be achieved through an effective cyber risk management system. Sub-goals for the management of cyber risks are defined in five elements listed in 4-9-14/3.1.2.

#### 3.1.2 Sub-goals per Functional Element

The sub-goals focused on five functional elements are covered in 4-9-13/3.1.2 TABLE 1. The sub-goals and relevant functional elements are to be concurrent and considered as parts of a single comprehensive risk management framework.

## TABLE 1
## Sub-goals

| *Sub-Goal No.* | *Functional Element* | *Sub-goal* | *Description* |
|---|---|---|---|
| 1 | Identify | Develop an organizational understanding to manage cybersecurity risk to onboard systems, people, assets, data, and capabilities. | The requirements for the "Identify" functional element are aimed at identifying: on one side, the computer based systems (CBSs) on board, their interdependencies and the relevant information flows; on the other side, the key resources involved in their management, operation and governance, their roles and responsibilities. |
| 2 | Protect | Develop and implement appropriate safeguards to protect the vessel against cyber incidents and maximize continuity of shipping operations. | The requirements for the "Protect" functional element are aimed at the development and implementation of appropriate safeguards supporting the ability to limit or contain the impact of a potential incident. |
| 3 | Detect | Develop and implement appropriate measures to detect and identify the occurrence of a cyber incident on board. | The requirements for the "Detect" functional element are aimed at the development and implementation of appropriate means supporting the ability to reveal and recognize anomalous activity on CBSs and networks on board and identify cyber incidents. |
| 4 | Respond | Develop and implement appropriate measures and activities to take action regarding a detected cyber incident on board. | The requirements for the "Respond" functional element are aimed at the development and implementation of appropriate means supporting the ability to minimize the impact of cyber incidents, containing the extension of possible impairment of CBSs and networks on board. |
| 5 | Recover | Develop and implement appropriate measures and activities to restore any capabilities or services necessary for shipping operations that were impaired due to a cyber incident. | The requirements for the "Recover" functional element are aimed at the development and implementation of appropriate means supporting the ability to restore CBSs and networks on board affected by cyber incidents. |

## 3.3 Organization

### 3.3.1

The system requirements are organized according to a goal-based approach. Functional/technical requirements are given for the achievement of specific sub-goals of each functional element.

### 3.3.2

A table containing an overview of requirements is included in Appendix 4-9-13-A1.

#### 3.3.3

A summary table of requirements and documents is included in Appendix 4-9-13-A2.

# 5 Scope

## 5.1

The provisions of Section 4-9-13 apply to the following systems:

### 5.1.1

Operational Technology (OT) systems on board vessels (i.e., computer-based systems (CBS) that use data to control or monitor physical processes that can be vulnerable to cyber incidents and, if compromised, could lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment). In particular, CBSs used for the operation of the following vessel functions and systems, if present on board, are included in the scope of Section 4-9-13.

*i)* Propulsion

*ii)* Steering

*iii)* Anchoring and mooring

*iv)* Electrical power generation and distribution

*v)* Fire detection systems

*vi)* Fire extinguishing systems

*vii)* Bilge and ballast systems

*viii)* Loading computer

*ix)* Watertight integrity and flooding detection

*x)* Lighting (e.g., emergency lighting, low locations, navigation lights, etc.)

*xi)* Any required safety system whose disruption or functional impairing may pose risks to vessel operations (e.g., emergency shutdown system, cargo safety system, pressure vessel safety system, gas detection system, etc.)

*xii)* Navigational systems required by statutory regulations

*xiii)* Internal and external communications systems required by ABS and statutory regulations

*Note:*

For navigation and radiocommunication systems, the application of IEC 61162-460 or other equivalent standards in lieu of the required security capabilities in 4-9-14/15 may be accepted on the condition that the requirements in Section 4-9-13 are complied with.

### 5.1.2

Any Internet Protocol (IP)-based communication interface from CBS's covered in Section 4-9-13 to other systems. Examples of such systems are, but not limited to, the following:

*i)* Passenger or visitor servicing and management systems,

*ii)* Passenger-facing networks

*iii)* Administrative networks

*iv)* Crew welfare systems

*v)* Any other systems connected to OT systems, either permanently or temporarily (e.g., during maintenance).

### 5.3

The cyber incidents considered in Section 4-9-13 are events resulting from any offensive maneuver that targets OT systems on board vessels as defined in 4-9-13/7.7.

### 5.5

System requirements covered in Section 4-9-13 are to be fulfilled by the following stakeholders involved in the design, building and operation of the vessel:

- Shipowner/Company
- System Integrator
- Supplier
- ABS

Whilst the above requirements may be fulfilled by these stakeholders, for the purposes of this section, responsibility to fulfil them will lie with the stakeholder who has contracted with ABS.

## 7 Definitions

### 7.1 Attack Surface

The set of all possible points where an unauthorized user can access a system, cause an effect on or extract data from. The attack surface comprises two categories: digital and physical. The digital attack surface encompasses all the hardware and software that connect to an organization's network. These include applications, code, ports, servers and websites. The physical attack surface comprises all endpoint devices that an attacker can gain physical access to, such as desktop computers, hard drives, laptops, mobile phones, removable drives and carelessly discarded hardware.

### 7.3 Authentication

Provision of assurance that a claimed characteristic of an entity is correct.

### 7.5 Compensating Countermeasure

An alternate solution to a countermeasure employed in lieu of or in addition to inherent security capabilities to satisfy one or more security requirements.

### 7.7 Cyber Incident

An event resulting from any offensive maneuver, either intentional or unintentional, that targets or affects one or more CBS on board, which actually or potentially results in adverse consequences to an onboard system, network and computer or the information that they process, store or transmit, and which may require a response action to mitigate the consequences. Cyber incidents include unauthorized access, misuse, modification, destruction or improper disclosure of the information generated, archived or used in onboard CBS or transported in the networks connecting such systems. Cyber incidents do not include system failures.

### 7.9 Cyber Resilience

The capability to reduce the occurrence and mitigating the effects of cyber incidents arising from the disruption or impairment of operational technology (OT) used for the safe operation of a vessel, which potentially lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment.

### 7.11 Essential Services

Services for propulsion and steering, and safety of the vessel. Essential services comprise "Primary Essential Services" and "Secondary Essential Services": Primary Essential Services are those services which need to be in continuous operation to maintain propulsion and steering; Secondary Essential Services are those services which need not necessarily be in continuous operation to maintain propulsion and steering but which are necessary for maintaining the vessel's safety.

### 7.13 Information Technology (IT)

Devices, software and associated networking focusing on the use of data as information, as opposed to Operational Technology (OT).

### 7.15 Integrated System

A system combining a number of interacting sub-systems and/or equipment organized to achieve one or more specified purposes.

### 7.17 Logical Network Segment

The same as "Network segment", but where two or more logical network segments share the same physical components.

### 7.19 Network

A connection between two or more computers for the purpose of communicating data electronically by means of agreed communication protocols.

### 7.21 Network Segment

In the context of Section 4-9-13, a network segment is an OSI layer-2 Ethernet segment (a broadcast domain).

*Note on TCP/IP:* Network address plan is prefixed by their IP addresses and the network mask. Communication between network segments is only possible by the use of routing service at network layer (OSI Layer 3).

### 7.23 Operational Technology (OT)

Devices, sensors, software and associated networking that monitor and control onboard systems. Operational technology systems may be thought of as focusing on the use of data to control or monitor physical processes.

### 7.25 Physical Network Segment

The same as "Network segment". The physical components are not shared by other network segments.

### 7.27 Protocol

A common set of rules and signals that computers on the network use to communicate. Protocols allow to perform data communication, network management and security. Onboard networks usually implement protocols based on TCP/IP stacks or various fieldbuses.

### 7.29 Security Zone

A collection of CBSs in the scope of applicability of this section that meet the same security requirements. Each zone consists of a single interface or a group of interfaces, to which an access control policy is applied.

### 7.31 Untrusted Network

Any network outside the scope of applicability of this section.

## 9 Plans and Data

The plans and data indicated in 4-9-13/9 TABLE 2 below are to be submitted for review, as applicable.

## TABLE 2
## Plans and Data to be Submitted for Review

| | | *Systems Integrator* | | | *Shipowner* | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | *FAS* | *AS* | *SS* |
| | *Plans and Data (Documentation)* | Design | Construction | Commissioning | Operation | First Annual Survey | Annual Survey | Special Survey |
| 1 | Approved supplier documentation 4-9-13/15.1 | | M | M | M | | | |
| 2 | Zones and conduits diagram 4-9-13/15.3.1 | S | M | M | M | | | |
| 3 | Cyber security design description 4-9-13/15.3.2 | S | M | M | M | | | |
| 4 | Vessel asset inventory 4-9-13/15.3.3 | S | M | M | M | | | |
| 5 | Risk assessment for the exclusion of CBSs 4-9-13/15.3.4 [(1)] | S | M | M | M | | | |
| 6 | Description of compensating countermeasures 4-9-13/15.3.5 [(1)] | S | M | M | M | | | |
| 7 | Vessel cyber resilience test procedure 4-9-13/15.5.1 | | S | D | M | | | D |

| | | *Systems Integrator* | | | *Shipowner* | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | *FAS* | *AS* | *SS* |
| | *Plans and Data (Documentation)* | Design | Construction | Commissioning | Operation | First Annual Survey | Annual Survey | Special Survey |
| 8 | Vessel cyber security and resilience program 4-9-13/15.7.6<br>• Management of change (MoC)<br>• Management of software updates<br>• Management of firewalls<br>• Management of malware protection<br>• Management of access control<br>• Management of confidential information<br>• Management of remote access<br>• Management of mobile and portable devices<br>• Detection of security anomalies<br>• Verification of security functions<br>• Incident response plans<br>• Recovery plans | | | | M | S | D | |
| ***Note:***<br>**1** If applicable | | | | | | | | |

Legend:

| | | |
|---|---|---|
| S | Submit | The stakeholder is to submit the document for verification and approval of compliance with requirements in Section 4-9-13. |
| M | Maintain | The stakeholder is to keep the document updated in accordance with procedure for management of change (MoC). Updated document and change management records are to be submitted to ABS as per 4-9-3/9 and 4-9-3/10. |
| D | Demonstrate | The stakeholder is to demonstrate compliance in accordance with the approved document. |

## 11 References

*i)* IACS Unified Requirement (UR) E22 "Computer based Systems" includes requirements for design, construction, commissioning and maintenance of computer-based systems where they depend on software for the proper achievement of their functions. The requirements in UR E22 focus on the functionality of the software and on the hardware supporting the software which provide control, alarm, monitoring, safety or internal communication functions subject to classification requirements.

*ii)* IACS UR E26 "Cyber Resilience of Ships" includes requirements for cyber resilience of vessels, with the purpose of providing technical means to stakeholders which would lead to cyber resilient vessels.

*iii)* IACS UR E27 "Cyber Resilience of On-board Systems and Equipment" includes requirements for cyber resilience for on-board systems and equipment.

*iv)* IACS Recommendation no. 166 on Cyber Resilience covers non-mandatory recommended technical requirements that stakeholders may reference and apply to assist with the delivery of cyber resilient vessels, whose resilience can be maintained throughout their service life. IACS Recommendation 166 on Cyber Resilience is intended for ships contracted for construction after its publication and may be used as a reference for vessels already in service prior to its publication. For vessels to which UR E26 applies as mandatory instrument, when both UR E26 and Recommendation 166 are used, should any difference in requirements addressing the same topic be found between the two instruments, the requirements in UR E26 are to prevail.

# 13 System Requirements

## 13.1 Identify

### 13.1.1 Vessel Asset Inventory

*13.1.1(a) Requirement*

An inventory of hardware and software (including application programs, operating systems, if any, firmware and other software components) of the CBSs and of the networks connecting such systems to each other and to other CBSs on board or ashore are to be provided and kept up to date during the entire life of the vessel.

*13.1.1(b) Requirement Details*

*i)* The inventory is to be kept updated during the entire life of the vessel. Software and hardware modifications potentially introducing new vulnerabilities or modifying functional dependencies or connections among systems are to be recorded in the inventory.

*ii)* If confidential information is included in the inventory (e.g., IP addresses, protocols, port numbers), special measures are to be adopted to limit the access to such information only to authorized people.

*iii)* *Hardware*

For all hardware devices in the scope of applicability of Section 4-9-13, the vessel asset inventory is to include at least the information in 4-9-14/9.1.1.

In addition, the vessel asset inventory may specify system category and security zone associated with the CBS.

*iv)* *Software*

For all software, in the scope of applicability of Section 4-9-13 (e.g., application program, operating system, firmware), the vessel asset inventory is to include at least the information in 4-9-14/9.1.1.

The software of the CBSs in the scope of applicability of Section 4-9-13 is to be maintained and updated in accordance with the shipowner's process for management of software maintenance and update policy in the Vessel cyber security and resilience program, see 4-9-13/15.7.6.

***Commentary:***

The inventory of CBSs on board and relevant software used in OT systems, is essential for an effective management of cyber resilience of the ship vessel, the main reason being that every CBS becomes a potential point of vulnerability. Cybercriminals can exploit unaccounted and out-of-date hardware and software to hack systems. Moreover, managing CBS assets enables Companies understand the criticality of each system to ship vessel safety objectives.

**End of Commentary**

*13.1.1(c) Demonstration of Compliance - Design Phase*

The systems integrator is to submit the vessel asset inventory to ABS (see 4-9-13/15.3.3).

The vessel asset inventory is to incorporate the asset inventories of all individual CBSs falling under the scope of Section 4-9-13. Any equipment in the scope of Section 4-9-13 delivered by the systems integrator is also to be included in the vessel asset inventory.

*13.1.1(d) Demonstration of Compliance – Construction Phase*

The systems integrator is to keep the vessel asset inventory updated.

*13.1.1(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (see 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(i).

*13.1.1(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the annual surveys and special surveys demonstrate compliance with 7-6-2/1.1.22(a) and 7-6-2/3.14.i. of the ABS *Rules for Survey After Construction (Part 7)*.

## 13.3 Protect

### 13.3.1 Security Zones and Network Segmentation

*13.3.1(a) Requirement*

***i)*** All CBSs are to be grouped into security zones with well-defined security policies and security capabilities.

***ii)*** Security zones are to be either isolated (i.e., air gapped) or connected to other security zones or networks by means providing control of data communicated between the zones (e.g., firewalls/routers, simplex serial links, TCP/IP diodes, dry contacts, etc.).

***iii)*** Only explicitly allowed traffic is to traverse a security zone boundary.

*13.3.1(b) Requirement Details*

***i)*** A security zone may contain multiple CBSs and networks, all of which are to comply with applicable security requirements in Section 4-9-14.

***ii)*** The network(s) of a security zone are to be logically or physically segmented from other zones or networks. See also 4-9-13/13.3.6(b).

***iii)*** CBSs providing required safety functions are to be grouped into separate security zones and are to be physically segmented from other security zones.

***iv)*** Navigational and communication systems are not be in same security zone as machinery or cargo systems. If navigation and/or communication systems are approved in accordance with other equivalent standards (see 4-9-13/5.1.1), these systems should be in a dedicated security zone.

*v)* Wireless devices are to be in dedicated security zones. See also 4-9-13/13.3.5

*vi)* Systems, networks or CBSs outside the scope of this section are considered untrusted networks and are to be physically segmented from security zones required by this section. Alternatively, it is accepted that such systems are part of a security zone if these OT-systems meet the same requirements as demanded by the zone.

*vii)* It is to be possible to isolate a security zone without affecting the primary functionality of the CBSs in the zone, see also 4-9-13/13.7.3.

***Commentary:***

While networks may be protected by firewall perimeter and include Intrusion Detection Systems (IDS) or Intrusion Prevention Systems (IPS) to monitor traffic coming in, breaching that perimeter is always possible. Network segmentation makes it more difficult for an attacker to perpetrate an attack throughout the entire network. The main benefits of security zones and network segmentation are to reduce the extent of the attack surface, prevent attackers from achieving lateral movement through systems, and improve network performance. The concept of allocating the CBSs into security zones allows grouping the CBSs in accordance with their risk profile.

**End of Commentary**

*13.3.1(c) Demonstration of Compliance - Design Phase*

The systems integrator is to submit the Zones and conduits diagram and the Cyber security design description (see 4-9-13/15.3.1 and 4-9-13/15.3.2).

The Zones and conduits diagram is to illustrate the CBSs in the scope of applicability of Section 4-9-13, how they are grouped into security zones, and include the following information:

- Clear indication of the security zones.
- Simplified illustration of each CBS in scope of applicability of Section 4-9-13, and indication of the security zone in which the CBS is allocated, and indication of physical location of the CBS/equipment.
- Reference to the approved version of the CBS system topology diagrams provided by the suppliers (4-9-14/9.1.2).
- Illustration of network communication between systems in a security zone.
- Illustration of any network communication between systems in different security zones (conduits).
- Illustration of any communication between systems in a security zone and untrusted networks (conduits).

The systems integrator is to include the following information in the Cyber security design description:

- A short description of the CBSs allocated to the security zone. It is to be possible to identify each CBS in the Zones and conduits diagram.
- Network communication between CBSs in the same security zone. The description is to include the purpose and characteristics (i.e., protocols and data flows) of the communication.
- Network communication between CBSs in different security zones. The description is to include the purpose and characteristics (i.e., protocols and data flows) of the communication. The description is also to include zone boundary devices and specify the traffic that is permitted to traverse the zone boundary (e.g., firewall rules).
- Any communication between CBSs in security zones and untrusted networks. The description is to include discrete signals, serial communication, and the purpose and characteristics (i.e., protocols and data flows) of IP-based network communication. The description is also to

include zone boundary devices and specify the traffic that is permitted to traverse the zone boundary (e.g., firewall rules).

*13.3.1(d) Demonstration of Compliance – Construction Phase*

The systems integrator is to keep the Zones and conduits diagram updated.

*13.3.1(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(ii).

*13.3.1(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the annual surveys and special surveys demonstrate compliance with 7-6-2/1.1.22(b) and 7-6-2/3.14.ii. of the ABS *Rules for Survey After Construction (Part 7)*.

### 13.3.2 Network Protection Safeguards

*13.3.2(a) Requirement*

***i)*** Security zones are to be protected by firewalls or equivalent means as specified in 4-9-13/13.3.1. The networks are also to be protected against the occurrence of excessive data flow rate and other events which could impair the quality of service of network resources.

***ii)*** The CBSs are to be implemented in accordance with the principle of Least Functionality (i.e., configured to provide only essential capabilities and to prohibit or restrict the use of non-essential functions), where unnecessary functions, ports, protocols and services are disabled or otherwise prohibited.

*13.3.2(b) Requirement Details*

***i)*** The design of network is to include means to meet the intended data flow through the network and minimize the risk of denial of service (DoS) and network storm/high rate of traffic.

***ii)*** Estimation of data flow rate is to at least consider the capacity of network, data speed requirement for intended application and data format.

***Commentary:***

Network protection covers a multitude of technologies, rules and configurations designed to protect the integrity, confidentiality and availability of networks. The threat environment is always changing, and attackers are always trying to find and exploit vulnerabilities.

There are many layers to consider when addressing network protection. Attacks can happen at any layer in the network layers model, so network hardware, software and policies must be designed to address each area.

While physical and technical security controls are designed to prevent unauthorized personnel from gaining physical access to network components and protect data stored on or in transit across the network, procedural security controls consist of security policies and processes that control user behaviour.

**End of Commentary**

*13.3.2(c) Demonstration of Compliance - Design Phase*

Demonstration not required.

*13.3.2(d) Demonstration of Compliance – Construction Phase*

Demonstration not required.

*13.3.2(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(iii).

*13.3.2(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the special surveys demonstrate compliance with 7-6-2/3.14(iii) of the ABS *Rules for Survey After Construction (Part 7)*.

### 13.3.3 Antivirus, Antimalware, Antispam, and Other Protections from Malicious Code

*13.3.3(a) Requirement*

***i)*** CBSs are to be protected against malicious code such as viruses, worms, trojan horses, spyware, etc.

*13.3.3(b) Requirement Details*

***i)*** Malware protection is to be implemented on CBSs. CBSs having an operating system for which industrial-standard anti-virus and/or anti-malware software is available and maintained up-to-date, anti-virus and anti-malware software is to be installed, maintained and regularly updated, unless the installation of such software impairs the ability of CBS to provide the functionality and level of service required (e.g., for Cat.II and Cat.III CBSs performing real-time tasks).

***ii)*** On CBSs where anti-virus and anti-malware software cannot be installed, malware protection is to be implemented in the form of operational procedures, physical safeguards, or according to manufacturer’s recommendations.

***Commentary:***

A virus or any unwanted program that enters a user’s system without his/her knowledge can self-replicate and spread, perform unwanted and malicious actions that end up affecting the system’s performance, user’s data/files, and/or circumvent data security measures.

Antivirus, antimalware, antispam software will act as a closed door with a security guard fending off the malicious intruding viruses performing a prophylactic function. It detects potential virus and then works to remove it, mostly before the virus gets to harm the system.

Common means for malicious code to enter CBSs are electronic mail, electronic mail attachments, websites, removable media (for example, universal serial bus (USB) devices, diskettes or compact disks), PDF documents, web services, network connections and infected laptops.

**End of Commentary**

*13.3.3(c) Demonstration of Compliance - Design Phase*

The systems integrator is to include the following information in the Cyber security design description.

- For each CBS, summary of the approved mechanisms provided by the supplier for protection against malicious code or unauthorized software.
- For CBSs with anti-malware software, information about how to keep the software updated.
- Any operational conditions or necessary physical safeguards to be implemented in the shipowner’s management system.

*13.3.3(d) Demonstration of Compliance – Construction Phase*

The systems integrator is to ensure that malware protection is kept updated during the construction phase.

*13.3.3(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(iv).

*13.3.3(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to in the Vessel cyber security and resilience program describe the management of malware protection, addressing at least the following requirements in Section 4-9-13:

- Maintenance/update (4-9-13/13.3.3(b))
- Operational procedures, physical safeguards (4-9-13/13.3.3(b))
- Use of mobile, portable, removable media (4-9-13/13.3.4(b).v and 4-9-13/13.3.7(b))
- Access control (4-9-13/13.3.4)

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the annual surveys and special surveys demonstrate compliance with 7-6-2/1.1.22(c) and 7-6-2/3.14(iv) of the ABS *Rules for Survey After Construction (Part 7)*.

### 13.3.4 Access Control

*13.3.4(a) Requirement*

***i)*** CBSs and networks are to provide physical and/or logical/digital measures to selectively limit the ability and means to communicate with or otherwise interact with the system itself, to use system resources to handle information, to gain knowledge of the information the system contains or to control system components and functions.

***ii)*** Such measures are not to hamper the ability of authorized personnel to access CBS for their level of access according to the least privilege principle.

*13.3.4(b) Requirement Details*

***i)*** Access to CBSs and networks and all information stored on such systems is only to be allowed to authorized personnel, based on their need to access the information as a part of their responsibilities or their intended functionality.

***ii)*** *Physical access control*

CBSs of Cat.II and Cat.Ill are to be generally located in rooms that can normally be locked or in controlled space to prevent unauthorized access, or are to be installed in lockable cabinets or consoles. Such locations or lockable cabinets/consoles are to be easily accessible to the crew and various stakeholders who need to access to CBSs for installation, integration, operation, maintenance, repair, replacement, disposal etc. so as not to hamper effective and efficient operation of the vessel.

***iii)*** *Physical access control for visitors*

Visitors such as authorities, technicians, agents, port and terminal officials, and shipowner representatives are to be restricted regarding access to CBSs on board whilst on board (e.g., by allowing access under supervision).

***iv)*** *Physical access control of network access points*

Access points to onboard networks connecting Cat.II and/or Cat.III CBSs are to be physically and/or logically blocked except when connection occurs under supervision or according to documented procedures (e.g., for maintenance).

Independent computers isolated from all onboard networks, or other networks, such as dedicated guest access networks, or networks dedicated to passenger recreational activities, are to be used in case of occasional connection requested by a visitor (e.g., for printing documents).

***v)*** *Removable media controls*

A policy for the use of removable media devices is to be established, with procedures to check removable media for malware and/or validate legitimate software by digital signatures and watermarks and scan prior to permitting the uploading of files onto a ship's system or downloading data from the vessle's system. See also 4-9-13/13.3.7.

***vi)*** *Management of credentials*

***a)*** CBSs and relevant information are to be protected with file system, network, application, or database specific Access Control Lists (ACL). Accounts for onboard and onshore personnel is to be left active only for a limited period according to the role and responsibility of the account holder and is to be removed when no longer needed.

***Note:***

CBSs are to identify and authenticate human users as per item No.1 in 4-9-14/15.1 TABLE 1. In other words, it is not necessary to "uniquely" identify and authenticate all human users.

***b)*** Onboard CBSs are to be provided with appropriate access control that fits to the policy of their Security Zone but does not adversely affect their primary purpose. CBSs which require strong access control may need to be secured using a strong encryption key or multi-factor authentication.

***c)*** Administrator privileges are to be managed in accordance with the policy for access control, allowing only authorized and appropriately trained personnel full access to the CBS, who as part of their role in the company or on board need to log on to systems using these privileges.

***vii)*** *Least privilege principle*

***a)*** Any human user allowed to access CBS and networks are to have only the bare minimum privileges necessary to perform its function.

***b)*** The default configuration for all new account privileges is to be set as low as possible. Wherever possible, raised privileges are to be restricted only to moments when they are needed (e.g., using only expiring privileges and one-time-use credentials). Accumulation of privileges over time is to be avoided (e.g., by regular auditing of user accounts).

***Commentary:***

Attackers may attempt to access the vessel's systems and data from either on board the ship, within the company, or remotely through connectivity with the internet. Physical and logical access controls to cyber assets, networks etc., should be implemented to ensure safety of the vessel and its cargo.

Physical threats and relevant countermeasures are also considered in the ISPS Code. Similarly, the ISM Code contains guidelines to ensure safe operation of vessels and protection of the environment. Implementation of ISPS and ISM Codes may imply inclusion in the Ship Security Plan (SSP) and Safety Management System (SMS) of instructions and procedures for access control to safety critical assets.

**End of Commentary**

*13.3.4(c) Demonstration of Compliance - Design Phase*

The systems integrator is to include the following information in the Cyber security design description.

- Location and physical access controls for the CBSs. Devices providing Human Machine Interface (HMI) for operators needing immediate access need not enforce user identification and authentication provided they are located in an area with physical access control. Such devices are to be specified.

*13.3.4(d) Demonstration of Compliance – Construction Phase*

The systems integrator is to prevent unauthorized access to the CBSs during the construction phase.

*13.3.4(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(v).

*13.3.4(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to in the Vessel cyber security and resilience program describe the management of logical and physical access, addressing at least the following requirements in Section 4-9-13:

- Physical access control (4-9-13/13.3.4(b).ii)
- Physical access control for visitors (4-9-13/13.3.4(b).iii)
- Physical access control of network access points (4-9-13/13.3.4(b).iv)
- Management of credentials (4-9-13/13.3.4(b).vi)
- Least privilege policy (4-9-13/13.3.4(b).vii)

The shipowner is to in the Vessel cyber security and resilience program describe the management of confidential information, addressing at least the following requirements in Section 4-9-13:

- Confidential information (4-9-13/13.1.1(b).ii)
- Information allowed to authorized personnel (4-9-13/13.3.4(b).i)
- Information transmitted on the wireless network (4-9-13/13.3.5(b).i)

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the annual surveys demonstrate compliance with 7-6-2/1.1.22(d) of the ABS *Rules for Survey After Construction (Part 7)*

### 13.3.5 Wireless Communication

*13.3.5(a) Requirement*

***i)*** Wireless communication are to be designed, implemented and maintained to ensure that:

  ***a)*** Cyber incidents will not propagate to other control systems

  ***b)*** Only authorized human users will gain access to the wireless network

  ***c)*** Only authorized processes and devices will be allowed to communicate on the wireless network

  ***d)*** Information in transit on the wireless network cannot be manipulated or disclosed

*13.3.5(b) Requirement Details*

*i)* Cryptographic mechanisms such as encryption algorithms and key lengths in accordance with industry standards and best practices are to be applied to ensure integrity and confidentiality of the information transmitted on the wireless network.

*ii)* Devices on the wireless network are to communicate only on the wireless network (i.e., they are not to be "dual-homed")

*iii)* Wireless networks are to be designed as separate segments in accordance with 4-9-13/13.3.1 and protected as per 4-9-13/13.3.2.

*iv)* Wireless access points and other devices in the network are to be installed and configured such that access to the network can be controlled.

*v)* The network device or system utilizing wireless communication are to provide the capability to identify and authenticate all users (humans, software processes or devices) engaged in that communication.

***Commentary:***

Wireless networks give rise to additional or different cybersecurity risks than wired networks. This is mainly due to less physical protection of the devices and the use of the radio frequency communication.

Inadequate physical access control may lead to unauthorized personnel gaining access to the physical devices, which in turn could lead to circumventing logical access restrictions or deployment of rogue devices on the network.

Signal transmission by radio frequency introduces risks related to jamming as well as eavesdropping which in turn could cater for attacks such as Piggybacking or Evil Twin attacks (see https://us-cert.cisa.gov/ncas/tips/ST05-003).

**End of Commentary**

*13.3.5(c) Demonstration of Compliance - Design Phase*

The systems integrator is to include the following information in the Cyber security design description.

- Description of wireless networks in the scope of applicability of Section 4-9-13 and how these are implemented as separate security zones. The description is to include zone boundary devices and specify the traffic that is permitted to traverse the zone boundary (e.g., firewall rules).

*13.3.5(d) Demonstration of Compliance – Construction Phase*

The systems integrator is to prevent unauthorized access to the wireless networks during the construction phase.

*13.3.5(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(vi).

*13.3.5(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the special surveys demonstrate compliance with 7-6-2/3.14(v) of the ABS *Rules for Survey After Construction (Part 7)*.

### 13.3.6 Remote Access Control and Communication with Untrusted Networks

*13.3.6(a) Requirement*

*i)* CBSs are to be protected against unauthorized access and other cyber threats from untrusted networks.

*13.3.6(b) Requirement Details*

*i)* User's manual is to be delivered for control of remote access to onboard IT and OT systems. Roles and permissions with functions are to be identified.

*ii)* The IP address of the CBS is not to be exposed to untrusted networks.

*iii)* Communication with or via untrusted networks requires secure connections (e.g., tunnels) with endpoint authentication, protection of integrity and authentication and encryption at network or transport layer. Confidentiality is to be ensured for information that is subject to read authorization.

*iv)* *Design*

CBSs are to meet the following:

*a)* Have the capability to terminate a connection from the onboard connection endpoint. Any remote access is not to be possible until explicitly accepted by a responsible role on board.

*b)* Be capable of managing interruptions during remote sessions so as not to compromise the safe functionality of OT systems or the integrity and availability of data used by OT systems.

*c)* Provide a logging function to record all remote access events and retain for a period of time sufficient for offline review of remote connections(e.g., after detection of a cyber incident).

*v)* *Additional requirements for remote maintenance*

When remote access is used for maintenance, the following requirements are to be complied with in addition to those in 4-9-13/13.3.6(iv):

*a)* Documentation is to be provided to show how they connect and integrate with the shore side.

*b)* Security patches and software updates are to be tested and evaluated before they are installed to ensure they are effective and do not result in side effects or cyber events that cannot be tolerated. A confirmation report from the software supplier towards above is to be obtained, prior to undertaking remote update.

*c)* Suppliers are to provide plans for- and make security updates available to the shipowner, see 4-9-14/17.3.2, 4-9-14/17.3.3 and 4-9-14/17.3.4.

*d)* At any time, during remote maintenance activities, authorized personnel is to have the possibility to interrupt and abort the activity and roll back to a previous safe configuration of the CBS and systems involved.

*e)* Multi-factor authentication is required for any access by human users to CBSs in scope from an untrusted network.

*f)* After a configurable number of failed remote access attempts, the next attempt is to be blocked for a predetermined length of time.

*g)* If the connection to the remote maintenance location is disrupted for some reason, access to the system is to be terminated by an automatic logout function.

***Commentary:***

Onboard CBSs have become increasingly digitalized and connected to the internet to perform a wide variety of legitimate functions. The use of digital systems to monitor and control onboard CBSs makes them vulnerable to cyber incidents. Attackers may attempt to access onboard CBSs through connectivity with the internet and may be able to make changes that affect a CBS's operation or even achieve full control of the CBS, or attempt to download information from the vessel's CBS. In addition, since use of legacy IT and OT systems that are no longer supported and/or rely on obsolete operating systems affects cyber resilience, special care should be put to relevant hardware and software installations on board to help maintain a sufficient level of cyber resilience when such systems can be remotely accessed, also keeping in mind that not all cyber incidents are a result of a deliberate attack.

**End of Commentary**

*13.3.6(c) Demonstration of Compliance - Design Phase*

The systems integrator is to include the following information in the Cyber security design description.

- Identification of each CBS in the scope of applicability of Section 4-9-13 that can be remotely accessed or that otherwise communicates through the security zone boundary with untrusted networks.
- For each CBS, a description of compliance with requirements in 4-9-13/13.3.6(b), as applicable

*13.3.6(d) Demonstration of Compliance – Construction Phase*

The systems integrator is to ensure that any communication with untrusted networks is only temporarily enabled and used in accordance with the requirements of this section.

*13.3.6(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(vii).

*13.3.6(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to in the Vessel cyber security and resilience program describe the management of remote access and communication with/via untrusted networks, addressing at least the following requirements in 4-9-13.

- User's manual (4-9-13/13.3.6(b))
- Roles and permissions (4-9-13/13.3.6(b))
- Patches and updates (4-9-13/13.3.6(b).v)
- Confirmation prior to undertaking remote software update (4-9-13/13.3.6(b).v)
- Interrupt, abort, roll back (4-9-13/13.3.6(b).v)

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the annual surveys and special surveys demonstrate compliance with 7-6-2/1.1.22(e) and 7-6-2/3.14(vi) of the ABS *Rules for Survey After Construction (Part 7)*.

### 13.3.7 Use of Mobile and Portable Devices

*13.3.7(a) Requirement*

*i)* The use of mobile and portable devices in CBSs are to be limited to only necessary activities and be controlled in accordance with 4-9-14/15.1 item 10.

***ii)*** For any CBS that cannot fully meet the requirements in 4-9-13/13.3.7(a).i, the interface ports are to be physically blocked.

*13.3.7(b) Requirement Details*

***i)*** Mobile and portable devices are only to be used by authorized personnel. Only authorized devices may be connected to the CBSs. All use of such devices is to be in accordance with the shipowner's policy for use of mobile and portable devices, taking into account the risk of introducing malware in the CBS.

***Commentary:***

It is generally known that CBSs can be impaired due to malware infection via a mobile or a portable device. Therefore, connection of mobile and portable devices should be carefully considered. In addition, mobile equipment that is required to be used for the operation and maintenance of the vessel should be under control of the Shipowner.

**End of Commentary**

*13.3.7(c) Demonstration of Compliance - Design Phase*

The systems integrator is to include the following information in the Cyber security design description.

- Any CBSs in the scope of applicability that do not meet the requirements in 4-9-14/15.1 item 10, i.e., that have protection for interface ports by physical means such as port blockers.

*13.3.7(d) Demonstration of Compliance – Construction Phase*

The systems integrator is to ensure that use of physical interface ports in the CBSs is controlled in accordance with 4-9-14/15.1 item 10, and that any use of such devices follows procedures to prevent malware from being introduced in the CBS.

*13.3.7(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(viii).

*13.3.7(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to in the Vessel cyber security and resilience program describe the management of mobile and portable devices, addressing at least the following requirements in Section 4-9-13.

- Policy and procedures (4-9-13/13.3.4(b).v)
- Physical block of interface ports (4-9-13/13.3.7(a))
- Use by authorized personnel (4-9-13/13.3.7(b))
- Connect only authorized devices (4-9-13/13.3.7(b))
- Consider risk of introducing malware (4-9-13/13.3.7(b))

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the annual surveys and special surveys demonstrate compliance with 7-6-2/1.1.22(f) and 7-6-2/3.14(vii). of the ABS *Rules for Survey After Construction (Part 7)*

## 13.5 Detect

### 13.5.1 Network Operation Monitoring

*13.5.1(a) Requirement*

***i)*** Networks are to be continuously monitored, and alarms are to be generated if malfunctions or reduced/degraded capacity occurs.

*13.5.1(b) Requirement Details*

***i)*** Measures to monitor networks are to have the following capabilities:

***a)*** Monitoring and protection against excessive traffic

***b)*** Monitoring of network connections

***c)*** Monitoring and recording of device management activities

***d)*** Protection against connection of unauthorized devices

***e)*** Generate alarm if utilization of the network's bandwidth exceeds a threshold specified as abnormal by the supplier. See 4-9-3/13.1.1.

***ii)*** Intrusion detection systems (IDS) may be implemented, subject to the following:

***a)*** The IDS is to be qualified by the supplier of the respective CBS

***b)*** The IDS is to be passive and not activate protection functions that may affect the performance of the CBS

***c)*** Relevant personnel are to be trained and qualified for using the IDS

***Commentary:***

Cyber-attacks are becoming increasingly sophisticated, and attacks that target vulnerabilities that were unknown at the time of construction could result in incidents where the vessel is ill-prepared for the threat. To enable an early response to attacks targeting these types of unknown vulnerabilities, technology capable of detecting unusual events is required. A monitoring system that can detect anomalies in networks and that can use post-incident analysis provides the ability to appropriately respond and further recover from a cyber event.

**End of Commentary**

*13.5.1(c) Demonstration of Compliance - Design Phase*

Demonstration not required.

*13.5.1(d) Demonstration of Compliance – Construction Phase*

Demonstration not required.

*13.5.1(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(ix).

Any Intrusion detection systems in the CBSs in scope of applicability to be implemented is to be subject to verification by ABS. Relevant documentation is to be submitted for approval, and survey/tests are to be carried out on board.

*13.5.1(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to in the Vessel cyber security and resilience program describe the management activities to detect anomalies in the CBSs and networks, addressing at least the following requirements in Section 4-9-13:

- Reveal and recognize anomalous activity (4-9-13/13.5)(see also the description of sub-goal No. 3 in 4-9-13/3.1.2 TABLE 1)
- Inspection of security audit records (4-9-13/13.5.1(b))
- Instructions or procedures to detect incidents (4-9-13/13.7.1(a))

The above activities may be addressed together with incident response in 4-9-13/13.7.1.

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the annual surveys and special surveys demonstrate compliance with 7-6-2/1.1.22(g) and 7-6-2/3.14(viii) of the ABS *Rules for Survey After Construction (Part 7)*.

### 13.5.2 Verification and Diagnostic Functions of CBS and Networks

*13.5.2(a) Requirement*

***i)*** CBSs and networks are to be capable to check performance and functionality of security functions in this section.

***ii)*** Diagnostic functions are to provide adequate information on CBSs integrity and status for the use of the intended user and means for maintaining their functionality for a safe operation of the vessel.

*13.5.2(b) Requirement Details*

CBSs and networks' diagnostics functionality are to be available to verify the intended operation of all required security functions during test and maintenance phases of the vessel.

***Commentary:***

The ability to verify intended operation of the security functions is important to support management of cyber resilience in the lifetime of the ship vessel. Tools for diagnostic functions may comprise automatic or manual functions such as self-diagnostics capabilities of each device, or tools for network monitoring (such as ping, traceroute, ipconfig, netstat, nslookup, Wireshark, nmap, etc.).

It should be noted however that execution of diagnostic functions may sometimes impact the operational performance of the CBS.

**End of Commentary**

*13.5.2(c) Demonstration of Compliance - Design Phase*

Demonstration not required.

*13.5.2(d) Demonstration of Compliance – Construction Phase*

Demonstration not required.

*13.5.2(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(x).

*13.5.2(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to in the Vessel cyber security and resilience program describe the management activities to verify correct operation of the security functions in the CBSs and networks, addressing at least the following requirements in Section 4-9-13:

- Test and maintenance periods (4-9-13/13.5.2(b))
- Periodic maintenance (4-9-13/15.7.8)

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the annual surveys demonstrate compliance with 7-6-2/1.1.22(h) of the ABS *Rules for Survey After Construction (Part 7)*.

## 13.7 Respond

### 13.7.1 Incidence Response Plan

*13.7.1(a) Requirement*

***i)*** An incident response plan is to be developed by the shipowner covering relevant contingencies and specifying how to react to cyber security incidents.

***ii)*** The Incident response plan is to contain documentation of a predetermined set of instructions or procedures to detect, respond to, and limit consequences of incidents against CBSs

*13.7.1(b) Requirement Details*

***i)*** The various stakeholders involved in the design and construction phases of the vessel are to provide information to the shipowner for the preparation of the Incident Response Plan to be placed on board at the first annual Survey.

***ii)*** The Incident Response Plan is to be kept up-to-date (e.g., upon maintenance) during the operational life of the vessel.

***iii)*** The Incident response plan is to provide procedures to respond to detected cyber incidents on networks by notifying the proper authority, reporting needed evidence of the incidents and taking timely corrective actions, to limit the cyber incident impact to the network segment of origin.

***iv)*** The incident response plan, as a minimum, is to include the following information:

***a)*** Breakpoints for the isolation of compromised systems;

***b)*** A description of alarms and indicators signalling detected ongoing cyber events or abnormal symptoms caused by cyber events;

***c)*** A description of expected major consequences related to cyber incidents;

***d)*** Response options, prioritizing those which do not rely on either shut down or transfer to independent or local control, if any.

***e)*** Independent and local control information for operating independently from the system that failed due to the cyber incident, as applicable;

***v)*** The incident response plan is to be kept in hard copy in the event of complete loss of electronic devices enabling access to it.

***Commentary:***

An incident response plan is an instrument aimed to help responsible persons respond to cyber incidents. As such, the Incident response plan is as effective as it is simple and carefully designed. When developing the Incident response plan, it is important to understand the significance of any cyber incident and prioritize response actions accordingly.

Means for maintaining as much as possible the functionality and a level of service for a safe operation of the vessel (e.g., transfer active execution to a standby redundant unit) should also be indicated. Designated personnel ashore should be integrated with the vessel in the event of a cyber incident.

**End of Commentary**

*13.7.1(c) Demonstration of Compliance - Design Phase*

The systems integrator is to include the following information in the Cyber security design description.

- References to information provided by the suppliers (see 4-9-14/9.1.8) that may be applied by the shipowner to establish plans for incident response.

*13.7.1(d) Demonstration of Compliance – Construction Phase*

Demonstration not required.

*13.7.1(e) Demonstration of Compliance – Commissioning Phase*

Demonstration not required.

*13.7.1(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to in the vessel cyber security and resilience program describe incident response plans. The plans are to cover the CBSs in scope of applicability of Section 4-9-13 and are to address at least the following requirements in Section 4-9-13:

- Description of who, when and how to respond to cyber incidents in accordance with requirements of 4-9-13/13.7.1.
- Procedures or instructions for local/manual control in accordance with requirements in 4-9-13/13.7.2.
- Procedures or instructions for isolation of security zones in accordance with requirements in 4-9-13/13.7.3.
- Description of expected behavior of the CBSs in the event of cyber incidents in accordance with requirements in 4-9-13/13.7.4.

The shipowner is to submit the vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the annual surveys demonstrate compliance with 7-6-2/1.1.22(i) of the ABS *Rules for Survey After Construction (Part 7)*.

### 13.7.2 Local, Independent and/or Manual Operation

*13.7.2(a) Requirement*

***i)*** Any CBS needed for local backup control as required by SOLAS II-1 Regulation 31 is to be independent of the primary control system. This includes also necessary Human Machine Interface (HMI) for effective local operation.

*13.7.2(b) Requirement Details*

***i)*** The CBS for local control and monitoring is to be self-contained and not depend on communication with other CBS for its intended operation.

***ii)*** If communication to the remote control system or other CBS's is arranged by networks, segmentation and protection safeguards as described in 4-9-13/13.3.1 and 4-9-13/13.3.2 are to be implemented. This implies that the local control and monitoring system is to be considered a separate security zone. Notwithstanding the above, special considerations can be given to CBSs with different concepts on a case by case basis.

***iii)*** The CBS for local control and monitoring otherwise is to comply with requirements in this section.

***Commentary:***

Independent local controls of machinery and equipment needed to maintain safe operation is a fundamental principle for manned vessels. The objective of this requirement has traditionally been to ensure that personnel can cope with failures and other incidents by performing manual operations in close vicinity of the machinery. Since incidents caused by malicious cyber events should also be considered, this principle of independent local control is no less important

**End of Commentary**

*13.7.2(c) Demonstration of Compliance - Design Phase*

The systems integrator is to include the following information in the Cyber security design description.

- Description of how the local controls specified in SOLAS II-1 Reg.31 are protected from cyber incidents in any connected remote or automatic control systems.

*13.7.2(d) Demonstration of Compliance – Construction Phase*

Demonstration not required.

*13.7.2(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(xi).

*13.7.2(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the special surveys demonstrate compliance with 7-6-2/3.14(ix) of the ABS *Rules for Survey After Construction (Part 7)*.

### 13.7.3 Network Isolation

*13.7.3(a) Requirement*

*i)* Means to terminate network-based communication to or from a security zone is to be available.

*13.7.3(b) Requirement Details*

*i)* Where the Incident Response Plan indicates network isolation as an action to be done, it is to be possible to isolate security zones according to the indicated procedure, e.g., by operating a physical ON/OFF switch on the network device or similar actions such as disconnecting a cable to the router/firewall. Instructions and clear marking on the device that allows the personnel to isolate the network in an efficient manner are to be available.

*ii)* Individual system's data dependencies that may affect function and correct operation, including safety, are to be identified, clearly showing where systems must have compensations for data or functional inputs if isolated during a contingency.

***Commentary:***

In the event that a security breach has occurred and is detected, it is likely that the incident response plan includes actions to prevent further propagation and effects of the incident. Such actions could be to isolate network segments and control systems supporting essential functions.

**End of Commentary**

*13.7.3(c) Demonstration of Compliance - Design Phase*

The systems integrator is to include the following information in the Cyber security design description.

- Specification of how to isolate each security zone from other zones or networks. The effects of such isolation is also to be described, demonstrating that the CBSs in a security zone do not rely on data transmitted by IP-networks from other zones or networks.

*13.7.3(d) Demonstration of Compliance – Construction Phase*

Demonstration not required.

*13.7.3(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(xii).

*13.7.3(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the special surveys demonstrate compliance with 7-6-2/3.14(x) of the ABS *Rules for Survey After Construction (Part 7)*.

### 13.7.4 Fallback to a Minimal Risk Condition

*13.7.4(a) Requirement*

***i)*** In the event of a cyber incident impairing the ability of a CBS or network to provide its intended service, the affected system or network is to fall back to a minimal risk condition (i.e., bring itself in a stable, stopped condition to reduce the risk of possible safety issues).

*13.7.4(b) Requirement Details*

***i)*** As soon as a cyber incident affecting the CBS or network is detected, compromising the system's ability to provide the intended service as required, the system is to fall back to a condition in which a reasonably safe state can be achieved. Fall-back actions can include:

***a)*** Bringing the system to a complete stop or other safe state;

***b)*** Disengaging the system;

***c)*** Transferring control to another system or human operator;

***d)*** Other compensating actions.

***ii)*** Fall-back to minimum risk conditions is to occur in a time frame adequate to keep the vessel in a safe condition.

***iii)*** The ability of a system to fall back to a minimal risk condition is to be considered from the design phase by the supplier and the systems integrator.

***Commentary:***

The ability of a CBS and integrated systems to fallback to one or more minimal risk conditions to be reached in case of unexpected or unmanageable failures or events is a safety measure aimed to keep the system in a consistent, known and safe state.

Fallback to a minimal risk condition usually implies the capability of a system to abort the current operation and signal the need for assistance, and may be different depending on the environmental conditions, the voyage phase of the vessel (e.g., port depart/arrival vs. open sea passage) and the events occurred.

**End of Commentary**

*13.7.4(c) Demonstration of Compliance - Design Phase*

The systems integrator is to include the following information in the Cyber security design description.

- Specification of safe state for the control functions in the CBSs in the scope of applicability of Section 4-9-13.

*13.7.4(d) Demonstration of Compliance – Construction Phase*

Demonstration not required.

*13.7.4(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(xiii).

*13.7.4(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the special surveys demonstrate compliance with 7-6-2/3.14(xi) of the ABS *Rules for Survey After Construction (Part 7)*.

## 13.9 Recover

### 13.9.1 Recovery Plan

*13.9.1(a) Requirement*

***i)*** A recovery plan is to be made by the shipowner to support restoring CBSs to an operational state after a disruption or failure caused by a cyber incident. Details of where assistance is available and by whom are to be part of the recovery plan.

*13.9.1(b) Requirement Details*

***i)*** The various stakeholders involved in the design and construction phases of the vessel are to provide information to the shipowner for the preparation of the recovery plan to be placed on board at the first annual Survey. The recovery plan are to be kept up-to-date (e.g., upon maintenance) during the operational life of the vessel.

***ii)*** Recovery plans are to be easily understandable by the crew and external personnel and include essential instructions and procedures to ensure the recovery of a failed system and how to get external assistance if the support from ashore is necessary. In addition, software recovery medium or tools essential for recovery on board are to be available.

***iii)*** When developing recovery plans, the various systems and subsystems involved are to be specified. The following recovery objectives are also to be specified:

- ***a)*** System recovery: methods and procedures to recover communication capabilities are to be specified in terms of Recovery Time Objective (RTO). This is defined as the time required to recover the required communication links and processing capabilities.
- ***b)*** Data recovery: methods and procedures to recover data necessary to restore safe state of OT systems and safe vessel operation are to be specified in terms of Recovery Point Objective (RPO). This is defined as the longest period of time for which an absence of data can be tolerated.

***iv)*** Once the recovery objectives are defined, a list of potential cyber incidents are to be created, and the recovery procedure developed and described. Recovery plans are to include, or refer to the following information;

- ***a)*** Instructions and procedures for restoring the failed system without disrupting the operation from the redundant, independent or local operation.
- ***b)*** Processes and procedures for the backup and secure storage of information.
- ***c)*** Complete and up-to-date logical network diagram.
- ***d)*** The list of personnel responsible for restoring the failed system.
- ***e)*** Communication procedure and list of personnel to contact for external technical support
- ***f)*** Including system support vendors, network administrators, etc.
- ***g)*** Current configuration information for all components.

*v)* The operation and navigation of the vessel is to be prioritized in the plan in order to help ensure the safety of onboard personnel.

*vi)* Recovery plans in hard copy on board and ashore are to be available to personnel responsible for cyber security and who are tasked with assisting in cyber incidents.

***Commentary:***

Incident response procedures are an essential part of system recovery. Responsible personnel should consider carefully and be aware of the implications of recovery actions (such as wiping of drives) and execute them carefully.

It should be noted, however, that some recovery actions may result in the destruction of evidence that could provide valuable information on the causes of an incident.

Where appropriate, external cyber incident response support should be obtained to assist in preservation of evidence whilst restoring operational capability.

**End of Commentary**

*13.9.1(c) Demonstration of Compliance - Design Phase*

The systems integrator is to include the following information in the Cyber security design description.

- References to information provided by the suppliers (see 4-9-14/9.1.8) that may be applied by the shipowner to establish plans to recover from cyber incidents.

*13.9.1(d) Demonstration of Compliance – Construction Phase*

Demonstration not required.

*13.9.1(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(xiv).

*13.9.1(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to in the vessel cyber security and resilience program describe incident recovery plans. The plans are to cover the CBSs in scope of applicability of Section 4-9-13 and are to address at least the following requirements in Section 4-9-13:

- Description of who, when and how to restore and recover from cyber incidents in accordance with requirements in 4-9-13/13.9.1.
- Policy for backup addressing frequency, maintenance and testing of the backups, considering acceptable downtime, availability of alternative means for control, vendor support arrangements and criticality of the CBSs in accordance with requirements in 4-9-13/13.9.2.
- Reference to user manuals or procedures for backup, shutdown, reset, restore and restart of the CBSs in accordance with requirements in 4-9-13/13.9.2 and 4-9-13/13.9.3.

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the annual surveys demonstrate compliance with 7-6-2/1.1.22(j) of the ABS *Rules for Survey After Construction (Part 7)*.

### 13.9.2 Backup and Restore Capability

*13.9.2(a) Requirement*

*i)* CBSs and networks are to have the capability to support back-up and restore in a timely, complete and safe manner. Backups are to be regularly maintained and tested.

*13.9.2(b) Requirement Details*

***i)*** Restore Capacity

***a)*** CBSs are to have backup and restore capabilities to enable the vessel to safely regain navigational and operational state after a cyber incident.

***b)*** Data is to be restorable from a secure copy or image.

***c)*** Information and backup facilities are to be sufficient to recover from a cyber incident.

***ii)*** Backup

***a)*** CBSs and networks are to provide backup for data. The use of offline backups is also to be considered to improve tolerance against ransomware and worms affecting online backup appliances.

***b)*** Backup plans are to be developed, including scope, mode and frequency, storage medium and retention period.

***Commentary:***

In general, the purpose of a backup and restore strategy should protect against data loss and reconstruct the database after data loss. Typically, backup administration tasks include the following: Planning and testing responses to different kinds of failures; Configuring the database environment for backup and recovery; Setting up a backup schedule; Monitoring the backup and recovery environment; Creating a database copy for long-term storage; Moving data from one database or one host to another, etc.

**End of Commentary**

*13.9.2(c) Demonstration of Compliance - Design Phase*

Demonstration not required.

*13.9.2(d) Demonstration of Compliance – Construction Phase*

Demonstration not required.

*13.9.2(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (ref. 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(xv).

*13.9.2(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the special surveys demonstrate compliance with 7-6-2/3.14(xi) of the ABS *Rules for Survey After Construction (Part 7)*.

### 13.9.3 Controlled Shutdown, Reset, Roll-back and Restart

*13.9.3(a) Requirement*

***i)*** CBS and networks are to capable of controlled shutdown, reset to an initial state, roll-back to a safe state and restart from a power-off condition in such state, in order to allow fast and safe recovery from a possible impairment due to a cyber incident.

***ii)*** Suitable documentation on how to execute the above-mentioned operations is to be available to onboard personnel.

*13.9.3(b) Requirement Details*

***i)*** CBS and networks are to be capable of:

*a)* Controlled shutdown allowing other connected systems to commit/rollback pending transactions, terminating processes, closing connections, etc. leaving the entire integrated system in a safe, consistent and known state.

*b)* Resetting themselves, instructing the system to go through the process of shutting down, clear memory and reset devices to their initialized state.

*c)* Rolling back to a previous configuration and/or state, to restore system integrity and consistency.

*d)* Restarting and reloading a fresh image of all the software and data (e.g., after a rollback operation) from a read-only source. Restart time is to be compatible with the system's intended service and is not to bring other connected systems, or the integrated system it is part of, to an inconsistent or unsafe state.

Documentation is to be available to onboard personnel on how to execute the above-mentioned operations in case of a system affected by a cyber incident.

***Commentary:***

**i** Controlled shutdown consists in turning a CBS or network off by software function allowing other connected systems to commit/rollback pending transactions, terminating processes, closing connections, etc. leaving the entire integrated system in a safe and known state. Controlled shutdown is opposed to hard shutdown, which occurs for example when the computer is forcibly shut down by interruption of power.

**ii** While in the case of some cyber incidents hard shutdowns may be considered as a safety precaution, controlled shutdown is preferable in case of integrated systems to keep them in a consistent and known state with predictable behavior. When standard shutdown procedures are not done, data or program and operating system files corruption may occur. In case of OT systems, the result of corruption can be instability, incorrect functioning or failure to provide the intended service.

**iii** The reset operation would typically kick off a soft boot, instructing the system to go through the process of shutting down, clear memory and reset devices to their initialized state. Depending on system considered, the reset operation might have different effects.

**iv** Rollback is an operation which returns the system to some previous state. Rollbacks are important for data and system integrity, because they mean that the system data and programs can be restored to a clean copy even after erroneous operations are performed. They are crucial for recovering from crashes ad cyber incidents, restoring the system to a consistent state.

**v** Restarting a system and reloading a fresh image of all the software and data (e.g. after a rollback operation) from a read-only source appears to be an effective approach to recover from unexpected faults or cyber incidents. Restart operations should be however controlled in particular for integrated systems, where unexpected restart of a single component can result in inconsistent system state or unpredictable behavior.

**End of Commentary**

*13.9.3(c) Demonstration of Compliance - Design Phase*

The systems integrator is to include the following information in the Cyber security design description.

- References to product manuals or procedures describing how to safely shut down, reset, restore and restart the CBSs in the scope of applicability of Section 4-9-13.

*13.9.3(d) Demonstration of Compliance – Construction Phase*

Demonstration not required.

*13.9.3(e) Demonstration of Compliance – Commissioning Phase*

The systems integrator is to submit the Vessel cyber resilience test procedure (see 4-9-13/15.5.1 and 4-9-10/5.2) and demonstrate compliance in accordance with 4-9-10/5.2.2(d)(xvi).

*13.9.3(f) Demonstration of Compliance - Operation Phase*

For general requirements to surveys in the operation phase, see 4-9-13/15.7.

The shipowner is to submit the Vessel cyber security and resilience program (ref. 4-9-13/15.7.6 and 7-6-2/1.1.22 of the ABS *Rules for Survey After Construction (Part 7)*) and during the special surveys demonstrate compliance with 7-6-2/3.14(xii) of the ABS *Rules for Survey After Construction (Part 7)*.

# 15 Demonstration of Compliance

## 15.1 General

Evaluation of compliance with requirements in Section 4-9-13 will be carried out by assessment of documentation and survey in the relevant phases as specified in the following subsections.

*i)* Documentation to be submitted by suppliers is specified in Section 4-9-14. The approved versions of this documentation are also to be provided by the suppliers to the systems integrator as specified in 4-9-14/15.1 TABLE 1.

*ii)* Documents to be provided by the systems integrator are listed in 4-9-13/15.3 and 4-9-13/15.5.

*iii)* Documents to be provided by the shipowner are listed in 4-9-13/15.7.

*iv)* Upon delivery of the ship, the systems integrator is to provide below documentation to the shipowner:

- Documentation of the CBSs provided by the suppliers (4-9-14/15.1 TABLE 1)
- Documentation produced by the systems integrator (see 4-9-13/15.3 and 4-9-13/15.5)

See also 4-9-13/9 TABLE 2 for plans and data as well as Appendix 4-9-13-A2 for a summary table of documents.

Information in 4-9-13/15.3 is to be produced during the different phases of the vessel's life for the design, development, maintenance and implementation of a Test Plan:

## 15.3 During Design and Construction Phases

The supplier is to demonstrate compliance by following the certification process specified in 4-9-14/21.

The systems integrator is to demonstrate compliance by submitting documents in the following subsections for assessment.

During the design and construction phases, modifications to the design are to be carried out in accordance with the management of change (MoC) requirements in 4-9-3/9.

### 15.3.1 Zones and Conduits Diagram

The content of this document is specified in 4-9-13/13.3.1(c).

### 15.3.2 Cyber Security Design Description

The content of this document is specified in subsections “Design phase” for each requirement in 4-9-13/13.

### 15.3.3 Vessel Asset Inventory

The content of this document is specified in paragraph 4-9-13/13.1.1.

### 15.3.4 Risk Assessment for the Exclusion of CBSs

The content of this document is specified in 4-9-13/17.

#### 15.3.5 Description of Compensating Countermeasures

If any CBS in the scope of applicability of Section 4-9-13 has been approved with compensating countermeasures in lieu of a requirement in Section 4-9-14, this document is to specify the respective CBS, the lacking security capability, as well as provide a detailed description of the compensating countermeasures. See also 4-9-14/9.1.3(e) and 4-9-14/13.7 requiring that the supplier describes such compensating countermeasures in the system documentation.

### 15.5 Upon Vessel Commissioning

Before final commissioning of the vessel, the systems integrator is to perform the following:

*1)* Submit updated design documentation (as-built versions of the documents in 4-9-13/15.3).

*2)* Submit Vessel cyber resilience test procedure describing how to demonstrate compliance with Section 4-9-13 by testing and/or analytic evaluation.

*3)* Carry out testing, witnessed by ABS, in accordance with the approved Vessel cyber resilience test procedure.

See 4-9-10/5.2 for Cyber Resilience integration requirements.

#### 15.5.1 Vessel Cyber Resilience Test Procedure

The content of this document is specified for the Commissioning phase in each subsection “Demonstration of compliance” in 4-9-14/13.13.

For each CBS, the required inherent security capabilities and configuration thereof are verified and tested in the certification process of each CBS (see Section 4-9-14). Testing of such security functions may be omitted if specified in the respective subsection "Commissioning phase", on the condition that these security functions have been successfully tested during the certification of the CBS as per Section 4-9-14. Nevertheless, all tests are to be included in the Vessel cyber resilience test procedure as well as any plan to omit tests. Any plan to omit tests is subject to ABS review and agreement. Tests may generally not be omitted if findings/comments are carried over from the certification process to the commissioning phase, if the respective requirements have been met by compensating countermeasures, or due to other reasons such as modifications of the CBS after the certification process.

The Vessel cyber resilience test procedure is also to specify how to test any compensating countermeasures described in 4-9-3/15.3.5.

The Vessel cyber resilience test procedure is to include means to update status and record findings during the testing, and specify the following information:

- Necessary test setup (i.e., to ensure the test can be repeated with the same expected result)
- Test equipment
- Initial condition(s)
- Test methodology, detailed test steps
- Expected results and acceptance criteria

Before submitting the Vessel cyber resilience test procedure, the systems integrator is to verify that the information is updated and placed under change management; that it is aligned with the latest configurations of CBSs and networks connecting such systems together on board the vessel and to other CBSs not on board (e.g., ashore); and that the tests documented are sufficiently detailed as to allow verification of the installation and operation of measures adopted for the fulfilment of relevant requirements on the final configuration of CBSs and networks on board.

The systems integrator is to document verification tests or assessments of security controls and measures in the fully integrated vessel, maintaining change management for configurations, and noting in the documented test results where safety conditions may be affected by specific circumstances or failures addressed in the Vessel cyber resilience test procedure.

The testing is to be carried out on board in accordance with the approved Vessel cyber resilience test procedure after other commissioning activities for the CBSs are completed. ABS may request execution of additional tests.

## 15.7 During the Operational Life of the Vessel

### 15.7.1

After the vessel has been delivered to the shipowner, the shipowner is to manage technical and organizational security countermeasures by establishing and implementing processes as specified in this Section 4-9-13.

Modifications to the CBSs in scope of applicability of Section 4-9-13 are to be carried out in accordance with the management of change (MoC) requirements in 4-9-3/10. This includes keeping documentation of the CBSs up to date.

### 15.7.2

The shipowner, with the support of suppliers, is to keep the Vessel cyber resilience test procedure up to date and aligned with the CBSs on board the vessel and the networks connecting such systems to each other and to other CBSs not on board (e.g., ashore). The shipowner is to update the Vessel cyber resilience test procedure considering the changes occurred on CBSs and networks on board, possible emerging risks related to such changes, new threats, new vulnerabilities and other possible changes in the vessels's operational environment.

### 15.7.3

The shipowner is to prepare and implement operational procedures, provide periodic training and carry out drills for the onboard personnel and other concerned personnel ashore to familiarize them with the CBSs on board the vessel and the networks connecting such systems to each other and to other CBSs not on board (e.g., ashore), and to properly manage the measures adopted for the fulfilment of requirements.

### 15.7.4

The shipowner, with the support of suppliers, is to keep the measures adopted for the fulfilment of requirements up to date (e.g., by periodic maintenance of hardware and software of CBSs on board the vessel and the networks connecting such systems).

### 15.7.5

The shipowner is to retain on board a copy of results of execution of tests and an updated Vessel cyber resilience test procedure and make them available to ABS.

### 15.7.6 First Annual Survey

In due time before the first annual survey of the vessel, the shipowner is to submit the Vessel cyber security and resilience program documenting management of cyber security and cyber resilience of the CBSs in the scope of applicability of Section 4-9-13.

The Vessel cyber security and resilience program is to include policies, procedures, plans and/or other information documenting the processes/activities specified in subsections “Demonstration of compliance” in 4-9-13/13.

After ABS has approved the Vessel cyber security and resilience program, the shipowner is to in the first annual survey demonstrate compliance by presenting records or other documented evidence of implementation of the processes described in the approved Vessel cyber security and resilience program.

Change of vessel management company will require a new verification of the Vessel cyber security and resilience program.

#### 15.7.7 Subsequent Annual Survey

In the subsequent annual surveys of the vessel, the shipowner is to upon request by ABS demonstrate implementation of the Vessel cyber security and resilience program.

#### 15.7.8 Special Survey

Upon renewal of the vessel's classification certificate, the shipowner is to carry out testing witnessed by ABS in accordance with the Vessel cyber resilience test procedure. Certain security safeguards are to be demonstrated at the Special survey whereas other need only be carried out upon request by ABS based on modifications to the CBSs as specified in subsections "Operation phase" in 4-9-13/13.

## 17 Risk Assessment for Exclusion of CBS from the Application of Requirements

### 17.1 Requirement

#### 17.1.1

A risk assessment is to be carried out in case any of the CBSs falling under the scope of applicability of this section is excluded from the application of relevant requirements. The risk assessment is to provide evidence of the acceptable risk level associated to the excluded CBSs.

### 17.3 Requirement Details

#### 17.3.1

Risk assessment is to be made and kept up to date by the systems integrator during the Design and building phase considering possible variations of the Original design and newly discovered threats and/or vulnerabilities not known from the beginning.

#### 17.3.2

During the operational life of the vessel, the shipowner is to update the risk assessment considering the constant changes in the cyber scenario and new weaknesses identified in CBS on board in a process of continuous improvement. Should new risks be identified, the shipowner is to update existing, or implement new risk mitigation measures.

#### 17.3.3

Should the changes in the cyber scenario be such as to elevate the risk level associated to the CBS under examination above the acceptable risk threshold, the shipowner is to inform ABS and submit the updated risk assessment for evaluation.

#### 17.3.4

The envisaged operational environments for the CBS under examination are to be analyzed in the risk assessment to discern the likelihood of cyber incidents and the impact they could have on the human safety, the safety of the vessel or the marine environment, taking into account the category of the CBS. The attack surface is to be analyzed, taking into account the connectivity of the CBS, possible interfaces for portable devices, logical access restrictions, etc.

#### 17.3.5

Emerging risks related to the specific configuration of the CBS under examination are also to be identified. In the risk assessment, the following elements are to be considered:

*i)* Asset vulnerabilities;

*ii)* Threats, both internal and external;

*iii)* Potential impacts of cyber incidents affecting the asset on human safety, safety of the vessel and/or threat to the environment;

*iv)* Possible effects related to integration of systems, or interfaces among systems, including systems not on board (e.g., if remote access to onboard systems is provided).

### 17.5 Acceptance Criteria

#### 17.5.1

Exclusion of a CBS falling under the scope of applicability of this section from the application of relevant requirements can be accepted by ABS only if assurance is given that the operation of the CBS has no impact on the safety of operations regarding cyber risk.

#### 17.5.2

The said exclusion may be accepted for a CBS which does not fully meet the additional criteria as per 4-9-13/17.5.4 below, but is provided with a rational explanation together with evidence that is found satisfactory by ABS. ABS may also require submittal of additional documents to consider the said exclusion.

#### 17.5.3

The following criteria is to be met to exclude a system from the scope of applicability of Section 4-9-13:

*i)* The CBS is to be isolated (i.e., have no IP-network connections to other systems or networks)

*ii)* The CBS is to have no accessible physical interface ports. Unused interfaces are to be logically disabled. It is not to be possible to connect unauthorized devices to the CBS

*iii)* The CBS must be located in areas to which physical access is controlled

*iv)* The CBS is not to be an integrated control system serving multiple ship functions as specified in the scope of applicability of this Section (see 4-9-13/1.3)

#### 17.5.4

The following additional criteria should be considered for the evaluation of risk level acceptability:

*i)* The CBS should not serve ship functions of category III;

*ii)* Known vulnerabilities, threats, potential impacts deriving from a cyber incident affecting the CBS have been duly considered in the risk assessment;

*iii)* The attack surface for the CBS is minimized, having considered its complexity, connectivity, physical and logical access points, including wireless access points;

***Commentary:***

Exclusion of a CBS falling under the scope of applicability of this section from the application of relevant requirements needs to be duly justified and documented. Such exclusion can be accepted by the ABS only if evidence is given that the risk level associated to the operation of the CBS is under an acceptable threshold by means of specific risk assessment.

The risk assessment is to be based on available knowledge bases and experience on similar designs, if any, considering the CBS category, connectivity and the functional requirements and specifications of the vessel and of the CBS. Cyber threat information from internal and external sources may be used to gain a better understanding of the likelihood and impact of cybersecurity events.

**End of Commentary**

# PART 4

## CHAPTER 9

## Automation and Computer Based Systems

## SECTION 13

## Appendix 1 - Overview of Requirements *(1 July 2024)*

| *Item* | *Requirement* | *Functional Element* | *ABS MVR 4-9-13/* | *D* | *C* | *CS* | *AS* | *SS* |
|---|---|---|---|---|---|---|---|---|
| 1 | Vessel asset inventory | Identify | 13.1.1 | D | C | CS | AS | SS |
| 2 | Security Zones and Network Segmentation | Protect | 13.3.1 | D | C | CS | AS | SS |
| 3 | Network protection safeguards | Protect | 13.3.2 | | | CS | | SS |
| 4 | Antivirus, antimalware, antispam and other protections from malicious code | Protect | 13.3.3 | D | C | CS | AS | SS |
| 5 | Access control | Protect | 13.3.4 | D | C | CS | AS | |
| 6 | Wireless communication | Protect | 13.3.5 | D | C | CS | | SS |
| 7 | Remote access control and communication with untrusted networks | Protect | 13.3.6 | D | C | CS | AS | SS |
| 8 | Use of Mobile and Portable Devices | Protect | 13.3.7 | D | C | CS | AS | SS |
| 9 | Network operation monitoring | Detect | 13.5.1 | | | CS | AS | SS |
| 10 | Verification and diagnostic functions of CBS and networks | Detect | 13.5.2 | | | CS | AS | |
| 11 | Incident response plan | Respond | 13.7.1 | D | | | AS | |
| 12 | Local, independent and/or manual operation | Respond | 13.7.2 | D | | CS | | SS |
| 13 | Network isolation | Respond | 13.7.3 | D | | CS | | SS |
| 14 | Fallback to a minimal risk condition | Respond | 13.7.4 | D | | CS | | SS |
| 15 | Recovery plan | Recover | 13.9.1 | D | | CS | AS | |
| 16 | Backup and restore capability | Recover | 13.9.2 | | | CS | | SS |
| 17 | Controlled shutdown, reset, roll-back and restart | Recover | 13.9.3 | D | | CS | | SS |

Legend

| | |
|---|---|
| D | Design phase |
| C | Construction Phase |
| CS | Commissioning Phase |
| AS | Annual Survey (Operation Phase) |
| SS | Special Survey (Operation Phase) |

***Note:*** For required documentation see the Plans and Data section (4-9-13/9).

PART 4

CHAPTER 9

# Automation and Computer Based Systems

SECTION 13

## Appendix 2 - Summary Table of Requirements and Documents *(1 July 2024)*

| | | | |
|---|---|---|---|
| 1 | Vessel asset inventory (4-9-13/13.1.1) | | |
| | *CBS security capabilities* | Provide documentation of product security updates<br>Provide documentation of dependent component security updates<br>Provide security updates | 4-9-14/17.3.2<br>4-9-14/17.3.3<br>4-9-14/17.3.4 |
| | *CBS documentation* | CBS asset inventory<br>Management of change plan | 4-9-14/9.1.1<br>4-9-14/9.1.9 |
| | *Vessel design documentation* | Vessel asset inventory | 4-9-13/13.1.1(c) |
| | *Vessel cyber security and resilience program* | Management of change | 4-9-13/13.1.1(f) |
| | | Management of software updates | 4-9-13/13.1.1(f) |
| 2 | Security zones and network segmentation (4-9-13/13.3.1) | | |
| | *CBS security capabilities* | | |
| | *CBS documentation* | Topology diagrams | 4-9-14/9.1.2 |
| | *Vessel design documentation* | Zones and conduit diagram<br>Design description<br>Vessel cyber resilience test procedure | 4-9-13/13.3.1(c)<br>4-9-13/13.3.1(c)<br>4-9-13/13.3.1(e) |
| | *Vessel cyber security and resilience program* | Management of security zone boundary devices (e.g., firewalls) | 4-9-13/13.1.1(f) |
| 3 | Network protection safeguards (4-9-13/13.3.2) | | |
| | *CBS security capabilities* | Denial of service (DoS) protection (item 24)<br>Deterministic output (item 20) | 4-9-14/15.1 |

| | | | |
|---|---|---|---|
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities | 4-9-14/9.1.3<br>4-9-14/9.1.4 |
| | *Vessel design documentation* | Vessel cyber resilience test procedure | 4-9-13/13.3.2(e) |
| | *Vessel cyber security and resilience program* | | |
| 4 | Antivirus, antimalware, antispam and other protections from malicious code (4-9-13/13.3.3) | | |
| | *CBS security capabilities* | Malicious code protection (item 18) | 4-9-14/15.1 |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities | 4-9-14/9.1.3<br>4-9-14/9.1.4 |
| | *Vessel design documentation* | Design description<br>Vessel cyber resilience test procedure | 4-9-13/13.3.3(c)<br>4-9-13/13.3.3(e) |
| | *Vessel cyber security and resilience program* | Management of malware protection | 4-9-13/13.3.3(f) |
| 5 | Access Control (4-9-13/13.3.4) | | |
| | *CBS security capabilities* | Human user id. and auth. (item 1)<br>Account management (item 2)<br>Identifier management (item 3)<br>Authenticator management (item 4)<br>Authorisation enforcement (item 8) | 4-9-14/15.1 |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities | 4-9-14/9.1.3<br>4-9-14/9.1.4 |
| | *Vessel design documentation* | Design description<br>Vessel cyber resilience test procedure | 4-9-13/13.3.4(c)<br>4-9-13/13.3.4(e) |
| | *Vessel cyber security and resilience program* | Management of confidential information | 4-9-13/13.3.4(f) |
| | | Management of logical and physical access | 4-9-13/13.3.4(f) |
| 6 | Wireless communication (4-9-13/13.3.5) | | |
| | *CBS security capabilities* | Wireless access management (item 5)<br>Wireless use control (item 9) | 4-9-14/15.1 |

| | | | |
|---|---|---|---|
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities | 4-9-14/9.1.3<br>4-9-14/9.1.4 |
| | *Vessel design documentation* | Design description<br>Vessel cyber resilience test procedure | 4-9-13/13.3.5(c)<br>4-9-13/13.3.5(e) |
| | *Vessel cyber security and resilience program* | | |
| 7 | Remote access control and communication with untrusted networks (4-9-13/13.3.6) | | |
| | *CBS security capabilities* | Multifactor authentication (item 31)<br>Process / device id. and auth. (item 32)<br>Unsuccessful login attempts (item 33)<br>System use notification (item 34)<br>Access via untrusted networks (item 35)<br>Explicit access request approval (item 36)<br>Remote session termination (item 37)<br>Cryptographic integrity protection (item 38)<br>Input validation (item 39)<br>Session integrity (item 40)<br>Invalidation of session ID (item 41) | 4-9-14/15.3 |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities | 4-9-14/9.1.3<br>4-9-14/9.1.4 |
| | *Vessel design documentation* | Design description<br>Vessel cyber resilience test procedure | 4-9-13/13.3.6(c)<br>4-9-13/13.3.6(e) |
| | *Vessel cyber security and resilience program* | Management of remote access and communication with/via untrusted networks | 4-9-13/13.3.6(f) |
| 8 | Use of mobile and portable devices (4-9-13/13.3.7) | | |
| | *CBS security capabilities* | Use control for portable devices (item 10) | 4-9-14/15.1 |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities | 4-9-14/9.1.3<br>4-9-14/9.1.4 |
| | *Vessel design documentation* | Design description<br>Vessel cyber resilience test procedure | 4-9-13/13.3.7(c)<br>4-9-13/13.3.7(e) |

| | | | |
|---|---|---|---|
| | *Vessel cyber security and resilience program* | Management of mobile and portable devices | 4-9-13/13.3.7(f) |
| 9 | Network operation monitoring (4-9-13/13.5.1) | | |
| | *CBS security capabilities* | Use control for portable devices (item 10)<br>Auditable events (item 13)<br>Denial of service (DoS) protection (item 24) | 4-9-14/15.1 |
| | | Alarm excessive bandwidth use | 4-9-3/13.1.1 |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities | 4-9-14/9.1.3<br>4-9-14/9.1.4 |
| | *Vessel design documentation* | Vessel cyber resilience test procedure | 4-9-13/13.5.1(e) |
| | *Vessel cyber security and resilience program* | Incident response plans | 4-9-13/13.5.1(f) |
| 10 | Verification and diagnostic functions of CBS and networks (4-9-13/13.5.2) | | |
| | *CBS security capabilities* | Security function verification (item 19) | 4-9-14/15.1 |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities<br>Plans for maintenance and verification | 4-9-14/9.1.3<br>4-9-14/9.1.4<br>4-9-14/9.1.7 |
| | *Vessel design documentation* | Vessel cyber resilience test procedure | 4-9-13/13.5.2(e) |
| | *Vessel cyber security and resilience program* | Verification of security functions | 4-9-13/13.5.2(f) |
| 11 | Incident response plan (4-9-13/13.7.1) | | |
| | *CBS security capabilities* | | |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities<br>Information supporting incident response and recovery plans | 4-9-14/9.1.3<br>4-9-14/9.1.4<br>4-9-14/9.1.8 |
| | *Vessel design documentation* | Design description<br>Vessel cyber resilience test procedure | 4-9-13/13.7.1(c)<br>4-9-13/13.7.1(e) |
| | *Vessel cyber security and resilience program* | Incident response plans | 4-9-13/13.7.1(f) |
| 12 | Local, independent and/or manual operation (4-9-13/13.7.2) | | |
| | *CBS security capabilities* | | |

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|---|---|---|---|
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities<br>Information supporting incident response and recovery plans | 4-9-14/9.1.3<br>4-9-14/9.1.4<br>4-9-14/9.1.8 |
| | *Vessel design documentation* | Design description<br>Vessel cyber resilience test procedure | 4-9-13/13.7.2(c)<br>4-9-13/13.7.2(e) |
| | *Vessel cyber security and resilience program* | Incident response plans | 4-9-13/13.7.2(f) |
| 13 | Network isolation (4-9-13/13.7.3) | | |
| | *CBS security capabilities* | | |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities<br>Information supporting incident response and recovery plans | 4-9-14/9.1.3<br>4-9-14/9.1.4<br>4-9-14/9.1.8 |
| | *Vessel design documentation* | Design description<br>Vessel cyber resilience test procedure | 4-9-13/13.7.3(c)<br>4-9-13/13.7.3(e) |
| | *Vessel cyber security and resilience program* | Incident response plans | 4-9-13/13.7.3(f) |
| 14 | Fallback to a minimal risk condition (4-9-13/13.7.4) | | |
| | *CBS security capabilities* | Deterministic output (item 20) | 4-9-14/15.1 |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities<br>Information supporting incident response and recovery plans | 4-9-14/9.1.3<br>4-9-14/9.1.4<br>4-9-14/9.1.8 |
| | *Vessel design documentation* | Design description<br>Vessel cyber resilience test procedure | 4-9-13/13.7.4(c)<br>4-9-13/13.7.4(e) |
| | *Vessel cyber security and resilience program* | Incident response plans | 4-9-13/13.7.4(f) |
| 15 | Recovery plan (4-9-13/13.9.1) | | |
| | *CBS security capabilities* | | |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities<br>Information supporting incident response and recovery plans | 4-9-14/9.1.3<br>4-9-14/9.1.4<br>4-9-14/9.1.8 |

| | | | |
|---|---|---|---|
| | *Vessel design documentation* | Design description<br>Vessel cyber resilience test procedure | 4-9-13/13.9.1(c)<br>4-9-13/13.9.1(e) |
| | *Vessel cyber security and resilience program* | Recovery plans | 4-9-13/13.9.1(f) |
| 16 | Backup and restore capability (4-9-13/13.9.2) | | |
| | *CBS security capabilities* | System backup (item 26)<br>System recovery and reconstitution (item 27) | 4-9-14/15.1 |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities<br>Information supporting incident response and recovery plans | 4-9-14/9.1.3<br>4-9-14/9.1.4<br>4-9-14/9.1.8 |
| | *Vessel design documentation* | Vessel cyber resilience test procedure | 4-9-13/13.9.2(e) |
| | *Vessel cyber security and resilience program* | Recovery plan | 4-9-13/13.9.2(f) |
| 17 | Controlled shutdown, reset, roll-back, and restart (4-9-13/13.9.3) | | |
| | *CBS security capabilities* | System recovery and reconstitution (item 27) | 4-9-14/15.1 |
| | *CBS documentation* | Description of security capabilities<br>Test procedure for security capabilities<br>Information supporting incident response and recovery plans | 4-9-14/9.1.3<br>4-9-14/9.1.4<br>4-9-14/9.1.8 |
| | *Vessel design documentation* | Design description Vessel cyber resilience test procedure | 4-9-13/13.9.3(c)<br>4-9-13/13.9.3(e) |
| | *Vessel cyber security and resilience program* | Recovery plans | 4-9-13/13.9.3(f) |
| 18 | Risk assessment for exclusion of CBS from the application of requirements (4-9-13/17) | | |
| | *CBS security capabilities* | | |
| | *CBS documentation* | | |
| | *Vessel design documentation* | Risk assessment for the exclusion of CBSs | 4-9-13/15.3.4 |
| | *Vessel cyber security and resilience program* | | |

PART 4

CHAPTER 9

# Automation and Computer Based Systems

SECTION 14

# Cyber Resilience for Onboard Systems and Equipment *(1 July 2024)*

## 1 General

Technological evolution of vessels, ports, container terminals, etc., and increased reliance upon Operational Technology (OT) and Information Technology (IT) has created an increased possibility of cyber-attacks to affect business, personnel data, human safety, the safety of the vessel, and also possibly threaten the marine environment. Safeguarding shipping from current and emerging threats is to involve a range of controls that are continually evolving which would require incorporating security features in the equipment and systems at design and manufacturing stage.

This section provides the requirements for cyber resilience of onboard systems and equipment and is based on IACS Unified Requirement, UR E27.

***Note:*** For vessels with a construction contract date before 1 July 2024, the requirements in this section may be used as non-mandatory guidance.

## 3 Objective

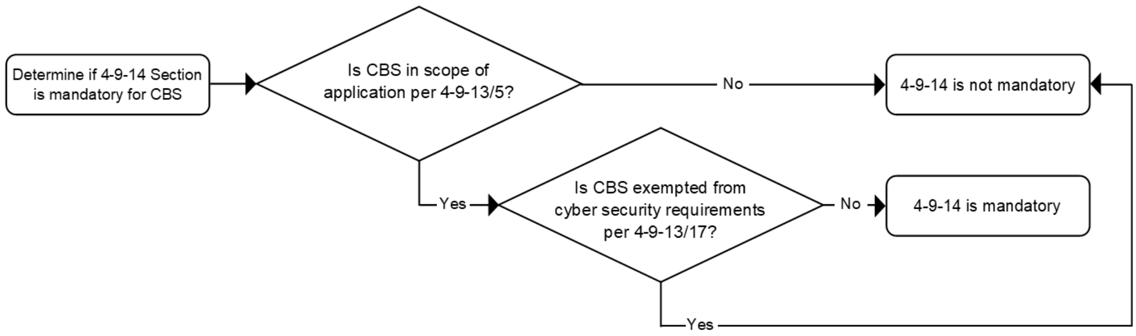
The objective in 4-9-13/3 is also applicable to this section.

## 5 Scope

The provisions of this section apply to the computer-based systems (CBS) covered in 4-9-13/5. However, for navigation and radio communication systems, the application of IEC 61162-460 or other equivalent standards in lieu of the required security capabilities in this section may be accepted, provided the requirements in Section 4-9-13 are complied with.

Suppliers in cooperation with the System Integrator and ABS can determine the applicability of this section based on the 4-9-14/5 FIGURE 1.

**FIGURE 1**
**Applicability of Section 4-9-14**




***Commentary:***

This section does not cover requirements related to environmental performance for the system hardware and the functionality of the software. These requirements are covered in the following Rules:

- Section 4-9-9 for environmental performance for the system hardware
- Section 4-9-3 for safety of equipment for the functionality of the software

The process in 4-9-14/5 FIGURE 1 also applies if other equivalent standards are applied for navigation and radio communication equipment. In such cases the process illustrates if the equivalent standard is mandatory in lieu of this section.

**End of Commentary**

# 7 Definitions

## 7.1 Control

Means of managing risk, including policies, procedures, guidelines, practices or organizational structures, which can be administrative, technical, management, or legal in nature.

## 7.3 Firewall

A logical or physical barrier that monitors and controls incoming and outgoing network traffic controlled via predefined rules.

## 7.5 Firmware

Software embedded in electronic devices that provide control, monitoring and data manipulation of engineered products and systems. These are normally self-contained and not accessible to user manipulation.

## 7.7 Hardening

Hardening is the practice of reducing a system's vulnerability by reducing its attack surface.

## 7.9 Integrated System

System combining a number of interacting sub-system and/or equipment organized to achieve one or more specified purposes.

## 7.11 Network Switch (Switch)

A device that connects devices together on a computer network, by using packet switching to receive, process and forward data to the destination device.

### 7.13 Offensive Cyber Maneuver

Actions that result in denial, degradation, disruption, destruction, or manipulation of OT or IT systems.

### 7.15 OT System

Computer based systems, which provide control, alarm, monitoring, safety or internal communication functions.

### 7.17 Patches

Software designed to update installed software or supporting data to address security vulnerabilities and other bugs or improve operating systems or applications.

### 7.19 Recovery

Develop and implement the appropriate activities to maintain plans for resilience and to restore any capabilities or services that were impaired due to a cybersecurity event. The Recovery function supports timely return to normal operations to reduce the impact from a cyber security event.

### 7.21 Supplier

A manufacturer or provider of hardware and/or software products, system components or equipment (hardware or software) comprising of the application, embedded devices, network devices, host devices, etc., working together as system or a subsystem. The Supplier is responsible for providing programmable devices, sub-systems or systems to the System Integrator.

### 7.23 System

Combination of interacting programmable devices and/or sub-systems organized to achieve one or more specified purposes.

### 7.25 System Categories (I, II, III)

System categories based on their effects on system functionality, which are defined in Section 4-9-3.

### 7.27 System Integrator

The specific person or organization responsible for the integration of systems and products provided by suppliers into the system invoked by the requirements in the ship specifications and for providing the integrated system. The system integrator may also be responsible for integration of systems in the ship. Until vessel delivery, this role is to be taken by the Shipyard unless an alternative organization is specifically contracted/assigned this responsibility.

## 9 Plans and Data

The following plans and data are to be submitted for review, as appropriate, for each CBS:

The supplier is to provide the ABS-reviewed version of the documents to the System Integrator, which are necessary for designing cyber security aspects for the overall system of systems per Section 4-9-13.

***Commentary:***

The documentation provided by the Supplier to System Integrator can show black box diagram of the system and black box description of the system's security capabilities without including company's intellectual property.

**End of Commentary**

The following symbols are used in this Section for the type of review of the documents:

R: Documents to be reviewed.

I: Documentation for information and verification for consistency with related review.

## 9.1 CBS Documentation

### 9.1.1 CBS Asset Inventory (R)

The CBS asset inventory is to include the information below.

*9.1.1(a) List of hardware components (e.g., host devices, embedded devices, network devices)*

***i)*** Name

***ii)*** Brand/manufacturer

***iii)*** Model/type

***iv)*** Short description of functionality/purpose

***v)*** Physical interfaces (e.g., network, serial)

***vi)*** Name/type of system software (e.g., operating system, firmware)

***vii)*** Version and patch level of system software

***viii)*** Supported communication protocols

*9.1.1(b) List of software components (e.g., application software, utility software)*

***i)*** The hardware component where it is installed

***ii)*** Brand/manufacturer

***iii)*** Model/type

***iv)*** Short description of functionality/purpose

***v)*** Version of software

### 9.1.2 Topology Diagrams (R)

*9.1.2(a)*

The physical topology diagram is to illustrate the physical architecture of the system, identifying the hardware components in the CBS asset inventory. The diagram is to include the following:

***i)*** All endpoints and network devices, including identification of redundant units

***ii)*** Communication cables (networks, serial links), including communication with I/O units

***iii)*** Communication cables to other networks or systems

*9.1.2(b)*

The logical topology diagram is to illustrate the data flow between components in the system. The diagram is to include the following:

***i)*** Communication endpoints (e.g., workstations, controllers, servers)

***ii)*** Network devices (switches, routers, firewalls)

***iii)*** Physical and virtual computers - Physical and virtual communication paths

***iv)*** Communication protocols

One combined topology diagram covering 4-9-14/9.1.2(a) and 4-9-14/9.1.2(b) may be accepted if all the requested information can be clearly illustrated.

### 9.1.3 Description of Security Capabilities (R)

*9.1.3(a)*

This document is to describe how the CBS with its hardware and software components meets the required security capabilities in section 4-9-14/15.

*9.1.3(b)*

Any network interfaces to other CBSs in the scope of applicability per 4-9-13/5 are to be described. The description is to include destination CBS, data flows, and communication protocols. If the System integrator has allocated the destination CBS to another security zone, components providing protection of the security zone boundary (see 4-9-13/13.3.2(a)) is to be described in detail if delivered as part of the CBS.

*9.1.3(c)*

Any network interfaces to other systems or networks outside the scope of applicability per 4-9-13/5 (untrusted networks) are to be described. The description is to specify compliance with the additional security capabilities in section 4-9-14/15.3, and include relevant procedures or instructions for the crew. Components providing protection of the security zone boundary (see 4-9-13/13.3.2(a)) are to be described in detail if delivered as part of the CBS.

*9.1.3(d)*

A separate chapter is to be designated for each requirement. All hardware and software components in the system are to be addressed in the description, as relevant.

*9.1.3(e)*

If any requirement is not fully met, this is to be specified in the description, and compensating countermeasures are to be proposed. The compensating countermeasures are to be designed to meet the following:

***i)*** Protect against the same threats as the original requirement

***ii)*** Provide an equal level of protection as the original requirement

***iii)*** Not be a security control that is required by other requirements in this section

***iv)*** Not introduce higher security risk

*9.1.3(f)*

Any supporting documents (e.g., OEM information) necessary to verify compliance with the requirements are to be referenced in the description and submitted.

### 9.1.4 Test Procedure of Security Capabilities (R)

*9.1.4(a)*

This document is to describe how to demonstrate by testing that the system complies with the requirements in section 4-9-14/15.1 and 4-9-14/15.3, including any compensating countermeasures. Demonstration of compliance by analytic evaluation may be specially considered.

*9.1.4(b)*

The test procedure is to include a separate chapter for each applicable requirement and describe:

***i)*** Necessary test setup (i.e., to ensure the test can be repeated with the same expected result)

***ii)*** Test equipment

***iii)*** Initial condition(s)

***iv)*** Test methodology, detailed test steps

***v)*** Expected results and acceptance criteria

The procedure is to also include means to update test results and record findings during the testing.

#### 9.1.5 Security Configuration Guidelines (I)

This document is to describe recommended configuration settings of the security capabilities and specify default values.

The objective is to ensure the security capabilities are implemented in accordance with 4-9-13 and any specifications by the System integrator (e.g., user accounts, authorisation, password policies, safe state of machinery, firewall rules, etc.).

The document is to serve as basis for verification of item no. 29 in 4-9-14/15.1 TABLE 1.

#### 9.1.6 Secure Development Lifecycle Documents (R)

This documentation is to describe the supplier's processes and controls in accordance with requirements for secure development lifecycle in 4-9-14/17. Software updates and patching procedures are to be included. The document is to support ABS survey per 4-9-14/21.1.4.

#### 9.1.7 Plans for Maintenance and Verification of the CBS (I)

This document is to include procedures for security-related maintenance and testing of the system. The document is to include instructions for how the user can verify correct operation of the system's security functions as required by item no.19 in 4-9-14/15.1 TABLE 1.

#### 9.1.8 Information Supporting the Owner's Incident Response and Recovery Plan (I)

This document is to include procedures or instructions allowing the user to accomplish the following:

*i)* Local independent control (see 4-9-13/13.7.2)

*ii)* Network isolation (see 4-9-13/13.7.3)

*iii)* Forensics by use of audit records (see 4-9-14/15.1 TABLE 1, item no.13)

*iv)* Deterministic output (see 4-9-13/13.7.4 and 4-9-14/15.1 TABLE 1, item no. 20)

*v)* Backup (see 4-9-14/15.1 TABLE 1, item no. 26)

*vi)* Restore (see 4-9-14/15.1 TABLE 1, item no. 27)

*vii)* Controlled shutdown, reset, roll-back and restart (see 4-9-13/13.9.3)

#### 9.1.9 Management of Change Plan (I)

The management of change procedure is not expected to be specfic for cyber security. It is to cover any changes to the computer based system as per 4-9-3/10.

#### 9.1.10 Test Reports (I)

Test reports signed by the supplier demonstrating that the supplier has completed design, construction, testing, configuration, and hardening.

## 11 References

*1)* IACS Unified Requirement (UR) E22 “Computer based Systems” includes requirements for design, construction, commissioning and maintenance of computer-based systems where they depend on software for the proper achievement of their functions. The requirements in UR E22 focus on the functionality of the software and on the hardware supporting the software which provide control, alarm, monitoring, safety or internal communication functions subject to classification requirements.

*2)* IACS Unified Requirement (UR) E26 "Cyber Resilience of Ships" includes requirements for cyber resilience of vessels, with the purpose of providing technical means that to lead to cyber resilient ships.

*3)* IACS Unified Requirement (UR) E10 "Test Specification for Type Approval" includes requirements for electrical, electronic and programmable equipment intended for control, monitoring, alarm and protection systems for use in ships vessels.

*4)* IACS Recommendation 166 "Recommendation on Cyber Resilience" includes non-mandatory recommended technical requirements that may be referred and applied to assist with the delivery of cyber resilient ships, whose resilience can be maintained throughout their service life.

*5)* IACS Recommendation 171 "Recommendation on incorporating cyber risk management into Safety Management Systems"

*6)* IEC 62443-3-3 (2013): Industrial communication networks – Network and system security. Part 3-3: System security requirements and security levels.

*7)* IEC 62443-4-1 (2018): Security for industrial automation and control systems Part 4-1: Secure product development lifecycle requirements

# 13 Security Philosophy

## 13.1 Systems and Equipment

### 13.1.1

A System can consist of group of hardware and software enabling safe, secure and reliable operation of a process. Typical example could be Engine control system, DP system, etc.

### 13.1.2

Equipment may be one of the following:

*i)* Network devices (i.e., routers, managed switches)

*ii)* Security devices (i.e., firewall, intrusion detection system)

*iii)* Computers (i.e., workstation, servers)

*iv)* Automation devices (i.e., programmable logic controllers)

*v)* Virtual machine cloud-hosted

## 13.3 Cyber Resilience

The cyber resilience requirements in 4-9-14/15.1 are applicable for all systems in scope of this section. Additional requirements related to interface with untrusted networks covered in 4-9-14/15.3 only apply for systems where such connectivity is designed.

## 13.5 Essential Systems Availability

### 13.5.1

Security measures for essential systems are not to adversely affect the systems availability.

### 13.5.2

Implementation of security measures is not to cause loss of safety functions, loss of control functions, loss of monitoring functions or loss of other functions which could result in health, safety and environmental consequences.

#### 13.5.3

The system is to be adequately designed to allow the vessel to continue its mission critical operations in a manner that ensures the confidentiality, integrity, and availability of the data necessary for safety of the vessel, its systems, personnel and cargo.

### 13.7 Compensating Countermeasures

#### 13.7.1

Compensating countermeasure can be employed in lieu of or in addition to inherent security capabilities to satisfy one or more security requirements.

Compensating countermeasure(s) are to meet the intent and rigor of the original stated requirement considering the referenced standards as well as the differences between each requirement and the related items in the standards, and follow the principles specified in 4-9-13/9.1.3.

### 13.7 Essential Systems Availability

#### 13.7.1

Security measures for essential systems are not to adversely affect the systems availability.

#### 13.7.2

Implementation of security measures is not to cause loss of protection, loss of control, loss of view or loss of other essential functions which could result in health, safety and environmental consequences.

#### 13.7.3

The system is to be adequately designed to allow the ship to continue its mission critical operations in a manner that ensures the confidentiality, integrity, and availability of the data necessary for safety of the vessel, its systems, personnel and cargo.

## 15 System Requirements

CBSs in the scope of this section are to be designed with following security capabilities:

***Commentary:***

The requirements in this section are based on the selected requirements in IEC 62443-3-3. To determine the full content, rationale and relevant guidance for each requirement, the reader should consult the referenced standard.

**End of Commentary**

### 15.1 Required Security Capabilities

The following security capabilities are required for all CBSs in the scope of this section.

**TABLE 1**
**Minimum Required Security Capabilities**

| *Item No.* | *Objective* | *Requirements* |
|---|---|---|
| Protect against casual or coincidental access by unauthenticated entities | | |
| 1 | Human user identification and authentication | The CBS is to identify and authenticate all human users who can access the system directly or through interfaces.<br>(based on IEC 62443-3-3/SR 1.1) |

| *Item No.* | *Objective* | *Requirements* |
|---|---|---|
| 2 | Account management | The CBS is to provide the capability to support the management of all accounts by authorized users, including adding, activating, modifying, disabling and removing account.<br>(based on IEC 62443-3-3/SR 1.3) |
| 3 | Identifier management | The CBS is to provide the capability to support the management of identifiers by user, group and role.<br>(based on IEC 62443-3-3/SR 1.4) |
| 4 | Authenticator management | The CBS is to provide the capability to:<br>- Initialize authenticator content<br>- Change all default authenticators upon control system installation<br>- Change/refresh all authenticators<br>- Protect all authenticators from unauthorized disclosure and modification when stored and transmitted.<br>(based on IEC 62443-3-3/SR 1.5) |
| 5 | Wireless access management | The CBS is to provide the capability to identify and authenticate all users (humans, software processes or devices) engaged in wireless communication.<br>(based on IEC 62443-3-3/SR 1.6) |
| 6 | Strength of password-based authentication | The CBS is to provide the capability to enforce configurable password strength based on minimum length and variety of character types.<br>(based on IEC 62443-3-3/SR 1.7) |
| 7 | Authenticator feedback | The CBS is to obscure feedback during the authentication process.<br>(based on IEC 62443-3-3/SR 1.10) |
| Protect against casual or coincidental access by unauthenticated entities | | |
| 8 | Authorization enforcement | On all interfaces, human users are to be assigned authorizations in accordance with the principles of segregation of duties and least privilege.<br>(based on IEC 62443-3-3/SR 2.1) |
| 9 | Wireless use control | The CBS is to provide the capability to authorize, monitor and enforce usage restrictions for wireless connectivity to the system according to commonly accepted security industry practices.<br>(based on IEC 62443-3-3/SR 2.2) |
| 10 | Use control for portable and mobile devices | When the CBS supports use of portable and mobile devices, the system is to include the capability to<br>a) Limit the use of portable and mobile devices only to those permitted by design<br>b) Restrict code and data transfer to/from portable and mobile devices<br>Note: Port limits / blockers (and silicone) could be accepted for a specific system<br>(based on IEC 62443-3-3/SR 2.3) |
| 11 | Mobile code | The CBS is to control the use of mobile code such as java scripts, ActiveX and PDF.<br>(based on IEC 62443-3-3/SR 2.4) |
| 12 | Session lock | The CBS is to be able to prevent further access after a configurable time of inactivity or following activation of manual session lock.<br>(based on IEC 62443-3-3/SR 2.5) |
| 13 | Auditable events | The CBS is to generate audit records relevant to security for at least the following events: access control, operating system events, backup and restore events, configuration changes, loss of communication.<br>(based on IEC 62443-3-3/SR 2.8) |

| *Item No.* | *Objective* | *Requirements* |
|---|---|---|
| 14 | Audit storage capacity | The CBS is to provide the capability to allocate audit record storage capacity according to commonly recognized recommendations for log management. Auditing mechanisms are to be implemented to reduce the likelihood of such capacity being exceeded.<br>(based on IEC 62443-3-3/SR 2.9) |
| 15 | Response to audit processing failures | The CBS is to provide the capability to prevent loss of essential services and functions in the event of an audit processing failure.<br>(based on IEC 62443-3-3/SR 2.10) |
| 16 | Timestamps | The CBS is to timestamp audit records.<br>(based on IEC 62443-3-3/SR 2.11) |
| Protect the integrity of the CBS against casual or coincidental manipulation | | |
| 17 | Communication integrity | The CBS is to protect the integrity of transmitted information.<br>Note: Cryptographic mechanisms are to be employed for wireless networks.<br>(based on IEC 62443-3-3/SR 3.1) |
| 18 | Malicious code protection | The CBS is to provide capability to implement suitable protection measures to prevent, detect and mitigate the effects due to malicious code or unauthorized software. It is to have the feature for updating the protection mechanisms.<br>(based on IEC 62443-3-3/SR 3.2) |
| 19 | Security functionality verification | The CBS is to provide the capability to support verification of the intended operation of security functions and report when anomalies occur during maintenance.<br>(based on IEC 62443-3-3/SR 3.3) |
| 20 | Deterministic output | The CBS is to provide the capability to set outputs to a predetermined state if normal operation cannot be maintained as a result of an attack. The predetermined state could be:<br>• Unpowered state<br>• Last-known value or<br>• Fixed value<br>(based on IEC 62443-3-3/SR 3.6) |
| Prevent the unauthorized disclosure of information via eavesdropping or casual exposure | | |
| 21 | Information confidentiality | The CBS is to provide the capability to protect the confidentiality of information for which explicit read authorization is supported, whether at rest or in transit.<br>Note: For wireless network, cryptographic mechanisms are to be employed to protect confidentiality of all information in transit.<br>(based on IEC 62443-3-3/SR 4.1) |
| 22 | Use of cryptography | If cryptography is used, the CBS is to use cryptographic algorithms, key sizes and mechanisms according to commonly accepted security industry practices and recommendations.<br>(based on IEC 62443-3-3/SR 4.3) |
| Monitor the operation of the CBS and respond to incidents | | |
| 23 | Audit log accessibility | The CBS is to provide the capability for accessing audit logs on read only basis by authorized humans and/or tools.<br>(based on IEC 62443-3-3/SR 6.1) |

| *Item No.* | *Objective* | *Requirements* |
|---|---|---|
| 24 | Denial of service protection | The CBS is to provide the minimum capability to maintain essential functions during DoS events.<br>(based on IEC 62443-3-3/SR 7.1)<br>**Note** :<br>*i)* It is acceptable that the CBS may operate in a degraded mode upon DoS events, but it is not to fail in a manner which may cause hazardous situations.<br>*ii)* Overload-based DoS events are to be considered (i.e., where the networks capacity is attempted flooded, and where the resources of a computer is attempted consumed). (IEC 62443-3-3/SR 7.1) |
| 25 | Resource management | The CBS is to provide the capability to limit the use of resources by security functions to prevent resource exhaustion.<br>(based on IEC 62443-3-3/SR 7.2) |
| 26 | System backup | The identity and location of critical files and the ability to conduct backups of user-level and system-level information (including system state information) is to be supported by the CBS without affecting normal operations.<br>(based on IEC 62443-3-3/SR 7.3) |
| 27 | System recovery and reconstitution | The CBS is to provide the capability to be recovered and reconstituted to a known secure state after a disruption or failure.<br>(based on IEC 62443-3-3/SR 7.4) |
| 28 | Alternative power source | The CBS is to provide the capability to switch to and from an alternative power source without affecting the existing security state or a documented degraded mode.<br>(based on IEC 62443-3-3/SR 7.5) |
| 29 | Network and security configuration settings | The CBS traffic is to provide the capability to be configured according to recommended network and security configurations as described in guidelines provided by the supplier. The CBS is to provide an interface to the currently deployed network and security configuration settings.<br>(based on IEC 62443-3-3/SR 7.6) |
| 30 | Least Functionality | The installation, the availability and the access rights of the following is to be limited to the strict needs of the functions provided by the CBS:<br>- operating systems software components, processes and services<br>- network services, ports, protocols, routes and hosts accesses and any software<br>(based on IEC 62443-3-3/SR 7.7) |

## 15.3 Additional Security Capabilities

The following additional security capabilities listed in 4-9-14/15.3 TABLE 2 are required for CBSs with network communication to untrusted networks (i.e., interface to any networks outside the scope of CBS covered in Section 4-9-13).

CBSs with communication traversing the boundaries of security zones are also to meet the requirements for network segmentation and zone boundary protection in 4-9-13/13.3.1, 4-9-13/13.3.2.

## TABLE 2
## Additional Security Capabilities

| *Item* | *Objective* | *Requirements* |
|---|---|---|
| 31 | Multifactor authentication for human users | Multifactor authentication is required for human users when accessing the CBS from or via an untrusted network.<br>(based on IEC 62443-3-3/SR 1.1, RE 2) |
| 32 | Software process and device identification and authentication | The CBS is to identify and authenticate software processes and devices.<br>(based on IEC 62443-3-3/SR 1.2) |
| 33 | Unsuccessful login attempts | The CBS is to enforce a limit of consecutive invalid login attempts from untrusted networks during a specified time period.<br>(based on IEC 62443-3-3/SR 1.11) |
| 34 | System use notification | The CBS is to provide the capability to display a system use notification message before authenticating. The system use notification message is to be configurable by authorized personnel.<br>(based on IEC 62443-3-3/SR 1.12) |
| 35 | Access via Untrusted Networks | Any access to the CBS from or via untrusted networks is to be monitored and controlled.<br>(based on IEC 62443-3-3/SR 1.13) |
| 36 | Explicit access request approval | The CBS is to deny access from or via untrusted networks unless explicitly approved by authorized personnel on board.<br>(based on IEC 62443-3-3/SR 1.13, RE1) |
| 37 | Remote session termination | The CBS is to provide the capability to terminate a remote session either automatically after a configurable time period of inactivity or manually by the user who initiated the session.<br>(based on IEC 62443-3-3/SR 2.6) |
| 38 | Cryptographic integrity protection | The CBS is to employ cryptographic mechanisms to recognize changes to information during communication with or via untrusted networks.<br>(based on IEC 62443-3-3/SR 3.1, RE1) |
| 39 | Input validation | The CBS is to validate the syntax, length and content of any input data via untrusted networks that is used as process control input or input that directly impacts the action of the CBS. (IEC 62443-3-3/SR 3.5) |
| 40 | Session integrity | The CBS is to protect the integrity of sessions. Invalid session IDs are to be rejected.<br>(based on IEC 62443-3-3/SR 3.8) |
| 41 | Invalidation of session IDs after session termination | The system is to invalidate session IDs upon user logout or other session termination (including browser sessions.<br>(based on IEC 62443-3-3/SR 3.8, RE1) |

# 17 Secure Development Lifecycle Requirements

## 17.1 General

### 17.1.1

A Secure Development Lifecycle (SDLC) broadly addressing security aspects in following stages is to be followed for the development of systems or equipment.

- Requirement analysis phase

- Design phase
- Implementation phase
- Verification phase
- Release phase
- Maintenance Phase
- End of life phase

#### 17.1.2

A document, is to be produced that records how the security aspects have been addressed in above phases and is at minimum to integrate controlled processes as set out in below 4-9-14/17.3.

### 17.3 Security Management

#### 17.3.1

The manufacturer is to have procedural and technical controls in place to protect private keys used for code signing, if applciable, from unauthorized access or modification.

***Commentary:***

This requirement is based on IEC 62443-4-1/SM-8.

**End of Commentary**

#### 17.3.2

A process is to be employed to ensure that documentation about product security updates is made available to users (which could be through establishing a cyber security point of contact or periodic publication which can be accessed by the user) that includes but is not limited to:

***i)*** The product version number(s) to which the security patch applies;

***ii)*** Instructions on how to apply approved patches manually and via an automated process;

***iii)*** Description of any impacts that applying the patch to the product can have, including reboot;

***iv)*** Instructions on how to verify that an approved patch has been applied; and

***v)*** Risks of not applying the patch and mediations that can be used for patches that are not approved or deployed by the asset owner.

***Commentary:***

This requirement is based on IEC 62443-4-1/SUM-2.

**End of Commentary**

#### 17.3.3

A process is to be employed to ensure that documentation about dependent component or operating system security updates is available to users that includes but is not limited to:

***i)*** Stating whether the product is compatible with the dependent component or operating system security update.

***Commentary:***

This requirement is based on IEC 62443-4-1/SUM-3.

**End of Commentary**

*17.3.4(a)*

*17.3.4(a)*

A process is to be employed to ensure that security updates for all supported products and product versions are made available to product users in a manner that facilitates verification that the security patch is authentic.

*17.3.4(b)*

The manufacturer is to have QA process to test the update before releasing.

***Commentary:***

This requirement is based on IEC 62443-4-1/SUM-4.

4-9-14/17.3.4(b) is an IACS supplemental requirement.

**End of Commentary**

### 17.3.5

A process is to exist to create product documentation that describes the security defence in depth strategy for the product to support installation, operation and maintenance that includes:

***i)*** Security capabilities implemented by the product and their role in the defence in depth strategy;

***ii)*** Threats addressed by the defence in depth strategy; and

***iii)*** Product user mitigation strategies for known security risks associated with the product, including risks associated with legacy code.

***Commentary:***

This requirement is based on IEC 62443-4-1/SG-1.

**End of Commentary**

### 17.3.6

A process is to be employed to create product user documentation that describes the security defence in depth measures expected to be provided by the external environment in which the product is to be used.

***Commentary:***

This requirement is based on IEC 62443-4-1/SG-2.

**End of Commentary**

### 17.3.7

A process is to be employed to create product user documentation that includes guidelines for hardening the product when installing and maintaining the product. The guidelines are to include, but are not limited to, instructions, rationale and recommendations for the following:

***i)*** Integration of the product, including third-party components, with its product security context

***ii)*** Integration of the product's application programming interfaces/protocols with user applications;

***iii)*** Applying and maintaining the product's defence in depth strategy

***iv)*** Configuration and use of security options/capabilities in support of local security policies, and for each security option/capability:

*a)* its contribution to the product's defence in depth strategy

*b)* descriptions of configurable and default values that include how each affects security along with any potential impact each has on work practices; and

*c)* setting/changing/deleting its value;

*v)* Instructions and recommendations for the use of all security-related tools and utilities that support administration, monitoring, incident handling and evaluation of the security of the product;

*vi)* Instructions and recommendations for periodic security maintenance activities;

*vii)* Instructions for reporting security incidents for the product to the product supplier;

*viii)* Description of the security best practices for maintenance and administration of the product.

***Commentary:***

This requirement is based on IEC 62443-4-1/SG-3.

**End of Commentary**

# 19 Approval Under the Type Approval Program

## 19.1 General

### 19.1.1 Application

Computer based systems that are routinely manufactured and include standardized software functions can be type approved in accordance with applicable requirements in Section 4-9-3 and Section 4-9-14 as part of the ABS Type Approval Program (see 4-1-1/3.3). See 4-9-3/11.

### 19.1.2 Product Design Assessment

(PDA) Upon application by the manufacturer, each computer based system or component with standardized software functions may be design assessed as described in 1A-1-A3/5.1 of the ABS *Rules for Conditions of Classification (Part 1A)*.

For this purpose, computer based systems or components are to be approved in accordance with requirements in 4-9-14/9.1.3 through 4-9-14/9.1.9, 4-9-14/15 and 4-9-3/11.3.1.

The test of security capabilities are to be conducted in accordance with an approved test schedule (4-9-14/9.1.4) and are to be witnessed by a Surveyor. See 4-9-14/21. Documentation to verify the secure lifestyle development is to inspected in accordance with 4-9-14/21.1.4. Also see 4-9-3/13.3.2 for other tests to be witnessed by the surveyor.

Computer based systems or components so approved may be applied to ABS for listing on the ABS website as Products Design Assessed. Once listed, and subject to renewal and updating of certificate as required by 1A-1-A3/5.7 of the ABS *Rules for Conditions of Classification (Part 1A)*.

### 19.1.3 Mass Produced Products

Manufacturer of mass-produced CBS or its components, who operates a quality assurance system in the manufacturing facilities, may apply to ABS for quality assurance assessment described in 1A-1-A3/5.5 (PQA) of the ABS *Rules for Conditions of Classification (Part 1A)*.

Upon satisfactory assessment under 1A-1-A3/5.5 (PQA) of the ABS *Rules for Conditions of Classification (Part 1A)*, Computer based systems or components produced in those facilities will not require a Surveyor's attendance at the tests and inspections indicated in 4-9-14/9.1.4. Such tests and inspections are to be carried out by the manufacturer whose quality control documents will be accepted. Certification of CBS will be based on verification of approval of the design and on continued effectiveness of the quality assurance system. See 1A-1-A3/5.7.1(a) of the ABS *Rules for Conditions of Classification (Part 1A)*. See also 4-9-3/11.3.3.

### 19.1.4 Non-mass Produced products

Manufacturer of non-mass produced CBS or its components, who operates a quality assurance system in the manufacturing facilities, may apply to ABS for quality assurance assessment described in 1A-1-A3/5.3.1(a) (AQS) or 1A-1-A3/5.3.1(b) (RQS) of the ABS *Rules for Conditions of Classification (Part 1)*. Certification to 1A-1-A3/5.5 (PQA) of the ABS *Rules for Conditions of Classification (Part 1A)* may also be considered in accordance with 4-1-1/9 TABLE 3.

### 19.1.5 Type Approval Program

Computer based systems or components approved in accordance with 4-9-3/11.3.1 and 4-9-14/19.1.1 and the quality assurance system of their manufacturing approved in accordance with 4-9-3/11.3.3 or 4-9-3/11.3.4, 4-9-14/19.1.3 or 4-9-14/19.1.4 will be deemed Type Approved and will be eligible for listing on the ABS website as Type Approved.

### 19.1.6 Unit Certification

When a type approved computer based system or component is proposed for use on board a vessel, a vessel-specific system certification verifying complaince with applicable requirments from Sections 4-9-3, 4-9-13 and 4-9-14 is still required since vessel specific functions, parameter configurations and installation elements demand vessel specific verification are to be reviewed and tested.

Tests listed in 4-9-3/17 TABLE 5, 4-9-9/13.3 are to be witnessed by ABS Survey as part of the Unit Certification. See the following 4-9-14/19.1.6 TABLE 3 for the list of documents required for unit certification of CBS specific to cyber security.

## TABLE 3

Summary of Documents to be Submitted by the Supplier

| Rule Reference | Document | Requirements | Document Required for CBS without Type Approved Security Capabilities | Document Required for CBS with Type Approved Security Capabilities per 4-9-14 |
|---|---|---|---|---|
| 4-9-14/9.1.1 | CBS asset inventory | To be incorporated in Vessel asset inventory (see 4-9-13/13.1.1) | X | X |
| 4-9-14/9.1.2 | Topology diagrams | Enabling System integrator to design security zones and conduits (see 4-9-13/13.3.1) | X | X |

| | | | | |
|---|---|---|---|---|
| 4-9-14/9.1.3 | Description of security capabilities | Required security capabilities (see 4-9-14/15.1)<br>Additional security capabilities, if applicable (see 4-9-14/15.3) | X | |
| 4-9-14/9.1.4 | Test procedure for security capabilities | Required security capabilities(see 4-9-14/15.1)<br>Additional security capabilities, if applicable (see 4-9-14/15.3) | X | |
| 4-9-14/9.1.5 | Security configuration guidelines | Network and security configuration settings (see 4-9-14/15.1 Table 1, item 29) | X | |
| 4-9-14/9.1.6 | Secure development lifecycle | SDLC requirements (see 4-9-14/17) | X | |
| 4-9-14/9.1.7 | Plans for maintenance and verification | Security functionality verification (see 4-9-14/15.1 Table 1, item 19) | X | |
| 4-9-14/9.1.8 | Information supporting incident response and recovery plans | Auditable events (4-9-14/15.1 Table 1, item 13)<br>Deterministic output (4-9-14/15.1 Table 1, item 20)<br>System backup (4-9-14/15.1 Table 1, item 26)<br>System recovery and reconstitution (4-9-14/15.1 Table 1, item 27) | X | |
| 4-9-14/9.1.9 | Management of change plan | Management of change process (See 4-9-3/10) | X | |
| 4-9-14/9.1.10 | Test reports | Configuration of security capabilities and hardening (See 4-9-14/9.1.5,17.3.7) | X | X |

# 21 Testing, Inspection and Certification of Cyber Resilience Capabilities for Computer Based Systems

## 21.1 Shop Survey and Factory Acceptance Test (FAT)

The objective of the shop survey and FAT is to demonstrate by testing and/or analytic evaluation that the CBS complies with applicable cyber resilience requirements in this section. The survey and FAT is to be carried out at the supplier's premises or at other works having the adequate apparatus for testing and inspection.

After completed plan approval and survey/FAT, ABS will issue a report that is to be accompany the CBS upon delivery to the system integrator per 4-9-13/15 "Test Plan for Performance Evaluation and Testing".

The following activities are to be verified by/witnessed by the ABS Surveyor during the shop survey and FAT.

### 21.1.1 General

*i)* Surveyor is to verify the design, construction, and internal testing has been completed.

*ii)* Surveyor is to verify the system to be delivered is correctly represented by the approved documentation. This is to be done by inspecting the system and comparing the components and arrangement/architecture with the asset inventory (4-9-14/9.1.1) and the topology diagrams (4-9-14/9.1.2).

### 21.1.2 Test of Security Capabilities

*i)* Surveyor is to witness tests to verify the security capabilities of the system to be delivered. The tests are to be carried out in accordance with the ABS Engineering reviewed test procedure in 4-9-14/9.1.4. The tests are to provide the Surveyor with reasonable assurance that all requirements are met. Testing of identical components is normally not required.

### 21.1.3 Correct Configuration of Security Capabilities

*i)* The supplier is to test/demonstrate to the Surveyor that security settings in the system's components have been configured in accordance with the configuration guidelines in 4-9-14/9.1.5. This demonstration may be carried out in conjunction with testing of the security capabilities.

*ii)* The security settings are to be documented in a report (e.g., a ship-specific instance of the configuration guidelines).

### 21.1.4 Secure Development Lifecycle

The Supplier, in accordance with documentation in section 4-9-14/9.1.6, is to demonstrate compliance with requirements for secure development lifecycle in 4-9-14/17 to the attending Surveyor.

*21.1.4(a) Controls for private keys (IEC 62443-4-1/SM-8)*

*i)* This requirement applies if the system includes software that is digitally signed for the purpose of enabling the user to verify its authenticity. The Surveyor is to verify the Supplier presented management system documentation substantiating that policies, procedures and technical controls are in place to protect generation, storage and use of private keys used for code signing from unauthorized access. The policies and procedures are to address roles, responsibilities and work processes. The technical controls are to include e.g., physical access restrictions and cryptographic hardware (e.g., hardware security module) for storage of the private key.

*21.1.4(b) Security update documentation (IEC 62443-4-1/SUM-2)*

*i)* The Surveyor is to verify the Supplier presented management system documentation substantiating that a process is established in the organization to ensure security updates are informed to the users. The information to the users is to include the items listed in section 4-9-14/17.3.2.

*21.1.4(c) Dependent component security update documentation (IEC 62443-4-1/SUM-3)*

***i)*** The Surveyor is to verify the Supplier presented management system documentation, as required by section 4-9-14/17.3.3, substantiating that a process is established in the organization to ensure users are informed whether the system is compatible with updated versions of acquired software in the system (new versions/patches of operating system or firmware). The information is to address how to manage risks related to not applying the updated acquired software.

*21.1.4(d) Security update delivery (IEC 62443-4-1/SUM-4)*

***i)*** The Surveyor is to verify the Supplier presented management system documentation, as required by section 4-9-14/17.3.4, substantiating that a process is established in the organization ensuring that system security updates are made available to users, and describing how the user may verify the authenticity of the updated software.

*21.1.4(e) Product defence in depth (IEC 62443-4-1/SG-1)*

***i)*** The Surveyor is to verify the Supplier presented management system documentation, as required by section 4-9-14/17.3.5, substantiating that a process is established in the organization to document a strategy for defence-in-depth measures to mitigate security threats to software in the CBS during installation, maintenance and operation. Examples of threats could be installation of unauthorised software, weaknesses in the patching process, tampering with software in the operational phase of the ship.

*21.1.4(f) Defence in depth measures expected in the environment (IEC 62443-4-1/SG-2)*

***i)*** The Surveyor is to verify the Supplier presented management system documentation, as required by section 4-9-14/17.3.6, substantiating that a process is established in the organization to document defence-in-depth measures expected to be provided by the external environment, such as physical arrangement, policies and procedures.

*21.1.4(g) Security hardening guidelines (IEC 62443-4-1/SG-3)*

***i)*** The Surveyor is to verify the Supplier presented management system documentation, as required by 4-9-14/17.3.7, substantiating that a process is established in the organization to ensure that hardening guidelines are produced for the system. The guidelines is to specify how to reduce vulnerabilities in the system by removal/prohibiting /disabling of unnecessary software, accounts, services, etc.