INTERNATIONAL STANDARD

IEC 60092-504

Third edition
2001-03

Electrical installations in ships –

Part 504:
Special features – Control and instrumentation

Installations électriques à bord des navires –

Partie 504:
Caractéristiques spéciales – Conduite et instrumentation

Reference number
IEC 60092-504:2001(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE XA

For price, see current catalogue

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 504: Special features – Control and instrumentation

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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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3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
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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 third edition cancels and replaces the second edition, published in 1994, and constitutes a technical revision.

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

FDIS	Report on voting
18/889/FDIS	18/890/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 3.

The committee has decided that the contents of this publication will remain unchanged until 2005. At this date, the publication will be

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- withdrawn;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

A bilingual version of this standard may be issued at a later date.

The contents of the corrigendum of January 2011 have been included in this copy.

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 in seagoing ships.

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 a guide for future regulations which may be prepared and as a statement of practice for use by shipowners, 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 – Control and instrumentation

1 Scope

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

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60092. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60092 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*

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

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

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

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

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

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

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

IEC 60092-201, *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, *Man-machine interface (MMI) – Actuating principles*

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

IEC 60533, *Electrical and electronic installations in ships – Electromagnetic compatibility*

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: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test. Basic EMC Publication*

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

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

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

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

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

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

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

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

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

3 Definitions

For the purposes of this part of IEC 60092, the following definitions, having special application to the control, monitoring, alarm and protection equipment, 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

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

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 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 behavior 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 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

NOTE 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.

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

3.13
integrity
capability of a system to satisfactorily perform the required functions under all the stated conditions within a stated period of time

3.14
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

3.15
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

3.16
monitoring functions
functions intended to collect data from equipment and systems for the purpose of display and recording

3.17
protection functions
functions intended to prevent damage to equipment or systems in the event of a fault

3.18
reliability
ability of an item to perform a required function under given conditions for a given time interval

3.19
safety functions
functions intended to prevent harm or danger to personnel

3.20
software
program, procedures and associated documentation pertaining to the operation of a computer system and including application (user) program, middleware and operating system (firmware) program

3.21
system
collection of components organised to accomplish a specific function or set of functions

3.22
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

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, both in normal operation and under failure conditions. Functions shall be designed on the fail-to-safe 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.

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

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

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

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

Table 1 – Type tests, test procedures and severities

	Test [a]	Procedure according to	Severity		Other information
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
3	High voltage test		Rated insulation voltage U_n V	Test voltage AC V	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.
			$U_n \leq 65$	$2 \times U_n + 500$	
			$66 < U_n \leq 250$	1 500	
			$251 < U_n \leq 500$	2 000	
			$501 < U_n \leq 690$	2 500	
			Period of application of test voltage: 1 min		

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

Table 1 *(continued)*

<table>
<tr><th></th><th>Test [a]</th><th>Procedure according to</th><th>Severity</th><th>Other information</th></tr>
<tr><td>4a</td><td>Power supply variations</td><td>IEC 61000-4-11</td><td>
AC supply
<table>
<tr><th>Combination No.</th><th>Voltage variation (permanent)
%</th><th>Frequency variation (permanent)
%</th></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>
</table>
DC supply
<table>
<tr><td>Voltage tolerance continuous</td><td>±10 %</td></tr>
<tr><td>Voltage cyclic variation</td><td>5 %</td></tr>
<tr><td>Voltage ripple</td><td>10 %</td></tr>
</table>
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.
</td><td>Each combination shall be tested.</td></tr>
<tr><td>4b</td><td>Power supply failure</td><td>IEC 61000-4-11</td><td>Three interruptions during 5 minutes
30 s break time</td><td>Verification of the following:
– specified action of the equipment on loss and restoration of supply;
– there is no corruption of program or data held in programmable electronic systems, where applicable.</td></tr>
</table>

Table 1 *(continued)*

	Test [a]	Procedure according to	Severity				Other information
5	Insulation resistance [b]		Rated supply voltage V	Test voltage V	Minimum insulation resistance		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 MΩ	After test MΩ	
			$U_n \leq 65$	$2 \times U_n$ 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	+5 °C ± 3 °C 2 h		–25 °C ± 3 °C 2 h		Initial measurement of insulation resistance (see test 6) 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	55 °C ± 2 °C 16 h		70 °C ± 2 °C 2 h		Equipment operating during conditioning Operational test during last hour at test temperature Operational test after recovery
		IEC 60068-2-2 Test Bd for heat dissipating equipment	55 °C ± 2 °C 16 h		70 °C ± 2 °C 2 h		Equipment operating during conditioning with cooling system on if provided Operational test during last hour at test temperature Operational test after recovery

Table 1 *(continued)*

	Test [a]	Procedure according to	Severity	Other information	
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 (sinu-soidal)	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 $2\,^{+3}_{-0}$ 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 are to be demonstrated. Tests to 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.
			90 min		
			40 Hz to 2 000 Hz acceleration ±10 *g* 90 min		Only for extreme conditions e.g. on exhaust manifolds of diesel engines

Table 1 *(continued)*

	Test [a]	Procedure according to	Severity	Other information	
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		See table 5 of IEC 60092-201 for minimum requirements.
13	Electrostatic discharge	IEC 61000-4-2	Contact discharge: 6 kV Air discharge: 8 kV Interval between single discharges: 1 s No. of pulses: 10 per polarity According to 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: see note [f].
14	Electro-magnetic field	IEC 61000-4-3	Frequency range: 80 MHz – 2 GHz Modulation: 80 % AM at 1 000 Hz Field strength: 10 V/m Frequency sweep rate: $\leq 1{,}5 \times 10^{-3}$ decades/s (or 1 %/3 sec) According to 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: see note [g].
15	Conducted low frequency	IEC 60533	AC: Frequency range: rated frequency to 200th harmonic; Test voltage (r.m.s.): 10 % of supply to 15th harmonic reducing to 1 % at 100th harmonic and maintain this level to the 200th harmonic, max 2 W DC: Frequency range: 50 Hz – 10 kHz; Test voltage (r.m.s.): 10 % of supply, 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: see note [g].
16	Conducted radio frequency	IEC 61000-4-6	Frequency range: 150 kHz – 80 MHz Amplitude: 3 V r.m.s. [h] Modulation: 80 % AM at 1 000 Hz Frequency sweep range $\leq 1{,}5 \times 10^{-3}$ decades/s (or 1 %/3 sec.) According to 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 1 (continued)

	Test (note 1)	Procedure according to	Severity	Other information
17	Burst/fast transients	IEC 61000-4-4	Single pulse time: 5 ns (between 10 % and 90 % value) Pulse width: 50 ns (50 % value) Amplitude (peak): 2 kV line/line on power supply port; 1 kV lines/earth on I/O data control and signal lines; Pulse period: 300 ms; Burst duration: 15 ms; Duration/polarity: 5 min According to level 3 severity standard	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: see note [f].
18	Surge/show transient	IEC 61000-4-5	Pulse rise time: 1,2 µs, (between 10 % and 90 % value) Pulse width: 50 µs (50 % value) Amplitude (peak): 1 kV line/earth; 0,5 kV line/line Repetition rate ≥1 pulse/min No. of pulses: five per polarity Application: continuous According to level 2 severity standard	Interference generated for instance, by switching "ON" or "OFF" high power inductive consumers Test procedure in accordance with figure 10 of the standard for equipment where power and signal lines are identical Performance criterion B: see note [f].
19	Radiated emission	CISPR 16-1 CISPR 16-2	For equipment installed in the bridge and deck zone Frequency range: Limits: 0,15 – 0,3 MHz 80 – 52 dBµV/m 0,3 – 30 MHz 52 – 34 dBµV/m 30 – 2 000 MHz 54 dBµV/m except for: 156 – 165 MHz 24 dBµV/m For equipment installed in the general power distribution zone Frequency range: Limits: 0,15 – 30 MHz 80 – 50 dBµV/m 30 – 100 MHz 60 – 54 dBµV/m 100 – 2 000 MHz 54 dBµV/m except for: 156 – 165 MHz 24 dBµV/m	Procedure in accordance with the standard but distance 3 m between equipment and antenna

Table 1 *(continued)*

	Test [a]	Procedure according to	Severity	Other information
20	Conducted emission	CISPR 16-1 CISPR 16-2	For equipment installed in the bridge and deck zone Frequency range: Limits: 10 – 150 kHz 96 – 50 dBµV 150 – 350 kHz 60 – 50 dBµV 350 kHz – 30 MHz 50 dBµV For equipment installed in the general power distribution zone Frequency range: Limits: 10 – 150 kHz 120 – 69 dBµV 0,15 – 0.5 MHz 79 dBµV 0,5 – 30 MHz 73 dBµV	
21	Flame retardancy (cables)	IEC 60092-101	Flame application: – 5 times, 15 s each Interval between each application: – 15 s	The burnt-out or damaged part of the specimen is not to exceed 60 mm in length

[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, e.g. for equipment to be mounted in consoles, housings.

[e] Salt mist test to be carried out for equipment to be installed in non-weatherprotected 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 ; 3 ; 4 ; 6,2 ; 8,2 ; 12,6 ; 16,5 ; 18,8 ; 22 ; 25 MHz.

[i] On ships for the carriage of liquid gases and chemicals, the emergency power supply must 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.

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, e.g. 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 it 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, 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-circuit 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, e.g. due to environmental effect.

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. An alarm 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 for forced ventilated cabinets in machinery spaces to prevent insulation breakdown due to pollution deposits.

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 mechanical construction. All nut and bolt connections shall be locked.

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.

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 shall meet the relevant IEC requirements for navigation and communication equipment (see 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 made to the IMO Resolution A.830(19), Code on Alarms and Indicators, 1995.

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, 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 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.

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 series 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 and maintenance.

8.2.2 Temperature sensors

Temperature sensors shall be installed in pockets of suitable material. Connections shall be arranged to draw out 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 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.

8.2.5 Testing and calibration

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

8.3 Presentation of information

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

8.4 Controls

8.4.1 Remote controls

8.4.1.1 Continuous information

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

8.4.1.2 Independent control

Where control may be effected 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.

8.4.1.3 Exclusive control

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

8.4.1.4 Transfer of control

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.

8.4.1.5 Main command location

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

8.4.1.6 Security

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

8.4.1.7 Status indication

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

8.4.1.8 Interlocks

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

8.4.2 Man-machine interface

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

8.5 Alarm systems

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

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.

9.2 Machinery alarm 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.

9.2.2 General

An alarm installation shall have the following objectives:

– to direct the attention of personnel to an abnormal condition;

– 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 and the return to normal condition indicated.

9.2.3 Alarm requirements

9.2.3.1 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 connected to the machinery alarm installation.

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.

9.2.3.3 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.

Acknowledgement of the alarm condition shall be indicated by an alteration of the visual signal, for example, from flashing to steady light, and 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 at a repeater alarm panel shall not lead automatically to the acknowledgement of the original alarm at the centralised control position.

9.2.3.4 Inhibition

Inhibition of an alarm 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.

9.2.4 Display of information

9.2.4.1 Group arrangement

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

9.2.4.2 Legibility

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

9.2.4.3 Common audible alarm

If the audible alarm 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 complying with the relevant requirements of IMO Resolution 867E, Code on Alarms and Indicators, 1995.

9.2.4.4 Alarm differentiation

An existing alarm shall not prevent the indication of further faults.

9.2.4.5 First failure indication

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

9.2.5 Supply arrangements

9.2.5.1 Stand-by power supply

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

9.2.5.2 Alarm for supply failure

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

9.2.6 Design

9.2.6.1 Separation of functions

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

9.2.6.2 Monitoring equipment

Alarm system 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.

9.2.6.3 Time delays

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

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

9.2.6.4 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.

9.2.6.5 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).

9.2.6.6 Mutual fault independence

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

9.2.6.7 Audible alarm independence

A fault in alarm-indicating lamps, including a short-circuit in a lamp or lamp-holder, shall not affect the operation of the audible alarm.

9.2.6.8 System integrity

As far as is practicable, test facilities for checking the proper function or 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 Automatic starting installations for electrical motor-driven auxiliaries

9.4.1 Introduction

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

9.4.2 General

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

9.4.3 Automatic sequence starting

9.4.3.1 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 of, and during the procedure of, power restoration after the occurrence of a blackout.

9.4.3.2 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 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.

9.4.4 Starting installations for stand-by auxiliaries

9.4.4.1 Starting order

The starting order for the stand-by machine shall be given either from the controlled medium, or the electrical system, or both, as appropriate for the service concerned.

The starting order 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.

9.4.4.2 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, shall be indicated at the centralised control position, where provided, and the local control position(s).

9.4.4.3 Indication of start

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

9.4.5 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.

9.4.6 Manual control

A fault 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.

9.5 Machinery control installations

9.5.1 Introduction

This subclause relates to the control of machinery essential for the propulsion and safety of the ship.

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

9.5.2 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.

9.5.3 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 9.5.5.1).

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

9.5.4 Remote control of propulsion machinery from the bridge

9.5.4.1 Application

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

9.5.4.2 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.

9.5.4.3 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.

9.5.4.4 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.

9.5.4.5 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.

9.5.4.6 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.

9.5.4.7 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.

9.5.4.8 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.

9.5.4.9 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.

9.5.5 Indicators for remote control of machinery

9.5.5.1 Indication of control location

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

9.5.5.2 Running indication

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

9.5.5.3 Parameter indication

Indication 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.

9.5.6 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.

9.6 Machinery protection (safety) systems

9.6.1 Introduction

This subclause relates to the equipment required to initiate appropriate action whenever pre-set limits of the parameters of operating machinery are exceeded.

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).

9.6.2 General requirements

9.6.2.1 Principles of operation

Protection (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.

9.6.2.2 Propulsion system

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

9.6.2.3 Failure modes

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.

9.6.2.4 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. Visual means at least 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.

9.6.2.5 Power supplies

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.

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

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 Bow, inner, side shell and stern doors

9.7.1 Application

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

9.7.2 Remote control

If arranged for remote control, the requirements of 8.4 shall apply.

9.7.3 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.

9.7.4 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.

9.7.5 Fail-to-safe

The indicator and alarm system shall be designed on the fail-to-safe 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.

9.7.6 Testing

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

9.7.7 Independence

The alarm and indicator system 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, e.g. uninterruptible power supply (UPS).

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

9.7.8 Display

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

9.7.9 Sensors

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

9.7.10 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.

9.7.11 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.

An audible alarm shall be initiated on the navigation bridge and at the machinery control room.

9.7.12 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 9.7.11, shall be initiated on the navigation bridge if the water level exceeds 0,5 m above the car deck level in these areas.

9.7.13 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.

9.8 Power-operated watertight doors

9.8.1 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

9.8.2 Alarm

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

This alarm shall sound 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 may require the audible alarm to be supplemented by an intermittent visual signal on the door.

9.8.3 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.

9.8.4 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°.

9.8.5 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.

9.8.6 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).

9.8.7 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 warning signals; 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.

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

9.8.8 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.

9.8.9 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.

9.8.10 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.

9.8.11 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.

9.8.12 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 9.8.5. Loss of any such power supply shall activate an audible and visual alarm at the central operating console at the navigation bridge.

9.8.13 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. 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.

9.8.14 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 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.

9.8.15 Remote opening

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

9.9 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.

9.9.1 Audibility

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

9.9.2 Override

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

This function shall be protected against unauthorised use by, e.g., key or password operation.

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

9.9.3 Operation

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

9.9.4 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.

9.9.5 Level adjustment

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

9.9.6 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.

9.9.7 Interference

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

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

9.9.8 Fault tolerance

The system shall have multiple amplifiers and a distributed arrangement in order not to allow single failures to disrupt the total system.

9.9.9 Protection

Each loudspeaker shall be individually protected against short circuit.

9.9.10 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.

9.9.11 Segregation

Loudspeakers in public rooms, alleyways, stairways, and control stations shall be fed by multiple amplifiers.

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

9.9.12 Power supplies

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

9.9.13 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.

10 Computer-based systems

10.1 General

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.