IEC 60092-504

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REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Electrical installations in ships –
Part 504: ~~Special features~~ –
Automation, control and instrumentation

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRICAL INSTALLATIONS IN SHIPS –

Part 504: ~~Special features –~~ Automation, control and instrumentation

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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This Redline version provides you with a quick and easy way to compare all the changes between this standard and its previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60092-504 has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units.

This fourth edition cancels and replaces the third edition published in 2001. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) the part title has been changed, the term “Automation” was added;
b) the contents of the corrigendum of January 2011 have been included;
c) a new subclause 5.1 “General” with general requirements for type testing has been added;
d) Table 1 contents aligned with current version of document IACS Req. 1991/Rev. 5, 2006;
e) the revised IMO Resolution A.1021(26), Code on alerts and indicators:2009 has been taken into account;
f) IMO Resolution MSC.302(87) has been taken into account. As a consequence, the term “alert” has been used where the generic term applies. This concerns, in particular, the text in 8.4 and 9.3;
g) a new subclause 8.2.4: The revised IMO Resolution MSC.145(77), Performance standards for water level detectors on bulk carriers:2003 has been taken into account;
h) subclause 9.1 about fire detection and alarm systems has been completely revised, IMO Resolution MSC.98(73) (FSS Code) with amendment MSC.292(87): 2010 has been taken into account;
i) a new subclause 9.2 “Bilge systems” has been added;
j) the subclauses 9.4 “Automatic control installations for electrical power supply” and 9.5 “Automatic starting installations for electrical motor-driven auxiliaries” have been completely revised;
k) Clause 10 “Computer based systems” has been completely revised;
l) a new subclause 10.3.6 about wireless data communication has been added;
m) a new subclause 10.5 about remote access has been added.

The text of this standard is based on the following documents:

FDIS	Report on voting
18/1539/FDIS	18/1545/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60092 series, under the general title *Electrical installations in ships,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

IEC 60092 forms a series of international standards ~~intended to ensure safety in the design, selection, installation, maintenance and use of electrical equipment for the generation, storage, distribution and utilization of electrical energy for all purposes~~ for electrical installations in sea-going ships, incorporating good practice and coordinating, as far as possible, existing rules.

~~This part of IEC 60092 also incorporates and co-ordinates, as far as possible, existing rules and forms a code of interpretation, where applicable, of the requirements of the International Maritime Organization, and serves as~~ These standards form a code of practical interpretation and amplification of the requirements of the International Convention for the Safety of Life at Sea, a guide for future regulations which may be prepared and a statement of practice for use by ship owners, shipbuilders and appropriate organizations~~, and by constructors and appropriate organizations~~.

~~This standard is based on equipment and practices which are in current use, but it is not intended in any way to impede development of new or improved techniques.~~

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 504: ~~Special features –~~ Automation, control and instrumentation

1 Scope

This part of IEC 60092 ~~deals with~~ specifies electrical, electronic and programmable equipment intended for automation, control, monitoring, ~~alarm~~ alert, and safety and protection systems for use in ships.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at www.electropedia.org)

IEC 60068-2-1, *Environmental testing – Part 2: Tests – Test~~s~~ A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2: Tests – Test~~s~~ B: Dry heat*

IEC 60068-2-6, *Environmental testing – Part 2: Tests – Test~~s~~ Fc: Vibration (sinusoidal)*

IEC 60068-2-30, *Environmental testing – Part 2: Tests – Test~~s~~ Db ~~and guidance~~: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-52, *Environmental testing – Part 2: Tests – Test~~s~~ Kb: Salt mist, cyclic (sodium chloride solution)*

~~IEC 60092 (all parts), *Electrical installations in ships*~~

IEC 60092-101:1994, *Electrical installations in ships – Part 101: Definitions and general requirements*
IEC 60092-101:1994/AMD1:1995

IEC 60092-201:1994, *Electrical installations in ships – Part 201: System design – General*

IEC 60092-202, *Electrical installations in ships – Part 202: System design – Protection*

~~IEC 60092-204, *Electrical installations in ships – Part 204: System design – Electric and electrohydraulic steering gear*~~

IEC 60092-302, *Electrical installations in ships – Part 302: Low-voltage switchgear and controlgear assemblies*

~~IEC 60092-375, *Electrical installations in ships. Shipboard telecommunication cables and radio-frequency cables. General instrumentation, control and communication cables*~~

~~IEC 60092-376, *Electrical installations in ships – Part 376: Shipboard multicore cables for control circuits*~~

~~IEC 60092-401, *Electrical installations in ships – Part 401: Installation and test of completed installation*~~

IEC 60092-501, *Electrical installations in ships – Part 501: Special features – Electric propulsion plant*

IEC 60092-502, *Electrical installations in ships – Part 502: Tankers – Special features*

IEC 60447, *Basic and safety principles for man-machine interface ~~(MMI)~~, marking and identification – Actuating principles*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60533, *Electrical and electronic installations in ships – Electromagnetic compatibility (EMC) – Ships with a metallic hull*

IEC 60945, *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and ~~measurement~~ measuring techniques – Electrostatic discharge immunity test. ~~Basic EMC Publication~~*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test. ~~Basic EMC Publication~~*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and ~~measuring~~ measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61355-1, *Classification and designation of documents for plants, systems and equipment – Part 1: Rules and classification tables*

IEC 62443 (all parts), *Industrial communication networks – Network and system security*

ABS publication, *Guidance notes on the application of ergonomics to marine systems (2014-02)*

CISPR 16-1-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-2-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

EN 54 (all parts), *Fire detection and fire alarm systems*

~~IMO Assembly Resolution A.830 (19)1995, *Code on Alarms and Indicators* [1]~~

IMO Resolution A.1021(26):2009, *Code on alerts and Indicators*

~~NOTE Other informative IMO documents are referenced within the text of this standard.~~

IMO Resolution MSC.302(87):2010, *Adoption of performance standards for bridge alert management (BAM)*

IMO Resolution A.813(19):1995, *General Requirements for Electromagnetic Compatibility (EMC) for all Electrical and Electronic Ship's Equipment*

IMO Resolution MSC.98(73):2000, *Adoption of the international code for fire safety systems (FSS Code)*

SOLAS, *International Convention for the Safety of Life at Sea (SOLAS):1974, consolidated edition, 2009*

3 Terms and definitions

For the purposes of this document, the terms and definitions~~, having special application to the control, monitoring, alarm and protection equipment~~ given in IEC 60050 as well as the following apply.~~ For definitions of general and more particular terms, reference is made to IEC 60050 (IEV) and other normative documents.~~

3.1
accuracy
quality which characterizes the closeness of a measured value to the corresponding true value

~~**3.2**~~
~~**alarm functions**~~
~~functions intended to alert relevant personnel, by visual and audible means, in the event of any condition requiring their attention~~

3.2
administration
Government of the State whose flag the ship is entitled to fly

[SOURCE: SOLAS, Chapter I, Regulation 2, Definition (b)]

3.3
availability
ability of an item to be in a state to perform a required function under given conditions at a given time interval, assuming that the required external resources are provided

3.4
centralized control
control of all operations of a controlled system from one central control position

_____

~~[1] See IMO 867E:1996, *Code on Alarms and Indicators*, 1995~~

3.5
computer based system
system that consists of one or more programmable electronic devices with their connections, peripherals and software necessary to carry out automatically specified functions

Note 1 to entry: The following types of programmable devices could form part of a computer system: main-frame, mini-computer, micro-processor-based computer, programmable logic controller.

3.6
control functions
functions intended to regulate the behaviour of equipment or systems

3.7
control position
control station
group of control devices by which an operator can control the performance of a machine, apparatus, process or assembly of machines and apparatus

Note 1 to entry: A control position will generally enable an operator to verify the achievement of the desired conditions by means of an appropriate monitoring system

3.8
dependability
extent to which a system can be relied upon to perform its intended functions under defined operational and environmental conditions

3.9
essential services
functions necessary for the propulsion, steering and safety of the ship and its personnel

3.10
~~**fail-to-safe**~~
~~principle by which a failure or malfunction of a component of the system causes its output to automatically adjust to a predetermined safe state~~

failsafe
design property of an item which prevents its failures from resulting in critical faults

Note 1 to entry: The safe state, according to the application, will be predetermined in terms of priority for the safety of the ship and may generally be taken as the least critical one for the main components and auxiliaries of, for example, the propulsion/manoeuvring plant.

[SOURCE IEC 60050-821: 1998, 821-01-10, modified – a note has been added.]

3.11
function
elementary operation performed by the system which, in conjunction with other elementary operations (system functions), enables the system to perform a task

~~**3.12**~~
~~**indication functions**~~
~~functions intended to inform relevant personnel, by visual and/or audible means, of any equipment or system status~~

3.12
integrity
capability of a system to satisfactorily perform the required functions under all the stated conditions within a stated period of time

3.13
machinery control room
room or spaces where centralized controls and measuring and monitoring equipment for main equipment and essential auxiliary machinery are located together with the appropriate means of communication

3.14
maintainability
ability of an item under given conditions of use, to be retained in, or restored to, a state in which it can perform a required function, when maintenance is performed under given conditions and using stated procedures and resources

Note 1 to entry: The term "maintainability" is also used as a measure of maintainability performance.

3.15
monitoring functions
functions intended to collect data from equipment and systems for the purpose of display and recording

3.16
protection functions
functions intended to prevent damage to equipment or systems in the event of a fault

3.17
reliability (performance)
ability of an item to perform a required function under given conditions for a given time interval

Note 1 to entry: It is generally assumed that the item is in a state to perform this required function at the beginning of the time interval.

Note 2 to entry: Generally, reliability performance is quantified using appropriate measures. In some applications, these measures include an expression of reliability performance as a probability, which is also called reliability.

[SOURCE: IEC 60050-312:2001, 312-07-06, modified – notes 1 and 2 have been added.]

3.18
protection and safety functions
functions intended to prevent harm or danger to personnel and protect equipment/systems

3.19
software
computer programs, procedures, rules and associated documentation of a digital information processing system pertaining to the operation ~~of a computer system~~ and including application (user) program, middleware and operating system (firmware) program

3.20
system
collection of components organised to accomplish a specific function or set of functions

3.21
usability
extent to which a system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use

3.22
bridge and deck zone
area from which the ship is steered and navigated and where the antennas are located

3.23
machinery space
spaces between the watertight boundaries of a space containing the main and auxiliary propulsion machinery, including boilers, generators and electric motors primarily intended for propulsion

Note 1 to entry: In case of unusual arrangements, the administration may define the limits of the machinery spaces.

[SOURCE: SOLAS Chapter II-1, Regulation 2, Definition 15]

3.24
remote control
control of an operation at a point distant from the controlled switching device

[SOURCE IEC 60050-441:2000, 441-16-07]

3.25
process
systematic series of actions that lead to a particular result of an executing instance of a computer program

3.26
automation system
system to monitor and control a process

3.27
instrumentation
instruments and their application for monitoring, measurement and control

3.28
significant modification
modification of the system functionality and/or safety of the system

3.29
PMS
power management system
automatic control system for the generation and distribution of electrical energy

Note 1 to entry: This note applies to the French language only.

4 General requirements

4.1 Dependability

Systems shall be suitable for the user, the task and the application.

System integrity shall be appropriate for the functions supported, with due regard to factors such as availability, reliability and maintainability.

4.2 Safety

Systems shall be designed such that risk of harm to persons or the environment is reduced to a level acceptable to the ~~appropriate authority~~ administration, both in normal operation and under failure conditions. Functions shall be designed on the ~~fail-to-safe~~ failsafe principle.

4.3 Segregation

Systems shall be designed such that failure of one component part or sub-system will not unduly affect any other system, sub-system or component and, as far as is practicable, shall be detectable.

Failure in an automation system shall not influence the protection and safety functions.

Protection ~~(~~and safety~~)~~ functions shall be independent of control ~~and monitoring (alarm)~~ functions. As far as is practicable, control and monitoring (~~alarm~~ alert) functions shall also be independent.

Standby systems, or other redundancy arrangements, are to be functionally independent.

4.4 Performance

Systems shall maintain specified levels of performance in operation, and where necessary, under fault conditions.

Repeatability and accuracy shall be adequate for the proposed use and shall be maintained at their specified value during their expected lifetime and normal use.

Systems shall be stable throughout their operational range.

4.5 Usability

Systems shall be readily usable under all intended operating conditions and shall support effective and efficient operation.

Adequate safeguards against incorrect operation shall be provided.

4.6 Integration

Where safety of personnel may directly depend on correct system operation or failure, such systems shall not be integrated with, or be mutually dependent upon, any other system, except those providing complementary functions.

Where safety may indirectly depend on system operation or failure, the integrity of the integrated system shall be to the satisfaction of the ~~appropriate authority~~ administration.

4.7 Development activities

Activities undertaken in the development process, from initial design through to eventual realisation, and any modifications in use thereafter, shall be planned and structured in a systematic manner, and are to be properly managed. Persons responsible for carrying out these activities shall be competent to do so.

Activities, scopes, responsibilities and competencies shall be documented.

5 Environmental type testing parameters

5.1 General

Standard atmospheric conditions during functional test to equipment specification are defined in Table 1, No. 2.

The tests specified in Table 1 are applicable, but not confined, to all equipment used for:

– automation, control, protection and safety;

– internal communication.

Electrical and electronic equipment on board ships required neither by classification rules nor by International Conventions, liable to cause electromagnetic disturbance shall be of a type which fulfils the test requirements of test specifications regarding radiated and conducted emissions, see Table 1, No. 19 and No. 20.

5.2 Performance

Where equipment or systems are subject to type testing, the test procedures and severities specified in Table 1 shall apply.

~~NOTE~~ Compliance with IMO Resolution A.813(19)[2] will require all ships' electrical and electronic equipment to be tested to the relevant electromagnetic compatibility standard.

[2] ~~IMO A.813 (19):1995, *General requirements for electromagnetic compatibility (EMC) for all electrical and electronic ships equipment*~~

Table 1 – Type tests, test procedures and severities

<table>
<tr><th>No.</th><th>Test [a]</th><th>Procedure according to</th><th>Test parameters, severity</th><th>~~Other information~~ Additional requirement/s</th></tr>
<tr><td>1</td><td>Visual inspection</td><td></td><td></td><td>Examination of the equipment for:
– conformity to drawings and design data;
– compliance with applicable IEC standards;
– quality of workmanship and construction.</td></tr>
<tr><td>2</td><td>Functional test to equipment specification</td><td></td><td>Standard atmospheric conditions:
– temperature: 25 °C ± 10 °C
– relative humidity: 60 % ± 30 %
– air pressure: 96 kPa ± 10 kPa</td><td></td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">High voltage test</td><td rowspan="3"></td><td>Rated insulation voltage U_n
V</td><td>Test voltage AC
V</td><td rowspan="3">Frequency of test voltage: 50 Hz or 60 Hz.
Separate circuits to be tested against each other.
All circuits connected with each other are to be tested against earth.
Contact pieces are to be tested across their open points of contact.
Printed circuits with electronic components which could be subject to damage may be removed during the test.</td></tr>
<tr><td>$U_n \leq 65$
$66 < U_n \leq 250$
$251 < U_n \leq 500$
$501 < U_n \leq 690$</td><td>$2 \times U_n + 500$
1 500
2 000
2 500</td></tr>
<tr><td colspan="2">Period of application of test voltage: 1 min</td></tr>
<tr><td rowspan="11">4a</td><td rowspan="11">Power supply variations</td><td rowspan="11">IEC 61000-4-11</td><td colspan="3">AC supply</td><td></td></tr>
<tr><td>Combination No.</td><td>Voltage variation (permanent)
%</td><td>Frequency variation (permanent)
%</td><td rowspan="10">Each combination shall be tested.</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></td><td>Voltage transient (duration 1,5 s)</td><td>Frequency transient (duration 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">DC supply</td></tr>
</table>

No.	Test [a]	Procedure according to	Test parameters, severity				Other information Additional requirement/s
			Voltage tolerance continuous		±10 %		
			Voltage cyclic variation		5 %		
			Voltage ripple		10 %		
			Electrical battery supply: +30 % to –25 % for equipment connected to charging battery or as determined by the charging/discharging characteristics, including ripple voltage from the charging device; +20 % to –25 % for equipment not connected to the battery during charging.				
4b	Power supply failure	IEC 61000-4-11	Three interruptions during 5 min 30 s break time				Verification of: – specified action of the equipment on loss and restoration of supply; – possible corruption of program or data held in programmable electronic systems, where applicable.
5	Insulation resistance [b]		Rated supply voltage V	Test voltage V	Minimum insulation resistance MΩ		Between all circuits and earth; on the supply terminals where appropriate. Resistance shall be measured before and after high voltage test, damp heat test, cold test and salt mist test.
					Before test	After test	
			$U_n \leq 65$	$2 \times U_n$ min. 24	10	1	
			$U_n > 65$	500	100	10	
6	Cold with gradual change of temperature [c]	IEC 60068-2-1 Test Ab for non-heat dissipating equipment IEC 60068-2-1 Test Ad for heat dissipating equipment	Temperature +5 °C ± 3 °C Duration 2 h		Temperature –25 °C ± 3 °C Duration 2 h		Initial measurement of insulation resistance (see test No 5). Equipment not operating during conditioning except for operational tests. Operational test during last hour at test temperature. Insulation resistance measurement and operational test after recovery.
7	Dry heat with gradual change of temperature [d]	IEC 60068-2-2 Test Bb for non-heat dissipating equipment	Temperature 55 °C ± 2 °C Duration 16 h		Temperature 70 °C ± 2 °C Duration 16 h		Equipment operating during conditioning. Operational test during last hour at test temperature. Operational test after recovery.
		IEC 60068-2-2 Test Be for heat dissipating equipment	Temperature 55 °C ± 2 °C Duration 16 h		Temperature 70 °C ± 2 °C Duration 16 h		Equipment operating during conditioning with cooling system on if provided. Operational test during last hour at test temperature. Operational test after recovery.

No.	Test [a]	Procedure according to	Test parameters, severity	~~Other information~~ Additional requirement/s
8	Damp heat, cyclic (12 h+12 h cycle) [j]	IEC 60068-2-30 Test Db	Temperature: 55 °C Humidity: 95 % Duration: two cycles (12 h + 12 h)	Measurement of insulation resistance before test. Equipment operating during the complete first cycle and switched off during second cycle except for functional test. Functional test during the first 2 h of the first cycle at the test temperature and during the last 2 h of the second cycle at the test temperature. Recovery at standard atmosphere conditions. Insulation resistance measurements and performance test.
9	Salt mist [e]	IEC 60068-2-52 Test Kb	Four spraying periods with a storage of 7 days after each	Initial measurement of insulation resistance and initial functional test. Equipment in its normal position during test. Equipment not operating during conditioning. Operational test on day 7 of each spraying period. Insulation resistance measurement and performance test 4 h to 6 h after the recovery period.
10	Vibration (sinusoidal)	IEC 60068-2-6 Test Fc	For general applications: 2^{+3}_{0} Hz to 13,2 Hz Amplitude ± 1 mm > 13,2 Hz to 100 Hz Acceleration ± 0,7 g Endurance at: – each resonance frequency at which an amplification factor $Q \geq 2$ is recorded; – 30 Hz if no resonance frequency is recorded. For equipment mounted on reciprocating machines, installed in steering gear compartment or similar locations: 2,0 Hz to 25 Hz Amplitude ± 1,6 mm > 25 Hz to 100 Hz Acceleration ± 4 g Endurance at: – each resonance frequency at which an amplification factor $Q \geq 2$ is recorded; – 30 Hz if no resonance frequency is recorded.	During the vibration test, operational conditions shall be demonstrated. Tests shall be carried out in three mutually perpendicular planes. It is recommended as guidance that Q does not exceed 5. If sweep test is chosen, where several resonance frequencies are detected close to each other, duration of test shall be 120 min.

No.	Test [a]	Procedure according to	Test parameters, severity	~~Other information~~ Additional requirement/s
			Only for extreme conditions: 40 Hz to 2 000 Hz, acceleration ±10 g Duration 90 min	For example on exhaust manifolds of diesel engines
11a	Inclination steady [a, i]		22,5°	Each direction Equipment operating
11b	Inclination dynamic		22,5° 0,1 Hz	Each direction Equipment operating Duration of test not less than 15 min
12	Enclosure protection	IEC 60529	Dependent on location	Minimum requirements for the degree of protection are given in IEC 60092-201.
13	Electrostatic discharge	IEC 61000-4-2	Contact discharge: 6 kV Air discharge: 8 kV Interval between single discharges: 1 s Number of pulses: 10 per polarity According to test level 3 ~~severity standard~~	Electrostatic discharge as may occur when persons touch the appliance. The test is to be confined to the points and surfaces that can normally be reached by the operator. Performance criterion B [f].
14	Electro-magnetic field	IEC 61000-4-3	Frequency range: 80 MHz to 6 GHz Modulation: 80 % AM at 1 000 Hz Field strength: 10 V/m Frequency sweep rate: ≤ 1,5 × 10^{-3} decades/s (or 1 %/3 s) According to test level 3 ~~severity standard~~	Electromagnetic fields radiated by different transmitters. If for tests of equipment an input signal with a modulation frequency of 1 000 Hz is necessary, a modulation frequency of 400 Hz may be chosen. Performance criterion A [g].
15	Conducted low frequency	IEC 60533	AC power supply port: Frequency range: rated frequency to 200th harmonic Test voltage (r.m.s.): 10 % of supply voltage to 15th harmonic reducing to 1 % at 100th harmonic and maintain this level to the 200th harmonic, max. 2 W DC power supply port: Frequency range: 50 Hz to 10 kHz Test voltage (r.m.s.): 10 % of supply voltage, max. 2 W	Distortions in the power supply system generated for instance by electronic consumers and coupled in as harmonics. Method of the test in accordance with IEC 60945. Performance criterion A [g].
16	Conducted radio frequency	IEC 61000-4-6	Frequency range: 150 kHz to 80 MHz Amplitude: 3 V r.m.s. [h] Modulation: 80 % AM at 1 000 Hz Frequency sweep range ≤ 1,5 × 10^{-3}decades/s (or 1 %/3 s) According to test level 2 ~~severity standard~~	Electromagnetic fields coupled as high frequency into the test specimen via the connecting lines. If for tests of equipment an input signal with a modulation frequency of 1 000 Hz is necessary, a modulation frequency of 400 Hz may be chosen. Performance criterion A: see note [g].

<table>
<tr><th>No.</th><th>Test [a]</th><th>Procedure according to</th><th>Test parameters, severity</th><th>~~Other information~~ Additional requirement/s</th></tr>
<tr><td>17</td><td>Burst/fast transients</td><td>IEC 61000-4-4</td><td>Single pulse time: 5 ns (between 10 % and 90 % value)
Pulse width: 50 ns (50 % value)
Amplitude (peak):
– 2 kV line on power supply port to earth port (PE);
– 1 kV on I/O data control and communication ports (with coupling clamp);
Pulse period: 300 ms
Burst duration: 15 ms
Duration perpolarity: 5 min
According to test level 3 ~~severity standard~~</td><td>Arcs generated when actuating electrical contacts.
Interference effect occurring on the power supply, as well as the external wiring of the test specimen.
Performance criterion B [f].</td></tr>
<tr><td>18</td><td>Surge/slow transients</td><td>IEC 61000-4-5</td><td>Test applies to AC and DC power supply ports.
Pulse rise time: 1,2 µs (between 10 % and 90 % value)
Pulse width: 50 µs (50 % value)
Amplitude (peak): 1 kV line-to-earth
0,5 kV line-to-line
Repetition rate ≥1 pulse/min
Number of pulses: 5 per polarity
Application: continuous
According to test level 2 ~~severity standard~~</td><td>Interference generated for instance, by switching "ON" or "OFF" high power inductive consumers.
Procedure in accordance with Figure 10 of IEC 61000-4-5:2014 for equipment where power and signal lines are identical.
Performance criterion B [f].</td></tr>
<tr><td>19</td><td>Radiated emission</td><td>CISPR 16-1-1
CISPR 16-2-1</td><td>For equipment installed in the bridge and deck zone:
<table>
<tr><th>Frequency range: MHz</th><th>Limits: dBµV/m</th></tr>
<tr><td>0,15 to 0,3
0,3 to 30
30 to ~~2 000~~ 6 000</td><td>80 to 52
52 to 34
54</td></tr>
<tr><td>except for:
156 to 165</td><td>
24</td></tr>
</table>
For equipment installed in the general power distribution zone:
<table>
<tr><th>Frequency range: MHz</th><th>Limits: dBµV/m</th></tr>
<tr><td>0,15 to 30
30 to 100
100 to ~~2 000~~ 6 000</td><td>80 to 50
60 to 54
54</td></tr>
<tr><td>except for:
156 to 165</td><td>
24</td></tr>
</table></td><td>Procedure in accordance with the standard but at a distance of 3 m between equipment and antenna.</td></tr>
</table>

<table>
<tr><th>No.</th><th>Test [a]</th><th>Procedure according to</th><th>Test parameters, severity</th><th>~~Other information~~ Additional requirement/s</th></tr>
<tr><td>20</td><td>Conducted emission</td><td>CISPR 16-1-1
CISPR 16-2-1</td><td>For equipment installed in the bridge and deck zone:
<table>
<tr><th>Frequency range:</th><th>Limits:
dBμV</th></tr>
<tr><td>10 kHz to 150 kHz</td><td>96 to 50</td></tr>
<tr><td>150 kHz to 350 kHz</td><td>60 to 50</td></tr>
<tr><td>350 kHz to 30 MHz</td><td>50</td></tr>
</table>
For equipment installed in the general power distribution zone:
<table>
<tr><th>Frequency range:</th><th>Limits:
dBμV</th></tr>
<tr><td>10 kHz to 150 kHz</td><td>120 to 69</td></tr>
<tr><td>150 kHz to 500 kHz</td><td>79</td></tr>
<tr><td>0,5 MHz to 30 MHz</td><td>73</td></tr>
</table></td><td></td></tr>
<tr><td>~~21~~</td><td>~~Flame retardancy (cables)~~</td><td>~~IEC 60092-101~~</td><td>~~Flame application:~~
~~5 times, 15 s each~~
~~Interval between each application:~~
~~15 s~~</td><td>~~The burnt out or damaged part of the specimen is not to exceed 60 mm in length~~</td></tr>
</table>

[a] The static inclination test is not required on equipment with no moving parts.

[b] Insulation resistance test to be carried out before and after damp heat test, cold test and salt mist test.

[c] For equipment installed in non-weather-protected locations or cold locations, test is to be carried out at –25 °C.

[d] Dry heat at 70 °C is to be carried out to withstand a high degree of heat, for example for equipment to be mounted in consoles, housings.

[e] Salt mist test to be carried out for equipment to be installed in non-weather protected areas, for example on open deck.

[f] Performance criterion B: the equipment under test (EUT) shall 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.

Recovery times shall be consistent with continued safe operation, taking due account of the need to preserve essential services.

[g] Performance criterion A: the equipment under test (EUT) shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed, as defined in the technical specification published by the manufacturer.

[h] For equipment installed on the bridge and deck zone the test levels shall be increased to 10 V r.m.s. for spot frequencies in accordance with IEC 60945 at 2,0 MHz; 3,0 MHz; 4,0 MHz; 6,2 MHz; 8,2 MHz; 12,6 MHz; 16,5 MHz; 18,8 MHz; 22,0 MHz; 25,0 MHz.

[i] On ships for the carriage of liquid gases and chemicals, the emergency power supply ~~must~~ shall also remain operational with the ship flooded up to maximum athwarthship inclination of 30°.

[j] This test shall be carried out for equipment located in non-air-conditioned spaces.

6 Design

6.1 Environmental and supply conditions

Equipment shall be designed to operate satisfactorily within the expected environmental and supply conditions, with due regard to the limits specified in Annex B of IEC 60092-101:1994.

6.2 Circuit design

Circuits shall be designed to enable efficient test, calibration, maintenance and repair. ~~Preferably, they shall be suitable for repair by unit or card replacement. In some cases, it may be desirable to provide simulation circuits or similar means to check correct operation of the equipment.~~

6.3 Mutual effects

Systems shall be arranged such that faults will not affect any function provided by any other system.

6.4 Electrical subdivision

Design of circuits shall be such that there is no direct connection to any point of the ship's main power supply system, for example isolating transformers shall be used for power supplies. The chassis may not form part of any circuit, except earthing for functional reasons.

It is recommended that extensive systems be subdivided and the supplies to the sections be electrically separated or individually protected.

Control circuits shall be separated from signal and indicating circuits in such a way that faults in the indicating circuits will not impair the operation of the equipment or apparatus, and vice versa.

6.5 Signal level

Signal levels shall be kept high enough to overcome the effects of contact corrosion and noise pick-up.

Transducers and amplifiers shall be situated as close to each other as is practicable.

Particular attention shall be paid to the earthing (grounding) of screens and signal reference systems.

To avoid possible interference on control and instrumentation cables, suitable installation features shall be provided, such as:

– screening and/or twisted pairs;
– use of balanced input amplifiers;
– separation between signal and other cables.

6.6 Power supply

6.6.1 Independent supplies

Where required, for example by the administration, redundant power supplies shall be independent and the system selectively fed.

6.6.2 Capacity

The capacity of any back-up source shall be sufficient to ensure the normal operation of the system until safety conditions are reached.

6.6.3 Protection

Each circuit shall be separately protected against short circuits and overloads.

7 Construction and materials

7.1 Adjustments

Where necessary, equipment shall be arranged for simple adjustment. The set points shall be readily identifiable and suitable means shall be provided to protect against changes, for example due to environmental effects.

7.2 Accessibility

Ease of access to interchangeable parts for repairs and maintenance shall be ensured.

As far as is practicable, equipment shall be free of voltage, temperature, or other such factors which may present unsafe working conditions.

7.3 Replacement

Each replaceable assembly shall be simple to replace and shall be constructed for easy and safe handling.

7.4 Non-interchangeability

Preferably, all replaceable parts shall be so arranged that it is not possible to connect them incorrectly or to use incorrect replacements. Where this is not practicable, the replaceable parts, as well as the associated connecting device, shall be clearly identified.

7.5 Cooling

Preferably, apparatus shall not depend on forced cooling media.

Consideration shall be given, when necessary, to prevent the build-up of deposits on cooling surfaces.

If forced cooling is required, ~~a redundant supply of cooling medium shall be provided for essential services~~ it shall be considered during any assessment of system redundancy requirements. An ~~alarm~~ alert shall be provided in the event of cooling system failure.

For other services appropriate means shall be provided to prevent damage to the equipment due to temperature rise.

~~NOTE Special precautions are required~~ Measures shall be taken for forced ventilated cabinets in machinery spaces to prevent pollution deposits from causing insulation breakdown.

7.6 Mechanical load on connectors

If plug and socket connections are used, the contacts shall not carry any mechanical load, other than that which is necessary for ensuring satisfactory contact pressure, even when withdrawing or replacing a unit.

Plug-in trays, printed circuit boards and other multi-point connectors shall incorporate a retainer to prevent ejection due to mechanical loads such as shock or vibration.

7.7 Mechanical features of cabinets

Cabinets shall be of ~~simple~~ stable mechanical construction. All nut and bolt connections shall be locked.

EXAMPLE Use of self-locking nuts, locking washers, suited adhesives.

7.8 Shock and vibration absorbers

If anti-shock or anti-vibration mounts are used, adequate clearance shall be provided ~~between cabinet and rack~~ to allow full freedom of travel. Systems with shock or vibration mounts in series shall be avoided. Connecting leads shall be arranged so that they do not interfere with the shock and vibration isolation.

7.9 Internal wiring

Cables and insulated conductors used for internal wiring shall ~~normally~~ be at least of a flame retardant type. In the case of wiring adjacent to equipment containing hydraulic or other oils, the insulation shall be resistant to that oil, or be adequately shielded from it.

~~Special precautions shall be taken to avoid mechanical damage to cables and insulated conductors due to vibration.~~

Chafing of cables and insulated wires caused by vibration on surfaces and edges shall be avoided.

7.10 Cable connections

Terminal boards on control equipment, including transducers, shall be constructed so that sufficient space is available to enable cables to be satisfactorily connected, preferably each conductor on its own terminal. All terminals shall be clearly identified and suitable arrangements provided to connect cable screens.

8 Installation and ergonomics

8.1 General

8.1.1 Layout

Control positions shall be ergonomically arranged for the convenience of the operator and hence the accuracy and safety of the operation.

Area or group identification shall be considered, especially in complex layouts, for example adequate spacing between display and control groups.

~~NOTE~~ Equipment in the bridge ~~area~~ and deck zone shall meet the requirements for navigation and communication equipment according to IEC 60945.

8.1.2 Compatibility

The arrangements of indicating instruments and control shall follow a logical sequence.

As far as possible, operating movements and the resulting movements of the indicating instruments shall be consistent with each other.

8.1.3 Labelling

Each operator control panel, subpanel, indicating instrument, control handle~~, alarm~~, signal lamp, recording instrument, etc., shall be clearly and systematically identified by means of self-explanatory and unambiguous labels.

8.1.4 Labels

Labels shall be permanently secured and consistently placed relative to controls and instrumentation and shall be made of durable material having clear and indelible characters.

8.1.5 Display colours

Colours for differentiation of operating conditions shall be readily distinguishable and identifiable.

NOTE Reference ~~may be~~ is made to IMO Resolution ~~A.830(19), Code on Alarms and Indicators, 1995~~ A.1021(26).

8.1.6 Illumination

Instruments and controls shall be illuminated so that they can be clearly read and operated in all ambient light conditions under which they are intended to be operated, without having uncomfortable shadow or glare. If the surrounding illumination makes it difficult to detect an indicator light, a suitable shade shall be provided. If equipment is installed in the bridge ~~area~~ and deck zone, means shall be provided to avoid interference with navigation by the output of any light source. Equipment mounted outside (e.g. on bridge wings) shall be satisfactorily illuminated for operation in both daylight and darkness.

8.1.7 Protection against fluid leakage

~~Electrical~~ Equipment covered by this standard shall not be installed in the same panel or cabinet as equipment employing a hydraulic medium, or pipelines carrying water, oil or steam unless effective means have been provided to protect the ~~electrical~~ equipment in case of leakage.

Pipelines carrying hydraulic mediums, water, oil or steam shall be avoided in the vicinity of control panels and shall be in accordance with the requirements in IEC 60092-201:1994, Table 5.

8.1.8 Protection from condensation

As far as is practicable, arrangements shall be made to prevent condensation in enclosures.

8.1.9 External cables and wiring

External cables and wiring shall comply with relevant IEC 60092 standards.

NOTE See ~~IEC 60092-375,~~ IEC 60092-376.

~~Special consideration shall be given to the mechanical strength and insulation qualities of cables and interconnecting wiring of smaller sizes than indicated in the above standards.~~

8.2 Sensors

8.2.1 Location of sensors

All sensors shall be located such that their output is a realistic measure of the parameter. Sensors shall be installed in places where there is a minimum risk for damage during normal overhaul, maintenance and operation.

8.2.2 Temperature sensors

Temperature sensors shall be installed in pockets of suitable material. Connections shall be arranged ~~to draw out~~ so that they can be removed for testing purposes.

8.2.3 Pressure sensors

Pressure sensors exposed to shocks and large vibration in their working medium shall be protected by damping chambers.

8.2.4 Water level detectors on bulk carriers

SOLAS Chapter XII, Regulation 12 shall apply. The detector indicating the water level should be capable of activating to an accuracy of ±100 mm. Visual and audible alerts should conform to the to the IMO Resolution A.1021(26) as applicable to an emergency alarm for the preservation or safety of the ship.

8.2.5 Enclosure

The enclosure of sensors and their terminal boxes shall be adequately protected for the expected place of installation, and for the type of cables installed.

8.2.6 Testing and calibration

Facilities shall be provided for testing and calibration of sensors which cannot be tested during normal operational conditions.

8.2.7 Presentation of information

Information shall be presented in a clear, consistent, and unambiguous manner.

8.3 Controls

8.3.1 Remote controls

8.3.1.1 Continuous information

At the remote control station, the users shall receive continuous information on the effects of ~~his~~ their orders.

8.3.1.2 Independent control

Where control may be affected from more than one location, the failure of any control equipment at one location shall not affect the ability to control from any other location.

8.3.1.3 Exclusive control

Where a process may be controlled from several locations, only one shall be in control of that process at any time.

8.3.1.4 Transfer of control

This requirement is applicable to command locations of the same priority level.

Actual control shall not 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 shall ~~give audible pre-warning~~ be indicated.

8.3.1.5 Main command location

Where a designated main command location is required for operational or safety reasons, or by the ~~appropriate authority~~ administration, this location shall have the capability to take control without acknowledgement.

8.3.1.6 Security

Significant alteration of process parameters shall be prevented during transfer of control from one location to another.

8.3.1.7 Status indication

On each alternative command location, it shall be indicated when this location is in control.

8.3.1.8 Interlocks

Control system elements shall include safety interlocks when the consequence of erroneous user actions may lead to damage or loss of essential services.

8.3.2 Man-machine interface

The man-machine interface shall be designed in accordance with IEC 60447.

8.4 ~~Alarm~~ Alert systems

The audible and visual signals and indications used in ~~alarm~~ alert systems (the former "machinery alarm systems") shall comply with the relevant requirements of IMO Resolution ~~867E, Code on Alarms and Indicators, 1995~~ A.1021(26).

Emergency alarms shall be assigned to category A according to IMO Resolution MSC.302(87).

Further alarms specified in IMO Resolution A.1021(26) shall be assigned to category B according to IMO Resolution MSC.302(87).

9 Specific installations

~~**9.1 Fire protection control installations**~~

~~**9.1.1 Introduction**~~

~~Subclause 9.1 relates to electrical fire protection control installations, which are provided for the purpose of fire safety on board ships.~~

~~NOTE Some clauses of SOLAS Chapter II-2 are not included in this clause.~~

~~**9.1.2 General**~~

~~**9.1.2.1 Applications**~~

~~Such fire protection control installations may include:~~

- ~~automatic fire detection and fire alarm systems, such as are used in unattended machinery spaces, in accommodation spaces, etc.;~~
- ~~control installations for fire extinction, such as the remote stopping equipment for ventilation fans and fuel oil pumps, remote starting of fire pumps, etc.~~

~~**9.1.2.2 Design and test**~~

~~Fire protection equipment and systems shall be suitably designed and tested, when required, according to Clauses 6 and 5 respectively.~~

~~**9.1.2.3 Indications**~~

~~The audible and visual signals and indications used shall comply with the relevant requirements of IMO Resolution 867E, Code on Alarms and Indicators, 1995.~~

~~**9.1.3 Fixed fire detection and fire alarm systems**~~

~~**9.1.3.1 Detectors**~~

~~**9.1.3.1.1** Detectors shall be activated by heat, smoke, or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered, provided that they are no less sensitive than the detectors first mentioned. Flame detectors shall only be used in addition to smoke or heat detectors.~~

~~**9.1.3.1.2** Smoke detectors required by 9.1.3.4.5 shall be certified to operate before the smoke density exceeds 12,5 % obscuration per metre, but not until the smoke density exceeds 2 % obscuration per metre. Smoke detectors to be installed in other spaces shall operate within sensitivity limits to the satisfaction of the appropriate authority, having regard to the avoidance of detector insensitivity or oversensitivity.~~

~~**9.1.3.1.3** Heat detectors shall be certified to operate before the temperature exceeds 78 °C, but not until it exceeds 54 °C, when raised to those limits at a rate of less than 1 °C per min. At higher rates of temperature rise, the heat detector shall operate within temperature limits to the satisfaction of the appropriate authority, having regard to the avoidance of detector insensitivity or oversensitivity.~~

~~**9.1.3.1.4** At the discretion of the appropriate authority, the permissible temperature of operation of heat detectors may be increased to 30 °C above the maximum deckhead temperature in drying rooms and similar spaces of a normal high ambient temperature.~~

~~**9.1.3.1.5** When fire detectors are provided with means to adjust their sensitivity, the arrangements shall be such that the set point can be fixed and readily identified.~~

~~**9.1.3.1.6** All detectors shall be of such a type that they can be tested for correct operation and restored to normal surveillance without the renewal of any component.~~

~~**9.1.3.2 Power supplies**~~

~~**9.1.3.2.1** Any fixed fire detection and fire alarm system with manually operated call points shall be capable of immediate operation at all times. There shall be not less than two sources of power supply for the electrical equipment used in the operation of the fire detection and fire alarm system, one of which shall be an emergency source to the satisfaction of the appropriate authority.~~

~~**9.1.3.2.2** Where a fixed fire detection and fire alarm system is provided, but is not required by the International Convention for the Safety of Life at Sea (SOLAS), it shall be supplied by two sources of power, one of which shall be an auxiliary source of power that is separate from the main source. Where such an auxiliary source of power is an accumulator battery, it shall be of sufficient capacity for supplying the fire alarm and fire detecting system for 6 h at least without recharging. For this duration, the system voltage shall not fall to less than 88 % of its nominal voltage.~~

~~During charging the voltage of the battery shall not exceed 12 % above its nominal voltage.~~

The supplies shall be provided by separate feeders reserved solely for that purpose. Such feeders shall run to an automatic changeover switch situated in, or adjacent to, the control panel for the detection system.

9.1.3.3 System requirements

9.1.3.3.1 Power supplies and electric circuits necessary for the operation of the system shall be designed with self-monitoring properties for loss of power, and at least the following conditions:

– failure of detecting loops due to wire breakage;

– failure due to short-circuit;

– insulation failure of isolated systems.

Occurrence of a fault condition shall initiate a visual and audible fault signal at the control panel, which shall be distinct from a fire signal.

9.1.3.3.2 Means shall be provided for testing each detecting loop. Indicators shall be fitted to show when a detector or loop has been disconnected.

9.1.3.3.3 Simultaneous activation of detectors shall not impair the operation of the system.

9.1.3.3.4 Where necessary, for example in machinery spaces, means shall be provided for adjusting the response sensitivity of detectors to meet local needs.

9.1.3.3.5 Detectors and manually operated call points shall be grouped into sections. The activation of any detector or manually operated call point shall initiate a visual and audible fire signal at the control panel and indicating units. Indicating units shall denote the section in which a detector or manually operated call point has operated. This signal shall be maintained until it is acknowledged on the control panel. Total resetting of activated section(s) shall only be possible when the detectors are within set points. If it is impossible to identify at a control panel which detector has been activated, each detector shall be equipped with a visual indicator. This signal shall be maintained until it is acknowledged. Indication of detectors shall be provided outside normally locked rooms, unless this indication is given at the control panel.

NOTE 1 Section: group of fire detectors and manually operated call points as reported in the indicating unit(s).

NOTE 2 Loop: electrical circuit linking detectors of various sections and connected to the control panel.

9.1.3.3.6 Clear information shall be displayed on or adjacent to each indicating unit about the spaces covered and the location of the sections.

9.1.3.3.7 In spaces where detectors are liable to be activated by certain operations, for example welding, cargo handling, etc., the detectors may be rendered temporarily inoperative, providing this is displayed on the indicating unit. The period of time shall be determined by considering, as far as is practicable, the time that the space is occupied. After this predetermined period of time, the detectors shall become operational automatically, unless they have been previously reset.

9.1.3.3.8 If the signals have not received attention within 2 min, an audible alarm shall be automatically sounded throughout the crew accommodation and service spaces, control stations and machinery spaces of category "A" according to SOLAS. This alarm sounder system need not be an integral part of the detection system.

9.1.3.3.9 Where the fire detection system does not include means of remotely identifying each detector individually, no section covering more than one deck within accommodation, service and control stations shall normally be permitted except a section which covers an

~~enclosed stairway. In order to avoid delay in identifying the source of fire, the number of enclosed spaces included in each section shall be limited as determined by the appropriate authority. In no case shall more than 50 enclosed spaces be permitted in any section. If the detection system is fitted with remotely and individually identifiable fire detectors, the sections may cover several decks and serve any number of enclosed spaces.~~

~~The requirements that a section shall not cover more than one deck and shall not protect more than 50 enclosed spaces are considered to be met by a system with remotely and individually identifiable fire detectors by dividing the loop into various sections by means of isolating devices and limiting each section to that required by the above definitions.~~

~~**9.1.3.3.10** In passenger ships, if there is no fire detection system capable of remotely and individually identifying each detector, a section of detectors shall not serve spaces on both sides of the ship, nor on more than one deck; neither shall it be situated in more than one main vertical zone, unless the appropriate authority is satisfied that the protection of the ship against fire will not thereby be reduced, in which case it may permit such a section of detectors to serve both sides of the ship and more than one deck. In passenger ships fitted with individually identifiable fire detectors, a section may serve spaces on both sides of the ship and on several decks but may not be situated in more than one main vertical zone.~~

~~**9.1.3.3.11** The requirement on passenger ships contained in 9.1.3.3.10 that a section shall not serve spaces on both sides of the ship and shall not serve more than one deck, is considered to be met by a system with remotely and individually identifiable fire detectors when the loops are divided into various sections by means of isolating devices in such a way that each section covers only one side of the ship.~~

~~**9.1.3.3.12** The requirement on passenger ships contained in 9.1.3.3.10 that a section shall not be situated in more than one main vertical zone, is considered to be met by a system with a remotely and individually identifiable fire detector when a loop is limited to a main vertical zone.~~

~~**9.1.3.3.13** A section of fire detectors which covers a control station, a service space, or an accommodation space, shall not include a machinery space specified as being category "A" according to SOLAS.~~

~~**9.1.3.3.14** For fire detection systems with remotely and individually identifiable fire detectors, the requirement contained in 9.1.3.3.13 is considered to be met when a loop which covers control stations, service spaces and accommodation spaces does not include machinery spaces of category A.~~

~~**9.1.3.3.15** Fire detection systems with a zone address identification capability shall be so arranged that:~~

- ~~a loop cannot be damaged at more than one point by a fire;~~
- ~~all arrangements enable the initial configuration of the system to be restored in the event of failure (electrical, electronic, informatic);~~
- ~~the first initiated fire alarm will not prevent any other detector from initiating further fire alarms.~~

~~**9.1.3.3.16** The requirement contained in clause 9.1.3.3.15 that a system shall be so arranged that a loop cannot be damaged at more than one point by a fire, is considered satisfied by arranging the loop such that the data highway will not pass through a space covered by a detector more than once.~~

~~**9.1.3.3.17** The requirement contained in 9.1.3.3.15 that a system shall be arranged to ensure that any fault occurring in the loop shall not render the whole loop ineffective, is considered satisfied when a fault occurring in the loop only renders ineffective a part of the~~

loop not larger than a section of a system and without means of remotely identifying each detector.

9.1.3.3.18 The fire detection system shall not be used for any other purpose, except for initiating the closure of fire doors and similar functions, which may be permitted at the control panel.

9.1.3.3.19 The function of the detection system shall be tested on installation and thereafter periodically by means of equipment producing hot air at the appropriate temperature, or smoke or aerosol particles having the appropriate range of density or particle size, or other phenomena associated with incipient fires to which the detector is designed to respond.

NOTE Attention is drawn to the fact that computer-based systems may require additional provisions (see clause 10).

9.1.3.4 Installation requirements

9.1.3.4.1 The control panel shall be located on the navigation bridge or in the main fire control station.

9.1.3.4.2 Indicating units shall, as a minimum, denote the section in which a detector or manually operated call point has operated. At least one unit shall be so located that it is easily accessible to responsible members of the crew at all times, when at sea or in port, except when the ship is out of service. One indicating unit shall be located on the navigation bridge if the control panel is located in the main fire control station.

9.1.3.4.3 Detectors shall be located for optimum performance. A sufficient number and range of detector types shall be installed and positioned such that a fire will be rapidly detected and alarmed. Positions near beams and ventilation ducts or other positions where patterns of air flow could adversely affect performance, and positions where impact or physical damage is likely, shall be avoided. Detectors installed in spaces occupying elevated positions shall be at a minimum distance of 0,5 m away from bulkheads.

Smoke detectors working on the ionization chamber principle shall be installed in accordance with the applicable requirements for personal protection

9.1.3.4.4 Manually operated call points shall be installed throughout the accommodation spaces, service spaces and control stations. One manually operated call point shall be located at each exit. Manually operated call points shall be readily accessible in the corridors of each deck so that no part of the corridor is more than 20 m from a manually operated call point.

9.1.3.4.5 Smoke detectors shall be installed in all stairways, corridors and escape routes within accommodation spaces. Consideration shall be given to the installation of special purpose smoke detectors within exhaust ventilation ducting.

9.1.3.4.6 Where a fixed fire detection and fire alarm system is required for the protection of spaces other than those specified in 9.1.3.4.5, at least one detector complying with 9.1.3.1.1 shall be installed in each such space.

9.1.3.4.7 The maximum spacing of detectors shall be in accordance with table 2.

~~**Table 2 – Maximum spacing of detectors**~~

~~Type of detector~~	~~Maximum floor area per detector~~ m^2	~~Maximum distance apart between centres~~ ~~m~~	~~Maximum distance away from bulkheads~~ ~~m~~
~~Heat~~	~~37~~	~~9~~	~~4,5~~
~~Smoke~~	~~74~~	~~11~~	~~5,5~~
~~NOTE The appropriate authority may require or permit other spacings based upon test data which demonstrate the characteristics of the detectors.~~			

~~**9.1.3.4.8** Electrical wiring which forms part of the system shall be so arranged as to avoid galleys, machinery spaces of category "A" according to SOLAS and other enclosed spaces of high fire risk, except where it is necessary to provide for fire detection or fire alarm in such spaces, or to connect to the appropriate power supply.~~

~~**9.1.3.5 Instructions and spares**~~

~~Suitable instructions and component spares for testing and maintenance shall be provided.~~

~~**9.1.4 Remote control installations for fire extinction**~~

~~**9.1.4.1 Subdivision of remote stop circuits**~~

~~**9.1.4.1.1** Ventilation fan motors for cargo spaces, machinery spaces and accommodation spaces shall not be connected to the same remote stop circuit.~~

~~**9.1.4.1.2** Remote stop circuits for machinery for essential services and for their stand-by units shall be electrically separated.~~

~~**9.1.4.2 Resetting of remote stop circuits**~~

~~The activation of a remote stop circuit, manually initiated, shall continue until it is manually reset. When the possibility exists that, after resetting, motors may restart automatically, this shall be indicated at the remote stop position.~~

~~**9.1.4.3 Running indication of fire pump**~~

~~Where a fire pump is provided with a means of remote start, running indication shall be provided.~~

9.1 Fire safety systems

Arrangement and installation of fire detection and fire alarm systems shall be in accordance with SOLAS Chapter II-2 and IMO Resolution MSC.98(73), Fire Safety Systems Code (FSS Code).

Fire protection equipment and systems shall be suitably designed and tested according to the approval standards as stated in the relevant part of the EN 54 series and the specific test requirements for maritime environment of this standard, see Table 1.

Integration of fire safety systems into a monitoring and control system is permissible with approval of administration, see SOLAS Chapter II-2, Part F, Regulation 17.

The audible and visual signals and indications used shall comply with the relevant requirements of IMO Resolution A.1021(26).

9.2 Bilge systems

For bilge pumping arrangements, SOLAS Chapter II-1, Part B, Regulation 21 applies.

For bilge areas, the monitoring arrangement shall indicate the compartment in which the fault has occurred.

Where the bilge pumps are capable of being started automatically, means shall be provided to indicate when the influx of liquid is greater than the pump capacity, or when the pump is operating more frequently than would normally be expected.

Where automatically controlled bilge pumps are provided, special attention shall be given to oil pollution prevention requirements.

9.3 Machinery ~~alarm~~ alert installations

~~9.2.1 Introduction~~

~~This subclause relates to machinery alarm installations which are provided in order to give warning of abnormal conditions in ship's machinery systems.~~

9.3.1 General

A machinery ~~alarm~~ alert installation shall have the following objectives:

– to direct the attention of personnel to an abnormal condition in a ship's machinery system;
– to help establish the nature and location of the abnormal condition;
– to enable effective, corrective and, where possible, precautionary action to be taken;
– to have acknowledgement of the ~~alarm~~ alert and the return to normal condition indicated.

9.3.2 ~~Alarm~~ Alert requirements

9.3.2.1 Repeater ~~alarm~~ panels

Where repeater ~~alarm~~ panels are required, these shall also be provided with both visual and audible signals. These signals may be common for all, or for a group of ~~alarms~~ alerts connected to the machinery ~~alarm~~ alert installation. An existing alert shall not prevent annunciation of subsequent alerts because of previous alert acknowledgement.

~~9.2.3.2 Labelling~~

~~At the centralised control position, there shall be clear indication on each alarm of the fault conditions, for example "low lubrication oil pressure". At remote group alarm panels, the indication may be limited to a general fault condition.~~

9.3.2.2 Allocation

When local control panels with group alert up to the centralised control system are provided, it is acceptable that the group alert only is shown in the centralised control system.

9.3.2.3 Acknowledgement

~~Alarms shall be maintained until they are accepted and the visual indications of individual alarms shall remain until the fault has been corrected, at which time the alarm system shall reset automatically to the normal operation condition.~~

Generally, IMO Resolution MSC.302(87) applies.

Alarms and warnings shall be indicated until the abnormal condition has been corrected and the alarm or warning has been acknowledged.

Acknowledgement of the alarm ~~condition~~ or warning shall be indicated by an alteration of the visual signal, for example, from flashing to steady light.

Acknowledgement shall be possible only from the machinery space concerned, or the centralised control position associated with that machinery space.

The silencing of an audible alarm or warning at a repeater ~~alarm~~ panel shall not lead automatically to the acknowledgement of the ~~original~~ alarm or warning at the ~~centralised~~ control position.

The acknowledgement shall not reset the abnormal condition which caused the alarm or warning.

9.3.2.4 Inhibition

Inhibition of an alert channel shall be clearly indicated. ~~For essential services such channels are to be monitored or duplicated, such that no fault shall cause alarms to be inhibited without indication.~~ A list of manually inhibited channels shall be available in the system.

9.3.3 Display of information

9.3.3.1 Group arrangement

All visual ~~alarm~~ alert indications within the same priority group shall have the same colour significance and be arranged in logical groups.

9.3.3.2 Legibility

The ~~alarm~~ alert text, legend or symbol shall be clearly visible from the ~~alarm acknowledgement~~ control position.

9.3.3.3 Common audible ~~alarm~~ alert

If the audible ~~alarm~~ alert signal is also used for other purposes, for example telegraph or telephone, it shall be accompanied by (a) luminous call panel(s) indicating the system concerned, and comply with the relevant requirements of IMO Resolution ~~867E, Code on Alarms and Indicators, 1995~~ A.1021(26).

9.3.3.4 ~~Alarm~~ Alert differentiation

An existing ~~alarm~~ alert shall not prevent ~~the indication of further faults~~ annunciation of subsequent alerts because of previous alert acknowledgement.

9.3.3.5 ~~First failure~~ Alert indication

~~In alarm systems for complex machinery installations, consideration shall be given to means for indicating the first failure.~~

According to IMO Resolution MSC.302(87).

9.3.3.6 Alert recording

Alerts shall be recorded in chronological order with date and time stamp. The status of coming, acknowledging and going of any alert shall be clearly recorded.

9.3.4 Supply arrangements

9.3.4.1 ~~Stand-by~~ Power supply

~~Consideration shall be given to the provision of A stand-by power supply for the alarm installation.~~

The machinery alert installation shall be continuously powered. A stand-by power supply with automatic change-over shall be provided with a capacity of at least 30 min.

9.3.4.2 ~~Alarm~~ Alert for supply failure

Visual and audible ~~alarm signals~~ alerts shall be initiated at the failure of the ~~alarm installation~~ power supplies of the machinery alert installation.

9.3.5 Design

~~**9.2.6.1 Separation of functions**~~

~~Alarm installations shall be separated from control systems and, as far as is practicable, their sensors.~~

9.3.5.1 Monitoring equipment

~~Alarm system~~ Machinery alert installations may be combined with monitoring equipment, such as equipment provided with analogue read-outs of measured variables or with data loggers~~, or alarm data printers~~.

9.3.5.2 Time delays

~~Alarm~~ Alert channels, where necessary, shall be provided with suitable time delays.

Transient~~s~~ phenomena, such as pressure waves in protected pressure systems, sensor contact bouncing or electromagnetic interference from other systems, shall not cause the ~~alarm~~ alert installation to operate. All level ~~alarms~~ alerts shall have a time delay related to the frequency of the ship's movements.

9.3.5.3 ~~Closed~~ Circuits

~~Normally closed circuits shall be used to prevent non-indication of an alarm due to a broken sensor loop. Alternatively, open circuits may be used, if they are monitored for sensor circuit faults.~~

Alarm signals should be based on normally closed loops, giving alarm upon signal failure.

Shut-down circuits of essential machinery should be based on normally open circuits with loop monitoring.

9.3.5.4 Earth fault

Earth fault(s) in alarm sensor circuits shall cause the alarm to operate, or to be indicated in an alternative manner, or otherwise not prevent indication of alarm(s).

9.3.5.5 Mutual fault independence

A fault in any one ~~alarm~~ alert channel, particularly in the external incoming and outgoing circuits, shall, as far as is practicable, not influence the normal operation of any other channels.

9.3.5.6 ~~Audible alarm~~ Alert independence

A fault in ~~alarm-indicating lamps, including a short-circuit in a lamp or lamp-holder,~~ the visual indication of an alert shall not affect the operation of the audible ~~alarm~~ indication and vice versa.

9.3.5.7 System integrity

As far as is practicable, test facilities for checking the proper function ~~or~~ of the electrical ~~alarm~~ circuits, including audible and visual devices, shall be provided.

~~9.3 Automatic control installations for electrical power supply~~

~~9.3.1 Introduction~~

~~This subclause relates to automatic control installations for generating sets, which are provided in order to safeguard the electrical power supply.~~

~~9.3.2 General~~

~~Such automatic control systems for generating sets may include:~~

- ~~automatic starting of a set;~~
- ~~automatic connecting onto a dead bus bar;~~
- ~~automatic parallelling and load sharing;~~
- ~~automatic shut-down of a set;~~
- ~~automatic disconnecting of non-essential services;~~
- ~~automatic analysis of power reserve.~~

~~9.3.3 Automatic starting~~

~~9.3.3.1 Initiation of starting commands~~

~~Commands for automatic starting may be given, for example, by:~~

- ~~no voltage (blackout);~~
- ~~prolonged voltage drop;~~
- ~~prolonged frequency drop;~~
- ~~expected frequency reduction or expected stop of running set;~~
- ~~overload (mechanical or electrical or both);~~
- ~~increase of power demand;~~
- ~~start signal for large electric power consumer(s), for example transverse thruster motor;~~
- ~~failure of running sets;~~
- ~~pressure drop in exhaust gas boilers;~~
- ~~remote manual means.~~

~~9.3.3.2 Delay of signal~~

~~In order to avoid inadvertent starting, signals caused by acceptable transient conditions, for example high motor starting currents, shall not cause the automatic starting of a set.~~

~~**9.3.3.3 Transfer of starting order**~~

~~If more than one set is fitted with automatic starting devices, consideration shall be given to fitting either a sequence system, which, in case of starting failure, automatically transfers the starting order to the next set(s), or a selector switch for manual use.~~

~~**9.3.3.4 Pre-starting conditions**~~

~~Means shall be provided to ensure that proper starting and running conditions exist at any time regarding starting air, fuel, cooling water, etc.~~

~~**9.3.3.5 Stand-by indication**~~

~~Stand-by indication shall be arranged at the control panel and, to safeguard personnel, locally at the individual machine(s).~~

~~**9.3.3.6 Starting interlock**~~

~~Every set shall be capable of being interlocked against inadvertent starting in order that maintenance and repair may be carried out in safety. Indication shall be provided to warn that the set is unavailable for automatic starting.~~

~~**9.3.3.7 Start indication and restriction**~~

~~**9.3.3.7.1** The automatic starting and running of a set shall be indicated.~~

~~**9.3.3.7.2** The number and the duration of starting attempts in case of starting failure shall be limited.~~

~~**9.3.3.7.3** Starting failure of a set shall give a visual and audible alarm signal.~~

~~**9.3.4 Automatic connecting onto a dead bus bar**~~

~~**9.3.4.1 Connection at blackout**~~

~~It shall be ensured, when closing a generator circuit-breaker onto a bus bar, that the generator voltage is sufficiently high. In order that the initial load does not exceed the capability of the generator, consideration shall be given to limiting or sequencing the reconnection of the loads, or both.~~

~~**9.3.4.2 Non-simultaneous closing**~~

~~Simultaneous automatic closing of two or more generator circuit-breakers shall be prevented.~~

~~**9.3.4.3 Undue closing**~~

~~Means shall be provided to prevent automatic closing of the generator circuit-breaker in the event of any failure of the starting order sensing element, e.g., erroneous operation of a low voltage relay.~~

~~**9.3.4.4 Short circuit**~~

~~After a short circuit, stand-by generator circuit-breakers shall be prevented from closing on to a faulty bus-bar section. A manual reset shall be provided for this facility. Generator circuit-breakers shall not be permitted more than one attempt to close onto a short circuit.~~

9.3.4.5 Disconnecting of a running set

If a set has been started, due to a prolonged voltage or frequency drop not directly causing a running generator to trip, consideration shall be given to having the faulty generator set disconnected as soon as the stand-by set is ready for taking over.

9.3.5 Automatic load management

9.3.5.1 Required conditions

In order to achieve automatic paralleling, it will be necessary to ensure efficient automatic synchronising and automatic closure of the circuit-breaker.

NOTE Attention is drawn to the possibility of fast frequency fluctuations occurring due to heavy load rushes. Where this may be expected, the use of quick-closing circuit-breakers, or synchronising reactors, or similar means should be considered.

A reverse power tripping device shall be provided for electrical generators intended for parallel operation.

Where an automatic load sharing function is provided, a fault in any system providing such a function should not result in the loss of the main electrical power.

9.3.6 Automatic shut-down

9.3.6.1 Initiation of shut-down

In the case of failures which may cause damage to a set, e.g. overspeed or low pressure of lubrication oil, the set shall be automatically disconnected and shut down.

9.3.6.2 Prediction alarm

In order to prevent unnecessary shut-down, consideration shall be given to the provision of an additional visual and audible alarm signal, thus allowing manual precautions to be taken before the dangerous condition is reached.

9.3.6.3 Disconnection due to decrease of load

In systems with automatic generator disconnection upon decrease of load, the disconnection shall be delayed.

9.3.6.4 Sets cooling down

Where necessary, or desired, a running out sequence may be programmed, permitting the set to smooth the thermal-mechanical effects of sudden change from high to no load.

9.3.6.5 Indication of shut-down

Automatic shut-down of a set due to a failure shall cause a visual and audible alarm signal.

9.3.6.6 Prevention of restarting

Automatic restarting of a set after an automatic stop due to a failure shall be prevented.

9.3.6.7 Power supply

The power supply to the system providing automatic shutdown functions shall be taken from an independent source. Consideration shall be given to providing visual and audible alarm indication that the power supply has failed. Where auxiliary power is necessary to maintain the main electrical power supply, for example power to electronic governors, at least two

~~independent auxiliary power systems shall be provided. Generator protection equipment shall be located in separate cubicles as for other generators.~~

~~**9.3.7 Automatic disconnecting of non-essential services**~~

~~**9.3.7.1 Causes of disconnecting**~~

~~In order to safeguard electrical power supply for essential services, provision of a system to disconnect automatically non-essential services shall be considered in the following cases:~~

- ~~when one generating set is normally used to supply the electrical load, but where the possibility exists that, due to the automatic switching on of additional loads, whether manually or automatically initiated, the total load exceeds the rated generator capacity;~~
- ~~when generators are operated in parallel to supply the load and when, in case of failure of one of the running generators, the total load exceeds the combined capacity of the remaining generator(s).~~

~~**9.3.7.2 Design conditions**~~

~~When designing the protection system to trip the non-essential services in case of generator overload, due account shall be taken of loads with power factors deviating from rated values, the decreased efficiency of engines, etc. In order to safeguard the electrical power supply in such cases, consideration shall also be given to providing, for example, low-frequency relays in addition to generator current relays.~~

9.4 Power management systems

9.4.1 General

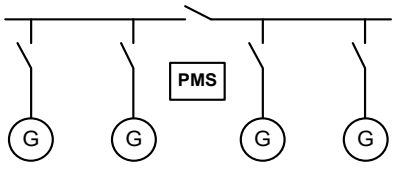
The requirements of 9.4 shall apply where a power management system is specified for the automatic control of electrical power generation and distribution.

Power management systems can be categorized in three different designs (see Figure 1):

a) one common system for all control functions;

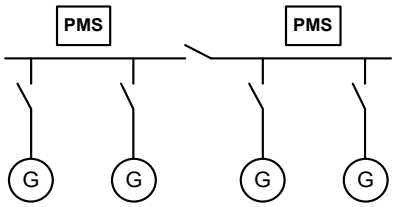
b) one independent system per busbar section;

c) one independent system per main power supply unit.



IEC

a) One common system for all control functions



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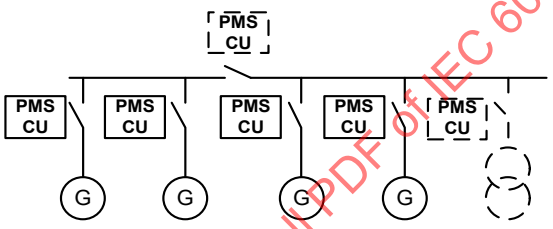
b) One independent system per busbar section



IEC

c) One independent system per main power supply unit

Key

PMS Power management system

G Generator

CU Control unit

Figure 1 – Typical designs of power management systems

An independent manual control shall be provided regardless of the chosen design. Such automatic control systems for electrical power supply may include in general (see Figure 1 a), b) and c)):

– the load dependent starting/stopping of a generator-set;
– the load distribution and frequency control;
– the heavy load request and power reserve for big consumers;
– the control of equipment for the improvement of overall efficiency.

The designs shown in Figure 1 b) and c) may include the following additional functions:

- control of non-essential consumers;
- paralleling of generator-sets and busbar sections;
- shaft generator control (PTI/ PTO);
- black-out recovery.

The designs described in 9.4.1 c) and Figure 1 c) may include the following additional functions:

1) generator and prime mover protection;
2) synchronizing.

9.4.2 Automatic starting and stopping of main power supply equipment

9.4.2.1 Initiation of starting and stopping commands

Commands for automatic starting and stopping of the main power supply equipment may be initiated in the following cases:

– under-voltage;
– under-frequency;
– expected stop of running set (delayed shut-down);
– overload, overcurrent;
– load dependent start;
– load dependent stop;
– failure of running sets.

9.4.2.2 Delay of signal

In order to avoid inadvertent starting, signals caused by acceptable transient conditions, for example high motor starting currents, shall not cause the automatic starting of a set.

9.4.2.3 Disconnection due to decrease of load

In systems with automatic generator disconnection upon decrease of load, the disconnection shall be provided with an appropriate delay.

9.4.2.4 Warming up and cooling down sequence

Where necessary, or desired, a warming up and a cooling down sequence may be programmed.

9.4.2.5 Pre-starting conditions

Means shall be provided to ensure that proper starting and running conditions exist at any time regarding starting air, fuel, cooling water, etc.

9.4.2.6 Stand-by indication

Stand-by indication shall be arranged at the control panel. An alarm shall be triggered when no stand-by set is available.

9.4.2.7 Start indication and restriction

The running of a set shall be indicated.

The number and the duration of automatic starting attempts shall be limited.

The starting failure of a set shall provide a visual and audible alarm. A sequence system shall be provided, which, in case of starting failure, automatically transfers the starting order to the next set.

9.4.3 Heavy load request and power reserve calculation

A power management system shall calculate on request if the load reserve is sufficient to start a heavy consumer. Where load reserve is not sufficient the heavy consumer will be blocked until an additional generator-set is connected. When a heavy consumer is in operation the power management calculates and maintains the necessary load reserve.

9.4.4 Black-out recovery

9.4.4.1 Connection at black-out

It shall be ensured, when closing a generator circuit-breaker onto a bus bar, that the generator voltage is sufficiently high. In order that the initial load does not exceed the capability of the generator, consideration shall be given to limiting or sequencing the reconnection of the loads, or both.

9.4.4.2 Non-simultaneous closing

Simultaneous automatic closing of two or more generator circuit-breakers shall be prevented.

9.4.4.3 Short circuit

After a short circuit, stand-by generator circuit-breakers as well as bus tie-breakers shall be prevented from closing on to a faulty bus-bar section. Generator circuit-breakers shall not be permitted more than one attempt to close onto a short circuit. A resetting of a triggered short circuit protection device may be possible locally and manually only.

9.4.4.4 Disconnecting of a running set

If a set has been started, due to under-voltage or under-frequency not directly causing a running generator to trip, consideration shall be given to having the faulty generator set disconnected as soon as the stand-by set is ready for taking over (switching over via black-out).

9.4.5 Load sharing and frequency control

Where an automatic load sharing and frequency control function is provided, a fault in any system providing such a function shall not result in the loss of the main source of electrical power.

9.4.6 Shut-down of diesel engine

9.4.6.1 Shut-down

When the safety system of the diesel engine triggers a shut-down, the set shall be automatically disconnected.

9.4.6.2 Pre-alarm

Pre-alarms or delayed shut-downs shall allow a manual or automatic action before a shut-down occurs.

9.4.6.3 Prevention of restarting

The starting of a generator set shall not be possible when a shut-down or stop signal is active.

9.4.7 Automatic disconnection of non-essential consumers

In order to safeguard electrical power supply for essential services, provision of a system to disconnect automatically non-essential consumers shall be considered in the following cases:

– the total load exceeds the rated generator capacity;
– under-frequency or under-voltage;
– failure of one of the generators running in parallel if the total load exceeds the combined capacity of the remaining generator(s). In this case disconnection shall be undelayed.

9.4.8 Design requirements of power management systems (PMSs)

9.4.8.1 General

The PMS shall operate independently. The PMS shall provide different control levels: full automatic control, remote control and local control. Local control of the PMS from the switchboard applies only to Figure 1 b) and c).

For remote control of the PMS from the automation system an interface may be provided. Local control of the PMS shall have higher priority than remote control and automatic control of the PMS.

Any PMS failure shall trigger an alert.

Malfunctioning of the PMS may not lead to loss of the main source of power.

Manual control of the switchboards may not be affected by the automation system and/or PMS system.

9.4.8.2 One common system for all control functions (Figure 1 a))

The PMS shall be supplied from an uninterruptible power supply (UPS) system supplied from the main and emergency source of power.

9.4.8.3 One independent system per busbar section (Figure 1 b))

Each PMS shall be supplied from an independent UPS system supplied from main and emergency source of power. If one of the PMS fails the remaining one shall take control of the complete system.

9.4.8.4 One independent system per main power supply unit (Figure 1 c))

Each PMS shall be supplied from a UPS system supplied from the the main and emergency source of power. Each unit shall also be supplied from the busbar voltage and if applicable from the generator voltage.

If the diesel safety system and/or the generator protection are integrated in the PMS (integrated protection and control system), then a failure of the PMS shall trigger an alarm but not trip the generator-set.

Each generator-set shall be equipped with operation-, indication- and protection-devices, so as to operate the generator-set by manual means also when the integrated protection and control system has failed.

Manual operation of the prime mover means that the following functions are still available:

a) start/stop of the engine;
b) over-speed protection, as far as required;

c) lubrication monitoring , as far as required;

d) required control equipment and instrumentation;

e) speed/load control of the engine.

Manual operation for the generator and the switchgear means:

1) short circuit protection;

2) control, indication and instrumentation in the generator panel.

9.5 Automatic starting installations for electrical motor-driven auxiliaries

9.5.1 ~~Introduction~~ General

Subclause 9.5 relates to automatic installations for electrical motor-driven auxiliaries such as lubricating oil pumps, cooling water pumps, etc.

All equipment employed in automatic starting installations for electrical motor-driven auxiliaries shall, where applicable, comply with the ~~recommendations of~~ requirements according to IEC 60092-202 and IEC 60092-302.

9.5.2 Automatic sequence starting

9.5.2.1 Prevention of overload

Controlgear used for the automatic restart of electrical motors shall, where necessary, be provided with an automatic sequence starting system to prevent overloading of the generating equipment at the moment, and during the procedure, of power restoration after the occurrence of a black-out.

9.5.2.2 Starting delays

The sequence starting system~~, when provided,~~ shall ensure the shortest possible starting delay for those auxiliaries which are most vital for the ship's propulsion ~~or its propulsion machinery, such as steering gear motors and lubricating oil pumps~~.

~~**9.4.3.3 Interlock system**~~

~~If the rating of motors is such that more than one generating set is required to be connected to the supply system before the motors may start automatically, an interlock system shall be provided.~~

9.5.3 Starting installations for stand-by auxiliaries

9.5.3.1 Starting ~~order~~ commands

The starting ~~order~~ command for the stand-by machine shall be ~~given either from~~ initiated by a process value measured in the controlled medium~~, or the electrical system, or both, as appropriate for the service concerned~~. In case of electrical failure of the auxiliary drive in operation the stand-by auxiliary drive shall be started immediately.

The starting ~~order~~ command for a stand-by lubricating oil pump motor, for example, shall be taken from the lubricating oil pressure~~, flow, or gravity tank level, depending on the system design,~~ and not only from the controlgear of the running lubricating oil pump motor.

9.5.3.2 Stand-by indication

Selection of the stand-by position for an electrical motor-driven auxiliary, together with the ~~state of readiness of its power supply~~ information “motor starter ready for remote operation”, shall be indicated at the centralized control position~~, where provided, and the local control~~

~~position(s)~~ as stand-by indication. If the availability of the stand-by function is lost during operation a stand-by alert shall be triggered.

9.5.3.3 Indication of start

Automatic starting of a stand-by auxiliary shall cause ~~a visual and audible alarm signal to be initiated~~ an alert.

9.5.4 Control voltages

~~The voltage of control circuits incorporating sensing elements, such as pressure sensors or similar devices mounted in the ship's machinery equipment, shall not exceed 250 V d.c. and a.c.~~

The automatic changeover system shall be supplied from a UPS system supplied from the main and emergency source of power or directly from the dedicated motor starters.

9.5.5 Manual control

A ~~fault~~ failure in the controlgear of one motor ~~or in the automatic changeover system for running or stand-by motors~~ shall not render more than one motor unavailable for manual control. In case of failure in the automatic changeover system both motors shall be available for manual control.

9.5.6 Mechanically driven auxilaries in low speed range

Where auxiliary machinery is mechanically driven from the propulsion system, stand-by units shall be provided for automatic start-up when carrying out manoeuvres in the lower speed range where the output of the mechanically-driven auxiliary machines is not adequate under these conditions.

9.5.7 Mechanically driven auxilaries

No alert shall be triggered in case of machinery installations with mechanically connected pumps, when the independent electrical pumps start up in the course of normal operation.

9.5.8 Sensors

The sensors for stand-by circuits shall be independent from other systems, especially from the related process alerts.

9.6 Machinery control installations

9.6.1 ~~Introduction~~ General

Subclause 9.6 relates to the control of machinery essential for the propulsion and safety of the ship.

For electric and electrohydraulic steering gear SOLAS Chapter II-1, Part C, Regulation 30 applies.

For machinery controls SOLAS Chapter II-1, Part C, Regulation 31 applies.

~~NOTE Control and instrumentation~~ Requirements for ~~steering gear are given in IEC 60092-204 and for~~ the electrical propulsion plant are given in IEC 60092-501.

9.6.2 General requirements

Main and auxiliary machinery essential for the propulsion, control and safety of the ship shall be independent or designed in such a way that failure of one system shall not degrade the performance of another system.

9.6.3 Transfer of control

The control of machinery and associated equipment shall be possible only from one control station at a time, and the changeover between control stations shall be arranged so that it may only be effected with the acceptance of the station taking control. The system shall be provided with interlocks or other suitable means to ensure effective transfer of control (see also 9.6.5.1).

NOTE Where control positions are located within close proximity to allow direct audible and visual contact, the ~~appropriate authority may~~ administration can waive this requirement.

9.6.4 Remote control of propulsion machinery from the bridge

9.6.4.1 Application

Where remote control of propulsion machinery from the navigation bridge is provided, the following features shall be incorporated.

9.6.4.2 Parameters under control

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

9.6.4.3 Control devices

The control shall 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 may also be controlled by one control device.

9.6.4.4 Emergency stop

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

~~NOTE~~ Where the propulsion prime mover(s) also provide power for the electrical installation, it may be sufficient to remove power from the propellers, for example by means of a clutch.

9.6.4.5 Order indication

Propulsion machinery orders from the navigation bridges shall be indicated in the main machinery control room, if provided, and the manoeuvring platform.

~~NOTE~~ The local control position(s) for the propulsion machinery may be taken as equivalent to the manoeuvring platform.

9.6.4.6 Transfer of control

Remote control of the propulsion machinery shall be possible from only one location at a time; at such locations, interconnected control positions are permitted.

The transfer of control between the navigation bridge and machinery spaces shall be possible only from the main machinery space, or the main machinery control room.

The transfer of control from one control station to another shall not significantly alter the parameters under control, i.e. speed, direction of thrust, or pitch.

The transfer of control shall not be initiated without the acceptance of the station taking the control.

9.6.4.7 Local control

It shall be possible to control the propulsion machinery and all machinery essential for the propulsion and safety of the ship locally, even in the case of failure in any part of the remote control system.

It shall also be possible to control the auxiliary machinery, essential for the propulsion and safety of the ship, at or near the machinery concerned.

9.6.4.8 Failure alarms

The failure of the remote control system shall initiate a visual and audible alarm. Unless impractical, the pre-set speed and direction of thrust of the propeller and, if applicable, the pitch shall be maintained until local control is in operation.

9.6.4.9 Start blocking

If the remote control system of the propulsion machinery is designed for automatic starting, the number of automatic consecutive attempts shall be limited and start-blocking at a pre-set low value of the starting air pressure shall be provided in order to safeguard sufficient starting air pressure for starting from the engine control room, or locally.

9.6.5 Indicators for remote control of machinery

9.6.5.1 Indication of control location

At each operating location, there shall be an indicator showing which location is in control of the machinery.

9.6.5.2 Running indication

Where remote operation is provided, running indication, or other equivalent arrangements, shall be provided at each operating location.

9.6.5.3 Parameter indication

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

– propeller speed and direction of rotation in the case of fixed pitch propellers;

– propeller speed and pitch position in the case of controllable pitch propellers;

– direction for azimuth thrusters.

9.6.6 Manual override

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

9.7 Machinery protection ~~(~~and safety~~)~~ systems

9.7.1 ~~Introduction~~ General

Subclause 9.7 relates to the equipment required to initiate appropriate action whenever pre-set limits of the parameters of operating machinery are exceeded. For electrical protection IEC 60092-202 applies.

~~NOTE~~ Attention is drawn to the fact that computer based safety systems for the protection of machinery may require additional and other provisions (see Clause 10).

9.7.2 General requirements

9.7.2.1 Principles of operation

Protection ~~(~~and safety~~)~~ systems are to ensure that a malfunction in machinery ~~or boiler~~ operations which presents an immediate danger shall initiate automatic protection, i.e. shut-down or load reduction of that part of the plant, and that a visual and audible alarm shall be given.

~~NOTE Automatic protection (safety) would be required, for example for the following:~~

~~a) Reciprocating internal combustion engines:~~

~~— critical loss of lubrication of the engine and/or reduction gear;~~

~~— overspeed.~~

~~b) Steam and gas turbines:~~

~~— critical loss of lubrication of the turbine and/or reduction gear;~~

~~— overspeed.~~

~~c) Steam generating plants:~~

~~— excessively low water level;~~

~~— excessively high water level;~~

~~— combustion air failure;~~

~~— flame failure.~~

9.7.2.2 Separation

Protection and safety systems shall be independent from open and closed loop control and alert systems.

9.7.2.3 Propulsion system

~~Shut-down of the propulsion system shall be limited to those cases which would lead to serious damage, complete breakdown or explosion.~~

Requirements for propulsion systems are stated in IEC 60092-501.

9.7.2.4 Failure modes

Safety systems and as far as is practicable protection ~~(safety)~~ systems, shall be designed so that a single failure within this system gives a visual and audible alarm and does not result in the total loss of propulsion power.

9.7.2.5 Override arrangements

Where arrangements for overriding the shut-down of the main propelling machinery are fitted, these shall be such as to preclude inadvertent operation. A visual ~~means at least~~ and audible alarm shall be provided to indicate that the override has been activated~~; A visual and audible alarm to warn the engineer is recommended~~.

~~Facilities for automatic resetting or overriding of protection systems are not recommended and should not be provided. Exceptionally, and where essential for certain applications, the number of attempts shall be limited.~~

9.7.2.6 Stand-by power ~~supplies~~ supply

~~Protection systems shall be automatically supplied by a stand-by power supply (for example an accumulator battery) in the event of a failure of the normal electrical power supply to the protection system. A failure of the normal supply of the protection system shall be indicated by a visual and audible alarm. The stand-by power supply shall be capable of supplying the protection system for at least 30 min.~~

The protection and safety system shall be continuously powered. A stand-by power supply for the protection and safety system with automatic change-over shall be provided with a capacity for at least 30 min.

~~NOTE~~ Depending on the application, a greater capacity may be necessary, either to achieve safe conditions or where required by the ~~appropriate authority~~ administration.

~~9.6.2.6 Starting and stopping~~

~~Consideration shall be given to making it possible for a protection circuit to be cut off in order to prevent an unintentional protection actuation, when excessive deviation from the set point occurs as an inherent consequence of the normal procedure of starting and stopping the machinery in question. The arrangement shall be such that the protection is only switched off in the case of the subject machinery having been stopped intentionally.~~

9.7.2.7 Alarm for supply failure

Visual and audible alarm signals shall be initiated at the failure of the power supplies of the protection and safety systems.

9.8 Bow, inner, side shell and stern doors

9.8.1 Application

These requirements apply to "roll-on, roll-off" (ro-ro) passenger ships.

9.8.2 Remote control

If arranged for remote control, the requirements of 8.3 shall apply.

9.8.3 Indicator system

The following separate indicators shall be provided for each door:

– door fully closed;

– door fully secured (all locking devices in closed position).

Each door shall be separately indicated.

These indications shall be provided both on the bridge and at the operating panels.

9.8.4 Mode selection

The panel on the bridge shall be equipped with a mode selection function "harbour/sea voyage", so arranged that a visual and audible alarm is initiated in the sea voyage mode if any door is not fully closed or not fully secured.

~~NOTE~~ A manual changeover switch may be acceptable to the ~~appropriate authority~~ administration.

9.8.5 ~~Fail-to-safe~~ Failsafe

The indicator and alarm system for the shell doors shall be designed on the ~~fail-to-safe~~ failsafe principle, that is, in the event of a fault within the system, it shall not result in an incorrect indication that any door is fully closed or fully secured if this is not the case.

~~NOTE~~ Where a part of the system can fail in more than one way, precedence shall be given to the most probable fault.

9.8.6 Testing

A means to test both the indication, for example lamp test, and the audible alarm shall be provided at the navigation bridge panel.

9.8.7 Independence

The indicator and alarm system for the shell doors shall be independent of the door control system.

The power supplies to these systems shall be separately protected and shall be provided with a back-up or secure power supply, for example UPS.

Failure of any power supply shall initiate an audible and visual alarm on the navigation bridge.

9.8.8 Display

Indication shall be effective and continuously displayed in all anticipated lighting conditions.

9.8.9 Sensors

Sensors for the indicator and alarm system for the shell doors shall be protected from water, ice formation and mechanical damage.

9.8.10 Television surveillance

A television surveillance system shall be provided to enable monitoring from the navigation bridge of shell doors where leakage may lead to flooding of ro-ro cargo spaces.

For bow doors, both the inner door and the space between the bow doors and inner doors shall be monitored.

Special consideration shall be given for lighting and contrasting colour of objects under surveillance.

Consideration shall also be given to monitoring special category spaces and ro-ro cargo spaces.

9.8.11 Water leakage detection

A water leakage alarm system shall be provided to detect leakage through any doors which could lead to flooding of a special category space or ro-ro cargo space.

For bow doors, leakage through the inner door shall be monitored.

Whenever flooding is detected, a visual and audible alarm shall be initiated on the navigation bridge and at the machinery control room.

9.8.12 Drainage alarm

In the area between bow door and ramp, and in the area between the ramp and inner door where fitted, a drainage system shall be provided.

A separate visual and audible alarm, in addition to that required by 9.8.11, shall be initiated on the navigation bridge if the water level exceeds 0,5 m above the car deck level in these areas.

9.8.13 Control location

Remote control of all closing and securing devices shall be provided from a position above the freeboard deck for bow doors and inner doors giving access to vehicle decks.

9.9 Power-operated watertight doors

9.9.1 General

For power-operated watertight doors, SOLAS Chapter II-1, Part B, Regulation 15 applies.

9.9.2 Indications

All power-operated sliding watertight doors shall be provided with an indication which will show at all remote operating positions whether each door is open or closed, i.e. at the navigation bridge and at the location where hand operation above the bulkhead deck is arranged.

9.9.3 Alarm

An audible alarm, distinct from any other alarm in the area, shall be provided locally for each sliding door.

This alarm shall ~~sound~~ be active whenever the door is closed remotely by power, and for at least 5 s, but no more than 10 s, before the door begins to move.

The alarm shall continue sounding until the door is completely closed.

~~NOTE~~ In passenger areas and areas of high ambient noise, the ~~appropriate authority~~ administration may require the audible alarm to be supplemented by an intermittent visual signal on the door.

9.9.4 Closure rate

Sliding doors shall have an approximately uniform rate of closure under power. The closure time, from the time the door begins to move to the time it reaches the completely closed position, shall in no case be less than 20 s or more than 40 s ~~with the ship in the upright position~~ under normal operating conditions as stated in Table 1.

9.9.5 Power supply

The electrical power required for sliding doors shall be supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck.

The associated control, indication and alarm circuits shall be supplied as specified above.

In addition, in the event of failure of either the main or emergency source of electrical power, they shall be supplied by the transitional source of emergency electrical power.

The transitional source of emergency electrical power shall have sufficient capacity to operate the door at least three times, i.e. closed-open-closed against an ~~adverse list of 15°~~ inclination value according to Table 1, items No. 11a and No. 11b.

9.9.6 Dedicated circuits

Each electrically operated sliding door shall be provided with its own motor and associated circuits, capable of opening and closing the door.

A single failure in these circuits shall not prevent hand operation of the door.

9.9.7 Location of equipment

As far as is practicable, electrical equipment and components for watertight doors shall be situated above the bulkhead deck and outside hazardous areas and spaces (see IEC 60092-502).

9.9.8 Enclosures

The enclosures of electrical components, necessarily situated below the bulkhead deck, shall provide suitable protection against the ingress of water as specified below:

a) electrical motors, associated circuits and control components: protected to at least IPX7 standard;

a) door position indicators and associated circuit components: protected to IPX8 standard;

b) door movement ~~warning signals~~ indicating devices: protected to at least IPX6 standard.

The water pressure testing of the enclosures protected to IPX8 shall be based on the pressure that may occur at the location of the component during flooding for a period of 36 h with the ship afloat.

~~NOTE~~ Other arrangements for the enclosures of electrical components may be fitted, provided the ~~appropriate authority~~ administration is satisfied that an equivalent protection is achieved.

9.9.9 Leakage

As far as is practicable, arrangements shall be such that leakage of water into the electrical equipment located below the bulkhead deck will not cause the door to open.

9.9.10 Independent circuits

Electric power, control, indication and alarm circuits shall be protected against fault in such a way that a failure in one door circuit will not cause a failure in any other door circuit.

9.9.11 Failure of alarm circuits

Short circuits or other faults in the alarm or indicator circuits of a door shall not result in a loss of power operation of that door.

9.9.12 Failure of control circuits

A single electrical failure in the power operating or control system of a sliding door shall not result in a closed door opening.

9.9.13 Power supply monitoring

The power supply shall be continuously monitored at a point in the electrical circuit as near as practicable to each of the motors required by 9.9.5. Loss of any such power supply shall activate an audible and visual alarm at the central operating console at the navigation bridge.

9.9.14 Mode selection

The central operating console at the navigation bridge shall have a "master mode" switch with two modes of control: a "local control" mode which shall allow any door to be locally opened and locally closed after use without automatic closure, and a "doors closed" mode, which shall automatically close any door that is open. The "doors closed" mode shall permit doors to be opened locally and shall automatically re-close the doors upon release of the local control mechanism with a delay sufficient to pass the door. The "master mode" switch shall normally be in the "local control" mode. The "doors closed" mode shall only be used in an emergency or for testing purposes. Special consideration shall be given to the reliability of the "master mode" switch.

9.9.15 Indication on navigation bridge

The central operating console at the navigation bridge shall be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. Indication shall be effective and continuously ~~displayed~~ available in all anticipated lighting conditions.

A red light shall indicate a door is fully open and a green light shall indicate a door is fully closed.

When the door is closed remotely, the red light shall indicate the intermediate position by flashing.

The indicating circuit shall be independent of the control circuit for each door.

9.9.16 Remote opening

It shall not be possible to remotely open any door from the central operating console.

9.10 Public address systems on passenger ships

~~NOTE Reference should also be made to IMO MSC/Circ. 808, 1997[3], which recommends performance standards for public address systems on passenger ships.~~

9.10.1 ~~Audibility~~ General

~~The public address system shall be clearly audible above the ambient noise in all spaces.~~

A public address system or other effective means of communication complying with the requirements of SOLAS Chapter III, Part B, Regulation 6.5 shall be available throughout the accommodation and service spaces, control stations and open decks.

9.10.2 Override

An override function shall be provided, capable of interrupting any broadcast on the system from any other location on board and be effective even if a speaker has been switched off or its volume turned down.

———————

~~[3] IMO MSC/Circ. 808:1997, *Recommendation for performance standards for public address systems on passenger ships, including cabling*~~

Access to this function shall be provided from the navigation bridge, and at other control stations be accessible in the event of an emergency, the number and location of these emergency control stations being to the satisfaction of the relevant ~~authority~~ administration.

These functions shall be protected against unauthorised use by, for example, key or password operation.

9.10.3 Operation

It shall be possible to broadcast messages simultaneously to all loudspeakers, or to a limited number, for example, crew and work locations, by simple operations.

9.10.4 Emergency broadcast

Facilities for performing emergency broadcasts from at least two positions shall be provided.

One of these positions shall have an interrupt facility, capable of broadcasting by simple operation without any action at the other position.

9.10.5 Level adjustment

The systems shall be provided with facilities for adjusting the sound level.

9.10.6 Minimum sound level

The system shall be capable of generating a minimum sound level of:

a) 75 dB (A) in interior spaces, and at least 20 dB (A) above the speech interference level,

b) 80 dB (A) in exterior spaces, and at least 15 dB (A) above the speech interference level.

9.10.7 Interference

The system shall be capable of preventing feedback or other interference.

9.10.8 Fault tolerance

The system shall ~~have multiple amplifiers and a distributed arrangement in order not to allow single failures to~~ be so arranged that a single failure does not disrupt the total system.

9.10.9 Protection

Each loudspeaker shall be individually protected against short circuit.

9.10.10 Fire zones

All areas of each fire zone shall have at least two dedicated loops sufficiently separated throughout their length, and have two separate and independent amplifiers.

9.10.11 Segregation

Loudspeakers in public rooms, alleyways, stairways, and control stations shall ~~be fed by multiple~~ have at least two loops and two separate and independent amplifiers.

9.10.12 Power supplies

The systems shall be supplied from the main, emergency and transitional source of power.

9.10.13 Cabling

As far as is practicable, cables and wiring shall be routed clear of galleys, laundries, machinery spaces of category A and their casings and other high fire-risk areas.

Where practicable, all such cables should be installed in such a way as to prevent damage caused by heating of the bulkheads due to a fire in an adjacent space.

Cables and wires shall be at least of flame retardant type except the cables passing through high fire-risk areas which shall be of fire-resistant type.

Cable routes shall be separated, or fire-resistant cables shall be used.

10 Computer based systems

~~**10.1.1 Scope**~~

~~This clause gives specific requirements for computer-based systems which are additional to the requirements contained in other clauses of this standard.~~

~~**10.1.2 Performance**~~

~~Computer-based systems shall provide functions to the system in which they are used in a safe, stable and repeatable manner under all operating conditions, including emergency conditions. Response times shall be adequate for all functions, taking into account both normal and abnormal operating conditions.~~

~~**10.2 System safety**~~

~~**10.2.1 Operational safety**~~

~~The computer-based system shall be capable of safe operation, taking into account:~~

~~– danger to persons;~~

~~– environmental impact;~~

~~– damage to equipment;~~

~~– usability;~~

~~– operability of non-computer devices and systems, etc.~~

~~**10.2.2 Fail-to-safe**~~

~~In the event of a failure of a computer-based system, the process shall automatically revert to a pre-defined condition providing an appropriate level of safety. Failure shall initiate an audible and visual alarm.~~

~~On initial start-up or re-start after failure, the computer-based system shall revert to a pre-defined state providing an appropriate level of safety.~~

~~**10.2.3 Essential services**~~

~~Where an essential service depends upon a computer-based system, a secondary independent means, of appropriate diversity, providing the service shall be available.~~

~~NOTE Human intervention may be acceptable for some services.~~

~~**10.3 System configuration**~~

~~**10.3.1 Security**~~

~~Computer-based systems shall be provided with effective physical and/or logical security arrangements to prevent unauthorised access to functions or alteration of configuration, programs or data.~~

~~**10.3.2 Allocation of functions**~~

~~Process functions shall be allocated to the computer-based system in accordance with the needs of the user, the task and the environment.~~

~~**10.3.3 Modularity**~~

~~The hardware and software shall be of a modular, hierarchical design in order to minimise the consequence of any system failure and to ensure ease of testing and maintenance.~~

~~**10.3.4 Selection of equipment**~~

~~The selection of the computer equipment shall be consistent with safe operation of the process in which it is to be used. Hardware shall be suitably designed to withstand conditions as specified in clause 6.~~

~~**10.4 System integration**~~

~~**10.4.1 Effective operation**~~

~~Operation with an integrated system shall be at least as effective as it would be with individual stand-alone equipment or systems.~~

~~**10.4.2 Integrated system failure**~~

~~Failure of one part of the integrated system shall not affect the functionality of other parts, except for those functions directly dependent on the defective part.~~

~~**10.4.3 Multi-function displays and controls**~~

~~Multi-function displays and controls shall be redundant and interchangeable. The number of units at control stations shall be sufficient to ensure 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.~~

~~**10.5 Power supply**~~

~~**10.5.1 Monitoring**~~

~~Power supply status shall be monitored and indicated and for essential services an alarm shall be initiated in the event of an abnormal condition.~~

~~**10.5.2 Protection of data**~~

~~Program and data held in the system shall be protected from corruption by loss of power.~~

~~**10.5.3 Process states**~~

~~In the event of power failure functions shall be protected against undefined and critical process states.~~

10.6 Data communications links

NOTE These include local area networks, instrument networks and other means which share a communication medium.

10.6.1 Node failure

Failure in a node shall not have any effect on the remaining part of the data communication link.

10.6.2 Initialisation

Data communication links shall be automatically initialised on power on. After a power interruption the links shall regain normal operation without manual intervention.

10.6.3 Data latency

The characteristics of the data communication link shall ensure that all information is transmitted in adequate time and overloading is prevented.

NOTE Overload may also be avoided by segregating non important functions from the main process network using bridges or other such devices. Voice communication and video signals may share the network if this requirement is complied with.

10.6.4 Detection of failures

The data communication link shall be self-checking, detecting failures on the link itself and data communication failures on nodes connected to the link. Detected failures shall initiate an alarm.

10.6.5 Network management

For a network, the self-check function may be implemented as a primary function in a dedicated network management unit or as a secondary function in a suitable device connected to the network. For essential functions, related data shall be subject to error and range checking at the receiving node.

10.6.6 Redundancy

To ensure data integrity in case of error in transmission or reception of data where two or more essential functions use the same data communication link, this link shall be redundant and the status of the links shall be monitored at all times.

10.6.7 Routing

Where redundant data communication links are required, they shall be routed with as much separation as is practicable, such that the risk of damage to both networks is minimised.

10.6.8 Automatic switching

Where redundant data communication links are required, switching between the links shall be automatic.

10.6.9 Mutual independence

Interconnected data communication links shall be mutually independent. Failure of any common components shall not result in an unacceptable degradation in performance.

~~**10.7 User interface**~~

~~**10.7.1 General**~~

~~**10.7.1.1 Operation**~~

~~The user interface shall ensure safe and efficient operation of the system by:~~

~~– providing necessary information;~~

~~– allowing appropriate user action;~~

~~– avoiding unnecessary stress;~~

~~– adapting work load to the user's capability.~~

~~NOTE Consideration shall be given to operator intervention, access control, security arrangements and ergonomics.~~

~~**10.7.1.2 Configuration**~~

~~Systems shall be configured to allow simultaneous monitoring and control.~~

~~**10.7.2 Input devices**~~

~~**10.7.2.1 Inadvertent operation**~~

~~Input devices, e.g. keyboard, track ball, mouse, touch screen, etc., shall be designed and arranged to avoid inadvertent operation.~~

~~**10.7.2.2 Defined functions**~~

~~Input devices shall have clearly defined functions, be reliable in use and allow safe operations under all conditions. A recognisable acknowledgement of given commands shall be provided.~~

~~**10.7.2.3 Dedicated functions**~~

~~Dedicated function keys shall be provided for frequently recurring commands and for commands which must be available for immediate execution.~~

~~**10.7.2.4 Multiple functions**~~

~~If multiple functions are assigned to keys, it shall be possible to recognise which of the assigned functions are selected.~~

~~**10.7.2.5 Essential services**~~

~~Input devices for essential functions shall be available on demand.~~

~~**10.7.2.6 View of displays**~~

~~Input devices shall be positioned such that the operator has a clear view of related displays.~~

~~**10.7.2.7 Arrangement**~~

~~Input devices shall be arranged in a logical manner and grouped by function.~~

~~**10.7.2.8 Confirmation of action**~~

~~The user shall be provided with positive confirmation of action.~~

~~**10.7.3 Output devices**~~

~~**10.7.3.1 Positioning**~~

~~Output devices, e.g. monitors, mimic panels, etc. shall be positioned such that the user has a clear view from the intended operating location.~~

~~**10.7.3.2 Presentation**~~

~~The information presented shall be clearly legible in all anticipated lighting conditions.~~

~~**10.7.3.3 Computer dialogue**~~

~~**10.7.3.3.1 User guidance**~~

~~Computer dialogue shall guide the user through the task.~~

~~**10.7.3.3.2 Warnings**~~

~~Clear warnings shall be given when using functions enabling alteration of control conditions, changing of data or programs in the memory, etc.~~

~~**10.7.3.3.3 Self description**~~

~~All menus and displays shall be self-descriptive.~~

~~**10.7.3.3.4 Updating of essential information**~~

~~Essential information updating shall not be blocked during dialogue.~~

~~**10.8 Alarm, control and safety functions**~~

~~**10.8.1 General**~~

~~Alarm control and safety systems shall be configured such that functions are mutually independent.~~

~~**10.8.2 Alarm functions**~~

~~**10.8.2.1 Presentation**~~

~~Alarms shall be visually and audibly presented with priority over other information in every operating mode of the system. They shall be clearly distinguishable from other information.~~

~~**10.8.2.2 Acknowledgement**~~

~~Acknowledgement of alarms shall be possible only at the location dedicated to respond to the alarm. Unacknowledged alarms shall be readily distinguishable.~~

~~**10.8.2.3 Essential functions**~~

~~Alarm messages for essential functions shall have priority over any other information presented on the display.~~

~~**10.8.2.4 Prioritization**~~

~~Alarms shall be displayed in the order in which they occur and shall be traceable.~~

~~**10.8.2.5 Colour discrimination**~~

~~If alarm messages are displayed on colour monitors, the distinctions in the alarm status shall be ensured even in the event of failure of a primary colour.~~

~~**10.8.3 Control functions**~~

~~**10.8.3.1 Essential functions**~~

~~Control of essential functions shall be available at only one control station at any time. Alternatively, conflicting control commands shall be prevented by means of interlocks and/or warnings.~~

~~**10.8.3.2 Station in control**~~

~~Indication of the station in control shall be provided at each control station.~~

~~**10.8.3.3 Transfer of control**~~

~~Transfer of control from one station to another shall be effected smoothly and without interruption to the service.~~

~~**10.8.4 Safety functions**~~

~~Computer-based systems for critical functions shall automatically intervene to ensure operational safety where process characteristics or operator reaction times exclude manual intervention in the event of any system failure.~~

~~**10.9 Software**~~

~~**10.9.1 General**~~

~~**10.9.1.1 Use of procedures**~~

~~Systematic procedures shall be followed during all phases of the software life cycle.~~

~~The software life cycle includes specification, quality planning, development, verification, implementation, validation, acceptance, installation and subsequent modification.~~

~~Modifications of program contents and data, as well as a change of version, shall be documented.~~

~~**10.9.1.2 Documentation of procedures**~~

~~The actions taken to comply with 10.9.1.1 shall be documented and implemented, and the execution of these actions shall be traceable.~~

~~**10.9.2 Configuration**~~

~~**10.9.2.1 Support functions**~~

~~Where essential functions can be maintained without the assistance of calculation, simulation or decision support modules, the application software shall be designed such that failure of such modules will not result in any loss of basic functionality.~~

~~**10.9.2.2 Basic software**~~

~~Operating systems or other such software supporting application software for multiple functions, i.e. middleware or firmware, shall enable:~~

- running several modules under allocated priorities;
- detection of execution failures of individual modules;
- discrimination of faulty modules to ensure maintained operation of modules at least of the same or of a higher priority.

10.9.2.3 Task prioritization

Individual application software modules allocated as tasks under an operating system as specified above are not to perform operations related to more than one function. Tasks shall be assigned priorities appropriate to the functions served.

10.9.2.4 Segregation

Where hardware, e.g. input/output devices, communication links, memory, etc., are configured to minimise the consequences of failures, the related software shall be separated into different computer tasks to secure the same degree of independence.

10.10 Tests

10.10.1 General

All tests shall be documented.

The documentation shall include a description of the methods of test, required test results and test results including tests performed by other suppliers of embedded or interconnected systems.

10.10.2 Hardware

Hardware shall be tested in accordance with the requirements of clause 5.

10.10.3 Software

10.10.3.1 Module testing

Software modules shall be tested prior to being installed in the associated hardware.

10.10.3.2 Pre-installation testing

Application software shall be fully tested prior to being installed on board.

10.10.4 System testing

10.10.4.1 Complete system

Testing shall be performed in full on the system comprising actual hardware components, software modules and application software, in accordance with an approved test program.

10.10.4.2 Function tests

System tests and visual examination shall verify that the system fulfills its functional specification.

10.10.4.3 Fault simulation

Failures shall be simulated as realistically as possible. Alarm and safety limits shall be checked preferably by exceeding the specified limits of monitored parameters.

~~**10.10.4.4 Operating conditions**~~

~~It shall be verified that the system functions as intended under normal and abnormal operating conditions.~~

~~**10.10.4.5 Integrated systems**~~

~~Integrated systems shall be tested to verify that correct functionality has been achieved.~~

~~**10.10.4.6 On-board testing**~~

~~Quay-side and sea trials shall verify the ability to perform intended functions with all systems interconnected.~~

10.1 General

Clause 10 applies to the use of computer based systems which provide control, alert, monitoring or safety functions which are additional to the requirements contained in other clauses of this standard.

10.2 General requirements

Computer based systems shall fulfil the requirements of the system under control for all operating conditions, taking into account human safety, environmental impact, damage to vessel as well as equipment, usability of computer based systems and operability of other equipment.

10.3 System categories

Computer based systems shall be assigned into four system categories as shown in Table 2 according to the possible extent of the damage caused by an event.

Consideration shall be given to the extent of the damage directly caused by a failure within the computer based system, but not to any consequential damage.

Table 2 – System categories

Category	Effects	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 function for informational / administrative tasks
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.	Alert and monitoring functions Control functions which 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 Protection functions
IV	Those systems, failure of which could immediately lead to catastrophic situations for human safety, safety of the vessel and / or threat to the environment.	Control systems for which manual intervention to avert danger in the event of failure or malfunction is not possible Safety functions

The assignment of a computer based system to the appropriate system category shall be made according to the worst case of direct damage (for examples, see Table 3).

Where independent effective backup or other means of adverting danger is provided the system category may be decreased.

The type and size of ship, the presence of persons in the danger area in terms of duration or frequency, the complexity of the system or the possibility to avert danger may lead to assignment to a different system category.

Table 3 – Examples of assignment to system categories

System category	Example
I	Maintenance support systems Information and diagnostic systems Loading instrument (stand alone)
II	Alert & monitoring equipment Tank capacity measuring equipment Control systems for auxiliary machinery Main propulsion remote control systems Fire detection systems Fire extinguishing systems Bilge systems Governors Loading instrument (on line)
III	Machinery protection systems/equipment Electronic fuel injection for diesel engines Control systems for propulsion and steering Synchronizing units for switchboards
IV	Burner control systems Course control systems of high speed craft (HSC) Dynamic positioning systems
NOTE The examples listed in Table 3 are not exhaustive.	

10.4 System configuration

10.4.1 General

The technical design of a computer system arises out of its assignment to a system category. The measures listed below by way of example, graded according to the requirements of the respective system category, shall be ensured.

The computer systems shall be fast enough to perform control operations and to inform the user correctly and carry out user instructions at the correct time under all operating conditions.

Computer systems shall monitor the program execution and the data flow automatically.

In the event of failure and restarting of computer systems, the process shall be protected from undefined and critical states.

10.4.2 Power supply

The power supply shall be monitored and faults shall be indicated by an alert.

Redundant systems shall be separately protected against short circuits and overloads and shall be separately fed. Program and data held in the system shall be protected from corruption by loss of power.

10.4.3 Hardware

The design of the hardware shall be clearly structured, for example separation of supply voltages. Interchangeable parts shall be easily accessible for repairs and maintenance.

Removable components and connectors shall be appropriately marked to protect against unintentional transposition.

Subsystems in integrated systems shall not mutually interfere.

Computer systems shall preferably be designed without artificial ventilation. If forced ventilation of computer systems is necessary, the provision of an over temperature alert is recommended.

10.4.4 Software

The manufacturer shall apply a systematic procedure during all the phases of software development including modifications appropriate to the relevant system category.

Software shall be tested as appropriate to the relevant system category.

Design and testing of software shall be appropriately documented.

The version of the software with the relevant date and release shall be documented and shall be clearly identifiable.

10.4.5 Data communication links

The reliability of data transmission shall be suitable for the particular application and the system category, and specified accordingly.

The loss of any communication link shall cause an alert.

The data communication link shall be continuously self-checking in order to detect failures on the link itself and data communication failure on nodes.

Switching between redundant links shall not disturb data communication or continuous operation of functions.

Data communication links shall be automatically initialised on power on. After a power interruption the link shall regain normal operation without manual intervention.

10.4.6 Wireless data communication

When an alternative design or arrangements deviating from these requirements are proposed, an engineering analysis is required to be carried out in accordance with a relevant international or national standard acceptable to the administration (see also SOLAS Chapter II-1 Part F, Regulation 55).

As a failure may lead to an accident with catastrophic severity, the use of unconventional technology for such applications will only be permitted exceptionally in cases where evidence is presented that demonstrates acceptable and reliable system performance to the satisfaction of the administration.

The requirements in 10.4.6 are in addition to the requirements of 10.4.5 and apply to system category I and II using wireless data communication links to transfer data between distributed programmable electronic equipment or systems.

Functions that are required to operate continuously to provide essential services dependant on wireless data communication links shall have an alternative means of control that can be brought in action within an acceptable period of time.

Wireless data communication shall employ recognised international wireless communication system protocols that incorporate the following:

- message integrity: fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message;
- configuration and device authentication: they shall only permit connection of devices that are included in the system design;
- message encryption: protection depending on the confidentiality and/ or criticality of the data content;
- security management: protection of network assets, prevention of unauthorised access to network assets.

The wireless system shall comply with the radio frequency and power level requirements of the International Telecommunications Union and administration requirements.

Consideration should be given to system operation in the event of port state and local regulations that pertain to the use of radio-frequency transmission prohibiting the operation of a wireless data communication link due to frequency and power level restrictions.

10.4.7 Network/integration of systems

The architecture and the configuration of a network shall be suitable for the particular system category.

The integration of independent subsystems shall not decrease the reliability of the system.

A failure in one of the subsystems shall not affect the function of other subsystems.

A failure of the transfer of data between interconnected independent subsystems shall not impair their independent functions.

The characteristics of the data communication link shall ensure that all information is transmitted in adequate time and overloading is prevented.

10.4.8 User interface

The user interface of a system shall be designed according to ergonomic principles. These can be found for example in the ABS publication “Guidance notes on the application of ergonomics to marine systems”.

The status (system health) shall be monitored and clearly displayed.

Failure or shut-down of subsystems or functional units shall be indicated by an alert and displayed at every related operator station.

A universal user guide shall be provided for the use of computer systems.

10.4.9 Input devices

Feedback of the effectiveness of control commands shall be indicated.

An assessment shall be performed to define the response time for control commands.

Operator panels located on the bridge shall be individually illuminated. The lighting shall be adaptable to the prevailing ambient conditions.

Where equipment operations or functions may be changed via keyboards, appropriate measures shall be provided to prevent unintentional operation.

If the operation of a key on a keyboard is able to cause dangerous operating conditions, measures shall be taken to prevent the execution by a single action only, such as:

– use of a special key lock;
– use of two or more keys.

Concurrent control interventions shall be prevented by means of interlock. The control station in operation shall be indicated as such.

Controls shall be in accordance to their position and direction of operation to the controlled equipment.

10.4.10 Output devices

The size, colour and density of text, graphic information and alert signals displayed on a visual display unit shall be such that it may be easily read from the normal operator position under all lighting conditions.

Information shall be prioritised, for example alerts (alarms, warnings, cautions) or general.

Alert information shall be displayed in both orders, chronological and prioritized, according to IMO Resolution MSC.302(87).

10.4.11 Graphical user interface

Information shall be presented clearly and intelligibly according to its functional significance and association. Screen contents shall be logically structured and their representation shall be restricted to the data which is directly relevant for the user.

When general purpose graphical user interfaces are employed, only those functions necessary for the respective process shall be made available.

Alerts shall be visually and audibly presented with priority to other information in every operating mode of the system; they shall be clearly distinguishable from other information.

10.5 Protection against modification and loss of data

Computer systems shall be protected against unintentional or unauthorised modification of programs and data, see for example IEC 62443.

For systems of system categories III and IV modifications of safety parameters may only be carried out by the manufacturer.

10.6 Software maintenance

Any software modification/upgrade shall be handled in accordance with change handling procedures, and necessary evidence shall be recorded:

- any revision which may affect compliance with this standard shall be approved by the administration and evidence of such revision shall be available on board;
- the procedure of the modification shall be available;
- integrity of the update software package shall be verified on board before the software update is carried out;
- a test program for verification of correct installation and correct functions shall be available;
- evidence for the reason for updating a software shall be documented in a software release note;
- in case the update software package has not been successfully installed, the previous version of the system shall be available for re-installation and re-testing.

10.7 Remote access

10.7.1 General

Remote access during the voyage of a ship shall be used only for monitoring purposes and with the prior acknowledgment by the ship's responsible crew member only.

The security of the remote access shall be ensured.

10.7.2 Remote software maintenance

The requirements according to 10.5 shall be adhered to.

Modification shall be possible only with the acceptance and acknowledgement by the ship's responsible crew member (for example the captain) and shall be carried out in a harbour only.

In case of unexpected failure after modification a fall back strategy shall be available.

10.8 Documentation

10.8.1 General

~~10.11.1.1 Clarity~~

All documentation shall provide relevant information in a clear and unambiguous manner.

~~10.11.1.2 Use of symbols and abbreviations~~

Symbols and abbreviations used shall be explained or referenced to an appropriate international standard or code.

Documents required for evaluation of computer based systems shall be graded according to the requirements of the respective system category.

Hardware and software versions shall be documented by the manufacturer and shall be retraceable.

Subsequent significant modifications to the software and hardware shall be submitted for approval.

For all tests required in accordance with the system category a test specification shall be prepared and the tests shall be documented.

Test programs and evidence shall be produced according to Table 4, item No. 6.

10.8.2 Hardware

The following documentation shall be provided:

a) system block diagram, showing the arrangement of individual parts, input and output devices and interconnections (see IEC 61355-1);

b) wiring ~~connection~~ diagrams (see IEC 61355-1);

c) details of input and output devices;

d) details of electric power supplies.

10.8.3 System functional description

Documentation shall be provided to verify compliance with relevant requirements of this standard, for example:

– system specification;

– system performance for normal and abnormal equipment operation;

– instructions for normal and abnormal operating modes;

– transfer of control;

– redundancy or reversionary modes;

– test facilities;

– failure detection and identification facilities (automatic and manual);

– data security;

– access restrictions;

– special aspects requiring user attention.

In addition, documentation shall be provided concerning procedures for:

- start-up;
- restoration of functions;
- maintenance and periodical testing;
- data back-up;
- software reload and system regeneration;
- failure location and repair.

10.8.4 Software

10.8.4.1 Quality plan

A plan for software life cycle activities shall be provided which shall refer to relevant procedures, responsibilities and system documentation, including configuration management.

10.8.4.2 Description

Software shall be ~~fully~~ described in accordance with the system category, see Table 3. The description of software shall include, for example:

– a description of the basic software installed in each hardware unit;

– a description of the communication software installed on nodes in a network;

– descriptions of application software (not program listings);
– tools for system set-up and process equipment configuration.

10.8.4.3 Application software

Application software shall be described in accordance with the system category, see Table 3. The description of application software shall include, for example:

– ~~information~~ identification of system modules that ~~must be~~ are operative in order to maintain functions including dependencies on other systems;
– detail of each module at a level sufficient to understand its function;
– ~~relationship between the software modules that must be operative in order to maintain each function;~~
– data and control flow between software modules;
– configuration of the software, including priority schemes;
– switching mechanisms for redundant systems.

10.8.4.4 Ranges and limits

A ~~schedule of anticipated equipment~~ measurement point list of operation ranges and limits for ~~alarm~~ alerts and safety functions shall be provided.

10.8.5 User interface

10.8.5.1 Documented design

Control station design and arrangement shall be detailed, including drawings, dimensions, ~~pictures~~ figures, etc., of each user input or output device at a level sufficient to assess the working principles.

10.8.5.2 Screen-based dialogue

Details of screen-based computer dialogue shall ~~be produced, including~~ include:

– description of the functions allocated to each input device;
– details of individual screen views~~, e.g. schematics, colour photos~~, etc.;
– description of menu operation.

10.8.6 Test ~~programs~~ and evidence

Test ~~programs~~ and evidence shall be ~~produced~~ in accordance with ~~10.10~~ Table 4.

Table 4 – Tests and evidence according to the system category

No.	Tests and evidence	System category			
		I	II	III	IV
1.	Evidence of quality system				
	Quality plan for software		M	M	M
	Inspection of components (only hardware) from sub-suppliers		M	M	M
	Quality control in production		M	M	M
	Final test reports	M	M	S	S
	Traceability of software	M	M	S	S
2.	Evidence of validity of hardware and software specification				
	Software specification		M	S	S
	Hardware specification		M	S	S
	Failure analysis for safety related functions only			S	S
3.	Evidence of software testing				
	Evidence of software testing according to quality plan		M	S	S
	Analysis regarding existence and fulfilment of programming procedures for safety related functions			S	S
	Code inspection, walk–through			M	M
	FMEA / FMECA				S
4.	Hardware tests				
	Tests according to Table 1		W	W	W
5.	Software tests				
	Module tests		M	S	S
	Subsystem tests		M	S	S
6.	Factory system tests				
	Function tests	M	W	W	W
	Operating conditions simulation		W	W	W
	Fault simulation		W	W	W
	Integration simulation tests		W	W	W
7.	On-board tests				
	Complete system tests	M	W	W	W
	Integration tests		W	W	W
8.	Modifications				
	Tests after modifications		W/S [a]	W/S [a]	W/S [a]

M Evidence kept by manufacturer and submitted on request

S Evidence checked by the administration

W To be witnessed by the administration

[a] Subsequent significant modifications to the software and hardware shall be submitted for approval (see 10.8.1).

When using demonstrably service-proven systems and components, the extent of the evidence and tests required and their location may be adjusted by agreement of the administration.

For definitions of the software tests and evidence according to Table 4, see IEC 61508-4.

11 Additional requirements for periodically unattended machinery spaces or for reduced attendance

11.1 ~~Introduction~~ General

~~This clause relates to the additional requirements on board ships having periodically unattended machinery spaces.~~

~~**11.2 General requirements**~~

The arrangements required by SOLAS Chapter II-1, Part E shall be provided.

The arrangements provided shall be such as to ensure that the safety of the ship in all sailing conditions, including manoeuvring, is equivalent to that of a ship having the machinery spaces attended.

The arrangements shall be appropriate for the intended duration of unattended operation.

The design of the arrangements shall be in accordance with Clause 9.

~~NOTE~~ For reduced attendance, the applicability of 11.2 to 11.7 shall be determined by the ~~appropriate authority~~ administration.

11.2 Fire precautions

The arrangements required by SOLAS Chapter II-1, Part E, Regulation 47 shall be provided.

~~**11.3.1 Risk of fire**~~

~~Means shall be provided to detect and give alarms at an early stage in case of fire:~~

~~– in boiler air-supply casings and exhausts (uptakes);~~

~~– in scavenging air belts of propulsion machinery, unless the appropriate authority considers this to be unnecessary in a particular case.~~

~~**11.3.2 Oil mist monitoring**~~

~~Internal combustion engines of 2 250 kW and above, or having cylinders of more than 300 mm bore, shall be provided with crankcase oil mist detectors or engine-bearing temperature monitors or equivalent devices.~~

~~**11.3.3 Fire detection and alarm**~~

~~A fire detection and fire alarm system in accordance with 9.1 shall be fitted in the machinery spaces.~~

~~**11.3.4 Position of detectors**~~

~~The fire detection system shall be designed and the detectors positioned so as to detect rapidly the onset of fire in any part of those spaces, and under any normal conditions of operation of the machinery and variations of ventilation, as required by the possible range of ambient temperatures.~~

~~Detection systems using only thermal detectors shall not be permitted, exception being made in spaces of restricted height, and where their use is specially appropriate.~~

~~The detection system shall initiate visual and audible alarms, distinct in both respects from the alarm of any other system not indicating fire, in sufficient places to ensure that the alarms~~

~~are heard and observed on the navigation bridge and by a responsible engineer officer. When the navigation bridge is unattended, the alarm shall sound in a place where a responsible member of the crew is on duty.~~

~~After installation, the system shall be tested under varying conditions of engine operation and ventilation.~~

11.3 Protection against flooding

The arrangements required by SOLAS Chapter II-1 Part E, Regulation 48 shall be provided.

~~11.4.1 Bilge well monitoring~~

~~Bilge wells in periodically unattended machinery spaces shall be monitored in such a way that the accumulation of liquids is detected at normal angles of trim and heel.~~

~~At least two level sensors are to be fitted in each machinery space and the tripping of these sensors shall be indicated by an individual alarm.~~

~~The monitoring arrangement shall indicate the compartment in which the fault has occurred.~~

~~11.4.2 Automatic bilge pumping~~

~~Where the bilge pumps are capable of being started automatically, means shall be provided to indicate when the influx of liquid is greater than the pump capacity, or when the pump is operating more frequently than would normally be expected.~~

~~Where automatically controlled bilge pumps are provided, special attention shall be given to oil pollution prevention requirements.~~

11.4 Control of propulsion machinery

The arrangements required by SOLAS Chapter II-1, Part E, Regulation 49 shall be provided.

~~Remote control of the propulsion machinery from the bridge shall be provided (see 9.5).~~

11.5 Alarm system and engineers' alarm

The arrangements required by SOLAS Chapter II-1 Part E, Regulation 51 shall be provided.

~~11.6.1 Indication of machinery faults~~

~~The machinery alarm shall comply with 9.2 and shall indicate any fault requiring attention.~~

~~11.6.2 Audible and visual alarms~~

~~The system shall be capable of giving visual and audible alarm in the machinery space, and in the machinery control room, if provided.~~

~~Each separate alarm shall be indicated visually at a suitable position.~~

~~11.6.3 Public rooms~~

~~The system shall have a connection to the engineers' public rooms and to each of the engineers' cabins through a selector to ensure connection to at least one of those cabins.~~

~~**11.6.4 Navigating bridge**~~

~~The system shall activate a visual and audible alarm on the navigation bridge for any situation which requires action by or attention of the officer on watch (in particular in case of automatic slow down or shut-down of the propulsion machinery).~~

~~**11.6.5 Failure to alarm condition**~~

~~As far as is practicable, any fault in the system shall initiate an alarm.~~

~~**11.6.6 Engineers' call**~~

~~The engineers' collective call shall be activated if an alarm function has not received attention locally within a limited time.~~

~~**11.6.7 Power supplies**~~

~~**11.6.7.1 Stand-by supply**~~

~~The alarm system shall be continuously powered and shall have an automatic changeover to a stand-by power supply in case of loss of normal power supply.~~

~~NOTE The supply changeover may cause a momentary break in the supply, that is, an uninterruptible supply is not mandatory.~~

~~**11.6.7.2 Failure alarm**~~

~~Failure of the normal power supply of the alarm system shall initiate a visual and audible alarm signal.~~

11.6 Protection (safety) systems

The arrangements required by SOLAS Chapter II-1 Part E, Regulation 52 shall be provided.

~~**11.7.1 Automatic shutdown**~~

~~Safety systems shall be provided to ensure that serious malfunctions in machinery or boiler operations, which present an immediate danger to human life, shall initiate the automatic shut-down of that part of the plant and that a visual and audible alarm shall be given.~~

~~**11.7.2 System design**~~

~~Machinery protection (safety) systems shall be designed in accordance with 9.6.~~

~~**11.8 Special requirements for Machinery, boiler and electrical installations**~~

~~**11.8.1 Power supply**~~

~~The main source of electrical power shall comply with the requirement of 9.3.~~

~~**11.8.2 Load shedding**~~

~~Where the electrical power can normally be supplied by one generator, suitable load shedding arrangements shall be provided to ensure the integrity of supplies to services required for propulsion and steering, as well as safety of the ship. In the case of loss of the generator in operation, adequate provision shall be made for the automatic starting and connection to the main switchboard of a stand-by generator of sufficient capacity to permit propulsion and steering, and to ensure the safety of the ship with automatic restarting of the essential auxiliaries including, where necessary, sequential operations.~~

~~NOTE The appropriate authority may dispense with this requirement for a ship of less than 1 600 tons gross tonnage, if it is considered impracticable.~~

~~**11.8.3 Preservation of supply**~~

~~If the electrical power is normally supplied by more than one generator simultaneously in parallel operation, provision shall be made, for instance by load shedding, to ensure that, in case of loss of one of these generating sets, the remaining ones are kept in operation, without overload, to permit propulsion and steering and to ensure the safety of the ship.~~

~~**11.8.4 Automatic changeover**~~

~~Where stand-by machines are required for other auxiliary machinery essential to propulsion, automatic changeover devices shall be provided in accordance with 9.4.~~

~~**11.8.5 Automatic control and alarm system**~~

~~**11.8.5.1 Main propulsion**~~

~~The control system shall be such that services needed for the operation of the main propulsion machinery and its auxiliaries are ensured through the necessary automatic arrangements.~~

~~**11.8.5.2 Automatic changeover**~~

~~A visual and audible alarm shall be initiated by the automatic changeover to the stand-by machine.~~

~~**11.8.5.3 Monitoring of essential parameters**~~

~~An alarm system complying with 11.6 shall be provided for all important pressures, temperatures, fluid levels and other essential parameters.~~

~~**11.8.5.4 Centralised alarm system**~~

~~A centralised control position shall be arranged with the necessary alarm panels and instrumentation indicating any alarm.~~

~~**11.8.6 Starting air**~~

~~**11.8.6.1 Pressure regulation**~~

~~Means shall be provided to keep the starting air pressure at the required level where internal combustion engines are used for main propulsion.~~

~~**11.8.6.2 Low pressure alarm**~~

~~A visual and audible alarm shall be provided on the navigation bridge and in the machinery space to indicate low starting air pressure and shall be set at a level that will permit further main engine starting operations. The indication on the navigation bridge is only required in case of a reversible main engine.~~

11.7 Machinery, boiler and electrical installations

The arrangements required by SOLAS Chapter II-1, Part E, Regulation 53 shall be provided.

12 Commissioning and testing

12.1 Tests of completed installation

Tests shall be carried out to demonstrate that the electrical control, monitoring and ~~alarm~~ alert systems have been correctly installed and are in good working order before being put into service. Tests shall be realistic and simulations avoided as far as is practicable.

After the completion of the installation, the entire control equipment shall be tested according to a prescriptive test program.

12.2 Operational tests

The ~~first~~ operational tests shall be performed to adjust and record the operational ability of each individual system, including associated sensors, actuators, transducers, indicating and recording instruments, controllers~~, alarms and other control items~~ and associated alerts. They shall also include operation in, and switching between, all methods of manual or automatic and local or remote control. The recordings shall be suitably documented.

The entire control system shall be tested for satisfactory operation during trials at quay and at sea, as far as practicable.

See also IEC 60092-401.

13 Documentation

~~13.1 Apparatus description~~

For each control apparatus, the manufacturer shall deliver sufficient information concerning principles of operation, technical specifications, mounting instructions, required starting up or commissioning procedures, fault-finding procedures, maintenance and repair, as well as lists of the necessary test facilities and replaceable parts.

Sufficient information shall be available to enable a complete system description to be prepared.

~~13.2 Circuit diagrams~~

Circuit diagrams on durable material shall, where relevant for each individual control apparatus, be prominently displayed in or near the apparatus to which it refers, or alternatively included in the control system handbook.

For computer based systems refer to 10.6.

Appropriate documentation specifying all set points shall be available.

Bibliography

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IEC 60092-401, *Electrical installations in ships – Part 401: Installation and test of completed installation*

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INTERNATIONAL STANDARD

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Electrical installations in ships – Part 504: Automation, control and instrumentation

Installations électriques à bord des navires – Partie 504: Automatisation, commande et instrumentation

IEC 60092-504:2016-09(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRICAL INSTALLATIONS IN SHIPS –

Part 504: Automation, control and instrumentation

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60092-504 has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units.

This fourth edition cancels and replaces the third edition published in 2001. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) the part title has been changed, the term "Automation" was added;
b) the contents of the corrigendum of January 2011 have been included;
c) a new subclause 5.1 "General" with general requirements for type testing has been added;
d) Table 1 contents aligned with current version of document IACS Req. 1991/Rev. 5, 2006;
e) the revised IMO Resolution A.1021(26), Code on alerts and indicators:2009 has been taken into account;

f) IMO Resolution MSC.302(87) has been taken into account. As a consequence, the term “alert” has been used where the generic term applies. This concerns, in particular, the text in 8.4 and 9.3;

g) a new subclause 8.2.4: The revised IMO Resolution MSC.145(77), Performance standards for water level detectors on bulk carriers:2003 has been taken into account;

h) subclause 9.1 about fire detection and alarm systems has been completely revised, IMO Resolution MSC.98(73) (FSS Code) with amendment MSC.292(87): 2010 has been taken into account;

i) a new subclause 9.2 “Bilge systems” has been added;

j) the subclauses 9.4 “Automatic control installations for electrical power supply” and 9.5 “Automatic starting installations for electrical motor-driven auxiliaries” have been completely revised;

k) Clause 10 “Computer based systems” has been completely revised;

l) a new subclause 10.3.6 about wireless data communication has been added;

m) a new subclause 10.5 about remote access has been added.

The text of this standard is based on the following documents:

FDIS	Report on voting
18/1539/FDIS	18/1545/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60092 series, under the general title *Electrical installations in ships,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

IEC 60092 forms a series of international standards for electrical installations in sea-going ships, incorporating good practice and coordinating, as far as possible, existing rules.

These standards form a code of practical interpretation and amplification of the requirements of the International Convention for the Safety of Life at Sea, a guide for future regulations which may be prepared and a statement of practice for use by ship owners, shipbuilders and appropriate organizations.

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 504: Automation, control and instrumentation

1 Scope

This part of IEC 60092 specifies electrical, electronic and programmable equipment intended for automation, control, monitoring, alert, and safety and protection systems for use in ships.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at www.electropedia.org)

IEC 60068-2-1, *Environmental testing – Part 2: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2: Tests – Test B: Dry heat*

IEC 60068-2-6, *Environmental testing – Part 2: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-30, *Environmental testing – Part 2: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-52, *Environmental testing – Part 2: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60092-101:1994, *Electrical installations in ships – Part 101: Definitions and general requirements*
IEC 60092-101:1994/AMD1:1995

IEC 60092-201:1994, *Electrical installations in ships – Part 201: System design – General*

IEC 60092-202, *Electrical installations in ships – Part 202: System design – Protection*

IEC 60092-302, *Electrical installations in ships – Part 302: Low-voltage switchgear and controlgear assemblies*

IEC 60092-501, *Electrical installations in ships – Part 501: Special features – Electric propulsion plant*

IEC 60092-502, *Electrical installations in ships – Part 502: Tankers – Special features*

IEC 60447, *Basic and safety principles for man-machine interface, marking and identification – Actuating principles*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60533, *Electrical and electronic installations in ships – Electromagnetic compatibility (EMC) – Ships with a metallic hull*

IEC 60945, *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measuring techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61355-1, *Classification and designation of documents for plants, systems and equipment – Part 1: Rules and classification tables*

IEC 62443 (all parts), *Industrial communication networks – Network and system security*

ABS publication, *Guidance notes on the application of ergonomics to marine systems (2014-02)*

CISPR 16-1-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-2-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

EN 54 (all parts), *Fire detection and fire alarm systems*

IMO Resolution A.1021(26):2009, *Code on alerts and Indicators*

IMO Resolution MSC.302(87):2010, *Adoption of performance standards for bridge alert management (BAM)*

IMO Resolution A.813(19):1995, *General Requirements for Electromagnetic Compatibility (EMC) for all Electrical and Electronic Ship's Equipment*

IMO Resolution MSC.98(73):2000, *Adoption of the international code for fire safety systems (FSS Code)*

SOLAS, *International Convention for the Safety of Life at Sea (SOLAS):1974, consolidated edition, 2009*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050 as well as the following apply.

3.1
accuracy
quality which characterizes the closeness of a measured value to the corresponding true value

3.2
administration
Government of the State whose flag the ship is entitled to fly

[SOURCE: SOLAS, Chapter I, Regulation 2, Definition (b)]

3.3
availability
ability of an item to be in a state to perform a required function under given conditions at a given time interval, assuming that the required external resources are provided

3.4
centralized control
control of all operations of a controlled system from one central control position

3.5
computer based system
system that consists of one or more programmable electronic devices with their connections, peripherals and software necessary to carry out automatically specified functions

Note 1 to entry: The following types of programmable devices could form part of a computer system: main-frame, mini-computer, micro-processor-based computer, programmable logic controller.

3.6
control functions
functions intended to regulate the behaviour of equipment or systems

3.7
control position
control station
group of control devices by which an operator can control the performance of a machine, apparatus, process or assembly of machines and apparatus

Note 1 to entry: A control position will generally enable an operator to verify the achievement of the desired conditions by means of an appropriate monitoring system

3.8
dependability
extent to which a system can be relied upon to perform its intended functions under defined operational and environmental conditions

3.9
essential services
functions necessary for the propulsion, steering and safety of the ship and its personnel

3.10
failsafe
design property of an item which prevents its failures from resulting in critical faults

Note 1 to entry: The safe state, according to the application, will be predetermined in terms of priority for the safety of the ship and may generally be taken as the least critical one for the main components and auxiliaries of, for example, the propulsion/manoeuvring plant.

[SOURCE IEC 60050-821: 1998, 821-01-10, modified – a note has been added.]

3.11
function
elementary operation performed by the system which, in conjunction with other elementary operations (system functions), enables the system to perform a task

3.12
integrity
capability of a system to satisfactorily perform the required functions under all the stated conditions within a stated period of time

3.13
machinery control room
room or spaces where centralized controls and measuring and monitoring equipment for main equipment and essential auxiliary machinery are located together with the appropriate means of communication

3.14
maintainability
ability of an item under given conditions of use, to be retained in, or restored to, a state in which it can perform a required function, when maintenance is performed under given conditions and using stated procedures and resources

Note 1 to entry: The term "maintainability" is also used as a measure of maintainability performance.

3.15
monitoring functions
functions intended to collect data from equipment and systems for the purpose of display and recording

3.16
protection functions
functions intended to prevent damage to equipment or systems in the event of a fault

3.17
reliability (performance)
ability of an item to perform a required function under given conditions for a given time interval

Note 1 to entry: It is generally assumed that the item is in a state to perform this required function at the beginning of the time interval.

Note 2 to entry: Generally, reliability performance is quantified using appropriate measures. In some applications, these measures include an expression of reliability performance as a probability, which is also called reliability.

[SOURCE: IEC 60050-312:2001, 312-07-06, modified – notes 1 and 2 have been added.]

3.18
protection and safety functions
functions intended to prevent harm or danger to personnel and protect equipment/systems

3.19
software
computer programs, procedures, rules and associated documentation of a digital information processing system pertaining to the operation and including application (user) program, middleware and operating system (firmware) program

3.20
system
collection of components organised to accomplish a specific function or set of functions

3.21
usability
extent to which a system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use

3.22
bridge and deck zone
area from which the ship is steered and navigated and where the antennas are located

3.23
machinery space
spaces between the watertight boundaries of a space containing the main and auxiliary propulsion machinery, including boilers, generators and electric motors primarily intended for propulsion

Note 1 to entry: In case of unusual arrangements, the administration may define the limits of the machinery spaces.

[SOURCE: SOLAS Chapter II-1, Regulation 2, Definition 15]

3.24
remote control
control of an operation at a point distant from the controlled switching device

[SOURCE IEC 60050-441:2000, 441-16-07]

3.25
process
systematic series of actions that lead to a particular result of an executing instance of a computer program

3.26
automation system
system to monitor and control a process

3.27
instrumentation
instruments and their application for monitoring, measurement and control

3.28
significant modification
modification of the system functionality and/or safety of the system

3.29
PMS
power management system
automatic control system for the generation and distribution of electrical energy

Note 1 to entry: This note applies to the French language only.

4 General requirements

4.1 Dependability

Systems shall be suitable for the user, the task and the application.

System integrity shall be appropriate for the functions supported, with due regard to factors such as availability, reliability and maintainability.

4.2 Safety

Systems shall be designed such that risk of harm to persons or the environment is reduced to a level acceptable to the administration, both in normal operation and under failure conditions. Functions shall be designed on the failsafe principle.

4.3 Segregation

Systems shall be designed such that failure of one component part or sub-system will not unduly affect any other system, sub-system or component and, as far as is practicable, shall be detectable.

Failure in an automation system shall not influence the protection and safety functions.

Protection and safety functions shall be independent of control functions. As far as is practicable, control and monitoring (alert) functions shall also be independent.

Standby systems, or other redundancy arrangements, are to be functionally independent.

4.4 Performance

Systems shall maintain specified levels of performance in operation, and where necessary, under fault conditions.

Repeatability and accuracy shall be adequate for the proposed use and shall be maintained at their specified value during their expected lifetime and normal use.

Systems shall be stable throughout their operational range.

4.5 Usability

Systems shall be readily usable under all intended operating conditions and shall support effective and efficient operation.

Adequate safeguards against incorrect operation shall be provided.

4.6 Integration

Where safety of personnel may directly depend on correct system operation or failure, such systems shall not be integrated with, or be mutually dependent upon, any other system, except those providing complementary functions.

Where safety may indirectly depend on system operation or failure, the integrity of the integrated system shall be to the satisfaction of the administration.

4.7 Development activities

Activities undertaken in the development process, from initial design through to eventual realisation, and any modifications in use thereafter, shall be planned and structured in a

systematic manner, and are to be properly managed. Persons responsible for carrying out these activities shall be competent to do so.

Activities, scopes, responsibilities and competencies shall be documented.

5 Environmental type testing parameters

5.1 General

Standard atmospheric conditions during functional test to equipment specification are defined in Table 1, No. 2.

The tests specified in Table 1 are applicable, but not confined, to all equipment used for:

– automation, control, protection and safety;
– internal communication.

Electrical and electronic equipment on board ships required neither by classification rules nor by International Conventions, liable to cause electromagnetic disturbance shall be of a type which fulfils the test requirements of test specifications regarding radiated and conducted emissions, see Table 1, No. 19 and No. 20.

5.2 Performance

Where equipment or systems are subject to type testing, the test procedures and severities specified in Table 1 shall apply.

Compliance with IMO Resolution A.813(19) will require all ships' electrical and electronic equipment to be tested to the relevant electromagnetic compatibility standard.

Table 1 – Type tests, test procedures and severities

No.	Test [a]	Procedure according to	Test parameters, severity	Additional requirement/s
1	Visual inspection			Examination of the equipment for: – conformity to drawings and design data; – compliance with applicable IEC standards; – quality of workmanship and construction.
2	Functional test to equipment specification		Standard atmospheric conditions: – temperature: 25 °C ± 10 °C – relative humidity: 60 % ± 30 % – air pressure: 96 kPa ± 10 kPa	

<table>
<tr><th>No.</th><th>Test [a]</th><th>Procedure according to</th><th colspan="4">Test parameters, severity</th><th>Additional requirement/s</th></tr>
<tr><td rowspan="3">3</td><td rowspan="3">High voltage test</td><td rowspan="3"></td><td colspan="2">Rated insulation voltage U_n
V</td><td colspan="2">Test voltage AC
V</td><td rowspan="2">Frequency of test voltage: 50 Hz or 60 Hz.
Separate circuits to be tested against each other.
All circuits connected with each other are to be tested against earth.
Contact pieces are to be tested across their open points of contact.
Printed circuits with electronic components which could be subject to damage may be removed during the test.</td></tr>
<tr><td colspan="2">$U_n \leq 65$
$66 < U_n \leq 250$
$251 < U_n \leq 500$
$501 < U_n \leq 690$</td><td colspan="2">$2 \times U_n + 500$
1 500
2 000
2 500</td></tr>
<tr><td colspan="4">Period of application of test voltage: 1 min</td><td></td></tr>
<tr><td rowspan="13">4a</td><td rowspan="13">Power supply variations</td><td rowspan="13">IEC 61000-4-11</td><td colspan="4">AC supply</td><td></td></tr>
<tr><td>Combina-tion No.</td><td colspan="2">Voltage variation (permanent)
%</td><td colspan="2">Frequency variation (permanent)
%</td><td rowspan="12">Each combination shall be tested.</td></tr>
<tr><td>1</td><td colspan="2">+6</td><td colspan="2">+5</td></tr>
<tr><td>2</td><td colspan="2">+6</td><td colspan="2">–5</td></tr>
<tr><td>3</td><td colspan="2">–10</td><td colspan="2">–5</td></tr>
<tr><td>4</td><td colspan="2">–10</td><td colspan="2">+5</td></tr>
<tr><td></td><td colspan="2">Voltage transient (duration 1,5 s)</td><td colspan="2">Frequency transient (duration 5 s)</td></tr>
<tr><td>5</td><td colspan="2">+20</td><td colspan="2">+10</td></tr>
<tr><td>6</td><td colspan="2">–20</td><td colspan="2">–10</td></tr>
<tr><td colspan="5">DC supply</td></tr>
<tr><td colspan="3">Voltage tolerance continuous</td><td colspan="2">±10 %</td></tr>
<tr><td colspan="3">Voltage cyclic variation</td><td colspan="2">5 %</td></tr>
<tr><td colspan="3">Voltage ripple</td><td colspan="2">10 %</td></tr>
</table>

No.	Test [a]	Procedure according to	Test parameters, severity				Additional requirement/s
			Electrical battery supply: +30 % to –25 % for equipment connected to charging battery or as determined by the charging/discharging characteristics, including ripple voltage from the charging device; +20 % to –25 % for equipment not connected to the battery during charging.				
4b	Power supply failure	IEC 61000-4-11	Three interruptions during 5 min 30 s break time				Verification of: – specified action of the equipment on loss and restoration of supply; – possible corruption of program or data held in programmable electronic systems, where applicable.
5	Insulation resistance [b]		Rated supply voltage V	Test voltage V	Minimum insulation resistance MΩ		Between all circuits and earth; on the supply terminals where appropriate. Resistance shall be measured before and after high voltage test, damp heat test, cold test and salt mist test.
					Before test	After test	
			$U_n \leq 65$	$2 \times U_n$ min. 24	10	1	
			$U_n > 65$	500	100	10	
6	Cold with gradual change of temperature [c]	IEC 60068-2-1 Test Ab for non-heat dissipating equipment IEC 60068-2-1 Test Ad for heat dissipating equipment	Temperature +5 °C ± 3 °C Duration 2 h		Temperature –25 °C ± 3 °C Duration 2 h		Initial measurement of insulation resistance (see test No 5). Equipment not operating during conditioning except for operational tests. Operational test during last hour at test temperature. Insulation resistance measurement and operational test after recovery.
7	Dry heat with gradual change of temperature [d]	IEC 60068-2-2 Test Bb for non-heat dissipating equipment	Temperature 55 °C ± 2 °C Duration 16 h		Temperature 70 °C ± 2 °C Duration 16 h		Equipment operating during conditioning. Operational test during last hour at test temperature. Operational test after recovery.
		IEC 60068-2-2 Test Be for heat dissipating equipment	Temperature 55 °C ± 2 °C Duration 16 h		Temperature 70 °C ± 2 °C Duration 16 h		Equipment operating during conditioning with cooling system on if provided. Operational test during last hour at test temperature. Operational test after recovery.

No.	Test [a]	Procedure according to	Test parameters, severity	Additional requirement/s
8	Damp heat, cyclic (12 h+12 h cycle) [j]	IEC 60068-2-30 Test Db	Temperature: 55 °C Humidity: 95 % Duration: two cycles (12 h + 12 h)	Measurement of insulation resistance before test. Equipment operating during the complete first cycle and switched off during second cycle except for functional test. Functional test during the first 2 h of the first cycle at the test temperature and during the last 2 h of the second cycle at the test temperature. Recovery at standard atmosphere conditions. Insulation resistance measurements and performance test.
9	Salt mist [e]	IEC 60068-2-52 Test Kb	Four spraying periods with a storage of 7 days after each	Initial measurement of insulation resistance and initial functional test. Equipment in its normal position during test. Equipment not operating during conditioning. Operational test on day 7 of each spraying period. Insulation resistance measurement and performance test 4 h to 6 h after the recovery period.
10	Vibration (sinusoidal)	IEC 60068-2-6 Test Fc	For general applications: $2\ ^{+3}_{0}$ Hz to 13,2 Hz Amplitude ± 1 mm > 13,2 Hz to 100 Hz Acceleration ± 0,7 g Endurance at: – each resonance frequency at which an amplification factor $Q \geq 2$ is recorded; – 30 Hz if no resonance frequency is recorded. For equipment mounted on reciprocating machines, installed in steering gear compartment or similar locations: 2,0 Hz to 25 Hz Amplitude ± 1,6 mm > 25 Hz to 100 Hz Acceleration ± 4 g Endurance at: – each resonance frequency at which an amplification factor $Q \geq 2$ is recorded; – 30 Hz if no resonance frequency is recorded.	During the vibration test, operational conditions shall be demonstrated. Tests shall be carried out in three mutually perpendicular planes. It is recommended as guidance that Q does not exceed 5. If sweep test is chosen, where several resonance frequencies are detected close to each other, duration of test shall be 120 min.

No.	Test [a]	Procedure according to	Test parameters, severity	Additional requirement/s
			Only for extreme conditions: 40 Hz to 2 000 Hz, acceleration ±10 g Duration 90 min	For example on exhaust manifolds of diesel engines
11a	Inclination steady [a, i]		22,5°	Each direction Equipment operating
11b	Inclination dynamic		22,5° 0,1 Hz	Each direction Equipment operating Duration of test not less than 15 min
12	Enclosure protection	IEC 60529	Dependent on location	Minimum requirements for the degree of protection are given in IEC 60092-201.
13	Electrostatic discharge	IEC 61000-4-2	Contact discharge: 6 kV Air discharge: 8 kV Interval between single discharges: 1 s Number of pulses: 10 per polarity According to test level 3	Electrostatic discharge as may occur when persons touch the appliance. The test is to be confined to the points and surfaces that can normally be reached by the operator. Performance criterion B [f].
14	Electro-magnetic field	IEC 61000-4-3	Frequency range: 80 MHz to 6 GHz Modulation: 80 % AM at 1 000 Hz Field strength: 10 V/m Frequency sweep rate: ≤ $1,5 \times 10^{-3}$ decades/s (or 1 %/3 s) According to test level 3	Electromagnetic fields radiated by different transmitters. If for tests of equipment an input signal with a modulation frequency of 1 000 Hz is necessary, a modulation frequency of 400 Hz may be chosen. Performance criterion A [g].
15	Conducted low frequency	IEC 60533	AC power supply port: Frequency range: rated frequency to 200th harmonic Test voltage (r.m.s.): 10 % of supply voltage to 15th harmonic reducing to 1 % at 100th harmonic and maintain this level to the 200th harmonic, max. 2 W DC power supply port: Frequency range: 50 Hz to 10 kHz Test voltage (r.m.s.): 10 % of supply voltage, max. 2 W	Distortions in the power supply system generated for instance by electronic consumers and coupled in as harmonics. Method of the test in accordance with IEC 60945. Performance criterion A [g].
16	Conducted radio frequency	IEC 61000-4-6	Frequency range: 150 kHz to 80 MHz Amplitude: 3 V r.m.s. [h] Modulation: 80 % AM at 1 000 Hz Frequency sweep range ≤ $1,5 \times 10^{-3}$ decades/s (or 1 %/3 s) According to test level 2	Electromagnetic fields coupled as high frequency into the test specimen via the connecting lines. If for tests of equipment an input signal with a modulation frequency of 1 000 Hz is necessary, a modulation frequency of 400 Hz may be chosen. Performance criterion A: see note [g].

<table>
<tr><th>No.</th><th>Test [a]</th><th>Procedure according to</th><th>Test parameters, severity</th><th>Additional requirement/s</th></tr>
<tr><td>17</td><td>Burst/fast transients</td><td>IEC 61000-4-4</td><td>Single pulse time: 5 ns (between 10 % and 90 % value)
Pulse width: 50 ns (50 % value)
Amplitude (peak):
– 2 kV line on power supply port to earth port (PE);
– 1 kV on I/O data control and communication ports (with coupling clamp);
Pulse period: 300 ms
Burst duration: 15 ms
Duration perpolarity: 5 min
According to test level 3</td><td>Arcs generated when actuating electrical contacts.
Interference effect occurring on the power supply, as well as the external wiring of the test specimen.
Performance criterion B [f].</td></tr>
<tr><td>18</td><td>Surge/slow transients</td><td>IEC 61000-4-5</td><td>Test applies to AC and DC power supply ports.
Pulse rise time: 1,2 µs (between 10 % and 90 % value)
Pulse width: 50 µs (50 % value)
Amplitude (peak): 1 kV line-to-earth
0,5 kV line-to-line
Repetition rate ≥1 pulse/min
Number of pulses: 5 per polarity
Application: continuous
According to test level 2</td><td>Interference generated for instance, by switching "ON" or "OFF" high power inductive consumers.
Procedure in accordance with Figure 10 of IEC 61000-4-5:2014 for equipment where power and signal lines are identical.
Performance criterion B [f].</td></tr>
<tr><td>19</td><td>Radiated emission</td><td>CISPR 16-1-1
CISPR 16-2-1</td><td>For equipment installed in the bridge and deck zone:
<table>
<tr><th>Frequency range:
MHz</th><th>Limits:
dBµV/m</th></tr>
<tr><td>0,15 to 0,3
0,3 to 30
30 to 6 000</td><td>80 to 52
52 to 34
54</td></tr>
<tr><td>except for:
156 to 165</td><td>
24</td></tr>
</table>
For equipment installed in the general power distribution zone:
<table>
<tr><th>Frequency range:
MHz</th><th>Limits:
dBµV/m</th></tr>
<tr><td>0,15 to 30
30 to 100
100 to 6 000</td><td>80 to 50
60 to 54
54</td></tr>
<tr><td>except for:
156 to 165</td><td>
24</td></tr>
</table></td><td>Procedure in accordance with the standard but at a distance of 3 m between equipment and antenna.</td></tr>
</table>

<table>
<tr><th>No.</th><th>Test [a]</th><th>Procedure according to</th><th>Test parameters, severity</th><th>Additional requirement/s</th></tr>
<tr><td>20</td><td>Conducted emission</td><td>CISPR 16-1-1
CISPR 16-2-1</td><td>For equipment installed in the bridge and deck zone:
<table>
<tr><th>Frequency range:</th><th>Limits:
dBμV</th></tr>
<tr><td>10 kHz to 150 kHz</td><td>96 to 50</td></tr>
<tr><td>150 kHz to 350 kHz</td><td>60 to 50</td></tr>
<tr><td>350 kHz to 30 MHz</td><td>50</td></tr>
</table>
For equipment installed in the general power distribution zone:
<table>
<tr><th>Frequency range:</th><th>Limits:
dBμV</th></tr>
<tr><td>10 kHz to 150 kHz</td><td>120 to 69</td></tr>
<tr><td>150 kHz to 500 kHz</td><td>79</td></tr>
<tr><td>0,5 MHz to 30 MHz</td><td>73</td></tr>
</table></td><td></td></tr>
</table>

[a] The static inclination test is not required on equipment with no moving parts.

[b] Insulation resistance test to be carried out before and after damp heat test, cold test and salt mist test.

[c] For equipment installed in non-weather-protected locations or cold locations, test is to be carried out at –25 °C.

[d] Dry heat at 70 °C is to be carried out to withstand a high degree of heat, for example for equipment to be mounted in consoles, housings.

[e] Salt mist test to be carried out for equipment to be installed in non-weather protected areas, for example on open deck.

[f] Performance criterion B: the equipment under test (EUT) shall 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.

Recovery times shall be consistent with continued safe operation, taking due account of the need to preserve essential services.

[g] Performance criterion A: the equipment under test (EUT) shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed, as defined in the technical specification published by the manufacturer.

[h] For equipment installed on the bridge and deck zone the test levels shall be increased to 10 V r.m.s. for spot frequencies in accordance with IEC 60945 at 2,0 MHz; 3,0 MHz; 4,0 MHz; 6,2 MHz; 8,2 MHz; 12,6 MHz; 16,5 MHz; 18,8 MHz; 22,0 MHz; 25,0 MHz.

[i] On ships for the carriage of liquid gases and chemicals, the emergency power supply shall also remain operational with the ship flooded up to maximum athwarthship inclination of 30°.

[j] This test shall be carried out for equipment located in non-air-conditioned spaces.

6 Design

6.1 Environmental and supply conditions

Equipment shall be designed to operate satisfactorily within the expected environmental and supply conditions, with due regard to the limits specified in Annex B of IEC 60092-101:1994.

6.2 Circuit design

Circuits shall be designed to enable efficient test, calibration, maintenance and repair.

6.3 Mutual effects

Systems shall be arranged such that faults will not affect any function provided by any other system.

6.4 Electrical subdivision

Design of circuits shall be such that there is no direct connection to any point of the ship's main power supply system, for example isolating transformers shall be used for power supplies. The chassis may not form part of any circuit, except earthing for functional reasons.

It is recommended that extensive systems be subdivided and the supplies to the sections be electrically separated or individually protected.

Control circuits shall be separated from signal and indicating circuits in such a way that faults in the indicating circuits will not impair the operation of the equipment or apparatus, and vice versa.

6.5 Signal level

Signal levels shall be kept high enough to overcome the effects of contact corrosion and noise pick-up.

Transducers and amplifiers shall be situated as close to each other as is practicable.

Particular attention shall be paid to the earthing (grounding) of screens and signal reference systems.

To avoid possible interference on control and instrumentation cables, suitable installation features shall be provided, such as:

– screening and/or twisted pairs;
– use of balanced input amplifiers;
– separation between signal and other cables.

6.6 Power supply

6.6.1 Independent supplies

Where required, for example by the administration, redundant power supplies shall be independent and the system selectively fed.

6.6.2 Capacity

The capacity of any back-up source shall be sufficient to ensure the normal operation of the system until safety conditions are reached.

6.6.3 Protection

Each circuit shall be separately protected against short circuits and overloads.

7 Construction and materials

7.1 Adjustments

Where necessary, equipment shall be arranged for simple adjustment. The set points shall be readily identifiable and suitable means shall be provided to protect against changes, for example due to environmental effects.

7.2 Accessibility

Ease of access to interchangeable parts for repairs and maintenance shall be ensured.

As far as is practicable, equipment shall be free of voltage, temperature, or other such factors which may present unsafe working conditions.

7.3 Replacement

Each replaceable assembly shall be simple to replace and shall be constructed for easy and safe handling.

7.4 Non-interchangeability

Preferably, all replaceable parts shall be so arranged that it is not possible to connect them incorrectly or to use incorrect replacements. Where this is not practicable, the replaceable parts, as well as the associated connecting device, shall be clearly identified.

7.5 Cooling

Preferably, apparatus shall not depend on forced cooling media.

Consideration shall be given, when necessary, to prevent the build-up of deposits on cooling surfaces.

If forced cooling is required, it shall be considered during any assessment of system redundancy requirements. An alert shall be provided in the event of cooling system failure.

For other services appropriate means shall be provided to prevent damage to the equipment due to temperature rise.

Measures shall be taken for forced ventilated cabinets in machinery spaces to prevent pollution deposits from causing insulation breakdown.

7.6 Mechanical load on connectors

If plug and socket connections are used, the contacts shall not carry any mechanical load, other than that which is necessary for ensuring satisfactory contact pressure, even when withdrawing or replacing a unit.

Plug-in trays, printed circuit boards and other multi-point connectors shall incorporate a retainer to prevent ejection due to mechanical loads such as shock or vibration.

7.7 Mechanical features of cabinets

Cabinets shall be of stable mechanical construction. All nut and bolt connections shall be locked.

EXAMPLE Use of self-locking nuts, locking washers, suited adhesives.

7.8 Shock and vibration absorbers

If anti-shock or anti-vibration mounts are used, adequate clearance shall be provided to allow full freedom of travel. Systems with shock or vibration mounts in series shall be avoided. Connecting leads shall be arranged so that they do not interfere with the shock and vibration isolation.

7.9 Internal wiring

Cables and insulated conductors used for internal wiring shall be at least of a flame retardant type. In the case of wiring adjacent to equipment containing hydraulic or other oils, the insulation shall be resistant to that oil, or be adequately shielded from it.

Chafing of cables and insulated wires caused by vibration on surfaces and edges shall be avoided.

7.10 Cable connections

Terminal boards on control equipment, including transducers, shall be constructed so that sufficient space is available to enable cables to be satisfactorily connected, preferably each conductor on its own terminal. All terminals shall be clearly identified and suitable arrangements provided to connect cable screens.

8 Installation and ergonomics

8.1 General

8.1.1 Layout

Control positions shall be ergonomically arranged for the convenience of the operator and hence the accuracy and safety of the operation.

Area or group identification shall be considered, especially in complex layouts, for example adequate spacing between display and control groups.

Equipment in the bridge and deck zone shall meet the requirements for navigation and communication equipment according to IEC 60945.

8.1.2 Compatibility

The arrangements of indicating instruments and control shall follow a logical sequence.

As far as possible, operating movements and the resulting movements of the indicating instruments shall be consistent with each other.

8.1.3 Labelling

Each operator control panel, subpanel, indicating instrument, control handle, signal lamp, recording instrument, etc., shall be clearly and systematically identified by means of self-explanatory and unambiguous labels.

8.1.4 Labels

Labels shall be permanently secured and consistently placed relative to controls and instrumentation and shall be made of durable material having clear and indelible characters.

8.1.5 Display colours

Colours for differentiation of operating conditions shall be readily distinguishable and identifiable.

NOTE Reference is made to IMO Resolution A.1021(26).

8.1.6 Illumination

Instruments and controls shall be illuminated so that they can be clearly read and operated in all ambient light conditions under which they are intended to be operated, without having uncomfortable shadow or glare. If the surrounding illumination makes it difficult to detect an indicator light, a suitable shade shall be provided. If equipment is installed in the bridge and deck zone, means shall be provided to avoid interference with navigation by the output of any light source. Equipment mounted outside (e.g. on bridge wings) shall be satisfactorily illuminated for operation in both daylight and darkness.

8.1.7 Protection against fluid leakage

Equipment covered by this standard shall not be installed in the same panel or cabinet as equipment employing a hydraulic medium, or pipelines carrying water, oil or steam unless effective means have been provided to protect the equipment in case of leakage.

Pipelines carrying hydraulic mediums, water, oil or steam shall be avoided in the vicinity of control panels and shall be in accordance with the requirements in IEC 60092-201:1994, Table 5.

8.1.8 Protection from condensation

As far as is practicable, arrangements shall be made to prevent condensation in enclosures.

8.1.9 External cables and wiring

External cables and wiring shall comply with relevant IEC 60092 standards.

NOTE See IEC 60092-376.

8.2 Sensors

8.2.1 Location of sensors

All sensors shall be located such that their output is a realistic measure of the parameter. Sensors shall be installed in places where there is a minimum risk for damage during normal overhaul, maintenance and operation.

8.2.2 Temperature sensors

Temperature sensors shall be installed in pockets of suitable material. Connections shall be arranged so that they can be removed for testing purposes.

8.2.3 Pressure sensors

Pressure sensors exposed to shocks and large vibration in their working medium shall be protected by damping chambers.

8.2.4 Water level detectors on bulk carriers

SOLAS Chapter XII, Regulation 12 shall apply. The detector indicating the water level should be capable of activating to an accuracy of ±100 mm. Visual and audible alerts should conform to the to the IMO Resolution A.1021(26) as applicable to an emergency alarm for the preservation or safety of the ship.

8.2.5 Enclosure

The enclosure of sensors and their terminal boxes shall be adequately protected for the expected place of installation, and for the type of cables installed.

8.2.6 Testing and calibration

Facilities shall be provided for testing and calibration of sensors which cannot be tested during normal operational conditions.

8.2.7 Presentation of information

Information shall be presented in a clear, consistent, and unambiguous manner.

8.3 Controls

8.3.1 Remote controls

8.3.1.1 Continuous information

At the remote control station, the users shall receive continuous information on the effects of their orders.

8.3.1.2 Independent control

Where control may be affected from more than one location, the failure of any control equipment at one location shall not affect the ability to control from any other location.

8.3.1.3 Exclusive control

Where a process may be controlled from several locations, only one shall be in control of that process at any time.

8.3.1.4 Transfer of control

This requirement is applicable to command locations of the same priority level.

Actual control shall not 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 shall be indicated.

8.3.1.5 Main command location

Where a designated main command location is required for operational or safety reasons, or by the administration, this location shall have the capability to take control without acknowledgement.

8.3.1.6 Security

Significant alteration of process parameters shall be prevented during transfer of control from one location to another.

8.3.1.7 Status indication

On each alternative command location, it shall be indicated when this location is in control.

8.3.1.8 Interlocks

Control system elements shall include safety interlocks when the consequence of erroneous user actions may lead to damage or loss of essential services.

8.3.2 Man-machine interface

The man-machine interface shall be designed in accordance with IEC 60447.

8.4 Alert systems

The audible and visual signals and indications used in alert systems (the former "machinery alarm systems") shall comply with the relevant requirements of IMO Resolution A.1021(26).

Emergency alarms shall be assigned to category A according to IMO Resolution MSC.302(87).

Further alarms specified in IMO Resolution A.1021(26) shall be assigned to category B according to IMO Resolution MSC.302(87).

9 Specific installations

9.1 Fire safety systems

Arrangement and installation of fire detection and fire alarm systems shall be in accordance with SOLAS Chapter II-2 and IMO Resolution MSC.98(73), Fire Safety Systems Code (FSS Code).

Fire protection equipment and systems shall be suitably designed and tested according to the approval standards as stated in the relevant part of the EN 54 series and the specific test requirements for maritime environment of this standard, see Table 1.

Integration of fire safety systems into a monitoring and control system is permissible with approval of administration, see SOLAS Chapter II-2, Part F, Regulation 17.

The audible and visual signals and indications used shall comply with the relevant requirements of IMO Resolution A.1021(26).

9.2 Bilge systems

For bilge pumping arrangements, SOLAS Chapter II-1, Part B, Regulation 21 applies.

For bilge areas, the monitoring arrangement shall indicate the compartment in which the fault has occurred.

Where the bilge pumps are capable of being started automatically, means shall be provided to indicate when the influx of liquid is greater than the pump capacity, or when the pump is operating more frequently than would normally be expected.

Where automatically controlled bilge pumps are provided, special attention shall be given to oil pollution prevention requirements.

9.3 Machinery alert installations

9.3.1 General

A machinery alert installation shall have the following objectives:

– to direct the attention of personnel to an abnormal condition in a ship's machinery system;
– to help establish the nature and location of the abnormal condition;
– to enable effective, corrective and, where possible, precautionary action to be taken;
– to have acknowledgement of the alert and the return to normal condition indicated.

9.3.2 Alert requirements

9.3.2.1 Repeater panels

Where repeater panels are required, these shall also be provided with both visual and audible signals. These signals may be common for all, or for a group of alerts connected to the machinery alert installation. An existing alert shall not prevent annunciation of subsequent alerts because of previous alert acknowledgement.

9.3.2.2 Allocation

When local control panels with group alert up to the centralised control system are provided, it is acceptable that the group alert only is shown in the centralised control system.

9.3.2.3 Acknowledgement

Generally, IMO Resolution MSC.302(87) applies.

Alarms and warnings shall be indicated until the abnormal condition has been corrected and the alarm or warning has been acknowledged.

Acknowledgement of the alarm or warning shall be indicated by an alteration of the visual signal, for example, from flashing to steady light.

Acknowledgement shall be possible only from the machinery space concerned, or the centralised control position associated with that machinery space.

The silencing of an audible alarm or warning at a repeater panel shall not lead automatically to the acknowledgement of the alarm or warning at the control position.

The acknowledgement shall not reset the abnormal condition which caused the alarm or warning.

9.3.2.4 Inhibition

Inhibition of an alert channel shall be clearly indicated. A list of manually inhibited channels shall be available in the system.

9.3.3 Display of information

9.3.3.1 Group arrangement

All visual alert indications within the same priority group shall have the same colour significance and be arranged in logical groups.

9.3.3.2 Legibility

The alert text, legend or symbol shall be clearly visible from the control position.

9.3.3.3 Common audible alert

If the audible alert signal is also used for other purposes, for example telegraph or telephone, it shall be accompanied by (a) luminous call panel(s) indicating the system concerned, and comply with the relevant requirements of IMO Resolution A.1021(26).

9.3.3.4 Alert differentiation

An existing alert shall not prevent annunciation of subsequent alerts because of previous alert acknowledgement.

9.3.3.5 Alert indication

According to IMO Resolution MSC.302(87).

9.3.3.6 Alert recording

Alerts shall be recorded in chronological order with date and time stamp. The status of coming, acknowledging and going of any alert shall be clearly recorded.

9.3.4 Supply arrangements

9.3.4.1 Power supply

The machinery alert installation shall be continuously powered. A stand-by power supply with automatic change-over shall be provided with a capacity of at least 30 min.

9.3.4.2 Alert for supply failure

Visual and audible alerts shall be initiated at the failure of the power supplies of the machinery alert installation.

9.3.5 Design

9.3.5.1 Monitoring equipment

Machinery alert installations may be combined with monitoring equipment, such as equipment provided with analogue read-outs of measured variables or with data loggers.

9.3.5.2 Time delays

Alert channels, where necessary, shall be provided with suitable time delays.

Transient phenomena, such as pressure waves in protected pressure systems, sensor contact bouncing or electromagnetic interference from other systems, shall not cause the alert installation to operate. All level alerts shall have a time delay related to the frequency of the ship's movements.

9.3.5.3 Circuits

Alarm signals should be based on normally closed loops, giving alarm upon signal failure.

Shut-down circuits of essential machinery should be based on normally open circuits with loop monitoring.

9.3.5.4 Earth fault

Earth fault(s) in alarm sensor circuits shall cause the alarm to operate, or to be indicated in an alternative manner, or otherwise not prevent indication of alarm(s).

9.3.5.5 Mutual fault independence

A fault in any one alert channel, particularly in the external incoming and outgoing circuits, shall, as far as is practicable, not influence the normal operation of any other channels.

9.3.5.6 Alert independence

A fault in the visual indication of an alert shall not affect the operation of the audible indication and vice versa.

9.3.5.7 System integrity

As far as is practicable, test facilities for checking the proper function of the electrical circuits, including audible and visual devices, shall be provided.

9.4 Power management systems

9.4.1 General

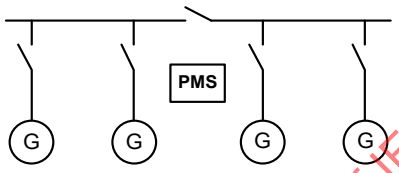
The requirements of 9.4 shall apply where a power management system is specified for the automatic control of electrical power generation and distribution.

Power management systems can be categorized in three different designs (see Figure 1):

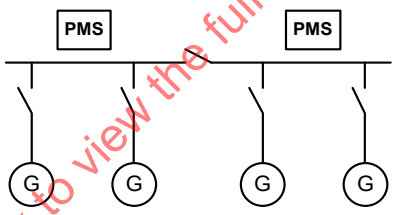
a) one common system for all control functions;

b) one independent system per busbar section;

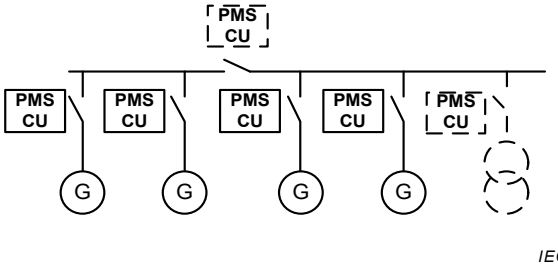
c) one independent system per main power supply unit.



a) One common system for all control functions



b) One independent system per busbar section



c) One independent system per main power supply unit

Key

PMS Power management system

G Generator

CU Control unit

Figure 1 – Typical designs of power management systems

An independent manual control shall be provided regardless of the chosen design. Such automatic control systems for electrical power supply may include in general (see Figure 1 a), b) and c)):

– the load dependent starting/stopping of a generator-set;
– the load distribution and frequency control;
– the heavy load request and power reserve for big consumers;
– the control of equipment for the improvement of overall efficiency.

The designs shown in Figure 1 b) and c) may include the following additional functions:

- control of non-essential consumers;
- paralleling of generator-sets and busbar sections;
- shaft generator control (PTI/ PTO);
- black-out recovery.

The designs described in 9.4.1 c) and Figure 1 c) may include the following additional functions:

1) generator and prime mover protection;
2) synchronizing.

9.4.2 Automatic starting and stopping of main power supply equipment

9.4.2.1 Initiation of starting and stopping commands

Commands for automatic starting and stopping of the main power supply equipment may be initiated in the following cases:

– under-voltage;
– under-frequency;
– expected stop of running set (delayed shut-down);
– overload, overcurrent;
– load dependent start;
– load dependent stop;
– failure of running sets.

9.4.2.2 Delay of signal

In order to avoid inadvertent starting, signals caused by acceptable transient conditions, for example high motor starting currents, shall not cause the automatic starting of a set.

9.4.2.3 Disconnection due to decrease of load

In systems with automatic generator disconnection upon decrease of load, the disconnection shall be provided with an appropriate delay.

9.4.2.4 Warming up and cooling down sequence

Where necessary, or desired, a warming up and a cooling down sequence may be programmed.

9.4.2.5 Pre-starting conditions

Means shall be provided to ensure that proper starting and running conditions exist at any time regarding starting air, fuel, cooling water, etc.

9.4.2.6 Stand-by indication

Stand-by indication shall be arranged at the control panel. An alarm shall be triggered when no stand-by set is available.

9.4.2.7 Start indication and restriction

The running of a set shall be indicated.

The number and the duration of automatic starting attempts shall be limited.

The starting failure of a set shall provide a visual and audible alarm. A sequence system shall be provided, which, in case of starting failure, automatically transfers the starting order to the next set.

9.4.3 Heavy load request and power reserve calculation

A power management system shall calculate on request if the load reserve is sufficient to start a heavy consumer. Where load reserve is not sufficient the heavy consumer will be blocked until an additional generator-set is connected. When a heavy consumer is in operation the power management calculates and maintains the necessary load reserve.

9.4.4 Black-out recovery

9.4.4.1 Connection at black-out

It shall be ensured, when closing a generator circuit-breaker onto a bus bar, that the generator voltage is sufficiently high. In order that the initial load does not exceed the capability of the generator, consideration shall be given to limiting or sequencing the reconnection of the loads, or both.

9.4.4.2 Non-simultaneous closing

Simultaneous automatic closing of two or more generator circuit-breakers shall be prevented.

9.4.4.3 Short circuit

After a short circuit, stand-by generator circuit-breakers as well as bus tie-breakers shall be prevented from closing on to a faulty bus-bar section. Generator circuit-breakers shall not be permitted more than one attempt to close onto a short circuit. A resetting of a triggered short circuit protection device may be possible locally and manually only.

9.4.4.4 Disconnecting of a running set

If a set has been started, due to under-voltage or under-frequency not directly causing a running generator to trip, consideration shall be given to having the faulty generator set disconnected as soon as the stand-by set is ready for taking over (switching over via black-out).

9.4.5 Load sharing and frequency control

Where an automatic load sharing and frequency control function is provided, a fault in any system providing such a function shall not result in the loss of the main source of electrical power.

9.4.6 Shut-down of diesel engine

9.4.6.1 Shut-down

When the safety system of the diesel engine triggers a shut-down, the set shall be automatically disconnected.

9.4.6.2 Pre-alarm

Pre-alarms or delayed shut-downs shall allow a manual or automatic action before a shut-down occurs.

9.4.6.3 Prevention of restarting

The starting of a generator set shall not be possible when a shut-down or stop signal is active.

9.4.7 Automatic disconnection of non-essential consumers

In order to safeguard electrical power supply for essential services, provision of a system to disconnect automatically non-essential consumers shall be considered in the following cases:

– the total load exceeds the rated generator capacity;

– under-frequency or under-voltage;

– failure of one of the generators running in parallel if the total load exceeds the combined capacity of the remaining generator(s). In this case disconnection shall be undelayed.

9.4.8 Design requirements of power management systems (PMSs)

9.4.8.1 General

The PMS shall operate independently. The PMS shall provide different control levels: full automatic control, remote control and local control. Local control of the PMS from the switchboard applies only to Figure 1 b) and c).

For remote control of the PMS from the automation system an interface may be provided. Local control of the PMS shall have higher priority than remote control and automatic control of the PMS.

Any PMS failure shall trigger an alert.

Malfunctioning of the PMS may not lead to loss of the main source of power.

Manual control of the switchboards may not be affected by the automation system and/or PMS system.

9.4.8.2 One common system for all control functions (Figure 1 a))

The PMS shall be supplied from an uninterruptible power supply (UPS) system supplied from the main and emergency source of power.

9.4.8.3 One independent system per busbar section (Figure 1 b))

Each PMS shall be supplied from an independent UPS system supplied from main and emergency source of power. If one of the PMS fails the remaining one shall take control of the complete system.

9.4.8.4 One independent system per main power supply unit (Figure 1 c))

Each PMS shall be supplied from a UPS system supplied from the the main and emergency source of power. Each unit shall also be supplied from the busbar voltage and if applicable from the generator voltage.

If the diesel safety system and/or the generator protection are integrated in the PMS (integrated protection and control system), then a failure of the PMS shall trigger an alarm but not trip the generator-set.

Each generator-set shall be equipped with operation-, indication- and protection-devices, so as to operate the generator-set by manual means also when the integrated protection and control system has failed.

Manual operation of the prime mover means that the following functions are still available:

a) start/stop of the engine;
b) over-speed protection, as far as required;
c) lubrication monitoring , as far as required;
d) required control equipment and instrumentation;
e) speed/load control of the engine.

Manual operation for the generator and the switchgear means:

1) short circuit protection;
2) control, indication and instrumentation in the generator panel.

9.5 Automatic starting installations for electrical motor-driven auxiliaries

9.5.1 General

Subclause 9.5 relates to automatic installations for electrical motor-driven auxiliaries such as lubricating oil pumps, cooling water pumps, etc.

All equipment employed in automatic starting installations for electrical motor-driven auxiliaries shall, where applicable, comply with the requirements according to IEC 60092-202 and IEC 60092-302.

9.5.2 Automatic sequence starting

9.5.2.1 Prevention of overload

Controlgear used for the automatic restart of electrical motors shall, where necessary, be provided with an automatic sequence starting system to prevent overloading of the generating equipment at the moment, and during the procedure, of power restoration after the occurrence of a black-out.

9.5.2.2 Starting delays

The sequence starting system shall ensure the shortest possible starting delay for those auxiliaries which are most vital for the ship's propulsion.

9.5.3 Starting installations for stand-by auxiliaries

9.5.3.1 Starting commands

The starting command for the stand-by machine shall be initiated by a process value measured in the controlled medium. In case of electrical failure of the auxiliary drive in operation the stand-by auxiliary drive shall be started immediately.

The starting command for a stand-by lubricating oil pump motor, for example, shall be taken from the lubricating oil pressure, and not only from the controlgear of the running lubricating oil pump motor.

9.5.3.2 Stand-by indication

Selection of the stand-by position for an electrical motor-driven auxiliary, together with the information “motor starter ready for remote operation” shall be indicated at the centralized control position as stand-by indication. If the availability of the stand-by function is lost during operation a stand-by alert shall be triggered.

9.5.3.3 Indication of start

Automatic starting of a stand-by auxiliary shall cause an alert.

9.5.4 Control voltages

The automatic changeover system shall be supplied from a UPS system supplied from the main and emergency source of power or directly from the dedicated motor starters.

9.5.5 Manual control

A failure in the controlgear of one motor shall not render more than one motor unavailable for manual control. In case of failure in the automatic changeover system both motors shall be available for manual control.

9.5.6 Mechanically driven auxilaries in low speed range

Where auxiliary machinery is mechanically driven from the propulsion system, stand-by units shall be provided for automatic start-up when carrying out manoeuvres in the lower speed range where the output of the mechanically-driven auxiliary machines is not adequate under these conditions.

9.5.7 Mechanically driven auxilaries

No alert shall be triggered in case of machinery installations with mechanically connected pumps, when the independent electrical pumps start up in the course of normal operation.

9.5.8 Sensors

The sensors for stand-by circuits shall be independent from other systems, especially from the related process alerts.

9.6 Machinery control installations

9.6.1 General

Subclause 9.6 relates to the control of machinery essential for the propulsion and safety of the ship.

For electric and electrohydraulic steering gear SOLAS Chapter II-1, Part C, Regulation 30 applies.

For machinery controls SOLAS Chapter II-1, Part C, Regulation 31 applies.

Requirements for the electrical propulsion plant are given in IEC 60092-501.

9.6.2 General requirements

Main and auxiliary machinery essential for the propulsion, control and safety of the ship shall be independent or designed in such a way that failure of one system shall not degrade the performance of another system.

9.6.3 Transfer of control

The control of machinery and associated equipment shall be possible only from one control station at a time, and the changeover between control stations shall be arranged so that it may only be effected with the acceptance of the station taking control. The system shall be provided with interlocks or other suitable means to ensure effective transfer of control (see also 9.6.5.1).

NOTE Where control positions are located within close proximity to allow direct audible and visual contact, the administration can waive this requirement.

9.6.4 Remote control of propulsion machinery from the bridge

9.6.4.1 Application

Where remote control of propulsion machinery from the navigation bridge is provided, the following features shall be incorporated.

9.6.4.2 Parameters under control

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

9.6.4.3 Control devices

The control shall 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 may also be controlled by one control device.

9.6.4.4 Emergency stop

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

Where the propulsion prime mover(s) also provide power for the electrical installation, it may be sufficient to remove power from the propellers, for example by means of a clutch.

9.6.4.5 Order indication

Propulsion machinery orders from the navigation bridges shall be indicated in the main machinery control room, if provided, and the manoeuvring platform.

The local control position(s) for the propulsion machinery may be taken as equivalent to the manoeuvring platform.

9.6.4.6 Transfer of control

Remote control of the propulsion machinery shall be possible from only one location at a time; at such locations, interconnected control positions are permitted.

The transfer of control between the navigation bridge and machinery spaces shall be possible only from the main machinery space, or the main machinery control room.

The transfer of control from one control station to another shall not significantly alter the parameters under control, i.e. speed, direction of thrust, or pitch.

The transfer of control shall not be initiated without the acceptance of the station taking the control.

9.6.4.7 Local control

It shall be possible to control the propulsion machinery and all machinery essential for the propulsion and safety of the ship locally, even in the case of failure in any part of the remote control system.

It shall also be possible to control the auxiliary machinery, essential for the propulsion and safety of the ship, at or near the machinery concerned.

9.6.4.8 Failure alarms

The failure of the remote control system shall initiate a visual and audible alarm. Unless impractical, the pre-set speed and direction of thrust of the propeller and, if applicable, the pitch shall be maintained until local control is in operation.

9.6.4.9 Start blocking

If the remote control system of the propulsion machinery is designed for automatic starting, the number of automatic consecutive attempts shall be limited and start-blocking at a pre-set low value of the starting air pressure shall be provided in order to safeguard sufficient starting air pressure for starting from the engine control room, or locally.

9.6.5 Indicators for remote control of machinery

9.6.5.1 Indication of control location

At each operating location, there shall be an indicator showing which location is in control of the machinery.

9.6.5.2 Running indication

Where remote operation is provided, running indication, or other equivalent arrangements, shall be provided at each operating location.

9.6.5.3 Parameter indication

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

– propeller speed and direction of rotation in the case of fixed pitch propellers;
– propeller speed and pitch position in the case of controllable pitch propellers;
– direction for azimuth thrusters.

9.6.6 Manual override

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

9.7 Machinery protection and safety systems

9.7.1 General

Subclause 9.7 relates to the equipment required to initiate appropriate action whenever pre-set limits of the parameters of operating machinery are exceeded. For electrical protection IEC 60092-202 applies.

Attention is drawn to the fact that computer based safety systems for the protection of machinery may require additional and other provisions (see Clause 10).

9.7.2 General requirements

9.7.2.1 Principles of operation

Protection and safety systems are to ensure that a malfunction in machinery operations which presents an immediate danger shall initiate automatic protection, i.e. shut-down or load reduction of that part of the plant, and that a visual and audible alarm shall be given.

9.7.2.2 Separation

Protection and safety systems shall be independent from open and closed loop control and alert systems.

9.7.2.3 Propulsion system

Requirements for propulsion systems are stated in IEC 60092-501.

9.7.2.4 Failure modes

Safety systems and as far as is practicable protection systems, shall be designed so that a single failure within this system gives a visual and audible alarm and does not result in the total loss of propulsion power.

9.7.2.5 Override arrangements

Where arrangements for overriding the shut-down of the main propelling machinery are fitted, these shall be such as to preclude inadvertent operation. A visual and audible alarm shall be provided to indicate that the override has been activated.

9.7.2.6 Stand-by power supply

The protection and safety system shall be continuously powered. A stand-by power supply for the protection and safety system with automatic change-over shall be provided with a capacity for at least 30 min.

Depending on the application, a greater capacity may be necessary, either to achieve safe conditions or where required by the administration.

9.7.2.7 Alarm for supply failure

Visual and audible alarm signals shall be initiated at the failure of the power supplies of the protection and safety systems.

9.8 Bow, inner, side shell and stern doors

9.8.1 Application

These requirements apply to "roll-on, roll-off" (ro-ro) passenger ships.

9.8.2 Remote control

If arranged for remote control, the requirements of 8.3 shall apply.

9.8.3 Indicator system

The following separate indicators shall be provided for each door:

– door fully closed;

– door fully secured (all locking devices in closed position).

Each door shall be separately indicated.

These indications shall be provided both on the bridge and at the operating panels.

9.8.4 Mode selection

The panel on the bridge shall be equipped with a mode selection function "harbour/sea voyage", so arranged that a visual and audible alarm is initiated in the sea voyage mode if any door is not fully closed or not fully secured.

A manual changeover switch may be acceptable to the administration.

9.8.5 Failsafe

The indicator and alarm system for the shell doors shall be designed on the failsafe principle, that is, in the event of a fault within the system, it shall not result in an incorrect indication that any door is fully closed or fully secured if this is not the case.

Where a part of the system can fail in more than one way, precedence shall be given to the most probable fault.

9.8.6 Testing

A means to test both the indication, for example lamp test, and the audible alarm shall be provided at the navigation bridge panel.

9.8.7 Independence

The indicator and alarm system for the shell doors shall be independent of the door control system.

The power supplies to these systems shall be separately protected and shall be provided with a back-up or secure power supply, for example UPS.

Failure of any power supply shall initiate an audible and visual alarm on the navigation bridge.

9.8.8 Display

Indication shall be effective and continuously displayed in all anticipated lighting conditions.

9.8.9 Sensors

Sensors for the indicator and alarm system for the shell doors shall be protected from water, ice formation and mechanical damage.

9.8.10 Television surveillance

A television surveillance system shall be provided to enable monitoring from the navigation bridge of shell doors where leakage may lead to flooding of ro-ro cargo spaces.

For bow doors, both the inner door and the space between the bow doors and inner doors shall be monitored.

Special consideration shall be given for lighting and contrasting colour of objects under surveillance.

Consideration shall also be given to monitoring special category spaces and ro-ro cargo spaces.

9.8.11 Water leakage detection

A water leakage alarm system shall be provided to detect leakage through any doors which could lead to flooding of a special category space or ro-ro cargo space.

For bow doors, leakage through the inner door shall be monitored.

Whenever flooding is detected, a visual and audible alarm shall be initiated on the navigation bridge and at the machinery control room.

9.8.12 Drainage alarm

In the area between bow door and ramp, and in the area between the ramp and inner door where fitted, a drainage system shall be provided.

A separate visual and audible alarm, in addition to that required by 9.8.11, shall be initiated on the navigation bridge if the water level exceeds 0,5 m above the car deck level in these areas.

9.8.13 Control location

Remote control of all closing and securing devices shall be provided from a position above the freeboard deck for bow doors and inner doors giving access to vehicle decks.

9.9 Power-operated watertight doors

9.9.1 General

For power-operated watertight doors, SOLAS Chapter II-1, Part B, Regulation 15 applies.

9.9.2 Indications

All power-operated sliding watertight doors shall be provided with an indication which will show at all remote operating positions whether each door is open or closed, i.e. at the navigation bridge and at the location where hand operation above the bulkhead deck is arranged.

9.9.3 Alarm

An audible alarm, distinct from any other alarm in the area, shall be provided locally for each sliding door.

This alarm shall be active whenever the door is closed remotely by power, and for at least 5 s, but no more than 10 s, before the door begins to move.

The alarm shall continue sounding until the door is completely closed.

In passenger areas and areas of high ambient noise, the administration may require the audible alarm to be supplemented by an intermittent visual signal on the door.

9.9.4 Closure rate

Sliding doors shall have an approximately uniform rate of closure under power. The closure time, from the time the door begins to move to the time it reaches the completely closed position, shall in no case be less than 20 s or more than 40 s under normal operating conditions as stated in Table 1.

9.9.5 Power supply

The electrical power required for sliding doors shall be supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck.

The associated control, indication and alarm circuits shall be supplied as specified above.

In addition, in the event of failure of either the main or emergency source of electrical power, they shall be supplied by the transitional source of emergency electrical power.

The transitional source of emergency electrical power shall have sufficient capacity to operate the door at least three times, i.e. closed-open-closed against an inclination value according to Table 1, items No. 11a and No. 11b.

9.9.6 Dedicated circuits

Each electrically operated sliding door shall be provided with its own motor and associated circuits, capable of opening and closing the door.

A single failure in these circuits shall not prevent hand operation of the door.

9.9.7 Location of equipment

As far as is practicable, electrical equipment and components for watertight doors shall be situated above the bulkhead deck and outside hazardous areas and spaces (see IEC 60092-502).

9.9.8 Enclosures

The enclosures of electrical components, necessarily situated below the bulkhead deck, shall provide suitable protection against the ingress of water as specified below:

a) electrical motors, associated circuits and control components: protected to at least IPX7 standard;

b) door position indicators and associated circuit components: protected to IPX8 standard;

c) door movement indicating devices: protected to at least IPX6 standard.

The water pressure testing of the enclosures protected to IPX8 shall be based on the pressure that may occur at the location of the component during flooding for a period of 36 h with the ship afloat.

Other arrangements for the enclosures of electrical components may be fitted, provided the administration is satisfied that an equivalent protection is achieved.

9.9.9 Leakage

As far as is practicable, arrangements shall be such that leakage of water into the electrical equipment located below the bulkhead deck will not cause the door to open.

9.9.10 Independent circuits

Electric power, control, indication and alarm circuits shall be protected against fault in such a way that a failure in one door circuit will not cause a failure in any other door circuit.

9.9.11 Failure of alarm circuits

Short circuits or other faults in the alarm or indicator circuits of a door shall not result in a loss of power operation of that door.

9.9.12 Failure of control circuits

A single electrical failure in the power operating or control system of a sliding door shall not result in a closed door opening.

9.9.13 Power supply monitoring

The power supply shall be continuously monitored at a point in the electrical circuit as near as practicable to each of the motors required by 9.9.5. Loss of any such power supply shall activate an audible and visual alarm at the central operating console at the navigation bridge.

9.9.14 Mode selection

The central operating console at the navigation bridge shall have a "master mode" switch with two modes of control: a "local control" mode which shall allow any door to be locally opened and locally closed after use without automatic closure, and a "doors closed" mode, which shall automatically close any door that is open. The "doors closed" mode shall permit doors to be opened locally and shall automatically re-close the doors upon release of the local control mechanism with a delay sufficient to pass the door. The "master mode" switch shall normally be in the "local control" mode. The "doors closed" mode shall only be used in an emergency or for testing purposes. Special consideration shall be given to the reliability of the "master mode" switch.

9.9.15 Indication on navigation bridge

The central operating console at the navigation bridge shall be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. Indication shall be effective and continuously available in all anticipated lighting conditions.

A red light shall indicate a door is fully open and a green light shall indicate a door is fully closed.

When the door is closed remotely, the red light shall indicate the intermediate position by flashing.

The indicating circuit shall be independent of the control circuit for each door.

9.9.16 Remote opening

It shall not be possible to remotely open any door from the central operating console.

9.10 Public address systems on passenger ships

9.10.1 General

A public address system or other effective means of communication complying with the requirements of SOLAS Chapter III, Part B, Regulation 6.5 shall be available throughout the accommodation and service spaces, control stations and open decks.

9.10.2 Override

An override function shall be provided, capable of interrupting any broadcast on the system from any other location on board and be effective even if a speaker has been switched off or its volume turned down.

Access to this function shall be provided from the navigation bridge, and at other control stations be accessible in the event of an emergency, the number and location of these emergency control stations being to the satisfaction of the relevant administration.

These functions shall be protected against unauthorised use by, for example, key or password operation.

9.10.3 Operation

It shall be possible to broadcast messages simultaneously to all loudspeakers, or to a limited number, for example, crew and work locations, by simple operations.

9.10.4 Emergency broadcast

Facilities for performing emergency broadcasts from at least two positions shall be provided.

One of these positions shall have an interrupt facility, capable of broadcasting by simple operation without any action at the other position.

9.10.5 Level adjustment

The systems shall be provided with facilities for adjusting the sound level.

9.10.6 Minimum sound level

The system shall be capable of generating a minimum sound level of:

a) 75 dB (A) in interior spaces, and at least 20 dB (A) above the speech interference level,

b) 80 dB (A) in exterior spaces, and at least 15 dB (A) above the speech interference level.

9.10.7 Interference

The system shall be capable of preventing feedback or other interference.

9.10.8 Fault tolerance

The system shall be so arranged that a single failure does not disrupt the total system.

9.10.9 Protection

Each loudspeaker shall be individually protected against short circuit.

9.10.10 Fire zones

All areas of each fire zone shall have at least two dedicated loops sufficiently separated throughout their length, and have two separate and independent amplifiers.

9.10.11 Segregation

Loudspeakers in public rooms, alleyways, stairways, and control stations shall have at least two loops and two separate and independent amplifiers.

9.10.12 Power supplies

The systems shall be supplied from the main, emergency and transitional source of power.

9.10.13 Cabling

As far as is practicable, cables and wiring shall be routed clear of galleys, laundries, machinery spaces of category A and their casings and other high fire-risk areas.

Where practicable, all such cables should be installed in such a way as to prevent damage caused by heating of the bulkheads due to a fire in an adjacent space.

Cables and wires shall be at least of flame retardant type except the cables passing through high fire-risk areas which shall be of fire-resistant type.

Cable routes shall be separated, or fire-resistant cables shall be used.

10 Computer based systems

10.1 General

Clause 10 applies to the use of computer based systems which provide control, alert, monitoring or safety functions which are additional to the requirements contained in other clauses of this standard.

10.2 General requirements

Computer based systems shall fulfil the requirements of the system under control for all operating conditions, taking into account human safety, environmental impact, damage to vessel as well as equipment, usability of computer based systems and operability of other equipment.

10.3 System categories

Computer based systems shall be assigned into four system categories as shown in Table 2 according to the possible extent of the damage caused by an event.

Consideration shall be given to the extent of the damage directly caused by a failure within the computer based system, but not to any consequential damage.

Table 2 – System categories

Category	Effects	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 function for informational / administrative tasks
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.	Alert and monitoring functions Control functions which 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 Protection functions
IV	Those systems, failure of which could immediately lead to catastrophic situations for human safety, safety of the vessel and / or threat to the environment.	Control systems for which manual intervention to avert danger in the event of failure or malfunction is not possible Safety functions

The assignment of a computer based system to the appropriate system category shall be made according to the worst case of direct damage (for examples, see Table 3).

Where independent effective backup or other means of adverting danger is provided the system category may be decreased.

The type and size of ship, the presence of persons in the danger area in terms of duration or frequency, the complexity of the system or the possibility to avert danger may lead to assignment to a different system category.

Table 3 – Examples of assignment to system categories

System category	Example
I	Maintenance support systems Information and diagnostic systems Loading instrument (stand alone)
II	Alert & monitoring equipment Tank capacity measuring equipment Control systems for auxiliary machinery Main propulsion remote control systems Fire detection systems Fire extinguishing systems Bilge systems Governors Loading instrument (on line)
III	Machinery protection systems/equipment Electronic fuel injection for diesel engines Control systems for propulsion and steering Synchronizing units for switchboards
IV	Burner control systems Course control systems of high speed craft (HSC) Dynamic positioning systems
NOTE The examples listed in Table 3 are not exhaustive.	

10.4 System configuration

10.4.1 General

The technical design of a computer system arises out of its assignment to a system category. The measures listed below by way of example, graded according to the requirements of the respective system category, shall be ensured.

The computer systems shall be fast enough to perform control operations and to inform the user correctly and carry out user instructions at the correct time under all operating conditions.

Computer systems shall monitor the program execution and the data flow automatically.

In the event of failure and restarting of computer systems, the process shall be protected from undefined and critical states.

10.4.2 Power supply

The power supply shall be monitored and faults shall be indicated by an alert.

Redundant systems shall be separately protected against short circuits and overloads and shall be separately fed. Program and data held in the system shall be protected from corruption by loss of power.

10.4.3 Hardware

The design of the hardware shall be clearly structured, for example separation of supply voltages. Interchangeable parts shall be easily accessible for repairs and maintenance.

Removable components and connectors shall be appropriately marked to protect against unintentional transposition.

Subsystems in integrated systems shall not mutually interfere.

Computer systems shall preferably be designed without artificial ventilation. If forced ventilation of computer systems is necessary, the provision of an over temperature alert is recommended.

10.4.4 Software

The manufacturer shall apply a systematic procedure during all the phases of software development including modifications appropriate to the relevant system category.

Software shall be tested as appropriate to the relevant system category.

Design and testing of software shall be appropriately documented.

The version of the software with the relevant date and release shall be documented and shall be clearly identifiable.

10.4.5 Data communication links

The reliability of data transmission shall be suitable for the particular application and the system category, and specified accordingly.

The loss of any communication link shall cause an alert.

The data communication link shall be continuously self-checking in order to detect failures on the link itself and data communication failure on nodes.

Switching between redundant links shall not disturb data communication or continuous operation of functions.

Data communication links shall be automatically initialised on power on. After a power interruption the link shall regain normal operation without manual intervention.

10.4.6 Wireless data communication

When an alternative design or arrangements deviating from these requirements are proposed, an engineering analysis is required to be carried out in accordance with a relevant international or national standard acceptable to the administration (see also SOLAS Chapter II-1 Part F, Regulation 55).

As a failure may lead to an accident with catastrophic severity, the use of unconventional technology for such applications will only be permitted exceptionally in cases where evidence is presented that demonstrates acceptable and reliable system performance to the satisfaction of the administration.

The requirements in 10.4.6 are in addition to the requirements of 10.4.5 and apply to system category I and II using wireless data communication links to transfer data between distributed programmable electronic equipment or systems.

Functions that are required to operate continuously to provide essential services dependant on wireless data communication links shall have an alternative means of control that can be brought in action within an acceptable period of time.

Wireless data communication shall employ recognised international wireless communication system protocols that incorporate the following:

- message integrity: fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message;
- configuration and device authentication: they shall only permit connection of devices that are included in the system design;
- message encryption: protection depending on the confidentiality and/ or criticality of the data content;
- security management: protection of network assets, prevention of unauthorised access to network assets.

The wireless system shall comply with the radio frequency and power level requirements of the International Telecommunications Union and administration requirements.

Consideration should be given to system operation in the event of port state and local regulations that pertain to the use of radio-frequency transmission prohibiting the operation of a wireless data communication link due to frequency and power level restrictions.

10.4.7 Network/integration of systems

The architecture and the configuration of a network shall be suitable for the particular system category.

The integration of independent subsystems shall not decrease the reliability of the system.

A failure in one of the subsystems shall not affect the function of other subsystems.

A failure of the transfer of data between interconnected independent subsystems shall not impair their independent functions.

The characteristics of the data communication link shall ensure that all information is transmitted in adequate time and overloading is prevented.

10.4.8 User interface

The user interface of a system shall be designed according to ergonomic principles. These can be found for example in the ABS publication “Guidance notes on the application of ergonomics to marine systems”.

The status (system health) shall be monitored and clearly displayed.

Failure or shut-down of subsystems or functional units shall be indicated by an alert and displayed at every related operator station.

A universal user guide shall be provided for the use of computer systems.

10.4.9 Input devices

Feedback of the effectiveness of control commands shall be indicated.

An assessment shall be performed to define the response time for control commands.

Operator panels located on the bridge shall be individually illuminated. The lighting shall be adaptable to the prevailing ambient conditions.

Where equipment operations or functions may be changed via keyboards, appropriate measures shall be provided to prevent unintentional operation.

If the operation of a key on a keyboard is able to cause dangerous operating conditions, measures shall be taken to prevent the execution by a single action only, such as:

– use of a special key lock;
– use of two or more keys.

Concurrent control interventions shall be prevented by means of interlock. The control station in operation shall be indicated as such.

Controls shall be in accordance to their position and direction of operation to the controlled equipment.

10.4.10 Output devices

The size, colour and density of text, graphic information and alert signals displayed on a visual display unit shall be such that it may be easily read from the normal operator position under all lighting conditions.

Information shall be prioritised, for example alerts (alarms, warnings, cautions) or general.

Alert information shall be displayed in both orders, chronological and prioritized, according to IMO Resolution MSC.302(87).

10.4.11 Graphical user interface

Information shall be presented clearly and intelligibly according to its functional significance and association. Screen contents shall be logically structured and their representation shall be restricted to the data which is directly relevant for the user.

When general purpose graphical user interfaces are employed, only those functions necessary for the respective process shall be made available.

Alerts shall be visually and audibly presented with priority to other information in every operating mode of the system; they shall be clearly distinguishable from other information.

10.5 Protection against modification and loss of data

Computer systems shall be protected against unintentional or unauthorised modification of programs and data, see for example IEC 62443.

For systems of system categories III and IV modifications of safety parameters may only be carried out by the manufacturer.

10.6 Software maintenance

Any software modification/upgrade shall be handled in accordance with change handling procedures, and necessary evidence shall be recorded:

- any revision which may affect compliance with this standard shall be approved by the administration and evidence of such revision shall be available on board;
- the procedure of the modification shall be available;

- integrity of the update software package shall be verified on board before the software update is carried out;
- a test program for verification of correct installation and correct functions shall be available;
- evidence for the reason for updating a software shall be documented in a software release note;
- in case the update software package has not been successfully installed, the previous version of the system shall be available for re-installation and re-testing.

10.7 Remote access

10.7.1 General

Remote access during the voyage of a ship shall be used only for monitoring purposes and with the prior acknowledgment by the ship's responsible crew member only.

The security of the remote access shall be ensured.

10.7.2 Remote software maintenance

The requirements according to 10.5 shall be adhered to.

Modification shall be possible only with the acceptance and acknowledgement by the ship's responsible crew member (for example the captain) and shall be carried out in a harbour only.

In case of unexpected failure after modification a fall back strategy shall be available.

10.8 Documentation

10.8.1 General

All documentation shall provide relevant information in a clear and unambiguous manner.

Symbols and abbreviations used shall be explained or referenced to an appropriate international standard or code.

Documents required for evaluation of computer based systems shall be graded according to the requirements of the respective system category.

Hardware and software versions shall be documented by the manufacturer and shall be retraceable.

Subsequent significant modifications to the software and hardware shall be submitted for approval.

For all tests required in accordance with the system category a test specification shall be prepared and the tests shall be documented.

Test programs and evidence shall be produced according to Table 4, item No. 6.

10.8.2 Hardware

The following documentation shall be provided:

a) system block diagram, showing the arrangement of individual parts, input and output devices and interconnections (see IEC 61355-1);

b) wiring diagrams (see IEC 61355-1);

c) details of input and output devices;

d) details of electric power supplies.

10.8.3 System functional description

Documentation shall be provided to verify compliance with relevant requirements of this standard, for example:

– system specification;
– system performance for normal and abnormal equipment operation;
– instructions for normal and abnormal operating modes;
– transfer of control;
– redundancy or reversionary modes;
– test facilities;
– failure detection and identification facilities (automatic and manual);
– data security;
– access restrictions;
– special aspects requiring user attention.

In addition, documentation shall be provided concerning procedures for:

- start-up;
- restoration of functions;
- maintenance and periodical testing;
- data back-up;
- software reload and system regeneration;
- failure location and repair.

10.8.4 Software

10.8.4.1 Quality plan

A plan for software life cycle activities shall be provided which shall refer to relevant procedures, responsibilities and system documentation, including configuration management.

10.8.4.2 Description

Software shall be described in accordance with the system category, see Table 3. The description of software shall include, for example:

– a description of the basic software installed in each hardware unit;
– a description of the communication software installed on nodes in a network;
– descriptions of application software (not program listings);
– tools for system set-up and process equipment configuration.

10.8.4.3 Application software

Application software shall be described in accordance with the system category, see Table 3. The description of application software shall include, for example:

– identification of system modules that are operative in order to maintain functions including dependencies on other systems;
– detail of each module at a level sufficient to understand its function;
– data and control flow between software modules;

– configuration of the software, including priority schemes;
– switching mechanisms for redundant systems.

10.8.4.4 Ranges and limits

A measurement point list of operation ranges and limits for alerts and safety functions shall be provided.

10.8.5 User interface

10.8.5.1 Documented design

Control station design and arrangement shall be detailed, including drawings, dimensions, figures, etc., of each user input or output device at a level sufficient to assess the working principles.

10.8.5.2 Screen-based dialogue

Details of screen-based computer dialogue shall include:

– description of the functions allocated to each input device;
– details of individual screen views, etc.;
– description of menu operation.

10.8.6 Test and evidence

Test and evidence shall be in accordance with Table 4.

Table 4 – Tests and evidence according to the system category

No.	Tests and evidence	System category			
		I	II	III	IV
1.	Evidence of quality system				
	Quality plan for software		M	M	M
	Inspection of components (only hardware) from sub-suppliers		M	M	M
	Quality control in production		M	M	M
	Final test reports	M	M	S	S
	Traceability of software	M	M	S	S
2.	Evidence of validity of hardware and software specification				
	Software specification		M	S	S
	Hardware specification		M	S	S
	Failure analysis for safety related functions only			S	S
3.	Evidence of software testing				
	Evidence of software testing according to quality plan		M	S	S
	Analysis regarding existence and fulfilment of programming procedures for safety related functions			S	S
	Code inspection, walk–through			M	M
	FMEA / FMECA				S
4.	Hardware tests				
	Tests according to Table 1		W	W	W
5.	Software tests				
	Module tests		M	S	S
	Subsystem tests		M	S	S
6.	Factory system tests				
	Function tests	M	W	W	W
	Operating conditions simulation		W	W	W
	Fault simulation		W	W	W
	Integration simulation tests		W	W	W
7.	On-board tests				
	Complete system tests	M	W	W	W
	Integration tests		W	W	W
8.	Modifications				
	Tests after modifications		W/S [a]	W/S [a]	W/S [a]

M Evidence kept by manufacturer and submitted on request

S Evidence checked by the administration

W To be witnessed by the administration

[a] Subsequent significant modifications to the software and hardware shall be submitted for approval (see 10.8.1).

When using demonstrably service-proven systems and components, the extent of the evidence and tests required and their location may be adjusted by agreement of the administration.

For definitions of the software tests and evidence according to Table 4, see IEC 61508-4.

11 Additional requirements for periodically unattended machinery spaces or for reduced attendance

11.1 General

The arrangements required by SOLAS Chapter II-1, Part E shall be provided.

The arrangements provided shall be such as to ensure that the safety of the ship in all sailing conditions, including manoeuvring, is equivalent to that of a ship having the machinery spaces attended.

The arrangements shall be appropriate for the intended duration of unattended operation.

The design of the arrangements shall be in accordance with Clause 9.

For reduced attendance, the applicability of 11.2 to 11.7 shall be determined by the administration.

11.2 Fire precautions

The arrangements required by SOLAS Chapter II-1, Part E, Regulation 47 shall be provided.

11.3 Protection against flooding

The arrangements required by SOLAS Chapter II-1 Part E, Regulation 48 shall be provided.

11.4 Control of propulsion machinery

The arrangements required by SOLAS Chapter II-1, Part E, Regulation 49 shall be provided.

11.5 Alarm system and engineers' alarm

The arrangements required by SOLAS Chapter II-1 Part E, Regulation 51 shall be provided.

11.6 Protection (safety) systems

The arrangements required by SOLAS Chapter II-1 Part E, Regulation 52 shall be provided.

11.7 Machinery, boiler and electrical installations

The arrangements required by SOLAS Chapter II-1, Part E, Regulation 53 shall be provided.

12 Commissioning and testing

12.1 Tests of completed installation

Tests shall be carried out to demonstrate that the electrical control, monitoring and alert systems have been correctly installed and are in good working order before being put into service. Tests shall be realistic and simulations avoided as far as is practicable.

After the completion of the installation, the entire control equipment shall be tested according to a prescriptive test program.

12.2 Operational tests

The operational tests shall be performed to adjust and record the operational ability of each individual system, including associated sensors, actuators, transducers, indicating and recording instruments, controllers and associated alerts. They shall also include operation in, and switching between, all methods of manual or automatic and local or remote control. The recordings shall be suitably documented.

The entire control system shall be tested for satisfactory operation during trials at quay and at sea, as far as practicable.

See also IEC 60092-401.

13 Documentation

For each control apparatus, the manufacturer shall deliver sufficient information concerning principles of operation, technical specifications, mounting instructions, required starting up or commissioning procedures, fault-finding procedures, maintenance and repair, as well as lists of the necessary test facilities and replaceable parts.

Sufficient information shall be available to enable a complete system description to be prepared.

Circuit diagrams on durable material shall, where relevant for each individual control apparatus, be prominently displayed in or near the apparatus to which it refers, or alternatively included in the control system handbook.

For computer based systems refer to 10.6.

Appropriate documentation specifying all set points shall be available.

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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INSTALLATIONS ÉLECTRIQUES À BORD DES NAVIRES –

Partie 504: Automatisation, commande et instrumentation

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La Norme internationale IEC 60092-504 a été établie par le comité d'études 18 de l'IEC: Installations électriques des navires et des unités mobiles et fixes en mer.

Cette quatrième édition annule et remplace la troisième édition parue en 2001. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) le titre de la partie a été modifié avec addition du terme "Automatisation";
b) le contenu du corrigendum de janvier 2011 a été intégré;
c) un nouveau paragraphe 5.1 "Généralités" contenant les exigences générales applicables aux essais de type a été ajouté;

d) le Tableau 1 a été aligné sur la dernière version du document IACS Req. 1991/Rev. 5, 2006;

e) la version révisée de la Résolution OMI A.1021(26), Recueil de règles relatives aux alertes et aux indicateurs:2009, a été prise en compte;

f) la Résolution OMI MSC.302(87) a été prise en compte. Par conséquent, le terme "alerte" a été utilisé lorsqu'il est question du terme générique. Cela concerne notamment le texte de 8.4 et 9.3;

g) un nouveau paragraphe 8.2.4: la version révisée de la Résolution OMI MSC.145(77) Normes de fonctionnement des détecteurs de niveau d'eau à bord des vraquiers: 2003 a été pris en compte;

h) le paragraphe 9.1 relatif aux systèmes de détection et d'alarme d'incendie a été entièrement révisé; la Résolution OMI MSC.98(73) (Recueil FSS) et son amendement MSC.292(87): 2010 ont été pris en compte;

i) un nouveau paragraphe 9.2 "Systèmes de cales" a été ajouté;

j) le paragraphe 9.4 "Installations de commande automatique pour alimentation électrique" et le paragraphe 9.5 "Installations de démarrage automatique pour systèmes auxiliaires à motorisation électrique" ont été intégralement révisés;

k) l'Article 10 "Systèmes informatiques" a été intégralement révisé;

l) un nouveau paragraphe 10.3.6 "Communication de données sans fil" a été ajouté;

m) un nouveau paragraphe 10.5 "Accès à distance" a été ajouté.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
18/1539/FDIS	18/1545/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60092, publiées sous le titre général *Installations électriques à bord des navires,* peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

INTRODUCTION

L'IEC 60092 constitue une série de Normes internationales applicables aux installations électriques des navires maritimes, qui rassemblent les bonnes pratiques et coordonnent, dans la mesure du possible, les règles en place.

Lesdites normes forment un code d'interprétation pratique et de précision des exigences de la Convention internationale pour la sauvegarde de la vie humaine en mer, un guide destiné aux règlements qui pourront être préparés ultérieurement et un énoncé des pratiques à l'usage des propriétaires, des constructeurs de navires et des organismes appropriés.

INSTALLATIONS ÉLECTRIQUES À BORD DES NAVIRES –

Partie 504: Automatisation, commande et instrumentation

1 Domaine d'application

La présente partie de l'IEC 60092 définit les équipements électriques, électroniques et programmables destinés aux systèmes d'automatisation, de commande, de surveillance, d'alerte, et de sécurité et de protection utilisés à bord des navires.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050 (toutes les parties), *Vocabulaire électrotechnique international (VEI)* (disponible sous www.electropedia.org)

IEC 60068-2-1, *Essais d'environnement – Partie 2-1: Essais – Essai A: Froid*

IEC 60068-2-2, *Essais d'environnement – Partie 2-2: Essais – Essai B: Chaleur sèche*

IEC 60068-2-6, *Essais d'environnement – Partie 2-6: Essais – Essai Fc: Vibrations (sinusoïdales)*

IEC 60068-2-30, *Essais d'environnement – Partie 2-30: Essais – Essai Db: Essai cyclique de chaleur humide (cycle de 12 h + 12 h)*

IEC 60068-2-52, *Essais d'environnement – Partie 2-52: Essais – Essai Kb: Brouillard salin, essai cyclique (solution de chlorure de sodium)*

IEC 60092-101:1994, *Installations électriques à bord des navires – Partie 101: Définitions et prescriptions générales*
IEC 60092-101:1994/AMD1:1995

IEC 60092-201:1994, *Installations électriques à bord des navires – Partie 201: Conception des systèmes – Généralités*

IEC 60092-202, *Installations électriques à bord des navires – Partie 202: Conception des systèmes – Protection*

IEC 60092-302, *Installations électriques à bord des navires – Partie 302: Ensembles d'appareillage à basse tension*

IEC 60092-501, *Electrical installations in ships – Part 501: Special features – Electric propulsion plant* (disponible en anglais seulement)

IEC 60092-502, *Electrical installations in ships – Part 502: Tankers – Special features* (disponible en anglais seulement)

IEC 60447, *Principes fondamentaux et de sécurité pour l'interface homme-machine, le marquage et l'identification – Principes de manœuvre*

IEC 60529, *Degrés de protection procurés par les enveloppes (Code IP)*

IEC 60533, *Electrical and electronic installations in ships – Electromagnetic compatibility (EMC) – Ships with a metallic hull* (disponible en anglais seulement)

IEC 60945, *Matériels et systèmes de navigation et de radiocommunication maritimes – Spécifications générales – Méthodes d'essai et résultats exigibles*

IEC 61000-4-2, *Compatibilité électromagnétique (CEM) – Partie 4-2: Techniques d'essai et de mesure – Essai d'immunité aux décharges électrostatiques*

IEC 61000-4-3, *Compatibilité électromagnétique (CEM) – Partie 4-3: Techniques d'essai et de mesure – Essai d'immunité aux champs électromagnétiques rayonnés aux fréquences radioélectriques*

IEC 61000-4-4, *Compatibilité électromagnétique (CEM) – Partie 4-4: Techniques d'essai et de mesure – Essai d'immunité aux transitoires électriques rapides en salves*

IEC 61000-4-5:2014, *Compatibilité électromagnétique (CEM) – Partie 4-5: Techniques d'essai et de mesure – Essai d'immunité aux ondes de choc*

IEC 61000-4-6, *Compatibilité électromagnétique (CEM) – Partie 4-6: Techniques d'essai et de mesure – Immunité aux perturbations conduites, induites par les champs radioélectriques*

IEC 61000-4-11, *Compatibilité électromagnétique (CEM) – Partie 4-11: Techniques d'essai et de mesure – Essais d'immunité aux creux de tension, coupures brèves et variations de tension*

IEC 61355-1, *Classification et désignation des documents pour installations industrielles, systèmes et matériels – Partie 1: Règles et tableaux de classification*

IEC 62443 (toutes les parties), *Réseaux industriels de communication – Sécurité dans les réseaux et les systèmes*

Publication ABS, *Guidance notes on the application of ergonomics to marine systems (02-2014)* (disponible en anglais seulement)

CISPR 16-1-1, *Spécification des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-1: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Appareils de mesure*

CISPR 16-2-1, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 2-1: Méthodes de mesure des perturbations et de l'immunité – Mesures des perturbations conduites*

EN 54 (toutes les parties), *Systèmes de détection et d'alarme incendie*

Résolution OMI A.1021(26):2009, *Recueil de règles relatives aux alertes et aux indicateurs*

Résolution OMI MSC.302(87):2010, *Adoption de la recommandation sur les normes de performance pour la gestion des alertes à la passerelle (BAM)*

Résolution OMI A.813(19):1995, *Prescriptions générales relatives à la compatibilité électromagnétique de tous les équipements électriques et électroniques des navires*

Résolution OMI MSC.98(73):2000, *Adoption du recueil international des règles applicables aux systèmes de protection contre l'incendie (recueil FSS)*

SOLAS, *Convention internationale pour la sauvegarde de la vie humaine en mer (SOLAS, Safety Of Life At Sea):1974, édition consolidée, 2009*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions donnés dans l'IEC 60050 ainsi que les suivants s'appliquent.

3.1
exactitude
qualité qui caractérise la proximité d'une valeur mesurée par rapport à la valeur vraie correspondante

3.2
administration
gouvernement du pays où le navire est immatriculé

[SOURCE: SOLAS, Chapitre I, Règle 2, Définition (b)]

3.3
disponibilité
aptitude d'une entité à être en état d'accomplir une fonction exigée dans des conditions données pendant un intervalle de temps donné, en prenant pour hypothèse que la fourniture des moyens extérieurs exigés est assurée

3.4
commande centralisée
commande de l'ensemble des opérations d'un système depuis un poste central

3.5
système informatique
système constitué de plusieurs dispositifs électroniques programmables et de leurs connexions, périphériques et logiciels nécessaires à l'exécution de fonctions automatiquement spécifiées

Note 1 à l'article: Les types suivants de dispositifs programmables pourraient faire partie d'un système informatique: unité centrale, mini-ordinateur, ordinateur avec microprocesseur, automate programmable.

3.6
fonctions de commande
fonctions destinées à réguler le comportement des équipements ou systèmes

3.7
poste de commande
groupe de dispositifs de commande au moyen duquel un opérateur peut maîtriser les performances d'une machine, d'un appareil, d'un processus ou d'un ensemble de machines et d'appareils

Note 1 à l'article: Un poste de commande permettra généralement à l'opérateur de vérifier que les conditions souhaitées sont satisfaites au travers d'un système de surveillance adapté.

3.8
sûreté de fonctionnement
degré de fiabilité qui peut être affecté à un système concernant sa capacité à remplir ses fonctions prévues dans des conditions environnementales et opérationnelles définies

3.9
services essentiels
fonctions nécessaires à la propulsion, à la manœuvre et à la sécurité du navire et de son personnel

3.10
de sécurité intrinsèque
à sûreté intégrée
qualifie une entité qui est conçue en vue d'éviter que ses défaillances n'entraînent des pannes critiques

Note 1 à l'article: D'après l'application, la sécurité intrinsèque sera prédéterminée en termes de priorités concernant la sécurité du navire; en général, elle peut être considérée comme l'élément le moins critique parmi les composants et systèmes auxiliaires de l'installation industrielle de propulsion/manœuvre, par exemple.

[SOURCE: IEC 60050-821: 1998, 821-01-10, modifiée – une note a été ajoutée.]

3.11
fonction
opération élémentaire réalisée par le système conjointement avec d'autres opérations élémentaires (fonctions système) afin de permettre au système d'exécuter une tâche

3.12
intégrité
capacité d'un système à exécuter correctement les fonctions exigées dans l'ensemble des conditions énoncées et sur une période définie

3.13
salle de commande des machines
salle ou locaux rassemblant les commandes centralisées, les équipements de mesure et de surveillance des équipements principaux et des machines auxiliaires stratégiques, ainsi que les systèmes de communication dédiés

3.14
maintenabilité
dans des conditions données d'utilisation, aptitude d'une entité à être maintenue ou rétablie dans un état dans lequel elle peut accomplir une fonction exigée, lorsque la maintenance est accomplie dans des conditions données, avec des procédures et des moyens prescrits

Note 1 à l'article: Le terme "maintenabilité" est aussi employé comme caractéristique de cette aptitude.

3.15
fonctions de surveillance
fonctions destinées à collecter les données des équipements et systèmes à des fins d'affichage et d'enregistrement

3.16
fonctions de protection
fonctions destinées à prévenir la détérioration des équipements et systèmes en cas de panne

3.17
fiabilité
aptitude d'une entité à accomplir une fonction requise dans des conditions données pendant un intervalle de temps donné

Note 1 à l'article: Il est généralement admis que l'entité est en état d'accomplir la fonction exigée au début de l'intervalle de temps donné.

Note 2 à l'article: La fiabilité est généralement exprimée quantitativement par des caractéristiques appropriées. Dans certaines applications, l'une des caractéristiques est une expression de cette aptitude par une probabilité, appelée aussi fiabilité.

[SOURCE: IEC 60050-312:2001, 312-07-06, modifiée – les notes 1 et 2 ont été ajoutées.]

3.18
fonctions de protection et de sécurité
fonctions destinées à prévenir toute blessure ou tout risque pour le personnel, et à protéger les équipements/systèmes

3.19
logiciel
programmes informatiques, procédures, règles et documentation associée à un système numérique de traitement des informations rattaché aux opérations et intégrant un programme d'application (utilisateur), un middleware et un système d'exploitation (firmware)

3.20
système
ensemble de composants organisés de sorte à exécuter une fonction ou un ensemble de fonctions spécifique

3.21
aptitude à l'utilisation
degré auquel un système peut être utilisé par des utilisateurs spécifiés pour atteindre des buts définis de manière efficace, efficiente et satisfaisante dans un contexte d'utilisation spécifié

3.22
zone de passerelle et de pont
zone de manœuvre et de navigation du navire dans laquelle sont situées les antennes

3.23
local de machines
locaux situés entre les cloisonnements étanches à l'eau d'un local contenant les machines principales et auxiliaires servant à la propulsion, y compris chaudières, génératrices et moteurs électriques destinés essentiellement à la propulsion

Note 1 à l'article: Dans le cas de dispositions inhabituelles, l'administration peut définir les limites des locaux de machines.

[SOURCE: SOLAS, Chapitre II-1, Règle 2, Définition 15]

3.24
commande à distance
télécommande
commande d'une manœuvre, effectuée à partir d'un point éloigné du dispositif de connexion commandé

[SOURCE IEC 60050-441:2000, 441-16-07]

3.25
processus
série d'actions systématiques à l'origine d'un résultat spécifique lié à l'exécution d'une instance d'un programme informatique

3.26
système d'automatisation
système de surveillance et de commande d'un processus

3.27
instrumentation
instruments et applications de surveillance, de mesure et de commande

3.28
modification majeure
modification des fonctionnalités et/ou de la sécurité du système

3.29
PMS
système de gestion de l'alimentation
système de commande automatique dédié à la génération et à la distribution d'énergie électrique

Note 1 à l'article: L'abréviation PMS est dérivée du terme anglais développé correspondant "power management system".

4 Exigences générales

4.1 Sûreté de fonctionnement

Les systèmes doivent être adaptés à l'utilisateur, à l'activité et à l'application.

L'intégrité des systèmes doit être adaptée aux fonctions prises en charge, notamment eu égard aux facteurs tels que la disponibilité, la fiabilité et la maintenabilité.

4.2 Sécurité

Les systèmes doivent être conçus de sorte à réduire le risque de blessure ou le risque environnemental à un niveau acceptable pour l'administration, que ce soit en fonctionnement normal ou en conditions de défaillance. Les fonctions doivent être conçues d'après le principe de sécurité intrinsèque.

4.3 Séparation

Les systèmes doivent être conçus de sorte que la défaillance d'un composant d'un système n'affecte pas de manière excessive un autre système, sous-système ou composant, et doivent être, dans la mesure du possible, identifiables.

La défaillance d'un système d'automatisation ne doit pas influencer les fonctions de protection et de sécurité.

Les fonctions de protection et de sécurité doivent être autonomes par rapport aux fonctions de commande. Dans la mesure du possible, les fonctions de commande et de surveillance (alerte) doivent également être autonomes.

Les systèmes de secours ou autres dispositions redondantes doivent être autonomes du point de vue fonctionnel.

4.4 Performance

Les systèmes doivent respecter des niveaux de performance spécifiques en fonctionnement et, le cas échéant, en condition de panne.

La répétabilité et l'exactitude doivent être adaptées à l'utilisation proposée et doivent être maintenues aux valeurs spécifiées au cours de la durée de vie attendue et en usage normal.

Les systèmes doivent rester stables dans l'ensemble de la plage de fonctionnement.

4.5 Aptitude à l'utilisation

Les systèmes doivent être facilement utilisables dans les conditions de fonctionnement prévues et doivent garantir un fonctionnement efficace et efficient.

Des mesures de protection contre toute exploitation inadaptée doivent être instaurées.

4.6 Intégration

Lorsque la sécurité du personnel peut directement dépendre du fonctionnement correct ou de la défaillance d'un système, ledit système ne doit pas être intégré à un autre système ni en dépendre, à l'exception de ceux chargés des fonctions complémentaires.

Lorsque la sécurité peut indirectement dépendre du fonctionnement correct ou de la défaillance d'un système, l'intégrité du système intégré doit satisfaire aux exigences de l'administration.

4.7 Activités de développement

Les activités réalisées dans le cadre du processus de développement, depuis la conception initiale jusqu'à la réalisation finale, ainsi que toutes les modifications d'utilisation ultérieures, doivent être planifiées et structurées de manière systématique et doivent être gérées correctement. Les personnes chargées de l'exécution de ces activités doivent être compétentes en la matière.

Les activités, domaines d'application, responsabilités et compétences doivent être documentés.

5 Paramètres des essais de type environnementaux

5.1 Généralités

Les conditions atmosphériques normalisées applicables aux essais fonctionnels par rapport aux spécifications d'équipement sont définies au n° 2 du Tableau 1.

Les essais décrits au Tableau 1 sont applicables (mais non réservés) à l'ensemble des équipements utilisés pour:

– l'automatisation, la commande, la protection et la sécurité;
– la communication interne.

Le type des équipements électriques et électroniques des navires qui ne sont exigés ni par les règles de classification ni par les conventions internationales et qui sont susceptibles de provoquer des perturbations électromagnétiques doit satisfaire aux exigences d'essai des spécifications d'essai en matière d'émissions par rayonnement et d'émissions conduites, conformément aux n° 19 et n° 20 du Tableau 1.

5.2 Performances

Lorsque les équipements ou systèmes sont soumis aux essais de type, les procédures d'essai ainsi que les niveaux de sévérité spécifiés au Tableau 1 doivent s'appliquer.

La conformité à la Résolution OMI A.813(19) exigera de soumettre à essai tous les équipements électriques et électroniques des navires au regard des normes de compatibilité électromagnétique correspondantes.

Tableau 1 – Essais de type, procédures d'essai et niveaux de sévérité

N°	Essai [a]	Procédure conforme à	Paramètres d'essai, niveau de gravité		Exigences supplémentaires
1	Inspection visuelle				Examen des équipements concernant: – la conformité aux schémas et données de conception; – la conformité aux normes IEC applicables; – la qualité de l'exécution et de la construction.
2	Essai fonctionnel par rapport aux spécifications d'équipement		Conditions atmosphériques normalisées: – température: 25 °C ± 10 °C – humidité relative: 60 % ± 30 % – pression atmosphérique: 96 kPa ± 10 kPa		
3	Essai de haute tension		Tension d'isolement assignée U_n V	Tension d'essai en courant alternatif V	Fréquence de la tension d'essai: 50 Hz ou 60 Hz. Circuits séparés dont les essais doivent être comparés. La connexion à la terre de l'ensemble des circuits interconnectés doit être soumise à essai. Les points de contact ouverts des pièces de contact doivent être soumis à essai. Les circuits imprimés équipés de composants électroniques qui pourraient être détériorés peuvent être enlevés pendant l'essai.
			$U_n \leq 65$	$2 \times U_n + 500$	
			$66 < U_n \leq 250$	1 500	
			$251 < U_n \leq 500$	2 000	
			$501 < U_n \leq 690$	2 500	
			Durée d'application de la tension d'essai: 1 min		

<table>
<tr><th>N°</th><th>Essai [a]</th><th>Procédure conforme à</th><th colspan="4">Paramètres d'essai, niveau de gravité</th><th>Exigences supplémentaires</th></tr>
<tr><td rowspan="15">4a</td><td rowspan="15">Variation de l'alimentation</td><td rowspan="15">IEC 61000-4-11</td><td colspan="4">Alimentation en courant alternatif</td><td></td></tr>
<tr><td colspan="2">N° de combinaison</td><td>Variation de tension (permanente)
%</td><td>Variation de la fréquence (permanente)
%</td><td rowspan="14">Chaque combinaison doit être soumise à essai.</td></tr>
<tr><td colspan="2">1</td><td>+ 6</td><td>+ 5</td></tr>
<tr><td colspan="2">2</td><td>+ 6</td><td>– 5</td></tr>
<tr><td colspan="2">3</td><td>– 10</td><td>– 5</td></tr>
<tr><td colspan="2">4</td><td>– 10</td><td>+ 5</td></tr>
<tr><td colspan="2"></td><td>Tension transitoire (durée: 1,5 s)</td><td>Fréquence transitoire (durée: 5 s)</td></tr>
<tr><td colspan="2">5</td><td>+ 20</td><td>+ 10</td></tr>
<tr><td colspan="2">6</td><td>– 20</td><td>– 10</td></tr>
<tr><td colspan="4">Alimentation en courant continu</td></tr>
<tr><td colspan="2">Tolérance de la tension continue</td><td colspan="2">± 10 %</td></tr>
<tr><td colspan="2">Variation cyclique de la tension</td><td colspan="2">5 %</td></tr>
<tr><td colspan="2">Ondulation de la tension</td><td colspan="2">10 %</td></tr>
<tr><td colspan="4">Alimentation par batterie:
de + 30 % à – 25 % pour les équipements connectés à la batterie ou conformément aux caractéristiques de charge/décharge, y compris la tension ondulatoire du dispositif de charge;
de + 20 % à – 25 % pour les équipements non connectés à la batterie au cours de la charge.</td></tr>
<tr><td>4b</td><td>Défaillance d'alimentation</td><td>IEC 61000-4-11</td><td colspan="4">Trois interruptions en 5 min
Pauses de 30 s</td><td>Vérification de:
– l'action préconisée pour l'équipement concernant la coupure et la restauration de l'alimentation;
– la corruption potentielle du programme ou des données contenues dans les systèmes électroniques programmables, le cas échéant.</td></tr>
</table>

N°	Essai [a]	Procédure conforme à	Paramètres d'essai, niveau de gravité				Exigences supplémentaires
5	Résistance d'isolement [b]		Tension d'alimentation assignée V	Tension d'essai V	Résistance d'isolement minimale MΩ		Entre les circuits et la terre; au niveau des bornes d'alimentation, le cas échéant. La résistance doit être mesurée avant et après l'essai de haute tension, l'essai de chaleur humide, l'essai au froid et l'essai au brouillard salin.
					Avant l'essai	Après l'essai	
			$U_n \leq 65$	$2 \times U_n$ min. 24	10	1	
			$U_n > 65$	500	100	10	
6	Froid avec variation progressive de température [c]	IEC 60068-2-1 Essai Ab pour équipements non dissipatifs IEC 60068-2-1 Essai Ad pour équipements dissipatifs	Température: + 5 °C ± 3 °C Durée: 2 h		Température: –25 °C ± 3 °C Durée: 2 h		Mesure initiale de la résistance d'isolement (voir l'essai n° 5). Equipement non opérationnel pendant le conditionnement sauf pour l'essai fonctionnel. Essai fonctionnel effectué au cours de la dernière heure à température d'essai. Mesure de la résistance d'isolement et essai fonctionnel après reprise.
7	Chaleur sèche avec variation progressive de température [d]	IEC 60068-2-2 Essai Bb pour équipements non dissipatifs	Température: 55 °C ± 2 °C Durée: 16 h		Température: 70 °C ± 2 °C Durée: 16 h		Equipement opérationnel pendant le conditionnement. Essai fonctionnel effectué au cours de la dernière heure à température d'essai. Essai fonctionnel après reprise.
		IEC 60068-2-2 Essai Be pour équipements dissipatifs	Température: 55 °C ± 2 °C Durée: 16 h		Température: 70 °C ± 2 °C Durée: 16 h		Equipement opérationnel pendant le conditionnement et système de refroidissement allumé, le cas échéant. Essai fonctionnel effectué au cours de la dernière heure à température d'essai. Essai fonctionnel après reprise.

N°	Essai [a]	Procédure conforme à	Paramètres d'essai, niveau de gravité	Exigences supplémentaires
8	Essai cyclique de chaleur humide (cycle de 12 h + 12 h) [j]	IEC 60068-2-30 Essais Db	Température: 55 °C Humidité: 95 % Durée: deux cycles (12 h + 12 h)	Mesure de la résistance d'isolement avant l'essai. Equipement opérationnel pendant le premier cycle et éteint en cours du second cycle, sauf pour l'essai fonctionnel. Essai fonctionnel effectué au cours des deux premières heures du premier cycle à température d'essai et au cours des deux dernières heures du second cycle à température d'essai. Reprise en conditions atmosphériques normalisées. Mesure de la résistance d'isolement et essai de performance.
9	Brouillard salin [e]	IEC 60068-2-52 Essai Kb	Quatre périodes de vaporisation chacune suivie d'une période de stockage de 7 jours	Mesure initiale de la résistance d'isolement et essai fonctionnel initial. Equipement en position normale pendant l'essai. Equipement non opérationnel pendant le conditionnement. Essai opérationnel le 7^{e} jour de chaque période de vaporisation. Mesure de la résistance d'isolement et essai de performance 4 h à 6 h après la période de reprise.
10	Vibrations (sinusoïdales)	IEC 60068-2-6 Essai Fc	Pour les applications générales: $2\ ^{+3}_{-0}$ Hz à 13,2 Hz Amplitude: ± 1 mm > 13,2 Hz à 100 Hz Accélération: ± 0,7 g Endurance à: – chaque fréquence de résonance à laquelle un facteur d'amplification $Q \geq 2$ est enregistré; – 30 Hz lorsqu'aucune fréquence de résonance n'est enregistrée.	Au cours de l'essai de vibrations, les conditions de fonctionnement doivent être démontrées. Essais devant être réalisés sur trois plans mutuellement perpendiculaires. Il est recommandé (sous forme de lignes directrices) que Q ne dépasse pas 5. En cas d'essai de balayage, si plusieurs

N°	Essai [a]	Procédure conforme à	Paramètres d'essai, niveau de gravité	Exigences supplémentaires
			Pour les équipements montés sur les machines alternatives installées dans le compartiment de l'appareil à gouverner ou à un emplacement similaire: 2,0 Hz à 25 Hz Amplitude: ± 1,6 mm > 25 Hz à 100 Hz Accélération: ± 4 g Endurance à: – chaque fréquence de résonance à laquelle un facteur d'amplification $Q \geq 2$ est enregistré; – 30 Hz lorsqu'aucune fréquence de résonance n'est enregistrée.	fréquences de résonance rapprochées sont détectées, la durée de l'essai doit être de 120 min.
			En conditions extrêmes uniquement: De 40 Hz à 2 000 Hz, accélération: ± 10 g Durée: 90 min	Sur les collecteurs d'échappement des moteurs diesel, par exemple
11a	Inclinaison constante [a, i]		22,5°	Chaque direction Equipement opérationnel
11b	Inclinaison dynamique		22,5° 0,1 Hz	Chaque direction Equipement opérationnel Durée de l'essai supérieure à 15 min
12	Protection par enveloppe	IEC 60529	En fonction de l'emplacement	Les exigences minimales relatives au degré de protection sont fournies dans l'IEC 60092-201.
13	Décharge électrostatique	IEC 61000-4-2	Décharge par contact: 6 kV Décharge dans l'air: 8 kV Intervalle entre deux décharges simples: 1 s Nombre d'impulsions: 10 par polarité Conformément au 3e niveau d'essai	Des décharges électrostatiques peuvent se produire en cas de contact avec l'appareil. L'essai doit être réservé aux points et aux surfaces qui peuvent habituellement être accessibles à l'opérateur. Critère de performance B [f].
14	Champ électro-magnétique	IEC 61000-4-3	Plage de fréquences: 80 MHz à 6 GHz Modulation: 80 % AM à 1 000 Hz Intensité du champ: 10 V/m Vitesse de balayage en fréquence: $\leq 1,5 \times 10^{-3}$ décades/s (ou 1 %/3 s) Conformément au 3e niveau d'essai	Champs électromagnétiques émis par différents émetteurs. Si, dans le cadre d'essais pour équipements, un signal d'entrée avec fréquence de modulation de 1 000 Hz est nécessaire, une fréquence de modulation de 400 Hz peut être choisie. Critère de performance A [g].

N°	Essai [a]	Procédure conforme à	Paramètres d'essai, niveau de gravité	Exigences supplémentaires
15	Basse fréquence conduite	IEC 60533	Accès d'alimentation en courant alternatif: Plage de fréquences: fréquence assignée sur la 200^{e} harmonique; Tension d'essai (valeur efficace): tension d'alimentation de 10 % à la 15^{e} harmonique réduite à 1 % à la 100^{e} harmonique, ce niveau étant maintenu jusqu'à la 200^{e} harmonique; 2 W max. Accès d'alimentation en courant continu: Plage de fréquences: 50 Hz à 10 kHz; Tension d'essai (valeur efficace): 10 % de tension, 2 W max.	Déformations du système d'alimentation générées, par exemple, par des appareils électroniques clients et couplées sous forme d'harmoniques. Méthodologie d'essai conforme à la norme IEC 60945. Critère de performance A [g].
16	Radio-fréquence conduite	IEC 61000-4-6	Plage de fréquences: 150 kHz à 80 MHz Amplitude: 3 V efficaces [h] Modulation: 80 % AM à 1 000 Hz Plage de fréquences de balayage: $\leq 1{,}5 \times 10^{-3}$ décades/s (ou 1 %/3 s) Conformément au 2^{e} niveau d'essai	Champs électromagnétiques couplés en haute fréquence dans l'éprouvette d'essai via les lignes de connexion. Si, dans le cadre d'essais pour équipements, un signal d'entrée avec fréquence de modulation de 1 000 Hz est nécessaire, une fréquence de modulation de 400 Hz peut être choisie. Critère de performance A: voir note [g].
17	Transitoires rapides en salves	IEC 61000-4-4	Durée d'une impulsion simple: 5 ns (valeur entre 10 % et 90 %) Largeur d'une impulsion: 50 ns (valeur 50 %) Amplitude (de pointe): – ligne de 2 kV de l'accès de puissance à l'accès de terre (PE); – 1 kV sur les accès de communication et de commande de données E/S (avec pince de couplage); Période d'impulsion: 300 ms; Durée d'une salve: 15 ms; Durée par polarité: 5 min Conformément au 3^{e} niveau d'essai	Arcs générés lors de la manœuvre des contacts électriques. Effets perturbateurs au niveau de l'alimentation et du câblage externe de l'éprouvette d'essai. Critère de performance B [f].
18	Surtensions/ Transitoires	IEC 61000-4-5	L'essai s'applique aux accès de puissance en courant alternatif et en courant continu Temps de montée de l'impulsion: 1,2 µs (valeur entre 10 % et 90 %) Largeur d'une impulsion: 50 µs (valeur de 50 %) Amplitude (de pointe): 1 kV entre phase et terre 0,5 kV entre phases; Taux de répétition ≥1 impulsion/min Nombre d'impulsions: 5 par polarité Application: continue Conformément au 2^{e} niveau d'essai	Perturbations générées, par exemple, en allumant ou en éteignant des appareils clients hautement inductifs. Procédure conforme à la Figure 10 de l'IEC 61000-4-5:2014 applicable aux équipements dont les lignes d'alimentation et de signaux sont identiques. Critère de performance B [f].